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**Timothy Boronczyk and Christopher Negus**

*Foreword by Karanbir Singh, Core Developer on the CentOS Project*

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# CentOS Bible



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**Timothy Boronczyk  
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# Introduction

**W**ith the CentOS operating system and the instructions provided in this book, you can transform your computers into free, safe, and powerful enterprise-class systems. Not only can you configure your server to share files, printers, web pages, or directory services to other computers, but you can also use CentOS on everyday workstations as well to benefit from its security and stability.

Because CentOS includes enterprise-class software, the skills you learn by using CentOS can be applied to work with the largest, most secure, and most diverse Linux systems in the world. Using this book is a great start for becoming a Linux professional.

## Who You Are

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You don't need to be a programmer to take advantage of this book. Perhaps you are someone who just wants to use Linux to run programs, access the Internet, and so on. Or, perhaps you are someone who wants to learn how to administer an enterprise-grade Linux system.

We assume that you are somewhat computer literate but may have little or no experience with Linux (or UNIX). You may be migrating from Microsoft operating systems to Linux because of its networking and multiuser features. You may be looking to start a career as a computer technician or network administrator and find that spending a few dollars for an entire operating system and book is more economical than taking those technical classes offered on late-night television. Or you might just think a "free" enterprise operating system is cool.

## This Book's Learn-Through-Tasks Approach

---

The best way to learn a computer system is to get your hands on it. To help you learn Linux and CentOS, this book takes a task-oriented approach. Where possible, we step you through the process of working with a feature, such as setting up a network or configuring your desktop.

When you are done with a task, you should have a good, basic setup of the feature that it covers. After that, we often provide pointers to further information on tweaking and tuning the feature.

Instead of assuming that you already know about cryptic topics such as DNS, NFS, and TCP/IP, we ease you into those features with headings such as "Making Your Servers Public," "Setting Up

## Introduction

a File Server,” and “Connecting to the Internet.” If you already knew what all those things were and how to get them working, you wouldn’t need us, would you?

You will find that there are a lot of choices available in the Linux world. When many tools can be used to achieve the same results, we usually present one or two examples. In other words, we don’t describe six different Web browsers, 12 different text editors, and three different mail servers. We tell you how to get one or two similar tools really working and then note that others are available.

## What You Need

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To follow along with this book, you can install the complete CentOS 5 software found on the accompanying DVD. If you don’t have a DVD drive, you can use the CD that comes with this book to try out CentOS without installing it. Of course, you can also follow along on an existing CentOS system.

To install CentOS with the media that comes with this book, you need a PC with the following general configuration:

- An Intel Pentium or compatible CPU, 200 MHz Pentium or better (for text mode); 400 MHz Pentium II or better (for GUI mode)
- At least 64 MB of RAM (text-based install) or 128 MB of RAM (graphical install). To run the GNOME or KDE desktops, 192 MB are needed, although the CentOS Project recommends at least 512 MB.
- At least 3.0 GB of hard disk space for a typical workstation installation, or at least 1.1 GB of space for a server installation
- A DVD or CD drive. This is recommended for installation (because an installation DVD is provided along with this book), although you can install CentOS over a network or from a local hard disk instead. Chapter 2 describes methods of launching installations if you don’t have a bootable DVD drive.

Not every piece of PC hardware works with CentOS. You can see what hardware is supported by visiting the following site: [www.centoslinuxhcl.org](http://www.centoslinuxhcl.org).

## Conventions Used in This Book

---

Throughout the book, special typography indicates code and commands. Commands and code are shown in a monospaced font:

This is how code looks

In the event that an example includes both input and output, the monospaced font is still used, but input is presented in bold type to distinguish the two. Here's an example:

```
$ ftp ftp.example.com
Name (home:timothy): timothy
Password: *****
```

The following boxes are used to call your attention to points that are particularly important.

**NOTE**

A Note box provides extra information to which you need to pay special attention.

**TIP**

A Tip box shows a special way of performing a particular task.

**WARNING**

A Warning box alerts you to take special care when executing a procedure, or damage to your computer hardware or software could result.

**CROSS-REF**

A Cross-Reference box refers you to further information on a subject that you can find outside the current chapter.

## How This Book Is Organized

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This book is organized into four parts: Getting Started, Using CentOS, Administration, and Networking.

### Part I: Getting Started

Part I consists of Chapters 1 through 4. Chapters 1 and 2 contain brief descriptions of the Linux technology and tell you what you need to get the operating system installed. Chapter 1 serves as an introduction to the Linux OS and to CentOS in particular. Chapter 2 discusses what you need to install CentOS and how to make the decisions you'll be faced with during installation. It includes procedures for installing from DVD, hard disk, or network connections (NFS, FTP, or HTTP servers).

In Chapter 3, you learn about the GNOME and KDE desktop environments. These GUIs provide graphical means of using CentOS. Chapter 4 describes ways of exploring and understanding CentOS primarily from the Linux shell command interpreter. You learn how to use the `bash` shell, the `vi` text editor, and the commands for moving around the Linux file system.

### Part II: Using CentOS

Part II consists of Chapters 5 through 8, which include information for the average user who wants to use Linux to run applications and access the Internet.

## Introduction

Chapter 5 contains information on obtaining, installing, and running Linux applications. It also helps you run applications from other operating systems in Linux. Chapter 6 describes both old-time publishing tools and new, graphical word processors that are available with CentOS. Old tools include the `troff` and TeX text processing tools, whereas newer publishing software includes OpenOffice.org (included on the DVD) and StarOffice (available commercially).

Chapter 7 describes how to use audio and video players, as well as how to configure sound cards and CD burners. Chapter 9 describes tools for browsing the Web (such as the Firefox Web browser) and related tools (such as e-mail clients).

## Part III: Administration

Part III consists of Chapters 9 through 13, which cover general set-up and system maintenance tasks, including how to set up user accounts, automate system tasks, and back up your data. Chapter 9, in which you learn what you need to know about basic system administration, describes the root login, administrative commands, configuration files, SELinux, and log files. Chapter 10 describes how to set up and provide support for multiple users on your CentOS system.

In Chapter 11, you learn to create shell scripts and to use the `cron` facility to automate a variety of tasks on your CentOS system. Techniques for backing up your system and restoring files from backup are described in Chapter 12. Chapter 13 describes issues related to securing your computing assets in CentOS.

## Part IV: Networking

Part IV consists of Chapters 14 through 24, which describe step-by-step procedures for setting up a variety of server types. Simple configurations for what might otherwise be complex tasks are contained in each chapter. Learn to arrange, address, and connect your Linux computes to a local area network (LAN) in Chapter 14. Chapter 15 describes techniques for connecting your CentOS computer and LAN to the Internet, using features such as Point-to-Point Protocol (PPP), IP forwarding, IP masquerading, routing, and proxy servers.

Chapter 16 describes how to set up different types of print server interfaces, including Samba (to share with Windows systems) and native Linux CUPS printing. Chapter 17 describes file servers, such as Network File System (NFS) servers and Samba file servers. Chapter 18 describes how to configure Sendmail or Postfix e-mail servers.

Chapter 19 describes how to configure and secure an FTP server, as well as how to access the server using FTP client programs. Chapter 20 teaches you how to set up CentOS as a Web Server, focusing on the popular Apache server software. Chapter 21 explains how to use LDAP to create a shared address book. Chapter 22 describes how to set up a DHCP server to distribute information to client workstations on the network.

Chapter 23 describes how to set up and use a MySQL database server in CentOS. Chapter 24 takes you through the process of making the servers you configured in the other chapters available on the Internet by setting up a Domain Name System (DNS) server.

## About the Companion Media

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The CentOS 5 DVD that accompanies this book provides the software you need for a complete working CentOS system. With this software, you can install sets of software packages that result in an installation from a few hundred megabytes to up to well over 10 GB of software.

We also include a CentOS 5 Live CD. That CD can be booted to run a live CentOS GNOME desktop system without touching the contents of your hard disk.



# **CentOS Bible**





# Part I

# Getting Started

## IN THIS PART

Chapter 1  
An Overview of CentOS

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Chapter 2  
Installing CentOS

---

Chapter 3  
Getting Started with the Desktop

---

Chapter 4  
Using Linux Commands

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# Chapter 1

## An Overview of CentOS

The goal of the CentOS project ([www.centos.org](http://www.centos.org)) is to produce an enterprise-class Linux operating system distribution. Like most Linux distributions, CentOS leverages the work done by thousands of software developers around the world that release their software under free and Open Source (FOSS) licenses.

But unlike other Linux distributions, CentOS distinguishes itself not by how it is different, but by how it strives to be the same.

The CentOS Linux distribution includes software from many of the most respected and mature projects in the Open Source world. If you want to use CentOS as a server, you can take advantage of server software in CentOS that includes:

- **Apache Web Server** (<http://httpd.apache.org>) — The most popular HTTP server in the world
- **Samba** ([www.samba.org](http://www.samba.org)) — A suite of applications used for sharing files, printers, and related information using protocols that are native to Windows, OS/2, and other PC-based systems
- **Sendmail** ([www.sendmail.org](http://www.sendmail.org)) — An e-mail server that lets you send and store e-mail that can be accessed using a variety of e-mail clients
- **CUPS** ([www.cups.org](http://www.cups.org)) — The Common UNIX Printing System includes software for configuring print servers.
- **vsFTPD** (<http://vsftpd.beasts.org>) — A File Transfer Protocol (FTP) server that lets users upload and download files over a network
- **MySQL** ([www.mysql.com](http://www.mysql.com)) — A multiuser SQL database server

### IN THIS CHAPTER

**Introducing CentOS 5**

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**What is Linux?**

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**Linux's roots in UNIX**

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**Common Linux features**

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**Primary advantages of Linux**

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**Going forward with CentOS**

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- **BIND** ([www.isc.org/products/BIND](http://www.isc.org/products/BIND)) — The Berkeley Internet Name Domain (BIND) server that implements the Domain Name System (DNS) protocols to resolve hostnames to IP addresses on the Internet (or similar networks)

As for desktop client configurations, CentOS includes features that are appropriate for corporate desktops, but could also be useful for personal or small-office desktops. Those features include:

- **GNOME Desktop Environment** — GNOME is the standard desktop environment included with CentOS.
- **K Desktop Environment (KDE)** — KDE is another popular desktop environment that comes with CentOS.
- **X Window System** — Provides the framework on which the graphical user interface is supported.
- **Firefox** — The most popular Open Source Web browser (produced by the Mozilla project)
- **Thunderbird** — A client program for sending, receiving, composing and otherwise managing e-mail that, like Firefox, comes from the Mozilla project
- **OpenOffice.org Office Suite** — A full suite of office applications for working with documents, spreadsheets, presentations, and other personal productivity tasks
- **GNU Image Manipulation Program** — A powerful graphics editing application
- **Rhythmbox** — Audio application for playing and managing your music and other audio files

The server and desktop applications just mentioned are only a few of the software projects available with CentOS. While those are powerful and useful software projects, most other popular Linux distributions also include those features.

What you find in CentOS that you don't find in many Linux systems, particularly those geared toward personal or small-office use, are software packages for cluster computing and virtualization.

By configuring computers to work together in clusters, a group of servers can share a common file system, offer high-availability applications, load-balance to make best use of computing resources, and greatly improve performance. Clustering and other advanced features in CentOS include:

- **Global File System Suite (GFS)** — With GFS, multiple computers in a cluster can share a single, consistent file system namespace.
- **Management of High-Availability Services** — If a node in a cluster becomes inoperative, tools for managing high-availability services can move those services to another node.
- **Linux Virtual Server Routing** — Provides Internet Protocol load-balancing to distribute client requests evenly among server systems.

- **Linux Virtual Server Administration** — Xen virtualization tools are available to create, run, and manage virtual machines (guest operating systems) that run natively in CentOS.

While descriptions of some of these Enterprise-class features are beyond the scope of this book, detailed documentation on using these projects is included with the CentOS system itself. But finding out how those features work is only part of the trick.

Integrating enterprise-class software so all the pieces can work seamlessly together in financial institutions and government agencies for their mission-critical applications is a daunting task. That is why the CentOS project's own mission is to not only take advantage of the value produced from individual Open Source software projects, but also to leverage the work that was done integrating these many projects.

In short, the source code that CentOS uses to build its operating system doesn't come directly from individual software projects. Instead, it comes from rebuilding source code made available from a "prominent North American Enterprise Linux vendor," as the CentOS web site notes. That company is Red Hat, Inc.

## What You Get with CentOS

Some people think that Red Hat, Inc. is somehow associated with the CentOS project. It is not.

Projects such as the Apache project, Samba project, and GNU project create code that is licensed as Open Source and publicly released. Just as that code can be built into binaries and included in a Linux distribution (more on how that works later), so too can the source code subsequently released by each Linux distribution be rebuilt and reused.

CentOS takes the freely available Red Hat Enterprise Linux source code (not the binaries), removes trademark and branding information that identifies it as a Red Hat product, then rebuilds and rebrands that source code as CentOS. The results are:

- A Linux distribution that includes most of the same Open Source software projects contained in Red Hat Enterprise Linux
- A set of packages and ISO images, for installing CentOS or running it as a live CD, that can be freely distributed without paying subscription fees
- A dedicated, if small, band of developers and an active community of supporters that are accessible through forums, IRC chat, and mailing lists through the `CentOS.org` site

Although CentOS doesn't achieve 100 percent compatibility with Red Hat Enterprise Linux, it does strive to do so. For some people who just want to use CentOS to try out Linux or are willing to take full responsibility for the quality of that system in their business, CentOS can suit their needs.

## Stepping Stone to Red Hat Enterprise Linux

Some people use CentOS as a learning tool to become familiar with features that are in Red Hat Enterprise Linux. Once they are ready to make a serious commitment to a commercial use of Linux, however, they often buy subscriptions to Red Hat Enterprise Linux. In professional settings, there is a lot you get with Red Hat Enterprise Linux that you don't get with CentOS:

- **The Backing of a Major Linux Vendor** — If something goes wrong with a Red Hat Enterprise Linux system, your boss can contact Red Hat. If something goes wrong with CentOS, your boss calls you. (Of course, you might get called in either case, but with Red Hat, there's a commercial vendor behind you.)
- **Technical Support** — While CentOS offers forums and mailing lists to support its users, Red Hat offers full technical support programs that range from timely software updates and Web-based support through Red Hat Network to full 24 × 7 onsite support. By adding Satellite Servers to their locations, customers can centrally manage and monitor all their Red Hat Enterprise Linux systems on site.
- **Certified Hardware and Software** — With each release of Red Hat Enterprise Linux, dozens of hardware manufacturers (OEMs) and independent software vendors (ISVs) certify that their products work with that release. There are no such guarantees with CentOS. In fact, at least some of these vendors don't respond to bug reports of their products on CentOS systems.
- **Timely Security Patches and Updates** — The CentOS project strives to keep up with updates and security patches as they are released in Open Source from Red Hat, Inc. However, there will always be some delay (even if a short one) between when a patch comes out from Red Hat and when it can be rebuilt to be used for CentOS. And, of course, there will be some lag time after a new Red Hat release before a CentOS version can be built and made available.
- **Certification and Training** — If you are looking to become a Linux professional, there is no official training and certification with CentOS. Red Hat, Inc. offers professional certification for systems administrators, such as the Red Hat Certified Engineer and Red Hat Certified Technician certifications (more on that later in this chapter).

In short, using the CentOS operating system and learning about it using the documentation in this book or other places can provide a good value if your goal is to become a Linux professional or try out enterprise-class software. However, before committing your business or organization to CentOS, you should weigh your needs for stability and accountability for those systems against any cost savings it might bring.

So far in describing what CentOS is and is not, we have neglected a few critical issues. For example, we haven't talked about where Linux itself came from and how the free and Open Source software model works. The next sections address those issues.

## What Is Linux?

---

Linux is a free operating system that was created by Linus Torvalds when he was a student at the University of Helsinki in 1991. Torvalds started Linux by writing a *kernel* — the heart of the operating system — partly from scratch and partly by using publicly available software. (For the definition of an operating system and a kernel, see the sidebar “What Is an Operating System?” later in this chapter.) Torvalds then released the system to his friends and to a community of “hackers” on the Internet and asked them to work with it, fix it, and enhance it. It took off.

**NOTE**

I make the distinction here between *hackers* (who just like to play with computers) and *crackers* (who break into computer systems and cause damage).

Today, there are thousands of software developers around the world contributing software to the free and Open Source software (FOSS) community that feeds the Linux initiative. Because the source code for the software is freely available, anyone can work on it, change it, or enhance it. Developers are encouraged to pass their fixes and improvements back into the community so that Linux can continue to grow and improve.

On top of the Linux kernel effort, the creators of Linux also drew on a great deal of system software and applications that are now bundled with Linux distributions from the GNU project (GNU stands for “GNU is not UNIX”), which is directed by the Free Software Foundation ([www.gnu.org](http://www.gnu.org)). There is a vast amount of software that can be used with Linux, making it an operating system that can compete with or surpass features available in any other operating system in the world.

If you have heard Linux described as a free version of UNIX, there is good reason for it. Although much of the code for Linux started from scratch, the blueprint for what the code would do was created to follow POSIX (Portable Operating System Interface for UNIX) standards. POSIX is a computer industry operating system standard that every major version of UNIX complied with. In other words, if your operating system was POSIX-compliant, it was UNIX. Today, Linux has formed its own standards and services organizations to help interoperability among Linux systems, including the Linux Foundation, which supports such efforts as the Linux Standard Base ([www.linux-foundation.org/en/LSB](http://www.linux-foundation.org/en/LSB)).

## Linux’s Roots in UNIX

---

Linux grew within a culture of free exchange of ideas and software. Like UNIX — the operating system on which Linux is based — the focus was on keeping communications open among software developers. Getting the code to work was the goal, and the Internet was the primary communications medium. Keeping the software free and re-distributable was a means to that goal. What, then, were the conditions that made the world ripe for a computer system like Linux?



In the 1980s and 1990s, while Microsoft flooded the world with personal computers running DOS (Disk Operating System) and Windows operating systems, power users demanded more from an operating system. They ached for systems that could run on networks, support many users at once (multiuser), and run many programs at once (multitasking). DOS and Windows didn't cut it.

UNIX, on the other hand, grew out of a culture in which technology was king and marketing people were, well, hard to find. Bell Laboratories in Murray Hill, New Jersey, was a think tank where ideas came first and profits were somebody else's problem. A quote from Dennis Ritchie, co-creator of UNIX and designer of the C programming language, in a 1980 lecture on the evolution of UNIX, sums up the spirit that started UNIX. He was commenting on both his hopes and those of his colleagues for the UNIX project after a similar project called *Multics* had just failed:

*What we wanted to preserve was not just a good environment in which to do programming, but a system around which a fellowship could form. We knew from experience that the essence of communal computing as supplied by remote-access, time-shared machines, is not just to type programs into a terminal instead of a keypunch, but to encourage close communication.*

In that spirit, the first source code of UNIX was distributed free to universities. Like Linux, the availability of UNIX source code made it possible for a diverse population of software developers to make their own enhancements to UNIX and share them with others.

## What Is an Operating System?

An operating system is made up of software instructions that lie between the computer hardware (disks, memory, ports, etc.) and the application programs (word processors, Web browsers, spreadsheets, etc.). At the center is the *kernel*, which provides the most basic computing functions (managing system memory, sharing the processor, opening and closing devices, etc.). Associated with the kernel are a variety of basic services needed to operate the computer, including:

- **File Systems** — The file system provides the structure in which information is stored on the computer. Information is stored in files, primarily on hard disks inside the computer, but also on removable media such as CDs and DVDs. Files are organized within a hierarchy of directories. The Linux file system holds the data files that you save, the programs you run, and the configuration files that set up the system.
- **Device Drivers** — These provide the interfaces to each of the hardware devices connected to your computer. A device driver enables a program to write to a device without needing to know details about how each piece of hardware is implemented. The program opens a device, sends and receives data, and closes a device.

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*continued*

- **User Interfaces** — An operating system needs to provide a way for users to run programs and access the file system. Linux has both graphical and text-based user interfaces. GNOME and KDE provide graphical user interfaces, whereas shell command interpreters (such as `bash`) run programs by typing commands and options.
- **System Services** — An operating system provides system services, many of which can be started automatically when the computer boots. In Linux, system services can include processes that mount file systems, start your network, and run scheduled tasks. In Linux, many services run continuously, enabling users to access printers, web pages, files, databases, and other computing assets over a network.

Without an operating system, an application program would have to know the details of each piece of hardware, instead of just being able to say, “open that device and write a file there.”

By the early 1980s, UNIX development moved from the organization in Murray Hill to a more commercially oriented development laboratory in Summit, New Jersey (a few miles down the road). During that time, UNIX began to find commercial success as the computing system of choice for applications such as AT&T’s telephone switching equipment, for super-computer applications such as modeling weather patterns, and for controlling NASA space projects.

Major computer hardware vendors licensed the UNIX source code to run on their computers. To try to create an environment of fairness and community to its OEMs (original equipment manufacturers), AT&T began standardizing what these different ports of UNIX had to be able to do to still be called *UNIX*. To that end, POSIX standards and the AT&T UNIX System V Interface Definition (SVID) were specifications that UNIX vendors could use to create compliant UNIX systems. Those same documents also served as road maps for the creation of Linux.

Elsewhere, the UNIX source code that had been distributed to universities had taken on a life of its own. The Berkeley Software Distribution (BSD) began life in the late 1970s as patches to the AT&T UNIX source code from students and staff at the University of California at Berkeley. Over the years, the AT&T code was re-written and BSD became freely distributed, with offshoot projects such as FreeBSD, OpenBSD, and NetBSD still available.

Linux has been described as a UNIX-like operating system that reflects a combination of SVID, POSIX, and BSD compliance. Linux continues to aim toward POSIX compliance, as well as compliance with standards set by the new owner of the UNIX trademark, The Open Group ([www.unix.org](http://www.unix.org)). Much of the direction of Linux today comes from the Linux Foundation ([www.linux-foundation.org](http://www.linux-foundation.org)), which was founded in 2007 by a merger of the Free Standards Group and the Open Source Development Labs.

## Common Linux Features

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No matter what version of Linux you use, the piece of code common to all is the Linux kernel. Although the kernel can be modified to include support for the features you want, every Linux kernel can offer the following features:

- **Multiuuser** — Not only can you have many user accounts available on a Linux system, you can also have multiple users logged in and working on the system at the same time. Users can have their own environments arranged the way they want: their own home directory for storing files and their own desktop interface (with icons, menus, and applications arranged to suit them). User accounts can be password-protected, so that users can control who has access to their applications and data.
- **Multitasking** — In Linux, it is possible to have many programs running at the same time, which means that not only can you have many programs going at once, but that the Linux operating system can itself have programs running in the background. Many of these system processes make it possible for Linux to work as a server, with these background processes listening to the network for requests to log in to your system, view a web page, print a document, or copy a file. These background processes are referred to as *daemons*.
- **Hardware Support** — You can configure support for almost every type of hardware that can be connected to a computer. There is support for floppy disk drives, CD-ROMs, removable disks (such as DVDs and USB flash drives), sound cards, tape devices, video cards, and most anything else you can think of. As device interfaces, such as USB and FireWire, have been added to computers, support for those devices has been added to Linux as well.

For Linux to support a hardware device, Linux needs a *driver*, a piece of software that interfaces between the Linux kernel and the device. Drivers are available in the Linux kernel to support hundreds of computer hardware components that can be added or removed as needed.

### NOTE

Most hardware manufacturers don't provide Linux drivers with their peripheral devices and adapter cards. Although most popular hardware will be supported eventually in Linux, it can sometimes take a while for a member of the Linux community to write a driver. Also, some outdated hardware may not be updated to work with the latest Linux kernels.

- **Networking Connectivity** — To connect your Linux system to a network, Linux offers support for a variety of local area network (LAN) cards, modems, and serial devices. In addition to LAN protocols, such as Ethernet (both wired and wireless), all the most popular upper-level networking protocols can be built in. The most popular of these protocols is TCP/IP (used to connect to the Internet). Other protocols, such as IPX (for Novell networks) and X.25 (a packet-switching network type that is popular in Europe), are also available.
- **Network Servers** — Providing networking services to the client computers on the LAN or to the entire Internet is what Linux does best. A variety of software packages are

available that enable you to use Linux as a print server, file server, FTP server, mail server, Web Server, news server, or workgroup (DHCP or NIS) server.

To make a Linux distribution useful, components need to be added on top of the Linux kernel. For humans to access a Linux system, they can enter commands to a shell or use graphical interfaces to open menus, windows, and icons. Then you need actual applications to run. In particular, a useful Linux desktop system includes the following:

- **Graphical User Interface (X Window System)** — The powerful framework for working with graphical applications in Linux is referred to as the *X Window System* (or simply X). X handles the functions of opening X-based graphical user interface (GUI) applications and displaying them on an X server process (the process that manages your screen, mouse, and keyboard).

On top of X, you use an X-based desktop environment to provide a desktop metaphor and window manager to provide the look-and-feel of your GUI (icons, window frames, menus, and colors, or a combination of those items called *themes*). There are a few desktop environments and even more desktop managers to choose from. (CentOS focuses on the GNOME and KDE desktop environments, but also has several other desktop environments and window managers available.)

- **Application Support** — Because of compatibility with POSIX and several different Application Programming Interfaces (APIs), a wide range of free and Open Source software is available for Linux systems. Compatibility with the GNU C libraries is a major reason for the wide-ranging application support. Often, making an Open Source application available to a particular version of Linux can be done by simply recompiling the source code to run on that Linux version.

## Primary Advantages of Linux

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When compared to different commercially available operating systems, Linux's best assets are its price, its reliability, and the freedom it gives you. Scalability is one of its greatest assets. The reliability of Linux includes its built-in security features and architecture, both of which make Linux much more secure than Windows.

Most people know that its initial price is free (or at least under \$50 when it comes in a box or with a book). However, when people talk about Linux's affordability, they are usually thinking of its total cost, which includes no (or low) licensing fees, the ability to reuse any of the code as you choose, and the capability of using inexpensive hardware and compatible free, add-on applications. Although commercial operating systems tend to encourage upgrading to more powerful hardware, Linux doesn't require that (although faster hardware and larger disks are nice to have).

In terms of reliability, the general consensus is that Linux is comparable to many commercial UNIX systems but more reliable than most desktop-oriented operating systems. This is especially

true if you rely on your computer system to stay up because it is a Web Server or a file server. (You don't have to reboot every time you change something, unless you've replaced the kernel itself.)

This reliability also extends into the realm of safety. While there have been exploits aimed at Linux software, Linux users are for the most part safe from the same type of malware and viruses that plague Windows users.

With so many people peering at the Linux source code (a benefit of its freedom), mistakes are often fixed in record time. Of course, like a house that has doors and windows, if you leave them open, a burglar can come in. But by properly configuring, monitoring, and updating software on Linux systems that are created with security in mind, such as CentOS, your Linux system can be as secure as any operating system in the world.

Because you can get the source code, you are free to change any part of the Linux system, along with any Open Source software that comes with it, in any way that you choose. Unlike many self-contained commercial products, Open Source software tends to be built in pieces that are meant to interact with other pieces, so you are free to mix and match components to suit your tastes. As I mentioned earlier, Linux is a culture that encourages interoperability. For example, if you don't like a window manager, you can plug in a different one because so many were built to operate within the same framework.

Another advantage of using Linux is that help is always available on the Internet. There is probably someone out there in a Linux newsgroup or mailing list willing to help you get around your problem. Because the source code is available, if you need something fixed, you can even patch the code yourself! On the other hand, I've seen proprietary software vendors sit on reported problems for months without fixing them. Remember that the culture of Linux is one that thrives on people helping other people.

## Going Forward with CentOS

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If you find that you need additional support for your CentOS systems or want to increase your skills or become more involved with Linux, there are many directions in which you can go.

### Help from the CentOS Project

If you enjoy CentOS and want to become more connected to the project, there are many ways to do that. To contribute to the CentOS project, start by introducing yourself on a CentOS mailing list (<http://centos.org/modules/tinycontent/index.php?id=16>). For information on the status of the CentOS project, refer to the News page of the CentOS web site, at <http://centos.org/modules/news/>.

If you want to expand beyond the bounds of what CentOS offers, there are third-party repositories for CentOS containing software packages that are not part of the CentOS distribution. (See the descriptions of software repositories in Chapter 5.)

As the end-user forum of choice for CentOS users, visit the CentOS forums at <http://centos.org/modules/newbb/>. That site already has more than 18,350 topics and more than 67,000 posts you can search for answers to your questions.

## Training and Certification

If you are looking for a career in Linux, Red Hat offers some well-respected programs for becoming a certified expert in Red Hat Linux software. Those skills should translate easily to your work with CentOS. Learn about available programs from Red Hat's training web site ([www.redhat.com/training](http://www.redhat.com/training)).

If you plan to pursue any of the Red Hat certification programs, don't be surprised if after some theoretical training you are given a misconfigured computer and asked to fix it. Those who get Red Hat certifications are expected to be able to clean up and repair Linux systems in the real world, as well as install and secure Red Hat Enterprise Linux systems.

Here is a list of some available certifications from Red Hat:

- **Red Hat Certified Technician (RHCT)** — An RHCT is the most basic Red Hat certification. It focuses on core skills needed by a Red Hat system administrator. Besides being able to install and configure an RHEL system to come up on a corporate network, you are also expected to understand basic troubleshooting techniques.
- **Red Hat Certified Engineer (RHCE)** — The RHCE program builds on the skills developed in the RHCT program. For an RHCE, however, additional capabilities in security and deploying network services are expected.
- **Red Hat Certified Security Specialist (RHCSS)** — As the name implies, an RHCSS becomes proficient in security-related aspects of managing Red Hat Enterprise Linux systems. Courses with this certification include Enterprise Network Services Security, Enterprise Directory Services and Authentication, and SELinux Policy and Administration.
- **Red Hat Certified Architect (RHCA)** — An RHCA's skills are expected to go beyond those of an RHCT or RHCE. The RHCA program focuses on deploying and managing multiple Linux systems across an enterprise, with special attention given to systems management, storage management, performance tuning, and directory services.

For courses on RHCT, RHCE, RHCSS, and RHCA certifications, visit the Red Hat Certified Engineer Program page ([www.redhat.com/training/](http://www.redhat.com/training/)). Before taking the RHCT or RHCE certification exams, check out the *RHCE and RHCT Exam Preparation Guide* ([www.redhat.com/certification/rhce/prep\\_guide/](http://www.redhat.com/certification/rhce/prep_guide/)). Red Hat offers many courses online for Red Hat Linux training, as well as courses in networking, programming (Java, Object, web, and general programming), IT management, and e-business.

## Documentation

In addition to the documentation provided by the CentOS team, there are a lot of avenues to find help using RHEL-based products offered by Red Hat. A good place to start is the Red Hat

Enterprise Linux documentation ([www.redhat.com/docs/manuals/enterprise](http://www.redhat.com/docs/manuals/enterprise)), which includes manuals for installation, system administration, security, SELinux, reference materials, and release notes for different products. You can use keyword searches to find answers to your questions from the Red Hat Knowledgebase.

## Summary

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CentOS is an Open Source software project that aims at providing an enterprise-quality Linux operating system that can be distributed without cost to its supporters. The project builds its Linux system from source code that has been tested and deployed in mission critical settings.

This book specifically describes CentOS 5, a complete version of which is included on the DVD that comes with this book. Because CentOS aims at compatibility with Red Hat Enterprise Linux systems, CentOS can be used to learn the skills needed to grow your enterprise-class computing skills.

# Chapter 2

## Installing CentOS

A simplified installation procedure is one of the best reasons for using a Linux distribution such as CentOS. In many cases, for a computer dedicated to using CentOS, you can just pop in the DVD that comes with this book, choose from several pre-set configurations, and be up and running with Linux in less than an hour.

If you want to share your computer with both Linux and Microsoft Windows, CentOS offers several ways to go about doing that. A CentOS Live CD is included with this book to help prepare your computer before installation. If your computer doesn't have a DVD or CD drive, network and hard disk installs are available. To pre-configure CentOS to install on multiple, similar computers, you can use the kickstart installation.

In the past few releases of CentOS, the project has made some great improvements to the installation process. Most notably, a recent feature in anaconda lets you install software from multiple online repositories during the initial CentOS install.

Although this procedure focuses on installing CentOS on a standard PC (i386 32-bit architecture), the CentOS team also produces installable versions of CentOS for 64-bit PC architecture (x86\_64). Because the latest Apple Mac computers are based on Intel architecture, CentOS can be installed on those machines as well (although not completely without some hassles right now because of the EFI Macs use instead of the BIOS).

### IN THIS CHAPTER

**Quick installation**

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**Detailed installation instructions**

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**Special installation procedures**

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**Special installation topics**

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**Troubleshooting installation**

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## Using the CentOS Live CD

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The CentOS Live CD that comes with this book is a great way to try out CentOS before you commit to installing it. In addition to answering the obvious question of “Does CentOS run on my PC at all?” the CD itself contains useful tools for examining your hardware and preparing your computer for installation.

A *live CD* is a bootable medium (usually a CD, but other removable media, such as DVDs or USB flash drives can be used the same way) that contains an entire operating system. In most cases, you can boot the live CD without touching the contents of your hard drive.

With the CentOS 5 Live CD, you can boot up to a working GNOME desktop that works like most desktop computer systems installed to hard disk. If you don’t like the system, then reboot, remove the CD, and your computer will return to the way it was. If you like it, you can click a single button and install the same desktop system to your hard disk.

Here’s a quick set of steps to try out the CentOS 5 Live CD (included with this book):

### NOTE

The Live CD will not run well on less than 256 MB of RAM. Also, if you find that the Live CD hangs at some point in the boot process, refer to boot options later in this chapter. With the boot label highlighted on the Boot menu, press the [Tab] key to be able to add boot options to the boot command.

1. Insert the CentOS 5 Live CD into your CD drive and reboot.
2. From the Boot screen, either let the CD time out and boot or press any key to see other selections. From the Boot menu, highlight either “Boot” or “Verify and Boot,” then press [Enter]. (The verify step makes sure the medium isn’t corrupted.)
3. When you see the login screen, you can let the login prompt time out. (No password is required.) The GNOME desktop starts up.
4. From the GNOME desktop, here are a few things you can try from the Live CD:
  - **Run Applications** — Try any of the applications you choose from menus in the top panel. If you have an Internet connection (CentOS will automatically configure most wired Ethernet cards), you can try Web browsing and other Internet applications. You can even add more applications. Select Applications ► Add/Remove Software to select applications to install over the Internet. (Because the Live CD is a Read Only medium, software you add will disappear when you reboot.)
  - **Check Hardware** — Refer to the “Preparing for Installation Using the Live CD” section later in this chapter for suggestions on how to check out your computer hardware.
  - **Prepare for Dual Booting** — If you want to keep an installed Windows system that is already on your computer’s hard disk, you can prepare your computer to be able to dual-boot both Windows and a new install of CentOS. Refer to the “Setting up to Dual-Boot Linux and Windows” section later in this chapter for information on resizing your computer’s hard disk partitions to make room for CentOS.

## Quick Installation

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It can be a little intimidating to see a thick chapter on installation. But the truth is, if you have a little bit of experience with computers and a computer with common hardware, you can probably install CentOS pretty easily. The procedure in this section will get you going quickly if you have:

- **Media** — The CentOS installation DVD that comes with this book
- **PC** — A Pentium-class PC (at least 400 MHz Pentium II) with a built-in, bootable DVD or CD drive, at least 128 MB of RAM (for text mode) or 192 MB of RAM (for GUI mode; although 512 MB is the recommended minimum or you may experience some oddities when trying to install large packages like OpenOffice.org.).
- **Disk Space** — The amount of disk space you need to install CentOS depends on the packages you select. Therefore, depending on which packages you choose to install, the disk space you need can range from about 1.5 GB (for a minimal server with no GUI install) to 10 GB (to install all packages). I would recommend from 2 GB to 3 GB minimum if you are installing a desktop system. But don't forget you will want plenty of space free for user data and other files.

For this quick procedure, you must either be dedicating your entire hard disk to Linux, have a pre-configured Linux partition, or have sufficient free space on your hard disk outside any existing Windows partition.

**CAUTION** If you are not dedicating your whole hard disk to CentOS and you don't understand partitioning, skip to the following "Detailed Installation Instructions" section in this chapter. That section describes choices for having both Linux and Windows on the same computer.

Here's how you get started:

1. Insert the CentOS 5 installation DVD into your computer's drive.
2. Reboot your computer.
3. Press the [Enter] key to install or upgrade an existing system.

During installation, you are asked questions about your computer hardware and the network connections. After you have completed each answer, click Next. The following list describes the information you will need to enter. (If you need help, all of these topics are explained later in this chapter.)

- **Media Check** — If you are installing from the DVD, you can optionally check the DVD to be sure it is not damaged or corrupted.
- **Language Selection** — Choose the language used during the install (you can add other languages later).
- **Keyboard Configuration** — Select the type of keyboard you are using.

- **Install or Upgrade** — If you have an earlier version of CentOS installed, you can choose “Upgrade” to upgrade your system without losing data files. Otherwise, you can continue with a new installation by selecting “Reinstall System.”
- **Disk Partitioning Setup** — Choose to remove Linux partitions, all partitions, or no partitions (and use existing free space) to have space to install CentOS. Because repartitioning can result in lost data, I recommend that you refer to descriptions on repartitioning your hard disk later in this chapter.
- **Boot Loader Configuration** — Add the GRUB boot manager to control the boot process. (GRUB is described later in this chapter.) With multiple operating systems on the computer, select which one to boot by default.
- **Select Hostname** — Choose a hostname for your system.
- **Time Zone Selection** — Identify the time zone in which you are located. Uncheck the “System Clock uses UTC” box if you are booting multiple operating systems from this machine because most operating systems expect the BIOS clock to match local time.
- **Set Root Password** — Add the root user account password.
- **Choose Software** — You can choose from several pre-set installation classes, such as “Desktop” (for laptop, home, or desktop use), “Server” (file, print, Web and other server software), “Virtualization,” or “Clustering.” I suggest you also select “Customize” now so that you can see exactly which packages you have selected (and add others if you want).
- **About to Install** — Up to this point, you can quit the install process without having written anything to disk. When you select Next, the disk is formatted (as you chose) and selected packages are installed.

**NOTE**

After answering the questions, the actual installation of packages from the DVD takes between 20 and 60 minutes, depending on the number of packages and the speed of the computer hardware. Upgrades can take much longer.

When installation is done, remove the CentOS DVD and click Reboot to reboot your computer. After Linux boots for the first time, the Firstboot runs to let you read the license agreement, set system date and time, configure your display, check your hardware, add a user account, configure your sound card, and install additional CDs. On subsequent reboots, you will see a login prompt. You can log in and begin using your Linux system.

If you need more information than this procedure provides, go to the detailed installation instructions just ahead.

## Detailed Installation Instructions

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This section provides more detail on installation. Besides expanding on the installation procedure, this section also provides information on different installation types and on choosing computer hardware.

If anything goes wrong during installation and you get stuck, go to the “Troubleshooting Installation” section at the end of this chapter. It gives suggestions for solving common installation problems.

**CAUTION** If, when installing Windows or CentOS, you find that the other operating system is no longer available on your boot screen, don’t panic, and don’t immediately reinstall. You can usually recover from the problem by booting the Live CD that comes with this book and then using the `grub-install` command to reinsert the proper master boot record. Refer to the “Using the GRUB Boot Loader” section later in this chapter. If you are uncomfortable working in emergency mode, seek out an expert to help you.

## Installing CentOS 5

This chapter details how to install CentOS 5 from the DVD that comes with this book. The DVD that comes with this book and the installation procedures presented here are specific to 32-bit PCs.

### Install or Upgrade?

First, you should determine if you are doing a new install or an upgrade. If you are upgrading an existing CentOS system to the latest version, the installation process will try to leave your data files and configuration files intact as much as possible.

An upgrade installation takes longer than a new install. A new install will simply erase all data on the Linux partitions (or entire hard disk) that you choose. (You can optionally select which partitions to format.)

**NOTE** While you can upgrade to CentOS from previous CentOS releases, you cannot upgrade to CentOS from a Red Hat Enterprise Linux or Fedora system. The older the CentOS release you are upgrading from, however, the more likely you are to have problems upgrading.

If you choose to upgrade, you can save yourself some time (and disk space) by removing software packages that you don’t need. An upgrade will just skip packages that are not installed and not try to upgrade them. Here are a few other tips related to upgrades:

- **Conflicting Packages** — If you upgrade a system on which you installed packages from sources outside of the CentOS Project that conflict with CentOS packages, those features may no longer work. For example, if you replaced GNOME with Ximian GNOME or used a third-party KDE package set, you can’t upgrade those packages to CentOS 5. (It’s probably best to remove those packages before upgrading and then apply them again later if you like.)
- **Third-Party Packages** — If you have installed packages from third-party repositories that are specific to your current kernel (such as drivers for NVidia video cards or wireless LAN cards), you will need to get new versions of those packages that match your upgraded kernel.

- **Kernel Requirements** — To upgrade, you must have at least a Linux 2.0 kernel installed on the system you are upgrading.
- **Configuration Files** — With an upgrade, your configuration files that are replaced are saved as *filename.rpm<sub>save</sub>* (e.g., the hosts file is saved as *hosts.rpm<sub>save</sub>*). More often, however, your old configuration files will remain in place, while the system copies new configuration files to *filename.rpm<sub>new</sub>*. The location of those files, as well as other upgrade information, is written to */root/upgrade.log*. The upgrade installs the new kernel, any changed software packages, and any packages that the installed packages depend on being there. Your data files and configuration information should remain intact.
- **Digital Certificates** — If you are using digital certificates on your system, you must relocate them to the */etc/pki* directory after the upgrade. (See Chapter 13 for information on setting up digital certificates.)
- **Java** — If you used the Java RPM from Sun Microsystems to provide Java support, conflicts with that package may cause it to be erased during an upgrade. If that occurs, you can install the Java RPM from *jpackage.org* or install the Java tarball from Sun Microsystems into your */opt* directory. You can also consider removing that version of Java from your system and instead using the Open Source Java IcedTea packages.

## From DVD, Network, or Hard Disk?

When you install CentOS, the distribution doesn't have to come from the installation DVD. After booting the installation DVD, type **linux askmethod** at the boot prompt. You are offered the choice of installing CentOS from the following locations:

- **Local DVD or CDROM** — This is the most common method of installing CentOS and the one you get by simply pressing [Enter] from the installation boot prompt. All packages needed to complete the installation are on the DVD that comes with this book.
- **Hard Drive** — If you can place a copy of the CentOS distribution on your hard drive, you can install it from there. (Presumably, the distribution is on a hard drive partition to which you are *not* installing.)
- **NFS Directory** — Allows you to install from any shared directory on another computer on your network using the Network File System (NFS) facility.
- **FTP** — Lets you install from an FTP site (*ftp://*).
- **HTTP** — Lets you install from a web page address (*http://*).

If your computer doesn't have a DVD drive, you can use the *boot.iso* CD image that comes on the DVD with the book (see below) to start a network install (HTTP, FTP, or NFS). Just type **linux askmethod** at the boot prompt to begin the installation process.

If you don't have a bootable DVD or CD drive, there are other ways to start the CentOS installation. If you don't have a bootable DVD or CD drive, you need to start the install process from some other medium (such as a PXE server or hard drive, as described later in this chapter).

The following specialty installation types also may be of interest to you:

- **Boot CD** — You can create a boot CD from the boot images contained on the CentOS installation DVD that comes with this book. Copy and burn the file `boot.iso` from the `images` directory on the DVD. You can use the CD you create from that image to begin the install process if you have a DVD drive that is not bootable or if you have the CentOS 5 software available on any of the media described in the `linux askmethod` section.
- **USB or Other Bootable Media** — If your computer can be configured to boot from alternate bootable media, such as a USB pen drive, that is larger than a floppy disk, you can copy the `diskboot.img` file to that medium and install from there. That image is contained in the `images` directory on the DVD.
- **Kickstart Installation** — Lets you create a set of answers to the questions CentOS asks you during installation. This can be a time-saving method if you are installing CentOS on many computers with similar configurations.

An installation guide is available if you find you need further information. It may not be up to date, however. You can access the guide here:

[www.centos.org/docs/5/html/5.3/Installation\\_Guide/](http://www.centos.org/docs/5/html/5.3/Installation_Guide/)

## Choosing Computer Hardware

This may not really be a choice. You may just have an old PC lying around that you want to try CentOS on. Or you may have a killer workstation with some extra disk space and want to try out CentOS on a separate partition or whole disk. To install the 32-bit PC version of CentOS, the computer must have the following:

- **x86 Processor** — Your computer needs an Intel-compatible CPU. With the latest version, it is recommended that you at least have a Pentium II/Pentium Pro-class processor supporting the i686 instruction set to run CentOS. The installer kernel and the subsequent distributions have no i586 support.
- **DVD or CD-ROM Drive** — You need to be able to boot up the installation process from a DVD, CD-ROM, or other bootable drive. (Other drives can include a USB flash memory drive that you can use with a `diskboot.img` image included on the DVD.) Once you have booted from one of the media just described, you can use the Internet or a LAN connection to install CentOS software packages from a server on the network, or figure out a way to copy the contents of the DVD to a local hard disk to install from there.
- **Hard Disk** — The minimum amount of space you need varies depending on the installation type and packages you select. If you are an inexperienced user, you want at least 2.3 GB of space so you can get the GUI (with some Office and Productivity apps) or 3 GB for a Software Development install (if you want to do software development).
- **RAM** — You should have at least 128 MB of RAM to install CentOS (text mode only). If you are running in graphical mode, you will want at least 512 MB. You need a minimum of 768 MB available between RAM and swap space, otherwise `yum` will not work correctly.

**NOTE**

With demanding applications such as the Openoffice.org office suite and automatic features for monitoring your desktop being added, CentOS demands more RAM to use it effectively than it used to. At least 512 MB of RAM is recommended for good performance from a CentOS desktop.

- **Keyboard and Monitor** — Although this seems obvious, the truth is that you need only a keyboard and monitor during installation. You can operate CentOS quite well over a LAN using either a shell interface from a network login or an X terminal.

## Installing CentOS on a Laptop

**B**ecause laptops can contain non-standard equipment, before you begin installing on a laptop, you should find out about other people's experiences installing Linux on your model. Do that by visiting the Linux on Laptops site ([www.linux-on-laptops.com](http://www.linux-on-laptops.com)).

Most modern laptops contain bootable CD/DVD drives. If yours doesn't, you probably need to install from a device connected to a USB or PCMCIA slot on your laptop. PCMCIA slots let you connect a variety of devices to your laptop using credit card-sized cards (sometimes called *PC Cards*). Linux supports hundreds of PCMCIA devices. You can use your laptop's PCMCIA slot to install CentOS from several different types of PCMCIA devices, including:

- A DVD drive
- A CD-ROM drive
- A LAN adapter

## Preparing for Installation Using the Live CD

Before you begin installing CentOS 5, there are ways to check your computer hardware and prepare your computer to install Linux. By booting a live CD, you can make sure that:

- The Linux kernel (the heart of the operating system) will boot.
- Device drivers are available for the hardware on your computer.
- Your hard disk has enough free space to install CentOS (and if there's not enough, you can use tools on the Live CD to resize your hard disk partitions to make space).

You can try out CentOS using the CentOS Live CD that comes with this book without making any changes to your existing setup. You can identify your hardware drivers and disk partitions. Then, if you need to, you can change your hard disk to prepare it to install CentOS (primarily if you need to retain an existing operating system, such as Windows, to dual-boot with Linux).

To use the CentOS Live CD, insert the CD that comes with this book, and then reboot your computer. After a 10-second time-out period, the live CD begins booting CentOS.

After taking a few moments to detect your hardware and start up services, the CentOS Live CD should present you with a graphical (GNOME) desktop.

With the Live CD running on the PC where you want to install CentOS, there are many ways you can check the hardware on your computer. You can also take additional steps to configure and debug any hardware problems before you begin installing CentOS. The following procedures describe what you can do with the CentOS Live CD to prepare to install CentOS.

## Display Hardware Information

To display information about your computer's hardware from the CentOS Live CD, open a Terminal window (from the main menu, select Applications > Accessories > Terminal). Then, from the Terminal window, type the following command:

```
$ /sbin/lspci -vv | less
```

Press the spacebar to page through the list of PCI devices on your computer (press q to exit). Note the model names and numbers of any hardware that doesn't seem to be working. Next, plug in any USB devices you want to use (USB flash drives, cameras, Webcams, etc.) and type the following:

```
$ /sbin/lusb
```

If you would like a more graphical way of displaying hardware information and you have an active Internet connection, you can install the Hardware Browser to your running CentOS Live CD. To install the Hardware Browser, type the following:

```
# su -  
# yum install hwbrowser
```

You can open the Hardware Browser now by typing **hwbrowser**. From the Hardware Browser, select the following items from the left column to check out your computer:

- **Hard Drives** — Tells you your available disk partitions. Your hard disk partitions will probably appear as `/dev/sd??` (for IDE and SCSI disks), where the two question marks are replaced by a letter (*a* for the first, *b* for the second, etc.), then a number (1, 2, 3, etc.). The file system type listed for each partition might give you some idea of the contents of that partition. For example, NTFS and VFAT file systems are common for Windows systems, while ext3, ext2, and reiserfs are generally for Linux or similar systems. For each disk, you can see the sector each partition starts and ends on, the size of the partition (in megabytes, MB), and the type of file system. (In the “Setting up to Dual-Boot Linux and Windows” section later in this chapter, I describe how to get more information about your partitions.)
- **Network Devices** — Displays device information, drivers, and the device name for any wired or wireless Ethernet cards installed on your computer.
- **Sound Cards** — Tells which sound cards are installed on your computer.



- **System Devices** — Shows information about the PCI devices on your computer. This could provide much good information about your computer's bus and bridges.
- **Video Cards** — Describes the type of video card and chipset connected to your computer.

To check out information about your computer's memory, open System > Administration > System Monitor from the menu panel. Then select the Resources. The following information about your computer's available memory is displayed:

- **User Memory** — Shows how much RAM is available on your computer and how much is being used currently.
- **Swap Memory** — If there is a swap partition (which there won't be if you are starting with a Windows-only PC), you will see the amount of space available on that partition, as well as how much is being used.

**NOTE**

If you already have a Linux system installed on the machine, you may need to turn on the swap partition manually. For example, if the swap partition were located at `/dev/sda2`, you could type `swapon /dev/sda2` from a Terminal window as root user to turn on that swap partition.

Writing down the information about your hardware and memory will help you later if something goes wrong. So, for example, if you try to use Google to search for an answer or ask a question at a forum, you will know exactly what hardware is not working.

## Test Your Hardware

Although most configuration you do will disappear when you reboot your computer after using the live CD, running through some tests and a bit of setup can help you when you configure the same equipment on the installed CentOS. Here are a few ways to test useful hardware devices from the CentOS Live CD:

- **Sound Card** — To test your sound card, select System > Administration > Sound Card Detection to open the Audio Configuration window. The window will show you information associated with the sound card. Click one of the Sound Test buttons to see if the driver worked.
- **Network/Internet** — To test your network connection, you can simply open a Web browser to see if you have an active connection. If you don't, select System > Administration > Network. From the Network Configuration window that appears, select New. Use the Add New Device Type window to configure your Ethernet, ISDN, modem, token ring, wireless card, or xDSL connection (as described in Chapters 14 and 15).
- **Video Card** — To check your video card, open the Display Settings window (select System > Administration > Display). Select the Hardware tab to see your video card type and monitor. If you prefer to use the command line to check what video card was detected, type the following from a Terminal window:

```
# grep Chipset /var/log/Xorg.0.log
```

You can try other hardware devices as well by opening whatever applications you need to access the device (a Web browser, a File Manager, etc.). Many USB devices (digital cameras, pen drives, etc.) will be detected and often displayed on the desktop. Running the `lsmod` and `modinfo` commands can help you determine which devices were loaded for those modules. Here are a few other quick commands for checking out your computer:

- `cat /proc/interrupts` — Show what interrupts are in use.
- `cat /proc/cpuinfo` — Show CPU information.
- `cat /proc/bus/usb/devices` — Show attached and detected USB devices.
- `/sbin/lspci` — Show listing of PCI devices found (`-vv` for more verbose info).
- `cat /proc/cmdline` — Show command-line options the system booted with.
- `cat /proc/ioports` — Show ioports in use and the devices using them.
- `less /var/log/messages` — Page through the log of system start-up messages.

For any hardware that is not working properly, write down as much information you can about it (its name, model number, version, driver, etc.). Check CentOS mailing lists or use your favorite search engine to search for that hardware, plus keywords such as Linux or CentOS.

If your computer has an existing Windows operating system installed, you can use the Live CD to set up your computer to dual-boot Linux and Windows. See the section “Setting up to Dual-Boot Linux and Windows” later in this chapter for details. Besides describing how to resize your hard disk to fit Linux on it, the section also describes how you can later mount and access Windows (VFAT and NTFS file systems) from Linux.

## Beginning the Installation

If you feel you have properly prepared to install CentOS, you can begin the installation procedure. Throughout most of the procedure, you can click Back to make changes to earlier screens. However, once you go forward after being warned that packages are about to be written to hard disk, there's no turning back. Most items that you configure can be changed after CentOS is installed.

**CAUTION** If your computer contains any data that you want to keep, be sure to back it up now. Even if you have multiple disk partitions and don't expect to write over the partitions you want, a backup is a good precaution in case something should go wrong.

1. **Insert the DVD** — This procedure assumes that you are booting and installing from the CentOS installation DVD that comes with this book.

**CROSS-REF** If you are not able to boot from a DVD, refer to the “Alternatives for Starting Installation” section. If you are booting installation from the DVD but installing the software packages from a network or hard disk, refer to the “Installing from Other Media” section.

The DVD can be used for any type of install.

2. **Start Your Computer** — If you see the CentOS boot screen, continue to the next step.

**NOTE**

If you don't see the boot screen, your DVD drive may not be bootable. Creating a bootable floppy is no longer an option because the 2.6 kernel doesn't fit on a floppy. However, you may have the choice of making your DVD drive bootable or copying a boot image to a bootable USB device (such as a pen drive). Here's how: Restart the computer. Immediately, you should see a message telling you how to go into setup, such as by pressing the [F1], [F2], or [Del] key. Enter setup and look for an option such as "Boot Options" or "Boot from." If the value is "A: First, Then C:" change it to "CD-ROM First, Then C:" or something similar. Save the changes and try to install again.

If installation succeeds, you may want to restore the boot settings. If your DVD drive still won't boot, you may need to use an alternative method to boot CentOS installation (described in "Alternatives for Starting Installation" later in this chapter).

3. **Start the Boot Procedure** — Press [Enter] at the boot screen to begin a graphical installation or upgrade.

The boot screen is parameter-driven. So if you want to change any of the boot options, type **linux** at the boot prompt followed by any options you want. For example, to install from a different medium (such as over the network), type **linux askmethod**.

**CROSS-REF**

See the sidebar "Choosing Different Install Modes" for more boot options.

The previous section on "Quick Installation" covers the basic options and choices you need to make when installing. The following sections add detail to the selections you need to make for the CentOS Install DVD.

- **Media Check** — At this point, you may be asked to check your installation media. If so, press [Enter] to check that the DVD is in working order. If a disk is damaged, this step saves you the trouble of getting deep into the install before failing. After the DVD is checked, select Skip to continue.
- **Continue** — When the Welcome screen appears, click Next when you're ready to continue.
- **Choose a Language** — When prompted, indicate the language that you would like to use during the installation procedure by moving the arrow keys and selecting Next. (Later, you will be able to add additional languages.) Click Next once you've made your selection.
- **Choose a Keyboard** — Select the correct keyboard layout (U.S. English, with Generic 101-key PC keyboard by default). Some layouts enable dead keys (on by default). Dead keys let you use characters with special markings (such as circumflexes and umlauts). Click Next to proceed.
- **Choose a Fresh Install or Upgrade** — Select either "Install CentOS" for a new install or "Upgrade an existing installation" to upgrade an existing version of CentOS. Click Next.

4. **Choose Your Partitioning Strategy** — You have the following choices related to how your disk is partitioned for a CentOS installation:
- **“Remove all partitions on selected drives and create default layout”** — This erases the entire contents of the hard disks you select.
  - **“Remove Linux partitions on selected drives and create default layout”** — This erases all Linux partitions but leaves Windows partitions intact.
  - **“Use free space on selected drives and create default layout”** — This works only if you have enough free space on your hard disk that is not currently assigned to any partition.

**NOTE**

You can choose this option if you resized your Windows partition to make space for Linux, as described in the “Setting up to Dual-Boot Linux and Windows” section later in this chapter.

- **“Create custom layout”** — Select this if you want to create your own custom partitioning.

**NOTE**

If you selected to create a custom layout, refer to the section on partitioning your hard disk later in this chapter for details on using those tools.

If you have multiple hard disks, you can select which of those disks should be used for your CentOS installation. Check the “Review and Modify Partitioning Layout” checkbox to see how Linux is choosing to partition your hard disk. Click Next to continue.

**NOTE**

Instead of installing to a local hard disk, you can identify an iSCSI initiator as the storage device by selecting the “Advanced Storage Configuration” button and entering the IP address and iSCSI Initiator Name of the SCSI device. Once that is identified, you can use that device for installing CentOS.

5. **Review and Modify Partitioning Layout** — If you chose to review or customize your partitioning, you will see the Disk Setup tool with your current partitioning layout displayed. You can change any of the partitions you choose, provided that you have at least one root (/) partition that can hold the entire installation and one swap partition. A small /boot partition (about 100 MB) is also recommended.

**WARNING**

Partitioning your disk improperly can cause you to lose your data. Refer to the “Partitioning Your Disks” section later in this chapter for further information on disk partitioning.

The swap partition is often set to twice the size of the amount of RAM on your computer (e.g., for 512 MB of RAM you could use 1,024 MB of swap). Linux uses swap space when active processes have filled up your system’s RAM. At that point, an inactive process is moved to swap space. You get a performance hit when the inactive process is moved to swap and another hit when that process restarts (moves back to RAM). For example, you might notice a delay on a busy system when you reopen a window that has been minimized for a long time.

The reason you need to have enough swap space is that when RAM and swap fill up, no other processes can start until something closes. Bottom line: add RAM to get better performance; add swap space if processes are failing to start. The CentOS Project suggests a minimum of 32 MB and a maximum of 2 GB of swap space.

Click on the Next button (review partitions that are being reformatted, and select “Format” if the changes are acceptable) to continue.

- 6. Configure Boot Loader** — All bootable partitions and default boot loader options that are detected are displayed. By default, the install process will use the GRUB boot loader, install the boot loader in the master boot record of the computer, and choose CentOS as your default operating system to boot.

**NOTE**

If you keep the GRUB boot loader, you have the option of adding a GRUB password. The password protects your system from having potentially dangerous kernel options sent to the kernel by someone without that password. This password can and should be different from the root password you are asked to enter later. The GRUB boot loader is described later in this chapter.

The names shown for each bootable partition will appear on the boot loader screen when the system starts. Change a bootable partition name by clicking on it and selecting “Edit.” To change the location of the boot loader, click “Change device” and select where to install the boot loader. If you do not want to install a boot loader (because you don’t want to change the current boot loader), click “No boot loader will be installed.” (If the defaults are OK, skip the next step.)

- 7. Change Device** — If you selected to configure advanced boot loader options, you can now choose where to store the boot loader. Select one of the following:
  - **Master Boot Record (MBR)** — This is the preferred place for GRUB. It causes GRUB to control the boot process for all operating systems installed on the hard disk.
  - **First Sector of Boot Partition** — If another boot loader is being used on your computer, you can have GRUB installed on your Linux partition (first sector). This lets you have the other boot loader refer to your GRUB boot loader to boot CentOS. If you take this option, you will need to modify your other boot loader to point to your CentOS partition (or you won’t be able to boot the CentOS you are installing).
- 8. Set the Hostname** — Enter a hostname for your system. This is the name identifying your computer within your domain. For example, if your computer were named `zarkov` in the `example.com` domain, your full hostname would be `zarkov.example.com`. You can enter the domain name or have it assigned automatically if your network uses DHCP.
- 9. Choose a Time Zone** — Select the time zone. Either click a spot on the map or choose from the dropdown box. Before you click on your exact location on the map, click on the area of the map that includes your continent, or move the slider to zoom in. Then select the specific city. You can click “System clock uses UTC” to have your computer use Coordinated Universal Time (also known as *Greenwich Mean Time*). With multiple operating systems installed, you might want to uncheck this box, because some operating systems expect the BIOS to be set to local time.

## Choosing Different Install Modes

Although most computers with more than 512 MB of RAM automatically install CentOS in the default mode (graphical), there may be times when your video card does not support that mode.

Also, although the install process will detect most computer hardware, there may be times when your hard disk, Ethernet card, or other critical piece of hardware cannot be detected and you'll need to enter special information at boot time.

The following is a list of different installation options you can use to start the CentOS install process. You would typically try these modes only if the default mode failed (i.e., if the screen was garbled or installation failed at some point). For a list of other supported modes, refer to the `/usr/share/doc/anaconda*/command-line.txt` file (if you have a running CentOS system somewhere with the `anaconda` package installed) or press the [F1] through [F5] keys to see short descriptions of some of these types.

To use these boot options, append the appropriate value or values at the boot prompt.

- `text` — Type **text** to run installation in a text-based mode. Do this if installation doesn't seem to recognize your graphics card. The installation screens aren't as pretty, but they work just as well.
- `ks` — Type **ks** to run a CentOS installation using a kickstart file. A kickstart file provides some or all of the installation options you would otherwise have to select manually. (A section on creating and using kickstart files is contained later in this chapter.)
- `lowres` — Type **lowres** to run installation in 640 × 480 screen resolution for graphics cards that can't support the higher resolution. To choose a particular resolution, use the `resolution` option. For example: `resolution=1024x768`.
- `noprobe` — Typically, the installation process will try to determine what hardware you have on your computer. In `noprobe` mode, installation will not probe to determine your hardware; you will be asked to load any special drivers that might be needed to install it.
- `mediacheck` — Type **mediacheck** to check your DVD before installing. Because media checking is done next in the normal installation process, you should do this only to test the media on a computer you are not installing on.
- `rescue` — The **rescue** mode is not really an installation mode. This mode boots from DVD, mounts your hard disk, and lets you access useful utilities to correct problems preventing your Linux system from operating properly.
- `vnc vncconnect=hostname vncpassword=*****` — Run the install in VNC mode to step through the installation process from another system (a VNC client represented by `hostname`). See the "Starting a VNC Install" section later in this chapter for information on setting up a VNC server to do this type of install.

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- `dd` — Type **dd** if you have a driver disk you want to use to install.
- `expert` — Type **expert** if you believe that the installation process is not properly auto-probing your hardware. This mode bypasses probing so you can choose your mouse, video memory, and other values that would otherwise be chosen for you.
- `askmethod` — Type **askmethod** to have the installation process ask where to install from (local DVD/CD, NFS image, FTP, HTTP, or hard disk).
- `nocddma` — Type **nocddma** to turn off DMA. Errors with some CD drives can be overcome by turning off the DMA feature. This is a good option to try if an install CD or DVD you know to be good fails media check. You could also try `ide=nodma` to turn off DMA for all IDE devices.
- `updates` — Type **updates** to install from an update disk.

You can add other options to the `linux` boot command to identify particular hardware that is not being detected properly. For example, to specify the number of cylinders, heads, and sectors for your hard disk (if you believe the boot process is not detecting these values properly), you could pass the information to the kernel as follows: `linux hd=720,32,64`. In this example, the kernel is told that the hard disk has 720 cylinders, 32 heads, and 64 sectors. You can find this information in the documentation that comes with your hard disk (or stamped on the hard disk itself on a sticker near the serial number).

**CROSS-REF** Refer to Chapter 14 for descriptions of IP addresses, netmasks, and other information you need to set up your LAN, and to Chapter 15 for information related to domain names.

10. **Set Root Password** — You must choose a password for your `root` user at this point. The `root` password provides complete control of your CentOS system. Without it, and before you add other users, you will have no access to your own system. Enter **Root Password**, and then type it again in the Confirm box. (Remember the `root` user's password and keep it confidential! Don't lose it!) Click Next to continue.

**TIP**

Use the `passwd` command to change your password later. See Chapter 13 for suggestions on how to choose a good password. See Chapter 10 for information on setting up user accounts.

11. **Install Classes** — For a new install, the installer automatically selects a set of basic software to install. In addition to that set, you can choose one or more of the following groups of software, referred to as *tasks*. For each of these installation tasks, you have the opportunity to install a set of pre-set packages or customize that set.
  - **Desktop** — Installs software appropriate for a home or office personal computer or laptop computer. This includes the GNOME desktop and various desktop-related tools (word processors, Internet tools, etc.). Server tools, software development tools, and many system administration tools are not installed.

- **Server** — Installs the software packages that you would typically need for a Linux Web Server (in particular, Apache Web Server and print server). It does not include many other server types by default (FTP, DHCP, mail, DNS, FTP, SQL, or news servers).
  - **Virtualization** — Installs the necessary software packages that are needed for Virtualization. The concept of virtualization is to allow multiple operating systems to run on a single computer. This includes the ability to run multiple instances of CentOS 5 or to run guest operating systems on one machine at the same time. In most cases, special virtualized hardware is needed, such as Intel Virtualization Technology or AMD Virtualization processors.
  - **Clustering** — Installs the software packages needed for cluster-based High Performance Computing (HPC). With HPC clusters, computing that needs to be done within an organization can be spread across multiple *compute nodes* (also called *worker nodes*). All compute nodes are configured identically, and master nodes are set up to direct the worker nodes.
  - **Storage Clustering** — Installs the software packages needed for cluster storage using the GFS File System. Servers are connected to a storage area network (SAN) that acts as a clustered file system. The fact that a GFS file system may reside across multiple disks on multiple storage units is invisible to the people and applications using the data.

A recent feature in CentOS lets you select software repositories outside of CentOS, from which you can select packages to install during the initial CentOS installation. Use the checkbox to be able to install from other software repositories. Select “Add additional software repositories” to add other repositories (such as those described in Chapter 5). Then, select the “Customize Now” button if you want to further specifically select which packages in the selected tasks are installed:
  - **Customize Now** — Select the “Customize Now” button after selecting the task (or tasks) you want to install to see the packages to be installed (based on install categories and package groups). This lets you see which categories from each task and which packages within those categories are selected to be installed. It also lets you add or remove package selections. Note that packages from multiple repositories can appear in the same category (e.g., you would see games from both CentOS and KBS-Extras packages appearing in the Games category if the KBS-Extras repository were enabled).
- 12. Customize Categories** — If you selected “Customize Now,” you are presented with categories of software on the left side of the screen and package groups on the right side. Select a category to see which groups it contains. Select a group and click on the “Optional packages” to see which optional packages are available in that group and which are selected to be installed. Categories include:
- **Desktop Environments** — The GNOME desktop environment is selected by default. KDE is also available as a desktop environment. (Desktop environments are described in Chapter 3.)



- **Applications** — This category includes packages of authoring and publishing applications, editors, games, sound and video players, Internet tools, and other applications. (Many of these applications are described in Chapters 5 through 8.)
- **Development** — General and specialized software development tools are included in packages in this category.
- **Servers** — Packages in this category are for Web, mail, FTP, database, and a variety of other network server types.
- **Base System** — Contains basic system administration tools, many common utilities, and support for basic system features (such as X Window System, Java, and Legacy software support).
- **Virtualization** — Packages in this category provide virtualization support.
- **Cluster** — Packages in this category provide support for cluster computing and administration tools to manage clusters.
- **Cluster Storage** — Packages in this category provide support for cluster storage.
- **Languages** — Packages containing support for multiple languages are contained in this category.

After you have chosen the packages you want to install, select Next to continue. The installer will take some time to check for dependencies among the packages you selected.

13. **About to Install** — A screen tells you that you are about to begin writing to hard disk. You can still back out now, and your hard disk will not have changed. Click Next to proceed. (To quit without changes, eject the DVD and restart the computer.) Now the file systems are created and the packages are installed. This typically takes from 20 to 60 minutes to complete, although it can take much longer on older computers.
14. **Finish Installing** — When you see the Congratulations screen, you are done. Eject the DVD and click Reboot.

Your computer will restart. If you installed GRUB, you will see a graphical boot screen that gives you several seconds to press a key to view and/or change the bootable partitions. After that, your CentOS installation should boot.

The first time your system boots after installation, CentOS Firstboot runs to do some initial configuration of your system. The next section explains how CentOS Firstboot works.

## Running CentOS Firstboot

The first time you boot CentOS 5, after it is installed, CentOS Firstboot runs to configure some initial settings for your computer.

### NOTE

Firstboot runs automatically only if you have configured CentOS to boot to a graphical login prompt. To start it from a text login, log in as root and type the following from a Terminal window:

```
# rm /etc/sysconfig/firstboot
# /usr/sbin/firstboot
```

The first screen you see is the Welcome screen. Click Forward to step through each procedure as follows:

- **Firewall** — Firewall settings allow or deny access to the services running on your CentOS system to other computers on your network.
- **SELinux** — SELinux is an additional layer of security that provides finer-grained security controls than the traditional access permission scheme. The default setting on CentOS is that SELinux security is enforced.
- **Date and Time** — Set the date and time, or enable the network time protocol to keep your system clock properly set. Click Forward.
- **Create User** — For your daily use of CentOS, you should have your own user account. You should typically log in with this username (of your choosing) and use only the `root` user to perform administrative tasks. In the first of the four textboxes on the screen, type a username (e.g., **dmiller** or **mjohnson**). Next, type your full name (e.g., **Devin Miller** or **Mel Johnson**). Then type your password in the Password textbox and again in the “Confirm Password” textbox. Click Forward.  
  
If some form of network authentication is used, such as LDAP, Kerberos, or SMB authentication, you can click on the Use Network Login button. See the “Enabling Authentication” sidebar for information on choosing different authentication types.
- **Sound Card** — This stage lets you test your system’s sound card settings. Click Forward.
- **Additional CDs** — Specify any additional installation CDs or DVDs that you have to install more software.

Firstboot is complete. Click Finish to continue. You may need to reboot. See Chapter 3 for a description of how to log in to CentOS and start learning how to use Linux.

When CentOS starts up the next time, it will boot up normally to a login prompt. A graphical boot screen is displayed (instead of a scrolling list of services starting up).

## Enabling Authentication

In most situations, you will enable shadow passwords and MD5 passwords (as selected by default) to authenticate users who log in to your computer from local password and shadow password files. To change that behavior, you can select the “Use Network Login” button during the Create User setup during Firstboot.

The shadow password file prevents access to encrypted passwords. MD5 is an algorithm used to encrypt passwords in Linux and other UNIX systems. It replaces an algorithm called *crypt*, which was used with early UNIX systems. When you enable MD5 passwords, your users can have longer passwords that are harder to break than those encrypted with *crypt*. You can also use SHA512 or SHA256 for encrypting passwords.

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If you are on a network that supports one of several different forms of network-wide authentication, you may choose one of the following features (on the Authentication tab):

- **Enable Kerberos Support** — Tick this checkbox to enable network authentication services available through Kerberos. After enabling Kerberos, you can add information about a Kerberos Realm (a group of Kerberos servers and clients), KDC (a computer that issues Kerberos tickets), and Admin server (a server running the Kerberos `kadmind` daemon).
- **Enable LDAP Support** — If your organization gathers information about users, you can tick this checkbox to search for authentication information in an LDAP server. You can enter the LDAP Server name and optionally an LDAP distinguished name to look up the user information your system needs.
- **Enable Smart Card Support** — Tick this checkbox to allow users to log in using a certificate and key associated with a smart card.
- **Enable SMB Support** — Tick this checkbox to configure your computer to use Samba for file and print sharing with Windows systems. If you enable SMB authentication, you can enter the name of the SMB server for your LAN and indicate the workgroup you want your computer to belong to.
- **Enable Winbind Support** — Tick this checkbox to configure your computer to authenticate users from information retrieved from NTDOM or ADS servers.

Besides those services just mentioned, you can also select from various ways of gathering distributed user information, if any of these methods are supported on your Network.

- **Configure Hesiod** — If your organization uses Hesiod for holding user and group information in DNS, you can add the LHS (domain prefix) and RHS (Hesiod default domain) to use for doing Hesiod queries.
- **Configure NIS** — Select this button and type the NIS Domain name and NIS server location if your network is configured to use the Network Information System (NIS). Instead of selecting an NIS Server, you can click the checkbox to broadcast to find the server on your network.

## Going Forward after Installation

If your CentOS system installed successfully, you are ready to start using it. Before you head off in your chosen direction, however, there are a few things that I strongly recommend that you do:

- **Get Updates** — As bugs and security vulnerabilities are discovered in CentOS, updates to your software packages are made available. Look for a desktop applet to alert you that updates are available. Select that icon to see available updates, then select to download and install them when you are ready. As an alternative, you can run `yum update` from a

Terminal window (as `root` user) to get available updates downloaded and installed on your computer. (See Chapter 5 for further information on getting software updates.)

- **Check Your Security** — There is a security checklist in Chapter 13. It steps you through different levels of security that are built into your Linux system. I suggest you go through that checklist. Sometimes a feature won't work because of the way permissions, firewalls, SELinux, and other security facilities are set on your system.
- **Learn the Desktop and the Shell** — Go through Chapter 3 to learn your way around the GNOME and KDE desktops that are available with CentOS. After that, learn about the shell in Chapter 4. If something goes wrong with your system, the help you will get from forums and mailing lists will almost always include commands to run from the shell.
- **Check Non-Working Hardware** — If a printer, network card, or other hardware component isn't working immediately, try tools for configuring those items under the System > Administration menu (described throughout this book). If that doesn't work, there are a few standard places to look for information. Review the Release Notes.

After you have examined these topics, you can go anywhere else in the book that interests and excites you.

The rest of this chapter is devoted to special topics relating to installing CentOS. If you're happy with the way your CentOS system installed, you can skip to the next chapter.

## Special Installation Procedures

---

If you don't want to, or can't, use the procedure to install CentOS from the DVD, the procedures in the following sections give you alternatives. After the install procedure boots, use the "Installing from Other Media" section that follows to learn how to install CentOS from media other than the DVD (using FTP, HTTP, NFS, or hard disk installs). If you want to have the installation screens appear on another computer as you install, refer to the "Starting a VNC Install" section. The subsection following that describes how to do kickstart installations.

### Alternatives for Starting Installation

Your computer may not have a DVD drive or may have one that is unbootable, so you need to find an alternative way to boot the install process. Although booting installation from 1.44-MB floppy disks is no longer supported (the 2.6 kernel won't fit on one), you have a couple other alternatives:

- Boot installation from hard disk.
- Do a PXE install.

Procedures for starting installation in those ways are described in the following sections.

## Booting Installation from Hard Disk

Booting the install process is similar to booting a regular Linux system. To start an install from your hard disk, all you really need to do is:

- Put the files needed to boot installation on your hard disk.
- Configure your boot loader to tell your computer's master boot record about those installation files.

This procedure presumes that there is already a CentOS system running on the computer (so you are doing an upgrade or a fresh install of CentOS). It also presumes that you can find a way to get those files onto the hard disk. (I'll describe how to do that from a DVD or CD that can be mounted even if it can't be booted.)

### NOTE

See the section later in this chapter on setting up install servers if you need the contents of the CentOS installation DVD accessible from somewhere other than the DVD itself.

1. Insert the CentOS DVD into the DVD drive while CentOS is running. If the DVD isn't automatically mounted, as `root` user, type the following to mount it:

```
# mount /media/disk
```

Note that the mount point for the DVD may be in a different location for you. Another option if the DVD doesn't mount is to create a mount point and mount the DVD there. For example, you could type **`mkdir /mnt/dvd ; mount /dev/dvd /mnt/dvd`**.

2. Copy the `vmlinuz` and `initrd` files from the installation DVD to your boot directory:

```
# cd /media/disk/isolinux
# cp initrd.img /boot/initrd-boot.img
# cp vmlinuz /boot/vmlinuz-boot
```

### NOTE

If you are not able to mount a DVD on the machine, you could copy the files from another machine on the network using `scp`. Or you could download those files to your `/boot` directory from a CentOS FTP site that contains the CentOS distribution.

3. Change your local `/boot/grub/grub.conf` file to include an entry for the `vmlinuz` and `initrd` files you just added to your boot directory. For example:

```
title CentOS 5 installation
    root (hd0,0)
    kernel /vmlinuz-boot
    initrd /initrd-boot.img
```

This example assumes that your `/boot` partition exists on the first partition of your first IDE hard drive (`hd0,0`, which is `/dev/sda1`). You can type **`df`** to see where your `/boot` partition is located.

4. Reboot your computer.

5. When the boot countdown message appears, press any key to display the GRUB boot screen. From there, press the down arrow key to move to the entry titled “CentOS 5 installation” and press [Enter]. From there you should be able to start installation normally.

## Booting Installation Using PXE

Another method to begin CentOS installation is to use Pre-eXecution Environment (PXE). With PXE, the installation process begins by setting the BIOS of your computer to look on the network for a PXE server to boot from.

For information on how to do a PXE install, refer to `/usr/share/doc/syslinux-*/pxelinux.doc` (provided that the `syslinux` package is installed). For the PXE install server, you can use the kernel and `initrd` images from the `images/pxeboot` directory on the CentOS DVD. You need to be able to set up a DHCP server and Tftp server to complete this procedure. Then you can get the CentOS installation files from any of the media types described in the next section.

## Installing from Other Media

Once the installation process has booted (from the DVD as described in the previous section), CentOS will let you get the actual packages that are to be installed from a Web Server (HTTP), an FTP server, a shared NFS directory, or a local hard disk.

### NOTE

To use HTTP, FTP, or NFS installations, your computer must be connected via an Ethernet connection to a network that can reach the computer containing the CentOS distribution. You cannot use a direct dial-up connection. For a local hard disk install, the distribution must have been copied to a local disk (or separate disk partition) that is not being used for installation. See the section “Setting up an HTTP, FTP, or NFS Install Server” for details on copying the distribution and making it available.

## Beginning Installation

You can use the DVD that comes with this book to start a network or hard disk install.

1. **Insert the CentOS Installation DVD into the Drive.**
2. **Reboot the Computer** — You should see the CentOS boot screen.
3. **Start `askmethod`** — Enter the following at the boot prompt:

```
linux askmethod
```

You are prompted to select a language.

4. **Select the Language** — You are prompted to choose a keyboard type.
5. **Select Your Keyboard Type** — You are prompted to select an installation method.
6. **Choose the Installation Method** — Select any of the following installation methods: Local CDROM, NFS image, FTP, HTTP, or hard drive.

- 7. Configure the Network Card** — For any of the network installs, you are asked to select your Ethernet card from the list shown. (This may be detected automatically.) If your card is not on the list, you need to obtain a driver disk that contains the driver needed by your network card.

**NOTE**

The CentOS project does not offer a driver disk, so you need to obtain the appropriate driver on your own. However, any vendor-supplied driver disk that is supposed to work under Red Hat Enterprise Linux 5 should work under CentOS 5.

- 8. Configure TCP/IP** — For any of the network install types (NFS, FTP, and HTTP), you are prompted to configure TCP/IP for your computer. (See the section on configuring networking earlier in this chapter for information on how to add to these fields.)
- 9. Identify the Location of the CentOS Distribution** — You must identify the NFS server name, FTP site name, or web site name that contains the CentOS directory that holds the distribution (e.g., `http://mirror.centos.org/centos/5/os/i386` for a 32-bit installation). Or, if you are installing from hard disk, you must identify the partition containing the distribution and the directory that actually contains the CentOS directory.

**NOTE**

For an FTP install, if you are not downloading from a public FTP site that allows anonymous login, you must select the “Use non-anonymous FTP” checkbox when you identify the server and directory. You will need a username and password that has access to the shared directory.

- 10. Continue with Installation** — If the distribution is found in the location you indicated, continue the installation as described in the previous section.

The next section describes how to set up your own server for installing CentOS.

## Setting up an HTTP, FTP, or NFS Install Server

If you have a LAN connection from your computer to a computer that has at least 2.5 GB of disk space and offers NFS, FTP, or Web Services, you can install CentOS from that server. Likewise, you can install from a spare disk partition by using a hard disk install. The following procedures let you set up a Linux install server by copying all files from the DVD or by copying images of the DVD.

### Configuring an Install Server Using Files

To do an FTP or HTTP install, you must copy the files from the installation DVD to a directory that you make available to the network. For example, you could do the following:

```
# mkdir /tmp/rh
# mount /media/disk           With DVD inserted
# cp -r /media/disk/* /tmp/rh/
# umount /media/disk; eject /media/disk
```

In this example, all files were copied. Setting up an NFS install server or hard disk install requires copying the DVD image to the shared NFS directory.

## Configuring an Install Server Using Disk Images

Instead of copying all files from the installation DVD, you can copy the entire DVD image to your hard disk for NFS or hard disk installs. To install the DVD, do the following:

```
# mkdir /tmp/rh
# dd if=/dev/cdrom of=/tmp/rh/disk1.iso With DVD inserted
# umount /media/disk ; eject /media/disk
```

## NFS Server

Add an entry to the `/etc/exports` file to share the distribution directory you created. Remember that for NFS installs, this directory must contain the DVD ISO image. The following entry makes the directory available in Read Only form to any computer:

```
/tmp/rh *(ro)
```

Next, restart NFS by typing the following as root user:

```
# /etc/init.d/nfs restart
```

To set the NFS service to be on permanently (it is off by default), type the following as root:

```
# chkconfig nfs on
```

## Web Server

If your computer is configured as a Web Server, you need to simply make the distribution directory available. For example, with just the ISO image (or images) in the current directory, you could type the following:

```
# mkdir /var/www/html/rh/
# cp *.iso /var/www/html/rh
```

Then simply start the Web Server as you would normally (`service httpd start`). If your computer were named `pine.handsonhistory.com`, you would identify the install server as `pine.handsonhistory.com` and the directory as `rh`.

## FTP Server

If your computer is configured as an FTP server, you need to make the distribution directory available in much the same way you did with the Web Server. For example, after creating the distribution directory as described, type the following:

```
# ln -s /tmp/rh /var/ftp/pub/rh
```

If your computer were named `pine.handsonhistory.com`, you would identify the install server as `pine.handsonhistory.com` and the directory as `pub/rh`.



### Hard Disk Install

With the ISO images of the DVD copied to a disk partition that is not being used for your CentOS install, you can use the hard disk install. If the ISO images exist in the `/tmp/rh` directory of the first partition of your IDE hard disk, you could identify the device as `/dev/sda1` and the directory holding the images as `/tmp/rh`.

## Starting a VNC Install

The VNC CentOS installation type doesn't exactly fit into the other installation categories, but I'm adding it here because you might find it useful. With a VNC install, you can boot up the installation process on the machine you want to install CentOS to and then step through the installation screens on another computer (running a VNC server). This can be convenient if you want to sit at your own desk while you install CentOS on a computer down the hall. Here's what to do:

1. Go to the computer from which you want to view the install process (in our example, the one with IP address 10.0.0.1) and start a VNC client process by typing the following from a Terminal window:

```
# vncviewer -listen
```

If `vncviewer` is not found, install the `vnc` package (`yum install vnc`).

2. From the computer you want to install CentOS to, insert the installation DVD and reboot the computer. The CentOS installation boot screen should appear.
3. Start the VNC install procedure by identifying the computer screen you want to watch the install from. You should also enter a password (at least six characters). For example, to have the install screens appear on the computer at IP address 10.0.0.1 with a password of `myC5pass`, specify the following for the boot line (password is optional):

```
vnc vncconnect=10.0.0.1 vncpassword=myF10pass
```

4. Answer the first few questions as you would for a normal CentOS install from DVD: Media check, Choose a Language, and Keyboard Type. Next you're asked if you want to configure TCP/IP.
5. Choose either dynamic IP configuration (if you have a BOOTP or DHCP server configured on your network) or enter your own IP address, Netmask, Default gateway, and Primary nameserver for the local computer. Select OK to continue. If the network connection starts up successfully, you will see messages such as the following (your text may differ):

```
Starting VNC...
The VNC server is now running
Attempting to connect to vnc client on host 10.0.0.1...
Connected!
Starting graphical installation...
```

6. Return to the desktop where you are going to view the install procedure. A VNC window should appear on the desktop containing the CentOS Welcome screen. Proceed with installation as you would normally.

**NOTE**

If you are not able to connect to the `vncviewer`, make sure that port 5500 is open and accepting connections on your desktop system. Check the descriptions of iptables in Chapter 13 for further information on opening ports in your firewall.

## Performing a Kickstart Installation

If you are installing CentOS on multiple computers, you can save yourself some trouble by pre-configuring the answers to questions asked during installation. The method of automating the installation process is referred to as a *kickstart installation*.

**WARNING**

Based on the information you provide in your `ks.cfg` file, kickstart will silently go through and install CentOS without intervention. If this file is not correct, you could easily remove your master boot record and erase everything on your hard disk. Check the `ks.cfg` file carefully, and test it on a noncritical computer before trying it on a computer holding critical data.

The general steps of performing a kickstart installation are as follows:

1. **Create a Kickstart File** — The kickstart file, named `ks.cfg`, contains the responses to questions that are fed to the installation process.
2. **Install kickstart file** — You have to place the `ks.cfg` on a floppy disk or CD, on a local hard disk, or in an accessible location on the network.
3. **Start Kickstart Installation** — When you boot the installation procedure, you need to identify the location of the `ks.cfg` file.

In the example in this chapter, you create your kickstart file directly with a text editor. If you prefer, you can use the Kickstart Configurator (`system-config-kickstart` command, from the package of the same name), which is a graphical tool for creating kickstart files.

### Creating the Kickstart File

A good way to begin creating your kickstart file is from a sample `ks.cfg` file. When you install CentOS, the installation process places a file called `anaconda-ks.cfg` into the `/root` directory. You can use this file as the basis for the `ks.cfg` file that you will use for your kickstart installs.

The particular `/root/anaconda-ks.cfg` file you get is based on the information you entered during a regular installation (CD, NFS, etc.). Presumably, if you are installing CentOS on other computers for the same organization, multiple computers may have a lot of the same hardware and configuration information. That makes this a great file for you to start creating your `ks.cfg` file from.

**NOTE**

For further details about how to use kickstart, refer to the *Red Hat Linux Configuration Guide*. You can get this guide from any Red Hat mirror site. To use a more graphical tool for configuring kickstart, run the `system-config-kickstart` command (after installing the package of the same name with the `yum install system-config-kickstart` command).

To start, log in as the `root` user. Then make a copy of the `anaconda-ks.cfg` file to work on.

```
# cp anaconda-ks.cfg ks.cfg
```

Use any text editor to edit the `ks.cfg` file. Remember that required items should be in order and that any time you omit an item, the user will be prompted for an answer. Entries from a `ks.cfg` file that was created from a regular DVD installation of CentOS are used as a model for the descriptions below. You should start with your own `anaconda-ks.cfg` file, and as a result, your file will start out somewhat differently. Commented lines begin with a pound sign (`#`).

The first uncommented line in the `ks.cfg` file should indicate whether the installation is an upgrade or an install. The `install` option runs a new installation. You can use the `upgrade` keyword instead to upgrade an existing system. (For an upgrade, the only requirements are a language, an install method, an install device, a keyboard, and a boot loader.)

```
install
```

The method of installation is indicated on the next line. Possible locations for the installation media include: NFS (`nfs --server=servername --dir=installdir`), FTP (`url --url ftp://user:passwd@server/dir`), HTTP (`url --url http://server/dir`), or hard drive (`harddrive --dir=/dir --partition=/dev/partition`). For the default DVD install, you will see

```
cdrom
```

The required `lang` command sets the language (and to be more specific, the country as well) in which CentOS is installed. The value is U.S. English (`en_US.UTF-8`) by default:

```
lang en_US.UTF-8
```

You can install multiple languages to be supported in CentOS. Here is an example of the default being set to U.S. English:

```
langsupport --default en_US.UTF-8 en_US.UTF-8
```

The required `keyboard` command identifies a U.S. (`us`) keyboard by default. More than 70 other keyboard types are supported. (Run `system-config-keyboard` to see a list of available keyboard types.)

```
keyboard us
```

The optional `xconfig` command can be used to configure your monitor and video card. If you use the `skipx` command instead (as shown in the following code sample), no X configuration

is done. (After the system is installed, run `system-config-desktop` to set up your X configuration.) When you use the `xconfig` command, you can identify the type of X server to use based on your video card (`--card`) and monitor specs (`--hsync` and `--vsync`). A handful of other options enable you to set the color depth in bits (`--depth`), the screen resolution (`--resolution`), whether the default desktop is GNOME or KDE (`--defaultdesktop`), whether the login screen is graphical (`--startxonboot`), and the amount of RAM on your video card (`--videoram`). (All the information after `xconfig` should actually appear on one line.)

```
skipx
```

or

```
xconfig --card="NVIDIA GeForce FX (generic)" --videoram=131072
--hsync=31.5-37.9 --vsync=50-70 --resolution=800x600
--depth=16 --startxonboot --defaultdesktop gnome
```

The optional `network` command lets you configure your CentOS system's interface to your network. The example tells your computer to get its IP address and related network information from a DHCP server (`--bootproto dhcp`). If you want to assign a particular IP address, use the `--bootproto static` option. Then change the IP address (`--ip`), netmask (`--netmask`), IP address of the gateway (`--gateway`), and IP address of the DNS server (`--nameserver`) to suit your system. You can also add a hostname (`--hostname`).

## NOTE

Although the network values appear to be on three lines, all values must be on the same line.

```
network --device eth0 --bootproto dhcp
```

or

```
network --device=eth0 --bootproto static --ip=192.168.0.1
--netmask 255.255.255.0 --gateway 192.168.0.1
--nameserver 192.168.0.254 --hostname duck.example.com
```

The `rootpw` command sets the password to whatever word follows (in the following example, `paSSword`). It is a security risk to leave this password hanging around, so you should change this password (with the `passwd` command) after Linux is installed. You also have the option of adding an encrypted password instead (`--iscrypted g.UJ.RQe0V3Bg -enablemd5`).

```
rootpw paSSword
```

or

```
rootpw --iscrypted g.UJ.RQe0V3Bg --enablemd5
```

The `firewall` command lets you set the default firewall used by your CentOS system. The default value is `enabled` (if the firewall is turned on). You can also set `firewall` to `disabled` (no firewall). (These values are described in the installation procedure earlier in this chapter.) As

you can see in the example, you can optionally indicate that there be no restrictions from host computers on a particular interface (`--trust eth0`). You can also allow an individual service (`--ssh`) or a particular `port:protocol` pair (`--port 1234:udp`).

```
firewall --enabled --trust=eth0 --ssh --port=1234:udp
```

The required `authconfig` command sets the type of authentication used to protect your user passwords. The `--enablshadow` option enables the `/etc/shadow` file to store your passwords. The `--passalgo=sha512` option enables SHA512-based encryption for the passwords. (You would typically use both.)

```
authconfig --enablshadow --passalgo=sha512
```

The `selinux` command indicates whether or not Security Enhanced Linux is enabled. The following line shows it as enabled and enforcing:

```
selinux --enforcing
```

The `timezone` command sets the time zone for your Linux system. The default, shown here, is United States, New York (`America/New_York`). The `--utc` option indicates that the computer's hardware clock is set to UTC time. If you don't set a time zone, `US/Eastern` is used. Run the `timeconfig` command to see other valid time zones.

```
timezone --utc America/New_York
```

The `bootloader` command sets the location of the boot loader (GRUB, by default). For example, `--location=mbr` adds GRUB to the master boot record. (Use `--location=none` to not add GRUB.) The `driveorder=` option describes which hard disk to look on first for the master boot record. You can also add kernel options to be read at boot time using the `append` option (`--append hdd=ide-scsi`) or an optional password for GRUB (`--password=GRUBpassword`).

```
bootloader --location=mbr --driveorder=sda --append="rghb quiet"
password=GRUBpassword
```

Partitioning is required for a new install, optional for an upgrade. The code that follows is from the sample `ks.cfg` file. The `clearpart --linux` value removes existing Linux partitions (or use `--all` to clear all partitions) on the first hard drive (`--drives=sda`). The `part /boot, /` and `swap`, sets the file system type (`--fstype`) and partition name (`onpart`) for each partition assignment. You can also set sizes of the partitions (`--size`) to however many megabytes you want. You can also create logical volume group (`volgroup`) and individual logical volume (`logvol`) entries for your partitioning.

```
# The following is the partition information you requested
# Note that any partitions you deleted are not expressed
# here so unless you clear all partitions first, this is
# not guaranteed to work
#clearpart --linux --drives=sda
```

```
#part /boot --fstype ext3 --size=100 --ondisk=sda
#part / --fstype ext3 --size=700 --grow --ondisk=sda
#part swap --size=128 --grow --maxsize=256 --ondisk=sda
```

To indicate which packages to install, begin a section with the `%packages` command. (A few examples follow.) Designate whole installation groups, individual groups, or individual packages. On the `%packages` line, you can indicate whether or not to resolve dependencies by installing those packages needed by the ones you selected (`--resolvedeps`). After `%packages`, start an entry with an `@` sign for a group of packages, and add each individual package by placing its name on a line by itself. Here is an example:

```
%packages --resolvedeps
@base
@editors
@games
@graphical-internet
@kde-desktop
@office
@sound-and-video
.
.
```

**NOTE**

The `%packages` command is not supported for upgrades. To install everything, you can remove the package names shown. Then, after the `%packages` line, you can add an `@everything` line.

The `%post` command starts the post-installation section. After it, you can add any shell commands you want to run after installation is completed. A useful thing to do is to add `useradd` commands for users you want to add during installation. You can also use the `usermod` command to add the user's password. Note that there is no `%post` section by default.

```
%post
/usr/sbin/useradd jake
chfn -f 'John W. Jones' jake
/usr/sbin/usermod -p '$1kQUMYbF0h79wECxnTuaH.' Jake
```

At this point, you should have a working `ks.cfg` file.

**Installing the Kickstart File**

Once the `ks.cfg` file is created, you need to put it somewhere accessible to the computer doing the installation. Typically, you will place the file on a floppy disk. However, you can also put the file on a computer that is reachable on the network or on a hard disk.

To copy the file to a floppy disk, create a DOS floppy and copy the file as follows:

```
# mcopy ks.cfg a:
```

When you do the CentOS kickstart installation, have this floppy disk with you. As an alternative, you can copy the `ks.cfg` file to a hard disk partition, CD drive, Web Server, or NFS share.

Being able to place the `ks.cfg` file on a computer on the network requires a bit more configuration. The network must have a DHCP or a BOOTP server configured that is set up to provide network information to the new install computer. The NFS server containing the `ks.cfg` file must export the file so that it is accessible to the computer installing Linux. To use a `ks.cfg` file from the local hard disk, you can place the file on any partition that is a Windows (VFAT) or Linux (ext3) partition.

### Booting a Kickstart Installation

If the kickstart file (`ks.cfg`) has been created and installed in an accessible location, you can start the kickstart installation. Here is an example of how you can do a kickstart installation using the CentOS DVD and a floppy containing a `ks.cfg` file:

1. Insert the CentOS DVD and restart the computer.
2. When you see the boot screen, insert the floppy containing the `ks.cfg` file, and type the following at the boot line:

```
linux ks=floppy
```

You should see messages about formatting the file system and reading the package list. The packages should install without any intervention. Next you should see a post-install message. Finally, you should see the Complete message.

3. Remove the floppy; then press the spacebar to restart your computer.

#### TIP

You can install using kickstart over NFS (`ks:nfs:server:path/ks.cfg`), from a Web Server (`ks=http://server/path/ks.cfg`), or from your hard drive (`ks=hd:device:/ks.cfg`).

## Special Installation Topics

---

Some things that you run into during installation merit whole discussions by themselves. Rather than bog down the procedures with details that not everyone needs, I have included instructions in this section to address issues such as setting up a dual-boot Linux and Windows system, disk partitioning, and boot loaders.

### Setting up to Dual-Boot Linux and Windows

It is possible to set up your computer so that you can have two (or more) complete operating systems installed on it. When you power up your computer, you can choose which operating system you want to boot. This setup is referred to as a *dual-boot computer*.

If a Microsoft Windows operating system was installed when you got your PC, it's likely that the entire hard disk is devoted to Windows. CentOS installation procedures retain existing Windows

partitions by default, but they don't let you take space from existing disk partitions without destroying them. If you want to be able to run Linux on that machine, you need to do one of the following:

- **Erase the Disk** — If you never wanted Windows in the first place (or if Windows is badly broken or infected), you may decide to completely erase it from your hard disk. In this case, you won't have a dual-boot system, but you can jump right to the CentOS install procedure and start installing (tell the install process to just erase the whole disk).
- **Add a Second Disk** — This lets you maintain your Windows installation on the computer without having to do the potentially dangerous resizing of your Windows partitions. (Refer to Chapter 9 for information on adding a second disk, then go right to the CentOS installation section.)
- **Resize Your Windows Partition(s)** — Many people choose this route for dual-booting Windows and Linux. If done successfully, you don't have to add hardware and you can keep your whole Windows system.

The rest of this section is devoted to a discussion and procedure for resizing your Windows partitions to create a dual-boot computer with Windows and Linux.

## Resizing Your Windows Partitions

By resizing your Windows partitions, you can free up disk space that can be used for your CentOS installation. Because there is some danger in resizing your disk partitions and changing how your computer boots, however, you should carefully read the Caution that follows.

Before you begin resizing your Windows system, boot Windows and do the following:

1. **Back up Your Data!** — Of course, you should always have a current backup of your important data. However, now is a particularly good time to do a backup, just in case one of those disk catastrophes I warned you about actually happens.
2. **Defragment Your Disk** — Before you resize your hard disk, you should use a defragmenting utility in Windows to have all files stored contiguously on the disk. That way, when you reassign free space to Linux partitions, you have a continuous area of the disk to work with. To defragment a disk in Windows XP, click Start ➤ All Programs ➤ Accessories ➤ System Tools ➤ Disk Defragmenter. Then select Defragment from the Disk Defragmenter window. Defragmenting can take a while, depending on your processor speed and disk size.

While you have the Disk Defragmenter window displayed, note a few things about your hard disk that you will need to know later:

- **File System** — The file system type will most likely be NTFS, although it may also be VFAT. If you have the option to install Windows from scratch, selecting VFAT as the file system type will work much better for Linux. Support for writing to NTFS has been considered unreliable from Linux, although reading from NTFS seems to work well. VFAT file systems, however, will work well for both Linux and Windows.



- **Free Space** — If your entire hard disk consists of a single Windows partition, you can resize your existing partition to use some of the free space to assign to Linux partitions. Note the amount of free space you have here, and compare it to the amounts you will need to install Linux (described earlier).

Despite the fact that I have successfully resized several NTFS partitions using the *GParted* utility, I still recommend caution (and a good backup of your data) before proceeding. If you feel more comfortable using commercial products to resize your partitions, I have listed a few of those below. I have not tested the products so I name them here only because I have heard good reports of success from others:

- **Norton Partition Magic** — I've heard good reports from people using Partition Magic ([www.symantec.com/norton/partitionmagic](http://www.symantec.com/norton/partitionmagic)) to resize NTFS partitions. Partition Magic also helps you create new partitions and manage them. It supports Windows XP Professional/Home, Windows 95b-98SE, Windows Me, Windows 2000 Professional, and NT 4.0 workstation (SP6a).
- **Acronis OS Selector** — This is another well-regarded product for managing, creating, and resizing partitions, which is now included in the Acronis Disk Director Suite. It supports a variety of file system types, including FAT12, FAT16, FAT32, NTFS, and Linux partition types (ext2, ext3, and Linux ReiserFS). It also supports the same Windows platforms that Partition Magic does.

Microsoft Windows Vista now comes with tools for resizing your disk partitions. From the Start menu, right-click on Computer and select Manage. In the left pane that appears, select Storage and click “Disk Management.” Then right-click on the volume you want to resize and select either “Extend Volume” or “Shrink Volume” to change its size.

The Open Source tool I describe here for resizing your disk is called *GParted*. It can be used to resize partitions that contain a variety of file system types.

If your Windows system is backed up and your disk defragmented, you can begin the process of resizing your NTFS or VFAT disk partition with *GParted* using the CentOS Live CD included with this book. Here's how to resize your NTFS partitions using the CD:

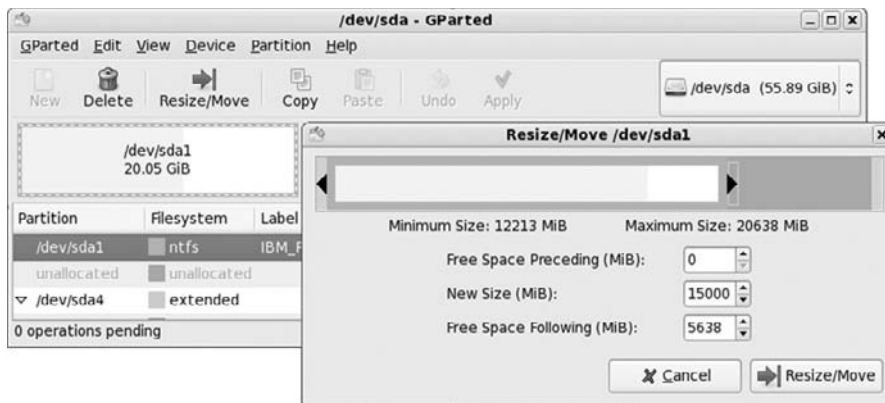
1. Insert the CentOS Live CD and reboot your computer.
2. When the CD boots to a GNOME desktop, to begin resizing your hard disk, you need to install the couple of packages that provide NTFS support (if your partition is VFAT, then you can skip installing the NTFS-related packages) and the *gparted* package from the RPMForge repository (see Chapter 5 on enabling third-party repositories). Assuming that you have an Internet connection, type the following from a Terminal window:

```
$ su -  
# yum install ntfsprogs fuse-ntfs-3g gparted
```
3. From the Applications menu, select System Tools > *GParted*. The *GParted* graphical partitioning tool opens, displaying your current disk partitions.

4. Select the disk (probably `/dev/sda`) and partition (probably NTFS or VFAT for a Windows partition) you want to resize. The Resize/Move button should become available.
5. Select the Resize/Move button to open a Resize/Move pop-up window.
6. Grab the slider bar from the right and move it to select how much you want to resize your partition. The “New Size” box shows the new size of your partition. The “Free Space Following MiB” box shows how much free space you will have after you are done. In my example, on a small disk, I resized `/dev/sda1` to about 15 GB, leaving me about 5 GB of free space that I can use later to install CentOS (normally, you would want more for CentOS, if space is available). Figure 2-1 shows the GParted window resizing about a 20-GB partition to about 15 GB.

**FIGURE 2-1**

Use GParted to resize your Windows NTFS partitions.



7. Click Resize/Move to begin resizing your partition. When it is done, you will see the resized partition and a new entry showing the free space.

**CAUTION**

The resize is committed in the next step. You can quit now without making any changes if you are nervous. In any case, make sure that the partition you are resizing is not mounted. (In this example, I'd type `umount /dev/sda1` as root user from a shell before running the next step.

8. If the new partition sizes look all right, click Apply to commit the changes.
9. At this point, you can close the GParted window and begin the regular installation procedure for CentOS, using the disk space that you just freed up.

After you have installed CentOS, there are a few other useful things you might want to do so you can use files from your Windows partitions in Linux.

**NOTE**

By default, CentOS is configured to hide the GRUB boot screen that lets you select which operating system to boot. You will have to press any key, as the CentOS boot screen counts down 5 seconds, to see the GRUB boot screen. You might consider editing the `grub.conf` file, as described later in this chapter. Personally, I removed the `hiddenmenu` line and increased the time-out from 5 to 10 seconds.

## Using Windows Partitions from Linux

With some space available on your disk, when you go to install Linux, consider adding a small FAT16 or FAT32 partition (maybe 2 GB) on your disk. Every x86 operating system (Linux, Windows 95, NT, 2000, XP, Vista, and DOS) supports those types. With that added, you will be able to freely exchange files between your Linux and Windows systems on the FAT16 partition.

With FAT partitions, however, keep in mind that there are limitations. FAT is limited to between 2-GB and 4-GB file sizes. Also, FAT16 doesn't support long filenames. The total partition size for FAT file systems is 32 GB.

After you have installed Linux in the space freed up by the previous procedure, you should be able to choose between Linux and Windows when the CentOS boot screen appears during boot time. Press any key to go to the GRUB boot screen. Then move the arrow key to choose to boot Linux or Windows.

The first time you boot Windows, you might be asked to check your disk (because your Windows partition will be a different size than expected). After that, there should be no change in how you use your Windows system. Your disk space will just be smaller.

Now, when you boot up Linux, if you have a lot of documents, digital images, music, or other content on your Windows partition, you probably want to be able to use that content from Linux. To do that, you need to:

- Determine which partition is your Windows partition.
- If you didn't do so during installation, add support for the file system type of your Windows partition to Linux. Since VFAT is already built in, that means adding NTFS support if that is the file system type.
- Mount the Windows partition on your Linux file system.

The following procedure describes how to do those things:

1. **Check Partitions** — To determine which partition contains your Windows file system, use the `fdisk` command as follows:

```
# fdisk -l
Disk /dev/sda: 60.0 GB, 60011642880 bytes
16 heads, 63 sectors/track, 116280 cylinders
Units = cylinders of 1008 * 512 = 516096 bytes
```

Device	Boot	Start	End	Blocks	Id	System
/dev/sda1	*	1	41725	21029053+	7	HPFS/NTFS
/dev/sda2		106741	116280	4808160	12	Compaq diagnostics
/dev/sda3		41725	41932	104422+	83	Linux
/dev/sda4		41932	106734	32660145	5	Extended
/dev/sda5		41932	106718	32652081	8e	Linux LVM

In this example, the Windows partition is on device `/dev/sda1` and is an NTFS file system. (The other common type of Windows file system is VFAT.)

- 2. Get NTFS Support** — If you have a VFAT file system, you can skip this step. If you have an NTFS file system and NTFS support is not already installed, you can install the necessary drivers and tools to be able to mount and use your NTFS file system in Linux. You'll need to activate the RPMForge repository (see Chapter 5) and then run the following yum command as root user from a Terminal window:

```
# yum install ntfsprogs fuse-ntfs-3g
```

Assuming you have an active connection to the Internet, this will install the NTFS support you need to access your NTFS partitions from Linux.

- 3. Mount Windows File System** — You can access your Windows file system from Linux using the `mount` command. Assuming that your Windows partition is an NTFS file system on `/dev/sda1` (as in the example above), you could type the following to create the Windows mount point and mount the file system there:

```
# mkdir /mnt/win
# chmod 755 /mnt/win
# mount -t ntfs /dev/sda1 /mnt/win
# chmod 755 /mnt/win
# ls /mnt/win
```

Replace the `ntfs` with `vfat` if your Windows partition is a VFAT file system. The `ls` command is just to find out if you can see the contents of your Windows partition.

You can have the mount occur permanently by adding an entry to the `/etc/fstab` file. Here's an example of the line you could add to `/etc/fstab` to have the partition mounted every time the system reboots:

```
/dev/sda1 /mnt/win ntfs ro 0 0
```

At this point, you can use the files from your Windows partition as you would any other files on your system. You can open a folder or change directories to the `/mnt/win` directory to see the contents. Then use any applications you choose to open your documents (OpenOffice.org), music (Rhythmbox), images (Gimp), or any other content type you want to use from your Windows partition in Linux.

## NOTE

If your Linux system uses an ext2 or ext3 file system (as CentOS typically does), you can do the reverse of what was just described as well: access your Linux partition from Windows. For information on how to do this, see the Ext2 Installable File System for Windows ([www.fs-driver.org](http://www.fs-driver.org)).

## Partitioning Your Disks

The hard disk (or disks) on your computer provides the permanent storage area for your data files, application programs, and the operating system, such as CentOS. *Partitioning* is the act of dividing a disk into logical areas that can be worked with separately. There are several reasons you may want to do partitioning:

- **Multiple Operating Systems** — If you install CentOS on a PC that already has a Windows operating system, you may want to keep both operating systems on the computer. To run efficiently, they must exist on completely separate partitions. When your computer boots, you can choose which system to run. Note that you are limited in the number of partitions you can have (with IDE drives, you can have 63 partitions; with SCSI devices, you are limited to 15 partitions per device).
- **Multiple Partitions within an Operating System** — To protect from having their entire operating system run out of disk space, people often assign separate partitions to different areas of the Linux file system. For example, if /home and /var were assigned to separate partitions, then a gluttonous user who fills up the /home partition wouldn't prevent logging daemons from continuing to write to log files in the /var/log directory. Multiple partitions also make it easier to do certain kinds of backups (such as an image backup). For example, an image backup of /home would be much faster (and probably more useful) than an image backup of the root file system (/).
- **Different File System Types** — Different kinds of file systems have different structures. File systems of different types must be on their own partitions. In CentOS, you need at least one file system type for / (typically ext3) and one for your swap area. File systems on CD-ROM use the iso9660 file system type.

### TIP

When you create partitions for CentOS, you will often assign the file system type as Linux native (using the ext3 type). A newer type, ext4, is also available. Reasons to use other types include needing a file system that allows particularly long filenames or many inodes (each file consumes an inode).

For example, if you set up a news server, it can use many inodes to store news articles. Another reason for using a different file system type is to copy an image back-up tape from another operating system to your local disk (such as one from an OS/2 or Minix operating system).

If you have used only Windows operating systems before, you probably had your whole hard disk assigned to C: and never thought about partitions. With CentOS, you can select to have Linux erase the whole disk, take it over, and partition it or have Linux keep separate partitions for Windows 9x/2000/NT/XP/Vista and Linux. The CentOS installation process also gives you the opportunity to view and change the default partitioning for the different installation types.

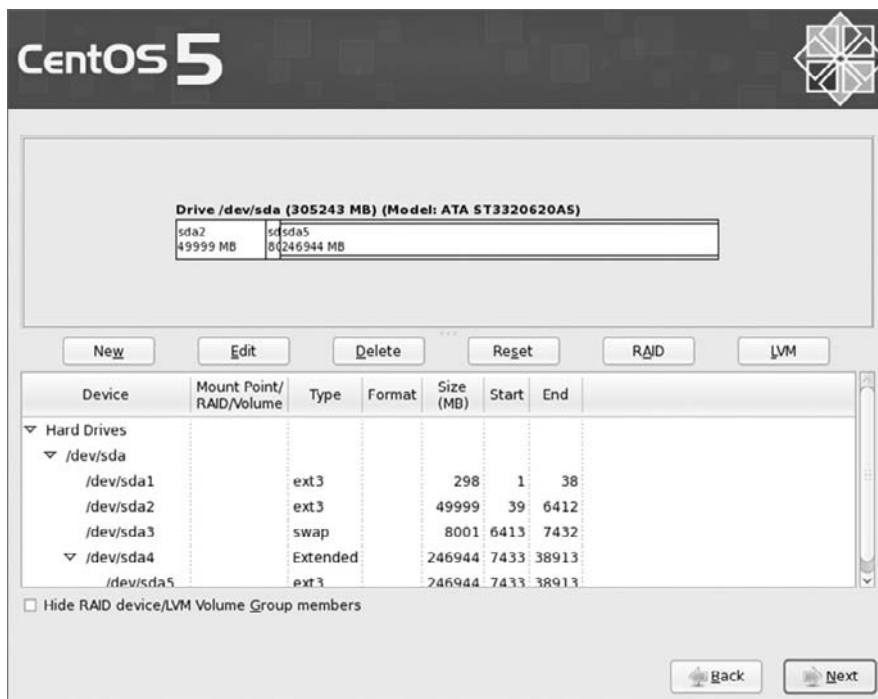
During installation, CentOS enables you to partition your hard disk using the Disk Setup utility (a graphical partitioning tool). The following sections describe how to use Disk Setup (during installation) or `fdisk` (when CentOS is up and running or by switching virtual terminals while the install is running). See the section “Tips for Creating Partitions” for some ideas for creating disk partitions.

## Partitioning with Disk Setup during Installation

During installation, you are given the opportunity to change how your hard disk is partitioned. It is recommended that you use the Disk Setup. The Disk Setup screen is divided into two sections. The top shows general information about each hard disk. The bottom shows details of each partition. Figure 2-2 shows an example of the Disk Setup window.

**FIGURE 2-2**

Partition your disk during installation from the Disk Setup window.



For each of the hard disk partitions, you can see:

- Device** — The device name is the name representing the hard disk partition in the /dev directory. Each disk partition device begins with two letters: *sd* for IDE disks or SCSI disks, *ed* for ESDI disks, or *xd* for XT disks. After that is a single letter representing the number of the disk (Disk 1 is *a*, Disk 2 is *b*, Disk 3 is *c*, etc.). The partition number for that disk (1, 2, 3, etc.) follows the letter.

- **Mount Point/Raid/Volume** — The directory where the partition is connected into the Linux file system (if it is). You must assign the root partition (/) to a native Linux partition before you can proceed. If you are using RAID or LVM, the name of the RAID device or LVM volume appears here.
- **Type** — The type of file system that is installed on the disk partition. In most cases, the file system will be Linux (ext3), Win VFAT (vfat), or Linux swap. However, you can also use the previous Linux file system (ext2), physical volume (LVM), or software RAID. In fact, LVM is used by default for your root file system when you install CentOS. This will allow you to add more disk space later to that partition, if needed, without having to create a new partition.
- **Format** — Indicates whether (checkmark) or not (no checkmark) the installation process should format the hard disk partition. Partitions marked with a check are erased! So, on a multiboot system, be sure your Windows partitions, as well as other partitions containing data are not checked!
- **Size (MB)** — The amount of disk space allocated for the partition. If you selected to let the partition grow to fill the existing space, this number may be much larger than the requested amount.
- **Start/End** — Represents the partition's starting and ending cylinders on the hard disk.

In the top section, you can see each of the hard disks that is connected to your computer. The drive name is shown first. That's followed by the model name of the disk. The total amount of disk space, the amount used, and the amount free are shown in megabytes (MB).

### ***Reasons for Partitioning***

There are different opinions about how to divide up a hard disk. Here are some issues:

- **Do You Want to Install Another Operating System?** — If you want Windows on your computer along with Linux, you will need at least one Windows (Win95 FAT16, VFAT, or NTFS type), one Linux (Linux ext3), and one Linux swap partition.
- **Is It a Multiuser System?** — If you are using the system yourself, you probably don't need many partitions. One reason for partitioning an operating system is to keep the entire system from running out of disk space at once. That also serves to put boundaries on what an individual can use up in his or her home directory (although disk quotas are good for that as well).
- **Do You Have Multiple Hard Disks?** — You need at least one partition per hard disk. If your system has two hard disks, you may assign one to / and one to /home (if you have lots of users) or /var (if the computer is a server sharing lots of data).

### ***Deleting, Adding, and Editing Partitions***

Before you can add a partition, there needs to be some free space available on your hard disk. If all space on your hard disk is currently assigned to one partition (as it often is in DOS or Windows), you must delete or resize that partition before you can claim space on another partition. The section "Resizing your Windows Partitions" earlier in this chapter discusses how to take disk

space from an existing Windows partition to use later for Linux partitions, without losing information in your existing single-partition system.

**CAUTION**

Make sure that any data that you want to keep is backed up before you delete the partition. When you delete a partition, all its data is gone.

Disk Setup is less flexible, but more intuitive, than the `fdisk` utility. Disk Setup lets you delete, add, and edit partitions.

**TIP**

If you create multiple partitions, make sure that there is enough room in the right places to complete the installation. For example, most of the Linux software is installed in the `/usr` directory (and subdirectories), whereas most user data is eventually added to the `/tmp`, `/home` or `/var` directories. It's a good idea to have separate partitions for every directory structure users can write to. Likewise, NFS shares also are often put on separate partitions.

To delete a partition in Disk Setup, do the following:

1. Select a partition from the list of Current Disk Partitions on the main Disk Setup window (click it or use the arrow keys).
2. To delete the partition, click Delete.
3. When asked to confirm the deletion, click Delete.
4. If you made a mistake, click Reset to return to the partitioning as it was when you started Disk Setup.

To add a partition in Disk Setup, follow these steps from the main Disk Setup window:

1. Select New. A window appears, enabling you to create a new partition.
2. Type the name of the Mount Point (the directory where this partition will connect to the Linux file system). You need at least a root (`/`) partition and a swap partition.
3. Select the type of file system to be used on the partition. You can select from Linux native (ext2 or preferably ext3), software RAID, Linux swap (swap), physical volume (LVM), or Windows FAT (vfat).

**TIP**

To create a different file system type from those shown, leave the space you want to use free for now. After installation is complete, use `fdisk` to create a partition of the type you want.

4. Type the number of megabytes to be used for the partition (in the Size field). If you want this partition to grow to fill the rest of the hard disk, you can put any number in this field (1 will do fine).
5. If you have more than one hard disk, select the disk on which you want to put the partition from the “Allowable Drives” box.
6. Type the size of the partition (in megabytes) into the “Size (MB)” box.



7. Select one of the following “Additional Size Options”:
  - **“Fixed size”** — Click here to use only the number of megabytes you entered into the Size textbox when you create the partition.
  - **“Fill all space up to (MB)”** — If you want to use all remaining space up to a certain number of megabytes, click here and fill in the number. (You may want to do this if you are creating a VFAT partition up to the 2,048-MB limit that Disk Setup can create.)
  - **“Fill to maximum allowable size”** — If you want this partition to grow to fill the rest of the disk, click here.
8. Optionally select “Force to Be a Primary Partition” if you want to be sure to be able to boot the partition or “Check for Bad Blocks” if you want to have the partition checked for errors.
9. Select OK if everything is correct. (The changes don’t take effect until several steps later when you are asked to begin installing the packages.)

To edit a partition in Disk Setup from the main Disk Setup window, follow these steps:

1. Click on the partition you want to edit.
2. Click on the Edit button. A window appears, ready to let you edit the partition definition.
3. Change any of the attributes (as described in the Add Partition procedure). For a new install, you may need to add the mount point (`/`) for your primary Linux partition.
4. Select OK. (The changes don’t take effect until several steps later, when you are asked to begin installing the packages.)

**NOTE**

If you want to create a RAID device, you need to first create at least two RAID partitions. Then click the RAID button to make the two partitions into a RAID device. For more information on RAID, refer to Chapter 9 or the *Red Hat Linux Customization Guide*. The latter is available here: [http://centos.org/docs/5/html/5.2/Deployment\\_Guide/ch-raid.html](http://centos.org/docs/5/html/5.2/Deployment_Guide/ch-raid.html). To create an LVM volume group, you must create at least one partition of type “physical volume (LVM).”

## Partitioning with `fdisk`

The `fdisk` utility does the same job as Disk Setup, but it’s no longer offered as an option during CentOS installations. (If you are old school, however, you could press `[Ctrl]+[Alt]+[F2]` during the installation process and run `fdisk` from the shell to partition your disk.)

The following procedures are performed from the command line as `root` user.

**CAUTION**

Remember that any partition commands can easily erase your disk or make it inaccessible. Back up critical data before using any tool to change partitions! Then be very careful about the changes you do make. Keeping an emergency boot disk handy is a good idea, too.

The `fdisk` command is one that is available on many different operating systems (although it looks and behaves differently on each). In Linux, `fdisk` is a menu-based command. To use `fdisk` to list all your partitions, type the following (as `root` user):

```
# fdisk -l

Disk /dev/sda: 40.0 GB, 40020664320 bytes
255 heads, 63 sectors/track, 4865 cylinders
Units = cylinders of 16065 * 512 = 8225280 bytes

   Device Boot      Start         End      Blocks   Id  System
/dev/sda1  *           1           13    104391   83  Linux
/dev/sda2             14         4833   38716650   83  Linux
/dev/sda3          4834         4865     257040   82  Linux swap
```

To see how each partition is being used on your current system, type the following:

```
# df -h

Filesystem                Size      Used Avail Use% Mounted on
/dev/sda2                  37G       5.4G   30G  16% /
/dev/sda1                   99M       8.6M    86M  10% /boot
none                       61M         0    61M   0% /dev/shm
```

From the output of `df`, you can see that the root of your Linux system (`/`) is on the `/dev/sda2` partition and that the `/dev/sda1` partition is used for `/boot`.

### CAUTION

Before using `fdisk` to change your partitions, I strongly recommend running the `df -h` command to see how your partitions are currently being defined. This will help reduce the risk of changing or deleting the wrong partition.

To use `fdisk` to change your partitions, begin (as `root` user) by typing:

```
# fdisk device
```

where *device* is replaced by the name of the device you want to work with. For example, here are some of your choices:

- `/dev/sda` — For the first IDE or SCSI hard disk; `sdb`, `sdc`, and so on for other SCSI disks
- `/dev/md0` — For a RAID device

After you have started `fdisk`, type **m** to see the options. Here is what you can do with `fdisk`:

- **Delete a Partition** — Type **d** and you are asked to enter a partition number on the current hard disk. Type the partition number and press [Enter]. For example, `/dev/sda2` would be partition number 2. (The deletion won't take effect until you write the change. Until then, it's not too late to back out.)

- **Create a Partition** — If you have free space, you can add a new partition. Type **n** and you are asked to enter **l** for a logical partition (5 or over) or **p** for a primary partition (1–4). Enter a partition number from the available range. Then choose the first cylinder number from those available. (The output from `fdisk -l` shown earlier will show you cylinders being used under the `Start` and `End` columns.)

Next, enter the cylinder number that the partition will end with (or type the specific number of megabytes or kilobytes you want: e.g., **+50M** or **+1024K**). You just created an `ext3` Linux partition. Again, this change isn't permanent until you write the changes.

- **Change the Partition Type** — Press **t** to choose the type of file system. Enter the partition number of the partition number you want to change. Type the number representing the file system type you want to use in hexadecimal code. (Type **L** at this point to see a list of file system types and codes.) For a Linux file system, use the number 83; use 82 for a Linux swap partition. For a Windows FAT32 file system, you can use the letter *b*.
- **Display the Partition Table** — Throughout this process, feel free to type **p** to display (print on the screen) the partition table as it now stands.
- **Saving and Quitting** — If you don't like a change you make to your partitions, press **q** to exit without saving. Nothing will have changed on your partition table.

Before you write your changes, display the partition table again and make sure that it is what you want it to be. To write your changes to the partition table, press **w**. You are warned about how dangerous it is to change partitions and asked to confirm the change.

An alternative to the `fdisk` command is `sfdisk`. The `sfdisk` command is command-line-oriented. Type the full command line to list or change partitions. (See the `sfdisk` man page for details.)

## Tips for Creating Partitions

Changing your disk partitions to handle multiple operating systems can be very tricky. Part of the reason is that each different operating system has its own ideas about how partitioning information should be handled, as well as different tools for doing it. Here are some tips to help you get it right.

- If you are creating a dual-boot system that includes Windows, try to install the Windows operating system first. Otherwise, the Windows installation may make the Linux partitions inaccessible.
- The `fdisk` man page recommends that you use partitioning tools that come with an operating system to create partitions for that operating system. For example, the DOS `fdisk` knows how to create partitions that DOS will like, and the CentOS `fdisk` will happily make your Linux partitions. Once your hard disk is set up for dual boot, however, you should probably not go back to Windows-only partitioning tools. Use Linux `fdisk` or a product made for multiboot systems (such as Partition Magic).
- You can have up to 63 partitions on an IDE hard disk. A SCSI hard disk can have up to 15 partitions. You probably won't need nearly that many partitions.

If you are using CentOS as a desktop system, you probably don't need a lot of different partitions within your Linux system. There are, however, some very good reasons for having multiple partitions for Linux systems that are shared by a lot of users or are public Web Servers or File servers. Multiple partitions within CentOS offer these advantages:

- **Protection from Attacks** — Denial-of-service attacks sometimes take action that tries to fill up your hard disk. If public areas, such as `/var`, are on separate partitions, a successful attack can fill up a partition without shutting down the whole computer. Because `/var` is the default location for Web and FTP servers, and therefore might hold a lot of data, often entire hard disks are assigned to the `/var` file system alone.
- **Protection from Corrupted File Systems** — If you have only one file system (`/`), corruption of that file system can cause the whole CentOS system to be damaged. Corruption of a smaller partition can be easier to correct and can often allow the computer to stay in service while the corruption is fixed.

Here are some directories that you may want to consider making into separate file system partitions:

- **`/boot`** — Sometimes the BIOS in older PCs can access only the first 1,024 cylinders of your hard disk. To make sure that the information in your `/boot` directory is accessible to the BIOS, create a separate disk partition (of only about 100 MB) for `/boot` and make sure that it exists below cylinder 1,024. Then, the rest of your Linux system can exist outside of that 1,024-cylinder boundary if you like. Even with several boot images, there is rarely a reason for `/boot` to be larger than 100 MB. For newer hard disks, you can sometimes avoid this problem by selecting the “Linear Mode” checkbox during installation. Then the boot partition can be anywhere on the disk.
- **`/usr`** — This directory structure contains most of the applications and utilities available to CentOS or RHEL users. Having `/usr` on a separate partition lets you mount that file system as Read Only after the operating system has been installed. This prevents attackers from replacing or removing important system applications with their own versions that may cause security problems. A separate `/usr` partition is also useful if you have diskless workstations on your local network. Using NFS, you can share `/usr` over the network with those workstations.
- **`/var`** — Your FTP (`/var/ftp`) and Web Server (`/var/www`) directories are, by default, stored under `/var`. Having a separate `/var` partition can prevent an attack on those facilities from corrupting or filling up your entire hard disk.
- **`/home`** — Because your user account directories are located in this directory, having a separate `/home` account can prevent an indiscriminate user from filling up the entire hard disk. (Disk quotas represent another way of controlling disk use. See Chapter 9.) Also, some people have a separate `/home` partition so they can reinstall the operating system, erasing the root (`/`) partition, and simply remounting the `/home` partition.
- **`/tmp`** — Protecting `/tmp` from the rest of the hard disk by placing it on a separate partition can ensure that applications that need to write to temporary files in `/tmp` are able to complete their processing, even if the rest of the disk fills up.

Although people who use CentOS casually rarely see a need for lots of partitions, those who maintain and have to recover large systems are thankful when the system they need to fix has several partitions. Multiple partitions can localize deliberate damage (such as denial-of-service attacks), problems from errant users, and accidental file system corruption.

## Using the GRUB Boot Loader

A boot loader lets you choose when and how to boot the bootable operating systems installed on your computer's hard disks. GRUB is the only boot loader offered for you to configure during CentOS installation. The following sections describe the GRUB boot loader.

With multiple operating systems installed and several partitions set up, how does your computer know which operating system to start? To select and manage which partition is booted and how it is booted, you need a boot loader. The boot loader that is installed by default with CentOS is called the *Grand Unified Boot loader* (GRUB).

GRUB is a GNU software package ([www.gnu.org/software/grub](http://www.gnu.org/software/grub)) that replaced LILO as the only boot loader available in CentOS. GRUB offers the following features:

- Support for multiple executable formats
- Support for multiboot operating systems (such as CentOS, Red Hat Enterprise Linux, Fedora, FreeBSD, NetBSD, OpenBSD, and other UNIX-like systems)
- Support for non-multiboot operating systems (such as Windows 95, Windows 98, Windows NT, Windows ME, Windows XP, Windows Vista, and OS/2) via a chain-loading function. *Chain-loading* is the act of loading another boot loader (presumably one that is specific to the proprietary operating system) from GRUB to start the selected operating system.
- Support for multiple file system types
- Support for automatic decompression of boot images
- Support for downloading boot images from a network

For more on how GRUB works, type **man grub** or **info grub**. The `info` command contains more details about GRUB. Or, see the GRUB wiki: <http://grub.enbug.org>.

When you install CentOS, information needed to boot your computer (with one or more operating systems) is automatically set up and ready to go. Simply restart your computer. When you see the boot message, press the [Enter] key (quickly, before it times out) and the GRUB boot screen appears (it says *GRUB* at the top and lists bootable partitions below it). Then you can do one of the following:

- **Default** — If you do nothing, the default operating system will boot automatically after a few seconds.
- **Select an Operating System** — Use the up and down arrow keys to select any of the operating systems shown on the screen. Then press [Enter] to boot that operating system.

- **Edit the Boot Process** — If you want to change any of the options used during the boot process, use the arrow keys to select the operating system you want and type **e** to select it. Follow the next procedure to change your boot options temporarily.


If you want to change your boot options so that they take effect every time you boot your computer, see the section on permanently changing boot options. Changing those options involves editing the `/boot/grub/grub.conf` file.

## Temporarily Changing Boot Options

From the GRUB boot screen, you can select to change or add boot options for the current boot session. First, quickly before GRUB times out and boots the default system, press any key. From the GRUB selection screen that appears, select the operating system you want (using the arrow keys) and type **e** (as described earlier). You will see a graphical screen that contains information like that shown in Figure 2-3, but with your Linux kernel and options listed.

**FIGURE 2-3**

Edit the boot entry from your CentOS system from the GRUB menu.



```
GNU GRUB version 0.97 (G30R lower / 522176R upper memory)

root (hd0,0)
kernel /vmlinuz-2.6.18-92.el5 ro root=/dev/UrGroup00/LogUr0100 rhgb q
initrd /initrd-2.6.18-92.el5.img

Use the ↑ and ↓ keys to select which entry is highlighted.
Press 'b' to boot, 'c' to edit the selected command in the
boot sequence, 'c' for a command line, 'o' to open a new line
after ('O' for before) the selected line, 'd' to remove the
selected line, or escape to go back to the main menu.
```

CentOS 5

There are three lines in the example of the GRUB editing screen that identify the boot process for the operating system you chose. The first line (beginning with `root`) shows that the entry for the GRUB boot loader is on the first partition of the first hard disk (`hd0,0`). GRUB represents the hard disk as `hd`, regardless of whether it is an SCSI, IDE, or other type of disk. You just count the drive number and partition number, starting from zero.

The second line of the example (beginning with `kernel`) identifies the boot image (`/boot/vmlinuz-2.6.18-92.el5` in this example) and several options. The `rhgb` option produces the graphical boot screen, while the `quiet` option prevents details of the boot process from being shown. The options identify the partition as initially being loaded `ro` (Read Only) and the location of the root file system on the partition `/dev/VolGroup00/LogVol00`. The third line (starting with `initrd`) identifies the location of the initial RAM disk, which contains the minimum files and directories needed during the boot process.

If you are going to change any of the lines related to the boot process, you would probably change only the second line to add or remove boot options. Here is how you do that:

1. Position the cursor on the `kernel` line and type **e**.
2. Either add or remove options after the name of the boot image. You can use a minimal set of bash shell command-line editing features to edit the line. You can even use command completion (type part of a filename and press [Tab] to complete it). Here are a few options you may want to add or delete:
  - **Boot to a Shell** — If you forgot your root password or if your boot process hangs, you can boot directly to a shell by adding `init=/bin/sh` to the boot line. (The file system is mounted Read Only, so you can copy files out. You need to remount the file system with Read/Write permission to be able to change files.)
  - **Turn off a Service** — If your boot process is hanging on a particular service, you can often turn off that service from the boot prompt. For example, you could add the options `noacpi` (to turn off ACPI power management), `nopcmcia` (to turn off PCMCIA card slot support), or `nodma` (to turn off DMA, if you are getting disk errors). Add `selinux=0` to temporarily turn off SELinux. Sometimes turning off a service at the boot prompt allows you to fix the problem after the system is up and running.
  - **Select a Run Level** — If you want to boot to a particular run level, you can add the word `linux` followed by the number of the run level you want. For example, to have CentOS boot to run level 3 (multiuser plus networking mode), add **linux 3** to the end of the boot line. You can also boot to single-user mode (**1**), multiuser mode (**2**), or X GUI mode (**5**). Level 3 is a good choice if your GUI is temporarily broken.
3. Press [Enter] to return to the editing screen.
4. Type **b** to boot the computer with the new options. The next time you boot your computer, the new options will not be saved. To add options so they are saved permanently, see the next section.

## Permanently Changing Boot Options

You can change the options that take effect each time you boot your computer by changing the GRUB configuration file. In CentOS, GRUB configuration centers around the `/boot/grub/grub.conf` file.

The `/boot/grub/grub.conf` file is created when you install CentOS. Here is an example of a `grub.conf` file:

```
# grub.conf generated by anaconda
#
# Note that you do not have to rerun grub after making
# changes to this file
# NOTICE: You have a /boot partition. This means that
#         all kernel and initrd paths are relative to /boot/, eg.
#         root (hd0,0)
#         kernel /vmlinuz-version ro root=/dev/VolGroup00/LogVol100
#         initrd /initrd-version.img
#boot=/dev/sda
default=0
timeout=5
splashimage=(hd0,0)/grub/splash.xpm.gz
hiddenmenu
title CentOS (2.6.18-92.el5)
    root (hd0,0)
    kernel /vmlinuz-2.6.18-92.el5 ro root=/dev/VolGroup00/LogVol100
    rhgb quiet
    initrd /initrd-2.6.18-92.el5.img
title Windows Vista
    rootnoverify (hd1,0)
    chainloader +1
```

The `default=0` line indicates that the first partition in this list (in this case, CentOS) will be the one that is booted by default. The line `timeout=5` causes GRUB to pause for 5 seconds before booting the default partition. (Because of the `hiddenmenu` option, you won't even see the GRUB boot screen if you don't press [Enter] before 5 seconds.)

**NOTE** GRUB indicates disk partitions using the following notation: (hd0,0). The first number represents the disk, and the second is the partition on that disk. So, (hd0,1) is the second partition (1) on the first disk (0). That would equate to `/dev/sda2` in Linux.

The `splashimage` line looks in the second partition on the first disk (hd0,0) for the boot partition (in this case, `/dev/sda1`, which is the `/boot` partition). GRUB loads `splash.xpm.gz` as the image on the splash screen (`/boot/grub/splash.xpm.gz`). The splash screen appears as the background of the boot screen.

**NOTE** You can replace the splash screen with any image you like, provided that it meets certain specifications. Using GIMP or another image editor, save the image to 640 × 480 pixels, 14 colors, and xpm format. Next, use `gzip` to compress the file. Then copy that file to the `/boot/grub` directory. The last step is to edit the `grub.conf` file to have the `splashimage` value point to the new file.

The two bootable partitions in this example are CentOS and Windows Vista. The title lines for each of those partitions are followed by the name that appears on the boot screen to represent each partition.

For the CentOS system, the `root` line indicates the location of the boot partition as the second partition on the first disk. So, to find the bootable kernel and the `initrd` initial RAM disk



boot image that is loaded, GRUB looks in the root of `hd0,0` (which is represented by `/dev/sda1` and is eventually mounted as `/boot`). Other options on the `kernel` line set the partition as Read Only initially (`ro`) and set the root file system to `/dev/VolGroup00/LogVol00`.

For the Windows Vista partition, the `rootnoverify` line indicates that GRUB should not try to mount the partition. In this case, Windows Vista is on the first partition of the second hard disk (`hd1,0`) or `/dev/sdb1`. Instead of mounting the partition and passing options to the new operating system, the `chainloader +1` indicates to hand control the booting of the operating system to another boot loader. The `+1` indicates that the first sector of the partition is used as the boot loader.

**NOTE**

Microsoft operating systems require that you use the `chainloader` to boot them from GRUB.

If you make any changes to the `/boot/grub/grub.conf` file, you *do not* need to load those changes. Those changes are automatically picked up by GRUB when you reboot your computer. If you are accustomed to using the LILO boot loader, this may confuse you at first, as LILO requires you to rerun the `lilo` command for the changes to take effect.

## Adding a New GRUB Boot Image

You may have different boot images for kernels that include different features. These days, as you get updated kernels for CentOS, you simply load an RPM containing the new kernel and that new kernel is added to the `grub.conf` file as the default kernel to be booted. At boot time, you can choose which kernel you want to run.

If you build your own kernel, however, or get one to use from another source, you need to modify the `grub.conf` file yourself to tell CentOS to boot that kernel. Here is the procedure for modifying the `grub.conf` file:

1. Copy the new image from the directory in which it was created (such as `/usr/src/kernels/linux-2.6.18/arch/i386/boot`) to the `/boot` directory. Name the file something that reflects its contents, such as `bz-2.6.18`. For example:

```
# cp /usr/src/linux-2.6.18/arch/i386/boot/bzImage /boot/bz-2.6.18
```

2. Add several lines to the `/boot/grub/grub.conf` file so that the image can be started at boot time if it is selected. For example:

```
title CentOS (My own build)
    root (hd0,1)
    kernel /bz-2.6.18 ro root=/dev/sda2
    initrd /initrd-2.6.18.img
```

3. Reboot your computer.
4. Press [Enter] at the boot prompt. When the GRUB boot screen appears, move your cursor to the title representing the new kernel and press [Enter].

The advantage to this approach, as opposed to copying the new boot image over the old one, is that if the kernel fails to boot, you can always go back and restart the old kernel. When you feel confident that the new kernel is working properly, you can use it to replace the old kernel or perhaps just make the new kernel the default boot definition.

## Troubleshooting Installation

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Troubleshooting your CentOS installation can be split into three different areas:

- **Identify Corrective Steps for Installation Issues** — The first is to find out what to try if you have trouble installing CentOS.
- **Identify Corrective Steps for Boot Issues** — Next, there's what to do if CentOS installs, but fails to boot up.
- **Troubleshoot Hardware Issues** — The final area describes how to go forward if CentOS is basically working, but selected features or hardware components aren't working.

If you have trouble installing CentOS, insert your CentOS boot media and reboot your computer. If your computer bypasses the DVD completely and boots right from hard disk, you may need to change the BIOS (as described earlier in this chapter). If the drive keeps blinking but doesn't install, you may either have a bad DVD or you might have an older drive that can't use DMA (in the latter case, try adding `nodma` to the boot command line). If it hangs at some point during the install, it might be because the install is hanging on a bad or unrecognized hardware item. There are many boot options to try (see descriptions of boot options earlier in the chapter).

If you were able to boot CentOS, you can see how the installation went by checking different aspects of your system. There are three log files to look at once the system comes up:

- **`/root/upgrade.log`** — When upgrading packages, output from each installed package is sent to this file. You can see what packages were installed and if any failed.
- **`/var/log/dmesg`** — This file contains the messages that are sent to the console terminal as the system boots up, including messages relating to the kernel being started and hardware being recognized. If a piece of hardware isn't working, you can check here to make sure that the kernel found the hardware and configured it properly.
- **`/var/log/boot.log`** — This file contains information about each service that is started up at boot time. You can see if each service started successfully. If a service fails to start properly, there may be clues in this file that will help you learn what went wrong.

If something was set wrong (such as your mouse) or just isn't working quite right (such as your video display), you can always go back after CentOS is running and correct the problem. Here is a list of utilities you can use to reconfigure different features that were set during installation:

- **Changing or Adding a Mouse** — `mouse-test`
- **Changing a Keyboard Language** — `system-config-keyboard`

- **Adding or Deleting Software Packages** — `yum` or `rpm`
- **Partitioning** — `fdisk`
- **Boot Loader** — `/boot/grub/grub.conf`
- **Networking (Ethernet and TCP/IP)** — `system-config-network`
- **Time Zone** — `timeconfig` or `firstboot`
- **User Accounts** — `useradd` or `system-config-users`
- **X Window System** — `system-config-display`

Here are a few other random tips that can help you during installation:

- If installation fails because the installation procedure is unable to detect your video card, try restarting installation in text mode. After CentOS is installed and running, use the `system-config-display` command to configure your video card and monitor. (For some cards, such as those from NVIDIA, you need to get and install special drivers from the manufacturer's web site.)

**CAUTION**

Some video card drivers from NVIDIA and ATI will overwrite important Xorg driver files. If you later change to a different video card, features of the new card (such as DRI) might fail. The solution is to entirely remove the NVIDIA or ATI drivers and reinstall your `xorg` and `mesa` packages. Or, you can install the NVIDIA or ATI drivers from RPMForge since those do not overwrite these files.

- If installation completes successfully, but your screen is garbled when you reboot, you should try to get CentOS to boot to a text-login prompt. To do this, add the number **3** to the end of the kernel boot line in GRUB. Linux will start with the GUI temporarily disabled. Run `system-config-display` to try to fix the problem. (See Chapter 3 for other advice related to fixing your GUI.)
- If your mouse is not detected during installation, you can use arrow keys and the [Tab] key to make selections. Then use `mouse-test` to track down the problem.
- If installation improperly probes your hardware or turns on a feature that causes problems with your hardware, you might be able to solve the problem by disabling the offending feature at the install boot prompt. Try adding one or more of the following after the word `linux` at the installation boot prompt: **`ide=nodma`** (if your system hangs while downloading the image); **`apm=off`** or **`acpi=off`** (if you experience random failures during install); or **`nousb`**, **`nopcmcia`**, or **`nofirewire`** (if you suspect that install is hanging on devices of those types).
- If you are still having problems installing CentOS, try searching the `CentOS.org` forums to see if they have an answer. If you are having problems with a particular piece of hardware, try searching the Solutions Database, using the name of the hardware in the search box. If you are having problems with particular hardware, chances are someone else did, too.

## Summary

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Installing Linux has become as easy as installing any modern operating system. Pre-compiled binary software and pre-selected packaging and partitions make most CentOS installations a simple proposition. Improved installation and GUI Configuration windows have made it easier for computer users who are not programmers to enter the Linux arena.

Besides providing some step-by-step installation procedures, this chapter discussed some of the trickier aspects of CentOS installations. In particular, this chapter covered specialty installation procedures (such as dual-booting with Windows), ways of partitioning your hard disk, and how to change the boot procedure.



# Chapter 3

## Getting Started with the Desktop

The desktop is the most personal feature of your computer. The way that icons, menus, panels, and backgrounds are arranged and displayed should make it both easy and pleasant to do your work. With CentOS, you have an incredible amount of control over how your desktop behaves and how your desktop is arranged.

The basic desktop is provided by the X.Org X server. The X server provides the framework on which GNOME, KDE, and other desktop applications and Window Managers rely. If you have used the XFree86 X server in other Linux distributions, special features of the X.org server described later in this chapter might interest you. (See Chapter 1 for a description of the X Window System.)

This chapter takes you on a tour of your desktop — going through the process of logging in, trying out some features, and customizing how your desktop looks and behaves. Sections on GNOME, KDE, and Xfce desktops contain reference information on how to set preferences, run applications, configure panels, and work with the file managers. The last section describes how to use the Display Settings window to configure your video card and monitor, if they were not properly detected.

### Logging in to CentOS

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Because Linux was created as a multiuser computer system, you start by logging in (even if you are the only person using the computer). Logging in accomplishes three functions:

- It identifies you as a particular user.

### IN THIS CHAPTER

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Logging in to Linux

---

Getting started with the desktop

---

Choosing KDE, GNOME, or Xfce desktops

---

Using the GNOME desktop environment

---

Enabling 3D desktop effects with AIGLX

---

Switching desktop environments

---

Using the KDE desktop environment

---

Using the Xfce desktop environment

---

Getting your desktop to work

---

- It starts up your own shell and desktop configurations (icons, panels, backgrounds, etc.).
- It gives you appropriate permissions to change files and run programs.

After the computer has been turned on and the operating system has started, you see either a graphical login screen (default) or a text-based login prompt. The text-based prompt should look something like this:

```
CentOS release 5.2 (Final)
Kernel 2.6.18-92.1.22.el5 on an i686
```

```
localhost login:
```

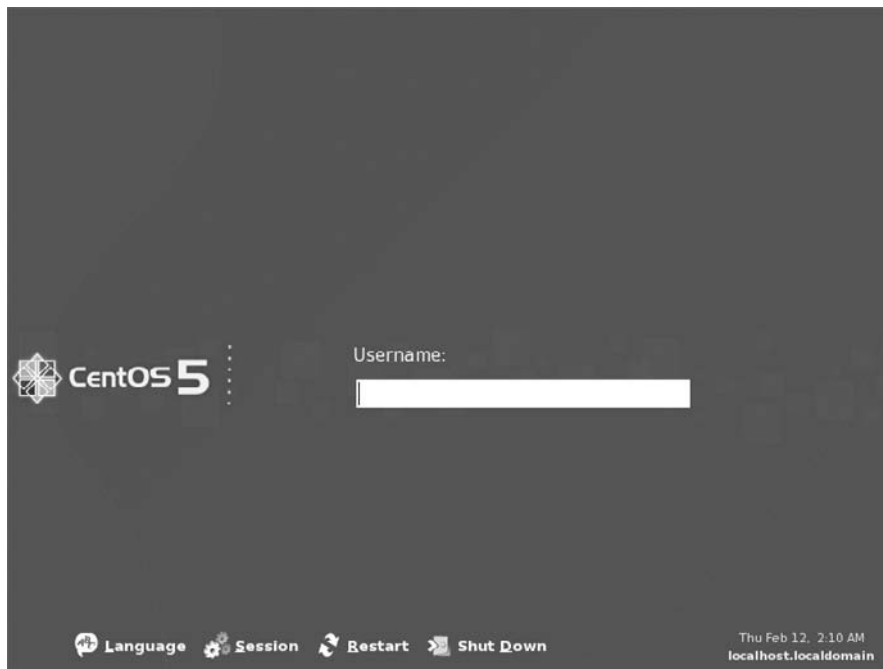
**NOTE**

If you see a text-based login prompt instead of the graphical login screen, and you want to use the GUI, type your username and password. Then when you see a command prompt, type **startx** to start up your desktop.

The graphical login is typically your entry into the graphical user interface (GUI). Figure 3-1 shows the graphical login screen.

**FIGURE 3-1**

A graphical login screen greets CentOS desktop users.



To log in, type your username and press [Enter], and then type your password and press [Enter]. You can log in as either a regular user or as the `root` user:

- **A Regular User** — As someone just using the Linux system, you probably have your own unique username and password. Often, that name is associated with your real name (such as `johnb`, `susanp`, or `djones`). If you are still not sure why you need a user login, see the sidebar “Why Do I Need a User Login?” You probably have at least one user account available that was added the first time you booted CentOS.
- **The `root` User** — Every Linux system has a `root` user assigned when Linux is installed. The `root` user (literally type the username **root**) can run programs, use files, and change the computer setup in any way. Because the `root` user has special powers and can therefore do special damage, you usually log in as a regular user, which allows access only to that user’s files and those that are open to everyone.

**CROSS-REF** See Chapter 9 for a description of the `root` user and Chapter 10 for information on how to set up and use other user accounts. Refer to Chapter 13 for suggestions on how to choose a good password. For information on instances where the `root` user doesn’t have complete control over the system, refer to the descriptions of SELinux (Security-Enhanced Linux) in Chapter 9.

If your desktop did not start, refer to the “Troubleshooting Your Desktop” section at the end of this chapter. Otherwise, continue on to the next section.

## Why Do I Need a User Login?

If you are working on a PC and you are the only one using your Linux computer, you may wonder why you need a user account and password. Unlike Windows, Linux (like its predecessor UNIX) was designed from the ground up to be a multiuser system. Here are several good reasons why you should use separate user accounts:

- Even as the only person using Linux, you want a username other than `root` for running applications and working with files so you don’t change critical system files by mistake during everyday computer use.
- If several people are using a Linux system, separate user accounts let you protect your files from being accessed or changed by others.
- Networking is probably the best reason for using a Linux system. If you are on a network, a unique username is useful in many ways. Your username can be associated with resources on other computers: file systems, application programs, and mailboxes, to name a few. Sometimes a `root` user is not allowed to share resources on remote Linux systems.

*continued*



*continued*

- Over time, you will probably change personal configuration information associated with your account. For example, you may add aliases, create your own utility programs, or set properties for the applications you use. By gathering this information in one place, it's easy to move your account or add a new account to another computer in the future.
- Keeping all your data files and settings under a home login directory (such as `/home/timothy`) makes it easier to back up the data and restore it later if needed.

## Getting Familiar with the Desktop

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The term *desktop* refers to the presentation of windows, menus, panels, icons, and other graphical elements on your computer screen. Originally, computer systems such as Linux operated purely in text mode — no mouse, no colors, just commands typed on the screen. Desktops provide a more intuitive way of using your computer.

As with most things in Linux, the desktop is built from a set of interchangeable building blocks. The building blocks of your desktop, to use a car analogy, are:

- The X Window System (which is like the frame of the car)
- The GNOME, KDE, or Xfce desktop environment (which is like a blueprint of how the working parts fit together)
- The Metacity Window Manager (which provides the steering wheel, seat upholstery, and fuzzy dice on the mirror)
- The desktop theme (the paint job and the pin stripe)

Once Linux is installed (see Chapter 2) and you have logged in (see the previous section), you should see the GNOME desktop. At this point, I'll take you on a tour of the desktop and step you through some initial setup to get your desktop going.

Figure 3-2 shows an example of the CentOS default desktop (GNOME).

Because GNOME is the default, I'll start by walking you around the GNOME desktop. The tour steps you through trying out your home folder, changing some preferences, and configuring your panel.

## Touring Your Desktop

If you are unfamiliar with the GNOME desktop that comes with CentOS, I suggest you take this quick tour to familiarize yourself with the desktop features. If you prefer to use the KDE desktop, refer to the KDE section later in this chapter for tips on using KDE.

**FIGURE 3-2**

After login, CentOS starts you off with a GNOME desktop by default.



### Step 1: Checking out Your Home Folder

Double-click on the *user's* Home icon on the desktop. (It should say something like “timothy’s Home” or “mike’s Home,” depending on your username.) The window that appears shows your File Manager window as it displays the contents of your home folder.

The location of the home folder (also referred to as the *home directory*) on your computer is usually `/home/user`, where *user* is replaced by your username. Here are some things to try out with your home folder:

- 1. Folders** — Create folders and subfolders to store your work (click **File** ➤ **Create Folder**, and then type the name of the new folder — something like **Images**, **Memos**, or **Projects**).
- 2. Open Location** — To open another folder on your computer, click **File** ➤ **Open Location** and type a directory name. For our tour, open a folder that has several different file types in it (e.g., `/usr/share/doc/bash-3.2/` contains some text, PostScript, and HTML files).

#### NOTE

To move down to a subfolder of the current folder, simply double-click on that folder, move up to a parent folder, and click on the current folder name in the bottom-left

corner of the window frame. From the menu that opens, you can select to go to any higher-level folder from there.

3. **Open With** — Click on any object in a folder with the right mouse button, and then select “Open With.” You should be able to see several programs you can use to open the object. For example, you can choose to open a web page (.html file) with Firefox or a text editor (depending on what is installed, you may see different options).
4. **Side Pane** — Right-click on any folder in the File Manager window, and then select “Browse Folder” to open the new folder with a side pane displayed. From the dropdown box at the top of the side pane, choose Information to show information about the selected folder or file. Next choose History to see files and folders previously viewed. Choose Tree to see a hierarchical representation of your file system. Select Places to see folders from removable media and your home folder. Using the button above the side pane, you can choose to have your location box be text-based or represented by buttons.
5. **Backgrounds** — Click Edit ► Backgrounds and Emblems. Drag-and-drop patterns or colors you like into the pane on your folder window. Click Emblems, and then drag-and-drop an emblem onto a file or folder. Use the emblem to remind yourself of something about the object (such as the fact that it’s a personal document or of an urgent nature).
6. **Organize Your Work** — As you create documents, add music, or download images from your camera, organize them into your home folder or any subfolders. Your home folder is not accessible to any other user on the computer except the `root` user, so you can safely store your work there. With the files you create, you can:
  - **Move** — Drag-and-drop to move a file to another folder icon or folder window.
  - **Delete** — Drag-and-drop a file to the Trash icon to delete it.
  - **Rename** — Right-click on the file, select Rename, and then type the new name.

As with any window, with the Folder window you can:

- **Minimize/Unminimize** — Click on the Minimize button (first button, upper-right corner of the title bar) to minimize the window to the window pane. Click on the minimized window in the desktop panel to return it to your desktop.
- **Maximize** — Click on the Maximize button (the second button in the upper-right corner of the title bar) to have the window go full screen.

**TIP**

The window shade feature, wherein a double-click in the title bar rolls up the window instead of maximizing or restoring it, is not on by default. To turn on that feature from the Desktop menu, click System ► Preferences ► Look and Feel ► Windows. From the pop-up window that appears, change “Maximize” to “Roll Up” (under “Double-click Title Bar to Perform This Action”).

- **Close** — Click on the X button (upper-right corner of the title bar) to close the window.

## Step 2: Change Some Preferences

More than 20 different preference categories are available from the GNOME desktop. Select the System menu, and then choose Preferences. From submenus on the Preferences menu, there are

a few preferences you might want to modify when you start out (see the GNOME and KDE preferences sections later in this chapter for further details):

- **Change Background** — Select System > Preferences > Desktop Background. The Desktop Background Preferences window appears, as shown in Figure 3-3. To change the background image, select one of the Desktop Wallpaper images shown. To add your own image, click on the “Add Wallpaper” button (to choose a file from your disk) or drag-and-drop an image onto the Location box. Select a Style, such as Centered, Fill Screen, Tiled, Zoom, or Scaled. To use just a color, select “No Wallpaper” in the “Desktop Wallpaper” box and choose a color under the Desktop Colors selector. You can choose a solid color or a vertical or horizontal gradient.

**FIGURE 3-3**

Select a color or picture for your desktop background.



- **Choose Browsers and Other Apps** — Select System > Preferences > Preferred Applications. When you open a web page, mail composer, or shell from the desktop, this Preferences window lets you choose which Web browser, mail reader, media player, or Terminal window to open by default. Firefox is the default Web browser, but you can choose Epiphany or Konqueror (the KDE browser) to run on your GUI. If you want a text-based Web browser, select W3M or Links. To use a different Web browser, select Custom and type the command line for the browser you want to use into the Command box.

Available Mail Readers include Evolution (the default), Thunderbird, KMail, and Mutt. On the System tab, GNOME Terminal is assigned as the default when you need a shell prompt. To add a different default terminal, select “Custom Terminal” and enter the command that starts the Terminal you want. You can also choose default multimedia players and accessibility applications.

**TIP**

The `konsole` command starts the Konsole (KDE) Terminal window. Programmers who use many Terminal windows at once often prefer Konsole over `gnome-terminal` (finding it to be more efficient and feature-rich). Monitoring a session for silence or activity when compiling long programs or waiting for a process to finish are examples of Konsole features that are useful to programmers.

- **Add a Screensaver** — Select System > Preferences > Screensaver. Try out a few screensavers. Click on different screensavers to see them, and click Preview to try them out. If you see only a few screensaver options, install the `xscreensaver-gli-extras-gss` package to install many more screensavers.

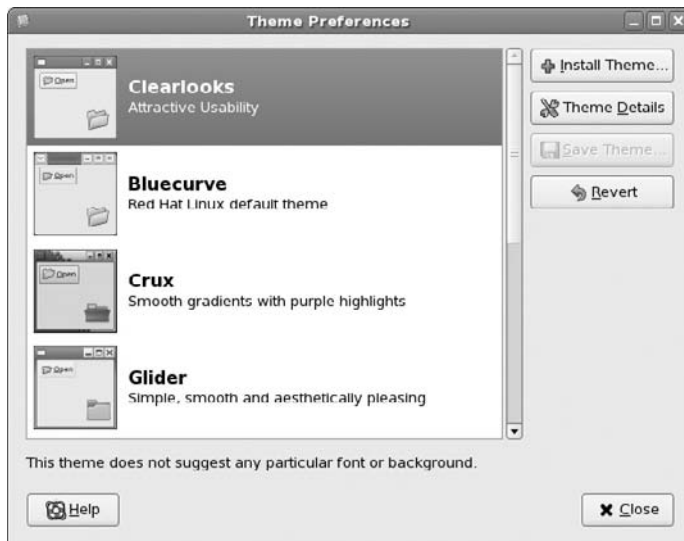
**TIP**

Click on the “Lock Screen When Screensaver is Active” checkbox and set the number of minutes after which the screensaver comes on and locks. This is a good option for an office environment, where you want your screen locked if you wander away for a few minutes. If you logged into a virtual terminal (e.g., you pressed `[Ctrl]+[Alt]+[F2]`, then logged in, then returned to the desktop with `[Ctrl]+[Alt]+[F7]`, be sure to log off the virtual terminal as well before leaving your desk.

- **Change the Theme** — Select System > Preferences > Themes. You can change the entire theme (colors, icons, borders, etc.) for your desktop. The default theme is called *Clearlooks*. Try any of the others to find one that suits you. Click “Theme Details” to mix and match attributes from different themes. Figure 3-4 shows the window for selecting a theme.

**FIGURE 3-4**

Change the default CentOS theme.



### Step 3: Configure Your Panels

Most people manage their desktops from panels that appear at the top and bottom of the screen. These panels provide an intuitive way to:

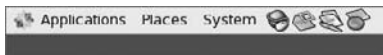
- Launch applications.
- Change workspaces.
- Add useful information (clocks, news tickers, CD players, etc.).

Step through the following procedure to learn about the GNOME desktop panels:

1. **Applications Menu** — Click Applications in the top panel. Most useful GUI applications and system tools that come with CentOS are available from the menus and submenus of this Applications menu.
  - **Start an Application** — Click Accessories, Education, Games, Graphics, Internet, Office, or Sound & Video menu items (assuming applications for those categories are installed), and then select any application to run.
  - **Try System Tools** — Select “System Tools” from the Applications menu. The submenu that appears contains some tools for managing certain applications.
2. **System Menu** — Click System in the top panel. Here are several actions you can do from that menu:
  - **Change Your Settings** — Click on the Preferences menu item to change preferences or the Administration menu item to change system-wide settings.
  - **Do Administrative Tasks** — Click Administration to select from a menu of administrative tasks, to do such things as configure your network, firewall, printers, sound cards, or system services. You need the `root` password to do most of these tasks.
  - **Log Out or Shut Down** — Click on the Log Out menu item to log out from your current desktop session. Click “Shut Down” to shut down, restart, or hibernate (for laptop computers) your computer.
3. **Places Menu** — Click Places in the top panel. From the menu that appears, you can open your Home Folder. You can also select “Connect to Server,” to connect to network servers using SSH (remote login), FTP (file transfer), Windows share (file and printer sharing), and WebDAV (HTTP file sharing). Select Search to search your computer for selected files.
4. **Select Desktop Applications** — CentOS includes icons for popular desktop applications right on the panel. Figure 3-5 shows default icons to launch a Web browser (Firefox), an e-mail reader (Evolution Email), a word processor (OpenOffice.org Writer), and spreadsheet application (OpenOffice.org Calc), respectively.

**FIGURE 3-5**

Launch popular desktop applications with one click.



5. **Use Workspaces** — Click on different panels in the Workspace Switcher (bottom panel, right side). Open an application, and then click on another workspace panel. Workspaces are a great way to have multiple windows and still keep your desktop uncluttered. Notice that there are tiny representations of each window you open on the workspace panel it is in. Drag-and-drop the tiny windows among the Workspace Switcher boxes to move applications to different workspaces, without leaving your workspace.
6. **Add Cool Stuff to Your Panel** — Right-click on an empty place in a panel so that a panel menu appears. It should say “Add to Panel” at the top. Because real estate is limited on your panel, I recommend adding a drawer, to which you can add some little applications that run in the panel and icons that launch other applications. To begin, click “Add to Panel,” and then from the window that appears, select Drawer. A Drawer icon appears on your panel (you can drag it where you want it to go). Click to open the drawer, and then right-click on the open drawer and click “Add to Drawer.” Here are a few things I suggest adding to a drawer on your panel:
  - **Terminal** — From the drawer menu, click Add to Drawer ➤ Application Launcher, and then click Forward. Next, select the down arrow next to System Tools, choose Terminal, and click Add. Now, when I ask you to type something into a Terminal window, you can launch one from the terminal icon that appears in this drawer.

**NOTE**

Throughout this book, I give examples that require you to use a Terminal window. Neither the new KDE nor GNOME desktops have a Terminal window launcher on the panel or desktop. I strongly suggest that you add a Terminal window to your desktop or panel in order to launch it easily. The alternative is to select Applications ➤ Accessories ➤ Terminal to open a Terminal window.

- **Weather Report** — From the Drawer menu, click Add to Drawer ➤ Weather Report. Right-click on the temperature icon that appears and choose Preferences. Click on the Location tab and select your country, state, and city from the list. Now, whenever you double-click on the temperature icon in your drawer, you can see weather conditions and a forecast for your city.
- **Popular Folder or Web Site** — Folders or web sites that you visit often should be easily accessible. Click Add to Drawer ➤ Custom Application Launcher and select Add. From the Create Launcher window, select Application as the Type and then type **nautilus folder** (where *folder* is replaced by the name of the folder you want to open) or **firefox url** (where *url* is replaced by the address of the desired web site). Click Icon and choose an icon to represent the item.

Figure 3-6 shows an example of a drawer, with the launchers I just described added to it.

You can do much more with the desktop and the panel. To learn more about configuring your desktop, check out the specific descriptions of the GNOME and KDE desktops later in this chapter.

**FIGURE 3-6**

A drawer is a great way to contain personal utilities and launchers.



## Tips for Configuring Your Desktop

Now that you have experimented with a few items on the desktop, you should configure certain features to get CentOS really working well for you. Most of the tips I describe here will help you get CentOS working well on the network.

### NOTE

Some of the tips described here should be carried out by the system administrator. They apply to you if you are the system administrator for your organization or if you are configuring your own home or office network.

- **Getting Updates** — If updates to any of the packages installed on your system are available, an icon and message box will appear in the upper-right corner of your panel. You can select to see the available updates, and then download and install them if you like. Or simply select **System** > **Administration** > **Update System** to use the Update System window to get software package updates.

### CROSS-REF

Refer to Chapter 5 for more information on using the `yum` utility to get updates.

- **Set up Your Network** — You may have configured your network interfaces (dial-up or LAN) during installation. If not, refer to Chapter 14 for setting up a LAN and Chapter 15 for setting up an Internet connection.
- **Configure E-Mail** — You must identify information about your e-mail account in order to use e-mail. Click on the Evolution Email icon in the panel to start the process of configuring e-mail. Refer to Chapter 8 for information on setting up and using e-mail.
- **Configure the Web Browser** — Open the Firefox Web browser from the panel. Although it should work fine at browsing the Internet once you have a network connection set up, there are a few things you should do to tune your browser. For example, you should choose a home page (click **Edit** > **Preferences**, and then type a home page location to use the current page or a bookmarked page). If you have bookmarks from another computer, you can export those bookmarks, copy the file to this computer, and import



those bookmarks here (click Bookmarks ➤ Organize Bookmarks, and then select Import and Backup ➤ Import from the Bookmark Manager window).

**NOTE**

If you are coming from a Windows environment, you may find that some Web content doesn't work by default in Firefox. Refer to Chapter 8 for suggestions on ways to enhance Firefox to change the appearance of some web pages and improve the ability to play certain multimedia content.

## Using the GNOME Desktop

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GNOME (pronounced *guh-nome*) provides the desktop environment that you get by default when you install CentOS. This desktop environment provides the software that is between your X Window System framework and the look-and-feel provided by the Window Manager. GNOME is a stable and reliable desktop environment, with a few cool features in it.

The GNOME 2.16 desktop comes with the most recent version of CentOS. If you have used an earlier version of GNOME, here are some additions you will find as you use existing GNOME features:

- **Improved Nautilus File Manager** — Nautilus File Manager provides new protocols and features for accessing local and remote file systems. Use the `cdda://cdrom` protocol to view track information from an audio CD or `gphoto2://` to access connected digital cameras. New information bars are displayed to let you select applications to handle the content displayed in the File Manager (such as a music player or image viewer).
- **Multiple Time Locations** — Using the GNOME Clock applet, you can select multiple locations around the world so that when you open your calendar you see the local time and weather for those locations.
- **Google Calendars** — You can add Google calendars to your Evolution calendars.
- **Keyboard Preferences Simplified** — Settings from keyboard layout and accessibility windows have been merged into a single Keyboard Preferences dialog.
- **Accessibility Improvements** — Several accessibility improvements make it easier for people with disabilities to use GNOME. The Orca screenreader includes improved accessibility with Firefox and web applications. There's support for level 2 contracted braille.

To use your GNOME desktop, you should become familiar with the following components:

- **Metacity (Window Manager)** — The default Window Manager for GNOME in CentOS is Metacity. The Window Manager provides such things as themes, window borders, and window controls. If you enable 3D acceleration, you will automatically be switched to the Compiz Window Manager (if your hardware can support AIGLX).
- **Nautilus (File Manager/Graphical Shell)** — When you open a folder (e.g., by double-clicking on the Home icon on your desktop), the Nautilus window opens and displays the contents of the selected folder. Nautilus can also display other types of content, such as shared folders from Windows computers on the network (using SMB).

- **GNOME Panels (Application/Task Launcher)** — These panels, which line the top and bottom of your screen, are designed to make it convenient for you to launch the applications you use, manage running applications, and work with multiple virtual desktops. By default, the top panel contains menu buttons (Applications, Places, and System), desktop application launchers (Firefox and Evolution Email), Tomboy sticky notes, Network-Manager applet, a clock, and a volume control icon. Other applets you could add include Mugshot, battery monitors, and various launchers.

Using the Fast User Switch applet, you can switch between different desktop users without shutting down the current desktop. The bottom panel has a “Hide Desktop” icon, a tray of active applications, a Workspace Switcher (for managing four virtual desktops), and a Trash Can icon (to drop files for deletion or view deleted files).

- **Desktop Area** — The windows and icons you use are arranged on the desktop area. The desktop area supports such things as drag-and-drop actions between applications, a desktop menu (right-click to see it), and icons for launching applications.

Besides the components just described, GNOME includes a set of Preferences windows (select System ► Preferences) that let you configure different aspects of your desktop. You can change backgrounds, colors, fonts, keyboard shortcuts, and other features relating to the look and behavior of the desktop.

## Using the Metacity Window Manager

The Metacity Window Manager seems to have been chosen as the default window manager for GNOME because of its simplicity. The creator of Metacity refers to it as a “boring window manager for the adult in you” — then goes on to compare other window managers to colorful, sugary cereal while Metacity is characterized as Cheerios.

There really isn’t much you can do with Metacity (except get your work done efficiently). Assigning new themes to Metacity and changing colors and window decorations is done through the GNOME preferences (and is described later). A few Metacity themes exist, but expect the number to grow. Signs that Metacity is willing to inch toward more sparkle for the desktop is its support for GLX extensions that allow three-dimensional (3D) screen effects (see the section “Running 3D Accelerated Desktop Effects” later in this chapter).

Basic Metacity functions that might interest you are keyboard shortcuts and the Workspace Switcher. Table 3-1 shows keyboard shortcuts to get around the Metacity Window Manager.

Another Metacity feature that may interest you is the Workspace Switcher. Four virtual workspaces appear in the Workspace Switcher on the GNOME panel. Here are some things to do with the Workspace Switcher:

- **Choose Current Workspace** — Four virtual workspaces appear in the Workspace Switcher. Click on any of the four virtual workspaces to make it your current workspace.

TABLE 3-1

## Metacity Keyboard Shortcuts

Actions	Keystrokes
<b>Window focus</b>	
Cycle forward, with pop-up icons	[Alt]+[Tab]
Cycle backward, with pop-up icons	[Alt]+[Shift]+[Tab]
Cycle forward, without pop-up icons	[Alt]+[Esc]
Cycle backward, without pop-up icons	[Alt]+[Shift]+[Esc]
<b>Panel focus</b>	
Cycle forward among panels	[Alt]+[Ctrl]+[Tab]
Cycle backward among panels	[Alt]+[Ctrl]+[Shift]+[Tab]
<b>Workspace focus</b>	
Move to workspace to the right	[Ctrl]+[Alt]+right arrow
Move to workspace to the left	[Ctrl]+[Alt]+left arrow
Move to upper workspace	[Ctrl]+[Alt]+up arrow
Move to lower workspace	[Ctrl]+[Alt]+down arrow
Minimize/unminimize all windows	[Ctrl]+[Alt]+D
Show window menu	[Alt]+spacebar
Close menu	[Esc]

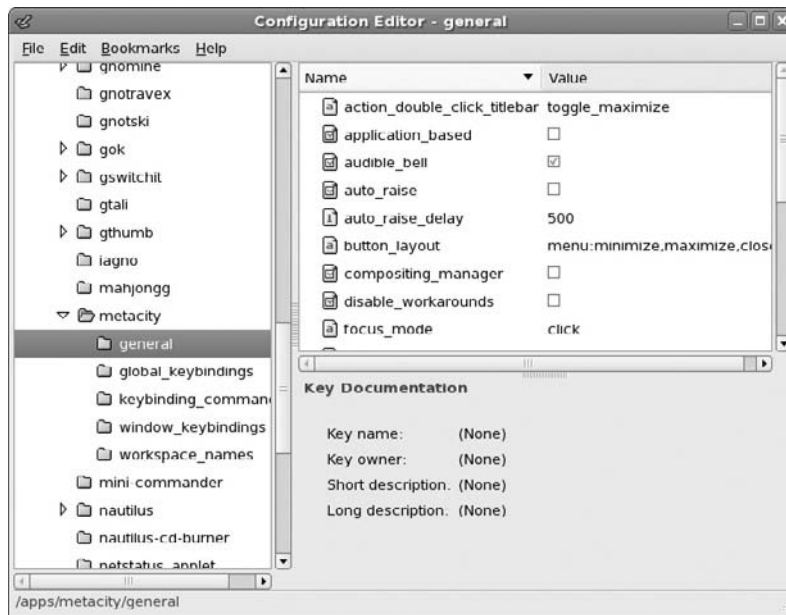
- **Move Windows to Other Workspaces** — Click on any window, each represented by a tiny rectangle in the Workspace Switcher, to drag-and-drop it to another workspace. Likewise, you can drag an application from the Window List to move that application to another workspace.
- **Add More Workspaces** — Right-click on the Workspace Switcher and select Preferences. You can add workspaces (up to 32).
- **Name Workspaces** — Right-click on the Workspace Switcher and select Preferences. Click in the Workspaces pane to change names of workspaces to any names you choose.

You can view and change information about Metacity controls and settings using the `gconf-editor` window (as `root`, type **`yum install gconf-editor`**, then **`gconf-editor`** as a regular user from a Terminal window). As the window says, it is not the recommended way of changing preferences. So, when possible, you should change the desktop through GNOME preferences. However, `gconf-editor` is a good way to see descriptions of each Metacity feature.

From the `gconf-editor` window, select `apps > metacity`. Then choose from `general`, `global_keybindings`, `keybindings_commands`, `window_keybindings`, and `workspace_names`. Click on each key to see its value, along with short and long descriptions of the key. (Type `yum install gconf-editor` if it's not yet installed on your system.) `gconf-editor` is shown in Figure 3-7.

**FIGURE 3-7**

`gconf-editor` allows you to edit settings and preferences for a multitude of installed applications.



## Using the GNOME Panels

CentOS includes panels on the top and bottom of the GNOME desktop. From those panels, you can start applications (from buttons or menus), see what programs are active, manage network interfaces, monitor power issues, adjust your audio volume, and switch workspaces. There are also many ways to change the top or bottom panel — by adding applications or monitors, or by changing the placement or behavior of the panel, for example.

Click on any open space on either panel to see the Panel menu. The Panel menu appears, as shown in Figure 3-8.

From the GNOME Panel menu, you can perform a variety of functions, including:

- **Use the Applications Menu** — Displayed on the Applications menu are most of the applications and system tools you will use from the desktop.

**FIGURE 3-8**

Right-click on any open spot on the GNOME panel to see the Panel menu.



- **Add to Panel** — You can add an applet, menu, launcher, drawer, or button.
- **Properties** — Change position, size, and background of the panel.
- **Delete This Panel** — You can delete the current panel.
- **New Panel** — You can add panels to your desktop in different styles and locations.

You can also work with items on a panel; for example, you can:

- **Move Items** — To move items on a panel, simply drag-and-drop them to a new position.
- **Set Preferences or Properties** — Right-click on an icon on the panel and select Preferences or Properties, depending on which is available. From the pop-up that appears, you can usually set properties of what is launched when the application is selected.

The following sections describe some things you can do with the GNOME panel.

## Use the Applications and System Menus

Click Applications on the panel and you see categories of applications, programming tools, and system tools that you can select. Click on the application you want to launch.

To add a menu or launch item to the panel, right-click on the Applications menu and select “Edit Menus.” The left column shows available menus and the center column shows items on those menus. Here are some ways you can change those menus:

- **Add/Remove Applications** — Click on checkboxes next to application items to add (check) or remove those items from the Applications menus.
- **Move Applications** — Select an application, and then click “Move up” or “Move down” to change its position on a menu.
- **New Menu** — Select “New Menu” to add a submenu to an existing menu.
- **New Separator** — Select the “New Separator” button to add a separator between menu entries.
- **New Item** — Select “New Item” to add an application launcher.

If you are adding a new application, after you select “New Item,” a Create Launcher pop-up window appears. Here is what you need to add to that window:

- **Type** — Select either Application or “Application in Terminal.” Select Application for any X-based application, and select “Application in Terminal” if the application is a command that expects to run in a shell.
- **Name** — A name to appear on the menu
- **Command** — The command that is executed when you select the menu item. You can browse for it.
- **Comment** — A comment for when you hover over the menu item with your mouse
- **Icon** — Select the “No Icon” button to display a list of icons from the /usr/share/pixmaps directory that you can use on the menu. Select Browse to find an icon from a different directory.

After you click OK, the new item will immediately appear on the menu (no need to restart anything).

### Adding an Applet

There are dozens of small GNOME applications called *applets* that you can run directly on the GNOME panel. These applets can show information you may want to see on an ongoing basis or may just provide some amusement. To see what applets are available and to add applets that you want to your panel, perform the following steps:

1. Right-click on an open space in the panel so that the Panel menu appears.
2. Select “Add to Panel.” An Add to Panel window appears.
3. Select from among several dozen applets, including a clock, dictionary lookup, stock ticker, weather report, lock screen, log out, run application, take screenshot, Wanda the Fortune-Telling Fish, eyes that follow your mouse, e-mail Inbox monitor, modem lights monitor, and many others. The applet appears on the panel, ready for you to use.

Figure 3-9 shows, from left to right, Wanda the Fish, Network Monitor, Weather Report, and System Monitor.

**FIGURE 3-9**

Applets let you monitor activities, check the weather, and many other important tasks.



After an applet is installed, right-click on it to see what options are available. For example, select Preferences for the Stock Ticker, and you can add or delete stocks whose prices you want to monitor. If you don't like the applet's location, right-click on it, click Move, slide the mouse until the applet is where you want it (even to another panel), and click to set its location.

A lot of interesting applets have been added recently that you can try out. Here are some examples of available applets and the packages you need to install to have them available:

- **Deskbar** (`deskbar-applet`) — A versatile search interface that lets you type words to search for programs and files on your local system, as well as launch a browser or e-mail when you type a URL or e-mail address. From the Deskbar Preferences, you can add many other neat search types as well, such as Bugzilla entries and dictionary terms.
- **CPU Temperature** (`gai-temp`) — Watch the temperature of your CPU or hard disk from your panel in Fahrenheit or Celsius degrees. Colors change from green to orange to red if temperature rises above normal limits.
- **Moon Data** (`glunarclock`) — Monitor the phases of the moon on your panel from this applet. Double-click on the applet to see more data on moon coordinates, moonrise, and moonset.
- **Network Traffic** (`gnome-applet-netspeed`) — Display the amount of traffic traveling across your network interfaces (both incoming and outgoing).

Keep in mind that applets can be a drain on system resources. If you no longer want an applet to appear on the panel, right-click on it, and then click “Remove From Panel.” The icon representing the applet will disappear. If you find that you have run out of room on your panel, you can add a new panel to another part of the screen, as described in the next section.

### Adding Another Panel

You can have several panels on your GNOME desktop. You can add panels that run along the sides of the screen to go with the ones that already go along the top and bottom. To add a panel, do the following:

1. Right-click on an open space in the panel so that the Panel menu appears.
2. Select “New Panel.” A new panel appears at the right side of the screen.
3. Right-click on an open space in the new panel and select Properties.
4. From the Panel Properties, select where you want the panel from the Orientation box (Top, Bottom, Left, or Right).

After you’ve added a panel, you can add applets or application launchers to it as you did to the default panel. To remove a panel, right-click on it and select “Delete This Panel.”

### Adding an Application Launcher

Icons on your panel represent a Web browser and several office productivity applications. You can add your own icons to launch applications from the panel as well. To add a new application launcher to the panel, do the following:

1. Right-click in an open space on the panel.
2. Select Add to Panel ➤ Application Launcher ➤ Forward from the menu. All application categories from your Applications menu appear.

3. Select the arrow next to the category of application you want, select the application, and select Add. (As an alternative, you can simply drag-and-drop the applet item onto the panel.) An icon representing the application appears.

To launch the application you just added, single-click on it.

If the application you want to launch is not on your Applications menu, you can build one yourself as follows:

1. Right-click in an open space on the panel.
2. Select Add to Panel ➤ Custom Application Launcher ➤ Add. The Create Launcher window appears.
3. Provide the following information for the application that you want to add:
  - **Type** — Select Application (to launch an application) or “Application in Terminal” (to launch an application within a Terminal window). Another selection is Link, to open a web address in a browser.
  - **Name** — A name to identify the application. (This appears in the tool tip when your mouse is over the icon.)
  - **Command** — The command line that is run when the application is launched. You should use the full path name plus any required options.
  - **Comment** — A comment describing the application. As with Name, this information appears when you later move your mouse over the launcher.
4. Click on the Icon box (it might say “No Icon”). Select one of the icons shown and click OK. Alternatively, you can browse the file system to choose an icon.

**NOTE**

Icons available to represent your application are contained in the `/usr/share/pixmaps` directory. These icons are either in `png` or `xpm` formats. If there isn't an icon in the directory you want to use, create your own and assign it to the application.

5. Click OK.

The application should now appear in the panel. Click on it to start the application.

## Adding a Drawer

By adding a drawer to your GNOME panel, you can add several applets and launchers and have them take up only one slot on your panel. You can use the drawer to show the applets and launchers as though they were being pulled out of a Drawer icon on the panel.

To add a drawer to your panel, right-click on the panel and then select Add to Panel ➤ Drawer. The drawer should appear on the panel. The drawer behaves just like a panel. Right-click on the drawer area, and add applets or launchers to it as you would to a panel. Click the Drawer icon to retract the drawer.



## Changing Panel Properties

Properties you can change that relate to a panel are limited to the orientation, size, hiding policy, and background. To open the Panel Properties window that applies to a specific panel, right-click on an open space on the panel, and then choose Properties. The Panel Properties window that appears includes the following values:

- **Orientation** — You can move the panel to different locations on the screen by clicking on a new position.
- **Size** — You can select the size of your panel by choosing its height in pixels (24 pixels by default).
- **Expand** — Click this checkbox to have the panel expand to fill the entire side or unselect the checkbox to make the panel only as wide as the applets it contains.
- **Autohide** — You can select whether or not a panel is automatically hidden (appearing only when the mouse pointer is in the area).
- **Show Hide Buttons** — You can choose whether or not the Hide/Unhide buttons (with pixmap arrows on them) appear on the edges of the panel.
- **Arrows on Hide Buttons** — If you select “Show hide buttons,” you can select to either have arrows on those buttons or not.
- **Background** — From the Background tab, you can assign a color to the background of the panel, assign a background image, assign a Style (using a slider to go from Transparent to Opaque), or just leave it as None (which causes the panel to get its background from the current system theme). Click on the “Background Image” radio button if you want to select an image for the background, and then select an image, such as a tile from `/usr/share/backgrounds/tiles` or other directory.

**TIP**

I usually turn on the AutoHide feature and turn off the Hide buttons. Using AutoHide gives you more space to work with on your desktop. When you move your mouse to the edge where the panel is, it pops up — so you don't need Hide buttons.

## Using the Nautilus File Manager

At one time, File Managers did little more than let you run applications, create data files, and open folders. These days, File Managers are expected to also offer different browsing choices, preview file content, select different applications to use on data files, and access files on other computers. The Nautilus File Manager, which is the default GNOME File Manager, is an example of just such a File Manager.

When you open the Nautilus File Manager window (from a GNOME menu or by opening the Home icon or other folder on your desktop), you see the name of the location you are viewing (such as the folder name) and what that location contains (files, folders, and applications). Figure 3-10 is an example of the File Manager window displaying the contents of `/usr/share/doc/bash-3.2/`.

**FIGURE 3-10**

Move around the file system, open directories, and launch applications.



The default Nautilus window has been greatly simplified in recent releases to show fewer controls and provide more space for file and directory icons. Double-click on a folder to open that folder in a new window. Select your folder name in the lower-left corner of the window to see the file system hierarchy above the current folder (as shown in Figure 3-10). Whatever size, location, and other setting you had for the folder the last time you opened it, GNOME will remember and return it to that state the next time you open it.

To see more controls, right-click on a folder and select “Browse Folder” to open it. Or select Applications ➤ System Tools ➤ File Browser to open Nautilus in Browser mode directly.

Icons on the toolbar of the Nautilus window let you move forward and back among the directories and web sites you visit. To move up the directory structure, click on the up arrow. To refresh the view of the folder or web page, click on the Reload button. The Home button takes you to your home page, and the Computer button lets you see the same type of information you would see from a “My Computer” icon on a Windows system (CD drive, floppy drive, hard disk file systems, and network folders).

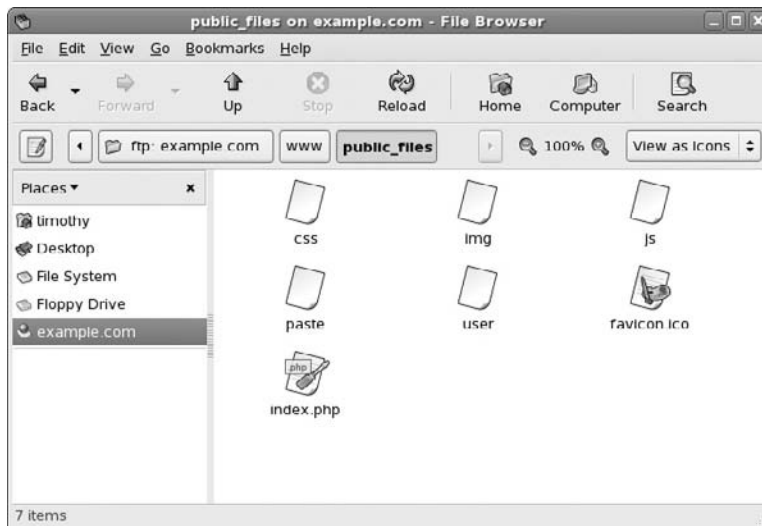
Icons in Nautilus often indicate the type of data that a particular file contains. The contents or file extension of each file can determine which application is used to work with the file. Or, you can right-click on an icon to open the file it represents with a particular application or viewer.

Some of the more interesting features of Nautilus are described here:

- **Sidebar** — From the Browse Folder view described previously, click on View ➤ Side Pane to have a sidebar appear in the left column of the screen. From the sidebar, you can click on tabs that represent different types of information you can select.
  - **Tree** — The Tree tab shows a tree view of the directory structure, so you can easily traverse your directories.
  - **Notes** — The Notes tab lets you add notes that become associated with the current directory or web page.
  - **History** — The History tab displays a history of directories and web sites you have visited, allowing you to click on those items to return to the sites they represent.Right-click in the sidebar to choose which of the sidebar tabs are displayed.
- **Windows File and Printer Sharing** — If your computer is connected to a LAN on which Windows computers are sharing files and printers, you can view those resources from Nautilus. Click File ➤ Connect to Server from a Nautilus window, and then choose the type of remote connection and provide the correct information. Figure 3-11 shows Nautilus displaying files on a remote FTP server.

**FIGURE 3-11**

Display remote files in Nautilus.



- **MIME Types and File Types** — To handle different types of content that may be encountered in the Nautilus window, you can set applications to respond based on MIME type and file type. With a folder being displayed, right-click on a file for which you want

to assign an application. Click “Open With Other Application.” If no application has been assigned for the file type, click “Associate Application” to be able to select an application. From the Add File Types window, you can add an application based on the file extension and MIME type representing the file.

**CROSS-REF** For more information on MIME types, see the description of MIME types in the “Changing GNOME Preferences” section later in this chapter.

- **Drag-and-Drop** — You can drag-and-drop files and folders within the Nautilus window, between the Nautilus and the desktop, or between multiple Nautilus windows. Many GNOME-compliant applications also support the GNOME drag-and-drop feature. So, for example, you could drag an image file from Nautilus and drop it on a gThumb image viewer to work with that image.

If you need more information on the Nautilus File Manager, visit the GNOME web site ([www.gnome.org/nautilus](http://www.gnome.org/nautilus)).

## Changing GNOME Preferences

There are many ways to change the behavior, look, and feel of your GNOME desktop. Most GNOME preferences can be modified from windows that you can launch from the System menu (click Preferences to see features to change).

The following items highlight some of the preferences you might want to change:

- **Accessibility** — If you have difficulty operating a mouse or keyboard, the Keyboard Preferences window lets you adapt mouse and keyboard settings to make those devices more accessible. From the System menu, select Preferences > Accessibility > Assistive Technology Preferences. Select “Enable assistance technologies” and then select the preferred applications to improve accessibility of your GNOME desktop. Figure 3-12 shows the Assistive Technology Preferences window.
- **Desktop Background** — Choose System > Preferences > Desktop Background. From the Desktop Background Preferences window, you can choose a solid color or an image to use as wallpaper. If you choose to use a solid color by selecting the blank wallpaper in the Desktop Wallpaper box, choose a color from the palette under the Desktop Colors section. To use wallpaper for your background, open a folder containing the image you want to use. Then drag the image into the Desktop Wallpaper box. You can choose from a variety of images in the `/usr/share/nautilus/patterns` and `/usr/share/backgrounds/tiles` directories. Then, choose to have the image as wallpaper that is tiled (repeated pattern), centered, scaled (in proportion), or stretched (using any proportion to fill the screen).
- **Screensaver** — Choose System > Preferences > Screensaver. You can choose from dozens of screensavers from the Screensaver Preferences window. Select “Random Screensaver” to have your screensaver chosen randomly each time it is activated, or select

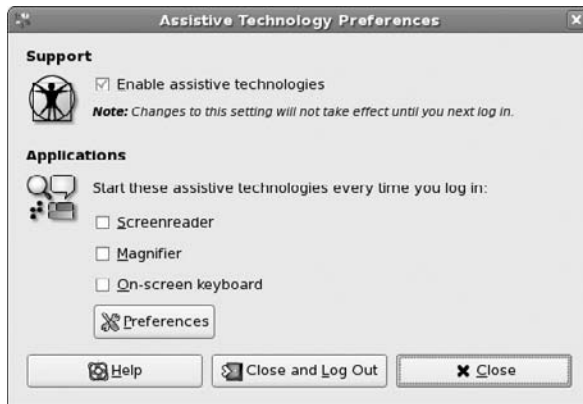
one that you like from the list to use all the time. Next, choose how long your screen must be idle before the screensaver starts (the default is 10 minutes).

**NOTE**

The `gnome-screensaver` is the default screensaver application in CentOS. While `gnome-screensaver` seems more stable, `xscreensaver` includes more flexibility in configuring your screensavers. To use `xscreensaver`, disable `gnome-screensaver`, install the `xscreensaver` package, and type `xscreensaver-demo` (to configure your screensaver).

**FIGURE 3-12**

Enable various assistive technologies from the Assistive Technology Preferences window.



- **Theme** — You can choose to have an entire theme of elements be used on your desktop. A desktop theme affects not only the background, but also the way that many buttons and menu selections appear. There are only a few themes available for the Window Manager (Metacity) in the CentOS distributions. You can get a bunch of other Metacity themes from <http://themes.freshmeat.net> (click Metacity).

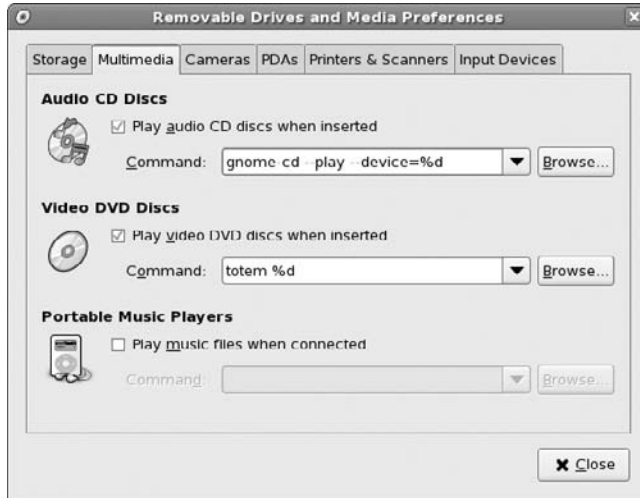
Choose System > Preferences > Theme to access the Theme Preferences window. From there, you can select from a handful of themes, or click “Theme Details” to modify the current theme. The screen appearance changes immediately as you click the new theme. If you download a new theme, click Install to browse to the theme in your file system and select to install it.

## Managing Removable Media

If you are looking for ways to change what happens when you insert CD and DVDs or connect removable storage devices, those preferences can be found on the Removable Drives and Media Preferences window. Select System > Preferences > Removable Drives and Media. You can then change which applications are launched when you insert audio CDs, DVD videos, blank CDs, and other media. Figure 3-13 shows an example of the Removable Drives and Media Preferences window.

**FIGURE 3-13**

Choose which removable drives and media are mounted and played.



## Trying Other GNOME Applications

The GNOME project stores and tracks bugs for a variety of Open Source projects that work well with GNOME desktops. Two such applications are the Tomboy desktop note-taking application and the GNOME Network Tools utility.

### Taking Notes with Tomboy

Tomboy ([www.beatniksoftware.com/tomboy](http://www.beatniksoftware.com/tomboy)) is an excellent tool for keeping track of lots of bits of information. Instead of putting little sticky notes all over your computer, Tomboy lets you put sticky notes *inside* your computer. Features in Tomboy enable you to link notes together, search your notes, and use fonts and colors to help information within your notes stand out.

Add the Tomboy Notes applet to your desktop panel as you would any GNOME applet (select “Tomboy Notes” from the Add to Panel window). Then click on the sticky notepad icon and select “Create New Note” to open a small window that’s ready for you to start typing your note.

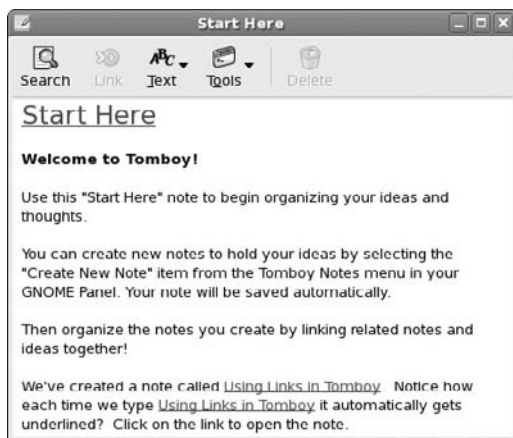
After you have created a sticky note with Tomboy, double-click on the title bar to be able to add a title, font, font color, and note color. You can add links to new notes (select some text and click on the Link button). You can go back and search for text in existing notes (click on the Search button). You can even see a table of contents of your notes (select the Tomboy applet icon, and then select “Table of Contents”).

Recent new features in Tomboy allow you to add links to items outside of your notes, such as URLs and files. Those items are automatically detected and highlighted as you type them.

If Tomboy is not available on your system, type **yum install tomboy** to install it. Figure 3-14 shows an example of the Tomboy applet.

**FIGURE 3-14**

Tomboy lets you create virtual sticky notes to keep important information at your fingertips.



## Checking Your Network from GNOME

The GNOME Network Tools window (recently added to GNOME) brings together several tools you would normally run from the command line to monitor network resources from a graphical window on your GNOME desktop. To open the Network Tools window, select Applications ➤ System Tools ➤ Network Tools. Eight tabs on that window let you perform different operations on your network.

If the GNOME Network Tools window is not available on your system, type **yum install gnome-nettool** to install it.

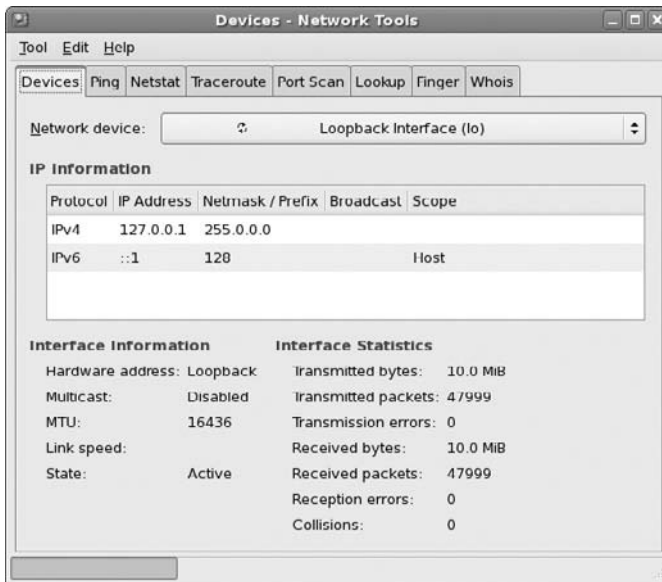
The Devices tab displays information about each of your network interfaces. It makes it easy to find the names and addresses associated with each of your network interfaces (IP addresses, broadcast, netmask) as well as information on data transmissions and collisions.

On other tabs, you can run graphical version of the ping command (to see if another computer can be reached on your network), netstat command (to see information about routes and network services), and traceroute command (to watch the network hops from your site to a remote host). You can do a port scan with Nmap (to check for open ports on a network interface), DNS lookup (to get information about a domain name system server), finger (to see who's logged into a local or remote host computer), and whois (to get information about domain name registration).

Figure 3-15 shows an example of the GNOME Network Tools window.

**FIGURE 3-15**

The GNOME Network Tools window gives you convenient access to common network diagnostic and lookup commands.



## Exiting GNOME

When you are done with your work, you can either log out from your current session or shut down your computer completely.

To exit from GNOME, do the following:

1. Click on the System button from the panel.
2. Select Log Out from the menu. A pop-up window appears, asking if you want to log out.
3. Select OK from the pop-up menu. This will log you out and return you to either the graphical login screen or to your shell login prompt.
4. Select OK to finish exiting from GNOME.

If you are unable to get to the “Log out” button (e.g., if your Panel crashed), there are two other exit methods. Try one of these two ways, depending on how you started the desktop:

- If you started the desktop by typing **startx** from your login shell, press [Ctrl]+[Alt]+[Backspace] to kill X and return to your login shell. Or you could type [Ctrl]+[Alt]+[F1] to return to where you first ran **startx**, and then press [Ctrl]+C to kill the desktop.



- If you started the desktop from a graphical login screen (and [Ctrl]+[Alt]+[Backspace] doesn't work), first open a Terminal window (right-click on the desktop and then select "New Terminal"). In the Terminal window, type **ps x | more** to see a list of running processes. Look for a command named `gnome-session` and determine its number under the PID column. Then type **kill -9 PID**, where *PID* is replaced by the PID number. You should see the graphical login screen.

Although these are not the most graceful ways to exit the desktop, they work. You should be able to log in again and restart the desktop.

## Running 3D Accelerated Desktop Effects

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The goal of the Accelerated Indirect GL X project (AIGLX) is to add three-dimensional (3D) effects to everyday desktop systems. It does this by implementing OpenGL (<http://opengl.org>) accelerated effects using the Mesa ([www.mesa3d.org](http://www.mesa3d.org)) Open Source OpenGL implementation.

Currently, AIGLX supports a limited set of video cards and implements only a few 3D effects. However, if you have one of those cards, AIGLX features in the current version of CentOS can give you some insights into the eye candy that is to come in later versions.

To use AIGLX, you must have one of the following supported video cards.

- **ATI Video Cards** — The ATI Radeon 7000 through X850 video cards are supported. Generations r100 through r400 are included.
- **Intel Video Cards** — The Intel i810 and i830 through i945 Intel video cards are supported.
- **3DFX Video Cards** — 3DFX Voodoo3 through Voodoo5 video cards should work, but have not been tested yet. (3DFX was bought out by NVIDIA a few years ago.)

Because direct rendering infrastructure (DRI) is required for AIGLX, cards that don't support that feature cannot be used. Support for NVidia cards is under development. Although not yet officially supported, the nouveau Xorg driver is an experimental 3D Open Source driver for NVidia cards that comes with CentOS. Cards that are known to *not* work with AIGLX include ATI Rage 128 and Mach 64, Matrox G200 through G550, and 3DFX Voodoo 1 and 2.

If you have a supported video card, the next trick in getting AIGLX to work in CentOS is to have the right software packages installed. If you have installed the GNOME desktop, you should already have all the packages you need. Those packages include `compiz` (for the Compiz Window Manager), `glx-utils`, `gtk2-engines`, `mesa-libGL`, `mesa-libGLU`, and `xorg-x11-drv-ati` or `xorg-x11-drv-i810` (depending on which driver your video card needs).

If your video card was properly detected and configured, you may be able to simply turn on the Desktop Effects feature to see the effects that have been implemented so far. To turn on Desktop Effects from the GNOME desktop, select System > Preferences > Desktop Effects.

When the Desktop Effects pop-up window appears, select “Enable Desktop Effects.” From the KDE desktop, open the System Settings window, then select Desktop ► Desktop Effects. Then choose “Enable Desktop Effects.” Enabling this does the following:

- Stops the current Window Manager and starts the Compiz Window Manager.
- Enables the “Windows Wobble When Moved” effect. With this effect on, when you grab the title bar of the window to move it, the window will wobble as it moves. Menus and other items that open on the desktop also wobble.
- Enables the “Workspaces on a Cube” effect. Drag a window from the desktop to the right or the left and the desktop will rotate like a cube, with each of your desktop workspaces appearing as a side of that cube. Drop the window on the workspace where you want it to go. You can also click on the Workspace Switcher applet in the bottom panel to rotate the cube to display different workspaces.

The following are some interesting effects you can get with your 3D AIGLX desktop:

- **Spin Cube** — Hold [Ctrl]+[Alt] keys and press right and left arrow keys. The desktop cube spins to each successive workspace (forward or back).
- **Slowly Rotate Cube** — Hold the [Ctrl]+[Alt] keys, press and hold the left mouse button, and move the mouse around on the screen. The cube will move slowly with the mouse among the workspaces.
- **Tab through Windows** — Hold the [Alt] key and press the [Tab] key. You will see reduced versions of all your windows in a strip in the middle of your screen, with the current window highlighted in the middle. Still holding the [Alt] key, press [Tab] or [Shift]+[Tab] to move forward or backward through the windows. Release the keys when the one you want is highlighted.
- **Scale and Separate Windows** — If your desktop is cluttered, hold [Ctrl]+[Alt] and press the up arrow key. Windows will shrink down and separate on the desktop. Still holding [Ctrl]+[Alt], use your arrow keys to highlight the window you want, and release the keys to have that window come to the surface.
- **Scale and Separate Workspaces** — Hold [Ctrl]+[Alt] and press the down arrow key to see reduced images of the workspace shown on a strip. Still holding [Ctrl]+[Alt], use right and left arrow keys to move among the different workspaces. Release the keys when the workspace you want is highlighted.
- **Send Current Window to Next Workspace** — Hold [Ctrl]+[Shift]+[Alt] keys together and press the left and right arrow keys. The current window will move to the next workspace to the left or right, respectively.
- **Slide Windows Around** — Press and hold the left mouse button, and then press the left, right, up, or down arrow keys to slide the current window around on the screen.

If you get tired of wobbling windows and spinning cubes, turning off the AIGLX 3D effects and returning Metacity as the Window Manager can be done quite simply. Just select System ► Preferences ► Desktop Effects again, and toggle off the “Enable Desktop Effects” button to turn off the feature.

If you have a supported video card but find that you are not able to turn on the Desktop Effects, check that your X server started properly. In particular, make sure that your `/etc/X11/xorg.conf` file is properly configured. Make sure that `dri` and `glx` are loaded in the Module section. Also, add an extensions section that appears as follows:

```
Section "extensions"  
    Option "Composite"  
EndSection
```

Another option is to add the following line to the `/etc/X11/xorg.conf` file in the Device section:

```
Option XAANoOffscreenPixmaps"
```

The `XAANoOffscreenPixmaps` option will improve performance.

Check your `/var/log/Xorg.log.0` file to make sure that DRI and AIGLX features were started correctly. The messages in that file can help you debug other problems as well.

## Switching Desktop Environments

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If you decide you want to try a different desktop environment, the Desktop Switcher provides a graphical means of changing your desktop environments between KDE, GNOME, Xfce, and several different Window Managers (including TWM), depending on what is installed. To open the Desktop Switcher, type **switchdesk** from a Terminal window and select the new desktop you want to use.

From the Desktop Switcher, select the desktop environment (GNOME, KDE, or Xfce) or Window Manager (TWM) you want to use next. You can have that change apply to the current display (just the next time you restart X only) or make the change permanent. Click OK. Then log out. The next time you log in, the new environment or Window Manager will take effect.

### NOTE

To use the Desktop Switcher window, you must have the `switchdesk-gui` package installed. Otherwise, you can use the `switchdesk` command, followed by the name of the desktop you want to switch to, from a Terminal window to change your desktop.

If you just want to change your desktop environment temporarily, you can select Session from the login screen and choose the desktop you want. You can choose it just for the current session or have it be your default desktop.

## Using the KDE Desktop

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The KDE desktop was developed to provide an interface to Linux and other UNIX systems that could compete with Mac OS or Microsoft Windows operating systems for ease of use. Integrated within KDE are tools for managing files, windows, multiple desktops, and applications. If you can work a mouse, you can learn to navigate the KDE desktop. CentOS includes version 3.5.4 of KDE.

**NOTE**

KDE is not installed by default for CentOS. Therefore, to use the procedures in this section, you might have to install KDE. During installation, you could use a Custom install type to install KDE. Otherwise, see Chapter 5 for information on how to use yum to add KDE.

The lack of an integrated, standardized desktop environment in the past has held back Linux and other UNIX systems from acceptance on the desktop. While individual applications could run well, you rarely could drag-and-drop files or other items between applications. Likewise, you couldn't open a file and expect the machine to launch the correct application to deal with it or save your windows from one login session to the next. KDE provides a platform for developers to create programs that easily share information and detect how to deal with different data types.

The following section describes how to get started with KDE. This includes using the KDE Setup Wizard, maneuvering around the desktop, managing files, windows, virtual desktops, and adding application launchers.

## Starting with KDE

You can select the KDE desktop from the login screen (provided that KDE is installed). Choose Session > KDE, and then provide your username and password as prompted to log in. A KDE desktop should appear, similar to the one shown in Figure 3-16.

**FIGURE 3-16**

The default KDE desktop after login



## KDE Desktop Basics

Here are some descriptions of what you will find when using the KDE desktop in CentOS:

- **Panel** — The Panel provides some quick tools for launching applications and managing the desktop. You can adapt the panel to your needs by resizing it, adding tools, and changing its location. By default, you start with an application launcher, taskbar, desktop pager, the Klipper mini-applet (a clipboard tool), and a clock.
- **Applets** — Applets can be added to the panel in KDE just as they can be in the GNOME desktop.
- **Mini-Applets** — Some applications, such as media players, clipboards, and battery power managers, will keep running after you have closed the related window. Some of those applications maintain a tiny applet in the Panel. Often clicking on these applets restores the windows they represent. This is convenient for music players if you don't want to take up desktop space while you play music, but you want to be able to open the player quickly to change songs.
- **Konqueror** — Konqueror is the default Web browser and File Manager for KDE.
- **Application Launcher/Menu** — This panel button is represented by a CentOS logo. The button opens the Kickoff Application menu, which gives you access to applications installed on your system and launches them. The menu also tracks Recently Used Applications so you can easily launch important and often-used programs.
- **Taskbar** — This button shows the tasks that are currently running on the desktop. The button for the window that is currently active appears pressed in. Click on a task to toggle between opening and minimizing the window.
- **Desktop Pager** — This box on the Panel consists of your virtual desktops, which contain small views of each desktop. There are four virtual desktops available to you, by default. These are labeled 1, 2, 3, and 4. You begin your KDE session on Virtual Desktop 1. If there are windows on the desktop, small icons representing them may cover the desktop number. You can change to any of the four desktops by clicking on it.
- **Clock** — The current time is shown on the far right-hand side of the panel. Click on it to see a calendar for the current month. Click on the arrow keys on the calendar to move forward and backward to other months.

### Getting around the Desktop

Navigating the desktop is done with your mouse and keyboard. You can use a two-button or three-button mouse. Using the keyboard to navigate requires some [Alt] and [Ctrl] key sequences.

#### *Using the Mouse*

The responses from the desktop to your mouse depend on which button you press and where the mouse pointer is located. Table 3-2 shows the results of clicking each mouse button with the mouse pointer placed in different locations.

TABLE 3-2

### Mouse Actions

Pointer Position	Mouse Button	Results
Window title bar or frame (current window active)	Left	Raise current window.
Window title bar or frame (current window active)	Middle	Lower current window.
Window title bar or frame (current window active)	Right	Open operations menu.
Window title bar or frame (current window not active)	Left	Activate current window and raise it to the top.
Window title bar or frame (current window not active)	Middle	Activate current window and lower it.
Window title bar or frame (current window not active)	Right	Open operations menu without changing position.
Inner window (current window not active)	Left	Activate current window, raise it to the top, and pass the click to the window.
Inner window (current window not active)	Middle	Activate current window and pass the click to the window.
Inner window (current window not active)	Right	Activate current window and pass the click to the window.
Any part of a window	Middle (plus hold [Alt] key)	Toggle between raising and lowering the window.
Any part of a window	Right (plus hold [Alt] key)	Resize the window.
On the desktop area	Left (hold and drag)	Select a group of icons.
On the desktop area	Right	Open system pop-up menu.

The mouse actions in the table are all single-click actions. Use single-click with the left mouse button to open an icon on the desktop. On a window title bar, double-clicking results in a window-shade action, where the window scrolls up and down into the title bar.

### Using Keystrokes

If you don't happen to have a mouse or you just like to keep your hands on the keyboard, there are several keystroke sequences you can use to navigate the desktop. Here are some examples:

- **Step through Windows** ([Alt]+[Tab]) — To step through each of the windows that are running on the current desktop, hold down the [Alt] key and press the [Tab] key until you see the one you want. Then release the [Alt] key to select it.

- **Open Run Command Box** ([Alt]+[F2]) — To open a KRunner box on the desktop that lets you type in a command and run it, hold the [Alt] key and press [F2]. Next, type the command in the box, and KRunner presents you with matching commands as you type. Either click on the command you want or press [Enter] after typing the whole command you want to run. You can also type a URL into this box to view a web page.
- **Close the Current Window** ([Alt]+[F4]) — To close the current window, press [Alt]+[F4].
- **Close another Window** ([Ctrl]+[Alt]+[Esc]) — To close an open window on the desktop, press [Ctrl]+[Alt]+[Esc]. When a skull and crossbones appears as the pointer, move the pointer over the window you want to close and click on the left mouse button. (This is a good technique for killing a window that has no borders or menu.)
- **Switch Virtual Desktops** ([Ctrl]+[F1], [F2], [F3], or [F4] key) — To step through virtual desktops, press and hold the [Ctrl] key and press [F1], [F2], [F3], or [F4] to go directly to Desktop 1, 2, 3, or 4, respectively. You could do this for up to eight desktops, if you have that many configured.
- **Open Window Operation Menu** ([Alt]+[F3]) — To open the operations menu for the active window, press [Alt]+[F3]. When the menu appears, move the arrow keys to select an action (Move, Size, Minimize, Maximize, and so on), and then press [Enter] to select it.

## Managing Files with the Konqueror File Manager

The Konqueror File Manager/Web browser helps elevate the KDE environment from just another X Window Manager to an integrated desktop that can compete with GUIs from Apple Computing or Microsoft. Konqueror can handle a wide range of content from local files and folders to remote Web content. The features in Konqueror rival those that are offered by those user-friendly desktop systems. Figure 3-17 shows an example of the Konqueror File Manager window.

Some of Konqueror's greatest strengths over earlier File Managers are the following:

- **Network Desktop** — If your computer is connected to the Internet or a LAN, features built into Konqueror let you create links to files (using FTP) and web pages (using HTTP) on the network and open them within the Konqueror window. Those links can appear as file icons in a Konqueror window or on the desktop. When a link is opened (single-click), the contents of the FTP site or web page appear right in the Konqueror window. Given proper folder permission, you could drag-and-drop files to your FTP server in this way.
- **Web Browser Interface** — The Konqueror interface works like Firefox, Internet Explorer, or another Web browser in the way you select files, directories, and Web content. You can open Web content by typing web-style addresses in a Location box.

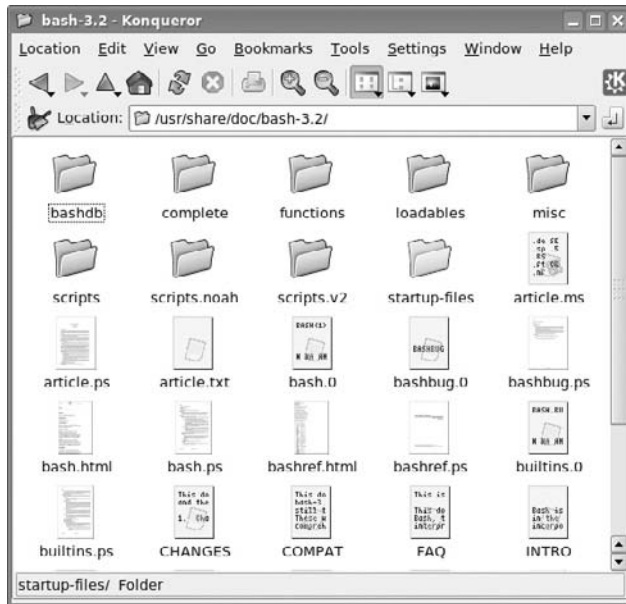
### TIP

Web pages that contain Java content will run by default in Konqueror. To double-check that Java support is turned on, choose **Settings > Configure Konqueror**. From the Settings window, click "Java & JavaScript" and select the Java tab. To enable Java, click on the "Enable Java Globally" box and click Apply. Try a game from [Java.com](http://Java.com) to see if Java is working. If

you need a later version of the Java Runtime Environment (JRE), you can download it from [www.java.com/en/download](http://www.java.com/en/download). After downloading the new JRE, change “Path to Java Executable” to `/usr/java/jre1.5.0_02/bin/java` to get it to work.

**FIGURE 3-17**

Konqueror provides a network-ready tool for managing files.



- File Types and MIME Types** — If you want a particular type of file to always be launched by a particular application, you can configure that file yourself. KDE already has dozens of Multipurpose Internet Mail Extensions (MIME) types defined that can automatically detect particular file and data types and start the right application. There are MIME types defined for audio, image, text, video, and a variety of other content types.

Of course, you can also perform many standard File Manager functions with Konqueror. For manipulating files, you can use features such as Select, Move, Cut, Paste, and Delete. You can search directories for files, create new items (files, folders, and links, to name a few), view histories of the files and web sites you have opened, and create bookmarks.

## Working with Files

Because most of the ways of working with files in both Konqueror and Dolphin are quite intuitive (by intention), I'll just give a quick rundown of how to do basic file manipulation:

- Open a File** — Click on a file. The file will open right in the Konqueror or Dolphin window, if possible, or in the default application set for the file type. You can also open a



directory (to make it the current directory), application (to start the application), or link (to open the target of a link) in this way.

- **Choose an Application** — Right-click to open a menu. When you right-click on a data file, select the “Open With” menu. The menu that appears shows which applications are set up to open the file.
- **Delete a File** — Right-click and select “Move to Trash.” You are asked if you really want to delete the file. Click Trash to move the item to the Trash folder. (If you are brave, you can use [Shift]+[Delete] to permanently delete a selected file. Just keep in mind that you won’t be able to restore it from the Trash if you change your mind.)
- **Copy a File** — Right-click and select Copy. This copies the file to your clipboard. After that, you can paste it to another folder. Click on the Klipper (clipboard) icon in the panel to see a list of copied files. (See the “Move a File” bullet item below for a drag-and-drop method of copying.)
- **Paste a File** — Right-click (on an open area of a folder) and select Paste. A copy of the file you copied previously is pasted in the current folder.
- **Move a File** — With the original folder and target folder both open on the desktop, press and hold the left mouse button on the file you want to move, drag the file to an open area of the new folder, and release the mouse button. From the menu that appears, click “Move Here.” (You could also copy or create a link to the file using this menu.)
- **Link a File** — Drag-and-drop a file from one folder to another. When the menu appears, click “Link Here.” (A linked file lets you access a file from a new location without having to make a copy of the original file. When you open the link, a pointer to the original file causes it to open.)

There are also several features for viewing information about the files and folders in your Konqueror window:

- **View Quick File Information** — Right-click on a file in a Konqueror window and select Properties. A pop-up window appears with information about the item, including its filename, file size, modification times, and file type.
- **View Hidden Files** — In Konqueror, select View ➤ Show Hidden Files. This allows you to see files that begin with a dot (.). Dot files tend to be used for configuration and don’t generally need to be viewed in your daily work.
- **Change Icon Size** — In Konqueror, select View ➤ Icon Size to make the file and folder icons bigger or smaller.
- **Change Icon View** — In Konqueror, select View ➤ View Mode, and then select to view the folder contents as icons, details, or columns.

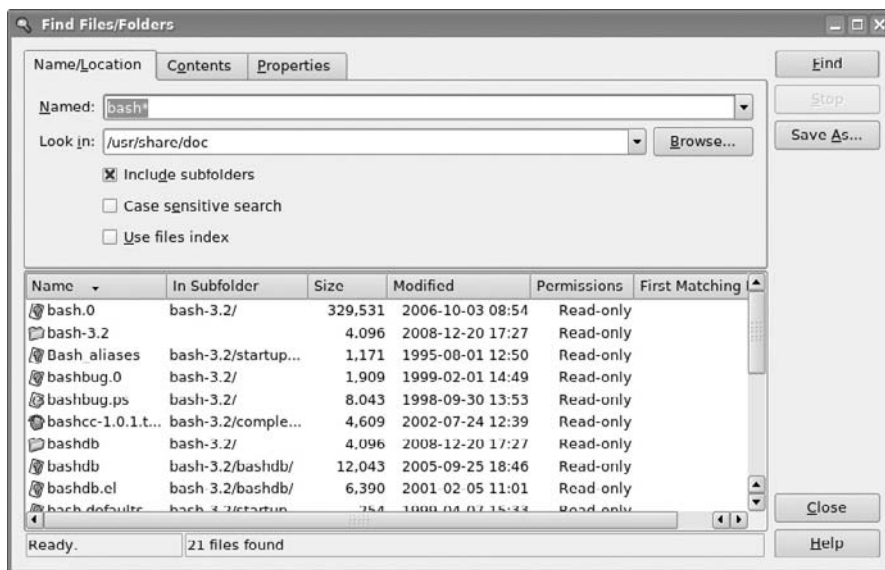
To act on a group of files at the same time, there are a couple of actions you can take. To select a group of files, click in an open area of the folder and drag the pointer across the files you want to select. All files within the box will be highlighted. When files are highlighted, you can move, copy, or delete the files as described earlier.

## Searching for Files with kfind

You can use the kfind application if you are looking for a particular file or folder. To open a Find Files/Folders window to search for a file from a Konqueror file manager, choose Tools > Find File, and the window will appear. You could also start the Find Files/Folders window by choosing the Find Files/Folders menu item from the Application Launcher on the panel. Figure 3-18 shows the Find Files/Folders window.

**FIGURE 3-18**

Search for files and folders from the Find Files/Folders window.



Simply type the name of the file you want to search for (in the Named textbox) and the folder, including all subfolders, you want to search in (in the “Look in” textbox). Then click on the Find button. Use metacharacters, if you like, with your search. For example, search for \*.rpm to find all files that end in .rpm or z\*.doc to find all files that begin with z and end with .doc. You can also select to have the search be case-sensitive or click on the Help button to get more information on searching.

To further limit your search, you can click on the Properties tab and then enter a date range (between), a number of months before today (during the previous x months), or the number of days before today (during the previous x days). Select the Contents tab to choose to limit the search to files of a particular type (“of Type”), files that include text that you enter (“Containing Text”), or that are of a certain size (“Size is”) in kilobytes.

## Creating New Files and Folders

You can create a variety of file types when using Konqueror. Choose **Edit** ➤ **Create New**, and select **Folder** (to create a new folder) or one of the following types under the **File** submenu:

- **HTML File** — Opens a dialog box that lets you type the name of an HTML file to create.
- **Link to Application** — Opens a window that lets you type the name of an application. Click on the **Permissions** tab to set file permissions (**Exec** must be on if you want to run the file as an application). Click on the **Execute** tab, and type the name of the program to run (in the field: “Execute on click”) and a title to appear in the title bar of the application (in the field: “Window Title”). If it is a text-based command, select the “Run in terminal” checkbox. Click on the checkbox to “Run as a different user” and add the username. Click on the **Application** tab to assign the application to handle files of particular MIME types. Click **OK**.
- **Link to Location (URL)** — Selecting this menu item opens a dialog box that lets you create a link to a web address. Type a name to represent the address and type the name of the URL (web address) for the site. (Be sure to add the `http://`, `ftp://`, or other prefix.)
- **Text File** — Opens a dialog box that lets you create a document in text format and place it in the Konqueror window. Type the name of the text document to create and click **OK**.

Under the “Link to Device” submenu, you select from many different device types. Here are examples of some you can use:

- **CD-ROM Device** — Opens a dialog box that lets you type a new CD-ROM device name. Click on the **Device** tab and type the device name (`/media/cdrecorder`), the mount point (such as `/media/cdrecorder`), and the file system type (you can use **iso9660** for the standard CD-ROM file system, **ext2** for Linux, or **msdos** for DOS). When the icon appears, you can open it to mount the CD-ROM and display its contents.
- **CDWRITER Device** — From the window that opens, enter the device name of your CD writer.
- **DVD-ROM Device** — Opens a dialog box that lets you type a new DVD-ROM device name. Click on the **Device** tab and type the device name (`/dev/cdrom`), the mount point (such as `/media/cdrecorder`), and the file system type (you can use **udf** for the standard DVD file system, **iso9660** for the standard CD-ROM file system, **ext2** for Linux, or **msdos** for DOS). When the icon appears, you can open it to mount the DVD-ROM and display its contents.
- **Camera Device** — In the dialog box that opens, identify the device name for the camera device that provides access to your digital camera.
- **Floppy Device** — Opens a dialog box to type a new floppy name. Click on the **Device** tab and type the device name (`/dev/fd0`), the mount point (such as `/media/floppy`), and the file system type (you can use **auto** to autodetect the contents, **ext2** for Linux, or **msdos** for DOS). When the icon appears, open it to mount the floppy and display its contents.

- **Hard Disk Device** — Opens a dialog box that lets you type the name of a new hard disk or hard-disk partition. Click on the Device tab and type the device (such as `/dev/sda1`), the mount point (such as `/mnt/win`), and the file system type (you can use **auto** to autodetect the contents, **ext2** or **ext3** for Linux, or **vfat** for a Windows file system). When the icon appears, you can open it to mount the file system and display its contents.

Creating MIME types and applications is described later in this chapter.

## Using the Konqueror Browser Features

Because Konqueror performs like a Web browser as well as a File Manager, it includes several other browser features. For example, you can keep a Bookmark List of web sites you have visited, using the bookmarks feature. Any bookmarks that you add to your Bookmarks List show up in the dropdown menu that appears when you click Bookmarks. Select from that list to return to a site. There are several ways to add and change your Bookmarks List:

- **Add Bookmark** — To add the address of the page that is currently being displayed to your Bookmark List, choose Bookmarks > Add Bookmark. The bookmark is silently added. The next time you click Bookmarks, you will see the bookmark you just added on the Bookmarks menu. In addition to web addresses, you can also bookmark any file or folder.
- **Edit Bookmarks** — Select Bookmarks > Edit Bookmarks to open a Tree view of your bookmarks. From the Bookmark Editor window that appears, you can change the URLs, the icon, or other features of the bookmark. There is also a nice feature that lets you check the status of the bookmark (i.e., whether the address is still valid).
- **Bookmark Tabs as Folder** — You can add a new folder of bookmarks to your Konqueror Bookmarks List. To create a Bookmarks folder, choose Bookmarks > Bookmark Tabs as Folder. Then type a name for the new Bookmarks folder and click OK. The new Bookmarks folder appears on your Bookmarks menu. You can add the current location to that folder by clicking on the folder name and selecting “Add Bookmark.”
- **New Bookmark Folder** — You can create a new bookmark folder by choosing Bookmarks > New Bookmark Folder. When a pop-up appears, type a new folder name and select OK.

## Configuring Konqueror Options

You can change many of the visual attributes of the Konqueror window. You can select which menu bars and toolbars appear. You can have any of the following bars appear on the Konqueror window: Menu bar, Toolbar, Extra Toolbar, Location Toolbar, Bookmark Toolbar. Select Settings > Toolbar and then click the menu item for the bar you want to have appear (or not appear). The bar appears when the checkmark is shown next to it.

You can modify a variety of options for Konqueror by choosing Settings > Configure Konqueror. The Konqueror Settings window appears, offering the following options:

- **Behavior** — Changes a few options that affect how Konqueror behaves as a File Manager, such as prompting for confirmation before deleting files.

- **Appearance** — Changes File Manager fonts and colors.
- **Previews & Meta-Data** — An icon in a Konqueror folder can be made to resemble the contents of the file it represents. For example, if the file is a JPEG image, the icon representing the file could be a small version of that image. Using the Previews features, you can limit the size of the file used (1 MB is the default) because many massive files could take too long to refresh on the screen. You can also select to have any thumbnail embedded in a file to be used as the icon or have the size of the icon reflect the shape of the image used.
- **File Associations** — Describes which programs to launch for each file type.
- **Web Browsing** — Click on the Behavior (Browser) button to open a window to configure the Web browser features of Konqueror. By enabling Form Completion, Konqueror can save form data you type and, at a later time, fill that information into other forms. If your computer has limited resources, you can speed up page display by clearing the “Automatically load images” checkbox or by disabling animations.
- **Java and JavaScript** — Use this selection to enable or disable Java and JavaScript content contained in web pages in your Konqueror window.
- **AdBlock Filters** — Click here to create a list of URLs that are filtered as you browse the Web. Filtering is based on frame and image names. Filtered URLs can be either thrown away or replaced with an image. You can also import and export lists of filters here.
- **Fonts** — Choose which fonts to use, by default, for various fonts needed on web pages (standard font, fixed font, serif font, sans serif font, cursive font, and fantasy font). The serif fonts are typically used in body text, while sans serif fonts are often used in headlines. You can also set the Minimum and Medium font sizes.
- **Web Shortcuts** — Click on the “Web Shortcuts” button to see a list of keyword shortcuts you can use to go to different Internet sites. For example, follow the word *ask* with a search string to search the Ask Jeeves web site ([www.ask.com](http://www.ask.com)).
- **History Sidebar** — Click here to modify the behavior of the list of sites you have visited (the history). By default, the most recent 500 URLs are stored, and after 90 days, a URL is dropped from the list. You will also find a button to clear your history. (To view your history list in Konqueror, open the left side panel, and then click on the tiny Scroll icon.)
- **Cookies** — Click on the Cookies button to select whether or not cookies are enabled in Konqueror. By default, you are asked to confirm that it is OK each time a web site tries to create or modify a cookie. You can change that to either accept or reject all cookies. You can also set policies for acceptance or rejection of cookies based on host and domain names.
- **Cache** — Click on the Cache button to indicate how much space on your hard disk can be used to store the sites you have visited (based on the value in the “Disk Cache Size” field).
- **Proxy** — Click on the Proxy button if you are accessing the Internet through a proxy server. You need to enter the address and port number of the computer providing HTTP or FTP proxy services or both.
- **Stylesheets** — Click on the Stylesheets button to select whether to use the default style sheet, a user-defined style sheet, or a custom style sheet. The style sheet sets the font

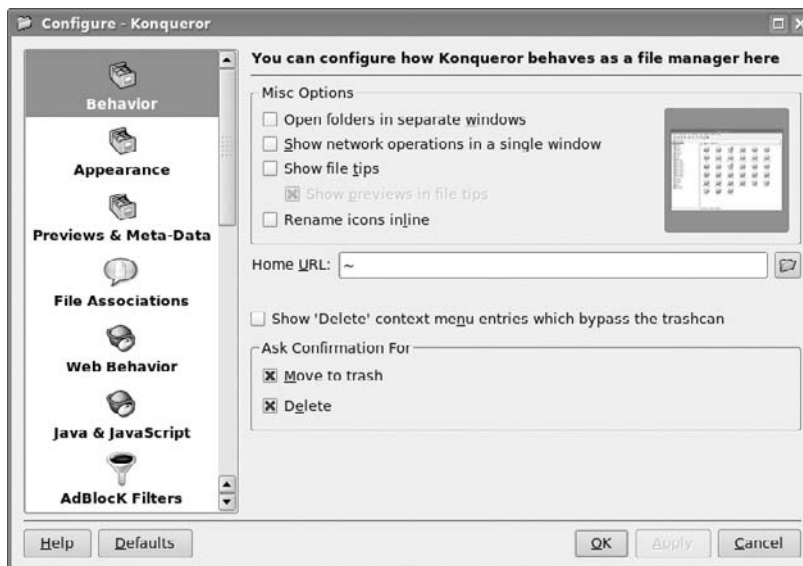
family, font sizes, and colors that are applied to web pages. (This won't change particular font requests made by the web page.) If you select a custom style sheet, click on the Customize tab to customize your own fonts and colors.

- **Crypto** — Click on the Crypto button to display a list of secure certificates that can be accepted by the Konqueror browser. By default, Secure Socket Layer (SSL) version 2 and 3 certificates are accepted, as is TLS support (if supported by the server). You can also select to be notified when you are entering or leaving a secure web site.
- **Browser Identification** — Click on the “Browser Identification” button to set how Konqueror identifies itself when it accesses a web site. By default, Konqueror tells the web site that it is the Mozilla Web browser. You can select Konqueror to appear as different Web browsers to specific sites. You must sometimes do this when a site denies you access because you do not have a specific type of browser (even though Konqueror may be fully capable of displaying the content).
- **Plugins** — Click on the Plugins button to see a list of directories that Konqueror will search to find plug-ins. Konqueror can also scan your computer to find plug-ins that are installed for other browsers in other locations.
- **Performance** — Select the Performance button to see configuration settings that can be used to improve Konqueror performance. You can pre-load an instance after KDE startup or minimize memory usage.

Figure 3-19 shows Konqueror's configuration window.

**FIGURE 3-19**

Change settings from the Konqueror Configure window.



## Managing Windows

If you have a lot of windows open at the same time, tricks for organizing and managing the windows on your desktop are very helpful. KDE helps you out by maintaining window lists you can work with and shortcuts for keeping the windows in order.

### Using the Taskbar

When you open a window, a button representing the window appears in the taskbar at the bottom of the screen. Here is how you can manage windows from the taskbar:

- **Toggle Windows** — You can left-click on any running task in the taskbar to toggle between opening the window and minimizing it.
- **Move Windows** — You can move a window from the current desktop to any other virtual desktop. Right-click on any task in the taskbar, select “To Desktop,” and then select any desktop number. The window moves to that desktop.
- **Position Windows** — You can indicate to have the selected window be above or below other windows or displayed in full screen. Right-click on the running task in the taskbar and select Advanced. Then choose “Keep Above Others,” “Keep Below Others,” or “Fullscreen.”

All the windows that are running, regardless of which virtual desktop you are on, appear in the taskbar. If there are multiple windows of the same type shown as a single task, you can right-click on that task; then select “All to Desktop” to move all related windows to the desktop you pick.

### Moving Windows

The easiest way to move a window from one location to another is to place the pointer on the window’s title bar; while holding down the mouse button, move the mouse so the window goes to a new location, and release the mouse button to drop the window. Another way to do it is to click on the window menu button (top-left corner of the title bar), click Move, move the mouse to relocate the window, and then click again to place it.

#### TIP

If somehow the window gets stuck in a location where the title bar is off the screen, there is a way you can move it back to where you want it. Hold down the [Alt] key and press the left mouse button in the inner window. Then move the window where you want it and release. An alternative is to right-click anywhere on the window frame and select Move to move the window.

### Resizing Windows

To resize a window, place the pointer over a corner or side of the window border, and, while holding down the mouse button, move it until it is the size you want. Grabbing a corner lets you resize vertically and horizontally at the same time. Grabbing the side lets you resize in only one direction.

You can also resize a window from the “Window Menu” button. Click on the “Window Menu” button (top-left corner of the title bar) and select Size. Move the mouse until the window is resized and click to leave it there.

### Pinning Windows on Top or Bottom

You can set a window to always stay on top of all other windows or always stay under them. Keeping a window on top can be useful for a small window that you want to always refer to (such as a clock or a small TV viewing window). To pin a window on top of the desktop, click in the window title bar. From the menu that appears, select Advanced ➤ Keep Above Others. Likewise, to keep the window on the bottom, select Advanced ➤ Keep Below Others.

### Using Virtual Desktops

To give you more space to run applications than will fit on your physical screen, KDE gives you access to several virtual desktops at the same time. Using the 1, 2, 3, and 4 buttons on the Panel, you can easily move between the different desktops. Just click on the one you want.

If you want to move an application from one desktop to another, you can do so from the window menu. Click on the “Window Menu” button for the window you want to move, click “To Desktop,” and then select Desktop 1, 2, 3, or 4. The window will disappear from the current desktop and move to the one you selected.

## Configuring the Desktop

If you want to change the look, feel, or behavior of your KDE desktop, the best place to start is the Control Center window. The Control Center window lets you configure dozens of attributes associated with colors, fonts, and screensavers used by KDE. There are also selections from that window that let you do basic computer administration, such as changing date/time settings and modifying your display. To open the Control Center window, select the CentOS menu and choose “Control Center.” The Control Center window appears, as shown in Figure 3-20.

Click on any item you want to configure, or type into the Search box to find a selection that matches what you type.

There are several ways you can change the look-and-feel of your desktop display from the Control Center window. Under the “Appearance & Themes,” you can select to change the appearance, desktop, notifications, or window behavior.

Here are a few of the individual desktop features you may want to change:

- **Change the Background** — Under the “Appearance & Themes” heading, select Background. From the view that appears, there are only a few backgrounds available by default. However, by installing the `kdeartwork-extras` package, you can get a lot more background images (and also screensavers) to choose from.



**FIGURE 3-20**

Configure your desktop from the KDE Control Center.



- **Change the Colors** — Under the “Appearance & Themes” heading in the Control Center window, select Colors. The view that appears lets you change the color of selected items on the desktop. Select a whole color scheme from the “Color Scheme” list box. Or select an item from the Colors tab to change a particular item. Items you can change include text, backgrounds, links, buttons, and title bars.
- **Change Fonts** — You can assign different fonts to different places in which fonts appear on the desktop. Under the “Appearance & Themes” heading, select Fonts. Select one of the categories of fonts (General, Fixed width, Small, Toolbar, Menu, Window title, Taskbar, and Desktop fonts). Then click on the Choose box to select a font from the “Select Font” list box that you want to assign to that category. If the font is available, you will see an example of the text in the Sample textbox.
- **Change the Screensaver** — Under the “Appearance & Themes” heading, select “Screen Saver.” Under the “Start Automatically” box, select how many minutes of inactivity before the screensaver turns on. You can also click “Require Password” to require that a password be entered before you can access your display after the screensaver has come on.

## Adding Widgets

You want to be able to quickly access the applications that you use most often. One of the best ways to make that possible is to add widgets to the Panel or the desktop that can either run continuously (such as a clock or news ticker) or launch the applications you need with a single click. Procedures for adding widgets to the Panel and desktop are described in the following sections.

### Adding Widgets to the Panel

You can add any KDE widgets to the KDE Panel quite easily. Here's how:

1. Right-click any place on the panel.
2. Select the widget you want to add.
3. Click "Add Widget."

An icon representing the widget should immediately appear on the Panel. (If the Panel seems a bit crowded, you might want to remove some widgets you don't use or add a widget directly to the desktop.) At this point, you can change any properties associated with the widget by right-clicking on the widget in the Panel and then selecting to change its settings.

If you decide later that you no longer want this widget to be available on the Panel, right-click on it and click Remove.

## Using the Xfce Desktop Environment

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The Xfce desktop environment provides a lightweight interface for using your CentOS system. Because it is designed to conserve system resources and load applications quickly, Xfce is usually the best choice if you are using CentOS on a less powerful computer (e.g., if you have less than 512 MB of RAM) or just want your desktop environment to consume a smaller amount of RAM so that it is available to other applications.

To use Xfce, you need to install the Xfce desktop packages (type **yum install xfce\***). To launch an Xfce desktop, you can either select Xfce from the Sessions box on the login screen or use the `switchdesk` feature (described earlier in this chapter) to make Xfce your default desktop.

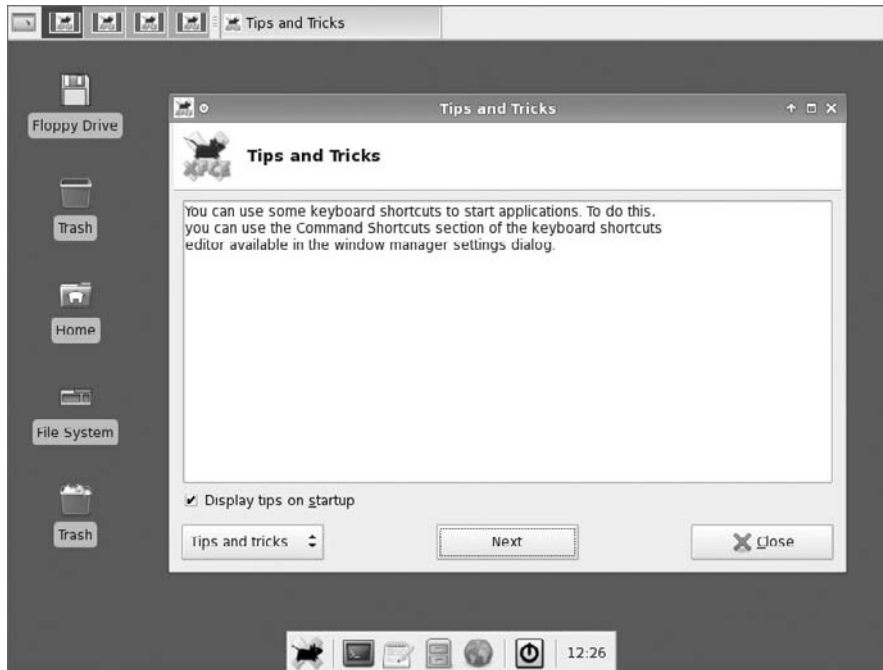
Figure 3-21 shows an example of the Xfce desktop after logging in.

To meet its goals of running fast and efficiently, Xfce offers its own applications for doing many desktop operations. Here are some examples:

- **Thunar File Manager** — A fast and efficient way of managing your files and folders

**FIGURE 3-21**

Xfce offers a lightweight desktop environment.



- **Xfce Application Finder** — A useful tool for finding every desktop-ready application on the system. (From the Xfce menu, select Accessories > Appfinder.)
- **Xfce Settings Manager** — Provides tools for changing desktop, display, File Manager, keyboard, mouse, sound, and various other desktop settings. (From the Xfce menu, select Settings > Settings Manager.)
- **Mousepad** — A simple and efficient text editor
- **Panel Items** — Dozens of items are available to add to the Xfce panel to monitor battery life, manage clipboards, display time, search dictionaries, watch system performance, and do many other tasks.

## Troubleshooting Your Desktop

If your desktop is not functioning properly (or at all), it may be that your video card was not configured properly. This section helps you get your video card configured properly and your desktop up and running smoothly.

## GUI Doesn't Work at Startup

If CentOS has been successfully installed (along with the desired desktop environment) but the GUI wasn't set to start at boot time, you may see only a simple text-based login prompt when you start CentOS. This login prompt may look something like this:

```
CentOS release 5.2 (Final)
Kernel 2.6.18-92.1.22.el5 on an i686

localhost login:
```

Log in as the `root` user. As noted earlier, you can check if you have a GUI that is at least working well enough for you to correct it. Type the following command:

```
# startx
```

## What Happens during Desktop Startup?

The X server and graphical login screen is started by the `prefdm` script. By default, the login screen is displayed by the GNOME display manager (`gdm` command), which handles both logging in and starting the desktop environment for your console monitor, as well as graphical logins from other computers and X terminals.

The `prefdm` script is launched only if the run level in the `/etc/inittab` file is set to 5, as follows:

```
id:5:initdefault:
```

If the `initdefault` state is 3, the system boots to a text-based login prompt. See Chapter 11 for information on Linux run states and start-up processes.

Some processes started during every X session are launched from scripts in the `/etc/X11/xinit/xinitrc.d` directory. Check those scripts to see if any of the settings they include might be causing problems. (You can also use those scripts to launch applications of your own each time X starts.)

If you are unable to get the video card and monitor configured properly or if you don't need a GUI, you can configure the computer to start up in text mode. To do this using any shell text editor (such as the `vi` command described in Chapter 4), change the `initdefault` line in the `/etc/inittab` file from `id:5:initdefault:` to `id:3:initdefault:`.

If you prefer to have CentOS boot to a GUI, change the 3 to a 5.

If the desktop works fine when you type `startx`, you might want to change to a graphical login, so the GUI starts automatically every time. See the “What Happens during Desktop Startup” sidebar for information on booting to a GUI. If X crashes, see `/var/log/Xorg.0.log` for clues about what went wrong.

If your GUI is so distorted you can't even see to correct it, switch to a virtual terminal to correct the problem. For example, hold the [Ctrl] and [Alt] keys, and press [F2]. You will see a plaintext login prompt. Log in as `root` user and type `init 3` to make the garbled GUI login

screen go away. As an alternative, press [Ctrl]+[Alt]+[Backspace] to close the X session. Then you can try tuning your video card as described in the following section.

**TIP**

Switching virtual terminals is a great way to get out of a GUI that is broken or stuck and run the commands you need to fix a problem. You can use any function key from [F1] through [F8] with [Ctrl]+[Alt] to switch terminals. The GUI itself is probably on the F7 virtual terminal. Linux experts use virtual terminals during CentOS installation to debug a problem or during startup to view text start-up messages.

## Tuning Your Video Card and Monitor

If your GUI is starting up but needs some tuning (to get better resolution, more colors, or to fix flickering), you can use the Display Settings window to fix your desktop. For the current CentOS versions, the Display Settings window was enhanced so that you can use it from a command line with no GUI running. The next sections describe how to run the Display Settings window, and then how to review the resulting `xorg.conf` file to understand your settings.

### Running the Display Settings Window

The CentOS Project replaced the `xconfigurator` tool with a new Display Settings window (`system-config-display` command). This window lets you set the most basic functions relating to your display, monitor, and video card. The Display Settings window is easy to use and no longer requires a running X desktop to use it.

To open the Display Settings window from the Desktop menu, click System ➤ Administration ➤

Display. To open that window from a text prompt (even with no GUI running), type **system-config-display** (as root).

From the Settings tab of the Display Settings window, you can try different resolutions (screen width and height in pixels) and color depths (from 256 colors to millions of color). Click on the Hardware tab to try to configure your monitor and video card. Click on the “Dual head” tab if you have a video card that supports two monitors that you can use side-by-side with CentOS. Click OK to save your changes.

Here are a few tips for using the Display Settings window:

- If you know your monitor type but it is not being detected, click on the Hardware tab and then click Configure. You can select the monitor from a list of monitors (by manufacturer) or, if it's not on the list, enter information about the monitor's horizontal and vertical sync rates from the manufacturer's instructions. If you don't see your monitor on the list, check the Web to find this information for your monitor (e.g., try [www.monitorworld.com/monitors\\_home.html](http://www.monitorworld.com/monitors_home.html)).
- If you don't know the vertical and horizontal sync rates, you can choose a generic monitor from the list. You could simply choose a generic CRT or Generic LCD at a resolution you would expect the monitor to support. Common resolutions for older monitors include  $1,280 \times 1,024$ ,  $1,024 \times 768$ , and  $800 \times 600$ .

Changes made in the Display Settings window result in the creation of a new `/etc/X11/xorg.conf` file. The next section describes what the `xorg.conf` file contains.

**TIP**

If the Display Settings window fails to create a working `xorg.conf` file, you can try another approach. With no GUI on as root user, type the following commands from a shell:

```
# Xorg -configure
# X -xf86config /root/xorg.conf.new
```

The first line creates `xorg.conf.new` in the `/root` directory. The second tries to start your GUI with that new config file. You should see the mouse cursor (an X) and a blank screen. If the GUI works, press `[Ctrl]+[Alt]+[Backspace]` to exit, and then copy `/root/xorg.conf.new` to `/etc/X11/xorg.conf`. You may need to run `system-config-mouse` to get the mouse working properly after this.

## Understanding the `xorg.conf` File

The XFree86 X server has been replaced by the X server from X.Org. Although that change should be invisible to most users, if you like to change X settings directly, you need to know that the main X configuration file is now `/etc/X11/xorg.conf` and not `/etc/X11/XF86Config`.

The `xorg.conf` file (located in the `/etc/X11` directory) contains definitions used by the X server to use your video card, keyboard, mouse, and monitor. In general, novice users should not edit this file directly. For some video cards, however, manual configuration may be required to get the card working properly.

The following is a description of the basic information contained in the `xorg.conf` file:

- **ServerLayout Section** — Binds input and output devices for your X session. Lets you set server definitions for different X servers (if necessary).
- **Module Section** — Describes which X server modules should be loaded.
- **Files Section** — Sets the locations of the RGB (color), modules, and fonts databases.
- **InputDevice Sections** — Separate sections identify keyboard and mouse input devices.
- **Monitor Section** — Sets the type of monitor, along with its horizontal sync rate, vertical refresh rate, and settings needed to operate at different resolutions.
- **Device Section** — Identifies your video card and, optionally, video RAM and clock information for the chipset.
- **Screen Section** — Binds the graphics board and monitor information to be referenced later by the `ServerLayout` section.
- **Keyboard Section** — Sets keyboard settings, including the layout of the keyboard and the way certain key sequences are mapped to the keyboard.
- **Pointer Section** — Selects the pointer you are using (typically a mouse linked to `/dev/mouse`). Also sets speed and button emulation, when appropriate.
- **DRI** — Provides information for Direct Rendering Infrastructure (used for accelerated 3D graphics).

## Configuring Video Cards for Gaming

Some games and video players require special features to work properly (or at all, in some cases). For games that require 3D hardware acceleration, including some that run under TransGaming's WineX, TransGaming recommends using NVIDIA GeForce Graphics cards.

Because only basic NVIDIA video card drivers are included in CentOS (NVIDIA's own drivers are not Open Source), you need to get NVIDIA drivers yourself to use those cards for gaming. You can get Linux NVIDIA drivers from [www.nvidia.com/object/linux.html](http://www.nvidia.com/object/linux.html).

**TIP**

To use hardware DRI acceleration on Voodoo 3 cards, you must have your display set to use 16bpp resolution. On Voodoo 5 cards, only 16bpp and 24bpp resolutions are supported. Voodoo chipsets and other 3DFX technology are now owned by NVIDIA.

## Getting More Information

If you tried configuring X and you still have a server that crashes or has a garbled display, your video card may either be unsupported or may require special configuration. Here are several locations you can check for further information:

- **X.Org** ([www.x.org](http://www.x.org)) — The latest information about the X servers that come with CentOS is available from the X.Org web site. X.Org is the freeware version of X recently used by many major Linux distributions to replace the XFree86 X server.
- **X Documentation** — README files that are specific to different types of video cards are delivered with the X.Org X server. A lot of good information can also be found on the `xorg.conf` man page (type **man xorg.conf**).

## Summary

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The X Window System provides the basis for most graphical user interfaces available for CentOS and other Linux systems today. Although X provides the framework for running and sharing applications, the GNOME, KDE, and Xfce desktop environments, along with a Window Manager and theme, provide the look-and-feel of your desktop.

Using various configuration files and commands, you can change nearly every aspect of your graphical environment. Backgrounds can be assigned a single color or can be filled with single or tiled graphic images. Menus can be changed or enhanced. Multiple virtual workspaces can be used and managed.

After reading this chapter, you should feel comfortable working with the GNOME and KDE desktops. The next chapter should help you work from the traditional command-line interface, referred to as the *shell*.

# Chapter 4

## Using Linux Commands

This chapter presents a view of Linux from the shell. The *shell* is a command-line interpreter that lets you access some of the most critical Linux tools. The shell is powerful, complex, and almost completely unintuitive.

Although at first it isn't obvious how to use the shell, with the right help you can quickly learn many of the most important shell features. In CentOS, `bash` is the shell command interpreter used by default, and therefore, the one used for most of the examples in this chapter. Other shells, such as `csh`, `ksh`, `sh`, and others, are also available and are therefore also noted in this chapter.

This chapter is your guide to working with the Linux system commands, processes, and file system from the shell. It describes the shell environment and helps you tailor it to your needs. It also describes how to use and move around the file system.

### The Shell Interface

---

Throughout this book, there are procedures that require you to use a shell to run commands. How you first get to a shell depends on whether your computer is configured to have a graphical user interface (GUI) or not. A desktop system, by its nature, starts with a GUI. Server systems often are run entirely from the command line. Here are ways of reaching a shell, depending on whether you have a desktop GUI running or not:

#### IN THIS CHAPTER

Understanding the shell

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Using the shell

---

Working with the Linux file system

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Using the `vi` text editor in Linux

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- **No Desktop** — If your Linux system has no GUI (or one that isn't working at the moment), you log in from a text-based prompt and immediately begin working from the shell.
- **With Desktop** — With the GNOME desktop running, you can open a Terminal window (select Applications > Accessories > Terminal) to start a shell. You can begin typing commands into the Terminal window.

If you are using a shell interface, the first thing you see is the shell prompt. The default prompt for a normal user is a dollar sign:

```
$
```

The default prompt for the root user is a pound sign (also called a hash mark or number sign):

```
#
```

If you use a shell other than the default `bash` shell in CentOS, in some cases you may see a percent sign (%) as the user prompt instead of the pound sign. For most Linux systems, the \$ or # prompts are preceded by your username, system name, and current directory name. So, for example, a login prompt for the user named *timothy* on a computer named *zarkov* with */tmp* as the current directory would appear as:

```
[timothy@zarkov tmp]$
```

You can change the prompt to display any characters you like. You could use as your prompt the current directory, the date, the local computer name, or any string of characters. You'll learn more about configuring the prompt later in this chapter in the section, "Setting Your Prompt."

Although a tremendous number of features are available with the shell, it's easy to begin by just typing a few commands. Try some of the commands shown in the remainder of this section to become familiar with your current shell environment.

In the examples that follow, the \$ (for an unprivileged user) or # (for the root user) symbols indicate a prompt. The prompt is followed by the command that you type and then by [Enter]. The lines that follow show the output that results from the command.

## Checking Your Login Session

When you log in to a Linux system, Linux views you as having a particular identity. That identity includes your username, group name, user ID, and group ID. Linux also keeps track of your login session: It knows when you logged in, how long you have been idle, and where you logged in from.

To find out information about your identity, use the `id` command as follows:

```
$ id
uid=500(timothy) gid=500(timothy) groups=10(wheel),100(users),500(timothy)
context=user_u:system_r:unconfined_t
```

This shows that the username is `timothy`, which is represented by the numeric user ID (uid) 500. Here, the primary group for `timothy` is also called `timothy`, which has a group ID (gid) of 500. `timothy` also belongs to other groups called `wheel` (gid 10) and `users` (gid 100). These names and numbers represent the permissions that `timothy` has to access computer resources.

If your computer has SELinux enabled, the `id` command also shows context information. In this example, you see `context=user_u:system_r:unconfined_t` on `id` output. SELinux is discussed later, in Chapter 9.

You can see information about your current login session by using the `who` command. In the following example, the `-m` option tells the `who` command to print information about the current user, `-u` says to add information about idle time and the process ID, and `-H` asks that a header be printed:

```
$ who -u -m -H
NAME          LINE          TIME          IDLE          PID          COMMENT
timothy       pts/1         2009-04-02 14:12  .            7264         (:0.0)
```

You can put multiple single-letter options together after a single dash:

```
$ who -umH
```

The output from this `who` command shows that the username is `timothy`, the user is logged in on `pts/1`, and his login session began at 14:12 on April 2. The IDLE time shows how long the shell has been open without any command being typed (the dot indicates that it is currently active). COMMENT would show the name of the remote computer the user had logged in from, if that user had logged in from another computer on the network, or the name of the local X display if you were using a terminal window (such as `:0.0`).

## NOTE

`pts` stands for *pseudo terminal slave*. The concept of a terminal comes from the old days, when people worked exclusively from character terminals. Today, a terminal typically represents a single person at a single screen.

## Checking Directories and Permissions

Associated with each shell is a location in the Linux file system known as the *current* or *working directory*. As previously mentioned, each user has a directory that is identified as the user's home directory. When you first log in to Linux, you begin with your home directory as the current directory.

When you request to open or save a file, your shell uses the current directory as the point of reference. Simply give a filename when you save a file, and it will be placed in the current directory. Alternatively, you can identify a file by its relation to the current directory (known as a *relative path*). Or you can ignore the current directory and identify a file by the full directory hierarchy that locates it (known as an *absolute path*).

To find out what your current directory is, type the `pwd` command:

```
$ pwd
/usr/bin
```

In this example, the current or working directory is `/usr/bin`. To find out the name of your home directory, type the `echo` command, followed by the `$HOME` variable:

```
$ echo $HOME
/home/timothy
```

In the preceding example, the home directory is `/home/timothy`. To get back to your home directory, you can simply type the change directory (`cd`) command. Although `cd`, followed by a directory name, changes the current directory to the directory that you choose, simply typing `cd` (with no directory name) takes you to your home directory:

```
$ cd
```

You can also use the tilde (`~`) character to indicate the home directory:

```
$ cd ~
```

This is useful when changing to long paths in your home directory, such as `~/local/files` instead of typing `/home/timothy/local/files`.

At this point, list the contents of your home directory, using the `ls` command. Either you can type the full path to your home directory to list its contents, or you can use the `ls` command without a directory name to list the contents of the current directory. Using the `-a` option to `ls` enables you to view the hidden files (files whose names start with a period) as well as all other files. With the `-l` option, you can see a long, detailed list of information on each file.

```
$ ls -la /home/timothy
total 204
drwx----- 15 timothy timothy 4096 Apr 02 10:24 .
drwxr-xr-x  3 root    root    4096 Apr 02 09:12 ..
-rw-----  1 timothy timothy  127 Apr 02 09:56 .bash_history
-rw-r--r--  1 timothy timothy   33 Apr 02 09:12 .bash_logout
-rw-r--r--  1 timothy timothy  176 Apr 02 09:12 .bash_profile
-rw-r--r--  1 timothy timothy  124 Apr 02 09:12 .bashrc
drwxr-xr-x  2 timothy timothy 4096 Apr 02 09:14 Desktop
-rw-----  1 timothy timothy   26 Apr 02 09:14 .dmrc
drwxr-x---  2 timothy timothy 4096 Apr 02 09:14 .eggccups
-rw-----  1 timothy timothy   16 Apr 02 09:24 .esd_auth
drwx-----  4 timothy timothy 4096 Apr 02 10:23 .gconf
drwx-----  2 timothy timothy 4096 Apr 02 10:24 .gconfd
drwxrwxr-x  3 timothy timothy 4096 Apr 02 09:14 .gnome
drwx-----  6 timothy timothy 4096 Apr 02 09:56 .gnome2
drwx-----  2 timothy timothy 4096 Apr 02 09:14 .gnome2_private
drwxrwxr-x  2 timothy timothy 4096 Apr 02 09:14 .gststreamer-0.10
```

```

-rw-r--r--  1 timothy timothy   89 Apr 02 09:14 .gtkrc-1.2-gnome2
-rw-----  1 timothy timothy  159 Apr 02 10:23 .ICEauthority
drwx-----  3 timothy timothy 4096 Apr 02 09:14 .metacity
drwxr-xr-x  4 timothy timothy 4096 Apr 02 09:12 .mozilla
drwxr-xr-x  3 timothy timothy 4096 Apr 02 09:56 .nautilus
-rw-rw-r--  1 timothy users    12 Apr 02 14:24 output.txt
drwxrwxr-x  3 timothy timothy 4096 Apr 02 09:14 .redhat
drwx-----  2 timothy timothy 4096 Apr 02 09:14 .Trash
-rw-----  1 timothy timothy  512 Apr 02 09:21 .viminfo
-rw-r--r--  1 timothy timothy  624 Apr 02 10:23 .xsession-errors

```

Displaying a long list (-l option) of the contents of your home directory shows you more about file sizes and directories. The current directory (given as `.`, which refers to `/home/timothy`) is owned by the user `timothy`, and the directory above the current directory (given as `..`, which refers to `/home`) is owned by `root`. All other files are owned by the user `timothy` (who also belongs to the `timothy` group). The file `output.txt` is owned by `timothy`, but is assigned to the `users` group.

The file or directory names shown on the right are mostly hidden files that are used to store GUI properties (`.gnome` directory) or shell properties (`.bash` files). If you were to run `ls` without the `-a` option, then only the `Desktop` directory and `output.txt` file would be listed since they are the only non-hidden items in the example.

```

$ ls -l /home/timothy
total 16
drwxr-xr-x  2 timothy timothy 4096 Apr 02 09:14 Desktop
-rw-rw-r--  1 timothy users    12 Apr 02 14:24 output.txt

```

At the beginning of each line is the permissions set for each file. The first letter of the permissions set shows what type of file the entry is. `d` denotes a directory, `l` denotes a symbolic link, and `-` denotes a regular file. Permissions and configuring shell property files are described later in this chapter. Other information in the listing includes the size of each file in bytes (column 4) and the date and time each file was most recently modified (column 5).

## NOTE

A *symbolic link* is a file that points to another file, effectively allowing you to have multiple filenames representing a single physical file. Permissions for a symbolic link appear as `lrwxrwxrwx`, but are not interpreted as full Read/Write/Execute permissions. If you try to open a symbolic link, the permissions on the file that link points to (the original file) determine whether or not you can access the file.

## Checking System Activity

In addition to being a multiuser operating system, Linux is also a multitasking system. *Multi-tasking* means that many programs can be running at the same time. An instance of a running program is referred to as a *process*. Linux provides tools for listing running processes, monitoring system usage, and stopping (or killing) processes when necessary.

The most common utility for checking running processes is the `ps` command. With `ps`, you can see which programs are running, the resources they are using, and who is running them. The following is an example of the `ps` command:

```
$ ps u
USER      PID %CPU %MEM    VSZ   RSS  TTY    STAT START  TIME COMMAND
timothy   6256 0.0  0.3  4544   1452 pts/1  Ss   14:53  0:00 bash
timothy   6263 0.0  0.2  4260    964 pts/1  R+   14:53  0:00 ps au
```

Note that `ps` does not use `-` before its options.

In this example, the `u` option asks `ps` to show usernames, as well as other information such as the time the process started and memory and CPU usage. You can have many terminals on one screen by opening multiple Terminal windows.

On this shell session, there isn't much happening. The first process shows that the user named *timothy* is using a `bash` shell, and the second shows that the user has just run the `ps au` command.

The `STAT` column represents the state of the process, with `R` indicating a currently running process and `S` representing a sleeping process. (A *sleeping process* is one that is still active, but is waiting for some event to complete before continuing. It may be waiting for someone to type something at a shell or for a process to send information it requested.) A small `s` indicates a session leader and `+` indicates the foreground process group.

The `USER` column shows the name of the user who started the process. The `a` option can be provided to ask `ps` to show processes of all users who are associated with your current terminal.

```
$ ps au
USER      PID %CPU %MEM    VSZ   RSS  TTY    STAT START  TIME COMMAND
root       5736 0.0  0.0  1664    436 tty1    Ss+  14:50  0:00 /sbin/mingetty
root       5739 0.0  0.0  1668    440 tty2    Ss+  14:50  0:00 /sbin/mingetty
root       5840 0.8  2.3 19020 11216 tty7    Ss+  14:50  0:00 /usr/bin/Xorg
timothy    6256 0.0  0.3  4544   1452 pts/1    Ss   14:53  0:00 bash
timothy    6263 0.0  0.2  4260    964 pts/1    R+   14:53  0:00 ps au
```

Each process is represented by a unique ID number, referred to as a *process ID* (PID). (You can use the PID if you ever need to terminate a runaway process.) The `%CPU` and `%MEM` columns show the percentage of the processor and random access memory, respectively, that the process is consuming. `VSZ` (virtual set size) shows the size of the image process (in kilobytes, KB), and `RSS` (resident set size) shows the size of the program in memory. `START` shows the time the process began running, and `TIME` shows the cumulative system time used.

Many processes running on a computer are not associated with a terminal. A normal Linux system has many processes running in the background. Background system processes perform such tasks as logging system activity or listening for data coming in from the network. They are

often started when Linux boots up and run continuously until it shuts down. To see and thereby monitor all the processes running on your Linux system, type:

```
$ ps aux | less
```

I added the pipe (|) and the `less` command to `ps aux` to allow you to page through the many processes that will appear on your screen. Otherwise, the information will scroll past you, and you will not be able to read all of it. A pipe lets you direct the output of one command to be the input of the next command. Use the spacebar to page through, and type **q** to end the list. You can also use the arrow keys to move one line at a time through the output.

## Exiting the Shell

To exit the shell when you are done, type **exit** or press [Ctrl]+D.

I just showed a few commands designed to familiarize you quickly with your Linux system. Hundreds of other commands that you can try are contained in directories such as `/bin` and `/usr/bin`. There are also administrative commands in `/sbin` or `/usr/sbin` directories.

# Understanding the Shell

---

Before icons and windows took over computer screens, you typed commands to interact with most computers. On UNIX systems, from which Linux was derived, the program used to interpret and manage commands was referred to as the *shell*.

The shell provides a way to run programs, work with the file system, compile computer code, and manage the computer. Although the shell is less intuitive than common GUIs, most Linux experts consider the shell to be much more powerful than GUIs. Because shells have been around for so long, many advanced features have been built into them. Many old-school Linux administrators and programmers primarily use a GUI as a way to open lots of shells.

The Linux shell illustrated in this chapter is called the *bash shell*, which stands for “Bourne Again SHell.” The name is derived from the fact that `bash` is compatible with the first UNIX shell: the Bourne shell (represented by the `sh` command). Other popular shells include the C shell (*csh*), which is popular among BSD UNIX users, and the Korn shell (*ksh*), which is popular among UNIX System V users. Linux also has a *tsh* shell (a C shell look-alike) and an *ash* shell (another Bourne shell look-alike). The default shell in CentOS is `bash`, but you can install `zsh` from the base CentOS repositories.

### NOTE

While you can invoke the Bourne shell with `/bin/sh`, the command actually runs the `bash` shell in `sh` compatibility mode. Running `/bin/sh` produces a shell that behaves more like `sh` than `bash`. The `sh` shell still exists primarily for compatibility with scripts that were written specifically for that shell.

Although most Linux users have a preference for one shell or another, when you know how to use one shell, you can quickly learn any of the others by occasionally referring to the shell's man page (e.g., type **man bash**). The **bash** shell is roughly compatible with the **sh** shell, but **bash** does have many features that **sh** does not.

## Using the Shell in Linux

When you type a command in a shell, you can also include other characters that change or add to how the command works. In addition to the command itself, these are some of the other items that you can type on a shell command line:

- **Options** — Most commands have one or more options you can add to change their behavior. Options typically consist of a single letter, preceded by a dash. You can also often combine several options after a single dash. For example, the command `ls -l a` lists the contents of the current directory. The `-l` asks for a detailed (long) list of information, and the `-a` asks that files beginning with a dot (`.`) also be listed. When a single option consists of a word, it is usually preceded by a double dash (`--`). For example, to use the `Help` option on many commands, you would enter `--help` on the command line. Here's an example of help information for the `ls` command (the output is piped to the `less` command to page through it; type **q** to quit):

```
$ ls --help | less
Usage: ls [OPTION]... [FILE]...
List information about the FILES (the current directory by default).
Sort entries alphabetically if none of the -cftuSUX nor --sort.

Mandatory arguments to long options are mandatory for short options too.
-a, --all                do not hide entries starting with .
-A, --almost-all        do not list implied . and ..
.
.
.
```

- **Arguments** — Many commands also accept arguments after any options are entered. An *argument* is an extra piece of information, such as a filename, that can be used by the command. For example, `cat /etc/passwd` displays the contents of the `/etc/passwd` file on your screen. In this case, `/etc/passwd` is the argument.
- **Environment Variables** — The shell itself stores information that may be useful to the user's shell session in what are called *environment variables*. Examples of environment variables include `$SHELL` (which identifies the shell you are using), `$PS1` (which defines your shell prompt), and `$MAIL` (which identifies the location of your mailbox).

### TIP

You can check your environment variables at any time. Type **declare** to list the current environment variables. Or you can type **echo \$VALUE**, where **VALUE** is replaced by the name of a particular environment variable you want to list.

- **Metacharacters** — These are characters that have special meaning to the shell. Metacharacters can be used to direct the output of a command to a file (>), pipe the output to another command (|), or run a command in the background (&), to name a few. Metacharacters are discussed later in this chapter.

To save you some typing, there are shell features that store commands you want to reuse, recall previous commands, and edit commands. You can create aliases that allow you to type a short command to run a longer one. The shell stores previously entered commands in a history list, which you can display and from which you can recall commands. This is discussed further in the remainder of this section.

Unless you specifically change to another shell, the `bash` shell is the one you use with CentOS. The `bash` shell contains most of the powerful features available in other shells. Although the description in this chapter steps you through many `bash` shell features, you can learn more about the `bash` shell by typing `man bash`. For other ways to learn about using the shell, refer to the sidebar “Getting Help with Using the Shell.”

## Locating Commands

If you know the directory that contains the command you want to run, one way to run it is to type the full path to that command. For example, you run the `date` command from the `/bin` directory by typing:

```
$ /bin/date
```

Of course, this can be inconvenient, especially if the command resides in a directory with a long name. The better way is to have commands stored in well-known directories, and then add those directories to your shell’s `$PATH` environment variable. The path consists of a list of directories that are checked sequentially for the commands you enter. To see your current path, type the following:

```
$ echo $PATH
/usr/kerberos/bin:/usr/local/bin:/usr/bin:/bin:/home/timothy/bin
```

The results show the default path for a regular Linux user. Directories in the path list are separated by colons. Most user commands that come with Linux are stored in the `/bin`, `/usr/bin`, or `/usr/local/bin` directories. The last directory shown is the `bin` directory in the user’s home directory. The `/usr/kerberos/bin` directory precedes other directories so that if you are doing network authentication with Kerberos, the Kerberos versions of many network clients are used instead of the regular Linux versions.

### TIP

If you want to add your own commands or shell scripts, place them in the `bin` directory in your home directory (such as `/home/timothy/bin` for the user named `timothy`). This directory is automatically added to your path (although you must type `mkdir $HOME/bin` to create the directory). As long as you add the command to your `bin` with Execute permission, you can immediately begin using the command by simply typing the command name at your shell prompt. Note that there are always security concerns when adding new commands. This is in part



why your local `bin` directory appears after the system `bin` directories in `$PATH`. Be careful when adding commands, and read the section on “Understanding File Permissions” later in this chapter carefully.

## Getting Help with Using the Shell

When you first start using the shell, it can be intimidating. All you see is a prompt. How do you know which commands are available, which options they use, or how to use more advanced features? Fortunately, lots of help is available. Here are some places you can look to supplement what you learn in this chapter:

- **Check the `PATH`** — Type `echo $PATH`. You see a list of the directories containing commands that are immediately accessible to you. Listing the contents of those directories (with the `ls` command) displays most standard Linux commands.
- **Use the `help` Command** — Some commands are built into the shell, so they do not appear in a directory. The `help` command lists those commands and shows options available with each of them. (Type `help | less` to page through the list.) For help with a particular built-in command, type `help command`, replacing *command* with the name that interests you. The `help` command works with the `bash` shell only.
- **Use `--help` with the Command** — Many commands include a `--help` option that you can use to get information about how the command is used. For example, type `date --help | less`. The output shows not only options, but also time formats you can use with the `date` command.
- **Use the `man` Command** — To learn more about a particular command, type `man command`. (Replace *command* with the command name you want.) The command name `man` is short for “manual.” A description of the command and its options appears on the screen.
- **Use the `pinfo` Command** — Command descriptions that aren’t available on `man` pages are often available for the `info` facility. Type `pinfo command` to see a text-based interface for stepping through information on the command.

The path directory order is important. Directories are checked from left to right. So, in this example, if there is a command called `foo` located in both the `/bin` and `/usr/bin` directories, the one in `/bin` is executed. To have the other `foo` command run, you either type the full path to the command or change your `$PATH` variable.

Not all the commands that you run are located in directories in your `PATH`. Some commands are built into the shell. Other commands can be overridden by creating aliases that define any commands and options that you want the command to run. There are also ways of defining a function that consists of a stored series of commands. Here is the order in which the shell checks for the commands you type:

1. **Aliases** — Names set by the `alias` command that represent a particular command and a set of options. Type **alias** to see what aliases are set. Often, aliases allow you to define a short name for a long, complicated command. Some users use aliases to map a command name from another operating system to the similar utility in Linux.
2. **Shell Reserved Word** — Words that are reserved by the shell for special use. Many of these are words that you would use in programming-type functions, such as `do`, `while`, `case`, and `else`.
3. **Function** — A set of commands that are executed together within the current shell
4. **Built-in Command** — A command that is built into the shell
5. **File System Command** — This is a command that is stored in and executed from the computer's file system. These are the commands that are indicated by the value of the `$PATH` variable.

To find out where a particular command is taken from, you can use the `type` command. For example, to find out where the `bash` shell command is located, type the following:

```
$ type bash
bash is /bin/bash
```

Try these few words with the `type` command to see other locations of commands: `which`, `case`, and `return`. If a command resides in several locations, you can add the `-a` option to have all the known locations of the command printed.

**TIP**

Sometimes you will run a command and receive an error message that the command was not found, or that permission to run the command was denied. In the first case, check that you spelled the command correctly and that it is located in your `PATH`. In the second case, the command may be in the `PATH`, but may not be executable. Adding Execute permissions to a command is described later in this chapter.

## Rerunning Commands

It's annoying, after typing a long or complex command line, to learn that you mistyped something. Fortunately, some shell features let you recall previous command lines, edit those lines, or complete a partially typed command line.

The *shell history* is a list of the commands that you have entered before. Using the `history` command, you can view your previous commands. Then, using various shell features, you can recall individual command lines from that list and change them however you please.

The rest of this section describes how to do command-line editing, how to complete parts of command lines, and how to recall and work with the history list.

## Command-Line Editing

If you type something wrong on a command line, the `bash` shell ensures that you don't have to delete the entire line and start over. Likewise, you can recall a previous command line and change the elements to make a new command.

By default, the `bash` shell uses command-line editing that is based on the `emacs` text editor. So, if you are familiar with `emacs`, you probably already know most of the keystrokes described here.

**TIP**

If you prefer the `vi` command for editing shell command lines, you can easily make that happen. Add the line

```
set -o vi
```

to the `.bashrc` file in your home directory. The next time you open a shell, you can use `vi` commands to edit your command lines.

To do the editing, you can use a combination of control keys, metakeys, and arrow keys. For example, `[Ctrl]+f` means to hold down the [Control] key and type **f**. `[Alt]+f` means to hold down the [Alt] key and type **f**.

To try out a bit of command-line editing, type the following command:

```
$ ls /usr/bin | sort -f | less
```

This command lists the contents of the `/usr/bin` directory, sorts the contents in alphabetical order (regardless of uppercase and lowercase), and pipes the output to `less` (so you can page through the results). Now, suppose you want to change `/usr/bin` to `/bin`. You can use the following steps to change the command from the shell:

1. Press `[Ctrl]+a`. This moves the cursor to the beginning of the command line.
2. Press `[Ctrl]+f` or the right arrow (`→`) key. Repeat this command a few times to position the cursor under the first slash.
3. Press `[Ctrl]+d`. Type this command four times to delete `/usr`.
4. Press `[Enter]`. This executes the command line.

As you edit a command line, at any point you can type regular characters to add those characters to the command line. The characters appear at the location of your cursor. You can use right (`→`) and left (`←`) arrows to move the cursor from one end to the other on the command line. You can also press the up (`↑`) and down (`↓`) arrow keys to step through previous commands in the history list to select a command line for editing.

There are many keystrokes you can use to edit your command lines. Table 4-1 lists the keystrokes that you can use to move around the command line.

TABLE 4-1

### Keystrokes for Navigating Command Lines

Keystroke	Full Name	Meaning
[Ctrl]+f	Character forward	Go forward one character.
[Ctrl]+b	Character backward	Go backward one character.
[Alt]+f	Word forward	Go forward one word.
[Alt]+b	Word backward	Go backward one word.
[Ctrl]+a ([Home] key)	Beginning of line	Go to the beginning of the current line.
[Ctrl]+e ([End] key)	End of line	Go to the end of the line.
[Ctrl]+l	Clear screen	Clear screen and leave line at the top of the screen.

Table 4-2 lists the keystrokes for editing command lines.

TABLE 4-2

### Keystrokes for Editing Command Lines

Keystroke	Full Name	Meaning
[Ctrl]+d	Delete current	Delete the current character.
[Backspace]	Delete previous	Delete the previous character.
[Ctrl]+t	Transpose character	Switch positions of current and previous characters.
[Alt]+t	Transpose words	Switch positions of current and previous words.
[Alt]+u	Uppercase word	Change the current word to uppercase.
[Alt]+l	Lowercase word	Change the current word to lowercase.
[Alt]+c	Capitalize word	Change the current word to an initial capital.
[Ctrl]+v	Insert special character	Add a special character. For example, to add a [Tab] character, press [Ctrl]+v+[Tab].

Table 4-3 lists the keystrokes for cutting and pasting text on a command line.

**TABLE 4-3**

### Keystrokes for Cutting and Pasting Text in Command Lines

Keystroke	Description
[Ctrl]+k	Cut text to the end of the line.
[Ctrl]+u	Cut text to the beginning of the line.
[Ctrl]+w	Cut the word located behind the cursor.
[Alt]+d	Cut the word following the cursor.
[Ctrl]+y	Paste most recently cut text.
[Alt]+y	Rotate back to previously cut text and paste it.
[Ctrl]+c	Cancel the entire command line.

### Command-Line Completion

To save you a few keystrokes, the `bash` shell offers several different ways of completing partially typed values. To attempt to complete a value, type the first few characters, and then press [Tab]. Here are some of the values you can type partially:

- **Environment Variable** — If the text begins with a dollar sign (\$), the shell completes the text with an environment variable from the current shell.
- **Username** — If the text begins with a tilde (~), the shell completes the text with a username. (This is actually just a case of file or directory expansion. For example, `~t i` might expand to `~t i m o t h y /`, which would identify the home directory `/home/timothy`.)
- **Command, Alias, or Function** — If the text begins with regular characters, the shell tries to complete the text with a command, alias, or function name.
- **Filenames** — After a command has been typed, anything beginning with a / or regular characters is completed as a path to a directory or filename. This is one of the most common forms of command-line completion because it can help you traverse directory paths with long names or complete long filenames.
- **Hostname** — If the text begins with an at (@) sign, the shell completes the text with a hostname taken from the `/etc/hosts` file.

#### TIP

To add hostnames from an additional file, you can set the `HOSTFILE` variable to the name of that file. The file must be in the same format as `/etc/hosts`.

Here are a few examples of command completion. (When you see `<Tab>`, it means to press the [Tab] key on your keyboard.) Type the following:

```
$ echo $0S<Tab>
$ cd ~ro<Tab>
$ fing<Tab>
$ cat /etc/redhat-r<Tab>
$ mail root@loc<Tab>
```

The first example causes `$0S` to expand to the `$OSTYPE` variable. In the next example, `~ro` expands to the root user's home directory (`~root/`). Next, `fing` expands to the `finger` command. After that, `/etc/redhat-r` expands to `/etc/redhat-release`, which contains information on your current release of CentOS. Finally, the address of `root@loc` expands to the computer name `localhost`.

Of course, there will be times when there are several possible completions for the string of characters you have entered. In that case, you can check the possible ways text can be expanded by pressing `[Tab]` twice at the point where you want to do completion. The following code shows the result you would get if you checked for possible completions on `$P`:

```
$ echo $P<Tab><Tab>
$PATH                $PPID                $PS1                $PS4
$PIPESTATUS          $PROMPT_COMMAND     $PS2                $PWD
$ echo $P
```

In this case, there are eight possible variables that begin with `$P`. After possibilities are displayed, the original command line returns, ready for you to complete it as you choose.

If text you are trying to complete is not preceded by a `$`, `~`, or `@` (unlike the preceding example), you can still try to complete the text with a variable, username, or hostname. Press the following to complete your text:

- **[Alt]+~** — Complete the text before this point as a username.
- **[Alt]+\$** — Complete the text before this point as a variable.
- **[Alt]+@** — Complete the text before this point as a hostname.
- **[Ctrl]+x+~** — List possible username text completions.
- **[Ctrl]+x+\$** — List possible environment variable completions.
- **[Ctrl]+x+@** — List possible hostname completions.
- **[Ctrl]+x+!** — List possible command name completions.

### TIP

You may find that only the `[Alt]` key on the left side of your keyboard works with the preceding examples. Also, remember that characters such as the tilde (`~`) and dollar sign (`$`) require the `[Shift]` key, as well as the `[Alt]` or `[Ctrl]` keys.

## Command-Line Recall

After you type a command line, that entire command line is saved in your shell's history list. The list is stored in a history file, from which any command can be recalled to run again. After it is recalled, you can modify the command line, as described earlier.

To view your history list, use the `history` command. Type the command without options or followed by a number to list many of the most recent commands. For example:

```
$ history 8
382 date
383 ls /usr/bin | sort -a | more
384 man sort
385 cd /usr/local/bin
386 man more
387 useradd -m /home/timothy -u 500 timothy
388 passwd timothy
389 history 8
```

A number precedes each command line in the list, using an exclamation point (!). Keep in mind that with an exclamation point, the command is run blind, without giving you a chance to confirm. There are several ways to run a command immediately from this list, including the following:

- **Run Command Number (!*n*)** — Replace the *n* with the number of the command line, and the command line indicated is run. For example, to repeat the `date` command shown as command number 382 from the previous history listing, you could type the following:

```
$ !382
date
Thu Apr 02 15:30:35 EST 2008
```

- **Run Previous Command (!!)** — Runs the previous command line. To run that same `date` command again immediately, type the following:

```
$ !!
date
Thu Apr 02 15:30:39 EST 2008
```

- **Run Command Containing String (!?*string*?)** — Runs the most recent command that contains a particular *string* of characters. For example, you could run the `date` command again by just searching for part of that command line as follows:

```
$ !?dat?
date
Thu Apr 02 15:30:42 EST 2008
```

Instead of just running a `history` command line immediately, you can recall a particular line and edit it. You can use these keys to do that:

- **Step** (Arrow Keys) — Press the up (↑) and down (↓) arrow keys to step through each command line in your history list to arrive at the one you want. ([Ctrl]+p and [Ctrl]+n do the same functions, respectively.)
- **Reverse Incremental Search** ([Ctrl]+r) — After you press these keys, you are asked to enter a search string to do a reverse search. As you type the string, a matching command line appears that you can run or edit.
- **Reverse Search** ([Alt]+p) — After you press these keys, you are asked to enter a string to do a reverse search. Type a string and press [Enter] to see the most recent command line that includes that string.
- **Forward Search** ([Alt]+n) — After you press these keys, you are asked to enter a string to do a forward search. Type a string and press [Enter] to see the most recent command line that includes that string.
- **Beginning of History List** ([Alt]+<) — Brings you to the first entry of the history list.
- **End of History List** ([Alt]+>) — Brings you to the last entry of the history list.

Another way to work with your history list is to use the `fc` command. Type `fc` followed by a history line number, and that command line is opened in a text editor. Make the changes that you want. When you exit the editor, the command runs. You can also give a range of line numbers (e.g., `fc 100 105`). All the commands open in your text editor and then run one after the other when you exit the editor.

The history list is stored in the `.bash_history` file in your home directory. Up to 1,000 history commands are stored for you by default. Note that this does serve as a history of your commands, something the root or other users may not want to expose.

## Connecting and Expanding Commands

A truly powerful feature of the shell is the capability to re-direct the input and output of commands to and from other commands and files. To allow commands to be strung together, the shell uses metacharacters. As noted earlier, a *metacharacter* is a typed character that has special meaning to the shell for connecting commands or requesting expansion.

### Piping Commands

The *pipe* (`|`) metacharacter connects the output from one command to the input of another command. This lets you have one command work on some data, and then have the next command deal with the results. Here is an example of a command line that includes pipes:

```
$ cat /etc/passwd | sort | cut -f1,5 -d: | less
```

This command lists the contents of the `/etc/passwd` file and pipes the output to the `sort` command. The `sort` command takes the usernames that begin each line of the `/etc/passwd` file, sorts them alphabetically, and pipes the output to the `cut` command. The `cut` command takes fields 1 and 5, with the fields delimited by a colon (`:`), then pipes the output to the `less` command.



The `less` command displays the output one page at a time, so that you can go through the output a line or a page at a time (press **q** to quit at the end of the output).

Pipes are an excellent illustration of how UNIX, the predecessor of Linux, was created as an operating system made up of building blocks. A standard practice in UNIX was to connect utilities in different ways to get different jobs done. For example, before the days of graphical word processors, users created plaintext files that included macros to indicate formatting. To see how the document really appeared, they used a command such as the following:

```
$ gunzip < /usr/share/man/man1/grep.1.gz | nroff -c -man | less
```

In this example, the contents of the `grep` man page (`grep.1.gz`) are directed as input to the `gunzip` command to be unzipped. The output from `gunzip` is piped to the `nroff` command to format the man page using the manual macro (`-man`). The output is piped to the `less` command to display the output. Because the file being displayed is in plaintext, you could have substituted any number of options to work with the text before displaying it. You could sort the contents, change or delete some of the content, or bring in text from other documents. The key is that, instead of all those features being in one program, you get results from piping and re-directing input and output between multiple commands.

## Sequential Commands

Sometimes you may want a sequence of commands to run, with one command completing before the next command begins. You can do this by typing several commands on the same command line and separating them with semicolons (`;`):

```
$ date ; troff -me very_large_document | lpr ; date
```

In this example, I was formatting a huge document and wanted to know how long it would take. The first command (`date`) showed the date and time before the formatting started. The `troff` command formatted the document and then piped the output to the printer. When the formatting was done, the date and time was printed again (so I knew when the `troff` command completed).

## Background Commands

Some commands can take a while to complete. Sometimes you may not want to tie up your shell waiting for a command to finish. In those cases, you can have the commands run in the background by using the ampersand (`&`).

Text formatting commands (such as `nroff` and `troff`, described earlier) are examples of commands that are often run in the background to format a large document. You also might want to create your own shell scripts that run in the background to check continuously for certain events to occur, such as the hard disk filling up or particular users logging in.

Here is an example of a command being run in the background:

```
$ troff -me very_large_document | lpr &
```

There are other ways to manage background and foreground processes (described in the “Managing Background and Foreground Processes” section later in this chapter).

## Expanding Commands

With command substitution, you can have the output of a command interpreted by the shell instead of by the command itself. In this way, you can have the standard output of a command become an argument for another command. The two forms of command substitution are `$(command)` or `'command'`. (The first case is the preferred method.)

The command in this case can include options, metacharacters, and arguments. Here is an example of using command substitution:

```
$ vi $(find /home | grep xyz123)
```

In this command line, the command substitution is done before the `vi` command is run. First, the `find` command starts at the `/home` directory and prints out all files and directories below that point in the file system. This output is piped to the `grep` command, which filters out all files except for those that include the text `xyz123`. Finally, the `vi` command opens all filenames for editing (one at a time) that include `xyz123`.

This particular example might be useful if you knew that you wanted to edit a file for which you knew the name but not the location. As long as the string was uncommon, you could find and open every instance of a filename existing beneath a point you choose in the file system.

## Expanding Arithmetic Expressions

There may be times when you want to pass arithmetic results to a command. There are two forms you can use to expand an arithmetic expression and pass it to the shell: `$(expression)` or `$( (expression) )`. Here is an example:

```
$ echo "I am $[2009 - 1979] years old."  
I am 30 years old.
```

In this example, the shell interprets the arithmetic expression first (`2009 - 1979`), and then passes that information to the `echo` command. The `echo` command displays the text, with the results of the arithmetic (`30`) inserted.

## Expanding Variables

Environment variables that store information within the shell can be expanded using the dollar sign (\$) metacharacter. When you expand an environment variable on a command line, the value of the variable is printed instead of the variable name itself, as follows:

```
$ ls -l $BASH
-rwxr-xr-x 1 root  root  625516 Apr 02 09:12 /bin/bash
```

Using \$BASH as an argument to `ls -l` causes a long listing of the `bash` command to be printed. For more information on shell environment variables, see the following section.

## Using Shell Environment Variables

Every active shell stores pieces of information that it needs to use in what are called *environment variables*. An environment variable can store things such as locations of configuration files, mailboxes, and path directories. They can also store values for your shell prompts, the size of your history list, and type of operating system.

To see the environment variables currently assigned to your shell, type the `declare` command. (It will probably fill more than one screen, so type `declare | less`.) You can refer to the value of any of those variables by preceding it with a dollar sign (\$) and placing it anywhere on a command line. For example:

```
$ echo $USER
timothy
```

This command prints the value of the `USER` variable, which holds your username (*timothy*). Substitute any other variable name for `USER` to print its value instead.

## Common Shell Environment Variables

When you start a shell (by logging in or opening a Terminal window), a lot of environment variables are already set. Here are some variables that are either set when you use a `bash` shell or that can be set by you to use with different features:

- `BASH` — Contains the full path name of the `bash` command. This is usually `/bin/bash`.
- `BASH_VERSION` — A number of the current version of the `bash` command
- `EUID` — This is the effective user ID number of the current user. It is assigned when the shell starts, based on the user's entry in the `/etc/passwd` file.
- `FCEDIT` — If set, this variable indicates the text editor used by the `fc` command to edit `history` commands. If this variable isn't set, the `vi` command is used. By default, this variable is not set.
- `HISTFILE` — The location of your history file. It is typically located at `$HOME/.bash_history`.

- HISTFILESIZE — The number of history entries that can be stored. After this number is reached, the oldest commands are discarded. The default value is 1,000.
- HISTCMD — This returns the number of the current command in the history list.
- HOME — This is your home directory. It is your current working directory each time you log in or type the `cd` command with any options.
- HOSTTYPE — A value that describes the computer architecture on which the Linux system is running. For Intel-compatible PCs, the value is `i386`, `i486`, `i586`, `i686`, or something like `i386-linux`. For AMD 64-bit and Intel EM64T machines, the value is `x86_64`. There is also `ppc` and `ppc64`, for Apple computers (PowerPC 32-bit and 64-bit).
- MAIL — This is the location of your mailbox file. The file is typically your username in the `/var/spool/mail` directory.
- OLDPWD — The directory that was the working directory before you changed to the current working directory
- OSTYPE — A name identifying the current operating system. For CentOS, the `OSTYPE` value is either `linux` or `linux-gnu`, depending on the type of shell you are using. (`bash` can run on other operating systems as well).
- PATH — The colon-separated list of directories used to find commands that you type. The default value for regular users is:  

```
/usr/kerberos/bin:/usr/local/bin:/usr/bin:/bin:/home/timothy/bin
```
- For the root user, the value also includes `/sbin`, `/usr/sbin`, and `/usr/local/sbin`.
- PPID — The process ID of the command that started the current shell (e.g., its parent process).
- PROMPT\_COMMAND — Can be set to a command name that is run each time before your shell prompt is displayed. Setting `PROMPT_COMMAND=date` lists the current date and time before the prompt appears.
- PS1 — Sets the value of your shell prompt. There are many items that you can read into your prompt (date, time, username, hostname, etc.). Sometimes a command requires additional prompts, which you can set with the variables `PS2`, `PS3`, and so on. (Setting your prompt is described later in this chapter.)
- PWD — This is the directory that is assigned as your current directory. This value changes each time you change directories using the `cd` command.
- RANDOM — Accessing this variable causes a random number to be generated. The number is between 0 and 32,767.
- SECONDS — The number of seconds since the time the shell was started.
- SHLVL — The number of shell levels associated with the current shell session. When you log in to the shell, the `SHLVL` is 1. Each time you start a new `bash` command (e.g., by using `su` to become a new user, or by simply typing `bash`), this number is incremented.
- TMOUT — Can be set to a number representing the number of seconds the shell can be idle without receiving input. After the number of seconds is reached, the shell exits. This is a

security feature that makes it less likely for unattended shells to be accessed by unauthorized people. (This must be set in the login shell for it to actually cause the shell to log out the user. You can use it in any terminal session to close the current shell after a set number of seconds, e.g., `TMOUT=30`.)

- **UID** — The user ID number assigned to your username. The user ID number is stored in the `/etc/passwd` file.

## Setting Your Own Environment Variables

Environment variables can provide a handy way of storing bits of information that you use often from the shell. You can create any variables that you want (avoiding those that are already in use) so that you can read in the values of those variables as you use the shell. The `bash` man page lists variables already in use.

To set an environment variable temporarily, you can simply type a variable name and assign it to a value. Here is an example:

```
$ CB=/home/timothy/Documents/writing/CentOS_Bible/ ; export CB
```

This example causes a long directory path to be assigned to the `$CB` variable. The `export CB` command says to export the value to the shell so that it can be propagated to other shells you may open. With `$CB` set, you can go to the directory by typing the following:

```
$ cd $CB
```

### NOTE

You may have noticed that the environment variables shown here are in all caps. Although case does matter with these variables, setting them as uppercase is a convention, not a necessity. You could just as easily name a new variable `xyz` as `XYZ` (variables are case-sensitive so these are not the same, but either will work if you use case consistently). System environment variables, such as `PATH`, are always uppercase.

The problem with setting environment variables in this way is that as soon as you exit the shell in which you set the variable, the setting is lost. To set variables more permanently, you should add variable settings to a `bash` configuration file, as described later in this section.

If you want to have other text right up against the output from an environment variable, you can surround the variable in braces. This protects the variable name from being misunderstood. For example, if you want to add a command name to the `$CB` variable shown earlier, you can type the following:

```
$ echo ${CB}wordcount
/home/tboronczyk/Documents/Writing/CentOS_Bible/wordcount
```

Remember that you must export the variable so that it can be picked up by other shell commands beyond the current shell, especially outside of a shell script. You must add the `export` line to a shell configuration file for it to take effect the next time you log in. The `export`

command is fairly flexible. Instead of running the `export` command after you set the variable, you can do it all in one step, as follows:

```
$ export XYZ=/home/xyz/bin
```

You can override the value of any environment variable. This can be temporary by simply typing the new value. Or you can add the new `export` line to your `$HOME/.bashrc` file. One useful variable to update is `PATH`. Here is an example:

```
$ export PATH=$PATH:/home/xyz/bin
```

In this example, I added the `/home/xyz/bin` directory to the `$PATH`, a useful technique if you want to run a bunch of commands from a directory that is not normally in your `$PATH`, without typing the full or relative path each time. Remember that the order of the `PATH` is important. If `/home/xyz/bin/ls` preceded by `$PATH` and the `/home/xyz/bin/ls` command existed, typing `ls` would use that command instead of `/bin/ls`.

If you decide that you no longer want a variable to be set, you can use the `unset` command to erase its value. For example, you could type **`unset XYZ`**, which would cause `$XYZ` to have no value set. Remember to remove the `export` from the `$HOME/.bashrc` file — if you added it there — or it will return the next time you open a shell.

## Managing Background and Foreground Processes

If you are using Linux over a network or from a *dumb* terminal (a monitor that allows only text input with no GUI support), your shell may be all that you have. You may be used to a windowing environment where you have a lot of programs active at the same time so that you can switch among them as needed. This shell thing can seem pretty limited.

### NOTE

One way to overcome the limitations of a single shell is to use the `screen` command. `screen` allows you to have multiple shells open at the same time, as well as disconnect and reconnect to different shell sessions without completely closing them. Install the `screen` package to use the `screen` command. Type **`man screen`** to read about the `screen` command.

Although the `bash` shell doesn't include a GUI for running many programs, it does let you move active programs between the background and foreground. In this way, you can have a lot of stuff running, while selectively choosing the one you want to deal with at the moment.

There are several ways to place an active program in the background. One mentioned earlier is to add an ampersand (`&`) to the end of a command line. Another way is to use the `at` command to run commands in a way in which they are not connected to the shell. (See Chapter 11 for more information about the `at` command.)

To stop a running command and put it in the background, press `[Ctrl]+z`. After the command is stopped, you can either bring it to the foreground to run (the `fg` command) or start it running in the background (the `bg` command).

## Starting Background Processes

If you have programs that you want to run while you continue to work in the shell, you can place the programs in the background. To place a program in the background at the time you run the program, type an ampersand (&) at the end of the command line. For example:

```
$ find /usr > /tmp/allusrfiles &
```

This command finds all files on your Linux system (starting from /usr), prints those filenames, and puts those names in the file /tmp/allusrfiles. The ampersand (&) runs that command line in the background. To check which commands you have running in the background, use the `jobs` command, as follows:

```
$ jobs
[1] Stopped (tty output) vi /tmp/myfile
[2] Running find /usr -print > /tmp/allusrfiles &
[3] Running nroff -man /usr/man2/* >/tmp/man2 &
[4]- Running nroff -man /usr/man3/* >/tmp/man3 &
[5]+ Stopped nroff -man /usr/man4/* >/tmp/man4
```

The first job shows a text-editing command (`vi`) that I placed in the background and stopped by pressing `[Ctrl]+z` while I was editing. Job 2 shows the `find` command I just ran. Jobs 3 and 4 show `nroff` commands currently running in the background. Job 5 had been running in the shell (foreground) until I decided too many processes were running and pressed `[Ctrl]+z` to stop Job 5 until a few processes had completed.

The plus sign (+) next to number 5 shows that it was most recently placed in the background. The minus sign (-) next to number 4 shows that it was placed in the background just before the most recent background job. Because Job 1 requires terminal input, it cannot run in the background. As a result, it is Stopped (preventing terminal output or input) until it is brought to the foreground again.

### TIP

To see the process ID for the background job, add the `-l` option to the `jobs` command. If you type `ps`, you can use the process ID to figure out which command is for a particular background job.

## Moving Commands to the Foreground and Background

Continuing with the example, you can bring any of the commands on the jobs list to the foreground. For example, to edit `myfile` again, type:

```
$ fg %1
```

You can skip the percent sign (%) if you wish. As a result, the `vi` command opens again, with all text as it was when you stopped the `vi` job.

### CAUTION

Before you put a text processor, word processor, or similar program in the background, make sure you save your file. It's easy to forget you have a program in the background and you will lose your data if you log out or the computer reboots later on.

To refer to a background job (to cancel or bring it to the foreground), use a percent sign (%) followed by the job number. You can also use the following to refer to a background job:

- % — A percent sign alone refers to the most recent command put into the background (indicated by the + sign). This action brings the command to the foreground.
- %*string* — Refers to a job where the command begins with a particular string of characters. The string must be unambiguous. (In other words, typing %*vi* when there are two *vi* commands in the background results in an error message.)
- %?*string* — Refers to a job where the command line contains a string at any point. The string must be unambiguous or the match will fail.
- %- — Refers to the previous job stopped before the one most recently stopped.

If a command is stopped, you can start it running again in the background using the `bg` command. For example, take Job number 5 from the jobs list in the previous example:

```
[5]+ Stopped          nroff -man man4/* >/tmp/man4
```

Type the following:

```
$ bg %5
```

After that, the job runs in the background. Its jobs entry appears as follows:

```
[5]  Running          nroff -man man4/* >/tmp/man4 &
```

If you would like to run a job in the background and have it continue to run after you close the shell from which you ran it, you can run that command by preceding it with the `nohup` command. For example, to update your `locate` database (which stores all files on your system so you can find them easily with the `locate` command) so it will keep running after you exit the shell, type the following command:

```
# nohup updatedb &
```

## Configuring Your Shell

You can tune your shell to help you work more efficiently. Your prompt can provide pertinent information each time you press [Enter]. You can set aliases to save your keystrokes and permanently set environment variables to suit your needs. To make each change occur when you start a shell, you can add this information to your shell configuration files.

Several configuration files support how your shell behaves. Some of the files are executed for every user and every shell. Others are specific to the user who creates the configuration file. Here are the files that are of interest to anyone using the `bash` shell in Linux:

- **/etc/profile** — This file sets up user environment information for every user. It is executed when you first log in. This file provides values for your path, as well as setting environment variables for such things as the location of your mailbox and the size of your history



files. Finally, `/etc/profile` gathers shell settings from configuration files in the `/etc/profile.d` directory. Note that you can override all of these settings in other start-up files.

- **`/etc/bashrc`** — By default, this file is executed for every user who runs the `bash` shell, each time a `bash` shell is opened. It sets the default prompt and may add one or more aliases. Values in this file can be overridden by information in each user's `~/.bashrc` file.
- **`~/.bash_profile`** — This file is used by each user to enter information that is specific to his or her own use of the shell. It is executed only once, when the user logs in. By default, it sets a few environment variables and executes the user's `.bashrc` file. You can instead create a file named `~/.bash_login` to serve the same purpose as `~/.bash_profile`.
- **`~/.bashrc`** — This file contains the information that is specific to your `bash` shells. It is read when you log in and also each time you open a new `bash` shell. This is the best location to add environment variables and aliases so that your shell picks them up.
- **`~/.bash_logout`** — This file executes each time you log out (exit the last `bash` shell). By default, it simply clears your screen.

To change the `/etc/profile` or `/etc/bashrc` files, you must be the root user. Users can change the information in the `$HOME/.bash_profile`, `$HOME/.bashrc`, and `$HOME/.bash_logout` files in their own home directories.

The following sections provide ideas about items to add to your shell configuration files. In most cases, you add these values to the `.bashrc` file in your home directory. However, if you administer a system, you may want to set some of these values as defaults for all of your Linux system's users.

## Setting Your Prompt

Your prompt consists of a set of characters that appear each time the shell is ready to accept a command. The `PS1` environment variable sets what the prompt contains. If your shell requires additional input, it uses the values of `PS2`, `PS3`, and `PS4`.

When your CentOS system is installed, your prompt is set to include the following information: your username, your hostname, and the base name of your current working directory. That information is surrounded by brackets and followed by a dollar sign (for regular users) or a pound sign (for the root user). Here's an example of that prompt:

```
[timothy@zarkov ~]$
```

When you change directories, the directory name changes to the name of the new directory. Likewise, if you were to log in as a different user or to a different host, that information would change.

You can use several special characters (indicated by adding a backslash to a variety of letters) to include different information in your prompt. These can include your terminal number, the date, and the time, as well as other pieces of information. Here are some examples:

- `\!` — Shows the current command history number. This includes all previous commands stored for your username.
- `\#` — Shows the command number of the current command. This includes only the commands for the active shell.
- `\$` — Shows the user prompt (`$`) or root prompt (`#`), depending on which user you are. Note that `\$` is specially set up at login. After login, using `\$` will result in a prompt with a dollar sign. The special support for `#` only occurs in the shell start-up files.
- `\W` — Shows only the current working directory base name. For example, if the current working directory was `/var/spool/mail`, this value would simply appear as `mail`.
- `\[` — Precedes a sequence of nonprinting characters. This could be used to add a terminal control sequence into the prompt for such things as changing colors, adding blink effects, or making characters bold. (Your terminal determines the exact sequences available.)
- `\]` — Follows a sequence of nonprinting characters.
- `\\` — Shows a backslash.
- `\d` — Displays the day, month, and number of the date. For example: `Sat Jan 23`.
- `\h` — Shows the hostname of the computer running the shell.
- `\n` — Causes a newline to occur.
- `\nnn` — Shows the character that relates to the octal number replacing `nnn`.
- `\s` — Displays the current shell name. For the `bash` shell, the value would be `bash`.
- `\t` — Prints the current time in hours, minutes, and seconds (e.g., `10:14:39`).
- `\u` — Prints your current username.
- `\w` — Displays the full path to the current working directory.

**TIP**

If you are setting your prompt temporarily by typing at the shell, you should put the value of `PS1` in quotes. For example, you could type `export PS1="[ \t \w] \$ "` to see a prompt that looks like this: `[20:26:32 /var/spool] $`.

To make a change to your prompt permanent, add the value of `PS1` to your `.bashrc` file in your home directory (assuming that you are using the `bash` shell). There may already be a `PS1` value in that file that you can modify. Refer to the Bash Prompt HOWTO at [www.tldp.org/HOWTO/Bash-Prompt-HOWTO](http://www.tldp.org/HOWTO/Bash-Prompt-HOWTO) for information on changing colors, commands, and other features for your `bash` shell prompt.

## Adding Environment Variables

You may consider adding a few environment variables to your `.bashrc` file. These can help make working with the shell more efficient and effective:

- `TMOUT` — This sets how long the shell can be inactive before `bash` automatically exits. The value is the number of seconds for which the shell has not received input. This can be a nice security feature, in case you leave your desk while you are still logged in to

Linux. To avoid getting logged off while you are working, you may want to set the value to something like `TMOU=1800` (to allow 30 minutes of idle time), or simply do not set this variable to disable this feature.

- **PATH** — As described earlier, the `$PATH` variable sets the directories that are searched for commands you use. If you often use directories of commands that are not in your `PATH`, you can permanently add them. To do this, add a `$PATH` variable to your `.bashrc` file. For example, to add a directory called `/example/bin`, add the following:

```
PATH=$PATH:/example/bin ; export PATH
```

- This example first reads all the current path directories into the new `PATH` (`$PATH`), adds the `/example/bin` directory, and then exports the new `PATH`.

### CAUTION

Some people add the current directory to their `PATH` by adding a directory identified simply as a dot (`.`), as follows:

```
PATH=.:$PATH ; export PATH
```

This lets you always run commands in your current directory. However, the security risk with this procedure is that you could be in a directory that contains a command that you don't intend to run from that directory. For example, a malicious person could put an `ls` command in a directory that, instead of listing the content of your directory, does something devious.

- **WHATEVER** — You can create your own environment variables to provide shortcuts in your work. Choose any name that is not being used and assign a useful value to it. For example, if you do a lot of work with files in the `/work/time/files/info/memos` directory, you could set the following variable:

```
M=/work/time/files/info/memos ; export M
```

- You can make that your current directory by typing `cd $M`. You can run a program called `reminder` from that directory by typing `$M/reminder`. You can edit a file called `cellphone_policy.txt` from there by typing `vi $M/cellphone_policy.txt`.

## Adding Aliases

Setting aliases can save you even more typing than setting environment variables. With aliases, you can have a string of characters execute an entire command line. You can add and list aliases with the `alias` command. Here are some examples:

```
alias p='pwd ; ls -CF'
alias rm='rm -i'
```

In the first example, the letter `p` is assigned to run the command `pwd`, and then to run `ls -CF` to print the current working directory and list its contents in column form. The second runs the `rm` command with the `-i` option each time you simply type `rm`. This is an alias that is set by default in CentOS for the root user, so that instead of just removing files, you are prompted for

each individual file removal. This prevents you from removing all the files in a directory by mistakenly typing something such as `rm *`.

While you are in the shell, you can check which aliases are set by typing the `alias` command. If you want to remove an alias, you can type `unalias`. Remember, that if the `alias` is set in a configuration file, it will be set again when you open another shell.

## Working with the Linux File System

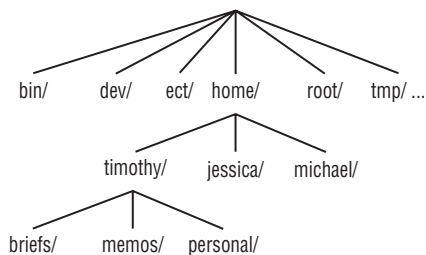
The Linux file system is the structure in which all the information on your computer is stored. Files are organized within a hierarchy of directories. Each directory can contain files, as well as other directories.

If you were to map out the files and directories in Linux, it would look like an upside-down tree. At the top is the root directory, which is represented by a single slash (`/`). Below that is a set of common directories in the Linux system, such as `bin`, `dev`, `home`, `lib`, and `tmp`, to name a few. Each of those directories, as well as directories added to the root, can contain subdirectories.

Figure 4-1 illustrates how the Linux file system is organized as a hierarchy. To illustrate how directories are connected, Figure 4-1 shows a `/home` directory that contains subdirectories for three users: `timothy`, `jessica`, and `michael`. Within the `timothy` directory are subdirectories: `briefs`, `memos`, and `personal`. To refer to a file called `inventory` in the `timothy/memos` directory, you could type the full path of **`/home/timothy/memos/inventory`**. If your current directory were `/home/timothy/memos`, you could refer to the file as simply `inventory`.

**FIGURE 4-1**

The Linux file system is organized as a hierarchy of directories.



The following Linux directories may be of interest to you:

- **`/bin`** — Contains common Linux user commands, such as `ls`, `sort`, `date`, and `chmod`.
- **`/boot`** — Has the bootable Linux kernel and boot loader configuration files (GRUB).

- **/dev** — Contains files representing access points to devices on your systems. These include terminal devices (`tty*`), floppy disks (`fd*`), hard disks (`hd*` or `sd*`), RAM (`ram*`), and CD-ROM (`cd*`). (Applications normally access these devices directly through the device files, but end-users rarely access them directly.)
- **/etc** — Contains administrative configuration files.
- **/home** — Contains directories assigned to each user with a login account.
- **/media** — Provides a location for mounting devices, such as remote file systems and removable media (with directory names of `cdrom`, `floppy`, etc.). In CentOS, many removable media are mounted automatically in this directory when the media is inserted (CD or DVD) or connected (USB pen drives or cameras).
- **/proc** — Provides a mechanism for the kernel to send information to processes.
- **/root** — Represents the root user's home directory.
- **/sbin** — Contains administrative commands and daemon processes.
- **/sys** — A `/proc`-like file system, added with the Linux 2.6 kernel and intended to contain files for getting hardware status and reflecting the system's device tree as it is seen by the kernel. It pulls many of its functions from `/proc`.
- **/tmp** — Contains temporary files used by applications.
- **/usr** — Contains user documentation, games, libraries (`lib`), and a variety of other user and administrative commands and files.
- **/var** — Contains directories of data used by various applications. In particular, this is where you would place files that you share as an FTP server (`/var/ftp`) or a Web Server (`/var/www`). It also contains all system log files (`/var/log`). In time, FTP, HTTP, and similar services will move to the `/srv` directory to adhere to the Linux Standards Base ([www.freestandards.org/spec](http://www.freestandards.org/spec)).

## Linux File Systems versus Windows-Based File Systems

Although similar in many ways, the Linux file system has some striking differences from file systems used in Windows operating systems. Here are a few:

- In Microsoft Windows file systems, drive letters represent different storage devices (e.g., A: is a floppy drive and C: is a hard disk). In Linux, all storage devices are fit into the file system hierarchy. So, the fact that all of `/usr` may be on a separate hard disk or that `/mnt/rem1` is a file system from another computer is invisible to the user.
- Slashes, rather than backslashes, are used to separate directory names in Linux. So, `C:\home\timothy` in an MS system is `/home/timothy` in a Linux system.

*continued*

*continued*

- Filenames almost always have suffixes in DOS (such as .txt for text files or .doc for word-processing files). Although at times you can use that convention in Linux, three-character suffixes have no required meaning in Linux. They can be useful for identifying a file type.
- Every file and directory in a Linux system has permissions and ownership associated with it. Security varies among Microsoft systems. Because Windows began as single-user systems, file ownership was not built into those systems when they were designed. Later releases added features such as file and folder attributes to address this problem.

## Creating Files and Directories

As a CentOS user, most of the files you save and work with will probably be in your home directory. Here are commands you use to create and use files and directories:

- `cd` — Change to another directory.
- `pwd` — Print the name of the current working directory.
- `mkdir` — Create a directory.
- `chmod` — Change the permission on a file or directory.
- `ls` — List the contents of a directory.

The following procedure steps you through creating directories within your home directory, moving among your directories, and setting appropriate file permissions:

1. Go to your home directory. To do this, simply type `cd`. (For other ways of referring to your home directory, see the “Identifying Directories” sidebar.)
2. To make sure that you got to your home directory, type `pwd`. When I do this, I get the following response (yours will reflect your home directory):

```
$ pwd
/home/timothy
```

3. Create a new directory called `test` in your home directory, as follows:

```
$ mkdir test
```

4. Check the permissions of the directory by typing:

```
$ ls -ld test
drwxr-xr-x 2 timothy timothy 1024 2009-04-02 12:17 test
```

Notice that this listing says that `test` is a directory (`d`), the owner is `timothy`, the group is `timothy`, and the file was most recently modified on April 2 at 12:17 p.m. Suppose that you want to prevent everyone else who uses this computer from using or

viewing the files in this directory. The permissions for the directory are `rwxr-xr-x`. I explain what these permissions mean later in this section.

**NOTE**

When you add a new user in CentOS, by default, the user is assigned to a group of the same name. You've seen this in several examples so far where the user `timothy` is assigned to the group `timothy`. This approach to assigning groups is referred to as the *user private group* scheme. For more information on user private groups, refer to Chapter 10.

5. For now, type the following:

```
$ chmod 700 test
```

This step changes the permissions of the directory to give you complete access and everyone else no access at all. The new permissions should read like `rwX-----`.

6. Make the test directory your current directory as follows:

```
$ cd test
```

## Identifying Directories

When you need to identify your home directory on a shell command line, you can use the following:

- `$HOME` — This environment variable stores your home directory name.
- `~` — The tilde (`~`) represents your home directory on the command line.

You can also use the tilde to identify someone else's home directory. For example, `~timothy` would be expanded to the `timothy` user's home directory (probably `/home/timothy`).

Other special ways of identifying directories in the shell include the following:

- `.` — A single dot (`.`) refers to the current directory.
- `..` — Two dots (`..`) refers to a directory directly above the current directory.
- `$PWD` — This environment variable refers to the current working directory.
- `$OLDPWD` — This environment variable refers to the previous working directory before you changed to the current one.

## Using Metacharacters and Operators

To make more efficient use of your shell, the `bash` shell lets you use certain special characters, referred to as *metacharacters* and *operators*. *Metacharacters* can help you match one or more files without typing each filename completely. *Operators* let you direct information from one command or file to another command or file.

## Using File-Matching Metacharacters

To save you some keystrokes and to be able to refer easily to a group of files, the `bash` shell lets you use metacharacters. Anytime you need to refer to a file or directory, such as to list it, open it, or remove it, you can use metacharacters to match the files you want. Here are some useful metacharacters for matching filenames:

- `*` — This matches any number of characters.
- `?` — This matches any one character.
- `[...]` — This matches any one of the characters between the brackets, which can include a dash-separated range of letters or numbers.

To try out some of these file-matching metacharacters, go to an empty directory (such as the test directory described in the previous section) and create some files. Here's an example of how to create some empty files (although the `touch` command is more commonly used to assign the current date and time to an existing file than to create new ones):

```
$ touch apple banana grape grapefruit watermelon
```

The next few commands show you how to use shell metacharacters to match filenames so they can be used as arguments to the `ls` command. Using the metacharacters shown in the code that follows, you can match the filenames you just created with the `touch` command. Type the following commands and see if you get the same responses:

```
$ ls a*
apple
$ ls g*
grape
grapefruit
$ ls g*t
grapefruit
$ ls *e*
apple grape grapefruit watermelon
$ ls *n*
banana watermelon
```

The first example matches any file that begins with an *a* (*apple*). The next example matches any files that begin with *g* (*grape*, *grapefruit*). Next, files beginning with *g* and ending in *t* are matched (*grapefruit*). Next, any file that contains an *e* in the name is matched (*apple*, *grape*, *grapefruit*, *watermelon*). Finally, any file that contains an *n* is matched (*banana*, *watermelon*).

Here are a few examples of pattern matching with the question mark (?):

```
$ ls ???e
apple grape
$ ls g???e*
grape grapefruit
```



The first example matches any five-character file that ends in *e* (*apple*, *grape*). The second matches any file that begins with *g* and has *e* as its fifth character (*grape*, *grapefruit*).

Here are a few examples of using brackets to do pattern matching:

```
$ ls [abw]*
apple banana watermelon
$ ls [agw]*[ne]
apple grape watermelon
```

In the first example, any file beginning with *a*, *b*, or *w* is matched. In the second, any file that begins with *a*, *g*, or *w* and also ends with either *n* or *e* is matched. You can also include ranges within brackets. For example:

```
$ ls [a-g]*
apple banana grape grapefruit
```

Here, any filenames beginning with a letter from *a* through *g* is matched.

## Using File Re-Direction Metacharacters

Commands receive data from standard input and send it to standard output. Standard input is normally user input from the keyboard, and standard output is normally displayed on the screen. Using pipes (described earlier), you can direct standard output from one command to the standard input of another. With files, you can use less-than (<) and greater-than (>) signs to direct data to and from files. Here are the file re-direction characters:

- < — Direct the contents of a file as input to the command (because many commands take a filename as an option, the < key is not usually needed).
- > — Direct the output of a command to a file, overwriting any existing file.
- >> — Direct the output of a command to a file, adding the output to the end of the existing file.

Here are some examples of command lines where information is directed to and from files:

```
$ mail root < ~/.bashrc
$ man chmod | col -b > /tmp/chmod
$ echo "Finished task on $(date)" >> ~/projects
```

In the first example, the contents of the `.bashrc` file in the home directory are sent in a mail message to the computer's root user. The second command line formats the `chmod` man page (using the `man` command), removes extra back spaces (`col -b`), and sends the output to the file `/tmp/chmod` (erasing the previous `/tmp/chmod` file, if it exists). The final command results in the following text being added to the user's project file:

```
Finished task on Thu Apr 02 13:46:49 EST 2008
```

You could also pipe the output of the previous command to another command. For example, the following command line would send the line just shown in a mail message to `example@example.com`:

```
$ echo "Finished task on $(date)" | mail -s 'Task Complete'
example@example.com
```

## Understanding File Permissions

After you've worked with Linux for a while, you are almost sure to get a "Permission denied" message. Permissions associated with files and directories in Linux were designed to keep users from accessing other users' private files and to protect important system files.

The 9 bits assigned to each file for permissions define the access that you and others have to your file. Permission bits appear as `rw-rw-rw-`. The first 3 bits apply to the owner's permission, the next 3 apply to the group assigned to the file, and the last 3 apply to all others. The `r` stands for read, the `w` stands for write, and the `x` stands for execute permissions. If a dash appears instead of the letter, it means that permission is turned off for that associated Read, Write, or Execute.

You can see the permission for any file or directory by typing the `ls -ld` command. The named file or directory appears as those shown in the following example:

```
$ ls -ld ch3 test
-rw-rw-r-- 1 timothy timothy 4983 Apr 02 22:13 ch3
drwxr-xr-x 2 timothy timothy 1024 Apr 02 13:47 test
```

The first line shows a file (`ch3`) that has Read and Write permission for the owner and the group. All other users have Read permission, which means they can view the file but cannot change its contents (although a user may be allowed to remove the file, since the ability to remove a file is based on directory permissions). The second line shows a directory (indicated by the letter `d` before the permission bits). The owner has Read, Write, and Execute permission, while the group and other users have only Read and Execute permissions. As a result, only the owner can add, change, or delete files in that directory. Any other user, however, can only read the contents, change to that directory, and list the contents of the directory. (Note that by using the `-d` option, the `test` directory entry is listed without listing its contents.)

If you own a file, you can change the permission on it as you please. You can do this with the `chmod` command. For each of the three sets of permission on a file (Read, Write, and Execute), `r` is assigned to the number 4, `w` to 2, and `x` to 1. So to make permissions wide open for yourself as owner, you would set the first number to 7 (4 + 2 + 1). The same would be true for group and other permissions. Any combination of permissions can result from 0 (no permission) through 7 (full permission).

Here are some examples of how to change permission on a file and what the resulting permission would be:

```

chmod 777 files → rwxrwxrwx
chmod 755 files → rwxr-xr-x
chmod 644 files → rw-r--r-
chmod 000 files → -----

```

You can also turn file permissions on and off using plus (+) and minus (-) signs, respectively. This can be done for the owner user (u), owner group (g), others (o), and all users (a). For example, each time starting with a file that has all permissions open (rwxrwxrwx), here are some chmod examples with resulting permissions after using a minus sign:

```

chmod a-w files → r-xr-xr-x
chmod o-x files → rwsrwsrw-
chmod go-rwx files → rwx-----

```

Likewise, here are some examples, starting with all permissions closed (-----), where the plus sign is used with chmod to turn permissions on:

```

chmod u+rw files → rw-----
chmod a+x files → --x--x--x
chmod ug+rx files → r-xr-x---

```

When you try to create a file, by default it is given the permission rw-r--r-. A directory is given the permission rwxr-xr-x. These default values are determined by the value of umask. Type umask to see what your umask value is. For example:

```

$ umask
022

```

The umask value represents the permissions that are not given on a new file. It masks the permissions value of 666 for a file and 777 for a directory. The umask value of 022 results in permission for a directory of 755 (rwxr-xr-x). That same umask results in a file permission of 644 (rw-r--r-). Execute permissions are off by default for regular files. The default umask value on CentOS is 0002.

**TIP**

Here's a great tip for changing the permission for lots of files at once. Using the -R options of chmod, you can change the permission for all of the files and directories within a directory structure at once. For example, if you want to open permissions completely to all files and directories in the /tmp/test directory, you can type the following:

```

$ chmod -R 777 /tmp/test

```

This command line runs chmod recursively (-R) for the /tmp/test directory, as well as any files or directories that exist below that point in the file system (e.g., /tmp/test/hat, /tmp/test/hat/caps, etc.). All would be set to 777 (full Read/Write/Execute permissions).

**CAUTION**

The -R option of chmod works best if you are opening permissions completely or adding Execute permission (as well as the appropriate Read/Write permission). The reason is that if you turn off Execute permission recursively, you close off your ability to change to

any directory in that structure. For example, `chmod -R 644 /tmp/test` turns off Execute permission for the `/tmp/test` directory, and then fails to change any files or directories below that point.

## Moving, Copying, and Deleting Files

Commands for moving, copying, and deleting files are fairly straightforward. To change the location of a file, use the `mv` command. To copy a file from one location to another, use the `cp` command. To remove a file, use the `rm` command. Here are some examples:

```
$ mv abc def
$ mv abc ~
$ cp abc def
$ cp abc ~
$ rm abc
$ rm *
```

Of the two move commands, the first moves the file `abc` to the file `def` in the same directory (essentially renaming it), whereas the second moves the file `abc` to your home directory (`~`). The first copy command copies `abc` to the file `def`, whereas the second copies `abc` to your home directory. The first remove command deletes the `abc` file; the second removes all the files in the current directory (except those that start with a dot).

### CAUTION

Be sure to use the `*` and other wildcard characters wisely, because you might match and remove files you don't intend to match. There is no undelete command in Linux.

### NOTE

For the root user, the `mv`, `cp`, and `rm` commands are aliased to each be run with the `-i` option. This causes a prompt to appear asking you to confirm each copy and removal, one file at a time. For file moves, the `-i` option will prompt you if the move would overwrite a file, but you may still unintentionally move a file, so be careful. This is done to prevent the root user from messing up a large group of files by mistake. To temporarily get around an alias, type the full path to the command (e.g., `/bin/rm -rf /tmp/junk/*`).

## Using the `vi` Text Editor

---

It's almost impossible to use Linux for any period of time and not need to use a text editor. If you are using a GUI, you can run `gedit`, which is fairly intuitive for editing text. Most Linux shell users will use either the `vi` or `emacs` commands to edit text files. The advantage of `vi` or `emacs` over a graphical editor is that you can use it from any shell, a character terminal, or a character-based connection over a network (e.g., when using `ssh`). No GUI is required.

This section provides a brief tutorial of the `vi` text editor. The tutorial was done using the `vi` or `vim` (Vi Improved) editors provided by the `vim-enhanced` package in CentOS.

Any time in this book that I suggest you manually edit a configuration file, you can use `vi` to do that editing from any shell. If `vi` doesn't suit you, see the sidebar “Exploring Other Text Editors” later in this chapter for other options.

The `vi` editor is difficult to learn at first. But when you know it, you will be able to edit and move around quickly and efficiently within files. Your fingers never have to leave the keyboard to pick up a mouse or press a function key.

## Starting with Vi

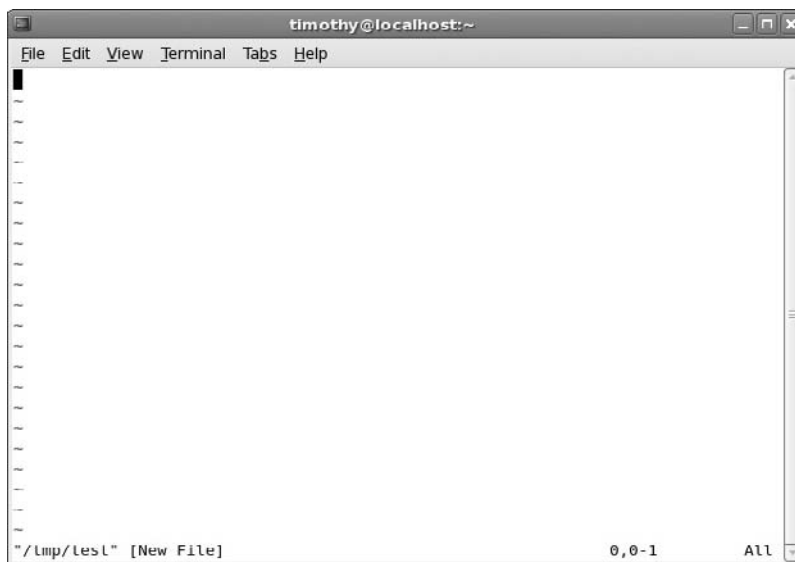
Most often, you start `vi` to open a particular file. For example, to open a file called `/tmp/test`, type the following command:

```
$ vi /tmp/test
```

If this is a new file, you should see something similar to Figure 4-2.

**FIGURE 4-2**

The `vi` editor allows you to create and edit text files from a terminal.



The box at the top represents where your cursor is. The bottom line keeps you informed about what is going on with your editing (here you just opened a new file). In between, there are tildes (~) as filler because there is no text in the file yet. Now here's the intimidating part: there are no hints, menus, or icons to tell you what to do. On top of that, you can't just start typing. If you do, the computer is likely to beep at you.

## Exploring Other Text Editors

Dozens of text editors are available to use with Linux. Here are a few contained in CentOS that you can try out if you find `vi` to be too taxing:

- `emacs` — Most experienced Linux and UNIX users traditionally have used `vi` or `emacs` as their text editor. Many extensions are available with `emacs` to handle editing of many different file types.
- `gedit` — The GNOME text editor that runs in the GUI
- `joe` — The `joe` editor is similar to many PC text editors. Use control and arrow keys to move around. Press `[Ctrl]+C` to exit with no save or `[Ctrl]+X` to save and exit.
- `kate` — A nice-looking editor that comes in the `kdebase` package. It has lots of bells and whistles, such as highlighting for different types of programming languages and controls for managing word wrap.
- `keditt` — A GUI-based text editor that comes with the KDE desktop
- `neditt` — A good tool for editing source code

If you use `ssh` to log in to other Linux computers on your network, you can use any editor to edit files. A GUI-based editor will pop up on your screen. With the `-X` option, `ssh` turns on X11 forwarding, which can make it more convenient to access remote systems. But there may be some security concerns in doing so, so use this with care. When no GUI is available, you will need a text editor that runs in the shell, such as `vi`, `jed`, or `joe`.

The first things you need to know are the different operating modes. The `vi` editor operates in either Command mode or Input mode. When you start `vi`, you are in Command mode. Before you can add or change text in the file, you have to type a command to tell `vi` what you want to do. A command consists of one or two letters and an optional number. To get into Input mode, you need to type an input command. To start out, type either of the following input commands:

- `a` — Add. After you type `a`, you can input text that starts to the right of the cursor.
- `i` — Insert. After you type `i`, you can input text that starts to the left of the cursor.

Type a few words and press `[Enter]`. Repeat that a few times until you have a few lines of text. When you are done typing, press `[Esc]`. You are now back in Command mode. Now that you have a file with some text in it, try moving around in your text with the following keys or letters.

### TIP

Remember the `[Esc]` key! It always places you back into Command mode.

- **Arrow Keys** — Use the arrow keys to move up, down, left, or right in the file one character at a time. To move left and right, you can also use `[Backspace]` and the Spacebar,

respectively. If you prefer to keep your fingers on the keyboard, use h (left), l (right), j (down), or k (up) to move the cursor.

- **w** — Moves the cursor to the beginning of the next word.
- **b** — Moves the cursor to the beginning of the previous word.
- **0 (zero) or ^** — Moves the cursor to the beginning of the current line.
- **\$** — Moves the cursor to the end of the current line.
- **H** — Moves the cursor to the upper-left corner of the screen (first line on the screen).
- **M** — Moves the cursor to the first character of the middle line on the screen.
- **L** — Moves the cursor to the lower-left corner of the screen (last line on the screen).

Now that you know how to input text and move around, the only other editing you need to know is how to delete text. Here are a few `vi` commands for deleting text:

- **x** — Deletes the character under the cursor.
- **X** — Deletes the character directly before the cursor.
- **dw** — Deletes from the current character to the end of the current word.
- **d\$** — Deletes from the current character to the end of the current line.
- **d0** — Deletes from the previous character to the beginning of the current line.

If you feel pretty good about creating text and moving around the file, you may want to wrap things up. Use the following keystrokes for saving and quitting the file:

- **ZZ** — Save the current changes to the file and exit from `vi`.
- **:w** — Save the current file but continue editing.
- **:wq** — Same as **ZZ**.
- **:q** — Quit the current file. This works only if you don't have any unsaved changes.
- **:q!** — Quit the current file and *don't* save the changes you just made to the file.

### TIP

If you've really trashed the file by mistake, the **:q!** command is the best way to exit and abandon your changes. The file reverts to the most recently changed version. So, if you just did a **:w**, you are stuck with the changes up to that point. If you just want to undo a few bad edits, press **u** to back out of changes.

You have learned a few `vi` editing commands. I describe more commands in the following sections. However, before I do, here are a few tips to smooth out your first trials with `vi`:

- **[Esc]** — Remember that [Esc] gets you back to Command mode. (I've watched people press every key on the keyboard trying to get out of a file.) [Esc] followed by **ZZ** gets you out of input mode, saves the file, and exits.
- **u** — Press **u** to undo the previous change you made. Continue to press **u** to undo the change before that, and the one before that. (With the traditional `vi` editor, **u** undoes a single command and **r** returns what you just undid.)

- **[Ctrl]+r** — If you decide you didn't want to undo the previous edit, use [Ctrl]+r for Redo. Essentially, this command undoes your undo.
- **[Caps Lock]** — Beware of hitting [Caps Lock] by mistake. Everything you type in *vi* has a different meaning when the letters are capitalized. You don't get a warning that you are typing capitals — things just start acting weirdly.
- **!*command*** — You can run a shell command while you are in *vi* using **!** followed by a command name. For example, type **!date** to see the current date and time, type **!pwd** to see what your current directory is, or type **!jobs** to see if you have any jobs running in the background. When the command completes, press [Enter] and you are back to editing the file. You could even do that with a shell (**!*bash***) to run a few commands from the shell, then type **exit** to return to *vi*. (I recommend doing a save before escaping to the shell, just in case you forget to go back to *vi*.)
- **-- INSERT --** — When you are in Input mode, the word *INSERT* appears at the bottom of the screen. Other messages also appear at the line at the bottom of the screen.
- **[Ctrl]+g** — If you forget what you are editing, pressing these keys displays the name of the file that you are editing and the current line that you are on. It also displays the total number of lines in the file, the percentage of how far you are through the file, and the column number the cursor is on. This just helps you get your bearings after you've stopped for a cup of coffee at 3 a.m.

## Moving around the File

Besides the few movement commands described earlier, there are other ways of moving around a *vi* file. To try these out, open a large file that you can't do much damage to. (Try copying `/var/log/messages` to `/tmp` and opening it in *vi*.) Here are some movement commands you can use:

- **[Ctrl]+f** — Page ahead, one page at a time.
- **[Ctrl]+b** — Page back, one page at a time.
- **[Ctrl]+d** — Page ahead a half page at a time.
- **[Ctrl]+u** — Page back a half page at a time.
- **G** — Go to the last line of the file.
- **gg** or **1G** — Go to the first line of the file. (Use any number with a *G* or *gg* to go to that line in the file.)

## Searching for Text

To search for the next occurrence of text in the file, use either the slash (`/`) or the question mark (`?`) character. Within the search, you can also use metacharacters. Here are some examples:

- `/hello` — Searches forward for the word *hello*.



- `?goodbye` — Searches backward for the word *goodbye*.
- `/The.*foot` — Searches forward for a line that has the word *The* in it and also, after that at some point, the word *foot*.
- `?[pP]rint` — Searches backward for either *print* or *Print*. Remember that case matters in Linux, so using brackets can search for words that could have different capitalization.

The `vi` editor was originally based on the `ex` editor. That editor did not let you work in Full-Screen mode. However, it did enable you to run commands that let you find and change text on one or more lines at a time. When you type a colon and the cursor goes to the bottom of the screen, you are essentially in `ex` mode. Here is an example of some of those `ex` commands for searching for and changing text. (I chose the words *Local* and *Remote* to search for, but you can use any appropriate words.)

- `:g/Local` — Searches for the word *Local* and prints every occurrence of that line from the file. (If there is more than a screenful, the output is piped to the `more` command.)
- `:s/Local/Remote` — Substitutes *Remote* for the word *Local* on the current line.
- `:g/Local/s//Remote` — Substitutes the first occurrence of the word *Local* on every line of the file with the word *Remote*.
- `:g/Local/s//Remote/g` — Substitutes every occurrence of the word *Local* with the word *Remote* in the entire file.
- `:g/Local/s//Remote/gp` — Substitutes every occurrence of the word *Local* with the word *Remote* in the entire file, then prints each line so that you can see the changes (piping it through `more` if output fills more than one page). Another way to globally search and replace without printing every line that changes is to type `:%s/Local/Remote/g`.

## Using Numbers with Commands

You can precede most `vi` commands with numbers to have the command repeated that number of times. This is a handy way to deal with several lines, words, or characters at a time. Here are some examples:

- `3dw` — Deletes the next three words.
- `5c1` — Changes the next five letters (i.e., removes the letters and enters input mode).
- `12j` — Moves down 12 lines.

Putting a number in front of most commands just repeats those commands. At this point, you should be fairly proficient at using the `vi` command. If you would like further instruction, I suggest you try the VIM Tutor by running the `vimtutor` command.

### NOTE

When you invoke `vi` on CentOS, you're actually invoking the `vim` text editor, which runs in `vi` compatibility mode. Those who do a lot of programming might prefer `vim`, because it shows different keywords of code in different colors. `vim` also has other useful features, such as the ability to open a document with the cursor at the same place where it was when you last exited that file.

## Summary

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Working from a shell command-line interpreter within Linux may not be as simple as using a GUI, but it offers many powerful and flexible features. This chapter describes how to log in to CentOS and use shell commands. Features for running commands include recalling commands from a history list, completing commands, and joining commands.

This chapter describes how shell environment variables can be used to store and recall important pieces of information. It also teaches you to modify shell configuration files to tailor the shell to suit your needs. Finally, this chapter describes how to use the Linux file system to create files and directories, use permissions, and work with files (moving, copying, and removing them), and how to edit text files from the shell using the `vi` command.



# Part II

# Using CentOS

## IN THIS PART

**Chapter 5**  
**Accessing and Running Applications**

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**Chapter 6**  
**Publishing with CentOS**

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**Chapter 7**  
**Music, Video, and Images in Linux**

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**Chapter 8**  
**Using the Internet and the Web**

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# Chapter 5

## Accessing and Running Applications

CentOS comes with thousands of software applications, covering every major category of desktop, server, and programming software. By accessing some third-party and CentOS- and RHEL-specific software repositories on the Internet, you have access to many more software packages. Often, getting a new software package downloaded and installed is as simple as running a single `yum` command.

Some of the same tools you use to get and install software packages in CentOS (such as `yum` and `rpm` commands) can also be used to manage your installed software and get updates or security patches when they become available. Options in those tools let you query which packages you installed, as well as list and verify the contents of those packages. Likewise, GUI tools such as `pirut`, `pup`, and `yumex` can be used to automatically grab and install new and updated packages as they become available.

Once an application is installed, launching it can be as easy as it is in any friendly desktop system: by clicking on a few menus on the desktop. There are also some neat ways to launch applications from another computer so that you can work with them (securely) from your own desktop.

In those cases in which you must have a specific application that isn't available for Linux (such as Microsoft Office or a particular media player), there are several emulators and compatibility software facilities to let you run software made for Windows, DOS, or other operating systems. You can also build and install your own software packages for CentOS, starting with software available as source RPMs or as tarballs.

This chapter covers these tools and procedures for getting, installing, and managing software applications in CentOS.

### IN THIS CHAPTER

Getting and installing software packages

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Getting CentOS software updates

---

Managing RPM packages

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Running desktop applications

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Using emulators to run applications from other operating systems

---

Running DOS applications

---

Running Windows applications with WINE

---

Running applications in virtual environments (KVM and Xen)

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## Getting and Installing Software Packages

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Applications that are packaged specifically to run on CentOS systems are usually stored in RPM format. Except for a few components used to start the system, most of the CentOS operating systems themselves are in RPM format. When you look for software to install in CentOS, you should start in the following locations:

- **Install DVD** — Any package you didn't install during the initial installation process can be installed later from the DVD that comes with this book (aside from a few game-related packages that were left off because of the DVD size limitations). To do that, you can use the `rpm` command. After initial installation, however, provided that you have an Internet connection, using online repositories to add packages using the `yum` command or the Add/Remove Software window is often the better method. That's because those tools can not only get and install the packages you request, but they will also find and get updated versions of the packages (if available), as well as any dependent packages required to install the packages you want.
- **CentOS Repository** — Your `yum` facility is automatically configured to use the online CentOS repository. Because there are multiple instances of the repository, `yum` points to mirror lists from the CentOS project to choose a repository that is near to you. A list of mirrors can be found at [www.centos.org/modules/tinycontent/index.php?id=30](http://www.centos.org/modules/tinycontent/index.php?id=30).
- **Third-Party Repositories** — Because of licensing issues and patent questions, some popular software is not included with CentOS itself. For example, commercial DVD movie and MP3 music players are not included in CentOS. You can download packages directly from these sites or (preferably) set up `yum` so that you can download and install packages more easily.

### CAUTION

Getting software from any sites that are not sanctioned by the CentOS project presents potential problems. While the project works hard to make sure that package dependencies across all official packages are handled consistently, you don't get the same guarantees with all other repositories.

- **Software Project Sites** — Often individual software projects will offer their own set of RPM packages for their own projects. This is particularly useful for projects under continuous development (such as the WINE project). If the project doesn't offer RPMs, they will typically offer code in what is called a *tarball*. The tarball may include binary code or, more often, source code you can build for your environment.

If you know what software package you want and it is available from more than one location, you should choose one from an official CentOS repository. Besides that, a repository outside of CentOS that's committed to being compatible with the main CentOS repository is your next best choice, since that will help take care of any dependency problems.

Most CentOS repositories are light on descriptions of the packages they offer. The following list summarizes some other web sites that you can browse to find detailed information about

software that runs in Linux. Then you can search various repositories for CentOS-specific versions of those packages.

- **Freshmeat** (<http://freshmeat.net>) — This site maintains a massive index of Linux software. You can do keyword searches for software projects or browse for software by category.
- **SourceForge** (<http://sourceforge.net>) — This site hosts thousands of Open Source software projects. You can download software and documentation from those projects through the SourceForge site.
- **RPMFind** ([www.rpmfind.net](http://www.rpmfind.net)) — Provides a way of searching for Open Source software that is packaged in the RPM Package Management (RPM) format across a variety of repositories. You can do a keyword search from this web site.
- **Google** ([www.google.com](http://www.google.com)) — Since we're just looking for help in finding software projects, Google (or other general-purpose search engine) can be used to find information about a project we are interested in.

Often, you can't just download a single software package to get the software in that package to work. Many packages depend on other packages. For example, software packages for playing audio and video typically rely on other software packages for decoding different kinds of content. To handle software dependency issues (along with the fact that it includes many other valuable features), CentOS has based its packaging tools on the `yum` facility.

## Downloading and Installing Applications with `yum`

The Yellow Dog Updater, Modified (`yum`) software package lets you install and update selected software packages in RPM format from software repositories on the Web. Once you know the software package that you want, `yum` is probably the best way to download and install that package. There are also features in `yum` for listing and managing RPMs after they are installed.

`yum` is the foundation for software updates in CentOS. Even the CentOS installer itself (`anaconda`) now uses `yum` as the underlying mechanism for getting and updating software.

The `yum` package is included on the DVD that comes with this book. To use `yum` to install RPM software packages, follow these basic steps:

1. **Configure** `yum` — You have the option to configure the `/etc/yum.conf` file to set options that relate to how you use your `yum` repositories, as described in the next section. Then add any repositories, outside of CentOS, that you want to get packages from. (Some software repositories may offer RPM packages that automatically configure entries in the `yum.repos.d` directory to point to those repositories.)
2. **Run** `yum` — The `yum` command can be used to download and install any package from the repositories, including any packages the one you want depends on.

Besides downloading and installing new software packages, `yum` can also be used to check for available updates and list various kinds of information about available packages.



## Configuring yum (/etc/yum.conf)

The `/etc/yum.conf` file already comes pre-configured to include options that affect how you download and use RPM packages with `yum`. All necessary, basic repository listings are contained in files in the `/etc/yum.repos.d` directory. Here is what the `yum.conf` file contains:

```
[main]
cachedir=/var/cache/yum
keepcache=0
debuglevel=2
logfile=/var/log/yum.log
distroverpkg=redhat-release
tolerant=1
exactarch=1
obsoletes=1
plugins=1

# Note: yum-RHN-plugin doesn't honor this.
metadata_expire=1h

# Default.
# installonly_limit = 3

# PUT REPOS HERE OR IN separate file.repo files
# in /etc/yum.repos.d
```

The `cachedir` (`/var/cache/yum`) is where the RPM files are downloaded to by `yum` when you ask to install or upgrade packages. The `keepcache=0` option causes all downloaded packages and headers to be erased after they are installed. If you select to save the RPM files (which some people do if they want to share packages with multiple machines, without multiple downloads), you need to set `keepcache=1` and make sure that the directory has enough disk space to handle it. During a testing cycle, I ended up with about 1 GB of RPMs in my `/var/cache/yum` file system. (Of course, they can just be deleted after they are installed.)

### NOTE

You can clean out a lot of the data cached by `yum` with the command `yum clean all`.

Messages related to `yum` processing are sent to `/var/log/yum.log` by default, using a debug level of 2 (0 to 10 is legal, with 2 producing minimal success or failure messages). The `exactarch` set to 1 indicates that you must match the name and release architecture exactly for a package.

The `distroverpkg` option specifies the package used by `yum` to determine the distribution's version. Because CentOS is based on RHEL, the value is set to `red-hat-release`.

The `tolerant` option configures `yum` to be tolerant of minor errors on the command line, such as requesting to install a package that has already been installed.

The `exactarch` option makes `yum` update packages with only packages for the same architecture that is installed.

The `obsoletes` option lets `yum` determine obsolete packages during updates.

With `plugins` turned on (set to 1), available extensions to `yum` are enabled. The value of `metadata_expire` determines when the metadata you have from a repository expires. The default of 1h seconds causes metadata to expire 1 hour after it is received.

Here are some tips relating to setting up `yum.conf`:

- **Getting Metadata** — The metadata that describes the contents of a `yum` repository is downloaded to your computer when you run the `yum` command. If you run the command again after the metadata expires (1 hour by default, as mentioned earlier), you will have to wait again while the metadata downloads before `yum` proceeds.

If `yum` is configured to access several repositories, it can take a long time to repeatedly download the metadata. To get around this problem, you can extend the `metadata_expire` value or run `yum` with the `-C` option on the command line (which forces `yum` to use the existing metadata). The downside is that if the repository data has changed, you might not be getting the latest packages.

- **Excluding Repositories** — Excluding repositories on the `yum` command line is another way to save time by preventing unneeded metadata from being downloaded.
- **Plug-Ins** — CentOS comes with the `plugins` feature enabled in the `yum.conf` file. This causes plug-ins in the `/usr/lib/yum-plugins` directory to be enabled. When you start out, the `yum-fastmirror` plug-in is installed and enabled. You might want to also install the `refresh-updatesd` plug-in. This plug-in tells `yum` to notify the `yum-updatesd` daemon to refresh the metadata. For information on other available plug-ins, refer to the YumPlugins wiki (<http://wiki.linux.duke.edu/YumPlugins>).

For more information about the `yum.conf` file, type **man yum.conf** from a shell.

## Adding yum Repositories (/etc/yum.repos.d/)

When you use the `yum` command to request to install a software package, it checks repositories listed in the `/etc/yum.conf` file and in files in the `/etc/yum.repos.d` directory. By default, you begin with the following repository listings in `CentOS-Base.repo`:

- **Base** — These are all the same packages that are on the DVD that comes with this book. You can install any of those packages, or updates to them, from the repositories using `yum`. There are thousands of software packages in this repository.
- **Updates** — As updates become available from CentOS, you can automatically access those updates from this repository.
- **CentOS Extras** — These packages extend the functionality of your CentOS system without breaking upstream compatibility. They do not update any base components.
- **CentOS Plus** — These packages are updates to the packages in Base but are not part of the upstream distribution.

The following is a list of other repositories you might consider adding to your own `/etc/yum.repos.d/` files. Several of these repositories have made it easy for you by offering an RPM that adds the `gpgkey` and `yum.repos.d` file needed to access their repositories. Keep in mind that repositories can change over time, as new ones are added, some are neglected, and others are consolidated.

**NOTE**

I recommend only adding repositories you need. Adding unnecessary repositories can slow down the performance of yum.

- **Extra Packages for Enterprise Linux (EPEL)** (<http://fedoraproject.org/wiki/EPEL>) — This repository offers Fedora packages rebuilt for RHEL.
- **RPMForge** (<https://rpmrepo.org/RPMforge>) — This site represented a merge of three separate repositories that offered RPM packages: Dag, FreshRPMs, and Dries. It is now transitioning to the RPMrepo project and offers packages for CentOS and RHEL.
- **KBS-Extras** (<http://centos.karan.org>) — This repository provides rebuilt Fedora Extras packages for CentOS. It has a reputation for being safe and stable.
- **ATrpms** (<http://atrpms.net>) — This site has RPMs containing many bleeding-edge drivers for video cards, wireless cards, and other hardware not included with CentOS.

For a more complete list of repositories, instructions on installing them, and a discussion of pros and cons, see <http://wiki.centos.org/AdditionalResources/Repositories>.

## Running yum to Download and Install RPMs

With the repositories identified, downloading and installing an RPM you want is as simple as running `yum` with the `install` option to request the RPM. With an active connection to the Internet, open a Terminal window as `root` user.

The first thing `yum` does is download metadata and headers for all packages you might want from each repository. Then, after presenting you with the list of dependencies it thinks you need, it asks if you want to install the necessary packages. Here is an example of using the `yum` command to download the `gcc` compiler:

```
# yum install gcc
Loading "fastestmirror" plugin
Loading mirror speeds from cached hostfile
 * base: mirror.fdcservers.net
 * updates: mirror.nyi.net
 * addons: mirror.nyi.net
 * extras: yum.singlehop.com
Setting up Install Process
Parsing package install arguments
Resolving Dependencies
--> Running transaction check
---> Package gcc.i386 0:4.1.2-42.el5 set to be updated
```

--> Processing Dependency: libgomp.so.1 for package: gcc

.  
.  
.

--> Finished Dependency Resolution

Dependencies Resolved

```
=====
```

Package	Arch	Version	Repository	Size
Installing:				
gcc	i386	4.1.2-42.e15	base	5.2 M
Installing for dependencies:				
glibc-devel	i386	2.5-24.e15_2.2	updates	2.0 M
glibc-headers	i386	2.5-24.e15_2.2	updates	611 k
kernel-headers	i386	2.6.18-92.1.22.e15	updates	854 k
libgomp	i386	4.1.2-42.e15	base	82 k

Transaction Summary

```
=====
```

Install	5 Package(s)
Update	0 Package(s)
Remove	0 Package(s)

Total download size: 8.7 M

Is this ok [y/N]: y

Downloading Packages

.  
.  
.

Running rpm\_check\_debug

Running Transaction Test

Finished Transaction Test

Transaction Test Succeeded

Running Transaction

```
Installing: libgomp ##### [1/5]
Installing: kernel-headers ##### [2/5]
Installing: glibc-headers ##### [3/5]
Installing: glibc-devel ##### [4/5]
Installing: gcc ##### [5/5]
```

Installed: gcc.i386 0:4.1.2-42.e15

Dependency Installed: glibc-devel.i386 0:2.5-24.e15\_2.2

glibc-headers.i386 0:2.5

-24.e15\_2.2 kernel-headers.i386 0:2.6.18-92.1.22.e15 libgomp.i386

0:4.1.2-42.e15

Complete!

As you can see from this example, yum checked four different software repositories for the current CentOS release. After listing the dependencies, yum asks if it is OK to install them. Type **y** and the package and all its dependencies are installed.

### Using yum to Install Packages Locally

If you want to install RPM packages with yum that are available from your local system (by inserting the CentOS DVD or copying an RPM to a local directory), you can use the `localinstall` option to yum. For example, if you were to insert the DVD that comes with this book (and it was mounted on `/media/disk`), you could type the following to install the `gftp` package:

```
# yum localinstall /media/disk/CentOS/gftp-*
yum localinstall /media/disk/CentOS/gftp-2.0.18 -3.2.2.i386.rpm
Loading "fastestmirror" plugin
Setting up Local Package Process
Loading mirror speeds from cached hostfile
.
.
.
Dependencies Resolved

=====
Package Arch Version Repository Size
=====
Installing:
gftp i386 1:2.0.18-3.2.2 gftp-2.0.18-3.2.2.i386.rpm 2.6 M

Transaction Summary
=====
Install 1 Package(s)
Update 0 Package(s)
Remove 0 Package(s)

Total download size: 2.6 M
Is this ok [y/N]: y
Downloading Packages:
Running rpm_check_debug
Running Transaction Test
Finished Transaction Test
Transaction Test Succeeded
Running Transaction
Installing: gftp ##### [1/1]

Installed: gftp.i386 1:2.0.18-3.2.2
Complete!
```

**TIP**

Using an asterisk on the command line, as shown in the example above, may include more files than you intend. It is best to check first and only install the packages you want to install.

A good reason for using `yum localinstall` instead of the `rpm` command to install RPM packages is that `yum` will check whether the package you are installing is dependent on any other packages being installed. If `yum` finds that it needs other packages, it will search any `yum` repositories you have configured (at least the main CentOS repository) to download and install what you need.

In this example, `yum` found that `gftp` didn't require any additional packages be installed. So, typing `y` at the prompt caused only the one package to be installed.

## Using yum for Listing Packages

Besides downloading and installing new RPM packages, `yum` can also be used to list available packages as well as those that are already installed. The following examples illustrate some uses of `yum`.

If you want to see a list of all packages that are available for download from the repositories you have configured, type the following:

```
# yum list | less
```

Adding the `less` command to the end lets you scroll through the list of software (it could be long, depending on which repositories you point to). If you try to install a package and it fails with a message like `package xyzpackage needs xyzfile (not provided)`, you can check for packages that include the missing file using the `provides` option as follows:

```
# yum provides */missingfile
```

With the `provides` option, `yum` will search your repositories for whatever file you enter (instead of `missingfile`) and return the name of any packages it finds that include that file.

To search software descriptions in repositories for a particular string, use the `search` option. For example, the following command searches for `arcade` in any package description (this search will find some games):

```
# yum search arcade
```

Because `yum` packages are not automatically deleted after being installed, you might want to go through on occasion and clean them out. To clear out packages from subdirectories of the `/var/cache/yum` directory, type the following:

```
# yum clean packages
```

If you would like to check to see RPMs that were installed from repositories outside of the main CentOS repository, you can do so using the `list extras` option:

```
# yum list extras
```

The list that appears may include a lot of packages, depending on your configuration. Note that this list includes all packages from repositories configured for your system that are outside of CentOS. For example, it would list packages installed from RPMforge.net and ATrpms, if those repositories were configured.

## Using the yum-utils Package

There are several utilities in the `yum-utils` package for working with repositories and managing software packages. To get these utilities, type the following `yum` command:

```
# yum install yum-utils
```

These utilities provide different ways of cleaning up repositories, getting packages without installing them, and doing different query types. Here are some examples:

- **package-cleanup** — Checks your local RPM database for dependency problems and packages that are not needed. Options include `--problems` (to check dependency problems in the RPM database), `--orphans` (to list packages that are not currently available in any of your repositories), and `--oldkernels` (to remove old kernel and kernel-devel packages). You can add `--keepdevel` when running `--oldkernels`, to keep the associated `kernel-devel` packages.
- **repoclosure** — Checks remote `yum` repositories for dependency problems. By default, this checks the repositories configured for your machine. To check a specific repository, use the `-r repoid` option. You may get the `repoid` from the first line of the `/etc/yum.repos.d` file for the repository. Other options include `-c file` to use a different configuration `file` containing repositories, or `-a arch` to indicate which base architecture to check for the repository. Note that this command consumes a lot of memory and can take a long time to run.
- **yumdownloader** — Downloads a package from a repository to a selected directory. This tool also downloads all dependent packages along with the requested package by adding the `--resolve` option. You can specify a download directory with the `--destdir` option or just list the URL where the package would be downloaded from, with the `--urls` option, without actually downloading. Use `--source` to download source packages as well.
- **repoquery** — Queries `yum` repositories for information about packages and groups. This command is similar to using `rpmquery` to query your local RPM database. You can list descriptions of a package with `-i`; list package dependencies with `--requires`; and show name, version, and release information with `-nvr`. Type `repoquery --help` for other options.

## Getting CentOS Software Updates

With new exploits being discovered daily, any computer connected to the Internet should get regular software updates to patch any potential holes and fix broken code. `yum` offers several ways of getting updates for CentOS. The GUI utility for getting updates is called `pup`.

### Getting Alerted to Available Updates

The first time you log in to CentOS and display the desktop, you will probably see a brown software box icon in the upper-right corner, alerting you that updates are available. That icon represents the Puplet update applet. Any time updates are available, that icon will appear.

Click on the button on the applet, and then select “View Updates.” The Package Updater window will open, listing the number of updates available. You can optionally select only particular packages to update by unchecking the undesired entries. Click on the “Apply Updates” button, and all selected updates will be downloaded to your computer and installed. Figure 5-1 shows an example of the Package Updater window.

**FIGURE 5-1**

Check for software updates with the Package Updater window.



### Getting Manual Updates with `yum`

At any time you can check whether updates are available for RPM packages installed on your CentOS system. Before doing updates with `yum`, however, you should always update `yum` itself first:



```
# yum update yum
```

Next, you can check for updates. Then you can choose to either update selected packages or all available packages. Here is how:

```
# yum check-update
```

The `check-update` option causes `yum` to check the software repositories for available updated versions of RPM packages you have installed. If you see a package you want to update, you can use the `update` option. For example, to update the `nmap-frontend` package, type the following:

```
# yum update nmap-frontend
```

To update all packages that have updates available, type the following:

```
# yum update
```

This command could take a while to complete, depending on how long it has been since the last time you installed updates and on how many total packages are installed on your computer. If, instead of trying to remember to do updates, you want them to happen automatically, the following section describes how to do that.

## Managing RPM Packages

---

Both graphical and command-line tools are available for managing your systems. The Add/Remove Software window lets you display categories of software packages installed on and available for your system. The `rpm` command offers an extensive range of features for installing, uninstalling, listing, and verifying your RPM packages.

### Using the Add/Remove Window

Unless you installed every package that comes with CentOS, as you go through this book, you will probably find that you want to add some software packages after your initial installation. To do that, you can use the `yum` command as already described. You can also use `rpm`, a general-purpose command for installing any software packages in RPM format, described in the following section. However, the application with the most user-friendly interface is the Add/Remove Software window, which provides a graphical interface for installing packages.

The Add/Remove Software window provides a lot of flexibility to search, browse, list, and install software packages from `yum` repositories. To open the Add/Remove Software window, select Applications > Add/Remove Software from the menu on the top panel.

With the Add/Remove Software window displayed, you can find both available and installed packages as follows:

- Click on the Browse tab to browse software by categories. Select a main category from the left column, and then a group. With the group checked, click on the “Optional packages” button to see all packages and select other packages from that category’s group that would be installed.

- Click on the Search tab and then enter all or part of a package name in the search box. The results will appear in the bottom window. You can search through all packages, only packages that are installed, or packages that are available but have not been installed yet by selecting the appropriate radio option.
- Click on the List tab to see all packages, installed packages, or available packages. This tab is similar to the Search tab except there is no search field and all packages matching the radio option are displayed.

Packages appear with open box icons if they are installed or closed box icons if they are not. Select a package to see information about the contents of that package. With a package selected, you can choose to either install or remove it, depending on its current state.

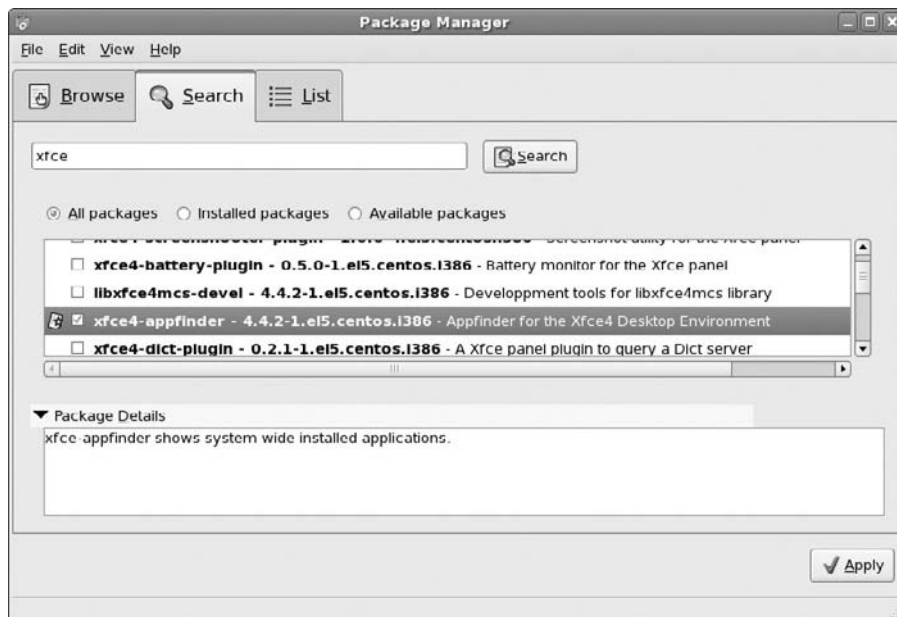
**NOTE**

Note that not all packages in a repository will necessarily show up in the groups shown on the left window pane. So, if you believe a package you want is in an enabled repository but you can't browse for it, use the Find box to search for it by name.

The Add/Remove Software window appears as shown in Figure 5-2. In this example, after searching for *xfce* and displaying all packages with that term, I selected one of the packages. In the bottom-right window I can then see a description of the package, a complete list of files it contains, and any packages that this package depends on or that depend on it.

**FIGURE 5-2**

Get additional software packages using the Add/Remove Software window.



## Using the rpm Command

The command used to work with RPM package files is `rpm`. To manage RPM packages, the `rpm` command has options that let you list all the packages that are installed, upgrade existing packages to newer versions, and query packages for information (such as the files or documentation included with the package). There is also a verify option to check that all files that make up the package are present and unchanged.

The `rpm` command has the following modes of operation:

- Install (`-i`)
- Upgrade (`-U`)
- Freshen (`-F`)
- Query (`-q`)
- Verify (`-V`)
- Signature check (`--checksig`)
- Uninstall (`-e`)
- Rebuild database (`--rebuilddb`)
- Fix permissions (`--setperms`)
- Set owners/groups (`--setugids`)
- Show RC (`--showrc`)

With these options, you can install RPM packages and verify that their contents are properly installed, correcting any problems that occur. You can also do special things, such as rebuild the RPM database and modify ownership. You must be logged in as the `root` user to add or remove packages. You may, however, list installed packages, query packages for information, or verify a package's contents without `root` permission.

The following sections describe how to use `rpm` to install and work with your RPM applications.

### NOTE

While the `rpm` command is good for installing a single RPM from a local directory, once your system is installed, the `yum` command is often a better choice for installing software. Some advantages to using `yum` are that, for the package you request, it will search your configured repositories, grab the latest available version, and automatically find dependent packages.

Even if you have an RPM package in a local directory or on a DVD, if the package is dependent on other packages, installing with `yum localinstall` will try to grab the needed packages from online repositories while the `rpm` command would just fail.

## Verifying rpm Package Integrity

When you add repositories to your yum facility, in the case of repositories that offer release RPMs, yum is automatically configured to use a valid GPG/DSA key and point to a valid online repository. When you ask to install a package from one of those repositories using yum, the key is used to validate each package before it is installed. On the other hand, if you are simply installing a local RPM package, you need to do some manual work to verify its contents.

To check all digests and signatures included in an RPM to make sure that it is original and not corrupted, you can use the `--checksig` option to rpm. For example, say I have a copy of the `dvgrab` package (which is part of CentOS) in my local directory and I wanted to check it. I could run the following command:

```
# rpm --checksig dvgrab.i386 0:3.0-1.e15.rpm,  
dvgrab.i386 0:3.0-1.e15.rpm: (sha1) dsa sha1 md5 gpg OK
```

The preceding output shows that the GPG/DSA key was found and used to check that the package's digital signatures (dsa, sha1, and md5) were correct. If, however, you got a package for which you didn't have the GPG/DSA key installed, you would need to get and import that key before you could verify the package.

If you trust the Internet site where you are getting the RPM you want to install, look for an indication that the site has signed its packages. Then download the GPG public key and import it. That will allow you to check the validity of the packages from that site. For example, I decided I wanted to use the KDE-redhat (<http://apt.kde-redhat.org>) project to replace all my KDE packages from CentOS. I downloaded the `digikam` package and tried to verify it as follows:

```
# rpm --checksig digikam-doc-0.9.4-2.fc10.rpm  
digikam-doc-0.9.4-2.fc10.rpm: (SHA1) DSA sha1 md5 (GPG) NOT OK (MISS-  
ING KEYS:  
GPG#ff6382fa)
```

Because the GPG public key was not installed, the contents couldn't be verified as correct. So, I went to the KDE-redhat project site and downloaded the GPG public key to the current directory. Then I imported the key as follows:

```
# rpm --import gpg-pubkey-ff6382fa-3e1ab2ca
```

With the GPG public key imported, the second check of the RPM showed that it was clean:

```
# rpm --checksig k3b-1.0.5-6.e15.i386.rpm  
k3b-1.0.5-6.e15.i386.rpm: (sha1) dsa sha1 md5 gpg OK
```

Most of the GPG public keys you need for the basic repositories used with CentOS are included in the `redhat-release` package. GPG public keys from other repositories should be stored with those keys in the `/etc/pki/rpm-gpg` directory.

Remember, however, that it is best to get packages automatically from known repositories with yum or related tools. Besides checking the signatures of packages, yum will also make sure all dependencies are cleared up.

## Installing with rpm

To install an RPM archive file that is not yet installed on your system with the `rpm` command, most people generally use the same options they would if they were upgrading (the `-U` option). Here's an example of a command line you could use to install a new RPM package:

```
# rpm -U [options] package
```

*Package* is the name of the RPM archive file. This package may be in the current directory, on a DVD or CD (e.g., `/media/disk/CentOS/whatever.rpm`), or on an accessible FTP site (e.g., `ftp://ftp.example.com/pub/whatever.i386.rpm`).

### CAUTION

Interrupting `rpm` during a package installation can leave stale lock files and possibly corrupt the database. As a result, subsequent `rpm` commands may hang. If this happens, you can probably correct the problem by removing old database locks. If that doesn't work, you can also try checking whether the database is corrupt and, if so, rebuilding the RPM database. Rebuilding the database can take a long time, so only do it if the other options don't clear up the problem. Here's how to remove lock files, check the database, and rebuild the database. You must be the root user:

```
# rm -f /var/lib/rpm/___db*
# rpm --rebuilddb
```

Along with the `-U` option, you can use the following options to get feedback during a new installation:

- `-v` — Prints debugging information during installation. This is a good way to see everything that happens during the install process. (This output can be long, so you may want to pipe it to the `less` command.) You can get more information by adding multiple `-v` options, for example, `-vv`.
- `-h` — Prints 50 hash marks (`#`) as the package unpacks. The intent is to see the progress of the unpacking process so you can tell if the program is still working or stalled.
- `-percent` — Prints the percentage of the total package that has been installed throughout the install process.

Before installing a package, `rpm` checks to make sure that it is not overwriting newer files or installing a package that has dependencies on other packages that are not installed. The following install options can be used to override conditions that may otherwise cause the installation to fail:

- `--force` — Forces the contents of the current package to be installed, even if the current package is older than the one already installed, contains files placed there by other packages, or is already installed. (This is the same as using the `oldpackage`, `replacefiles`, and `replacepkgs` options.) Although it is dangerous to do so, people often use

this option to override any issue that might cause the package install to fail (such as an older RPM).

- `--oldpackage` — Forces the package to be installed, even if the current package is older than the one already installed.
- `--replacefiles` — Forces files in this package to be installed, even if the files were placed there by other packages.
- `--replacepkgs` — Forces packages in this archive to be installed, even if they are already installed on the system.
- `--nodeps` — Skips package dependency checks and installs the package, even if packages it depends on are not installed. This option should be used with extreme caution! By not resolving dependencies properly, you can end up with broken software.
- `--ignorearch` — Forces package to be installed, even if the binaries in the package don't match the architecture of your host computer.
- `--excludedocs` — Excludes any man pages, texinfo documents, or other files marked as documentation.
- `--ignoreos` — Forces package to be installed, even if the binaries in the package don't match the architecture of your operating system.

The following is a simple `rpm` command line used to install an RPM package:

```
# rpm -U AdobeReader_enu-7.0.9-1.i386.rpm
```

I like to see some feedback when I install something. (By default, `rpm` is suspiciously quiet when it succeeds.) Here is what the command looks like when I add the `-vv` option to get more verbose feedback, along with some of the output:

```
# rpm -Uvv AdobeReader_enu-8.1.3-1.i486.rpm
D: ===== AdobeReader_enu-8.1.3-1.i486.rpm
D: Expected size:      49498106 = lead(96)+sigs(180)+pad(4)
  +data(49497826)
D:   Actual size:      49498106
D: loading keyring from pubkeys in /var/lib/rpm/pubkeys/*.key
D: couldn't find any keys in /var/lib/rpm/pubkeys/*.key
D: loading keyring from rpmdb
D: opening db environment /var/lib/rpm/Packages cdb:mpool:joinenv
D: opening db index      /var/lib/rpm/Packages rdonly mode=0x0
D: locked db index      /var/lib/rpm/Packages
D: opening db index      /var/lib/rpm/Name rdonly mode=0x0
D: read h#      963 Header sanity check: OK
D: added key gpg-pubkey-4ebfc273-48b5dbf3 to keyring
D: Using legacy gpg-pubkey(s) from rpmdb
D: AdobeReader_enu-8.1.3-1.i486.rpm: Header SHA1 digest: OK
  (5cfaf2bd3c585275d38f3faa98d1dc0b1971f791)
```

```
D: read h# 1489 Header SHA1 digest: OK
(5cfaf2bd3c585275d38f3faa98d1dc0b1971f791)
D: added binary package [0]
D: found 0 source and 1 binary packages
.
.
.
```

From this output, you can see that `rpm` finds one binary package in this archive, verifies the checksum, opens the RPM database, installs the packages, and closes the database when done. Another way to verify that the install is actually working is to add the `-h` option, as follows:

```
# rpm -Uvh AdobeReader_enu-8.1.3-1.i486.rpm
Preparing... #####
AdobeReader_enu #####
```

With the `-h` option, `rpm` chugs out 50 hash marks until the package is done installing. As you can see, when everything goes well, installing with `rpm` is quite simple. Some problems can occur, however. Here are a couple of them:

- **Package Dependencies Errors** — If the package you are installing requires an additional package for it to work properly, you will see an error noting the missing package. You should get and install that package before trying your package again. You can override the failure with the install options described above, but this isn't recommended because your package may not work without the dependent package.
- **Non-Root User Errors** — If `rpm -U` is run by someone who is not the `root` user, the command will fail. The output will likely indicate that the `/var/lib/rpm` database could not be opened. Log in as `root` user and try again.

## Upgrading Packages with `rpm`

The upgrade option (`-U`) with `rpm` can, as you might expect, also be used to upgrade existing packages. The format is the same as described above:

```
# rpm -U [options] package
```

### TIP

Although there is a separate install option (`-i`), I recommend using the `-U` option whether you are doing a new install or an upgrade. With `-U`, the package installs in either case. So `rpm -U` always works (with one exception), while `rpm -i` fails if the package is already installed.

The exception is when you are installing kernel packages. Use `-i` when installing a new kernel or your old (and presumably, working) kernel will be removed and you could be stuck with an unbootable system!

One issue when upgrading is installing an older version of a package. For example, if you install a new version of some software and it doesn't work as well, you will want to go back to the old version. To do this, you can use the `--oldpackage` option as follows:

```
# rpm -U --oldpackage AnotherLevel-0.7.4-1.noarch.rpm
```

If a later package of this name already exists, it is removed and the older version is installed.

## Freshening Packages with rpm

An option that is similar to the upgrade option is the freshen (-F) option. The main difference between the two is what happens if the RPM you are updating or freshening is not already installed on your system. The -U can do either a fresh install or an upgrade. The -F will only do an upgrade, so if the package is not already installed, rpm -F will do nothing.

A great use for freshen is when you have a directory full of updated RPM files that you want to install on your system. But you only want to update those packages that are already installed. In other words, there may be a lot of RPMs in the directory you don't want. Freshen lets you just update the packages you already have.

Let's say that you downloaded a directory of RPMs and you want to selectively freshen the ones you have installed. With the directory of RPMs as your current directory, you could type:

```
# rpm -Fhv *.rpm
```

Packages already installed are updated with the new RPMs. All other RPMs are skipped.

### CAUTION

Again, note that you should not do freshens or upgrades on kernel packages because it might cause your only working kernel to be removed when you add the new one.

## Removing Packages with rpm

If you no longer want to use a package, use the -e option to remove a package. In its simplest form, you use rpm with the -e option as follows:

```
# rpm -e package
```

If there are no dependencies on this package, it is silently removed. Before you remove a package, however, you may want to do a quick check for dependencies. The -q option is used for a variety of query options. Checking for dependencies isn't necessary because rpm checks for dependencies before it removes a package. You may want to do this for your own information, however. To check for dependencies, do the following:

```
# rpm -q --whatrequires package
```

If you decide to remove the package, I recommend using the -vv option with rpm -e. This lets you see the actual files that are being removed. I also suggest that you either direct the output to a file or pipe it to the less command because the output often runs off the screen. For example:

```
# rpm -evv jpilot | less
```

This example removes the jpilot package and shows you the files that are being removed one page at a time. Press the Spacebar to page through the output.

Other options that you can run with rpm -e can be used to override conditions that would prevent the package from being removed or to prevent some processing (such as not running preuninstall and postuninstall scripts). Three of those options are as follows:



- `--nodeps` — Uninstall the package without checking for dependencies.
- `--noscripts` — Uninstall the package without running any preuninstall or postuninstall scripts.
- `--notriggers` — Uninstall the package without executing scripts that are triggered by removing the package.

If you feel nervous about boldly removing a package, you can always run the uninstall in test mode (`--test`) before you do the real uninstall. Test mode shows you everything that would happen in the uninstall without actually uninstalling. (Add the `--vv` option to see the details.) Here's an example:

```
# rpm -evv --test jpilot | less
D:  0 0x0000fd00  4096  218926  2160537 /
D:  1 0x00000003  4096      0      -1 /proc
D:  2 0x00000000  4096      0      -1 /sys
D:  3 0x0000000b  4096      0      -1 /dev/pts
D:  4 0x00000801  1024   77585   26043 /boot
D:  5 0x00000013  4096   64436   64435 /dev/shm
D:  6 0x00000014  4096      0      -1 /proc/sys/fs/binfmt_misc
D:  7 0x00000015  4096      0      -1 /var/lib/nfs/rpc_pipefs
D: sanity checking 1 elements
D: running pre-transaction scripts
D: computing 84 file fingerprints
D: computing file dispositions
D: opening db index      /var/lib/rpm/Basenames rdonly mode=0x0
D: ===== --- jpilot-0.99.8-7.1 i386-linux 0x1
D:      erase: jpilot-0.99.8-7.1 has 84 files, test = 1
D: running post-transaction scripts
D: closed  db index      /var/lib/rpm/Pubkeys
D: closed  db index      /var/lib/rpm/Requirename
D: closed  db index      /var/lib/rpm/Basenames
D: closed  db index      /var/lib/rpm/Name
D: closed  db index      /var/lib/rpm/Packages
D: closed  db environment /var/lib/rpm/Packages
D: May free Score board((nil))
```

If the results look fine, you can run the command again, without the `--test` option, to have the package removed.

## Querying Packages with rpm

You can use the `-qx` options (at least one additional option is required after `q`) to `rpm` to get information about RPM packages. This can be simply listing the packages that are installed or printing detailed information about a package. Here is the basic format of an `rpm` query command:

```
# rpm -q [options]
```

The following list shows some useful options you can use with an `rpm` query:

- `-qa` — Lists all installed packages.
- `-qf file` — Lists the package that owns *file*. (The file must include the full path name or `rpm` assumes the current directory.)
- `-qi package` — Lists lots of information about a package.
- `-qR package` — Lists components (such as libraries and commands) that *package* depends on.
- `-q1 package` — Lists all the files contained in *package*.
- `-qd package` — Lists all documentation files that come in *package*.
- `-qc package` — Lists all configuration files that come in *package*.
- `-qp [option] package` — Query packages that are not yet installed. Using this option, along with other query options, allows you to query packages you have that are not yet installed.

To list all the packages installed on your computer, use the `-a` query option. Because this is a long list, you should either pipe the output to `less` or, possibly, use `grep` to find the package you want. The following command line displays a list of all installed RPM packages and then shows only those names that include the string of characters `xorg`. (The `-i` option to `grep` says to ignore case.)

```
# rpm -qa |grep -i xorg
```

If you are interested in details about a particular package, you can use the `rpm -i` query option. In the following example, information about the `dosfstools` package (for working with DOS file systems in Linux) is displayed:

```
# rpm -qi dosfstools
Name           : dosfstools                Relocations: (not relocatable)
Version        : 2.11                    Vendor: CentOS
Release        : 6.2.e15                 Build Date: Wed 14 Mar 2007
              : 09:03:25 AM EDT
Install Date: Sat 20 Dec 2008 05:27:09 PM EST   Build Host: builder6
Group          : Applications/System        Source RPM: dosfstools-
              : 2.11-6.2.e15.src.rpm
Size           : 120461                    License: GPL
Signature      : DSA/SHA1, Tue 03 Apr 2007 08:21:12 PM EDT,
              : Key ID a8a447dce8562897
Summary        : Utilities for making and checking MS-DOS FAT filesystems
on Linux.
Description    :
The dosfstools package includes the mkdosfs and dosfsck utilities,
which respectively make and check MS-DOS FAT filesystems on hard
drives or on floppies.
```

To find out about a package's contents, you can use the `-l` option with your query. The following example shows the complete path names of files contained in the `dosfstools` package:

```
# rpm -ql dosfstools | less
/sbin/dosfsck
/sbin/fsck.msdos
/sbin/fsck.vfat
/sbin/mkdosfs
/sbin/mkfs.msdos
/sbin/mkfs.vfat
/usr/share/man/man8/dosfsck.8.gz
.
.
.
```

Would you like to know how to use the components in a package? Using the `-d` option with a query will display the documentation (man pages, README files, HOWTOs, etc.) that is included with the package. If you are having trouble getting your X Window System running properly, you can use the following command line to find documents that may help:

```
# rpm -qd xorg-x11-server-Xorg | less
/usr/share/man/man1/Xorg.1x.gz
/usr/share/man/man1/Xserver.1x.gz
/usr/share/man/man1/cvt.1.gz
/usr/share/man/man1/gtf.1x.gz
/usr/share/man/man1/scanpci.1x.gz
/usr/share/man/man4/fbdevhw.4.gz
/usr/share/man/man5/xorg.conf.5.gz
```

Many packages have configuration files associated with them. To see what configuration files are associated with a particular package, use the `-c` option with a query. For example, this is what you would type to find configuration files that are used with the `ppp` package:

```
# rpm -qc ppp
/etc/logrotate.d/ppp
/etc/pam.d/ppp
/etc/ppp/chap-secrets
/etc/ppp/options
/etc/ppp/pap-secrets
```

If you ever want to know which package a particular command or configuration file came from, you can use the `-qf` option. In the following example, the `-qf` option displays the fact that the `chgrp` command comes from the `fileutils` package:

```
# rpm -qf /bin/chgrp
coreutils-5.97-14.el5
```

Before you install a package, you can do the same queries on it that you would do on an installed package. This can be a great tool for finding information from a package while it is in your current directory, or even in a software repository. Here is an example of using the `-qp` option with `-i` to see the description of a package in a software repository:

```
# rpm -qp -i http://centos.karan.org/e15/extras/testing/i386/RPMS
/caca-utils-0.99-0.1.beta11.e15.kb.i386.rpm
Name       : caca-utils           Relocations: (not relocatable)
Version    : 0.99                 Vendor: http://www.karan.org/
Release    : 0.1.beta11.e15.kb   Build Date: Mon 28 May 2007
          03:46:13 PM EDT
Install Date: (not installed)     Build Host: monk.karan.org
Group      : Amusements/Graphics  Source RPM: libcaca-0.99-0.1
          .beta11.e15.kb.src.rpm
Size       : 118940               License: LGPL
Signature  : DSA/SHA1, Tue 29 May 2007 05:06:22 AM EDT,
          Key ID 300dbd9e3e13cf5b
Packager   : Karanbir Singh <kbsingh@karan.org>
URL        : http://libcaca.zoy.org/
Summary    : Colour Ascii Art Text mode graphics utilities based on
          libcaca
Description:
This package contains utilities and demonstration programs for lib-
caca, the
Colour Ascii Art library.

cacaview is a simple image viewer for the terminal. It opens most
image
formats such as JPEG, PNG, GIF etc. and renders them on the
terminal using
ASCII art. The user can zoom and scroll the image, set the
dithering method
or enable anti-aliasing.

cacaball is a tiny graphic program that renders animated ASCII
metaballs on
the screen, cacafire is a port of AALib's aafire and displays
burning ASCII
art flames, and cacademo is a simple application that shows the
libcaca
rendering features such as line and ellipses drawing, triangle
filling and
sprite blitting.
```

In the previous example, the long command line that spans two lines should actually be typed on one line. If you are concerned about the content or legality of downloading a package, this example is a way to read the description of a package before you even download it.

In the following example, the command lists the files contained in a package that is in the current directory:

```
# rpm -qp -l AdobeReader_enu-8.3.1-1.i486.rpm
```

Again, this is an excellent way to find out what is in a package before you install it.

## Verifying Installed Packages with rpm

If something in a software package isn't working properly or if you suspect that your system has been tampered with, the `-V` option of `rpm` can help you verify installed software against its original software package. Information about each installed package is stored on your computer in the RPM database. By using the verify option, you can check whether any changes were made to the components in the package.

### NOTE

The verify option uses the uppercase letter (`-V`), while the verbose option uses the lowercase letter (`-v`).

Various file size and permissions tests are done during a verify operation. If everything is fine, there is no output. Any components that have changed from when they were installed will be printed along with information indicating how they were changed. Here's an example:

```
# rpm -V ppp
S.5....T. c /etc/ppp/chap-secrets
S.5....T. c /etc/ppp/options
S.5....T. c /etc/ppp/pap-secrets
```

This output shows that the `ppp` package (used to dial up a TCP/IP network such as the Internet) has had three files changed since it was installed. The notation at the beginning shows that the file size (S), the MD5 sum (5), and the modification time (T) have all changed. The letter `c` shows that these are all configuration files. By reviewing these files to see that the changes were only those that I made to get PPP working, I can verify that the software is OK.

The indicators that you may see when you verify the contents of a configuration file are:

- **5 (MD5 Sum)** — An MD5 checksum indicates a change to the file contents.
- **S (File size)** — The number of characters in the file has changed.
- **L (Symlink)** — The file has become a symbolic link to another file.
- **T (Mtime)** — The modification time of the file has changed.
- **D (Device)** — The file has become a device special file.
- **U (User)** — The username that owns the file has changed.
- **G (Group)** — The group assigned to the file has changed.
- **M (Mode)** — The ownership or permission of the file changed.

## Using Software in Different Formats

There may not be RPMs available for every piece of software you want to install on your CentOS system. Likewise, you may find that an RPM isn't configured exactly the way you would want it, so that you would be better served by building your own RPM from an RPM source code package. The following sections describe various forms in which you may encounter Open Source software and different ways of building and installing that software for you to use.

## Understanding Software Package Names and Formats

Whenever possible, you want to install the applications you use with CentOS from software packages in RPM format. However, if an RPM isn't available, the software that you want may come in other package formats.

Say you just downloaded a file from the Internet whose name contains lots of letters, numbers, dots, gzs, and tars. What does all that stuff mean? Well, when you break it down, it's really not that complicated.

Most of the names of archive files containing Linux applications follow the GNU-style package-naming conventions. The following example illustrates the package-naming format:

```
mycoolapp-4.2.3-1.i386.rpm  
mycoolapp-4.2.3.tar.gz  
mycoolapp-4.2.3.src.tar.gz  
mycoolapp-4.2.3.bin.SPARC.tar.gz  
mycoolapp-4.2.3.bin.ELF.static.tar.gz
```

These examples represent several different packages of the same software application. The name of this package is `mycoolapp`. Following the package name is a set of numbers that represent the version of the package. In this case, it is version 4.2.3 (the major version number is 4, followed by minor version number and patch level 2.3). After the version number is a dot, followed by some optional parts, which are followed by indications of how the file is archived and compressed.

The first line shows a package that is in the RPM Package Management (`.rpm`) format. The `.i386` before the `.rpm` indicates that the package contains binaries that are built to run Intel i386 architecture computers (in other words, PCs). The `-1` indicates the build level (the same package may have been rebuilt multiple times to make minor changes). See the sidebar “Using Binary RPMs versus Building from Source” for the pros and cons of using pre-built RPM binary packages as opposed to compiling the program yourself.

### Using Binary RPMs versus Building from Source

**B**inaries created in RPM format are easily installed, managed, and uninstalled using tools such as `rpm` and `yum`. This is the recommended installation method for CentOS novices. Sometimes, however, building an application from source code may be preferable. Here are some arguments on both sides:

*continued*

*continued*

- **RPM** — Installing applications from a binary RPM archive is easy. After the application is installed, there are both shell commands and GUIs for managing, verifying, updating, and removing the RPM package. You don't need to know anything about Makefiles or compilers. When you install a binary RPM package, RPM tools even check to make sure that other packages that the package depends on are installed. Because Red Hat has released RPM under the GPL, other Linux distributions also use it to distribute their software. Thus, most Linux applications are, or will be, available in RPM format.
- **Source Code** — Not all source-code packages are made into RPM binaries. If you use RPM, you may find yourself with software that is several versions old, when you could simply download the latest source code and run a few `tar` and `make` commands. Also, by modifying source code, you can tailor the package to better suit your needs.

For more information on RPMs, refer to the *Red Hat RPM Guide* by Eric Foster-Johnson (Red Hat Press/Wiley, 2003).

In the next two lines of the previous example, each file contains the source code for the package. The files that make up the package were archived using the `tar` command (`.tar`) and compressed using the `gzip` command (`.gz`). You use these two commands (or just the `tar` command with the `-z` option) to expand and uncompress the packages when you are ready to install the applications.

Between the version number and the `.tar.gz` extension there can be optional tags, separated by dots, that provide specific information about the contents of the package. In particular, if the package is a binary version, this information provides details about where the binaries will run. In the third line, the optional `.src` tag was added because the developer wanted to differentiate between the source and binary versions of this package. In the fourth line, the `.bin.SPARC` detail indicates that it is a binary package, ready to run on a SPARC workstation. The final line indicates that it is a binary package, consisting of statically linked ELF format executables.

Instead of using `gzip`, many software packagers today use the `bzip2` utility to compress their software archives. In that case, filenames shown in the examples above might instead end with `.bz2` or `.tar.bz2` extensions.

Here is a breakdown of the parts of a package name:

- **Name** — This is generally an all-lowercase string of characters that identifies the application.
- **Dash** (-)
- **Version** — This is shown as major to minor version number from left to right.

- **Dot (.)**
- **src or bin** — This is optional, with `src` usually implied if no indication is given.
- **Dot (.)**
- **Type of Binary** — This is optional and can include several different tags to describe the content of the binary archive. For example, `i386` indicates binaries intended for Intel architectures (Pentium CPU), and `SPARC` indicates binaries for a Sparc CPU.
- **Dot (.)**
- **Archive Type** — Often `tar` is used (`.tar`).
- **Compression Type** — Often `gzip` is used (`.gz`).

## Understanding Different Archive Formats

Many of the software packages that are not associated with a specific distribution use the `tar/gzip` method for archiving and compressing files. However, you may notice files with different suffixes at software project sites.

Table 5-1 describes the different file formats that you will encounter as you look for software at a Linux FTP site.

If you would like to convert a software package from one of the formats described above, you can try the `alien` utility (<http://freshmeat.net/projects/alien>). Although `alien` is not considered stable enough to use with important system packages, it can be a good tool for trying out some simple software packages on your CentOS system.

## Building and Installing from Source Code

If no binary version of the package that you want is available or if you just want to tailor a package to your needs, you can always install the package from source code. To begin, you can get the source code (SRPM) version of any binary packages in CentOS from the CentOS repository. You can modify the source code and rebuild it to suit your needs.

Software packages that are not available in RPM format are typically available in the form of a *tarball* (a bunch of files grouped together into a single file formatted by the `tar` utility) that has been compressed (typically by the `gzip` utility). Although the exact instructions for installing an application from a source code archive vary, many packages that are in the `.bz2`, `.tar.bz2`, `.tgz`, `.gz` and `.tar` formats follow the same basic procedure.

### TIP

Before you install from source code, you will need to install a variety of software development packages. If you have the disk space, I recommend that you install all software development packages that are recommended during CentOS installation.

The following is a minimal list of C programming software development tools:

- **gcc** — Contains the `gcc` (GNU C compiler) compiler.
- **make** — Contains the `make` command for making the binaries from Makefiles.



TABLE 5-1

## Linux Archive File Formats

Format	Extension	Description
gzip file	.gz	The file was compressed using the GNU <code>gzip</code> utility. It can be uncompressed using the <code>gzip</code> or <code>gunzip</code> utilities (they are both the same).
tar file	.tar	The file was archived using the <code>tar</code> command. <code>tar</code> is used to gather multiple files into a single archive file. You can expand the archive into separate files using <code>tar</code> with different options.
tar and gzip file	.tgz	A common practice for naming files that are <code>tar</code> archives that were compressed with <code>gzip</code> is to use the <code>.tgz</code> extension.
bzip2	.bz2	The file was compressed with the <code>bzip2</code> program.
Tar/compressed	.tar.gz or .tar.bz2	The file was archived with <code>tar</code> and compressed with the UNIX <code>compress</code> command.
Linux Software Map	.lsm	The file contains text that describes the content of an archive.
Debian Binary Package	.deb	The file is a binary package used with the Debian Linux distribution. (See descriptions of how to convert Debian to Red Hat formats later in this chapter.)
RPM Package Management	.rpm	The file is a binary package used with Red Hat–based systems. This format also available to other Linux distributions.

- `glibc` — Contains important shared libraries, the C library, and the standard math library.
- `glibc-devel` — Contains standard header files needed to create executables.
- `binutils` — Contains utilities needed to compile programs (such as the assembler and linker).
- `kernel-devel` — Contains the Linux kernel source code and is needed to rebuild the kernel.
- `rpm-build` — Contains the `rpmbuild` utility for building the RPM binary package from source code.
- `libc` — Contains libraries needed for programs that were based on `libc 5`, so older applications can run on `glibc (libc 6)` systems. If you use C++, there are several packages to get, especially `libstdc++` and `libstdc++-devel`.

## Installing Software in SRPM Format

To install a source package from the CentOS source directory, do the following:

1. Prepare your working environment.

```
# mkdir -p ~/rpmbuild/{SPECS,SRPMS,RPMS,BUILD,SOURCES}
# echo "%_topdir ~/rpmbuild" >> ~/.rpmmacros
```

2. Download the package you want to the current directory.

Install the source code package using the following command:

```
# rpm -iv packagename*.src.rpm
```

Replace *packagename* with the name of the package you are installing.

3. Change to the SPECS directory as follows:

```
# cd ~/rpmbuild/SPECS
```

4. Unpack the source code as follows. Note that you may need to install the `rpm-build` package:

```
# rpmbuild -bp packagename*.spec
```

The package's source code is installed to the `rpmbuild/BUILD/package` directory, where *package* is the name of the software package.

5. You can now make changes to the files in the package's BUILD directory. Read the README, Makefile, and other documentation files for details on how to build the individual package.

The `--rebuild` option to `rpmbuild` can be used to rebuild the RPM without installing it first. The resulting binary will be in `rpmbuild/RPMS/arch`, where *arch* is replaced by `i386` or other architecture for which you are building the RPM.

## Installing Software in tar.gz or tar.bz2 Formats

Here are some generic instructions that you can use to install many Linux software packages that are in the `gzip` or `tar` format:

1. Get the source code package from the Internet or from a CD distribution and copy it into an empty directory.
2. To check the contents of your tar archive before extracting it to your hard drive, you could use the following command:

```
# tar tvf package.tar.gz
```

### NOTE

Use the command `tar tvjf` if the file is compressed using `bzip2`.

3. Assuming that the file is compressed using `gzip`, uncompress the file using the following command:

```
# gunzip package.tar.gz
```

The result is that the package is uncompressed and the `.gz` is removed from the package name (e.g., `package.tar`). (If your package ends in `bz2`, use the `bzip2` command instead of `gunzip` shown above.)

4. From the resulting `tar` archive, run the `tar` command as follows:

```
# tar xvf package.tar
```

This command extracts the files from the archive and copies them to a subdirectory of the current directory. (Using `tar xvfz package.tar.gz`, you can do Steps 2 and 3 in one step. For a compressed `bzip2` file, run `tar xvfj package.tar.bz2` instead.)

5. Change directories to the new subdirectory created in Step 3, as follows:

```
# cd package
```

6. Look for a file called `INSTALL` or `README`. One of these files should give you instructions on how to proceed with the installation. In general, the `make` command is used to install the package. Here are a few things to look for in the current directory:

- If there is a `Make.in` file, try running:

```
# ./configure --prefix=/usr/local
# make all
```

- If there is an `Imake` file, try running:

```
# xmkmf -a
# make all
```

- If there is a `Makefile`, try running:

```
# make all
```

After the program is built and installed, you might have to do additional configuration. You should consult the man pages or the HOWTOs that come with the software for information on how to proceed.

## TIP

With some `tar.gz` files that include an RPM spec file, you could run the `rpm -ta file.tar.gz` and the `rpm` command will build an RPM from that tarball.

To try out this procedure, I downloaded the `whichman` package, which includes utilities that let you find manual pages by entering keywords. The file I downloaded, `whichman-2.2.tar.gz`, was placed in a directory that I created called `/usr/src/which`. I then ran the `gunzip` and `tar` commands, using `whichman-2.2.tar.gz` and `whichman-2.2.tar` as arguments, respectively.

I changed to the new directory, `cd /usr/src/which/whichman-2.2`. I then listed its contents. The `README` file contained information about the contents of the package and how to install it. As the `README` file suggested, I typed **make**, and then **make install**. The commands `whichman`, `ftwhich`, and `ftff` were installed in `/usr/bin`. At this point, you can check the man page for each component to see what it does.

The last thing I found in the README file was that a bit of configuration needed to be done. I added a MANPATH variable to my `$HOME/.bashrc` to identify the location of man pages on my computer to be searched by the `whichman` utility. The line I added looked like this:

```
export MANPATH=/usr/share/man:/usr/man/man1:/usr/X11R6/man:/usr/share/doc/samba-2.2.3a/docs
```

In case you are wondering, `whichman`, `ftwhich`, and `ftff` are commands that you can use to search for man pages. They can be used to find several locations of a man page, man pages that are close to the name you enter, or man pages that are located beneath a point in the directory structure, respectively.

## Using CentOS to Run Applications

---

Although operating systems are nice, people use desktop computers to run application programs. There has been a common belief that although CentOS can work well as a server, they are not ready to challenge Microsoft's dominance of the desktop arena. There are several reasons why, I believe, CentOS can replace Microsoft Windows on the desktop, if you are committed to doing it:

- Every category of desktop application now has an Open Source offering that will run in Linux. So, for example, although Adobe Photoshop doesn't run natively in Linux, you can use The GIMP or other applications to work with digital images in Linux.
- Your Windows applications that you absolutely must have can usually be run without problems using Windows emulators or compatibility programs, such as QEMU and WINE. Particular efforts have been made to get Windows games and office productivity applications running in Linux.
- With viruses and worms running rampant in Microsoft systems, many people now believe that Linux systems offer a more secure alternative, particularly if the desktop system is being used primarily for Web browsing and e-mail. With Linux, corporations that deploy hundreds or even thousands of desktop systems can exercise a great deal of control over the security and features in their employees' systems. In addition, most Linux administration can be done remotely using `ssh`, which offers encryption and authentication, along with all the advantages of a Linux shell.
- In the long run, as Linux systems become more profitable targets for viruses and malware, learning good practices in choosing software, using file ownership/permission, and monitoring system resources will become more important. However, such tools (including virus scanners like `clamav` and `clamscan`) are already available for any Linux system that chooses to include them. (For more information, refer to [www.clamav.net](http://www.clamav.net) and <http://clamav.sourceforge.net>.)
- A huge development community is working on Open Source applications to meet the needs of the Linux community. If you feel more secure having a company backing up your mission-critical applications, some strong commercial software offerings are available for Red Hat-based systems ([www.redhat.com/apps/isv\\_catalog](http://www.redhat.com/apps/isv_catalog)).

The bottom line is that it will take some effort for most people to discard their Microsoft Windows operating systems completely. However, if you are committed to making CentOS your sole application platform, there are several ways to ease that transition. Emulation programs let you run many programs that were created for other operating systems. Conversion programs can help you convert graphics and word processing data files from other formats to those supported by Linux applications.

**CROSS-REF** See Chapter 6 for information on importing and exporting word processing and graphics files.

If you are running Linux on a PC, chances are that you already paid for a Microsoft Windows XP or Vista operating system. You can either run Linux on a different PC from that you use for Windows, or have Windows and Linux on separate partitions of your hard disk on the same PC. The latter requires that you reboot each time you want to switch operating systems. (See Chapter 2 for information on setting up a Linux/Windows dual-boot system.) Recently, a third choice has been added, where you can run a virtual Windows system on your Linux desktop. (See the descriptions of Xen and KVM later in this chapter.)

The following section describes applications that run in CentOS that you can use to replace the Windows applications you are used to.

## Finding Common Desktop Applications in Linux

If you are going to use Linux as a desktop computer system, you have to be able to write documents, work with graphics, and crunch numbers. You probably also have other favorite applications, like a music player, a Web browser, and an e-mail reader.

**NOTE** Using WINE technology, the people at Codeweavers, Inc. offer a CrossOver Office product that lets you install and run Microsoft Office in Linux. See the “Running Windows Applications with WINE” section later in this chapter.

To give you a snapshot of what desktop applications are available, Table 5-2 contains a list of popular Windows applications, equivalent Linux applications, and where you can find the Linux applications. Although many of these applications have not reached the level of sophistication of their Windows counterparts, they can be cost-effective alternatives.

The following sections describe how to find and work with application programs that are included or available specifically for Linux.

## Investigating Your Desktop

More and more high-quality desktop applications are being packaged with or made available for CentOS, many as part of the GNOME or KDE desktop environments. In other words, to start finding some excellent office applications, games, multimedia players, and communications tools, you don't have to look any further than the Applications Menu button on your desktop panel.

TABLE 5-2

## Windows-Equivalent Linux Applications

Windows Applications	Linux Applications	Where to Get Linux Applications	Cost
Microsoft Office (office productivity suite)	OpenOffice.org (openoffice.org)	Included on CentOS DVD	Free
	Koffice	Included on CentOS DVD	Free
	StarOffice	<a href="http://www.sun.com/staroffice">www.sun.com/staroffice</a>	\$69.95
Microsoft Word (word processor)	OpenOffice.org Writer	Included on CentOS DVD	Free
	AbiWord	Included on CentOS DVD	Free
	KWord	Included on CentOS DVD	Free
Microsoft Excel (spreadsheet)	OpenOffice.org Calc	Included on CentOS DVD	Free
	Gnumeric	Included on CentOS DVD	Free
	KSpread	Included on CentOS DVD	Free
Microsoft PowerPoint (presentation)	OpenOffice.org Impress	Included on CentOS DVD	Free
	KPresenter	Included on CentOS DVD	Free
Microsoft Internet Explorer (Web browser)	Firefox	Included on CentOS DVD	Free
	Epiphany	<a href="http://projects.gnome.org/epiphany/">http://projects.gnome.org/epiphany/</a>	Free
	Konqueror	Included on CentOS DVD	Free
	Opera	<a href="http://www.opera.com">www.opera.com</a>	Free
Microsoft Outlook (e-mail reader)	Evolution	Included on CentOS DVD	Free
	KMail	Included on CentOS DVD	Free
	Thunderbird	Included on CentOS DVD	Free
	Mozilla Lightning	<a href="http://www.mozilla.org/projects/calendar/lightning/">www.mozilla.org/projects/calendar/lightning/</a>	Free

*continued*

**TABLE 5-2** (continued)

Windows Applications	Linux Applications	Where to Get Linux Applications	Cost
Adobe Photoshop (image editor)	The GIMP (gimp)	Included on CentOS DVD	Free
Microsoft Expression or Front Page (HTML editor)	Quanta	<a href="http://quanta.kdewebdev.org">http://quanta.kdewebdev.org</a>	Free
Quicken or Microsoft Money (personal finance)	GnuCash	<a href="http://www.gnucash.org">www.gnucash.org</a>	Free
AutoCAD (computer-aided design)	LinuxCad	<a href="http://www.linuxcad.com">www.linuxcad.com</a>	\$89
	NX	<a href="http://www.plm.automation.siemens.com/">www.plm.automation.siemens.com/</a>	See vendor
	ProEngineer	<a href="http://www.ptc.com/products/proengineer/">www.ptc.com/products/proengineer/</a>	See vendor

So, before you start hunting around the Internet for the software you need, see if you can use something already installed with CentOS. The chapters that follow this one describe how to use publishing tools, play games, work with multimedia, and communicate over the Internet — all with programs that are either on the DVD that comes with this book or are easily attainable.

Using your CentOS desktop to run applications is relatively easy. If you have used Microsoft Windows operating systems, you already know the most basic ways of running an application from a graphical desktop. X, however, provides a much more flexible environment for running native Linux applications.

## Starting Applications from a Menu

To run applications on your own desktop, most X window managers provide a menu, similar to the Microsoft Start menu, to display and select X applications. Applications are usually organized in categories. From the GNOME or KDE desktops in CentOS, open the Applications menu, select the category, and then select the application to run. Figure 5-3 shows an example of the Applications menu and the Accessories submenu in GNOME. You can install both GNOME and KDE applications on your Linux system.

## Starting Applications from a Run Application Window

Not all installed applications appear on the menus provided with your window manager. For running other applications, some window managers provide a window, similar to the Run Application window, that lets you type in the name of the program you want to run.

**FIGURE 5-3**

Starting X applications from the Applications menu.



To access the Run Application window:

1. Right-click on the panel and select “Add to Panel.”
2. Select “Run Application” and click Add. The Run Application icon should appear on the panel.
3. Click on the “Run Application” button. The Run Application window appears.
4. Click “Show List of Known Applications,” click on the program you want, and then click Run.
5. If the application you want isn’t on the list, you can either type the command you want to run (along with any options) and click Run, or you can click “Run with File” to browse through directories to select a program to run. If you are running a program that needs to run in a Terminal window, such as the `vi` command, click on the “Run in Terminal” button before running the command. Figure 5-4 is an example of the Run Application window.

## Starting Applications from a Terminal Window

I often prefer to run an X application, at least for the first time, from a Terminal window. There are several reasons why I prefer a Terminal window to selecting an application from a menu or Run Application window:

- If there is a problem with the application, you see the error messages. Applications started from a menu or Run Application window usually just fail silently.
- Applications from menus run with set options. If you want to change those options, you have to change the configuration file that set up the menu and make the changes there.
- If you want to try out a few different options with an application, a Terminal window is an easy way to start it, stop it, and change its options.



**FIGURE 5-4**

Select a program to run from the list in the Run Application window.



When you have found an application and figured out the options that you like, you can add it to a menu or a panel if your window manager supports those features. In that way, you can run a program exactly as you want, instead of the way it is given to you on a menu.

Here is a procedure to run X applications from a Terminal window:

1. Open a Terminal window from your desktop.
2. Type

```
$ echo $DISPLAY
```

The result should be something similar to the following:

```
:0.0
```

This indicates that the Terminal window will, by default, direct any X application you run from this window to display 0.0 on your local system. If you don't see a value when you type that command, type **export DISPLAY=:0.0** to set the display value.

3. With the `xmms` package installed, type the following command:

```
$ xmms &
```

The `xmms` program should appear on your desktop, ready to work with. If you do not have the `xmms` command, use the command `yum install xmms` to install the program. You should note the following:

- The `xmms` command runs in the background of the Terminal window (&). This means that you can continue to use the Terminal window while `xmms` is running.
- I encountered no errors running `xmms` on this occasion. With other applications, however, text sometimes appeared in the Terminal window after the command was run.

The text may say that the command can't find certain information or that certain fonts or colors cannot be displayed. That information would have been lost if the command were run from a menu.

4. If you want to know what options are available, type:

```
$ xmms --help
```

Try it with a few options. For example, if you want to begin by playing a file and you have an Ogg Vorbis audio file named *file.ogg*, you could type:

```
$ xmms file.ogg
```

5. When you are ready to close the *xmms* window, you can either do so from the *xmms* box window by right-clicking on the *xmms* window and selecting Exit, or you can kill the process in the Terminal window. Type **jobs** to see the job number of the process. If it was job number 2, for example, you would type **kill %2** to kill the *xmms* program. If, instead, you want to continue running *xmms* in the background, press [Ctrl]+Z (to put it in the background) and **bg** (to continue running it in the background).

You should try running a few other X commands. A couple of old X commands you might try are *xeyes* or *xcalc*.

## Running Remote X Applications

X lets you start an application from anywhere on the network and have it show up on your X display. Instead of being limited by the size of your hard disk and the power of your CPU and RAM, you can draw on resources from any computer that gives you access to those resources.

Think about the possibilities. You can work with applications launched from any other computer that can run an X application — from a small PC to a supercomputer. Given the proper permission, you can work with files, printers, back-up devices, removable drives, other users, and any other resources on the remote computer as though you were on that computer.

With this power, however, comes responsibility. You need to protect the access to your display, especially in networks where the other machines and users are not known or trusted. For example, you wouldn't want to allow anyone to display a login screen on your display, encouraging you to inadvertently give some cracker your login and password.

Traditionally, to run remote X applications, you basically only need to know how to identify remote X displays and how to use whatever security measures are put in place to protect your network resources. Using *ssh* to launch X applications is even simpler and more secure than the traditional method. Those issues are described in the following sections.

### Traditional Method to Run Remote X Applications

If there is an X application installed on another computer on your network and you want to use it from your desktop, follow these steps:

1. Open permissions to your X server so that the remote application can use your display.
2. Identify your X server display to the application when it starts up.

When you run an X client on your local system, your local display is often identified as `:0`, which represents the first display on the local system. To identify that display to a remote system, however, you must add your computer's hostname. For example, if your computer were named `whatever`, your display name would be:

```
whatever:0
```

**TIP**

In most cases, the hostname is the TCP/IP name. For the computers on your local network, the name may be in your `/etc/hosts` file, or it may be determined using the Domain Name System (DNS) service. You could also use a full domain name, such as `www.example.com`. X does support other types of transport, although transports other than TCP/IP aren't used much anymore.

You will probably use the display name in this form most of the time you run a remote X application. In certain cases, however, the information may be different. If your computer had multiple X displays (keyboard, mouse, and monitor), you may have numbers other than `:0` (`:1`, `:2`, etc.). It is also possible for one keyboard and mouse to be controlling more than one monitor, in which case you could add a screen number to the address, like this:

```
whatever:0.1
```

This address identifies the second screen (`.1`) on the first display (`:0`). The first screen is identified as `.0` (which is the default because most displays only have one screen). Unless you have multiple physical screens, however, you can skip the screen identifier.

There are two ways to identify your display name to a remote X application:

- **DISPLAY Shell Variable** — The `DISPLAY` shell variable can be set to the system name and number identifying your display. After this is done, the output from any X application run from that shell will appear on the display indicated. For example, to set the `DISPLAY` variable to the first display on `whatever`, type one of the following:

```
export DISPLAY=whatever:0
```

or

```
setenv DISPLAY whatever:0
```

The first example shows how you would set the `DISPLAY` variable on a `bash` or `ksh` shell. The second example works for a `csh` shell.

- **-display Option** — Another way to identify a remote display is to add the `-display` option to the command line when you run the X application. This overrides the `DISPLAY` variable. For example, to open an `xterm` window on a remote system so that it appears on the first display on `whatever`, type the following:

```
xterm -display whatever:0
```

With this information, you should be able to run an X application from any computer that you can access from your local computer. The following sections describe how you may use this information to start a remote X application.

## Launching a Remote X Application

Suppose you want to run an application from a computer named `remote1` on your local area network (in your same domain). Your local computer is `local1`, and the remote computer is `remote1`. The following steps show how to run an X application from `remote1` from your X display on `local1`.

**CAUTION** This procedure assumes that no special security procedures are implemented. It is the default situation and is designed for sharing applications among trusted computers (usually single-user workstations) on a local network. This method is inherently insecure and requires that you trust all users on computers to which you allow access. If you require a more secure method, refer to the section “Using SSH to Run Remote X Applications” later in this chapter.

You may need to enable your X server to support networked connections. To see if you need to enable networked connections, run the following command:

```
$ ps uax | grep Xorg
root      1941  0.0  2.1  54276  44972 tty1      Ss+  11:14   0:04 /usr/
  bin/Xorg :0
  -nr -verbose -auth /var/run/gdm/auth-for-gdm-D9SKms/database vt1
  -nolisten tcp
ericfj    6034  0.0  0.0   4212   724 pts/0      R+   12:21   0:00
  grep Xorg
```

If you see `-nolisten tcp` in the `Xorg` command, you need to enable networked connections. To do so, edit the file `/etc/gdm/custom.conf`, if you are using the GNOME Display Manager. Look for the `[security]` section and disable the `DisallowTCP` option:

```
[security]
DisallowTCP=false
```

After this, restart your system. Log in and check if the `-nolisten tcp` argument is still present:

```
$ ps uax | grep Xorg
root      2141  0.0  2.1  54276  44972 tty1      Ss+  12:04   0:04 /usr/
  bin/Xorg :0
  -nr -verbose -auth /var/run/gdm/auth-for-gdm-sZV27d/database vt1
ericfj    4021  0.0  0.0   4212   724 pts/0      R+   13:49   0:00
  grep Xorg
```

Once completed, follow these steps to enable remote applications to connect to your desktop.

1. Open a Terminal window on the local computer.
2. Allow access for the remote computer (e.g., `remote1`) to the local X display by typing the following from the Terminal window:

```
$ xhost +remote1
remote1 being added to access control list
```

3. Log in to the remote computer using any remote login command. For example:

```
$ telnet -l user remote1
Password:
```

4. Replace *user* with the name of the user login that you have on the remote computer. You will be prompted for a password.

**NOTE**

By default, the telnet service is not enabled in CentOS. The server's administrator (in this example, `flashg`) must consider security consequences of enabling remote login services. Data sent over telnet is sent in the clear, which is one of the reasons not to use telnet if security is a concern.

5. Type the password for the remote user login. (You are now logged in as the remote user in the Terminal window.)
6. Set the `DISPLAY` variable on the remote computer to your local computer. For example, if your computer were named `pine` in the local domain, the command could appear as:

```
$ export DISPLAY=pine:0
```

(If you are using a `csh` shell on the remote system, you may need to type **`setenv DISPLAY pine:0`**.)

7. At this point, any X application you run from the remote system from this shell will appear on the local display. For example, to run a remote Terminal window so that it appears locally, type:

```
$ xterm
```

The Terminal window appears on the local display.

You need to remember some things about the remote application that appears on your display:

- If you only use the login to run remote applications, you can add the line exporting the `DISPLAY` variable to a user configuration file on the remote system (such as `.bashrc`, if you use the bash shell). After that, any application that you run will be directed to your local display.
- Even though the application looks as though it is running locally, all the work is being done on the remote system. For example, if you ran a word processing program remotely, it would use the remote CPU, and when you save a file, it is saved to the remote file system.

**CAUTION**

Don't forget when a remote shell or file editor is open on your desktop. Sometimes people forget that a window is remote and will edit some important configuration file on the remote system by mistake (such as the `/etc/fstab` file). You could damage the remote system with this type of mistake.

## Using SSH to Run Remote X Applications

Not only does the `ssh` command provide a secure mechanism for logging in to a remote system, it also provides a way of securely running remote X applications. With X11 forwarding turned on, any X application you run from the remote location during your session will appear on your local desktop.

After you log in to the remote computer using `ssh`, you can use that secure channel to forward X applications back to your local display. Here is an example:

1. Type the following `ssh` command to log in to a remote computer (the `-X` option enables X11 forwarding):

```
$ ssh -X timothy@flashg
timothy@flashg's password: *****
```

2. Check that the `display` variable is set to forward any X applications you run through this session to your local display (this value is controlled by the `X11DisplayOffset` setting in `/etc/ssh/sshd_config`):

```
$ echo $DISPLAY
localhost:10.0
```

3. After you are logged in, type any X command, and the window associated with that command appears on your local display. For example, to start the `gedit` command, type:

```
$ gedit &
```

The SSH daemon (`sshd`) on the remote system sets up a secure channel to your computer for X applications. So as not to interfere with any real display numbers, the SSH daemon (by default) uses the display name of `localhost:10.0`.

The `xorg-x11-xauth` package needs to be installed for X forwarding feature to work. You also need to make sure that X forwarding is enabled on the other host as well (verify that the `X11Forwarding yes` value is set in the `/etc/ssh/sshd_config` file).

## Running Microsoft Windows, DOS, and Macintosh Applications

---

Linux is ready to run most applications that were created specifically for Linux, the X Window System, and many UNIX systems. Many other applications that were originally created for other operating systems have also been ported to Linux. However, there are still lots of applications created for other operating systems for which there are no Linux versions.

Linux can run some applications that are intended for other operating systems using *emulator* programs. An emulator, as the name implies, tries to act like something it is not. In the case of

an operating system, an *emulator* tries to present an environment that looks to the application like the intended operating system.

**NOTE**

The most popular of these emulators, called *WINE*, is not really an emulator at all. *WINE* is a mechanism that implements Windows application-programming interfaces; rather than emulating Microsoft Windows, it provides the interfaces that a Windows application would expect. In fact, some people claim that *WINE* stands for “WINE Is Not an Emulator.”

In the following sections, I discuss emulators that enable you to run applications that are intended for the following operating systems:

- DOS
- Microsoft Windows 3.1
- Microsoft Windows 95
- Microsoft Windows 98
- Microsoft Windows 2000
- Microsoft Window ME
- Microsoft Windows NT
- Microsoft Windows XP
- Microsoft Windows Vista
- Macintosh (Mac OS)

As for Mac OS X applications, because that operating system is based on a UNIX-like operating system called *Darwin*, many Open Source applications written for Mac OS X will have versions available that run in Linux. If you find an application that you like in Mac OS X and want to run in Linux, check the [sourceforge.net](http://sourceforge.net) site to see if the project that created the Mac OS X application offers a Linux version of it as well (or at least the source code to try to build the application yourself).

**NOTE**

In theory, any application that is Win32-compatible should be able to run using software such as *WINE* (described later). Whether or not a Microsoft Windows application will run in an emulator in Linux must really be checked on a case-by-case basis.

Available emulation programs include:

- **DOSBox** ([www.dosbox.com](http://www.dosbox.com)) — For running many classic DOS applications that won't run on new computers. (Install it from the RPMForge repository by typing **yum install dosbox** as root.)
- **DOSEMU** — Also for running classic DOS applications. (Refer to the DOSEMU site at <http://dosemu.sourceforge.net> for information. Select the “Stable Releases” link to find RPM binaries of DOSEMU that run in CentOS.)

- **WINE** — Which lets you run Windows binaries. Windows XP and Vista programs are not as well supported. However, because many Windows applications are written to work in earlier Windows systems (why limit their market just to use a couple of XP-specific calls?), they will run just fine in WINE as well. Check the documentation for the Windows application. If it only requires Windows 95 or Windows 98, it will often run in WINE.
- **ARDI Executor** — Which enables you to run applications that are intended for the Macintosh operating system (MAC OS)

In general, the older and less complex the program, the better chance it has to run in an emulator. Character-based applications generally run better than graphics-based applications. Also, programs tend to run slower in emulation, sometimes because of additional debugging code put into the emulators. However, because WINE “is not an emulator,” any application that doesn’t make system calls should run as fast in WINE as it does natively in Windows.

Yet another approach to running applications from other operating systems on Linux is to use virtualization products. One popular virtual machine product is VMWare player ([www.vmware.com/products/player](http://www.vmware.com/products/player)). However, included in CentOS itself is Xen virtualization software. Another approach to virtualization is KVM.

## Running DOS Applications

Because Linux was originally developed on PCs, a variety of tools were developed to help developers and users bridge the gap between Linux and DOS systems. A set of Linux utilities called *mtools* enables you to work with DOS files and directories within Linux. A DOS emulator called *DOSbox* lets you run DOS applications within a DOS environment that is actually running in Linux (much the way a DOS window runs within a Microsoft Windows operating system). DOSEMU is another DOS emulator that is available outside of the CentOS repository.

### Using mtools

*mtools* are mostly DOS commands that have the letter *m* in front of them and that run in Linux, although there are a few exceptions that are named differently. Using these commands, you can easily work with DOS files and file systems. Table 5-3 lists *mtools* that are available with Linux if you have the `mtools` package installed.

I used to use *mtools* to copy files between my Linux system and a Windows system that was not on my network. I would use `mcopy`, which let me copy files using drive letters instead of device names. In other words, to copy the file `vi.exe` from floppy drive A: to the current directory in Linux, I would type:

```
# mcopy a:\vi.exe .
```

### CAUTION

By default, the floppy-disk drive can be read from or written to only by the `root` user and the `floppy` group. To make the floppy drive accessible to everyone (assuming it is floppy drive A:), type the following as `root` user: `chmod 666 /dev/fd0`.



TABLE 5-3

## mtools Available with Linux

Command	Function
<code>mattrib</code>	The DOS <code>attrib</code> command, which is used to change an MS-DOS file attribute flag
<code>mbadblocks</code>	The DOS <code>badblocks</code> command, which tests a floppy disk and marks any bad blocks contained on the floppy in its FAT
<code>mcd</code>	The DOS <code>cd</code> command, which is used to change the working directory to another DOS directory (the default directory is <code>A:\</code> ) that is used by other mtools
<code>mcheck</code>	The DOS <code>check</code> command, which is used to verify a file
<code>mcopy</code>	The DOS <code>copy</code> command, which is used to copy files from one location to another
<code>mdel</code>	The DOS <code>del</code> command, which is used to delete files
<code>mdeltree</code>	The DOS <code>deltree</code> command, which deletes an MS-DOS directory along with the files and subdirectories it contains
<code>mdir</code>	The DOS <code>dir</code> command, which lists a directory's contents
<code>mdu</code>	The Linux <code>du</code> command, which is used to show the amount of disk space used by a DOS directory
<code>mformat</code>	The DOS <code>format</code> command, which is used to format a DOS floppy disk
<code>minfo</code>	This command is used to print information about a DOS device, such as a floppy disk.
<code>mkmanifest</code>	This command is used to create a shell script that restores Linux filenames that were truncated by DOS commands.
<code>mlabel</code>	The DOS <code>label</code> command, which is used to make a DOS volume label
<code>mmd</code>	The DOS <code>md</code> command, which is used to create a DOS directory
<code>mmount</code>	This command is used to mount a DOS disk in Linux.
<code>mmove</code>	The DOS <code>move</code> command, which is used to move a file to another directory and/or rename it
<code>mrd</code>	The DOS <code>rd</code> command, which is used to remove a DOS directory
<code>mren</code>	The DOS <code>ren</code> command, which is used to rename a DOS file
<code>mshowfat</code>	This command is used to show the FAT entry for a file in a DOS file system.
<code>mtoolstest</code>	This command is used to test the mtools configuration files.
<code>mtype</code>	The DOS <code>type</code> command, which is used to display the contents of a DOS text file
<code>mzip</code>	This command is used to perform operations with Zip disks, including eject, write protect, and query.

## Using DOSBox

To run your classic DOS applications, the RPMForge repository includes the `dosbox` package. To install `dosbox`, type the following as the `root` user:

```
# yum install dosbox
```

With DOSBox installed, just type **dosbox** to open a DOSBox window on your desktop. From that window, you have an environment wherein you can run many classic DOS applications. Assuming that you have some DOS applications you want to run already stored on your CentOS system, you can make those applications available by mounting the directory containing them. For example, to mount the `/home/timothy` directory to drive `C` in DOSBox, type the following:

```
Z:\> mount c /home/timothy
```

At this point, you can use standard DOS commands to access and run applications from the directory you just mounted. For example, type **dir c:** to see the contents of the directory you just mounted. Type **c:** to go to that directory. Then just run the DOS applications stored in that directory by typing their names.

To mount a CD-ROM, you need to indicate the file system type when you mount it. For example:

```
Z:\> mount d /media/disk -t cdrom
```

For information on using special keys and features in DOSBox, refer to the DOSBox README file (`/usr/share/doc/dosbox-*/README`).

## Running Microsoft Windows Applications in Linux

There are several promising approaches you can take to get your Windows applications to work during a running Linux session. Here are a few of them:

- **WINE** — The WINE project ([www.winehq.org](http://www.winehq.org)) has been making great strides in getting applications that were created for Microsoft Windows to run in Linux and other operating systems. WINE is not really an emulator because it doesn't emulate the entire Windows operating system. Instead, since it implements Win32 application programming interfaces (APIs) and Windows 3.x interfaces, the WINE project is more of a "Windows compatibility layer." WINE doesn't require that Windows be installed. It can, however, take advantage of Windows `.dll` files if you have some to add.
- **Win4Lin** — Win4Lin ([www.win4lin.com](http://www.win4lin.com)) is a commercial product for running a Windows system in Linux. You can try the software free for 14 days. Installation consists of three steps: Installing Win4Lin (available in RPM format), installing the guest operating system (Windows 98, 2000, or ME; XP is still experimental), and setting up a guest session. Then you run a full Windows system from a Linux desktop, installing and running any Windows applications you choose.

- **QEMU** — QEMU (<http://bellard.org/qemu/>) is an Open Source project that acts as a processor emulator. It can either emulate a full system or work in user mode emulation (where it can be used to test processes compiled for different CPUs). In full system emulation, QEMU can run a variety of operating systems, including Windows 3.11, 95, 98SE, ME, 2000, and possibly XP.

To try applications intended for other operating systems, QEMU can also run several Linux (Fedora, KNOPPIX, Mandrake, Morphix, Debian, and others) and other UNIX-like systems (NetBSD, Solaris, and others). QEMU can take advantage of virtualization features, using KVM, that have recently been added to the Linux kernel (described later in this chapter).

The rest of this section describes how to get and use WINE to run Windows applications in Linux. To get WINE for your CentOS system, you can go to the following places:

- **WINE in CentOS** — WINE is available from the EPEL repository.  
The `wine` and `wine-core` packages are needed to use WINE. Additional WINE support comes in the following packages: `wine-capi` (ISDN support), `wine-cms` (color management), `wine-esd` (ESD sound support), `wine-jack` (JACK sound support), `wine-ldap` (LDAP support), `wine-nas` (NAS sound support), and `wine-twin` (scanner support). Add `wine-devel`, for WINE development components.
- **Cedega** — A commercial version of WINE called Cedega is available from TransGaming, Inc. ([www.transgaming.com](http://www.transgaming.com)). TransGaming focuses on running Windows games in Linux, using WINE as its base.
- **CodeWeavers** — If you need Microsoft Office or Web browser plug-ins, CodeWeavers ([www.codeweavers.com](http://www.codeweavers.com)) offers CrossOver Linux. Although CrossOver Linux costs some money, it offers friendly interfaces for installing and managing the Windows software. A 30-day free trial is available.

While it's true that you can run many Windows applications using WINE, some fiddling is still required to get many Windows applications to work. If you are considering moving your desktop systems from Windows to Linux, the current state of WINE provides an opportunity to see if some Windows applications you need might run in Linux.

Besides developing software, the WINE project maintains a database of applications that run under WINE (<http://appdb.winehq.org>). More than 1,000 applications are listed, although many of them are only partially operational. The point, however, is that the list of applications is growing, and special attention is being paid to getting important Windows 2000 and XP applications running.

Although not an Open Source product, Win4Lin is another good way to run Windows applications, along with a Linux system on the same running computer. With the Open Source QEMU project, you can simultaneously run Microsoft Windows and Linux operating systems on the same PC. (Go to <http://bellard.org/qemu/status.html> and click on the “List of Supported Guest OSes” for a complete list of supported operating systems.)

In general, Windows applications are less likely to break in QEMU than they are in WINE (since you actually run the whole Windows operating system), but performance may not be as good (since you run an operating system within an operating system). The next section describes how to set up Linux to run Microsoft Windows applications using WINE.

## Running Windows Applications in WINE

For WINE to let you run Microsoft Windows applications, it needs to have an environment set up that looks like a Microsoft Windows system. The following section takes you through the steps of installing and configuring the WINE RPM available from CentOS. You can install WINE over the Internet by typing the following:

```
# yum install wine wine-core
```

The `yum` command line shown above will also pull in other Wine packages from the EPEL software repository such as those that include additional support for sound, scanners, and other features mentioned earlier.

The location of the basic Microsoft Windows operating-system directories for Wine is the `$HOME/.wine/drive_c` directory for each user, which looks like the C: drive to Wine. The `$HOME/.wine` directory is created automatically in your home directory the first time you run Wine Configuration (type **winecfg**):

```
$ winecfg
```

This opens the Wine Configuration window, where you can do most of your activities to add applications, configure the operating system, and integrate with the desktop. Figure 5-5 shows an example of the Wine Configuration window.

## Assigning Drive Letters

Before you begin installing Windows applications in WINE, you should become familiar with your WINE environment. Drive letters are assigned in the `$HOME/.wine/dosdevices` directory. Select the Drives tab on the Wine Configuration window to see which drive letters are assigned. At least drive C: and drive Z: should be set.

To configure additional drive letters, you can select Add (to add an individual drive) or select Autodetect (to have WINE assign all your partitions to drive letters) in the Windows Configuration window.

Within the `$HOME/.wine/drive_c` directory (i.e., your C: drive), you should see some things that are familiar to you if you are coming from an older Windows environment: Program Files and windows directories.

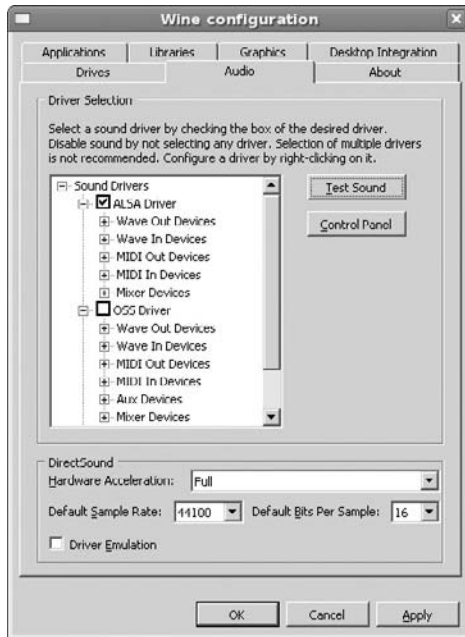
## Installing Applications in WINE

For Windows applications that are included on CDs or DVDs, you can try installing them by simply running the set-up program on that medium with the `wine` command. So, with a CD containing the application you want to install inserted and mounted, you would run a command like the following:

```
# wine d:\Setup.exe
```

**FIGURE 5-5**

Configure the environment in which Windows applications can run.



## Launching Applications

Depending on how the application's installer set up the application, there are a couple of ways in which you might launch your Windows application in WINE, as follows:

- **Control Panel** — If the application set up an applet for the Windows control panel, you can open a Windows control panel and then select the applet to launch the application from there. To start a Windows control panel, type the following:

```
$ wine control
```

- **WINE File System Browser** — If you installed the `wine-tools` package, you can launch the `winefile` command to see the Wine File window. This window displays a tree structure of the file system, as it relates to the drives you have configured for WINE. Select the drive letter containing the application you want to launch, browse to the application, and double-click on it to start.

Just as you launched the application's installer, as described earlier, you can also launch a Windows application installed on your file system from the command line. Again, you can use drive letters to indicate the location of the application you want to launch. However, to have the path to the application interpreted properly, you should typically surround it with quotes:

```
$ wine "C:\program files\appidr\app.exe"
```

As a Windows file path, you use backslashes (\) instead of slashes (/) to separate subdirectories. Instead of using double quotes, you can add an extra backslash before each space or backslash.

Once you have a working `wine` command line to run your Windows application, you can add that command to a launcher on your CentOS desktop. See Chapter 3 for information on adding application launchers to your panel, menus, or desktop area.

## Tuning and Configuring WINE

Because the Windows applications you run with WINE expect to find Windows resources on a Linux system, those resources either have to be provided by WINE or need to be mapped into the existing Linux system. For example, an application may require a specific DLL file that WINE doesn't include. Or, you may need to map your COM or LPT ports where WINE expects to find them.

Here are some tips to help you tune your WINE configuration:

- **Windows Version** — Different versions of Windows provide different environments for applications to run in. WINE emulates Windows XP by default, but allows you to have WINE run as nearly a dozen different Windows versions for each application. From the Wine Configuration window, select the Applications tab and choose the “Add Application” button. Choose the Windows application you want from your file system and then choose the Windows version you want it to run under.
- **Changing Registry Entries** — When you need to change Windows registry entries, WINE provides three files you can work with: `system.reg`, `user.reg`, and `userdef.reg`. All of these files are in the user's `$HOME/.wine` directory. You can use the `wineprefixcreate` utility to update your registry, but normally you should no longer need to, as this should happen automatically.
- **Configuring Ports** — As with Windows drive letters, you can add links to serial and parallel ports to your `$HOME/.wine/dosdevices` directory. For example, to add entries for your first parallel port (LPT1) and serial port (COM1), you could run the following commands from your `$HOME/.wine/dosdevices` directory:

```
$ ln -s /dev/lp0 lpt1
$ ln -s /dev/ttyS0 com1
```
- **Adding DLLs** — WINE provides many of the basic libraries (DLL files) needed for a functioning Windows system. However, some DLLs that may be required for your application may not be included, or some that are included may not work properly for your application. Using the Windows Configuration window (Libraries tab), you can replace DLLs provided by WINE or add other DLLs you have from applications you install.
- **Graphics Settings** — You can change settings associated with your graphics display from the Graphics tab on the Windows Configuration window. In particular, you can change how closely your Windows applications will be managed on your Linux desktop.

- **Adding Fonts** — To add fonts to your WINE installation, copy TrueType fonts (.ttf files) to the C:\windows\fonts directory on your WINE virtual drive.

For further information on configuring WINE to run your Windows applications in Linux, refer to the WINE User Guide ([www.winehq.org/docs/en/wineusr-guide.html](http://www.winehq.org/docs/en/wineusr-guide.html)).

### Finding More Windows Applications for WINE

For information on Windows applications that have been tested to run in WINE, refer to the WINE Application Database (<http://appdb.winehq.org>). CodeWeavers also keeps its own database of applications that have been tested to run under WINE. Refer to the CodeWeavers Compatibility Center ([www.codeweavers.com/compatibility](http://www.codeweavers.com/compatibility)) for information on running Windows applications. From there, you can view CodeWeavers' own application database of more than 3,300 Windows applications.

Another web site for information about WINE applications is Frank's Corner ([www.frankscorner.org](http://www.frankscorner.org)). The site is loaded with good tips for getting graphics, Internet, multimedia, office, games, and other applications running in WINE.

## Running Applications in Virtual Environments

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Virtualization has become a hot topic in Linux in recent years. Instead of being able to have just one operating system running on a computer at a time, virtualization allows multiple guest operating systems to run on a host system. When acting as the host operating system, CentOS offers two major approaches to virtualization: Xen and KVM.

There are many advantages to running multiple virtualized operating systems on one computer. For example, you can configure one virtual machine to contain only a Web Server. By compartmentalizing your Web Server in this way, you can have it tuned to run efficiently and to protect software running on the same computer from outside intruders. By running different operating systems separately, you can use the same hardware to run applications that weren't made for the same operating system.

The following sections introduce you to Xen and KVM virtualization software in CentOS.

### Running Applications Virtually with Xen

Xen ([www.xensource.com](http://www.xensource.com)) is virtualization software that is included in CentOS. Xen is owned by Citrix. Using Xen, you can run multiple operating system instances within a running CentOS system. These operating systems, referred to as *virtual machines*, not only can run applications built specifically for those operating systems, but also can appear to the network as though they are running on completely different machines.

To demonstrate Xen features, the procedures in this section describe how to set up a virtual machine of CentOS that will run on an installed host CentOS system. Currently, to run other operating systems on Xen in CentOS, you need to supply an OS image, rather than build one from scratch as shown in the procedure below.

You can find more information about how Xen works and what it is from the Xen Source wiki (<http://wiki.xensource.com/xenwiki>). In particular, select the Xen FAQ link for information on what Xen is, or the HowTos link for links to the user manual and specialty HowTos.

## Before Installing Xen

Xen requires a lot of resources to run. Each operating system instance (referred to as a *guest operating system*) will need almost the full amount of resources it would need to run separately. Therefore, before you begin, make sure your system has at least the following available:

- **RAM** — In general, your computer should have at least 256 MB of RAM available for each guest you want to have, plus the amount of RAM required for the type of CentOS install you selected.
- **Hard Disk** — On top of what you need to install CentOS, you need the entire amount of disk space required by each operating system guest you installed. Of course, these amounts can vary greatly, with minimal server installs starting at around 600 MB and average desktop installs typically starting at 2 GB or 3 GB.
- **Paravirtualization (PAE) Support** — Your computer's CPU must support the PAE extension. Many laptops will not have PAE support. To see if your computer has PAE support, type the following:

```
# cat /proc/cpuinfo | grep pae
flags : fpu vme de pse tsc msr pae mce cx8 apic
mtrr pge mca cmov pat pse36 mmx fxsr syscall
mmxext 3dnowext 3dnow up
```

In this example, PAE is supported. If it were not supported, nothing would be returned.

- **Fully Virtualized Guest Support** — In order to run fully virtualized guests, you need Intel VT or AMD-V support, depending on your processor. Check your `cpuinfo` again (as shown above), but this time `grep` for `vmx` or `svm` (on Intel or AMD processors, respectively). Again, if you see output, the program is supported.
- **GRUB Boot Loader** — A final requirement of the computer you are using is that GRUB be your boot loader. When you install Xen, it will automatically add itself to your GRUB boot loader as a secondary choice of operating system kernels that you can select to boot.

## Installing Xen

To run Xen in CentOS, you need to install and boot from a specially configured Xen kernel. Xen kernel packages are not installed by default with CentOS, so you have to either select them at install time or add them later. Here's how to install the Xen packages you need:



- **Using yum** — As root, type the following from a Terminal window:

```
# yum install xen-libs xen virt-manager gnome-applet-vm vnc
  xen-devel
```

Because Xen automatically adds an entry to your GRUB boot loader and installs it when you reboot, you should be ready to restart CentOS with the Xen kernel running. So the next step is to reboot your computer. After rebooting, run the Services Configuration application from the System > Administration > Server Settings > Services menu choice. Verify that all services starting with Xen are running.

## Installing a Guest Operating System

With CentOS running with the Xen kernel, the next step is to install a guest operating system to run in Xen on your CentOS system. You do this using the `virt-manager` utility.

For demonstration purposes, the procedure below shows how to install a Fedora 7 instance as a virtual guest operating system on CentOS. Before you start, you need a network connection and the location of an online Fedora 7 software repository. That location can be a local DVD that is shared via an NFS connection. This procedure gives you an idea of how the feature works, before you try installing other operating systems.

1. **Start libvirtd Service** — If it's not already running, start the `libvirtd` service:

```
# service libvirtd start
```

2. **Start Virtual Machine Manager** — As root user from a Terminal window, type the following:

```
# /usr/sbin/virt-manager
```

3. **Select Xen Host** — Select “Local Xen Host” and click File > Open Connection.
4. **Create New Guest** — Right-click on “Local Host” and click New. When the “Create a new virtual system” pop-up appears, click Forward. You are asked to name your virtual system.
5. **Virtual Machine Name** — Type a name to represent this virtual machine and click Forward. Keep the name simple (one word, fairly short, and no special characters) because the name is used to represent the virtual machine in filenames and on menus. You are asked the location of the media.
6. **Virtualization Method** — Select “Paravirtualization” (for faster, lightweight virtualization) or “Fully Virtualized” (slower, but supports more operating systems) and click Forward.
7. **Installation Media** — Type the location of an online software repository (you can also enter a kickstart file, if you have one). To use a Fedora DVD instead of an online repository, you export it as an NFS share (see the following Note). Here's an example of a software repository for Fedora 7 so you can create a Fedora 7 system to run on your CentOS system:

```
http://download.fedora.redhat.com/pub/fedora/linux/releases/7/
Fedora/i386/os
```

**NOTE**

Here's how to use your CentOS as a Xen guest repository. Install the `nfs-utils` package. Insert the DVD. Assuming it is mounted as `/media/disk`, add the line:

```
/media/disk *( ro)
```

to the `/etc/exports` file. Start `nfs` (`/etc/init.d/nfs start`). When you are prompted for a software repository, enter this address: `nfs:localhost:/media/disk`. If `localhost` doesn't work, try using your computer's IP address.

8. **Storage Location** — Choose to either use a file on an existing file system or the device name of a disk partition to store the installed system. For example, you could name the disk image `/home/timothy/xenimageA` as the file to use. I created a new disk partition as I was doing this procedure. Just make sure that the location you use has enough disk space to hold the operating system you are about to install. You are asked to allocate memory.
9. **Host Network** — Choose how would like your new virtual system to connect to the host network. In most cases, select “Virtual network.” However, you can also select a shared physical device (such as an Ethernet bridge or MAC address).
10. **Allocate Memory** — Type a number representing the maximum number of megabytes of RAM you want to dedicate to this virtual machine and the amount you want to start with, and click Forward. At least 256 MB of RAM are recommended. If you have more available, you should use more since it will improve performance. You can also select to use multiple virtual CPUs (1 is the default).
11. **Finish** — When all the information has been entered, a summary of the information you entered appears as shown in Figure 5-6. Click Finish. The new virtual machine should appear on the Virtual Machine Manager window. Select it and click Open.
12. **Start Installation** — A virtual machine console should appear, ready to start your guest Fedora 7 installation.
13. **Install Guest** — Install the Fedora system.

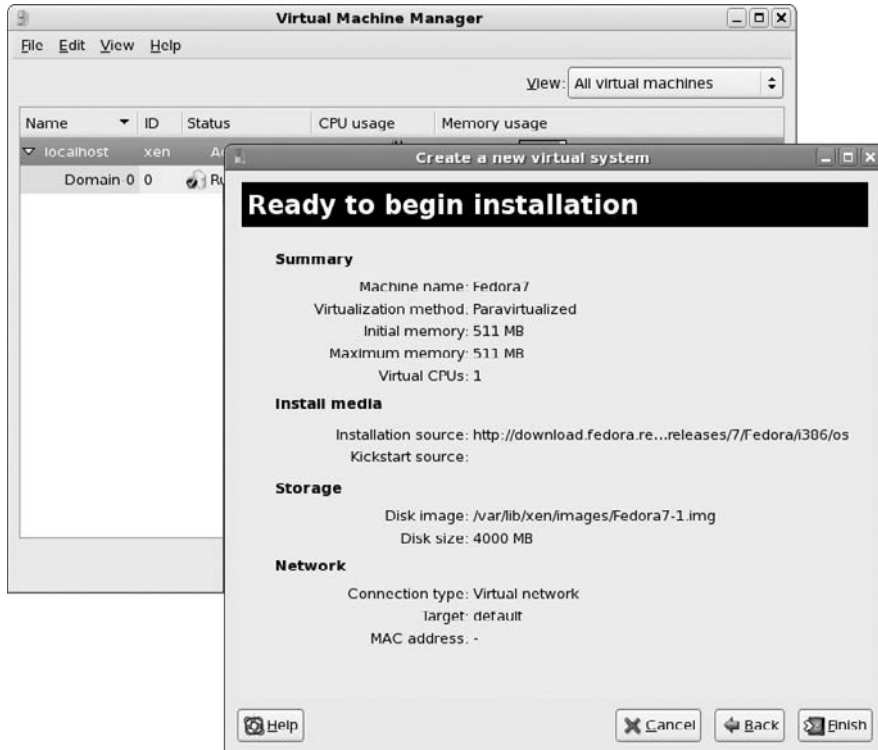
After Fedora is installed as a guest, you can open that virtual machine as you need it from the Virtual Machine Manager window. If you selected Ethernet bridging and there is a DHCP server on your network, your virtual machine can be assigned its own IP address. So you can use tools in Fedora to access the Internet and update and get new software as needed.

To manage your virtual machines from the command line, you can use the `xm` command. To see which virtual machines are currently available, type the following:

```
# xm list
Name                ID Mem  VCPUs  State  Time
Domain-0            0  453   1    r----- 1675.5
Fedora              264  264   1    r----- 243.9
```

**FIGURE 5-6**

Virtual Machine Manager lets you install and run guest operating systems.



If you want to save a snapshot of your virtual machine, use the `xm` command to save it to a file. For example, to save a virtual machine named `Fedora` to `/tmp/virt-save`, you could type the following:

```
# xm save Fedora /tmp/virt-save
```

Later, to restore the virtual machine, you could type:

```
# xm restore /tmp/virt-save
```

## Running Applications Virtually with KVM and QEMU

As with Xen, Kernel-based Virtual Machine (KVM) virtualization requires a computer that has either an Intel VT or AMD-V processor. KVM, however, is implemented using a loadable kernel module (`kvm.ko`) that works with the standard kernel, instead of using a special Xen kernel. QEMU (<http://bellard.org/qemu/>) is used to ultimately run the guest operating systems.

Within each virtual machine running under KVM is private, virtualized hardware that provides you with access to local hard disks, network interface cards, and other hardware resources. Some of the requirements for beginning with KVM virtualization are the same as they are for Xen:

- You need at least about 256 MB of RAM for each guest.
- For hard disk space, you probably need between 2 GB and 3 GB at least for each guest system (judging from an average-size Fedora desktop install).
- You need to have the GRUB bootloader installed.
- You need an Intel VT or AMD-V processor (see the “Before Installing Xen” section for information on how to check for PAE support).

Next, you want to install many of the same packages you installed for Xen. From the Add/Install Software window, you can simply search for and install all appropriate `xen` packages. In particular, add the `kvm` and `qemu` packages to those needed by Xen, such as `virt-manager`.

Before proceeding, make sure that you booted to the regular kernel and not the Xen kernel (if the `xen` packages are installed, both a regular and a Xen kernel should be available for you to boot from). Then run the following procedure to install a new guest operating system that will run using KVM and QEMU:

1. **Start libvirtd Service** — If it’s not already running, start the `libvirtd` service:

```
# service libvirtd start
```

2. **Start KVM Guest Install** — As the `root` user from a Terminal window, type the following:

```
# /usr/sbin/virt-manager
```

The Virtual Machine Manager window appears.

3. **Create New Guest** — Right-click `localhost (qemu)` and click `New`. When the “Create a new virtual system” pop-up appears, click `Forward`. You are asked to name your virtual system.
4. **Virtual Machine Name** — Type a name to represent this virtual machine and click `Forward`. Keep the name simple (one word, fairly short, and no special characters) because the name is used to represent the virtual machine in filenames and on menus. You are asked the virtualization method.
5. **Virtualization Method** — Choose “Fully Virtualized.” You can also choose to create a guest that uses a different CPU architecture (`i686`, `X86_64`, `ppc`, `sparc`, `mips`, or `mipsel`). You are asked to identify the location of the installation media.
6. **Installation Media** — Type the location of an ISO image or the CD or DVD drive that has your installation media inserted. Also identify the type (`generic`, `Linux`, `UNIX`, `Windows`, or `other`) and variant (e.g., `Fedora`, `Windows Vista`, `Sun Solaris`) of the operating system you are installing. You are asked to assign storage space.

7. **Assign Storage Space** — You can either identify a disk partition or create a virtual disk by identifying a filename and size. In either case, the storage area must be large enough to hold your installed guest operating system. You are asked to set up a network connection.
8. **Host Network** — Identify either a virtual network or shared physical network device to provide network connectivity for your guest operating system. Next allocate memory and CPU.
9. **Allocate Memory** — From the total memory shown on the screen, choose the amount of VM memory to use and the maximum amount to use. At least 256 MB is recommended. Also, choose the number of virtual CPUs to start with (typically not more than the logical CPUs on the host system). You are asked to review your install information.
10. **Start Installation** — If all the information is correct, click Finish to begin the install process.

At this point, you run through the installation process as you normally would for the operating system you selected. Once installation is complete, you can start and shut down the new virtual environment from the Virtual Machine Manager.

## Summary

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Between applications written directly for Linux and other UNIX systems, those that have been ported to Linux, and those that can run in emulation, thousands of applications are available to be used with CentOS systems

To simplify the process of installing and managing your Linux applications, Red Hat developed the RPM Package Management (RPM) format. Using tools developed for RPM, such as the `rpm` command, you can easily install, remove, and perform queries on Linux RPM packages. Tools for finding, downloading, and installing RPM packages include the `yum` utility and the Add/Remove Software window.

Of the types of applications that can run in Linux, those created for the X Window System provide the greatest level of compatibility and flexibility when used in Linux. However, using emulation software, it is possible to run applications intended for DOS, Microsoft Windows, and Macintosh operating systems. In the long run, virtualization software such as Xen and KVM will allow multiple operating systems to run as guests on CentOS. That, in turn, will provide a means for running a variety of applications within those systems on CentOS.

# Chapter 6

## Publishing with CentOS

**T**o survive as a desktop system, an operating system must be able to perform at least one task well: produce documents. It's no accident that, after Windows, Microsoft Word (which is bundled into Microsoft Office) is the foundation of Microsoft's success on the desktop. CentOS includes tools for producing documents, manipulating images, scanning, and printing. Almost everything you would expect a publishing system to do, you can do with CentOS.

This chapter describes popular Linux office suites (such as OpenOffice.org) for creating documents, presentations, and spreadsheets. For page layouts, Scribus is an excellent application that can be used to create brochures and pamphlets. For working with images, we cover the GNU Image Manipulation Program (The GIMP). For working with vector graphics, we describe the Inkscape vector graphics editor.

For displaying the content you create, there are several different viewers available for displaying output in PDF and PostScript formats. For example, there is the Evince viewer, which can view both PDF and PostScript files. There is also Ghostview, a dedicated PostScript viewer.

If you want to publish on the Web, there are tools for everything from writing basic HTML documents to making web photo sites to implementing full-blown content management systems. Software that is packaged for Linux to manage your own web sites includes MediaWiki (wiki), WordPress (blogging), Drupal (content management), and Gallery (photo web site).

### IN THIS CHAPTER

**Desktop publishing in Linux**

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**Trying graphical text editors**

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**Using OpenOffice.org**

---

**Creating documents with Groff and LaTeX**

---

**Creating DocBook documents**

---

**Displaying documents with Evince**

---

**Doing page layout with Scribus**

---

**Working with graphics**

---

**Making Inkscape vector graphics**

---

**Using scanners driven by SANE**

---

**Publishing on the Web**

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## Desktop Publishing in Linux

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Whether you are writing a letter, a memo, or a book, you usually begin with a word processor. If your computer doesn't have much power, you might start with a simple text editor or a less demanding word processor such as AbiWord. Most Linux users, however, begin with OpenOffice.org Writer. If all you need is to edit a plaintext document, however, you can begin with a simple text editor.

### Using Text Editors and Notepads

Before jumping into more complex word processors, here are a few applications you might want to try out if you just want to write some text quickly:

- **GNOME Text Editor (gedit)** — From the GNOME desktop, select Applications ➤ Accessories ➤ Text Editor. With the gedit window that opens, you can just type, cut, and paste, and use arrow keys to move around. Besides creating text documents, gedit has spell check and search tools. Highlight mode (select View ➤ Highlight Mode) causes different parts of the text you are writing like computer code (such as C or Java) or markup (such as HTML or XML) to be displayed in different colors.
- **KDE Text Editor (KWrite)** — From the KDE desktop, the KWrite application is the default text editor. KWrite includes many of the same text editing features as gedit, but also has bookmark features and support for multiple language input.
- **Sticky Notes (Tomboy)** — Different note taking applications include KNotes (for KDE) and Tomboy (for GNOME). Tomboy puts a notepad icon in your top panel, from which you can create and manage notes. Create a new note that includes URLs (click to open in a browser) and links to other notes. Spelling is checked as you type. Organize notes in notebooks or do keyword searches to find the note you want.

If you want to move text from your plaintext files or sticky notes to a more formal document, you can copy or cut, then paste the text into one of the word processors described in the next section.

### Using Word Processors

OpenOffice.org is a powerful Open Source office suite available as part of the CentOS distributions. Based on the Sun Microsystems StarOffice productivity suite, OpenOffice.org includes a word processor, spreadsheet, presentation manager, and other personal productivity tools. In many cases, OpenOffice.org can act as a drop-in replacement for Microsoft Office, in both its features and its ability to support files in Word, Excel, PowerPoint, and other Microsoft formats.

Commercial office suites include StarOffice, which contains not only a word processor, but also applications for creating and working with spreadsheets, presentations, and other office-oriented content.

## Using OpenOffice.org

Some have called OpenOffice.org a significant threat to Microsoft's dominance of the desktop market. If a need to work with documents in Microsoft Word format has kept you from using Linux as your desktop computer, OpenOffice.org is a big step toward removing that obstacle.

### NOTE

If you are willing to pay a few dollars, **CrossOver Office** from [Codeweavers.com](http://Codeweavers.com) lets you install and run different versions of Microsoft Office (97, 2000, XP, 2003, and 2007) from your Linux desktop. See Chapter 5 for further information or check out [www.codeweavers.com/products/cxoffice](http://www.codeweavers.com/products/cxoffice).

CentOS includes the entire OpenOffice.org suite of desktop applications. Based on the StarOffice source code, OpenOffice.org consists of the following office-productivity applications:

- **OpenOffice.org Writer** — A word processing application that can work with documents in file formats from Microsoft Word, StarOffice, and several others. Writer also has a full set of features for using templates, working with fonts, navigating your documents, including images and effects, and generating tables of contents.
- **OpenOffice.org Calc** — A spreadsheet application that lets you incorporate data from Microsoft Excel, StarOffice, Dbase, and several other spreadsheet formats. Some nice features in Calc enable you to create charts, set up database ranges (to easily sort data in an area of a spreadsheet), and use the data pilot tool to arrange data in different points of view.
- **OpenOffice.org Draw** — A drawing application that enables you to create, edit, and align objects; incorporate textures; include textures and colors; and work with layers of objects. It lets you incorporate images, vector graphics, AutoCAD, and a variety of other file formats into your drawings. Then you can save your drawing in the OpenOffice.org Drawing or StarOffice Draw formats.
- **OpenOffice.org Math** — A calculation program that lets you create mathematical formulas.
- **OpenOffice.org Impress** — A presentation application that includes a variety of slide effects. Using Impress, you can create and save presentations in the Microsoft PowerPoint, Draw, and Impress formats.

Unlike other applications that were created to work with Microsoft document and data formats, OpenOffice.org (although not perfect) does a very good job of opening and saving files from many different versions of Microsoft Word (.doc) and Excel (.xls) formats with fewer problems. Very basic styles and formatting that open in OpenOffice.org often don't look noticeably different from the way they appear in Microsoft Office. In fact, some older Word documents will actually work better in OpenOffice.org Writer than they do in the latest Microsoft Office suites.

### NOTE

The Open Office XML (OOXML) format, a 6,000-page tome, represent's Microsoft's recent efforts to claim to support standard document formats. This format is the default document type in Word 2007. Some people in the Open Source community, however,

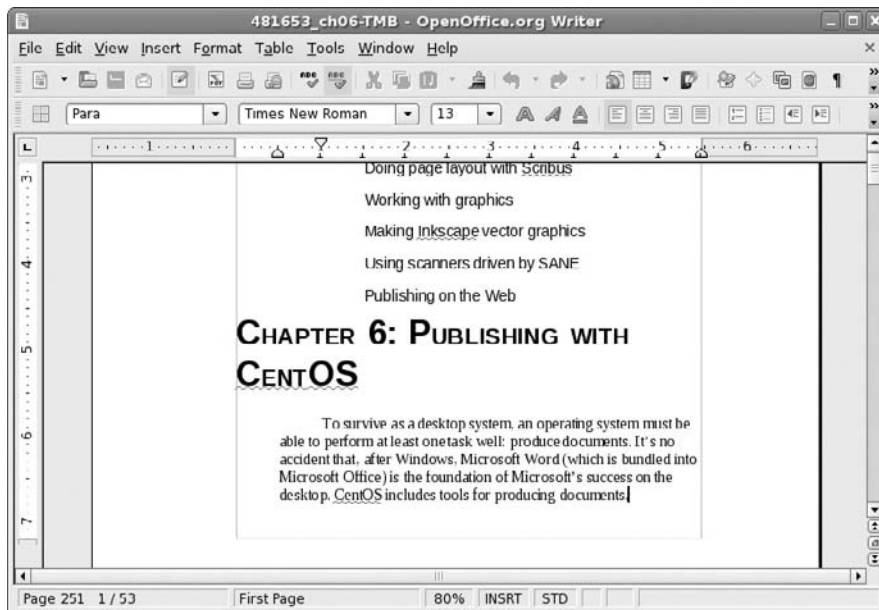


claim that OOXML is so specific in requiring support for Microsoft product features, without providing any guidance in how those Microsoft proprietary features can be implemented, that it is unusable as a standard. In other words, don't think that, because Microsoft is claiming to support standards, you will ever be able to fully use Microsoft document formats on other platforms.

To open OpenOffice.org Writer, Impress, Calc, and other office applications, click Office from the Applications menu. Then select the OpenOffice.org application you want to open. Figure 6-1 shows an example of OpenOffice.org.

**FIGURE 6-1**

Work with documents in OpenOffice.org Writer.



The controls in OpenOffice.org are similar to the ones you would find in Word prior to Word 2007. So if you were comfortable with those controls, you should find it easy to transition to OpenOffice.org Writer. In fact, you might find it easier than using Microsoft Word 2007, since many people have found the transition to Word 2007 difficult.

Toolbars in OpenOffice.org Writer include boxes for identifying filenames and changing styles, font types, and font sizes. Buttons enable you to save and print the file; change the text alignment; and cut, copy, and paste text. In other words, Writer includes almost everything you expect in an advanced word processor. In addition, Writer includes a handy PDF button to

output a file directly to the PDF format. This is very useful for exchanging documents or placing data on the Internet.

If you are just starting out with OpenOffice.org Writer, here are a few features you can try out:

- **Wizards** — Use a wizard to start a letter, fax, agenda, presentation, web page, Document Converter, or Euro Converter. Select File > Wizards and then choose one of the document types just mentioned. The Document Converter Wizard lets you convert a directory of Microsoft or StarOffice documents to OpenDocument format. The Euro Converter lets you convert files containing different European currencies to Euros.
- **Document Styles and Formatting** — Create the format of your documents using character, paragraph, frame, page, and numbering styles (select Format > Styles and Formatting). From the Styles and Formatting window, choose the type of style you want to change, right-click in the Styles box, and choose New to create your own style.
- **Checking Documents** — Try different features for checking and correcting your documents. Writer includes features such as spell checking (Tools > Spelling and Grammar) and autocorrection (Tools > AutoCorrect). You can display the content as a web page or in print layout and view font and character markup (View > Nonprinting Characters).
- **Drawing and Images** — Use drawing tools (View > Toolbars > Drawing) to create drawings, flow charts, callouts, or symbols in your documents. Insert background colors or graphics on your pages (Format > Page, select Background tab, and choose color or graphic). To insert a graphic, select Insert > Picture, and insert the image from a file or from your scanner.
- **Outputting PDF or Other Formats** — Writer provides a toolbar button that will output your current document to PDF format. PDF is a good format for sharing documents that you want others to read or print, but don't necessarily want to give them the original source file. You can also save Writer documents to other useful formats, including HTML (to publish your document to the Web) or Rich Text Format (to be able to share the document with different word processors).

**NOTE**

Find out more about OpenOffice.org at [www.OpenOffice.org](http://www.OpenOffice.org).

## Other Word Processors

As for commercial offerings, there is StarOffice from Sun Microsystems and TextMaker.

### *StarOffice*

The StarOffice productivity suite ([www.sun.com/staroffice](http://www.sun.com/staroffice)) from Sun Microsystems, Inc. is a commercial product that runs on Linux, UNIX, and Windows operating systems. StarOffice contains applications for word processing, spreadsheets, presentation graphics, e-mail, news, charting, and graphics. Like OpenOffice.org, StarOffice contains many features that make it compatible with Microsoft Office applications. In particular, it includes the capability to import Microsoft Word and Excel files.

StarOffice is probably the most complete integrated office suite for Linux. If you are working in a cross-platform environment, however, you can also get StarOffice for Sun Solaris and Microsoft Windows operating systems. StarOffice includes:

- **StarOffice Writer** — This is the StarOffice word processing application. It can import documents from a variety of formats, with special emphasis on Word documents.
- **StarOffice Calc** — This is the spreadsheet program that comes with StarOffice. You can import spreadsheets from Microsoft Excel and other popular programs.
- **StarOffice Impress** — This module enables you to create presentations.
- **StarOffice Draw** — This is a vector-oriented drawing program. It includes the capability to create 3D objects and to use texturing.
- **StarOffice Base** — You can manage your data with StarBase, a friendly front-end for databases. It can access a variety of database interfaces.

There are also other tools in StarOffice that enable you to create business graphics, edit raster images, and edit mathematical formulas (StarOffice Math).

You can download StarOffice 9 for Linux or purchase a boxed set from the StarOffice web site at [www.sun.com/software/star/staroffice/](http://www.sun.com/software/star/staroffice/).

Although StarOffice was once available free for download, the current price (at time of writing) to download the software for home users is \$34.95.

### ***TextMaker***

TextMaker is another popular commercial word processing package for Linux ([www.softmaker.com/english/tml\\_en.htm](http://www.softmaker.com/english/tml_en.htm)). This word processor requires much less memory than OpenOffice.org Writer, but still contains many powerful features. With TextMaker, interchanging documents between different operating systems is easy because there are also versions of TextMaker for Windows, Pocket PCs, Handhelp PCs, FreeBSD, and Zaurus.

## **Using Traditional Linux Publishing Tools**

---

The first document and graphics tools for Linux were mostly built on older, text-based tools. Despite their age, many of the older publishing tools such as Groff and LaTeX are still used by people in the technical community. With these old-school text processors, you can ignore document appearance while writing. Plaintext macros instruct post-processors how to lay out a document for printing after writing is done. With word processors (such as OpenOffice.org Writer and StarOffice Writer), you mark up text and see the basic layout of the document as you write.

Some attributes of the traditional Linux publishing tools make them particularly well suited for certain types of document publishing. Groff and LaTeX (which is based on TeX) come with CentOS and have been popular among technical people. Reasons for that include:

- You can manipulate files in plaintext. Using tools such as `sed` and `grep`, you can scan and change one document or hundreds with a single command or script.

- Scientific notation is supported. With `geqn`, you can create complex equations. LaTeX and TeX are suited for technical notation. Some math publications require LaTeX.
- Editing can be faster because traditional Linux documents are created with a text editor. You usually get better performance out of a text editor than a word processor.

Simple page layouts work well with Linux documentation tools. For example, a technical book with a few flow charts and images can be easily produced and maintained using Groff or TeX documentation tools. Letters and memos are also easy to do with these tools. And, of course, Linux man pages are created with text-based tools.

Also, Linux likes PostScript. Most Linux document-processing software includes print drivers for PostScript. There are many tools for converting PostScript to other formats. Also, some documents on the Web are distributed in PostScript (`.ps`).

The drawback to the traditional Linux document tools is that they are not intuitive. Rarely will a beginner try to use these tools, unless they have a need to support legacy UNIX or Linux documents (such as manual pages or old UNIX guides). Although there are some easier front-ends to LaTeX (see the description of LyX later on), if you are creating documents in a text editor, you need to learn what macros to type into your documents and which formatting and print commands to use.

**NOTE**

For many years, the UNIX system documentation distributed by AT&T was created in `troff/nroff` formats, which predate Groff. The documents used separate macro packages for man pages and guide material. Using a source code control system (SCCS), thousands of pages of documentation could be ported to different UNIX systems. Today, CentOS includes the same tools to work with man pages.

## Creating Documents in Groff or LaTeX

You can create documents for either of Linux's Groff (`troff/nroff`) or LaTeX (`TEX`) styles of publishing using any text editor. CentOS comes with several text editors, or you can download others from the Internet. See the section "Using Text Editors and Notepads," earlier in this chapter, for more information.

The process of creating documents in Groff or LaTeX consists of the following general steps:

1. Create a document with any text editor. The document will contain text and markup.
2. Format the document using a formatting command that matches the style of the document that you created (e.g., with `groff` or `latex`). During this step, you may need to indicate that the document contains special content, such as equations (`eqn` command), tables (`tbl` command), or line drawings (`pic` command).
3. Send the document to an output device. The device may be a printer or display program.

If you are used to a word processor with a GUI, you may find these publishing tools difficult. In general, Groff is useful to create man pages for Linux. LaTeX is useful if you need to produce mathematical documents, perhaps for publication in a technical journal.

## Text Processing with Groff

The `nroff` and `troff` text formatting commands were the first interfaces available for producing typeset-quality documents with the UNIX system. They aren't editors; rather, they are commands that you send your text through, with the result being formatted pages:

- `nroff` — Produces formatted plaintext and includes the ability to do pagination, indents, and text justification, as well as other features.
- `troff` — Produces typeset text, including everything `nroff` can do, plus the ability to produce different fonts and spacing. The `troff` command also supports kerning.

The `groff` command is the front-end for producing `nroff/troff` documentation. Because Linux man pages are formatted and output in Groff, most of the examples here help you create and print man pages with Groff.

People rarely use primitive `nroff/troff` markup. Instead, there are common macro packages that simplify the creation of `nroff/troff`-formatted documents:

- `man` — The `man` macros are used to create Linux man pages. You can format a man page using the `-man` option to the `groff` command.
- `mm` — The `mm` macros (memorandum macros) were created to produce memos, letters, and technical white papers. This macro package includes macros for creating a table of contents, lists of figures, references, and other features that are helpful for producing technical documents. You can format an `mm` document using the `-mm` `groff` option.
- `me` — The `me` macros were popular for producing memos and technical papers on Berkeley UNIX systems. Format an `me` document using the `-me` `groff` option.

Groff macro packages are stored in `/usr/share/groff/*/tmac`. The `man` macros are called from the `an.tmac` file, `mm` macros are from `m.tmac`, and `me` macros are from `e.tmac`. The naming convention for each macro package is `xxx.tmac`, where `xxx` is replaced by one or more letters representing the macro package. In each case, you can understand the name of the macro package by adding an `m` to the beginning of the file suffix.

**TIP**

Instead of noting a specific macro package, you can use `-mandoc` to choose a macro package.

When you run the `groff` formatting command, you can indicate on the command line which macro packages you are using. You can also indicate that the document should be run through any of the following commands that pre-process text for special formats:

- `eqn` — This pre-processor formats macros that produce equations in `groff`.
- `pic` — This pre-processor formats macros that create simple line drawings in `groff`.
- `tbl` — This pre-processor formats macros that produce tables within `groff`.

The formatted Groff document is output for a particular device type. The device can be a printer, a window, or (for plaintext) your shell. Here are output forms supported by Groff:

- **ps** — Produces PostScript output for a PostScript printer or a PostScript previewer.
- **lj4** — Produces output for an HP LaserJet4 printer or other PCL5-compatible printer.
- **ascii** — Produces plaintext output that can be viewed from a Terminal window.
- **dvi** — Produces output in TeX dvi, to output to a variety of devices described later.
- **X75** — Produces output for an X11 75 dots/inch previewer.
- **X100** — Produces output for an X11 100 dots/inch previewer.
- **latin1** — Produces typewriter-like output using the ISO Latin-1 character set.

## Formatting and Printing Documents with Groff

You can try formatting and printing an existing Groff document using any man pages on your CentOS system (such as those in `/usr/share/man/*`). (Those man pages are compressed, so you can copy them to a temporary directory and unzip them to try out Groff.)

These commands copy the `chown` man page to the `/tmp` directory and unzips it. Then, Groff formats the `chown` man page in plaintext so you can page through it on your screen.

```
$ cp /usr/share/man/man1/chown.1.gz /tmp
$ gunzip /tmp/chown.1.gz
$ groff -Tascii -man /tmp/chown.1 | less
```

In the previous example, the `chown` man page (`chown.1.gz`) is copied to the `/tmp` directory, is unzipped (using `gunzip`), and is output in plaintext (`-Tascii`) using the man macros (`-man`). The output is piped to `less`, to page through it on your screen. Instead of piping to `less ( | less)`, you can direct the output to a file (`> /tmp/chown.txt`).

To format a man page for typesetting, you can specify PostScript or HP LaserJet output. You should direct the output either to a file or to a printer. Here are a couple of examples:

```
$ groff -Tps -man /tmp/chown.1 > /tmp/chown.ps
$ groff -Tlj4 -man -l /tmp/chown.1
```

The first example creates PostScript output (`-Tps`) and directs it to a file called `/tmp/chown.ps`. That file can be read by a PostScript previewer (such as Ghostscript) or sent to a printer (`lpr /tmp/chown.ps`). The next example creates HP LaserJet output (`-Tlj4`) and directs it to the default printer (`-l` option).

### TIP

Using `man2html`, you can convert man pages to HTML format for display in a browser. For example: `zcat /usr/share/man/man1/chown.1.gz | man2html > /tmp/chown.htm`.

## Creating a Man Page with Groff

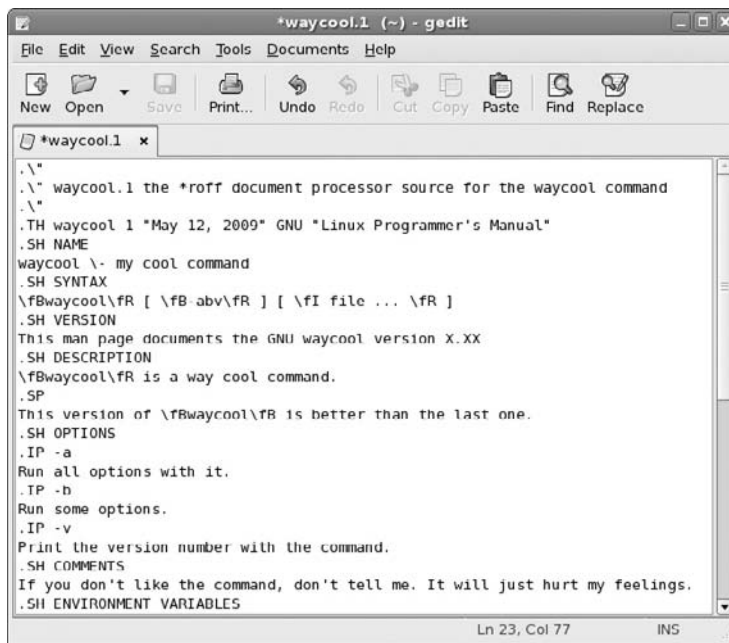
Before HowTos and info files, man pages were the foundation for information about UNIX (and UNIX-like) systems. Each command, file format, device, or other component either had its own man page or was grouped on a man page with similar components. Creating your own man page requires that you learn a few macros (in particular, man macros). Figure 6-2 shows the source for a fictitious man page for a command called `waycool`.

### TIP

Most man pages are stored in subdirectories of `/usr/share/man`. Before you create a man page, refer to similar man pages to see the markup and the headings they include. In `man1` are commands; `man2` has system calls; `man3` has library functions; `man4` has special device files (`/dev/*`); `man5` has file formats; `man6` has games; `man7` has miscellaneous components; and `man8` has administrative commands.

**FIGURE 6-2**

Simple markup is required to create man pages.



```
*waycool.1 (~) - gedit
File Edit View Search Tools Documents Help
New Open Save Print... Undo Redo Cut Copy Paste Find Replace
*waycool.1 x
.\
.\ " waycool.1 the *roff document processor source for the waycool command
.\
.TH waycool 1 "May 12, 2009" GNU "Linux Programmer's Manual"
.SH NAME
waycool \- my cool command
.SH SYNTAX
\FBwaycool\fR [ \fB abv\fR ] [ \fI file ... \fR ]
.SH VERSION
This man page documents the GNU waycool version X.XX
.SH DESCRIPTION
\FBwaycool\fR is a way cool command.
.SP
This version of \fBwaycool\fR is better than the last one.
.SH OPTIONS
.IP -a
Run all options with it.
.IP -d
Run some options.
.IP -v
Print the version number with the command.
.SH COMMENTS
If you don't like the command, don't tell me. It will just hurt my feelings.
.SH ENVIRONMENT VARIABLES
Ln 23, Col 77  INS
```

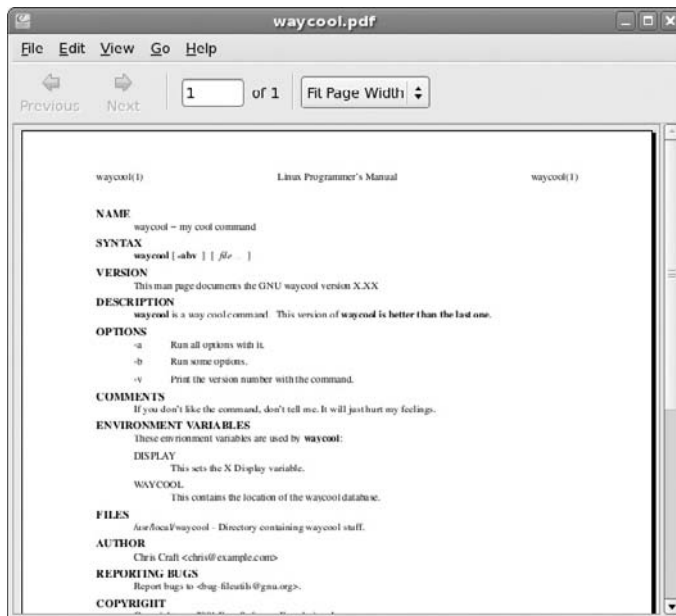
A few other kinds of macros are used in the man page. The `.IP` macros format indented paragraphs for things such as options. The man page also contains some lower-level font requests; for example, `\fB` says to change the current font to bold, `\fI` changes the font to italic, and

\fR changes it back to regular font. (This markup is better than asking for a particular font type because it just changes to bold, italic, or regular for the current font.) Figure 6-3 shows what the waycool man page looks like after it is formatted with groff:

```
$ groff -man -Tps -l waycool.1 | ps2pdf - > waycool.pdf
```

**FIGURE 6-3**

Man page formatting adds headers and lays out the page of text.



Macros are described on the man(7) manual page (type **man 7 man** to view that page).

## Text Processing with TeX/LaTeX

TeX (pronounced *tech*) is a collection of commands used primarily to produce scientific and mathematical typeset documents. The most common way to use TeX is by calling a macro package. The most popular macro package for TeX is LaTeX, which takes a higher-level approach to formatting TeX documents. TeX and LaTeX tools are contained in the `tetex-latex` package.

### NOTE

The `tetex-*` packages needed to use the TeX examples shown in this chapter are found on the DVD that accompanies this book.



TeX interprets the LaTeX macros from the `latex` format file (`latex.fmt`). By default, the `latex.fmt` and `plain.fmt` format files are the only ones that are built automatically when the TeX package is installed. Other macro files that you can use with TeX include:

- **amstex** — Mathematical publications, including the American Mathematical Society, use this as their official typesetting system.
- **eplain** — Includes macros for indexing and table of contents.
- **texinfo** — Macros used by the Free Software Foundation to produce software manuals. Text output from these macros can be used with the Linux `info` command.

You can create a TeX/LaTeX file using any text editor. After the text and macros are created, you can run the `tex` command (or one of several other related utilities) to format the file. The input file is in the form `filename.tex`. The output is generally three different files:

- **filename.dvi** — This is the device-independent output file that can be translated for use by several different types of output devices (such as PostScript).
- **filename.log** — This is a log file that contains diagnostic messages.
- **filename.aux** — This is an auxiliary file used by LaTeX.

The `.dvi` file produced can be formatted for a particular device. For example, you could use the `dvips` command to output the resulting `.dvi` file to your PostScript printer (`dvips filename.dvi`). Or you could use the `xdvi` command to preview the `.dvi` file in X.

## Creating and Formatting a LaTeX Document

Because LaTeX is the most common way of using TeX, this section describes how to create and format a LaTeX document. A LaTeX macro (often referred to as a command) appears in a document in one of the two following forms:

- `\string{option}[required]` — First, there is a backslash (`\`), which is followed by a string of characters. (Replace *string* with the name of the command.) Optional arguments are contained in braces (`{}`), and required arguments are in brackets (`[ ]`).
- `\?{option}[required]` — First, there is a backslash (`\`), which is followed by a single character that is not a letter. (Replace `?` with the command character.) Optional arguments are contained in braces (`{}`), and required arguments are in brackets (`[ ]`).

Each command defines some action to be taken. The action can control page layout, the font used, spacing, paragraph layout, or a variety of other actions on the document. The minimum amount of formatting that a LaTeX document can contain is the following:

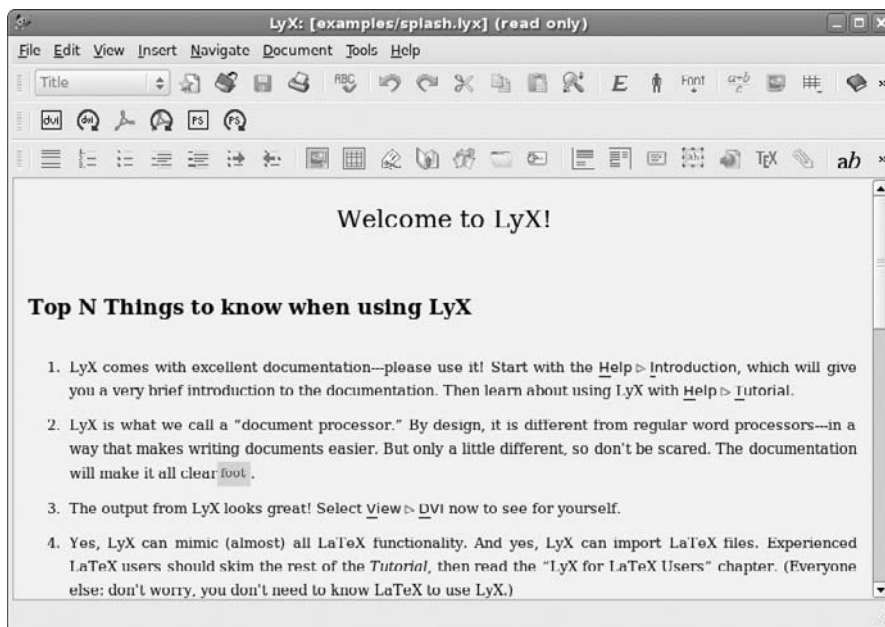
```
\documentclass{name}
\begin{document}
  TEXT GOES HERE!
\end{document}
```

You should replace `{name}` with the name of the class of document you are creating. Valid document classes include `article`, `book`, `letter`, `report`, and `slides`. The text for the file, along with your formatting commands, goes between the `begin` and `end` document commands.

The best way to get started with LaTeX is to use the LyX editor, available at [www.lyx.org/](http://www.lyx.org/). LyX provides a GUI for creating LaTeX documents. It also contains a variety of templates you can use instead of just creating a document from scratch. Figure 6-4 shows an example of the LyX editor.

**FIGURE 6-4**

Create LaTeX documents graphically with the LyX editor.



If you want to edit LaTeX in a regular text editor, you need to be familiar with the LaTeX commands. For a complete listing of the LaTeX commands, type **info latex** and then go to the section "Commands within a LaTeX Document."

## Converting Documents

Documents can come to you in many different formats. Search just some of the Linux FTP sites on the Internet and you will find files in PostScript, DVI, man, PDF, HTML, and TeX. There are also a variety of graphics formats. CentOS comes with lots of utilities to convert documents and

graphics from one format to another. The following is a list of document and graphics conversion utilities:

- `dos2unix` — Converts a DOS text file to a UNIX (Linux) text file. A reason you might want to use this command is that DOS text files include double-character carriage returns, whereas Linux (UNIX) text files have a single-character linefeed.
- `fax2ps` — Converts TIFF facsimile image files to a compressed PostScript format. The PostScript output is optimized to send to a printer on a low-speed line. This format is less efficient for images with a lot of black or continuous tones. (In those cases, `tiff2ps` might be more effective.)
- `fax2tiff` — Converts fax data (Group 3 or Group 4) to a TIFF format. The output is either low-resolution or medium-resolution TIFF format.
- `gif2tiff` — Converts a GIF (87) file to a TIFF format.
- `man2html` — Converts a man page to an HTML format.
- `pal2rgb` — Converts a TIFF image (palette color) to a full-color RGB image.
- `pdf2dsc` — Converts a PDF file to a PostScript document DSC file. The PostScript file conforms to Adobe Document Structuring Conventions (DSC). The output enables PostScript readers (such as Ghostview) to read the PDF file a page at a time.
- `pdf2ps` — Converts a PDF file to a PostScript file (Level 2).
- `pfb2pfa` — Converts Type 1 PostScript font (binary MS-DOS) to ASCII-readable.
- `pk2bm` — Converts a TeX pkfont font file to a bitmap (ASCII file).
- `ppm2tiff` — Converts a PPM image file to a TIFF format.
- `ps2ascii` — Converts PostScript or PDF files to ASCII text.
- `ps2epsi` — Converts a PostScript file to Encapsulated PostScript (EPSI). Some word processing and graphic programs can read EPSI. Output is often low quality.
- `ps2pdf` — Converts a PostScript file to Portable Document Format (PDF).
- `ps2pk` — Converts a Type 1 PostScript font to a TeX pkfont.
- `ras2tiff` — Converts a Sun raster file to a TIFF format.
- `tiff2bw` — Converts an RGB or Palette color TIFF image to a grayscale TIFF image.
- `tiff2ps` — Converts a TIFF image to PostScript.
- `unix2dos` — Converts a UNIX (Linux) text file to a DOS text file.

Besides these tools, many graphical applications, such as The GIMP, enable you to save images in several different formats (BMP, JPEG, PNG, TIFF, etc.), using the “Save As” feature.

## Creating DocBook Documents

Documentation projects often need to produce documents that are output in a variety of formats. For example, the same text that describes how to use a software program may need to be output as a printed manual, an HTML page, and a PostScript file. The standards that have been

embraced most recently by the Linux community for creating what are referred to as *structured documents* are SGML, XML, and DocBook.

## Understanding SGML and XML

*Standard Generalized Markup Language* (SGML) was created to provide a standard way of marking text so that it could be output later in a variety of formats. Because SGML markup is done with text tags, you can create SGML documents using any plaintext editor. Documents consist of the text of your document and tags that identify each type of information in the text.

Unlike markup languages such as Groff and HTML, SGML markup is not intended to enforce a particular look when you are creating the document. So, for example, instead of marking a piece of text as being bold or italic, you would identify it as an address, a paragraph, or a name. Later, a style sheet would be applied to the document to take the tagged text and assign a look and presentation.

Because SGML consists of many tags, to simplify producing documents based on SGML, other projects have cropped up to better focus the ways in which SGML is used. In particular, the Extensible Markup Language (XML) was created to offer a manageable subset of SGML that would be specifically tailored to work well with web-based publishing.

So far in describing SGML and XML, I have referred only to the frameworks that are used to produce structured documents. Specific documentation projects need to create and, to some extent, enforce specific markup definitions for the type of documents they need to produce. These definitions are referred to as *Data Type Definitions* (DTDs). For documentation of Linux itself and other Open Source projects, DocBook has become the DTD of choice.

## Understanding DocBook

*DocBook* is a DTD that is well suited for producing computer software documents in a variety of formats. It was originally created by the OASIS Consortium ([www.oasis-open.org/docbook](http://www.oasis-open.org/docbook)) and is now supported by many different commercial and Open Source tools.

**CROSS-REF** You can find official documentation for DocBook at [www.docbook.org](http://www.docbook.org).

DocBook's focus is on marking content, instead of indicating a particular look (i.e., font type, size, position, etc.). It includes markup that lets you automate the process of creating indexes, figure lists, and tables of contents, to name a few. Tools in CentOS enable you to output DocBook documents into HTML, PDF, DVI, PostScript, RTF, and other formats.

DocBook is important to the Linux community because many Open Source projects are using DocBook to produce documentation. For example, the following is a list of organizations, and related web sites, that use DocBook to create the documents that describe their software:

- Linux Documentation Project ([www.tldp.org/LDP/LDP-Author-Guide](http://www.tldp.org/LDP/LDP-Author-Guide))
- GNOME Documentation (<http://developer.gnome.org/projects/gdp/handbook/gdp-handbook>)

- KDE Documentation Project ([www.kde.org/documentation](http://www.kde.org/documentation))
- FreeBSD Documentation Project ([www.freebsd.org/docproj](http://www.freebsd.org/docproj))

If you want to contribute to any of the preceding documentation projects, refer to the web site for each organization. In all cases, they publish writers' guides or style guides that describe the DocBook tags that they support for their writing efforts.

## Creating DocBook Documents

You can create the documents in any text editor, using tags that are similar in appearance to HTML tags (with beginning and end tags appearing between `<` and `>` signs). There are also word processing programs that allow you to create DocBook markup. You can export documents from OpenOffice.org Writer to DocBook format, for example.

The following procedure contains an example of a simple DocBook document produced with a plaintext editor and output into HTML using tools that come with CentOS:

1. Create a directory in your home directory to work in and go to that directory. For example, you could type the following from a Terminal window:

```
$ mkdir $HOME/doctest
$ cd $HOME/doctest
```

2. Open a text editor to hold your DocBook document. For example, you could type:

```
$ gedit cardoc.sgm1
```

(A text editor such as jEdit, which you can get at [www.jedit.org](http://www.jedit.org), can also be useful for dealing with the long tag names used in DocBook.)

3. Enter the tags and text that you want to appear in your document. Most DocBook documents are either `<book>` type (large, multichapter documents) or `<article>` type (single-chapter documents). To try out a DocBook document, type the following:

```
<article>
  <title>Choosing a new car</title>
  <artheader>
    <abstract>
      In this article, you will learn how to price,
      negotiate for, and purchase an automobile.
    </abstract>
  </artheader>
  <section>
    <title>Getting Started</title>
    <para>
      The first thing you will learn is how to figure out
      what you can afford.
    </para>
  </section>
```

```
<section>
  <title>The Next Step</title>
  <para>
    After you know what you can afford, you can begin your
    search.
  </para>
</section>
</article>
```

You should notice a few things about this document. The entire document is wrapped in article tags (`<article>` `</article>`). The article title is in title tags (`<title>` `</title>`). The section tags (`<section>` `</section>`) indicate sections of text that have a title and paragraph each. These sections can later be treated separately in the TOC.

4. Save the file and exit from the text editor.
5. Next, you can try translating the document you just created into several different formats. For example, to create HTML output, you can type the following:

```
$ db2html cardoc.sgm1
```

The result is a new directory called *cardoc*. The result from `db2html` in the *cardoc* directory was: stylesheet-images directory, *t1.html* file, and *x8.html* file.

6. To view the HTML file just created, I typed the following:

```
$ firefox $HOME/doctest/cardoc/t1.html
```

Figure 6-5 shows an example of the output created from the `db2html` command. During conversion to HTML, the `db2html` command adds Next/Previous buttons to each page. It also puts the title of each section in a Table of Contents on page 1 and in the browser's title bar.

From this point, you can continue to add content and different types of tags. If you are writing documents for a particular project (such as the Linux projects mentioned earlier), you should get information on the particular tags and other style issues they require.

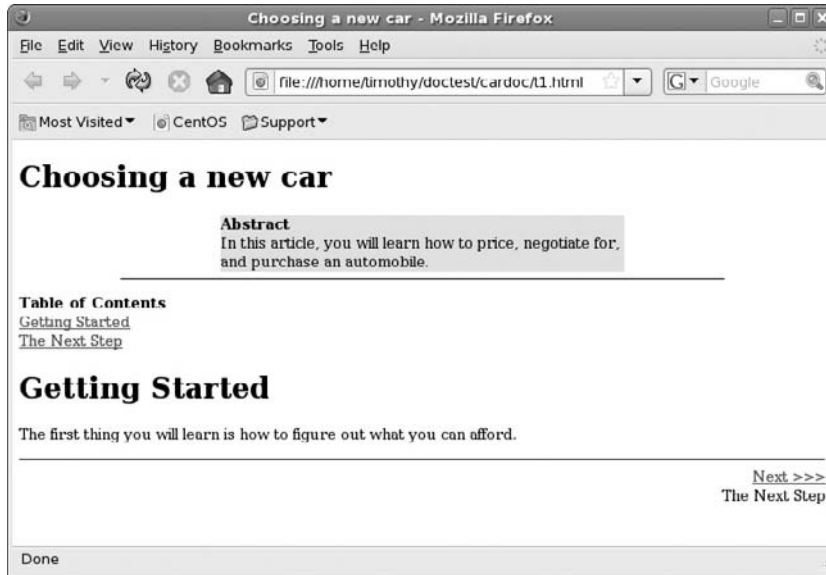
## Converting DocBook Documents

The previous example shows how to create a simple DocBook document and convert it to HTML output. The following CentOS utilities convert DocBook to other formats:

- `docbook2dvi` — Converts a DocBook file to Device Independent file format.
- `docbook2html` — Converts a DocBook file to HTML format.
- `docbook2man` — Converts a DocBook file to man page format.
- `docbook2pdf` — Converts a DocBook file to Portable Document Format (PDF).
- `docbook2rtf` — Converts a DocBook file to Rich Text Format (RTF).

**FIGURE 6-5**

The DocBook file is output in HTML with the `db2html` command.



- `docbook2tex` — Converts a DocBook file to TeX format.
- `docbook2texi` — Converts a DocBook file to GNU TeXinfo format.
- `docbook2txt` — Converts a DocBook file to a bare text format.

## Displaying PDF Files with Evince

Non-WYSIWYG publishing can be very paper-intensive if you send a Groff or LaTeX document to the printer each time you want to make a change to the document's content or formatting. To save paper and time spent running around, you can use some print preview programs to display a document on the screen as it will appear on the printed page. The following sections describe the Evince reader for displaying Portable Document Format (PDF) files.

PDF provides a way of storing documents as they would appear in print. With Evince, you can view PDF files in a very friendly way. Evince makes it easy to move around within a PDF file. A PDF file may include hyperlinks, a table of contents, graphics, and a variety of type fonts.

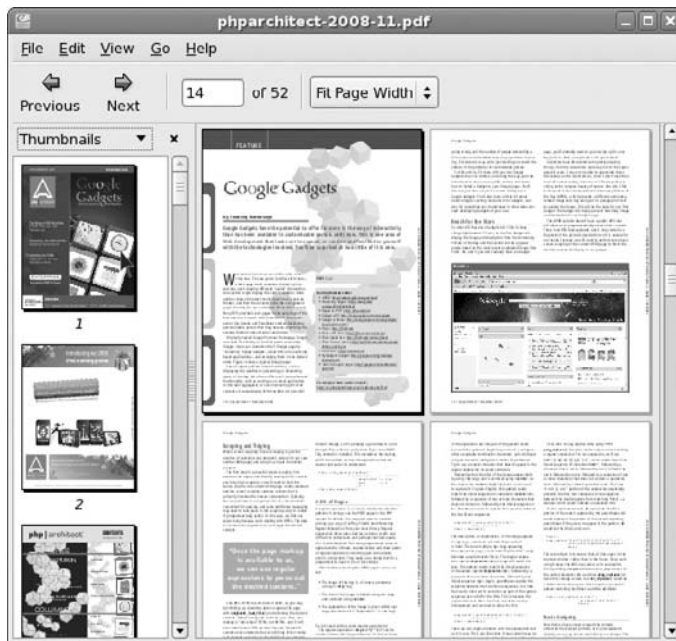
Type the following command to start the program:

```
$ evince
```

Select File ➤ Open, and then select the name of a PDF file you want to display. Figure 6-6 shows an example of a PDF file viewed in Evince.

**FIGURE 6-6**

Display PDF files in the Evince PDF Reader.



Evince has a lot of nice features. For example, you can display a table of contents alongside the document and click on an index entry to take you to a particular page. You can also display thumbnails of the pages to quickly scroll through and select a page.

Using the menu bar or buttons, you can page through the PDF document, zoom in and out, go to the beginning or end of the document, and display different views of the document (as well as display bookmarks and page thumbnails). To print a copy, select File ➤ Print.

## Doing Page Layout with Scribus

For brochures, magazines, newsletters, catalogs and other materials that need more sophisticated layouts than you can do with a word processor, you need a page layout application. The most popular Open Source page layout application is Scribus ([www.scribus.net](http://www.scribus.net)).



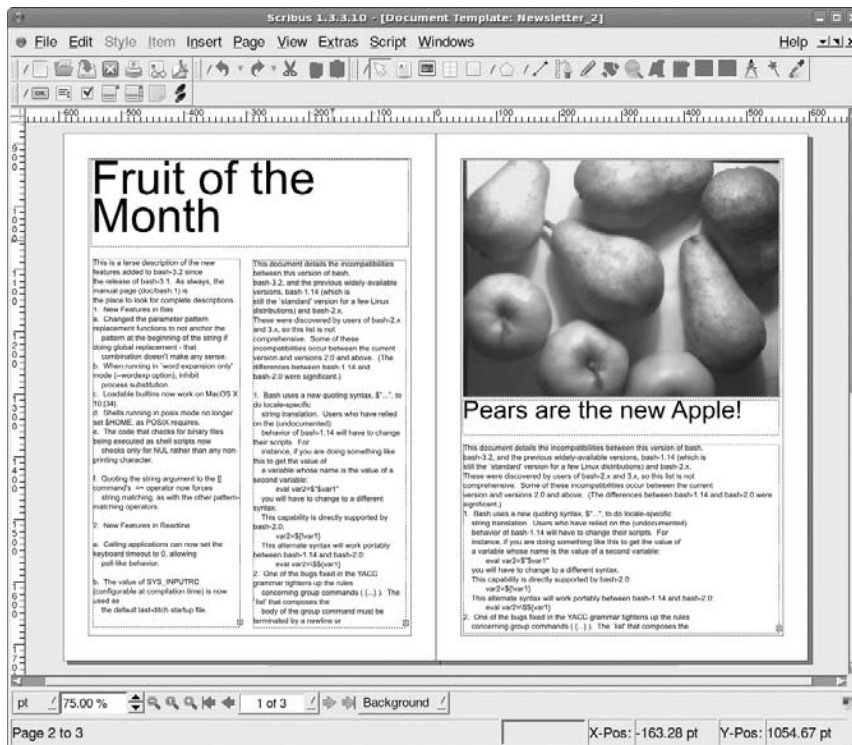
Although Scribus is intended primarily to produce print publications, you can also use Scribus to produce what are referred to as *intelligent PDFs*. With PDFs you create with Scribus, you can include JavaScript and other features to let others interact with your text (such as by filling in forms). Scribus is similar to the Publisher application available with Windows.

To use Scribus in CentOS, install the `scribus` package. The package comes with templates and samples you can use to start your own projects with (usually in `/usr/share/scribus/`).

With the `scribus` package installed, you can start Scribus from the GNOME desktop by selecting Applications > Office > Scribus. Figure 6-7 shows an example of a brochure layout in Scribus.

**FIGURE 6-7**

Produce professional quality layouts with Scribus.



After Scribus is running on your desktop, you can start by selecting a template (select File > New from Template). Choose a brochure, newsletter, presentation, or text-based layout to begin. Here are some steps you can take on the sample layout to get used to using Scribus:

- **Edit Text** — Right-click in a textbox and select “Edit Text.” In the Story Editor window that appears, change the text, point size, scaling width/height of the text, font, text

alignment, color, and other attributes. Select File ➤ Update Text Frame, and Exit to save the changes.

- **Add Images** — Right-click on an image box and select “Get Image.” Browse your folders for the image you want. If the image doesn’t fit, right-click on the image and select “Edit Image” to open the image in The GIMP to resize or otherwise modify it. Right-click on the image and select “Adjust Frame to Image” to resize the frame to fit your image.
- **Change Existing Frames** — Right-click in any frame, then click “Is Locked” so the checkbox disappears. Once it is unlocked, you can do a lot to change it. Grab a corner or side of the frame to resize it. Right-click on it and select “Sample Text” (to fill it with text), or Cut, Copy, or Delete it. Grab the frame with your mouse to drag-and-drop it somewhere else. If you are done changing the frame, select “Is Locked” to lock the frame in place again.
- **Change Document Attributes** — Select File ➤ Document Setup. From the Document Setup window that appears, you can change the size and orientation of the page, as well as the type of page (single, double-sided, three-fold, or four-fold). Likewise, you can change all margins. Select topics from the left to add information such as author, title, and keywords. You can also change fonts and hyphenation or add a table of contents.
- **Drawing** — You can do freehand drawing anywhere on your Scribus layout. Select the “Insert Freehand Line” button (pencil icon) or “Insert Bezier Curve” button (ink pen icon), then use the mouse to draw lines on the page. You can also draw boxes, polygons, or lines using buttons on the toolbar. Right-click on the drawn element and select Properties. From the Properties window, you can adjust the shape, line, and colors of the drawing.

When you are done creating your layout, you can print it by selecting File ➤ Print. The Preflight Verifier window appears within information about the printed document. At the top-right corner of the page, you can select to change PostScript to one of several PDF versions. You can choose now to direct the output to the printer or have it go to a PDF or PostScript file.

## Working with Graphics

---

Tools for creating and manipulating graphics are becoming both more plentiful and more powerful in Linux. Leading the list is The GNU Image Manipulation Program (*The GIMP*, or sometime simply *GIMP*). GIMP lets you compose and author images as well as retouch photographs. Other tools that come with CentOS for creating graphics include KSnapshot (a program for taking screen captures) and Inkscape for creating vector graphics.

**CROSS-REF** See Chapter 7 for descriptions of other multimedia applications, such as the gPhoto window for working with images from digital cameras.

## Manipulating Images with GIMP

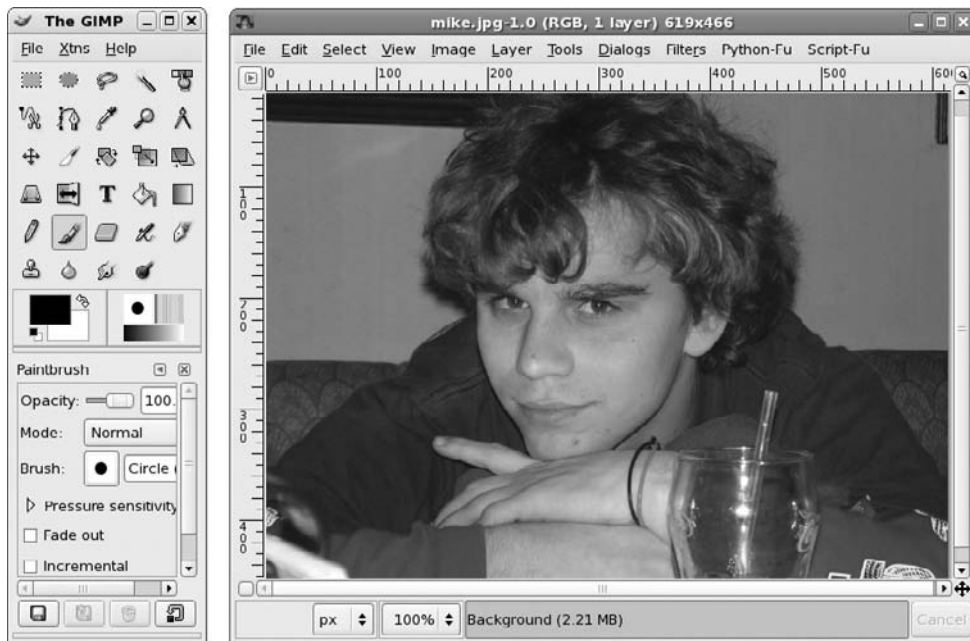
The GIMP is a free software program that comes with CentOS for manipulating photographs and graphical images. To create images with The GIMP, you can either import a drawing,

photograph, or 3D image, or you can create one from scratch. You can start The GIMP from the Applications menu by clicking Graphics ➤ The GIMP or by typing **gimp&** from a Terminal window.

Figure 6-8 shows an example of The GIMP.

**FIGURE 6-8**

The GIMP is a powerful tool for graphic manipulation.



In many ways, The GIMP is similar to Adobe Photoshop. Some people feel that GIMP's scripting features are comparable to, or even better than, Actions in Adobe Photoshop. One capability in which The GIMP has been behind Photoshop has been in the area of color management. With the latest features of The GIMP, however, you can calibrate screens and work with color profiles from your cameras and scanners (see <http://docs.gimp.org/en/gimp-imaging-color-management.html> for more information).

One of the easiest ways to become familiar with The GIMP is to crop, or trim, an image file already on your computer. To crop a file, follow these steps:

1. Start GIMP and open an image file.
2. Right-click on the image. From the contextual menu that appears, select Tools ➤ Transform Tools ➤ Crop. The crop cursor appears (a cross and knife icon).

3. Position the crop cursor at the upper-left corner of the area of the image that you want to crop. Click and drag the cursor to the lower-right corner of the area to be cropped. A selection rectangle will appear around the selected area as you do so.
4. Release the mouse button. Four selection squares appear in the corners of the border around the selected area. Click and drag the handles to resize the border.
5. When the border is in the right place, press the [Enter] key. The image will be cropped to the border.

**TIP**

If you make a mistake, select **Edit > Undo** from the GIMP menu, or press the [Ctrl]+Z key combination. Type [Ctrl]+Y to redo undone changes.

## Taking Screen Captures

If you want to show examples of the work you do on CentOS, you can use `gnome-screenshot` to capture screen images.

To open Gnome Screenshot, from the Applications menu click **Accessories > Take Screenshot**. Figure 6-9 shows an example of the screen capture.

**FIGURE 6-9**

Grab a picture of your desktop with Gnome Screenshot.



Another screen capture program that offers a bit more functionality than Gnome Screenshot is KSnapshot. KSnapshot is a component of the `kdegraphics` package (type **yum install kdegraphics**).

To open KSnapshot, from the Applications menu click **Accessories > Ksnapshot** (or type **ksnapshot**). When Screen Capture first opens, it takes a snapshot of the full desktop. Buttons on the window offer the following options:

- **New Snapshot** — Select the capture mode (Full Screen, Window under cursor, or Region). Click here to take a new snapshot of the selected content.

- **Save As** — Save the snapshot to a file in X bitmap, Windows icon, PNG, portable pixmap, JPEG, X pixmap, Encapsulated PostScript, or Windows BMP formats.
- **Copy to Clipboard** — Copy the image to the clipboard, so it can be pasted into a document, image editor, or other application.
- **Print** — Have the snapshot sent to your printer.

You can select a capture mode other than the default Full Screen. For example, you can choose to capture the window under the cursor, a particular region of the desktop (hold down the mouse and drag a box open), or a section of a window (the element of the window set to be captured will highlight). You can also delay the snapshot for a set number of seconds.

Figure 6-10 shows an example of KSnapshot in action.

**FIGURE 6-10**

Take a picture of your desktop or selected window with Screen Capture.



## Creating Vector Graphic Images with Inkscape

When you need to have maximum flexibility working with graphics and text, a vector graphic editor can let you deal with geometric elements (such as lines, curves, and boxes) instead of dots (as you do with image editors). As a result, you usually get cleaner edges on your fonts and graphics and the ability to bend and shape those elements as you like. Inkscape ([www.inkscape.org](http://www.inkscape.org)) is a popular vector graphics editor that is available with CentOS.

With Inkscape, you have an application with features similar to those you would find in commercial products such as Adobe Illustrator and CorelDraw. Inkscape creates images in Scalable Vector Graphics (SVG) format — an open standard from the W3C ([www.w3.org/Graphics/SVG](http://www.w3.org/Graphics/SVG)). Thousands of SVG graphics and clipart elements are available in the public domain or under Creative Commons licenses.

In CentOS, install the `inkscape` package to get Inkscape. With the `inkscape` package installed, select Applications ► Graphics ► Inkscape Vector Graphics Editor to open an Inkscape window. Figure 6-11 shows an example of the Inkscape window:

**FIGURE 6-11**

Inkscape lets you manipulate vector graphics and text.



You can start by opening one of the dozens of templates available with Inkscape (select File ► New and choose from web banner, business card, DVD cover, or other templates). With the new window open, here are some ways to get started with Inkscape:

- **Add Text** — Select the text icon from the toolbar on the left, click on the page, and begin typing. After typing some text, choose the Select icon and click on the text. Use the side or corner arrows to resize the text. Click the text again and use the arrows around the text to slant or rotate the text. Grab the textbox with the mouse and drag it where you want it

to go. With the text still selected, select Text ► Text and Font to see a window where you can choose the font family, font style, layout, and line spacing.

- **Add Graphical Elements** — From the toolbar on the left, select the rectangle, 3D box, circles, start, or swirls button. Move the mouse cursor to the place where you want the new element, click and hold the mouse on that place, and move the mouse so the new element grows to the size you want. Click on the color palette on the bottom of the screen to change the element's color.
- **Add Clipart** — Select File ► Import and browse your file system to import an image. Once the image is imported, use your mouse to select and shape it as you did with the text.
- **Group Objects** — Select a text or clipart object, then hold the [Shift] key and select other objects. When all the objects you want in the group are selected, choose Object ► Group. You can now move all the grouped objects around together as one unit.
- **Use Layers** — Select the Layer button to add, delete, raise, or lower layers.

When you are done creating your vector graphic, you can print that graphic by selecting File ► Print. From the Print window, you can select to have the image in vector or bitmap form from the Rendering tab.

## Using Scanners Driven by SANE

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Software for using a scanner with Linux is being driven by an effort called *Scanner Access Now Easy* (SANE). This effort hopes to standardize how device drivers for equipment such as scanners, digital still cameras, and digital videocameras are created, as well as help simplify the interfaces for applications that use those devices.

SANE is now included with CentOS. The `sane-backends`, `sane-frontends`, `xsane`, and `xsane-gimp` packages are all on the DVD that comes with this book. You can get the latest SANE driver packages from [www.sane-project.org](http://www.sane-project.org).

Someone wanting to use Linux as a publishing platform is generally interested in two issues about scanners: which scanners are supported and which applications are available to use the scanners. In the past, more SCSI scanners have been supported than parallel scanners. However, these have given way to the more convenient USB scanners.

Because of the ongoing development effort, new scanners are being supported all the time. You can find a current list of supported scanners at [www.sane-project.org/sane-supported-devices.html](http://www.sane-project.org/sane-supported-devices.html). As for applications, these are currently available with CentOS:

- **XSane** — This is an X-based graphical front-end for SANE scanners; XSane can work as a GIMP plug-in or as a separate application. (From the Applications menu, select Graphics ► Scanning.) It supports 8-bit output in JPG, TIFF, PNG, PostScript, and PNM formats. There is experimental 16-bit support for PNM (ASCII), PNG, and raw formats.

- `scanimage` — This is a command-line interface for obtaining scanned images. It supports the same formats as `xscanimage`. The command acquires the scanned image and then directs the data to standard output (so you can send it to a file or pipe it to another program).

In addition to these applications, the OpenOffice.org suite supports SANE.

Because of the architecture of SANE scanner drivers, it is possible to separate scanner drivers from scanner applications. This makes it possible to share scanners across a network.

## Web Publishing

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The final destination for your documents and images doesn't have to be paper. Publishing on the Web has become commonplace in the past few years. If you want to control your own web site for publishing your thoughts and pictures to the world, Linux systems include many software packages to help you do that.

If you are creating simple HTML web pages, you can create basic HTML documents using word processors such as OpenOffice.org Writer. If you are really brave, you might even try a plaintext editor and add the HTML markup manually. For more complex web sites, however, there are lots of options.

The following list describes Open Source software packages that can be used for publishing on the Web.

### CAUTION

**Web Servers are constant targets for bad guys on the Internet. If you decide to try some of the software described below, be sure to check with the project site to make sure that you get the latest security patches and updates.**

- **Image Galleries** — The Gallery project (<http://gallery.menalto.com>) lets you create online photo albums. Gallery makes it easy for you to organize photos into albums, edit your images, tag them, and present them using a variety of themes and colors.
- **Blogging Software** — The popular WordPress site ([www.wordpress.com](http://www.wordpress.com)) uses its own Open Source WordPress software ([www.wordpress.org](http://www.wordpress.org)) to offer blogging accounts to others. If you want your own blogging site, you can either sign up for a free account on [WordPress.com](http://WordPress.com) or you can use that software to set up your own blogging site.
- **Wiki Software** — Wikis let you gather and organize large amounts of information online. Instead of having to write everything on a subject by yourself, by creating a wiki you can allow people to sign up for accounts and add and correct articles on your site. Wiki software available to the Open Source community includes MediaWiki (install the `mediawiki` package) and MoinMoin (install the `moin` package). See the <http://MediaWiki.org> and <http://MoinMoin.wikiwikiweb.de> sites, respectively, for further information.



- **Content Management System (CMS) Software** — For some web sites, you might want to offer a range of information. For an active online community, you may want to offer articles, forums, online polls, downloads, and other diverse activities. Content management systems (CMSs) such as Drupal (install the `drupal` package) offer a platform for creating and managing those types of activities online. Other Open Source CMS systems include Plone ([www.plone.org](http://www.plone.org)) and Zope ([www.zope.org](http://www.zope.org)).

Before installing and making any of these types of web sites available on the Internet, you should keep in mind that it will take some commitment to stay current with software updates and keep the site maintained. But if you are willing to make that commitment, the Open Source projects just mentioned can help you produce high-quality sites for publishing on the Internet.

## Summary

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Tools available in Linux for publishing words and images on paper and the Web can compete with similar software available commercially. For producing hardcopy documents, you have word processors such as OpenOffice.org Writer and StarOffice. To lay out pages, there is Scribus. To work with photos, you have The GIMP, or for vector graphics, you can use Inkscape.

Software for publishing content on the Internet is also available now in almost any category you can think of. For blogging, you can create a WordPress site. For image galleries, there is Gallery software. Content management systems include Drupal, Plone, and Zope. To create wikis, there are MediaWiki and Moin Moin.

# Chapter 7

## Music, Video, and Images in Linux

**N**early every kind of audio and video format available today can be played, displayed, encoded, decoded, and managed in Linux. With the development of the Theora video codec, there are now patent-free, royalty-free formats available for every major type of multimedia content. If you are starting from scratch, today you can legally create, manipulate, and share your own multimedia content from Linux using all free applications and codecs.

This chapter covers many different tools that come with CentOS for playing or displaying digital music, video, and images. It also takes a swipe at explaining some of the legal issues surrounding software for playing commercial movie DVDs, MP3 music, and various audio/video formats in Linux.

Video content that is readily available on the Internet for playing movie clips, commercial films, and other content can be viewed using several different players in or available for CentOS. Also, you can view live television and video using TV cards and Webcams.

Because CD-ROM is the physical medium of choice for recorded music, this chapter describes how to set up and use CD burners to create your own music CDs. After your CD burner is set up to record music, you can use the same CD burner to back up your data or to create software CDs. (The same tools can be used to burn DVDs as well.)

### IN THIS CHAPTER

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Listening to music

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Using Webcams and TV cards

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Playing video

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Working with digital cameras and images

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## Understanding Multimedia and Legal Issues in Linux

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You can't play DVD movies or MP3 music with the software that is delivered with CentOS. The software needed to do so isn't included in those distributions because there are patent claims associated with the formats used to store, encode, and decode that content that would prevent Open Source software that worked with that content from being freely distributed.

Most commercial Linux vendors have decided not to add software codecs (which encode and decode multimedia formats), even if they were written from scratch and covered under the GPL, that are encumbered with contentious software patents. After Thomson and Fraunhofer Gesellschaft (which control the MP3 patent) began requesting licensing fees in 2002 of \$.075 for MP3 decoders (per system), many Linux distributions dropped MP3 support. (See [www.mp3licensing.com/royalty](http://www.mp3licensing.com/royalty) for details.)

Just to clarify, I am not talking about *copyright* here. Nobody can rightly claim that it is OK to copy someone else's commercial code and release it as free software. That would clearly violate copyright laws. What we are talking about is *patents*.

The idea of a *patent* is to allow someone to control the rights regarding who can make, sell, offer to sell, use, or import an invention that the patent applicant dreamed up. As it relates to multimedia software in particular, the encoding and decoding of audio and video content for many commercially released music and video formats are covered by patents. So, even if Open Source developers write every piece of code from scratch to encode and decode content, it may not be legal to distribute it without paying a royalty to the patent owner.

Major efforts are under way (especially in Europe) to oppose software patents. Refer to the Foundation for a Free Information Infrastructure web site (<http://ffii.org>) for further information. The contention is that so many ideas related to software are being patented that it could severely cripple the ability to innovate (especially for Open Source developers or small software companies without huge legal teams).

Patents have been granted in Europe for common items that might appear on a web page, such as selling things over a network, using an electronic shopping cart, and using rebate codes (see <http://webshop.ffii.org>). Although there are now laws in Europe that are aimed at preventing any further software patents, some software patents are still being granted, and existing patents are still being used to discourage innovation.

Despite efforts against software patents, however, the fact remains that CentOS distributions do not include some of the software that you would want to use to play your digital media. That doesn't mean, however, that there is nothing you can do to legally play the commercial audio and video content you want to play in Linux. In the latest version of CentOS, some features have been added to make sure that there are legal ways to get the codecs you need.

## Extending Freedom to Codecs

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CentOS may not be able to give you the audio decoders you need to play every kind of media you want, but it gives you the freedom (and the tools) to go out and get those decoders yourself. For example, you can purchase codecs for non-free audio and video content, such as MPEG4 video, Windows Media, and others.

A company called Fluendo ([www.fluendo.com](http://www.fluendo.com)), which is responsible for the GStreamer multimedia framework used in CentOS, purchased an unlimited MP3 license that allows you to download the Fluendo MP3 Audio Decoder for free, to play your MP3 audio files. You can pay a small fee to get audio/video codecs such as Dolby AC3 Audio Decoder, Windows Media MMS Network Stream Reader, MPEG2 Video Decoder, or MPEG4 Part 2 Video Decoder. Read the licensing agreement that appears before you accept the download. Unlike software that comes with CentOS, you cannot freely re-distribute the codecs you get from Fluendo.

## Listening to Music in Linux

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Good-quality sound hardware is considered a necessity for today's desktop and laptop computer systems. Whether playing songs downloaded from the Internet, sound tracks to digital movies, or audio from a TV card, any user-friendly operating system has to support a healthy list of sound hardware and audio applications.

Most popular sound devices for the PC, whether on separate cards or built into your computer's motherboard, will be automatically detected when a CentOS system boots up. Appropriate modules will be loaded, so you can immediately begin using your sound card.

Advanced Linux Sound Architecture (ALSA) is the default sound system in CentOS. The `alsa-utils` RPM package contains the commands and configuration files you can use to tune your sound card and adjust audio levels. Other friendly graphical tools have been added by the GNOME and KDE projects for managing sound.

After your sound card is working and audio levels are adjusted, you can use any of the dozens of audio applications that come with Linux with your sound card. Those applications include music players, video players, video conferencing applications, games, and audio recorders, to name a few.

As for audio content, the following list describes the types of audio content you might want to play, which players can be used for each type of content, and whether or not the software comes with CentOS. (If not, I describe where you can get software to play that content and issues associated with getting and using that software.)

- **Music CDs (CDDA)** — Commercial music CDs are nearly all stored in the Compact Disc Digital Audio system (CDDA). CentOS applications that can play music CDs include CD

Player (gnome-cd) and KsCD (kscd). Rhythmbox can play music CDs, as well import songs to your hard disk (using Sound Juicer) so you can manage your music from one location. Other applications in CentOS that can play audio files from CDs include xmms and grip.

- **Ogg Vorbis Audio** — If you are compressing and storing music from scratch, Ogg Vorbis is probably the best choice if you want to avoid completely any royalty issues. The libvorbis codec is included with CentOS and makes it possible to play audio encoded in Ogg Vorbis format in a variety of Linux music players, including xmms, Rhythmbox, ogg123, and many others. The `vorbis-tools` package also includes utilities for encoding (`oggenc`) and decoding (`oggdec`) Ogg Vorbis content to or from WAV and raw music formats. The Xiph.org Foundation develops both Ogg Vorbis audio formats and Theora video formats.
- **MP3 Audio** — MPEG Audio Layer 3 (MP3) has become the standard format for storing audio files that are transmitted over computer networks (such as the Internet). Because of licensing issues associated with distributing MP3 players, CentOS does not include codecs needed to encode or decode MP3 audio files in any of its distributions. However, CentOS does give you the opportunity to download free, legal MP3 decoders from Fluendo (as described earlier in this chapter).

Another way to get MP3 support, which may not be legal where you are, is to install the `xmms-mp3` package, which contains software needed by Linux audio players to play MP3 audio files with the xmms music player. You need the `lame` package to create compressed audio files from WAV, AIFF, or raw audio files that play on MP3 players. Many use the `mpg321` command-line MP3 player, which is available in the `mpg321` package. (All of these packages are available from the RPMforge RPM Repository. See Chapter 5 on installing software from third-party repositories.)

- **FLAC Audio** — FLAC is an Open Source lossless audio format. *Lossless* means that it compresses the audio as much as possible without losing sound quality. In comparing the same song compressed in Ogg Vorbis and FLAC (using default settings), FLAC files were on average about six times the size of the Ogg Vorbis files.

Many of the same applications that can play Ogg Vorbis files can play FLAC files as well. Rhythmbox, ogg123, and xmms can all play FLAC files. You can encode FLAC audio using Sound Juicer or the `flac` command, among others.

- **Other Audio Formats** — While the audio formats mentioned previously are the most common ones used for music files today, there are other audio formats you may want to play from Linux. Refer to the description of the `sox` utility for several audio formats that are supported by that utility. Use the `play` command (which comes with the `sox` package) or `aplay` (which is in the `alsa-utils` package) to play content stored in any of those supported formats.

Audio formats that are sometimes included with video files are described in the section on video players later in this chapter.

## Configuring a Sound Card

Configuring a sound card in Linux consists primarily of having the right modules load (which usually happens automatically at boot time) and then using the sound utilities you choose (such as the PulseAudio Volume Control, `alsamixer`, or `aumix`) to adjust the settings for the sound card. Today's sound cards often have more than the old Mic-In, Line-In, Speaker-out, and Joystick ports. So when you go to adjust your audio levels, there are more items you need to learn about.

### Sound Card Features

Sound cards can pack an amazing number of features these days. Most PCs these days come with built-in sound support. Here are some of the features you should look for if you want to purchase a sound card separately:

- **Sound Recording and Playback Quality** — When you record and play back audio, quality and file size are determined, in part, by word length (the number of bits that are used to hold a numerical value) and sample rates. Typical word lengths include 8-bit (less popular), 16-bit, or 24-bit digital sizes. To convert the sound, the board samples the sound in waves from 8 kHz to 96 kHz, or 8,000 to 96,000 times per second (of course, the higher the sampling, the better the sound and the larger the output).
- **Full-Duplex Support** — This allows for recording and playback to occur at the same time. This is particularly useful for bidirectional Internet communication or simultaneous recording and playback.
- **PCI or USB Interface** — Most people purchase a PCI sound card to put in the case of their desktop system, when sound ports on the computer's motherboard are not sufficient. However, if you are using a PC (such as a Shuttle) with limited slots or a laptop, there are USB sound cards that are supported in Linux.

Several different ports on the board enable you to connect input/output devices. These ports can include some or all of the following:

- **Line-In (blue)** — Connects an external CD player, cassette deck, synthesizer, MiniDisc, or other device for recording or playback. If you have a television card, you might also patch that card's line out to your sound card's line in.
- **Microphone (red)** — Connects a microphone for audio recording or communications.
- **Headphone/Line-Out/Speaker Out (green)** — Connects speakers, headphones, or a stereo amplifier. (On sound cards I've tested, this is marked as *Headphone* in mixer utilities.)
- **Joystick/MIDI (15-pin connector)** — Connects a joystick for gaming or MIDI devices. (Some sound cards no longer have these ports because they are now available from most motherboards.)
- **Digital Out (orange)** — A digital out connector can be used to connect a digital audio tape (DAT) device or CD recordable (CD-R) device.

- **Rear Out (black)** — Can be used to deliver audio output to powered speakers or an external amplifier.
- **Internal CD Audio** — This internal port connects the sound card to your computer's internal CD-ROM drive. (Typically, this port isn't exposed when the board is installed, which makes it more difficult to connect these devices directly.)

For some sound applications, you need to identify the device files used to communicate with the sound card and other sound hardware. While your system may not have all of these available, the devices that the audio programs use to access audio hardware in CentOS include:

- `/dev/audio`, `/dev/audio1` — Devices that are compatible with Sun workstation audio implementations (audio files with the `.au` extension)
- `/dev/cdrom` — Device representing your first CD-ROM drive. (Additional CD-ROM drives are located at `/dev/cdrom1`, `/dev/cdrom2`, etc.)
- `/dev/dsp`, `/dev/dsp1`, `/dev/adsp` — Digital sampling devices, which many audio applications identify to access your sound card
- `/dev/mixer`, `/dev/mixer1` — Sound-mixing devices
- `/dev/sequencer` — Device that provides a low-level interface to MIDI, FM, and GUS
- `/dev/midi00`, `/dev/midi` — Device that provides raw access to midi ports

**TIP**

Nodes in the `/dev` directory, such as `/dev/audio`, aren't just regular files. They represent access points to the physical devices (hard disks, COM ports, etc.) that are connected to your system, or to pseudo-devices (such as Terminal windows). For example, to find out the device of your current Terminal window, type `tty`. Then send some data to that device. For example, if your device name is `/dev/pts/0`, type:

```
$ echo "Hello There" > /dev/pts/0
```

The words *Hello There* appear in that Terminal window. You can try sending messages among several Terminal windows. If a user who is logged on to the computer has terminal permissions open, you can send messages to him or her in this way, too. (I knew people who would send a dictionary file to an unsuspecting user's terminal as a prank. Although it wasn't destructive, it certainly was annoying if you were trying to get work done.)

To get information from the ALSA service about your sound cards, list the contents of the following files (for example, `cat /proc/asound/devices`):

- **`/proc/asound/devices`** — Contains available capture, playback, and other devices associated with your sound system.
- **`/proc/asound/cards`** — Contains the names, model numbers, and IRQs of your sound cards.

For general information about sound in Linux, see the Sound-HOWTO (for tips about sound cards and general sound issues) and the Sound-Playing-HOWTO (for tips on software for

playing different types of audio files). You can also refer to the Linux Audio Users Guide (<http://lau.linuxaudio.org>).

**NOTE** You can find Linux HOWTOs at [www.tldp.org](http://www.tldp.org).

## Detecting Your Sound Card Driver

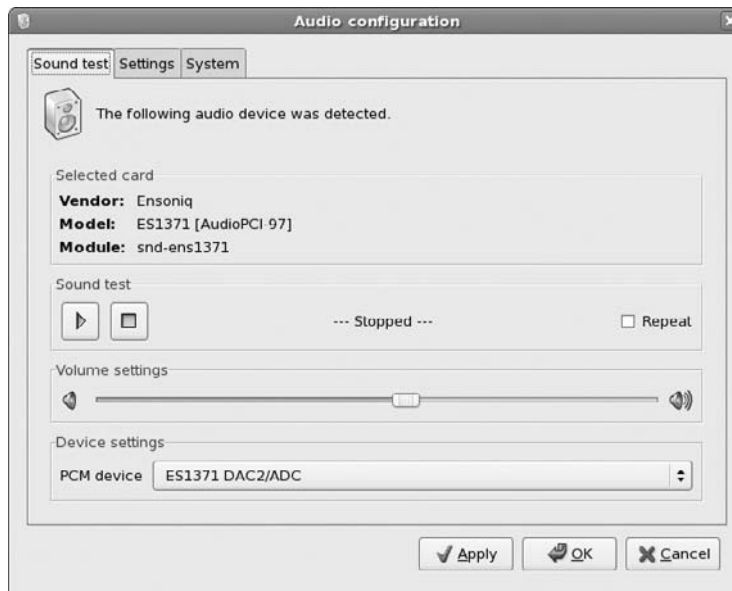
During the first startup after you install CentOS, the Firstboot set-up agent tries to detect and configure your sound card. If that process was not successful, it is recommended you file a bug report. You can adjust sound settings with the Sound choice under the Preferences menu.

**TIP** Audio may be muted when you first install CentOS. If you are not able to hear the test of your sound card, use Volume Control or `alsamixer` (as described later in this chapter) to unmute and adjust the volume on your audio input.

To open the Audio Configuration window, run the `system-config-soundcard` command. If your sound card was detected, the Audio Configuration window should appear, as shown in Figure 7-1. Click on the Play button to the left of the slider, and you should hear a test sound. You can move the slider to the right to make sure the volume is set high enough to hear it.

**FIGURE 7-1**

The Audio Configuration window detects your sound card.





The Audio Configuration window contains three tabs of settings you might want to adjust:

- **Sound Test** — In addition to letting you test your sound card, this tab shows information about each sound card you have installed. If your sound card isn't working, use the Vendor, Model, and Module information when you ask for help. You can also change the PCM device from this tab, for example, to try different outputs from the card.
- **Settings** — If you have multiple sound cards, you can select which card to use by default (Default Audio Card) and the Default PCM Device for that card (identifying where sound is output). From the Settings tab, you can also select "Disable Specific Card Configuration," to allow plug-ins to override default settings. Likewise, you can change the order in which audio cards are used on your system.
- **System** — You can view information about the ALSA sound system (driver versions, library packages, and utility packages) from this tab. You can also reload sound drivers or generate a report related to your sound system. The report is copied to `/root/sysconfig.log` and contains output from commands such as `lspci` and `lsmode`, as well as contents of your `/etc/asound.conf` file and output from the `aplay -l` command.

At this point, you can try playing an audio file. Insert a CD and open one of the CD players described in the following section. If you don't hear any sound, but the utility seems to have detected your sound card, refer to the next section and try adjusting your audio levels. If that doesn't work, try some of the debugging procedures suggested in the ALSA wiki (<http://alsa.opensrc.org/>).

**TIP**

If there is a data CD in your CD drive, you may not be able to simply eject it to play your music CD. To eject a data CD, close any windows that may have an open file from the CD, and then unmount the CD in your drive (if one is mounted) by typing `umount /media/cdrecorder` as root user from a Terminal window (the mount point name may be something other than `cdrecorder`). Then you can eject the old CD and place an audio CD in the drive. If the CD appears as an icon on the desktop, you can right-click on the CD icon and select "Eject" to eject the disc.

## Adjusting Sound Levels

Every audio output (Playback) and input (Capture) device associated with your sound cards can be adjusted or muted using one of several different tools that come with CentOS. To control volume on multiple audio applications, you can use the Volume Control window.

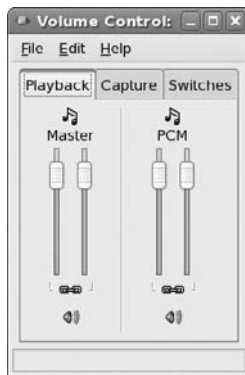
The Volume Control window displays volume slider bars for each active audio application on the system (typically associated with right and left channels). Besides controlling output volume, you can also select the volume on input devices. Double-click on the speaker icon that represents the Volume Control applet in the top taskbar. If the applet is not there, see Chapter 3 on how to add it.

Figure 7-2 shows an example of the Volume Control window with two available output devices. The chain lets you lock or unlock the two channels together. Then you can use the slider to

adjust volume levels together or separately. A Mute button lets you mute or unmute sound for each device.

**FIGURE 7-2**

The Volume Control window provides simple, intuitive controls for setting audio levels.



An alternative is to use the utilities that come with the `alsa-utils` package in CentOS. In particular, that package contains the `alsamixer` utility, which lets you adjust or mute the various sound tracks. It also lets you select the device from which you can record or otherwise capture audio input.

The `alsamixer` utility is an ncurses application, which means that it is viewed graphically from a shell. It can be used to manage sound levels for more than one sound card on a computer, each with multiple devices representing it. Type **`alsamixer`** from a Terminal window to start it in Playback mode (to adjust audio output) or **`alsamixer -V capture`** (to select an audio capture device and adjust audio capture level).

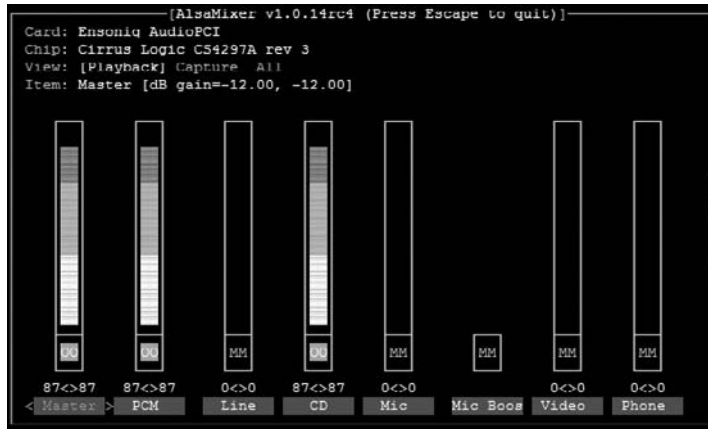
Figure 7-3 shows an example of the `alsamixer`.

Here are some ways to adjust your audio with `alsamixer`:

- Use the right and left arrow keys to move among the different sound tracks.
- Use the up and down arrow keys to adjust the levels of the current tracks.
- Press **m** to mute or unmute the current track (Playback mode only).
- Press the spacebar to make the current track the capture device, for devices such as microphone or line-in that are appropriate for capturing audio. Then adjust the Capture bar to set the level at which audio is captured. (Note that this feature works in Capture mode only: `alsamixer -V capture`.)

FIGURE 7-3

Adjust audio levels from the screen-oriented command-line `alsamixer` utility.



Tracks that are muted appear with an `MM` at the bottom of the slider. When unmuted, `00` appears instead. If more tracks are available than can appear on the screen, the right arrow key enables you to scroll to the right to display additional track bars.

If two channels are available on a track, you can adjust them individually. With the track selected, use the `q`, `w`, and `e` keys to adjust the left, both, and right channels up, respectively. Use `z`, `x`, and `c` to adjust those same channels down, respectively. When you are done using `alsamixer`, press the [Esc] key to exit.

Here are a few general rules for adjusting your audio channels:

- To avoid unwanted noise on playback or record, mute any tracks you are not using.
- An icon representing your GNOME Volume Control utility should appear on your desktop panel. The single slider associated with that icon may be set to adjust your master volume or headphone port output. Right-click on that icon and select Preferences to change to a different port.
- To test that your audio channels are working, use the `speaker-test` command. For example, `speaker-test -c4` will send a tone to each of four speakers in turn (front left, front right, rear left, and rear right) to check that each is working. Note that the tone output may surprise you with its loudness.

### TIP

If you have more than one sound card, each sound card is identified by a number, with zero identifying the first sound card. For example, to start `alsamixer` for your second sound card, type `alsamixer -c 1`.

## Setting Your Sound Card to Record

I added this section on setting your sound card to record because people often miss this step. You may run a communications application (such as Ekiga) and wonder why nothing records. The reason is that you need to identify the capture device to use before you record and make sure that its level is set high enough to work.

The easiest way to set the channel to use for audio capture is to use the GNOME Volume Control window described earlier. Click on the Device dropdown list and choose the Capture device that controls your computer microphone (or other input device). Then make sure that all audio devices are muted except the one you want to record from. Available devices might include microphone, line-in, and CD. A red X through a microphone icon beneath each capture device indicates that it is muted.

Move the slider for your capture device up to an appropriate level. Then connect your microphone or input device (to line-in) and start the application you want to record from.

## Choosing Audio Players

There are audio players in CentOS for playing music and sound files in a variety of formats. Without adding any software, you can play commercial music CDs and Ogg Vorbis audio (which you can rip and encode yourself). MP3 support can be added to some of these players, while MP3 players outside of CentOS distributions are also available.

- **Rhythmbox** (`rhythmbox`) — Import and manage your music collection with Rhythmbox music management and playback software for GNOME. Rhythmbox uses GStreamer and Sound Juicer to extract music from a CD and then compresses that music using Ogg Vorbis, FLAC, or a low-quality WAV (for speech) audio format. Besides allowing you to create playlists of your music library, Rhythmbox also has features for playing Internet radio stations. Open Rhythmbox from the Applications menu by selecting Sound & Video ➤ Music Player.
- **KsCD Player** (`kscd`) — The KsCD player comes with the KDE desktop. To use KsCD, the `kdemultimedia` package must be installed. From the Applications menu on a KDE desktop, select Sound & Video ➤ KsCD (or type `kscd` from a Terminal window). This player lets you get title, track, and artist information from the CD database and lets you submit information you type in yourself to a CD database (if your CD isn't found there).
- `ogg123`, `mpg321`, `aplay`, or `play` — If you don't have access to the desktop, you can use the text-based `ogg123`, `mpg321`, or `play` commands. The `ogg123` command comes with the `vorbis-tools` package, `aplay` is part of the `alsa-utils` package, and `play` comes with the `sox` package in CentOS. The `mpg321` command comes in the `mpg321` package, which is available from third-party RPM sites. (The `mpg321` command is covered under the GPL. There is an `mpg123` project, which is no longer maintained and is not fully covered under the GPL.)
- **XMMS** (`xmms`) — The X Multimedia System (XMMS) audio player, also available from third-party repositories, provides a simple, graphical player for playing Ogg Vorbis, WAV,

FLAC, and other audio formats. XMMS has a fairly simple Windows winamp-like look and feel, which you can adjust using a few dozen skins.

The default CD audio player is Rhythmbox for the current release. One advantage of Rhythmbox, and other GStreamer audio applications, is that it will work with the free and legal MP3 codecs you can download.

**NOTE**

If you try some of these CD players and your CD-ROM drive is not working, see the sidebar “Troubleshooting Your CD-ROM” for further information.

## Automatically Playing CDs

When you put an audio CD into your CD-ROM drive, a media player (Rhythmbox) automatically pops up on your desktop and begins playing the CD. If you are using the GNOME desktop, you can use the application launcher to handle music CDs (as well as other removable media) from a Nautilus folder window.

If you don't want to have CDs automatically start playing or if you want to use a different CD player by default, you can change that behavior. Select System ➤ Preferences ➤ Removable Drives and Media, and then choose the Multimedia tab. Then from the Multimedia tab, you can check or uncheck the “Play audio CD discs when inserted” box next to CD Audio and select which player to use when an audio CD is encountered.

## Troubleshooting Your CD-ROM

If you are unable to play CDs on your CD-ROM drive, here are a few things you can check to correct the problem:

- Verify that your sound card is installed and working properly (see “Configuring a Sound Card” earlier in this chapter).
- Verify that the CD-ROM drive was detected when you booted Linux. If your CD-ROM drive is an IDE drive, type **dmesg | grep -i cd**. You should see messages about your CD-ROM that look like this: `ata2.00: ATAPI: HL-DT-STCD-RW/DVD DRIVE GCC-4242N, 0201, max UDMA/33.`
- If you see no indication of a CD-ROM drive, verify that the power supply and cables to the CD-ROM are connected. To make sure that the hardware is working, you can also boot to DOS and try to access the CD.
- Try inserting a software CD-ROM. If you are running the GNOME desktop, a desktop icon should appear indicating that the CD is mounted by itself. If no such icon appears, go to a Terminal window and type **mount /media/cdrecorder**.

*continued*

*continued*

Then list the contents using the `ls /media/cdrecorder` command. This tells you if the CD-ROM is accessible.

- Check that your CD-ROM drive is not blacklisted because of buggy firmware or other issues. See [www.tldp.org/HOWTO/Hardware-HOWTO/cdrom.html](http://www.tldp.org/HOWTO/Hardware-HOWTO/cdrom.html).
- If you get the CD-ROM working, but it fails with the message `CDROM device: Permission denied` when you try to play music as a non-root user, the problem may be that the device related to that medium is not readable by anyone but root. Type `mount | grep media` to see what device name represents the drive. Then (as the root user), if, for example, the CD device were `/dev/scd0`, type `chmod 644 /dev/scd0` to enable all users to read your CD-ROM and to enable the root user to write to it. One warning: If others use your computer, they will be able to read any CD you place in this drive.

## Playing and Managing Music with Rhythmbox

*Rhythmbox* is a tool for gathering, managing, and playing your music collection from one application. It lets you import music (from a CD, URL, or folder) and then select and sort your music by album, artist, title, or other variables from the Rhythmbox window. Rhythmbox also lets you play Internet radio stations.

The first time you run Rhythmbox, consider setting some Rhythmbox Preferences by selecting Edit > Preferences. On the Library tab, you can tell Rhythmbox the folder in which to store your music files, as shown in Figure 7-4. (Remember this folder name. You will need it later when you configure Sound Juicer to rip CDs.)

### TIP

The location you choose for your music collection could require lots of disk space. Some people will add a hard disk or at least have a large, dedicated disk partition for storing their music and other multimedia content. Having this separate disk area can be useful later for doing backups. Also, if you later want to reinstall your operating system, you will be able to do so without harming your music collection.

After you set your Music folder and other preferences, close the Preferences menu and begin using the main music player (see Figure 7-5).

### NOTE

To get MP3 support for Rhythmbox, you can use the Fluendo codecs described earlier in this chapter.

Here are a few ways to use Rhythmbox:

- **Scan Removable Media** — Extract tracks from an audio CD by selecting Music > Scan Removable Media. If an audio CD is found, Sound Juicer launches to rip and compress the music from your CD (see the section “Extracting music CDs with Sound Juicer” for more on ripping audio CDs).

**FIGURE 7-4**

Define where you store your music with Rhythmbox.



- **Create Playlist** — To create a playlist, select Music > Playlist. If you have a really large music collection, select “New Automatic Playlist.” A pop-up window lets you choose search criteria to find songs, artists, title, or other criteria to load into your playlist. You can also create a new, empty playlist (“New Playlist”) or load a stored playlist from a file. Once a playlist is created, you can add songs to the list by importing (as described previously) or dragging and dropping from a Nautilus window. Right-click on a song to copy, cut, or delete it.
- **Check Statistics** — Rhythmbox stores the number of times a song has been played, when it was last played, and how you rate it (one to five stars). Select Edit > Preferences to select to have columns of that information appear on your Rhythmbox window.
- **Play Music Tracks** — With your music available, play that music by double-clicking on an album (to play the whole album), artist (to play the artist’s first album you have), or track (to start with that track). Buttons at the top of Rhythmbox let you play/pause or go forward or backward a track. Select Shuffle or Repeat boxes on the bottom of Rhythmbox to randomly play the songs in the album or play the same album repeatedly. Use the slider to move ahead or back in a song, and select the speaker icon to adjust volume.

- Play Internet Radio** — Rhythmbox can also play Internet radio stations. The easiest way to do this is to find a streaming radio station (you want to look for Shoutcast PLS files, usually with a .pls extension). Save the PLS file, right-click on the file in the Nautilus file browser, and then select “Open with Music Player.” Nautilus comes configured to launch Rhythmbox for playing audio. The sites [www.d1.fm](http://www.d1.fm) and [www.shoutcast.com](http://www.shoutcast.com) list several free Internet radio channels.

**FIGURE 7-5**

View your music library and play selected songs or albums with Rhythmbox.



If you are looking for new music, selections under Stores on the Rhythmbox window let you connect to Magnatune and Jamendo online music services. Select either of those services to see lists of music you can try out for free. You can also search those services for music that interests you.

Magnatune makes money by licensing the music of the artists it represents for use in movies, web sites, commercials, or other media. You can also purchase a whole album or physical music CD through those services. Jamendo provides the music of its artists for free, to help promote the music to a world-wide audience. In either case, those services provide a way for you to explore different kinds of music.



## Playing Music with XMMS Audio Player

The XMMS (X Multimedia System) Audio Player provides a graphical interface for playing music files in MP3, Ogg Vorbis, WAV, and other audio formats. XMMS has some nice extras, too, which include an equalizer, a Playlist Editor, and the ability to add more audio plug-ins. If the player looks familiar to you, that's because it is styled after the Windows winamp program.

### NOTE

Because XMMS is not a GStreamer application, the MP3 support you can get from Fluendo doesn't work with XMMS. You can get MP3 support by installing the `xmms-mp3` package from RPMforge.

The `xmms` package is available from the RPMforge repository (type `yum install xmms` to install the `xmms` package). To use XMMS to play CDs, you must also add the `xmms-cdread` package (also in the repository). With an Internet connection, this command will get both packages for you:

```
yum install xmms xmms-cdread.
```

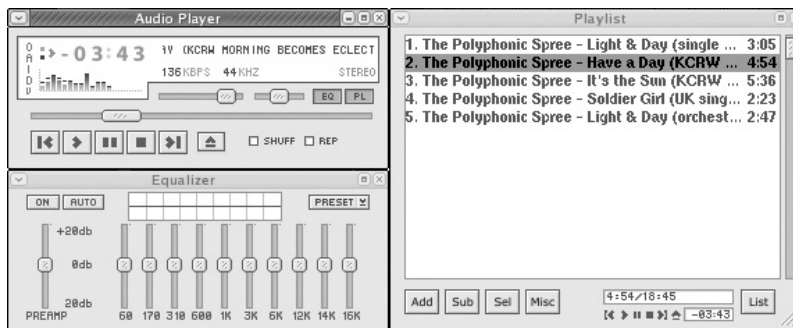
Start the XMMS Audio Player by typing the `xmms` command from a Terminal window. Figure 7-6 consists of the XMMS Audio Player with the associated equalizer (above) and the Playlist Editor (to the right).

### NOTE

You can download different themes from [www.xmms.org/skins.php](http://www.xmms.org/skins.php). Copy the skin's zip file to the `/usr/share/doc/xmms/Skins` directory. Then change the look of the player by right-clicking on XMMS and selecting `Options > Skin Browser`.

**FIGURE 7-6**

Play Ogg Vorbis and other audio files from the XMMS playlist.



As noted earlier, you can play several audio file formats. Supported audio file formats include the following:

- MP3 (with added `xmms-mp3` package)
- Ogg Vorbis

- FLAC (with added `xmms - flac` package)
- WAV
- AU
- CD Audio
- CIN Movies

You can get many more audio plug-ins directly from [www.xmms.org](http://www.xmms.org). The XMMS Audio Player can be used in the following way to play music files:

1. Obtain music files by either:
  - Ripping songs from a CD or copying them from the Web so that they are in an accessible directory.
  - Inserting a music CD in your CD-ROM drive. (XMMS expects the CD to be accessible from `/dev/cdrom`.)
2. From the Applications menu, select Sound & Video ➤ Audio Player. The X Multimedia System player appears.
3. Click on the Eject button. The Load Files window appears.
4. If you have inserted a CD, the content of that CD appears in the Files pane. (If it doesn't, change to `/dev/cdrom`, `/media/cdrom`, or `/media/cdrecorder`, as appropriate.) Select the files you want to add to your Playlist and click on the "Add Selected Files" or the "Add All Files in Directory" button to add all songs from the current directory. To add audio files from your file system, browse your files and directories and click on the same buttons to add the audio files you want. Select Close.
5. Click on the "Play List" button (the tiny button marked *PL*) on the console. A Playlist Editor window appears.
6. Double-click on the music file, and it starts to play.
7. With a file selected and playing, here are a few actions you can take:
  - **Control Play** — Buttons for controlling play are what you would expect to see on a physical CD player. From left to right, the buttons let you go to a previous track, play, pause, stop, go to the next track, or eject the CD. The Eject button opens a window, allowing you to load the next file.
  - **Adjust Sound** — Use the left slider bar to adjust the volume. Use the right slider bar to change the right-to-left balance.
  - **Display Time** — Click in the elapsed time area to toggle between elapsed time and time remaining.
  - **View File Information** — Click on the button in the upper-left corner of the screen to see the XMMS menu. Then select "View File Info." You can often find out a lot of information about the file: title, artist, album, comments, and genre. For an Ogg file, you can see specific information about the file itself, such as the format, bit rate, sample rate, frames, file size, and more. You can change or add to the tag information and click Save to keep it.

8. When you are done playing music, click on the Stop button to stop the current song. Then click on the X in the upper-right corner of the display to close the window.

Special features of the XMMS Audio Player let you adjust high and low frequencies using a graphic equalizer and gather and play songs using a Playlist Editor. Click on the button marked *EQ* next to the balance bar on the player to open the Equalizer. Click on the button marked *PL* next to that to open the Playlist Editor.

## Using the Equalizer

The Equalizer lets you use slider bars to set different levels to different frequencies played. Bars on the left adjust lower frequencies, and those on the right adjust higher frequencies. Click on the EQ button to open the Equalizer. Here are tasks you can perform with the Equalizer:

- If you like the settings you have for a particular song, you can save them as a Preset. Set each frequency as you like it and click on the Preset button. Then choose Save ➤ Preset. Type a name for the preset and click OK.
- To reload a preset you created earlier, click on the Preset button and select Load ➤ Preset. Select the preset you want and click OK to change the settings.

The small window in the center/top of the Equalizer shows the sound wave formed by your settings. You can adjust the Preamp bar on the left to boost different levels in the set range.

## Using the Playlist Editor

The Playlist Editor lets you put together a list of audio files that you want to play. You can add and delete files from this list, save them to a file, and use them again later. Click on the PL button in the XMMS window to open the Playlist Editor.

The Playlist Editor allows you to:

- **Add Files to the Playlist** — Click on the Add button. The Load Files window appears. Select the directory containing your audio files (it's useful to keep them all in one place) from the left column. Then either select a file from the right column and click “Add selected files” or click “Add all files in the directory.” Click OK. The selected file or files appear in the playlist. You can also drag music files from the Nautilus File Manager onto the Playlist window to add the files to the playlist.
- **Select Files to Play** — To select from the files in the playlist, use the Previous Track and Next Track buttons in the main XMMS window. The selected file is highlighted. Click on the Play button to play that file. Alternatively, you can double-click on any file in the playlist to start it playing.
- **Delete Files from the Playlist** — To remove files from the playlist, select the file or files you want to remove (Next/Previous Track buttons), right-click on the Playlist window, and click Remove ➤ Selected. The selected files are removed.

- **Sort Files on the Playlist** — To sort the playlist in different ways, click and hold the Misc button and move the mouse to select “Sort List.” Then you can select Sort List to sort by Title, Filename, Path and Filename, or Date. You can also randomize or reverse the list.
- **Save the Playlist** — To save the current playlist, hold the mouse button down on the List button and then select Save. Browse to the directory you want, and then type the name you want to assign to the playlist and click OK.
- **Load the Playlist** — To reload a saved playlist, click on the List button. Select a previously saved playlist from the directory in which you saved it and click OK.

There is also a tiny set of buttons on the bottom of the Playlist Editor screen. These are the same buttons as those on the main screen used for selecting different tracks or playing, pausing, stopping, or ejecting the current track.

## Using ogg123, mpg321, and play Command-Line Players

Command-line music players are convenient if you happen to be working from a shell (no GUI) or if you want to play audio files from a shell script. Here are a few command-line players that might interest you:

- **ogg123** — The `ogg123` command is a good way to play Ogg Vorbis or FLAC audio files from the command line. From the command line, you can play a file (`abc.ogg`), a playlist containing multiple music files (`--list=/tmp/myownlist`), or an HTTP or FTP location (`http://example.com/song.ogg`). The following is an example of the `ogg123` command playing an Ogg Vorbis file from the current directory:

```
$ ogg123 01-Rhapsody_in_Blue.ogg
Audio Device:  PulseAudi output

Playing: 01-Rhapsody_in_Blue.ogg
Ogg Vorbis stream: 2 channel, 44100 Hz
Title: Rhapsody in Blue
Artist: George Gershwin
Track number: 1
Tracktotal: 8
Album: Rhapsody in Blue
Genre: Instrumental
Time: 00:20.36 [15:29.65] of 15:50.01 (181.6 kbps) Output Buffer
      96.9%
```

To stop `ogg123` from playing a single song, press [Ctrl]+C. Do two [Ctrl]+C keystrokes to quit `ogg123` when multiple tracks are queued up. This command is part of the `vorbis-tools` package, which you can install with `yum`.

- **play** — The `play` command can be used to play any of the wide range of audio formats supported by `sox`. The syntax is simply `play file.xx`. To see what file formats can

be played by the `play` command, type **`sox -h`** to see a list. The `play` command is useful if you are looking in directories of sound effects, voice content, or other audio files that aren't your typical mainstream multimedia audio types. (You need the `sox` package installed, which comes with CentOS, to be able to use `play`.)

- `mpg321` — This is similar to the `ogg123` command, but it's used (as you might guess) to play MP3 audio files. Like `ogg123`, you can play a file (`abc.mp3`), a playlist containing multiple music files (`--list /tmp/myownlist`), or an HTTP or FTP location (`http://example.com/song.mp3`). Unlike `ogg123`, `mpg321` doesn't come with CentOS.

## Using MIDI Audio Players

*MIDI* stands for “Musical Instrument Digital Interface.” MIDI files are created from synthesizers and other electronic music devices. MIDI files tend to be smaller than other kinds of audio files because, instead of storing the complete sounds, they contain the notes played. The MIDI player reproduces the notes to sound like a huge variety of MIDI instruments.

There are lots of sites on the Internet for downloading MIDI files. Try the Ifni MIDI Music site ([www.ifnimidi.com](http://www.ifnimidi.com)), which contains songs by the Beatles, Led Zeppelin, Nirvana, and others organized by album. Most of the MIDI music is pretty simple, but you can have some fun playing with it.

CentOS come with the KMid MIDI player. KMid is not installed by default (you can find it in the `kdemultimedia`). KMid provides a GUI interface for midi music, including the ability to display karaoke lyrics in real time. There is also the TiMidity MIDI player (from the `timidity++` package from the kbs-CentOS-Testing repository), which lets you run MIDI audio from a Terminal window.

### NOTE

Use the TiMidity MIDI player if your sound card doesn't include MIDI support (install the `timidity++` package). It can convert MIDI input into WAV files that can play on any sound card. To start TiMidity, type **`timidity file.mid`** at the command-line prompt.

To start KMid, type **`kmid &`** from a Terminal window.

## Converting Audio Files with SoX

If you have a sound file in one format, but you want it to be in another format, Linux offers some conversion tools you can use to convert the file. The `sox` utility can translate to and from any of the audio formats listed in Table 7-1.

### NOTE

Type **`sox -h`** to see the supported audio types. This also shows supported options and effects.

TABLE 7-1

## Sound Formats Supported by the sox Utility

File Extension or Pseudonym	Description	File Extension or Pseudonym	Description
.8svx	8SVX Amiga musical instrument description format	.aiff	Apple IIc/IIgs and SGI AIFF files. May require a separate archiver to work with these files.
.au, .snd	Sun Microsystems AU audio files. This is a popular format.	.avr	Audio Visual Research format, used on the Mac
.cdr	CD-R files used to master compact disks	.cvs	Continuously variable slope delta modulation, which is used for voice mail and other speech compression
.dat	Text data files, which contain a text representation of sound data	.gsm	Lossy Speech Compression (GSM 06.10), used to shrink audio data in voice mail and similar applications
.hcom	Macintosh HCOM files	.maud	Amiga format used to produce sound that is 8-bit linear, 16-bit linear, A-law, and u-law in mono or stereo
.ogg	Ogg Vorbis compressed audio, which is best used for compressing music and streaming audio	.ossdsp	Pseudo-file, used to open the OSS /dev/dsp file and configure it to use the data type passed to sox. Used to either play or record.
.prc	Psion record.app format, newer than the WVE format	.sf	IRCAM sound files, used by CSound package and MixView sample editor
.sph	Speech audio SPHERE (Speech Header Resources) format from NIST (National Institute of Standards and Technology)	.smp	SampleVision files from Turtle Beach, used to communicate with different MIDI samplers
.sunau	Pseudo-file, used to open a /dev/audio file and set it to use the data type being passed to SoX	.txw	Yamaha TX-16W from a Yamaha sampling keyboard

*continued*

**TABLE 7-1** (continued)

File Extension or Pseudonym	Description	File Extension or Pseudonym	Description
.vms	Used to compress speech audio for voice mail and similar applications	.voc	Sound Blaster VOC file
.wav	Microsoft WAV RIFF files. This is the native Microsoft Windows sound format.	.wve	8-bit, A-law, 8-kHz sound files used with Psion Palmtop computers
.raw	Raw files (contain no header information, so sample rate, size, and style must be given)	.ub, .sb, .uw, .sw, .ul, .al, .lu, .la, .sl	Raw files with set characteristics. ub is unsigned byte; sb is signed byte; uw is unsigned word; sw is signed word; and ul is ulaw.

If you are not sure about the format of an audio file, you can add the `.auto` extension to the file-name. This triggers SoX to guess what kind of audio format is contained in the file. The `.auto` extension can be used only for the input file. If SoX can figure out the content of the input file, it translates the contents to the sound type for the output file you request.

In its most basic form, you can convert one file format (such as a WAV file) to another format (such as an AU file) as follows:

```
$ sox file1.wav file1.au
```

To see what `sox` is doing, use the `-V` option. For example:

```
$ sox -V file1.wav file1.voc

sox: Reading Wave file: Microsoft PCM format, 2 channel, 44100 samp/sec
sox: 176400 byte/sec, 4 block align, 16 bits/samp, 50266944 data bytes
sox: Input file: using sample rate 11025
      size bytes, style unsigned, 1 channel
sox: Input file1.wav: comment "file1.wav"

sox: Output file1.voc: using sample rate 44100
      size shorts, encoding signed (2's complement), 2 channels
sox: Output file: comment "file1.wav"
```

You can apply sound effects during the `sox` conversion process. The following example shows how to change the sample rate (using the `-r` option) from 10,000 kHz to 5,000 kHz:

```
$ sox -r 10000 file1.wav -r 5000 file1.voc
```

To reduce the noise, you can send the file through a low-pass filter. Here's an example:

```
$ sox file1.voc file2.voc lowp 2200
```

For more information on SoX and to get the latest download, go to the SoX — Sound eXchange home page (<http://sox.sourceforge.net>).

## Extracting and Encoding Music

Storing your music collection on your computer's hard disk makes it easy to manage and play your music. Using ripping software, you can copy music tracks from a music CD to your hard disk. As part of the same process (or as a separate step), you can encode each track into another form. That encoding is usually done to reduce the size of the audio files.

Tools that come with CentOS for extracting audio tracks from CDs and copying them to your hard disk include the Sound Juicer window and the `cdparanoia` command. Encoders that come with CentOS that are typically used for encoding music include `oggenc` and `flac`. Although encoding is often done as part of the extraction process (e.g., in Sound Juicer), I give an example of how to use `oggenc` to encode WAV files to Ogg Vorbis format on the command line.

### Extracting Music CDs with Sound Juicer

*Sound Juicer* is an intuitive graphical tool for extracting music tracks from commercial music CDs. It can read the tracks of a music CD; get CD album, artist, and track information about the CD (provided you have an Internet connection); and save the tracks to your hard disk. During that process, you can also have Sound Juicer encode the tracks in Ogg Vorbis, FLAC, or Voice-quality WAV format.

#### NOTE

You can use the **Fluendo** codecs, described earlier in this chapter, to get support for MP3 playback. There is a fee for purchasing MP3 decoding software.

To start Sound Juicer, select Applications ➤ Sound & Video ➤ Sound Juicer Audio CD Extractor. (Or you can launch it by typing **sound-juicer** or by selecting Music ➤ Import Audio CD from Rhythmbox.) Figure 7-7 shows an example of the Sound Juicer window.

Here's how to use Sound Juicer to extract songs from an audio CD and encode them to any supported encoding type:

1. After starting Sound Juicer, insert an audio CD into your computer's CD drive and select Re-read on the Sound Juicer window. (If another audio player starts up, you can close it.)
2. Select Edit ➤ Preferences. The Preferences window appears.



**FIGURE 7-7**

Extract songs from music CDs and encode them using Sound Juicer.



- Set the following Preferences:
  - **CD Drive** — If you have multiple CD drives, choose the one you want to extract from.
  - **Music Folder** — Choose the folder the music tracks will be written to. Make sure that the disk partition containing the folder has enough space for you to store your music collection. As I noted earlier, a separate partition is a good idea for a large collection.
  - **Track Names** — Here's where you identify the names that will be used to store your music. The Folder hierarchy is set to the artist's name, followed by the Album title. So multiple albums by the same artist will be in the same folder. The tracks themselves, indicated by the "File name" box, are stored by track number and song title, separated by a dash. You can choose different ways of indicating the files and folder names used to store your music.
  - **Output Format** — This sets the type of encoding that is done to each track. Your choices are FLAC, Ogg Vorbis, and WAV. With a `gst-plugins-mp3` package installed, you should have the choice of MP3 as well. I normally use Ogg Vorbis because the quality is good and it takes less disk space. In cases in which I want higher-quality output (with some compression), I tend to use FLAC. Choose WAV to store the file without compression (highest quality, largest size).
- Close the Preferences window and select Extract from Sound Juicer. The tracks are extracted, encoded, and stored on your hard disk to the folder you selected.

## Extracting and Encoding Music CDs from Commands

Instead of using a graphical tool (such as Sound Juicer) to extract and encode your music CDs, you can use commands instead. The commands described here are available on most Linux systems, while those systems might tend to offer different graphical tools. Using these commands, you also have more flexibility in setting options to use for your encoding.

This procedure takes you through the process of extracting tracks from CD (`cdparanoia`) and encoding them to Ogg Vorbis (`oggenc`).

1. Create a directory to hold the audio files, and change to that directory. Make sure the directory can hold up to 660 MB of data (or less if you are burning fewer songs). For example:

```
# mkdir /tmp/cd
# cd /tmp/cd
```

2. Insert the music CD into your CD-ROM drive. (If a CD player opens on the desktop, close it.)
3. Extract the music tracks you want by using the `cdparanoia` command. You need to run this command as `root`, or add a regular user to the `disk` group. Run the following command:

```
# cdparanoia -B
```

This example reads all of the music tracks from the CD-ROM drive (the location of your CD drive may be different). The `-B` option says to output each track to a separate file. By default, the `cdparanoia` command outputs the files to the WAV audio format.

Instead of extracting all songs, you can choose a single track or a range of tracks to extract. For example, to extract tracks 3 through 5, add the `3+5` option. To extract just track 9, add `9`.

Watch the “output smiles” on the progress bar as the tracks are extracted. Normal operation (low/no jitter) is represented by a smiley face `: -)`, while errors cause faces that are progressively more worried: `: - |`, `: - /`, `: - P`, and so on.

4. To encode your WAV files to Ogg Vorbis, you can use the `oggenc` command. In its most basic form, you can use `oggenc` with one or more WAV or AIFF files following it. For example:

```
$ oggenc *.wav
```

This command would result in Ogg Vorbis files created from all files ending with `.wav` in the current directory. An Ogg file is produced for each WAV file, with `oggenc` substituting `.ogg` for `.wav` as the file suffix for the compressed file.

Instead of using `oggenc` to convert the WAV files to Ogg Vorbis, you can use the `flac` command to convert the WAV files to FLAC format (`*.flac`). To give you an idea of the space consumed by each format, I started with a WAV file of 27 MB. When I encoded it with FLAC, it went to 11 MB, whereas encoding the WAV file to Ogg Vorbis ended in 1.5 MB.

## Creating Your Own Music CDs

CentOS contains tools for burning CDs and DVDs from either the command line or graphical window. CD and DVD burners are great for backing up your data and system files. The following sections describe how to use CD/DVD burning software specifically to create audio CDs.

### Creating Audio CDs with `cdrecord`

You can use the `cdrecord` command to create either data or music CDs. You can create a data CD by setting up a separate file system and copying the whole image of that file system to CD. Creating an audio CD consists of selecting the audio tracks you want to copy and copying them all at once to the CD.

This section focuses on using `cdrecord` to create audio CDs. The `cdrecord` command can use audio files in `.au`, `.wav`, or `.cdr` format, automatically translating them when necessary. If you have audio files in other formats, you can convert them to one of the supported formats by using the `sox` command (described previously in this chapter).

**CROSS-REF** See Chapter 12 for information on how to use `cdrecord` to create data CDs.

Start by extracting music tracks from your audio CD (using a tool such as `cdparanoia`, described earlier in this chapter). After you have created a directory of tracks (in WAV format) from your CD, you can copy those files to your CD writer as follows:

```
# cdrecord -v dev=/dev/cdrom -audio *.wav
```

The options to `cdrecord` tell the command to create an audio CD (`-audio`) on the writable CD device located at `/dev/cdrom`. The `cdrecord` command writes all files from the current directory that end in `.wav`. The `-v` option causes verbose output.

If you want to change the order of the tracks, you can type the track names in the order you want them written (instead of using `*.wav`). If you don't indicate a recording speed, `cdrecord` will try to choose an appropriate one. If you get errors while you are recording, sometimes reducing the recording speed can help. For example, try `speed=2` or `speed=4` on the `cdrecord` command line.

After you have created the music CD, indicate the contents of the CD on the label side of the CD. The CD should now be ready to play on any standard music CD player.

### Creating Audio and Data CDs with `K3b`

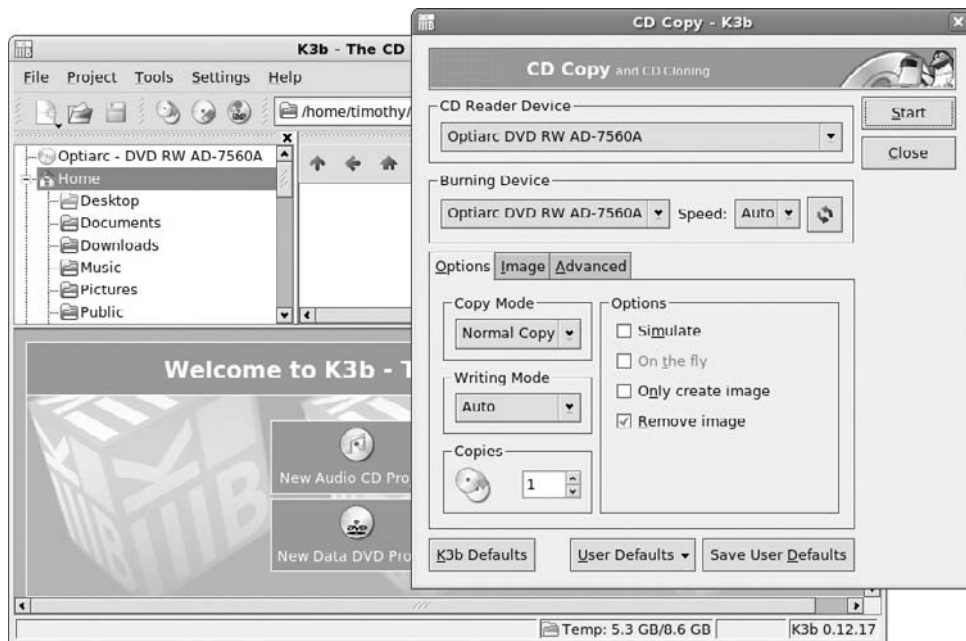
For anyone who has struggled to get the options just right with `cdrecord`, the `K3b` CD/DVD Burning Facility is a wonderful tool. Modeled after popular CD recording tools you can find in Windows environments, `K3b` provides a very intuitive way to master and burn your own CDs and DVDs.

Among the best uses of `K3b` are copying audio CDs and burning ISO images (perhaps containing a Linux distribution you want to try out) that you download from the Internet. To start `K3b`,

select Sound & Video ➤ K3b from the Applications menu. Figure 7-8 shows an example of the K3b window.

**FIGURE 7-8**

Master and burn CDs and DVDs using the K3b window.



### Creating a New Audio CD

If you have a bunch of audio tracks you want to put together for your own CD, here's how to do that from the K3b window:

1. Select the New Audio CD project icon from the main K3b window.
2. Open a folder window and go to the folder that contains the music track files you want to burn to CD.
3. Drag-and-drop the music tracks you want to the Current Projects pane on the bottom of the K3b screen.
4. Right-click on any track to see properties of that track. You can change or add to the information there. To change the order, you can drag tracks to different locations within the pane.
5. Select the Burn button in the upper-left corner of the K3b Current Projects screen.

6. From the Audio Project window that appears, select options for doing the burn and click on the Burn button to burn the CD. As an alternative, you can select “Only Create Image,” to create an ISO image of all the files that you can burn to CD at a later time.

### ***Copying a CD***

If there is an audio or data CD you want to copy, you can do so from the K3b window as follows:

1. Insert the CD you want to copy into your CD drive.
2. Select Tools ➤ Copy CD from the K3b window. The CD Copy window appears (as shown in Figure 7-8).
3. Choose options for the CD copy, such as the CD reader and burner devices (they can be the same if you have only one). You can also choose to do a normal copy or clone copy. Assuming that you have only one CD drive (and it's a burner), you need to set a temporary directory that can hold the entire contents of the CD.
4. When you are happy with the options, click Start. K3b begins copying the source disk to the temporary directory you indicated.
5. When prompted, remove the original CD and insert a blank CD into the CD drive.
6. Click Start to continue. K3b will tell you when the copy is complete.
7. Eject the CD and label it appropriately.

### ***Burning an ISO Image to CD***

Before your songs are copied to CD, they are gathered together into a single archive, referred to as an *ISO image*. You can download ISO images of software (such as the DVD or CD images used to install CentOS). Although an ISO image only looks like one big file before you burn it, after it is burned to a CD, it appears as a file system containing multiple files. To burn any of the images just described to a CD using K3b, do the following:

1. Download or otherwise copy an ISO image to a directory on your hard disk. A CD image will be up to about 700 MB, while a DVD image can be more than 4 GB.
2. From the K3b window, select Tools ➤ Burn CD Image. A Burn CD Image window appears.
3. Next to the “Image to Burn” box, select the folder icon to browse your file system to find the ISO image. After you select the image, it is loaded into the Burn CD Image window, which will display information about the image, including its MD5sum.
4. Check the MD5sum and compare it with the MD5sum provided with the ISO image when you downloaded it. (There is likely a file ending with md5 in the directory from which you downloaded the image.)

5. If the MD5sums match, continue by checking out the settings on the Burn CD Image window. I've had generally good luck using the default settings. However, I find that if I get a bad burn, often changing the speed from Auto to a slower speed that is autodetected will result in a good burn.
6. Click Start to begin burning the image to CD. When the writing is done, K3b tells you whether it thought the burn process was successful.

The descriptions for burning CDs apply to DVDs as well (provided you have a DVD burner). Remember that you are going to need a lot more temporary space on your hard disk to work with DVDs than you would to work with CDs.

## Creating CD Labels with `cdlabelgen`

The `cdlabelgen` command can be used to create tray cards and front cards to fit in CD jewel cases. You gather information about the CD, and `cdlabelgen` produces a PostScript output file that you can send to the printer. The `cdlabelgen` package also comes with graphics (in `/usr/share/cdlabelgen`) that you can incorporate into your labels. Install the package from RPMforge by typing **yum install cdlabelgen**.

Here is an example of a `cdlabelgen` command line that you can use to generate a CD label file in PostScript format. (Type it all on one line or use backslashes, as shown here, to put it on multiple lines.)

```
cdlabelgen -c "Grunge is Gone" -s "Yep HipHop" \  
-i "If You Feed Me%Sockin Years%City Road%Platinum and Copper%Fly \  
Fly \  
Fly%Best Man Spins%What A Headache%Stayin Put Feelin%Dreams Do Go \  
Blue%Us%Mildest Schemes" -o yep.ps
```

In this example, the title of the CD is indicated by `-c "Grunge is Gone"` and the artist by the `-s "Yep HipHop"` option. The tracks are entered after the `-i` option, with each line separated by a `%` sign. The output file is sent to the file `yep.ps` with the `-o` option. To view and print the results, you can use the `evince` command as follows:

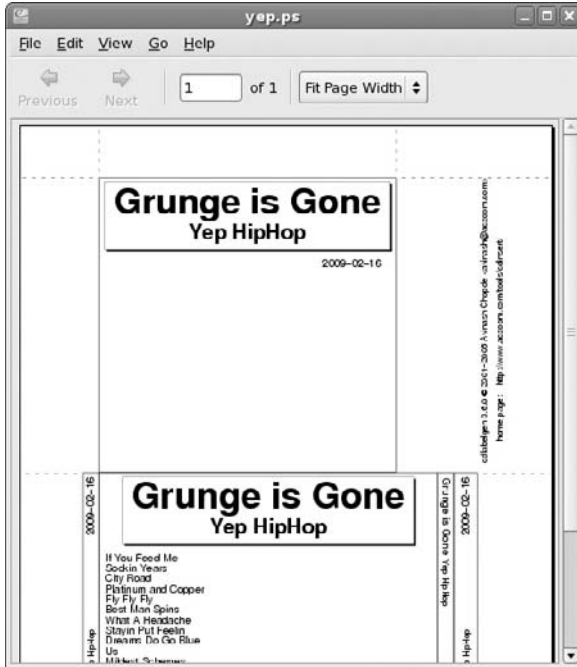
```
$ evince yep.ps
```

The results of this example are shown in Figure 7-9.

You will probably want to edit the command and rerun `evince` a few times to get the CD label correct. When you are ready to print the label (assuming you have a printer configured for your computer), click "Print All" to print the label.

**FIGURE 7-9**

Generate CD jewel case labels with `cdlabelgen` and print them with `evince`.



## Viewing TV and Webcams

Getting TV cards, Webcams, and other video devices to play in Linux is still a bit of an adventure. Most manufacturers of TV cards and Webcams are not losing sleep to produce Linux drivers. As a result, most of the drivers that bring video to your Linux desktop have been reverse-engineered (i.e., they were created by software engineers who watched what the video device sent and received, rather than seeing the actual code that runs the device).

The first, and probably biggest, trick is to get a TV card or Webcam that is supported in Linux. Once you are getting video output from that device (typically available from `/dev/video0`), you can try out a couple of applications to begin using it. This section describes the `tvtime` application for watching television and the `Ekiga` program for video conferencing.

### NOTE

If you run into problems with CentOS not recognizing your TV card, try installing the kernel from the CentOS Plus Repository. The CentOS Plus kernel has more drivers for TV cards compiled into it than the standard CentOS kernel does.

## Watching TV with Tvtime

The `tvtime` program (`tvtime` command) enables you to display video output — in particular, television channels — on your desktop. You can change the channels, adjust volume, and fine-tune your picture. In addition, `tvtime` sports a slick onscreen display and support for a widescreen display. It can be downloaded from RPMforge with **yum install tvtime**.

Tvtime will display, by default, any device producing video on the `/dev/video0` device. (Use the `-d` option to specify a different device.)

Therefore, you can use `tvtime` to view Webcams as well as receive television channels. The following sections describe how to choose a TV capture card and use `tvtime` to watch television on your desktop.

### NOTE

**Tvtime will not display output from some low-quality Webcams. To use your Webcam, consider obtaining the `xawtv` package, which is available by typing `yum install xawtv`.**

## Getting a Supported TV Card

*Video4Linux* is the video interface included with CentOS. It supports a variety of TV capture cards and cameras.

To see a list of supported TV cards that you can use with `tvtime`, refer to the `CARDLIST` and `Cards` files. To view these files, you need to have the `kernel-doc` package installed. You'll find the `CARDLIST.tuner` file in the following location on your Linux system:

```
/usr/share/doc/kernel-doc*/Documentation/video4linux/
```

The `CARDLIST.bttv` file applies to the *Video4Linux* `bttv` driver, which lists many TV capture cards by card number, name, and sometimes by chip set. Also, the `CARDLIST.tuner` lists tuner types that might be associated with different TV cards.

*Video4Linux* is designed to autodetect your TV capture card and load the proper modules to activate it. So, physically install the TV-card hardware (with the appropriate connection to your TV reception), boot CentOS, and run the `tvtime` command as described in the next section. You should be able to see video displayed on your `tvtime` window.

If your card appears not to be working, here are a few things you can try:

- To see if your TV card was properly seated in its slot and detected by Linux, type the following:

```
$ /sbin/lspci | less
```

This will show you a list of all valid PCI cards on your computer. If nothing shows up for the card that says something like “Multimedia video controller,” you probably have



a hardware problem. My Hauppauge WinTV Go card (with Brooktree chipset support) appears as:

```
Multimedia video controller: Brooktree Corporation Bt878 Video
Capture
```

- It is possible that the card is there, but the right card type is not being detected. Improper detection is most likely the issue if you have a card for which there are several revisions, with each requiring a different driver. If you think your card is not being properly detected, find your card in the CARDLIST files. Then add the appropriate line to the `/etc/modprobe.conf` file. For example, to add a Prolink PV-BT878P, revision 9B card, add the following line to `/etc/modprobe.conf`:

```
options bttv card=72
```

You can also add other options listed in the `Insmod-options` file for the `bttv` driver. If you are still having problems getting your card to work, a mailing list is available on which you can ask questions about Video4Linux issues:

```
http://listman.redhat.com/mailman/listinfo/video4linux-list
```

One possible reason that you don't see any video when you try to run `tvtime` or other video applications is that some other person or video application already has the video driver open. Only one application can use the video driver at a time in CentOS. Another quirk of Video4Linux is that the first person to open the device on your system becomes the owner. So you might need to open the permissions of the device file (such as `/dev/video0`) to allow people other than the first person to use it to access the video4linux driver (e.g., `chmod 666 /dev/video0`).

## Starting Tvtime

To start up the `tvtime` viewer, simply select the `tvtime` Television Viewer choice from the Sound & Video menu. Or type the following from a Terminal window on your desktop:

```
$ tvtime &
```

A video screen should appear in a window on the desktop. Click the left mouse button on the window to see the current channel number, current time, and current video source (Television, Composite1, etc.). Click the right mouse button to see the onscreen Setup menu.

If your card seems to have been detected and the needed modules were properly loaded but you don't see any video, try using the keyboard arrow keys to step forward until you find a valid channel. If that doesn't work, try going through the following adjustments (most important, the video source and television standard) to get `tvtime` working properly:

- **Configure Input** — This choice allows you to change the video source, choose the television standard (which defaults to NTSC for the United States), and change the resolution of the input. To change the video source to Composite1, S-Video, Television, or other input

source, right-click on the tvtime window, and select Input configuration ➤ Change video Source. To change the television standard, select “Television standard” and choose NTSC (U.S.), PAL (Europe), or other available settings.

- **Set Up the Picture** — Adjust the brightness, contrast, color, and hue. Right-click on the tvtime window; select Picture settings; and then choose Brightness, Contrast, Saturation, or Hue to adjust those attributes.
- **Adjust the Video Processing** — You can control the attempted frame rate, configure the deinterlacer, or add an input filter. Right-click on the Tvtime window, select “Video processing,” and then choose “Attempted framerate” (to slow the frame rate) or a Deinterlacer option (to change other processing features). You can also try Input filters to do some fun things like invert color, flip the video as though in a mirror image, or put the video in black and white (using Chroma killer).

If you view television often from your computer, consider adding an icon to your panel (right-click on the panel and select Add to Panel ➤ Application Launcher ➤ Sound & Video ➤ TVtime). With tvtime running, you can put it on top by right-clicking on the title bar and selecting “On Top.”

## Selecting Channels in Tvtime

With video input working and the picture adjusted to your liking, you should set up your channels. Right-click on the tvtime window, select Channel management ➤ Scan channels for signal. Tvtime will scan for all available channels and note which ones have active signals. Once channels have been scanned, you can use your mouse wheel to change among the active channels. If tvtime missed an active channel, use your keyboard arrow keys to go to the missed channel and select Channel management ➤ Current channel active in list.

### NOTE

The XMLTV Project provides a means of identifying and downloading TV listings for your area. Tvtime includes support for xmltv listing files, allowing you to display current television shows and station names while you go through tvtime channels. It can be tricky getting xmltv going. If you are interested, I suggest you start at the XMLTV Project site (<http://mibled.com/work/apps/xmltv>).

## Videoconferencing and VOIP with Ekiga

The Ekiga application enables you to communicate with other people over a network through video, audio, and typed messages. Because Ekiga supports the H323 protocol, you can use it to communicate with people using other videoconferencing clients, such as Microsoft NetMeeting, Cu-SeeMe, and Intel VideoPhone. Besides videoconferencing, Ekiga also supports VOIP and IP telephony, to make telephone calls over the Internet.

To be able to send video, you need a Webcam that is supported in Linux. Although not all Webcams are supported in Linux, you still have a few dozen models to choose from. The following sections show you how to set up your Webcam and use Ekiga for videoconferencing.

## Getting a Supported Webcam

As with support for TV capture cards, Webcam support is provided through the Video4Linux interface. Some of the supported cameras have a parallel-port interface, although most Webcams currently supported in Linux require a USB port.

Finding a Webcam to work in Linux is a bit of an adventure. Few (if any) Webcams come with Linux drivers or specs to allow Open Source developers to create those drivers. Webcam drivers that have been created often have limited features and sometimes break with new kernel releases. Also, Webcam vendors sometimes switch the chip sets they are using without changing the Webcam's name. And there are times when the same Webcam is marketed under different names.

So, instead of just telling you what Webcam to buy, I'll tell you what Webcams are supported by drivers that come with CentOS. I suggest that you use this information as a starting point. Combine that information with information from some sites where you can do further research and you should have what you need to make the best Webcam choice.

- **IBM C-it USB Webcams** (`ibmcam` driver) — Webcams that work with this driver have been sold under the names Xirlink C-It, IBM PC Camera, Veo Stingray, and Envision 123 Digital Camera. Before purchasing one of these Webcams, refer to the web site for this driver ([www.linux-usb.org/ibmcam](http://www.linux-usb.org/ibmcam)) for further information on supported cameras, tips for getting different models to work properly, and insights on how these cameras work.
- **Konica Webcams** (`konicawc` driver) — This driver should work with the Intel YC76 or any USB Webcams that have the following vendor or product codes: 0x04c8 or 0x0720. This includes the Intel Create and Share Camera Pack. Information about the driver is available from [www.si.org/konica](http://www.si.org/konica).
- **OmniVision Webcams** (`ov511` driver) — Webcams supported by this driver include USB Webcams based on OmniVision camera chips ([www.ovt.com/products/app2\\_table.asp?id=4](http://www.ovt.com/products/app2_table.asp?id=4)). Webcams include Creative WebCam 3, MediaForte MV300, AVERmedia Webcam, and D-Link DSB-C300.
- **Philips USB Webcams** (`pwc` driver) — This driver supports a variety of Philips USB Webcams, including PCA645, PCA646, PCVC675, PCVC680, PCVC690, PCVC730, PCVC740, and Askey VC010. These include a several inexpensive Logitech Webcams, including the QuickCam Pro 3000.
- **EndPoints Webcams** (`se401` driver) — Supports Webcams that contain the EndPoints SE401 chip sets. These include the Kensington VideoCam PC cameras (67014, 67015, 67016, and 67017) and the Aox se401 camera (se401).
- **SONiX PC Cameras** (`sn9c102` driver) — USB cameras based on the SONiX PC camera controllers are supported by this driver. These include the Sweex 100K, X-Eye, and Chicony Twinklecam Webcam. The sn9c10x driver is maintained by Linux Projects ([www.linux-projects.org](http://www.linux-projects.org)).
- **STMicroelectronics Webcams** (`stv680` driver) — Webcams containing the USB version of STV0680B chips from STMicroelectronics ([www.st.com](http://www.st.com)) are supported by this

driver. Cameras include the Aiptec Pencam and Nisis Quickpix 2 (Vendor/product ID 0553/0202). For information on the driver, refer to the Linux STV0680 USP Support page (<http://stv0680-usb.sourceforge.net>).

- **Ultracam Webcams** (ultracam driver) — Supports Webcams such as the IBM Ultra-Port Camera II. See the ultracam driver page ([www.gutwin.org/cam/source](http://www.gutwin.org/cam/source)) for information about the driver.
- **Vicam Webcams** (vicam driver) — The 3Com HomeConnect USB Webcam is supported by this driver. Refer to the driver's project page for further information (<http://homeconnectusb.sourceforge.net>).
- **Winbond Webcams** (w9968cf driver) — Supports the W9668cf JPEG USB dual mode camera chip from Winbond Electronics. Webcams that use that chip include the ADG-5000 Aroma Digi Pen, Ezonics EZ-802 EZMega Cam, and the Pretec DigiPen-480. Refer to the Linux Projects site ([www.linux-projects.org](http://www.linux-projects.org)) for further information.

Check out the following web sites for a more complete list of Webcams that are and are not supported in Linux. Keep in mind, however, that not all of the drivers for these Webcams will work in the latest kernels in CentOS.

- Linux USB Device Drivers ([www.linux-usb.org/devices.html](http://www.linux-usb.org/devices.html))
- Linux web cams ([http://302found.com/linux\\_webcams/](http://302found.com/linux_webcams/))

The Logitech QuickCam Pro 300 Webcam that I used for examples in this chapter works well with the pwc driver that comes with CentOS. To check that it was working, I ran the `lsmod` command to see that the pwc driver was loaded and associated with the videodev module:

```
# lsmod
pwc                43392      0
compat_ioctl32    5569       1 pwc
videodev          5120       1 pwc
```

To see information about the pwc module (which is specific to this Webcam), I typed the following `modinfo` command:

```
# modinfo -p pwc
dev_hint:Device node hints
leds:LED on,off time in milliseconds
compression:Preferred compression quality. Range 0 (uncompressed) to
           3 (high compression)
power_save:Turn power save feature in camera on or off
trace:For debugging purposes
mbufs:Number of external (mmap()) image buffers
fbufs:Number of internal frame buffers to reserve

fps:Initial frames per second. Varies with model, useful range 5-30
size:Initial image size. One of sqcif, qsif, qcif, sif, cif, vga
```

## Running Ekiga

To start Ekiga, select Applications > Internet > IP Telephone, VOIP and Video Conferencing. To start Ekiga from a Terminal window, type **ekiga &**. If it is not installed, you can install the `ekiga` package from the DVD that comes with this book. The first time you run Ekiga, the Ekiga Configuration Assistant starts. The assistant lets you enter the following information:

- **Personal Data** — Your first name, last name, e-mail address, comment, and location. You can also select whether or not you want to be listed in the Ekiga ILS directory.
- **Connection Type** — Indicate the speed of your Internet connection (56K modem, ISDN, DSL/Cable, T1/LAN, or Custom).
- **Audio Manager** — Typically, you would choose ALSA as your audio manager.
- **Video Manager and Devices** — Typically, you would choose Video4Linux as the video manager and your Webcam as the input device.

### NOTE

If you want to reconfigure Ekiga later, run the following command to clean out the old settings: `ekiga-config-tool --clean`. Make sure that all instances of Ekiga are stopped before running that configuration tool. In addition, be sure to shut down the panel application that may still be running even after stopping Ekiga. Run `ekiga` again to re-enter your settings.

Figure 7-10 shows the Ekiga window.

**FIGURE 7-10**

Make voice and videoconference calls with Ekiga.



In the Ekiga window that opens, you can click on the rolodex icon to open an address book. From the address book, select “Ekiga White Pages.” By typing a name into the search filter, you

can search for people who might be connected to Ekiga server by first name, last name, e-mail address, or location. Select a person from the list that appears and, if he or she accepts your call, you can begin videoconferencing. The History tab shows a log of your activities.

## Playing Video

---

Video recording (encoding) and playback (decoding) remain among the most contentious areas of potential litigation in Open Source software. On one hand, you have patent holders of complex video formats that might ask for royalties for Open Source codecs (even when the software was written from scratch). On the other hand, you have the movie industry, which has taken aim at those publishing what they had hoped were secret encryption techniques (DeCSS), to prevent the Open Source decoding of commercial movies. The problem is that the same technique that allows you to play movies in Linux also can be used to copy and share them.

### NOTE

*Codec stands for COder/Decoder or COmpressor/DECompressor, depending on whom you ask. In either case, codecs are what make it possible to process and encode audio and video on computers.*

As with audio recording, if you are starting from scratch, there is an Open Source codec called *Theora* ([www.theora.org](http://www.theora.org)) that you can use without paying any royalties, as of this writing. Provided you own the content you are recording, you can freely distribute that content as well and allow others to play it back. (See the sidebar “Converting Video to Theora” for details.)

When it comes to including video codecs (other than the free Theora), CentOS has taken the cautious approach. While CentOS now includes video players such as Totem (described later in this chapter), it does not include players (such as the MPlayer and Xine media players) that often are packaged with contentious codecs. If you want to play commercial movies, popular video clips, or other video content in a CentOS system, you have to get those codecs elsewhere.

This section describes some of the issues surrounding playing and creating videos in Linux. It also describes video players that come with CentOS, as well as those you can obtain to play a wide variety of video content.

## Examining Laws Affecting Video and Linux

I need to start out by reminding everyone that I am not a lawyer, so you need to take responsibility yourself regarding any software you put on your computers. However, there are several themes that have arisen in regard to playing video content with Open Source software in Linux:

- Licensing fees for patented codecs may be required. While many video codecs are covered by patents, some patent holders don't charge for personal use. However, you should check current policies of companies who own patents on codecs you plan to use, as the terms of use are constantly changing. For example, this statement that was once posted on the DivX

web site is no longer there: “Personal use of DivX video software is free. Commercial use is not and requires that you obtain a commercial use license from DivXNetworks.” (Refer to the DivX web site, [www.divx.com](http://www.divx.com), for information on DivX licensing.)

- Because MPEG-2 and MPEG-4 video formats are covered by a variety of patents, groups of patent holders have joined together to charge licensing fees for related encoders and decoders. These efforts are not sponsored by standards organizations that spearheaded the creation of those formats and may not cover every patent holder related to the software you are paying for. See the MPEG Industry Forum for details on MPEG patent issues ([www.m4if.org/patents](http://www.m4if.org/patents)).
- Remember that there are now ways to purchase codecs for many popular audio/video formats for use with Linux. See the section “Extending Freedom to Codecs” for information on purchasing codecs from Fluendo.
- Unauthorized copying of copyright-protected material is never legal. Even legal video codecs do not make it legal to copy commercial movies and other protected content and distribute them to others. There are questions as to whether or not, for example, it is legal to make a personal backup copy of a DVD movie (a commonly accepted legal practice with computer software). But any re-distribution of movie, music, or other media content is not legal without the owner’s permission.

Because patenting eliminates trade secret protection for the subject matter disclosed in the patent (or published patent application), many people have raised the question of why someone can’t freely distribute `libdvdcss` (based on DeCSS decryption) to play DVD movies. Without copyright or patent coverage on CSS, it should not be illegal to distribute `libdvdcss`, and there’s nobody to pay a license fee to for using it. In regard to `libdvdcss`, another issue arose in the United States: the Digital Millennium Copyright Act (DMCA). DMCA might make DeCSS illegal because the technology is used to break an encryption scheme to circumvent copyrighted material.

As for the software patent issues, those are being fought on several fronts besides those relating to multimedia content. As noted earlier, the contention held by many Open Source proponents is that software should be copyrighted and not patented (see the section “Understanding Multimedia and Legal Issues in Linux” earlier in this chapter).

With all that said, the next parts of this chapter go on to describe which players are available to play a wide range of video content in Linux. It is up to you to work out the maze of which codecs are free for you to use and in what ways.

## Understanding Video Content Types

Before launching into the video players themselves, I want to try to clear up a bit of confusion relating to video file formats and codecs:

- **Video File Formats** — A *video file format* essentially describes the structure of a video file for combining audio and video content. That structure can also define such things as subtitles and how audio and video are synchronized. However, a variety of video and audio codecs may have been used to encode that content. So, just because you can play

a video file that is marked as MPEG (.mpg), Audio Video Interleaved (.avi), QuickTime (.mov), RealMedia (.rm), Windows media (.wvm), Advanced Streaming Format (.asf), or other file format, it doesn't mean that you can play all video files marked as such.

- **Video and Audio Codecs** — *Codecs* are used to encode and decode video and audio content. A video encoded entirely with free software might use Theora to encode the video and Ogg Vorbis to encode the audio. Popular video codecs include MPEG-4, DivX, Xvid, RealVideo, and MJPEG.

Not all video codecs and file formats are suitable for streaming video. For example, AVI and MPEG-2 are not streamable. However, RealMedia, MPEG-4, and ASF format can be streamed, which reduces the load on a server and means you do not have to download an entire video to start watching. Check the descriptions of video players in the following sections for information on which players can support which codecs.

If you have a video file on your hard disk and you'd like to know what type of content it contains, you can use the `file` command. Here's an example of the `file` command for checking the contents of a movie trailer:

```
$ file movie.avi
movie.avi: RIFF (little-endian) data, AVI, 640 x 272, 23.98 fps,
video: DivX 3, audio: MPEG-1 Layer 3 (stereo, 44100 Hz)
```

This example shows that the file contains DivX 3 video and MPEG-1 Layer 3 audio. The size of the video is 640 × 272 pixels. Video was captured at 23.98 frames per second. This can lead you to the type of video player you need to play the content. Given that the right codecs are installed, MPlayer, Xine, VLC, or several other players would be able to play this content.

## Converting Video to Theora

There are not yet many tools for creating Theora video. To get a video to try out, I shot a video with my Sony Handycam, which stores video in 30-minute, 1.4-GB mini-DVDs. I downloaded a tool recommended from the Theora.org site, called *ffmpeg2theora* ([www.v2v.cc/~j/ffmpeg2theora](http://www.v2v.cc/~j/ffmpeg2theora)). My video camera stored my home movie as a VOB file, which I copied to my hard disk and converted to Theora/Ogg Vorbis as follows:

```
$ ffmpeg2theora VTS_01_1.VOB
Input #0, mpeg, from 'VTS_01_1.VOB':
Duration: 00:00:00.6, start: 0.197311, bitrate: -2147483 kb/s
Stream #0.0: Video: mpeg2video, 704x480, 29.97 fps, 9300 kb/s
Stream #0.1: Audio: ac3, 48000 Hz, stereo, 256 kb/s
```

*continued*



*continued*

```
Resize: 704x480 => 320x240
Resample: 48000Hz => 44100Hz
.
.
.
```

The original file was stored in mpeg-2 video (720 × 480 pixels) and ac3 audio (48,000 Hz). The `ffmpeg2theora` command resized the video to 704 × 480 pixels and resampled the audio to 44,100 Hz. The result was a second file (same filename with an `.ogg` extension added) that was 82 MB, compared to the original 1.1 GB.

## Watching Video with Xine

At the base of the Xine video player (<http://xinehq.de>) is the `xine-lib` core engine. While Xine has its own Xlib-based user interface, you can choose different video player front-ends to use with the core engine instead (including Totem, Kaffeine, and aaxine). You can also use Xine as a Mozilla plug-in, to have videos play in a browser window.

The Xine player is an excellent application for playing a variety of video and audio formats. You can get Xine from the RPMforge Repository, or from <http://xinehq.de>.

### NOTE

**The Xine Project offers the following disclaimer before you download or use its software:**

*Some parts of Xine (especially audio/video codecs) may be subject to patent royalties in some countries. If you provide pre-compiled binaries or intend to build derivative works based on the Xine source please consider this issue. The Xine project is not warranting or indemnifying you in any way for patent royalties. You are solely responsible for your own actions.*

You can start the Xine player by typing **`xine&`** from a Terminal window. Figure 7-11 shows an example of the Xine video player window.

Below the Xine window is the Xine controller, which has buttons that work like many physical DVD players. Right-click on the main window to see a menu of options. Select Settings ➤ Video to display another controller that lets you adjust hue, saturation, brightness, and contrast.

Xine supports many video and audio file formats and codecs. However, not all of these codecs are distributed with Xine:

- MPEG (1, 2, and 4)
- QuickTime (see “Xine Tips” if this content won’t play)

**FIGURE 7-11**

Play video CDs, MP3s, QuickTime, and other video formats with Xine.



- RealMedia (see “Xine Tips” if this content won’t play)
- WMV (see “Xine Tips” if this content won’t play)
- Motion JPEG
- MPEG audio (MP3)
- AC3 and Dolby Digital audio
- DTS audio
- Ogg Vorbis audio

Using the Xine controller, you can select to play content directly from a DVD, DVB, VCD, VCDO, or CD disk. If you are playing an audio CD (or any audio file), you can choose different visualizations (right-click, and then choose Audio > Visualization and select goom, oscopo, fftscope, or fftgraph) to appear in the Xine windows as music plays.

Xine can understand different file formats that represent streaming audio and video. These include .mpg (MPEG program streams), .ts (MPEG transport streams), .mpv (raw MPEG audio/video streams), .avi (MS AVI format), and .asf (Advanced Streaming format). While Xine can play video CDs and DVDs containing other content, it can’t play encrypted DVDs or video-on-CD hybrid format without adding other software (because of the legal issues mentioned earlier related to decrypting DVDs).

## Using Xine

With Xine started, right-click in the Xine window to see the controls. The quickest way to play video is to click on one of the following buttons, and then press the Play button (right arrow or Play, depending on the skin you are using):

- VCD (looks for a video CD)
- DVD (looks for a DVD in `/dev/dvd`)
- CDA (looks a music CD in `/dev/cdaudio`)
- DVB (looks for a DVB device supported by `linuxtv` drivers)

Next, you can use the Pause/Resume, Stop, Play, “Fast motion,” “Slow motion,” or Eject buttons to work with video. You can also use the Previous and Next buttons to step to different tracks. The controls are very similar to what you would expect on a physical CD or DVD player.

To select individual files or to put together your own list of content to play, you can use the Playlist feature.

## Creating Playlists with Xine

Click on the Playlist button on the left side of the Xine control window. A Playlist Editor appears, showing the files on your current playlist. You can add and delete content from this list and then save the list to call on later. Here’s how you use the Xine Playlist Editor:

- **CDA, DVD, or VCD** — Click on any of the buttons that represent a particular CD or DVD. All content from that CD or DVD is added to the playlist.
- **Add** — Click on the Add button to see the MRL Browser window. From that window, click File to choose a file from your Linux file system to add to the list. Click Select to add that file to the Playlist Editor.
- **Move Up/Move Down** — Use the “Move up selected MRL” and “Move down selected MRL” buttons to move up and down the playlist.
- **Delete** — Click on the “Delete Selected MRL” button to remove the current selection.
- **Delete All** — Click on the “Delete All Entries” button to clear the whole playlist.
- **Save** — Click on the Save button to save the playlist to your home directory (`$HOME/.xine/playlist.tox`; or give it another name).
- **Load** — To read in the playlist you saved, click on the Load button.

The Xine content is identified as media resource locators (MRLs). Each MRL is identified as a file, DVD, or VCD. Files are in the regular file path (`/path/file`) or preceded by `file:/`, `fifo:/`, or `stdin:/`. DVDs and VCD are preceded by `dvd` and `vcd`, respectively (e.g., `vcd://01`).

To play your playlist, click on the Play button (arrow key) on the Playlist Editor.

## Xine Tips

Getting video and audio to work properly can sometimes be a tricky business. Here are a few quick tips to using Xine:

- **Xine Won't Start** — To work best, Xine needs an X driver that supports xvid. If there is no xvid support for your video card in X, Xine will shut down immediately when it tries to open the default Xv driver. If this happens to you, try starting the `xine` command with the X11 video driver (which is slower, but should work) as follows:
 

```
$ xine -V XShm
```
- **Don't Run as root** — Run `xine` as a regular user, instead of as `root`. Once Xine is installed, you should be able to run it from the Applications menu on your panel by selecting Sound & Video ► Xine Media Player. There have been recently discovered vulnerabilities of some Open Source media players related to streaming media. Although that problem was fixed, it again highlighted the fact that running applications as a regular user, whenever possible, is a good idea.
- **Run `xine-check`** — To get an idea of how happy Xine is running on your system, run the `xine-check` command (as the user who will be using Xine). It will tell you if there are problems running Xine on your current operating system, kernel, and processor, among other things.
- **Xine Playback Is Choppy** — If playback of files from your hard disk is choppy, there are a couple of settings you can check: 32-bit IO and DMA. (If these two features are supported by your hard disk, they will generally improve hard disk performance.)

### CAUTION

Improper disk settings can result in destroyed data on your hard disk. Do this procedure at your own risk. This procedure is only for IDE hard drives (not SCSI)! Also, be sure to have a current backup and no activity on your hard disk if you change DMA or IO settings as described here.

1. First, test the speed of hard disk reads. To test the first IDE drive, type:

```
# hdparm -t /dev/sda
Timing buffered disk reads: 64 MB in 19.31 seconds = 3.31 MB/sec
```

2. To see your current DMA and IO settings, as `root` user type:

```
# hdparm -c -d /dev/sda
/dev/sda:
I/O support = 0 (default 16-bit)
using_dma = 0 (off)
```

3. This shows that both 32-bit IO and DMA are off. To turn them on, type:

```
# hdparm -c 1 -d 1 /dev/sda
/dev/sda:
I/O support = 1 (32-bit)
using_dma = 1 (on)
```

4. If you have problems with the DMA setting, run the command without the `-d 1` option. Now, test the disk again:

```
# hdparm -t /dev/sda
Timing buffered disk reads: 64 MB in 2.2 seconds = 28.83 MB/sec
```

As you can see from this example, buffered disk reads of 64 MB went from 19.31 seconds to 2.2 seconds after changing the parameters described. Playback should be much better now.

- **Xine Won't Play Particular Media** — Messages such as `no input plug-in` mean that either the file format you are trying to play is not supported or it requires an additional plug-in (as is the case with playing DVDs). If the message is `maybe xyz is a broken file`, the file may be a proprietary version of an otherwise supported format. For example, I had a QuickTime video fail that required an SVQ3 codec (which is currently not supported under Linux), although other QuickTime files will play fine.

If a particular multimedia format is not supported, but you have Windows DLLs available that support it, you can add those DLL files to the `/usr/lib/win32` directory. Some of these codec DLLs are available from [www.mplayerhq.hu/design7/download.html#binary\\_codecs](http://www.mplayerhq.hu/design7/download.html#binary_codecs) in a package called `essential`. Choose a mirror site from the table under the Binary Codec Packages heading.

**NOTE**

The CrossOver Plugin (described in Chapter 8) can be used to play a variety of content, including the version of QuickTime just mentioned.

## Using Totem Movie Player

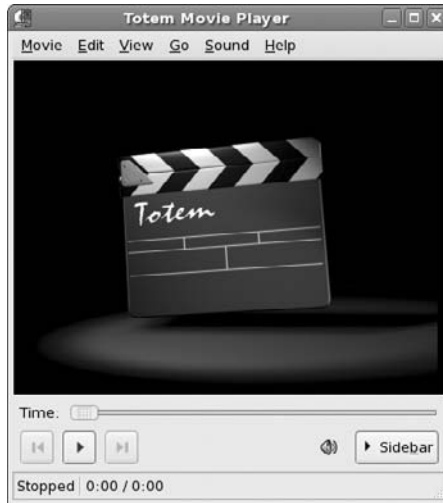
The Totem movie player ([www.gnome.org/projects/totem](http://www.gnome.org/projects/totem)) comes with the GNOME desktop environment. In CentOS, Totem can play video in Theora format with Ogg Vorbis audio. Totem is based on GStreamer (<http://gstreamer.freedesktop.org>) so it can be used with other video software from that project. In particular, free and fee-based codecs that you can purchase from [www.fluendo.com](http://www.fluendo.com) for playing a variety of commercial audio/video formats will work with Totem.

Totem also supports a Xine backend that allows it to play a wide range of video content (in other words, anything Xine supports). To play commercial DVD movies, however, you need to replace the version of Totem that comes with CentOS with the `totem-xine` package available from third-party RPM sites. You also need to add the `libdvdcss`, `libdvdnav`, and `xine-lib-extras-nonfree` packages (provided the software is legal where you live).

Besides common controls, you would expect with a movie player (play, pause, skip forward, skip backwards, etc.), Totem lets you create playlists, take a snapshot of the current frame, and adjust the volume. You can change preferences, which let you add proprietary plug-ins, select your DVD device, and balance color. Figure 7-12 shows an example of the Totem window.

**FIGURE 7-12**

Totem plays Theora video, plus any codecs supported by Xine and GStreamer.



## Using a Digital Camera

With the GNOME Volume Manager features in CentOS, getting images from a digital camera can be as easy in Linux as it is in any desktop operating system. With most digital cameras that can be connected to a USB port on your computer, simply plugging the camera into a USB port (with the camera set to send and receive) causes the GNOME Volume Manager to:

- Immediately prompt you to ask if you want to download images from your camera.
- Run the gThumb image viewer and browser program to look at, manipulate, and download the contents of your digital camera.

Although GNOME Volume Manager will open your camera's contents in an image viewer, you can treat the storage area in your camera much as you would the storage area on a hard disk or a pen drive. I describe how to use your camera to store other data as well.

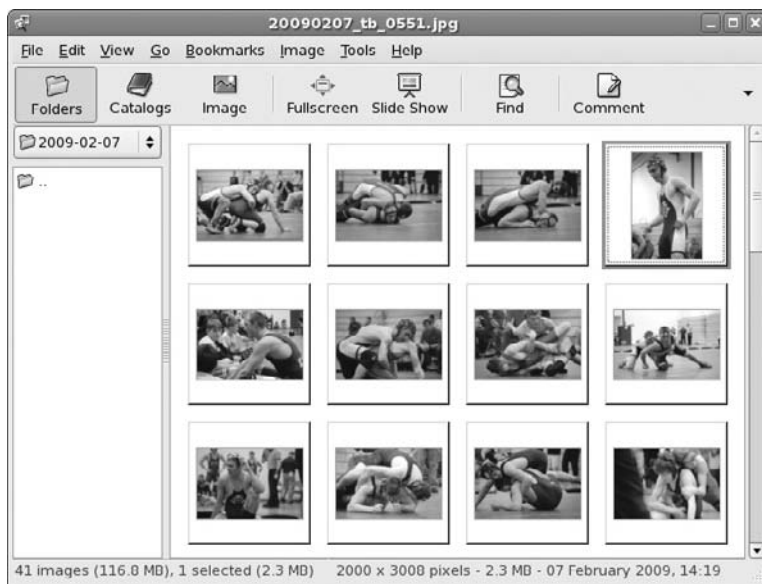
## Displaying Images in gThumb

The GNOME Volume Manager mounts the contents of your USB camera, treating the memory of your camera as it would any file storage device. When I tried it with an Olympus digital camera, my images were available from the `/media/usbdisk/dcim/100olymp` directory.

Figure 7-13 shows the gThumb window displaying images retrieved from a digital camera.

**FIGURE 7-13**

Download images from digital cameras with the gThumb image viewer.



With your camera connected and the gThumb window open, here are some things you can do with the images on your camera:

- **Download Images** — Click on a single image or select **Edit** ➤ **Select All** to highlight all images from your digital camera. Then select **File** ➤ **Import Photos**. From the **Import Photos** window, you can select the destination where you want the images to be downloaded. As an alternative, you can download selected images to a folder on the GNOME desktop.
- **View Slideshow** — Select **View** ➤ **Slide Show**. A full-screen slideshow appears on your display, with the images changing every few seconds. The toolbar that appears at the top lets you display information about the photo name, date, and size (click **Image Info**); go forward and back through the images; and zoom in or out.
- **Manipulate Images** — Double-click on an image to open it, and select the **Image** menu. That menu offers a set of tools for enhancing, resizing, cropping, or otherwise transforming the image. You can also adjust the color balance, hue/saturation, and brightness contrast.

- **Assign Categories** — With an image selected, click on the Categories button. The Categories pop-up window lets you assign the image to a category to help you organize your photos. Assign available categories (such as birthday, family, holidays, or games) or click New and add your own categories.

Once images are downloaded to your computer's hard disk, you can continue to work with them using gThumb or use any of several tools available for manipulating digital images (GIMP, KView, and Kuickshow, to name a few).

**NOTE**

If you have a camera that saves images to a floppy disk, just insert that disk into your disk drive, and the contents of the disk should open automatically on your desktop.

In addition, if your camera saves images to SD or CF cards, you can purchase a USB card reader and view these files from Linux.

Check the gPhoto2 web site ([www.gphoto.org/proj/libgphoto2/support.php](http://www.gphoto.org/proj/libgphoto2/support.php)) for information on supported cameras as well as other topics related to gPhoto.

## Using Your Camera as a Storage Device

As I noted with my example of an Olympus camera with a USB connector, the GNOME Volume Manager is capable of detecting that camera once it is connected, and mounting its contents as a storage device. With the contents of a digital camera mounted, you can use your camera as a USB mass storage device by:

- Opening the mounted directory in a folder window and using any File Manager features to work with the images.
- Changing to the mounted directory from the shell and using commands to copy, move, rename, or delete digital images.

Of course, with your camera mounted as a file system, you are not limited to using it only for digital images. You can use it to store any kind of files you like, essentially using the camera as a storage device. The following list is a partial summary of digital cameras that can be used as a USB storage device:

- **Casio** — Supported models: QV-2400UX, QV-2x00, QV-3x00, QV-4000, and QV-8000
- **Fuji** — FinePix 1300, 1400Zoom, 2300Zoom, 2400Zoom, 2800Zoom, 4200Z, 4500, 4700 Zoom, 4900 Zoom, 6800 Zoom, A101, A201, and S1 Pro
- **HP** — PhotoSmart 315, 318xi, 618, and C912
- **Konica** — KD200Z, KD400Z, and Revio KD300Z
- **Kyocera** — Finecam s3
- **Leica** — Digilux 4.3
- **Minolta** — Dimage 5, Dimage 7, and Dimage X
- **Nikon** — CoolPix 2500, 885, 5000, 775, and 995



- **Olympus** — Brio Zoom D-15, C-100, C-200Z, C-2040, C-220Z, C-2Z, C-3020Z, C-3040Z, C-4040Zoom, C-700, C-700UZ, C-860L, D-510, D-520Z, E-10, and E-20
- **Pentax** — EI2000, Optio 330, and Optio 430
- **Sony** — DSC-F505, DSC-F505V, DSC-F707, DSC-P1, DSC-P20, DSC-P5, DSC-P71, DSC-S30, DSC-S70, DSC-S75, DSC-S85, MVC-CD300, and MVC-FD92
- **Vivitar** — Vivicam 3550
- **Yashica** — Finecam s3

## Summary

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This chapter takes you through the steps of setting up and using audio, video, and digital cameras in CentOS. It covers topics such as troubleshooting your sound card and explains how to find software to play music through that card. Many popular music players included with CentOS, such as KsCD and Rhythmbox, are described.

With nearly every type of audio and video format available today in Linux, the biggest trick is figuring out which software is legal to use freely and which isn't. I tried to cover some of the legal issues surrounding multimedia software patents, so you can try to make informed decisions.

Live video from TV cards and Webcams is covered in the sections on tvtime and Ekiga. I covered the Xine and Totem players for playing a variety of video formats, followed by the GNOME Volume Manager for downloading images from a digital camera. If your computer has a CD burner, use the descriptions in this chapter to create your own music CDs and CD labels. You can also burn complete CD or DVD ISO images using the K3b window.

# Chapter 8

## Using the Internet and the Web

**W**ith your CentOS system connected to the Internet, you can take advantage of dozens of tools for browsing the Web, downloading files, getting e-mail, and communicating live with your friends. In most cases, you have several choices of GUI and command-line applications for using Internet services from your Linux desktop or shell.

This chapter describes some of the most popular tools available with CentOS for working with the Internet. These descriptions cover Web browsers, e-mail readers, instant messaging clients, commands for login and remote execution, and specialty applications such as BitTorrent for file sharing.

### Overview of Internet Applications and Commands

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When it comes to features and ease-of-use issues, applications that come with CentOS for accessing the Internet can rival those of any operating system. For every major type of Internet client application, there are at least three or four graphical and command-line tools to choose from.

While Linux has offered high-quality servers for Web, mail, FTP, and other Internet services for years, current versions of these desktop Internet applications have become both solid and rich in content. If Web browsing and e-mail are your primary needs in a desktop system, CentOS is ready today to let you leave your Windows desktop systems behind.

#### IN THIS CHAPTER

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Understanding Internet tools

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Browsing the Web

---

Communicating via e-mail

---

Participating in newsgroups

---

Using Pidgin Instant Messaging

---

Using BitTorrent cooperative software distribution

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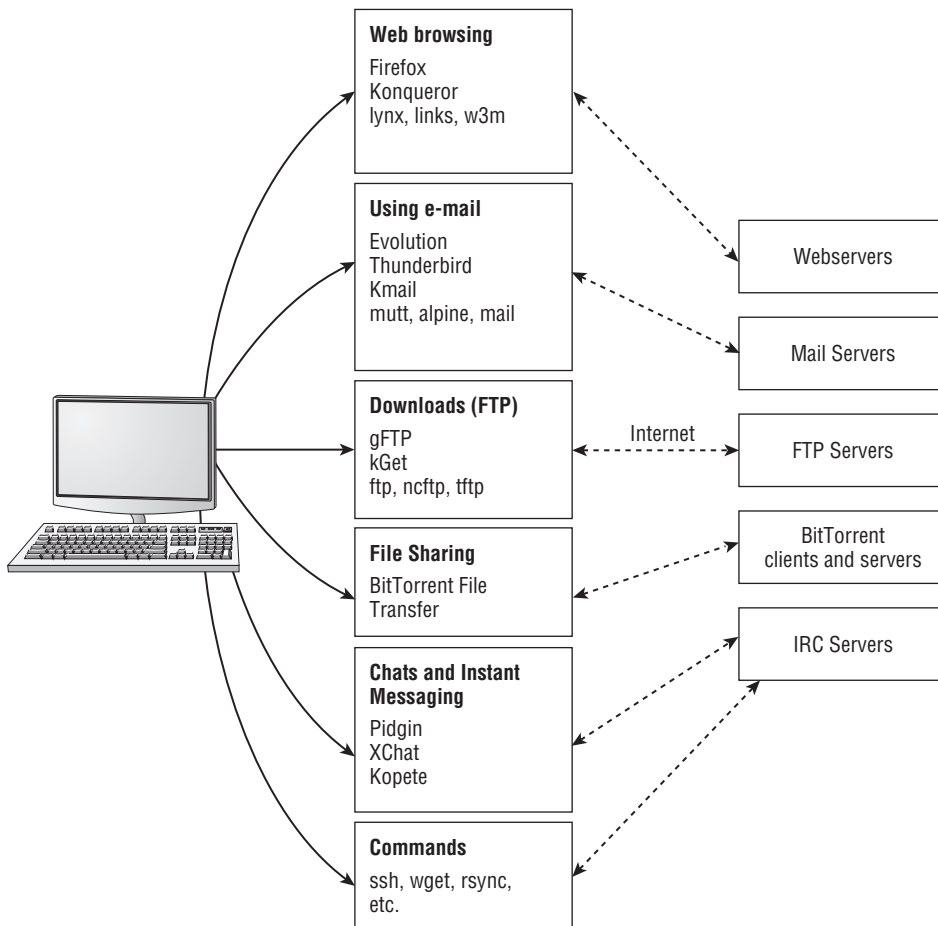
Using remote login, copy, and execution commands

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Figure 8-1 illustrates some of the most valuable Linux applications for using the Internet.

**FIGURE 8-1**

CentOS offers choices of Web browsers, e-mail clients, and other Internet client applications.



If you are using CentOS as a desktop system, the browsers and e-mail clients make requests to servers available on your LAN or the Internet. Software for configuring a computer as a Web, mail, FTP, or other server type is also included with CentOS systems. Someone starting out with Linux, however, can use applications for using the Internet as they would from any Windows or other desktop system.

The following Internet applications available in CentOS are covered in this chapter:

- **Web Browsers** — Most Web browsers available for Linux today follow from the legacy of Netscape Navigator. The Open Source Mozilla project, which was originally spawned from Netscape source code, is responsible for the award-winning Firefox Web browser. Another browser that comes with CentOS is the Konqueror browser/file manager.  
Relatively new ways for gathering content from the Web include RSS news feed readers, such as the liferea RSS/RDF feed reader. There are also several browsers, such as Lynx and w3m, that can run from the command line (with no graphical interface required).
- **E-Mail Clients** — The Evolution e-mail client has evolved into a full-fledged groupware suite, combining an e-mail reader with features for managing contacts, calendars, and tasks, as well as connecting to Microsoft Exchange servers. Thunderbird is a popular mail client from the Mozilla project. For those who prefer old-school e-mail readers, mutt, alpine, and mail commands let you read mail from the command line, often with limited abilities to handle attachments, HTML, or other modern e-mail features.
- **FTP Clients** — If you use the FTP protocol to download files from FTP servers, or to upload web pages to your server, graphical tools for doing those tasks include the gFTP and KGet applications. There are also many shell commands available for accessing FTP servers to look for files, download files, or upload files. Those commands include `ftp`, `lftp`, and `tftp`.
- **BitTorrent Clients/Servers** — BitTorrent is the popular Open Source software project for sharing files among many computers at the same time. With BitTorrent, as you *download* a file, you can simultaneously safely *upload* that same file to others. BitTorrent is particularly useful for publishing CD or DVD images containing large software distributions (such as CentOS) the minute they become available, without overstressing the original servers releasing the software.
- **Instant Messaging and Chats** — Typing live messages to friends, family, and associates has become a popular activity in recent years. Pidgin is an instant messaging client that lets you connect to AIM, IRC, MSN, Google, and ICQ servers. XChat is a popular Internet Relay Chat (IRC) client (a popular protocol among Linux enthusiasts for online chats). Kopete is an instant messaging client that integrates with a KDE desktop.
- **Remote Commands** (log in, file copy, etc.) — As you spend more time working with Linux, you will find that it is often quicker and more convenient to run commands than it is to run graphical applications. Some very powerful command-line tools exist in Linux for doing such things as remote login and remote execution (`ssh`) and remote file copy (`wget`, `scp`, and `rsync`).

**NOTE**

Besides the applications mentioned here, many more Internet-enabled applications are described in other parts of the book. For example, music players and video players described in Chapter 7 can grab audio and video files or streaming media from the Internet. Likewise, software installation tools such as `yum` are made to get software from software repositories on the Internet.

Because the Internet client applications featured in CentOS are designed to be intuitive, if you are accustomed to using the Internet from Windows or Macintosh, the transition to Linux shouldn't be that difficult. While I describe many of the basic features that come in these Internet applications, there are a few tricks you should learn to get the most out of them:

- **Tuning Your Browser** — While Firefox has made great strides in supporting different kinds of Web content, getting some multimedia, image, and document formats to play in Firefox can require some extra steps. In most cases, this is because software for playing many popular multimedia formats cannot be freely distributed, so you have to add them later. I describe some plug-ins and other software that you will want to add to Firefox (or another Web browser) to get it to play many popular types of content that it can't handle by default.
- **Managing E-Mail** — With e-mail volume increasing every day, tools for managing your e-mail are becoming more important. In the e-mail section, I explain how to use filter rules to sort your e-mail and how to identify junk mail. I also discuss ways to manage and use mailing lists effectively.
- **Useful Command Options** — Besides identifying some useful commands for remote login, file copying, and command execution, I identify options that are particularly helpful to use with them.

To get started with Internet applications in Linux, you need to set up a connection to the Internet from your Linux system (as described in Chapter 15). Most graphical Internet applications in CentOS are available from menus on the desktop. Click Applications ➤ Internet to see a list of Internet applications you can choose from. Icons to launch the Firefox browser and Evolution e-mail client are directly on the panel on the top of the display.

## Browsing the Web

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The most important client Internet program these days is the Web browser. In CentOS, you have several choices of Web browsers, including:

- **Firefox** — The Firefox browser is touted as the flagship Web browser from the Mozilla project and is aimed squarely at the dominance of Microsoft Internet Explorer in the browser space. Firefox offers easy-to-use features for dealing cleverly with issues that have wreaked havoc with other Internet browsers, such as viruses, spyware, and pop-ups. Firefox is the featured Web browser in CentOS.
- **Konqueror** — Although Konqueror is the File Manager for the KDE desktop, it can also display Web content. Using Konqueror, you can easily go back and forth between web sites and local files and folders. A testament to the quality of Konqueror is that the Mac OS X Safari browser uses the WebKit rendering engine, which is based on the Konqueror KHTML and KJS engines.

If you are working from a shell, there are several command-line utilities that allow you to browse the Web without a graphical interface. These include the `links`, `w3m`, and `lynx` commands.

## Understanding Web Browsing

Although the Internet has been around since the 1960s, the Web is a relatively new technology (ushered in by the creation of the first Web browser in 1990). The Web places an additional framework over Internet addresses that were once limited to hostnames and domain names. Before the Web, finding resources on the Internet was difficult. However, the Web now provides several features that make it much easier to access these resources:

- **Uniform Resource Locators (URLs)** — URLs identify the location of resources on the Web. Besides identifying the domain and host on which a resource resides, they can also identify the type of content and the specific location of the content.
- **Hypertext Markup Language (HTML) Web Pages** — When people talk about a web page, they are generally referring to information that is presented in HTML format. HTML changed the Internet from a purely plaintext-based resource to one that can present graphics and font changes. An HTML page can also contain hypertext links. *Links* are the threads that join together the Web, enabling someone viewing a web page to be immediately transported to another web page (or other content) by simply selecting a linked text string or image on the page.

The primary tool for displaying HTML web pages is the Web browser. Firefox is the featured Web browser in CentOS. It can display HTML (web pages), as well as other types of Web content. Now even File Managers, made for displaying local files and folders, have been extended to be able to display Web content (see the description of the Konqueror File Manager in Chapter 3).

This section contains general information about the Web and some specific hints for using several different browsers (in particular, Firefox) to browse the Web from your CentOS system.

### Uniform Resource Locators

To visit a site on the Internet, you either type a URL into the location box on your browser or click a link (either on a web page or from a menu or button on the browser). Although URLs are commonplace these days — you can find them on everything from business cards to cereal boxes — you may not know how URLs are constructed. The URL form is as follows:

```
protocol://host-domain/path
```

The *protocol* identifies the kind of content that you are requesting. By far, the most common protocol you come across is Hypertext Transfer Protocol (HTTP). HTTP is the protocol used to request web pages. In addition to HTTP, however, there are other protocols that might appear

at the beginning of a web address. Instead of showing you a web page, these other types of protocols may display different kinds of information in your browser or open a completely different application for working with the content.

Table 8-1 lists some of the protocols that can appear in a Web URL. (Some of these are no longer supported in modern browsers, as noted in the table.)

TABLE 8-1

### Protocols in Web URLs

Protocol Name	Description
http	Hypertext Transfer Protocol. Used to identify HTML web pages and related content. The secure version is Hypertext Transfer Protocol over Secure Socket Layer (https).
file	Identifies a file on a specific host. Most often used to display a file from your local computer.
ftp	File Transfer Protocol. Identifies a location where there are file archives from which you might want to download files.
gopher	Gopher Protocol. Provides databases of text-based documents that are distributed across the Internet. (Gopher is nearly obsolete.)
mailto	Electronic Mail Address. Identifies an e-mail address, such as <code>mailto:joe@example.com</code> . (Usually opens a mail composer.)
news	USENET newsgroup. Identifies a newsgroup, such as <code>news://news.example.com/comp.os.linux.networking</code> . (In Firefox, news is not a registered protocol by default.)
nntp	USENET news using nntp protocol
telnet	Logs in to a remote computer and begins an interactive session. An example of a telnet address is <code>telnet://localhost</code> . (Replace <code>localhost</code> with any host or IP address that allows you to log in.)
wais	Wide Area Information Server protocol. A WAIS address might look like the following: <code>wais://handsonhistory.com/waisdb</code> . (As with gopher, WAIS databases are nearly obsolete.)

The first part of a URL is the protocol. You don't always have to type the protocol. Most browsers are good at guessing the content you are looking for (mostly they guess HTTP). If the address you type starts with `www`, the browser assumes HTTP; if it starts with `ftp`, it assumes FTP.

The second part of a URL takes you to the computer that is hosting the Web content. By convention, Web Servers begin with `www` (or sometimes `home`). However, if you type the correct

protocol (usually `http`), you will be directed to the right service at the host computer. The next piece of this name is just the `host.domain` style of Internet address that is always used with the Internet (such as `example.com`, `whitehouse.gov`, or `linuxtoys.net`). An optional port number can be tacked on to the `host.domain` name. For example, to request the port used for HTTP services (port 80) from the host called `www.linuxtoys.net`, you can type **`http://www.linuxtoys.net:80`**.

**NOTE**

You can identify a specific port number to request the service attached to the port on the computer you request. A port number is a lot like a telephone extension in a big company. A main telephone number (such as the `host.domain` name) gets you to a company switchboard. The telephone extension (like the port number) connects you to the right person (like the service associated with a port).

The third part of a URL identifies the location of the content on the host computer. Sections in a web page can be identified with a pound sign (`#`) and an identifier following the web page location. For example, the craft section of the `bsched.htm` page at `handsonhistory.com` would appear as:

```
http://www.handsonhistory.com/bsched.htm#craft
```

The filename extension (such as `.htm` or `.html`) further identifies the content type.

## Web Pages

If you look at the HTML source code that produces web pages, you see that it consists of a combination of information and markup tags, all of which are in plaintext format. The idea is to have web pages be very portable and flexible. You can create a web page with `vi`, `emacs`, `gedit`, or any text editor on any computing platform. Alternatively, simplified front-end programs can be used to provide WYSIWYG (“What You See Is What You Get”) interfaces that let you see what you are creating as you go.

HTML tags are set apart by right and left angle brackets. Tags come in pairs, with a beginning tag, the information, and then an ending tag. The beginning tag contains the tag name, while an ending tag contains a forward slash (`/`) and the tag name. Here is a minimal HTML page:

```
<html>
<head>
<title>Greetings from Wisconsin</title>
</head>
<body>
Here we are in beautiful Madison.
</body>
</html>
```

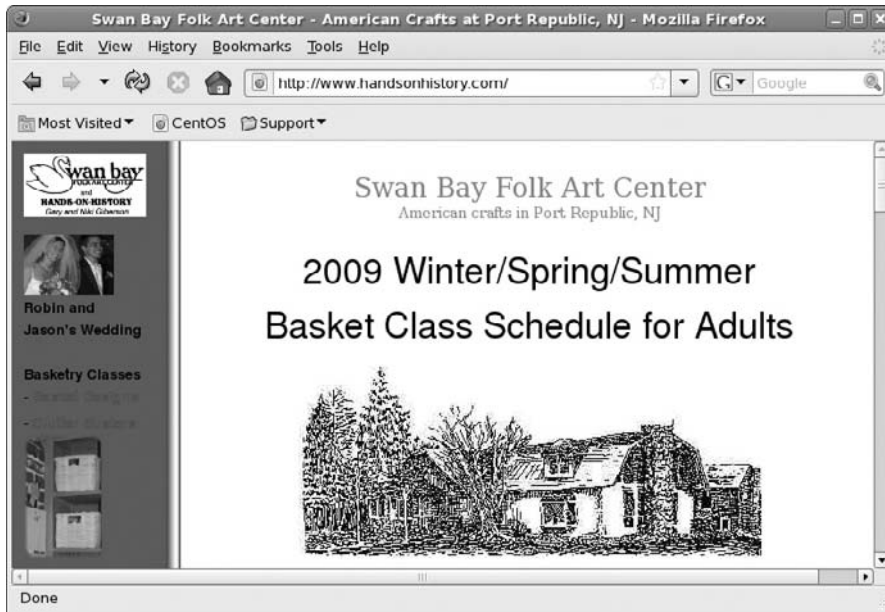
You can see that the document begins and ends with HTML tags (`<html>` and `</html>`). The beginning part of the web page is contained within the `head` tags. The body of the page is contained within the `body` tags. The title of the page is set apart by `title` tags.



Between the beginning and ending body tags, you can add all kinds of stuff. You can have different types of bulleted or numbered lists. You can have headings, images, and text. More complex pages can include forms, dynamic HTML (which changes the content as you move or select items), or special data. Figure 8-2 shows an example of a web page as it appears in Firefox.

**FIGURE 8-2**

Many web pages contain text, images, headings, and links.



Some of the HTML code that was used to create the web page shown in Figure 8-2 is shown here. The title of the web page appears between two `title` tags:

```
<title>Swan Bay Folk Art Center - American Crafts
in Port Republic, NJ</title>
```

The following code is used to create a link that opens a new mail message window:

```
<A HREF="mailto:webmaster@handsonhistory.com">Contact Us</A>
```

The text “Contact Us” is a link to an e-mail address. When someone clicks that link, a new message window appears, allowing that person to send e-mail to that address.

```
<A HREF="bsched.htm">
New Basket Class! </A>
```

The words *New Basket Class!* point to a link to another HTML page. If someone were to click on those words, the `bsched.htm` page would appear.

You can find some excellent resources on HTML at the World Wide Web Consortium ([www.w3.org](http://www.w3.org)) and Html Goodies ([www.htmlgoodies.com/](http://www.htmlgoodies.com/)).

## Browsing the Web with Firefox

The Firefox Web browser offers real competition to Microsoft Internet Explorer. Firefox is lightweight (so it performs fast), includes many ease-of-use features, and was built with security as a high priority. If you haven't switched to CentOS yet, you can get Firefox for Windows, Mac OS X, and other Linux systems. With the CentOS distribution that comes with this book, you can try Firefox out right now.

Figure 8-3 shows an example of the Firefox Web browser:

**FIGURE 8-3**

Firefox makes it easy to search, do tabbed browsing, and get plug-ins in a secure way.



Because Firefox is the default browser for CentOS, if you have done an install that includes the desktop, Firefox should already be installed. To start Firefox from your desktop, either select the globe icon from your panel or select Internet ► Firefox Web Browser from the Applications

menu. Firefox makes some of its best features available right in its main window. Here are some examples:

- **Tabbed Browsing** — Instead of opening multiple windows to have several web pages available at a time, Firefox includes a very efficient tabbed browsing feature. Select File > New Tab (or by pressing [Ctrl]+T). Then type the URL for the new web page you want. Figure 8-3 shows the Firefox window with two open browsing tabs. Tab options set from the Preferences window (Edit > Preferences > Tabs) can be set to automatically force new links to be opened in a new tab or open links from other applications in a new tab. This can help preserve screen real estate by containing multiple web pages in one window.

To close a tab, open a new tab, bookmark one or a group of tabs, or reload one or all tabs, right-click on one of the tabs at the top of the pane. A dropdown menu enables you to choose the function you want. One of the easiest ways to open a link in a tab is to right-click over a link on an HTML page. Select the “Open Link in New Tab” choice. Clicking on the middle button on a three-button mouse will open a link in a new tab.

- **Live Bookmarks** — For web sites that have RSS news and blog headlines available, a small RSS logo icon appears in the location box. Using that icon, you can bookmark the advertised RSS feed so that live headlines from that site can be displayed from your Bookmarks menu.

Try a site such as <http://slashdot.org>. Click on the RSS button. When prompted, choose to “Subscribe Now to Live Bookmarks” for the site. Select Bookmarks, and then select the new bookmark. To the right of the bookmark, a list of articles available today from the site appears. You can click to go straight to an article that looks interesting to you. Or, you can choose “Open in Tabs” to open all the articles in separate tabs.

**NOTE**

If you visit a web site that you know is an RSS site, but the headlines you want appear in XML code, it means that the page is not identifying itself to Firefox as an RSS site.

You can add a Live Bookmark for the site anyway by selecting Bookmarks > Subscribe to This Page. If Firefox recognizes the site as an RSS feed, it will display a “Subscribe Now” button at the top of the page. If this does not work, add the site as a normal bookmark. From the Library screen, select File > New Bookmark. When prompted, enter a name for the live bookmark, and then type (or cut and paste) the location of the RSS page into the “Feed Location” box and click OK. That new live bookmark, and today’s articles from that site, will appear on your Bookmarks list.

- **Using the Sidebar** — Select View > Sidebar to choose to have Bookmarks or History appear as a sidebar in the Firefox window. Add your own bookmarks, return to pages from your history list, or use the Search box to search for content from those lists. Type [Ctrl]+B and [Ctrl]+H to toggle on and off Bookmarks and History sidebars, respectively.
- **Web Searches** — A box for doing keyword searches from Google is built right into the Firefox Navigation toolbar. A dropdown menu lets you choose to search Yahoo!, Answers.com, Creative Commons, Amazon.com, or eBay. Or select “Manage Search

Engines” from the dropdown list to go to the Firefox Search Engines page, where you can choose from more than 20 different search engines.

- **Finding Text** — Click Edit ➤ Find in This Page to open a toolbar at the bottom of the window for searching the current page for a text string. This allows you to search the page for text without having a little pop-up window get in your way. After typing the text string, click “Find Next” or “Find Previous” to search for the string. You can also click Highlight to highlight all instances of the string on the page. As a shorthand, type a forward slash character (/) to display the Find toolbar.
- **Resizing text on Web Page** — There is a nice keyboard shortcut that lets you quickly resize the text on most web pages in Firefox. Hold the [Ctrl] key and press the plus (+) or minus (–) keys. The text on the web page (in most cases) gets larger or smaller, respectively. That page with the insanely small type font is suddenly readable. (Remember to hold the [Shift] key to type a + character.) To set the size back to 100 percent again, hold the [Ctrl] key and press 0 (zero).
- **Checking History** — Select History ➤ Show All History to have the History appear on the Library screen. From that window, you can do keyword searches for sites you have visited, display the site names you have visited in various ways (by date, site name, most visited, and last visited), and browse through and select to revisit a site.

Some of the best features in Firefox are not as near the surface. In particular, Firefox was designed for safe computing, so Firefox is very careful about what it will and will not allow by default. Here are some important features of Firefox that can contribute to safe and fun Web browsing:

- **Blocking Pop-Ups** — In Firefox, pop-up windows are blocked by default. To see or change how pop-ups are handled from Firefox, select Edit ➤ Preferences and select Content. The Block Pop-ups Windows option is either selected (to block pop-ups) or unselected (to allow them). If pop-ups are blocked, you can select Exceptions to add selected sites from which you will allow pop-ups. You can add additional restrictions to JavaScript code in web pages by clicking on the Advanced button associated with the “Enable JavaScript” checkbox.
- **Advanced Security Features** — With Firefox, you have a lot of control over what content can be played and what software can be downloaded to your computer. You can view or change many security features from the Preferences window (select Edit ➤ Preferences). The Content tab lets you choose to enable Java or JavaScript, load images, or block pop-up windows. The Privacy tab lets you manage cookies, passwords, history, and cache information.

If you have been using Firefox for a while but are new to Firefox 3, there are many new features that you may find interesting. Inside Firefox 3 is the new Gecko 1.9 Web rendering platform, with thousands of features to improve performance, rendering, and stability. You should notice improvements in color management and fonts.

One improvement that connects you to several new features in Firefox 3 is the Location box. Figure 8-4 shows two Location box examples that illustrate new ways of dealing with the web sites you request.

**FIGURE 8-4**

Verify sites and work with bookmarks from the Location box.



In Figure 8-4, the upper example shows what happens when you click on the icon on the left side of the Location box when visiting a secured site. You can see that Equifax verifies the authenticity of the site and that communications are encrypted. By selecting the star on the right side, you can work with bookmark information for a page and modify that information. Other icons that might appear in the Location box include a variety of security warnings, such as warnings for possible forged or dangerous content.

Go to the Mozilla Firefox site ([www.mozilla.org/products/firefox](http://www.mozilla.org/products/firefox)) for more information on Firefox. For help transitioning from Internet Explorer to Firefox, see the Firefox site at [www.mozilla.org/products/firefox/switch.html](http://www.mozilla.org/products/firefox/switch.html).

## Setting Up Firefox

There are many things you can do to configure Firefox to run like a champ. The following sections describe some ways to customize your browsing experience in Firefox.

## Setting Navigator Preferences

You can set your Firefox preferences in the Preferences window. To open Firefox Preferences, click Edit > Preferences. The Preferences window appears, as shown in Figure 8-5.

**FIGURE 8-5**

Change settings for navigating the Web from the Firefox Preferences window.



The following list shows some preferences that you might want to change from the Firefox Preferences window:

- **Choosing a Home Page** — To choose a home page from the Main tab, you can simply type a URL in the Location box. It can be a local file (`file://`) or a web page (`http://`). You can also have multiple home pages, with each appearing on a separate tab when Firefox starts, by separating URLs with a pipe (e.g., `http://linuxtoys.net|http://www.centos.org`).

To fill in your home page locations, you can also select buttons. “Use Current Page” adds the current pages on all tabs of your browser as your home pages. The “Use Bookmark” button lets you choose home pages from your Bookmarks list. Selecting “Use Blank Page” sets your home page to `about:blank`.

- **Saving Browsing Information** — Select the Privacy tab to choose how information about your Web browsing is saved. On the Privacy tab, you can choose how to save data related to your browsing history — data you enter into forms, passwords, downloaded files, and cookies. You can select to clear your history, forms data, passwords, download history, cookies, and cached web pages. Clearing this information is a good idea if you are using Firefox on someone else’s machine and want to keep your browsing private.
- **Setting Languages** — Set a list of preferences for the particular language a web page should be displayed in, if the page is available in several languages, by selecting the Content category and selecting the Choose button under Languages.
- **Blocking or Enabling Content** — Some content you encounter can be annoying or even dangerous to play or display from your browser. From the Content tab, select what to allow and block in regard to pop-up windows, sites trying to install extensions or themes, image display, and JavaScript content. You can also set exceptions to the general rules you set for handling the content just mentioned. There are numerous Firefox extensions you can use to aid in blocking content as well.

**NOTE**

The latest Firefox release helps you block forged web sites by displaying a “Suspected Web Forgery” pop-up message when Firefox encounters a page that has been reported as forged. You can choose to not display the page or ignore the warning. If you suspect a forged page that doesn’t display that message, select Help > Report Web Forgery to try to add the page to the Google Web Forgery list.

- **Defining Tabbed Browsing** — Use selections on the Tabs tab to determine how tabs are used when opening new content or closing the browser.
- **Download Manager and Folder** — Choose whether or not to see a download manager when file downloads are being done. Also, you can choose to either be asked where to place each file chosen to download or select a default folder to automatically download your files. Select “View & Edit Actions” to configure what actions to take.

The Advanced Preferences tab can be used to fine-tune your Web browsing experience. Here are some Advanced Preferences that might interest you:

- **General Settings** — Some settings on the General tab in the Advanced section let you change accessibility settings, browsing features (such as auto resizing of windows and scrolling) and system defaults.
- **Choosing Connection Settings** — If you have direct access to the Internet, you don’t need to change any proxy settings. However, if you need to access the Internet via a proxy server, you can identify the location of that server (or servers) by selecting Network > Connection Settings from the Advanced tab. To access the Web via proxy servers, you must explicitly identify the proxy server to use for each type of content you request (HTTP, SSL, FTP, Gopher, and SOCKS).
- **Get Browser Updates** — From the Update tab, Firefox can be set to automatically check for updates available for the search engine or installed extensions and themes. Select Show Update History to see a history of updates you have installed for Firefox.

- **Choose Security Settings** — From the Encryption tab of the Advanced section, choose which protocols (SSL and TLS) are acceptable for Firefox to use for secure browsing. There is also a Certificates section that lets you manage certificates to verify the authenticity of secure sites or authenticate yourself to remote sites. (See the “Securing Firefox” section for further information on securing Web browsing with Firefox.)

## Extending Firefox

Firefox can handle most standard Web content (HTML, JPEG, text files) without any trouble. As with any browser, however, some content requires additions of plug-ins or helper applications to be able to play or display that content. Firefox also allows you to add extensions that let you enhance the features available in Firefox.

## Using Plug-Ins

From Firefox, you can see what plug-ins are installed to Firefox by typing **about:plugins** in the location bar. As Firefox is delivered in CentOS systems, you will have at least a NPAPI plug-ins wrapper installed by default. The NPAPI plug-in allows you to use some plug-ins that were not built for Linux.

To find plug-ins that will work for Firefox in Linux systems, try the Mozilla Plugins page (<http://plugindoc.mozdev.org/linux.html>). Here are a few plug-ins that you might want to add to Firefox:

- **Adobe Acrobat Plug-In** ([www.adobe.com/support/downloads](http://www.adobe.com/support/downloads)) — Displays files in the Adobe Systems PDF (Portable Document Format) format. (Without this plug-in installed, Firefox will use the `evince` command to display PDF files in a separate window.)
- **DjVu Plug-In** (<http://djvu.sourceforge.net>) — Displays images in DjVu image compression technology. This plug-in is from AT&T.
- **Adobe Flash Player** ([www.adobe.com/products/flashplayer](http://www.adobe.com/products/flashplayer)) — With the explosion of YouTube and other sites carrying Flash video content, the Adobe Flash Player has become indispensable on desktop systems. Type **yum install mozilla-swfdec** to install the Open Source `swfdec` package to play Flash content in CentOS.

However, if you have problems playing Flash with `mozilla-swfdec` (as some have), you can uninstall that package and get an official (non-Open Source) Flash player directly from Adobe. Follow the links from the Adobe Flash Player site to find the Linux plug-in you need. I recommend the `yum` version, which will install the plug-in and make automatic updates of the flash player as they are available.

- **MPlayer Plug-In** (<http://mplayerplug-in.sourceforge.net>) — This plug-in implements the popular MPlayer video player to play embedded video content in the browser window. An RPM package of this plug-in (`mplayerplug-in`) is available.
- **CrossOver Plugin** ([www.codeweavers.com](http://www.codeweavers.com)) — Linux plug-ins are not yet available for some of the more interesting and popular plug-ins. QuickTime 5 movies;



Shockwave Director multimedia content; and various Microsoft movie, file, and data formats simply will not play natively in Firefox. Using software built on WINE for Linux on x86-based processors, CodeWeavers created the CrossOver Plugin. Although no longer offered as a separate product (you must buy the entire Crossover Office product for US\$39.95), the CrossOver Plugin lets you play some content that you could not otherwise use in Linux. (Download a demo from [www.codeweavers.com/site/products/download\\_trial](http://www.codeweavers.com/site/products/download_trial).)

After you install the CrossOver Plugin, you see a nice Plugin Setup window that enables you to selectively install plug-ins for QuickTime, Windows Media Player, Shockwave, Flash, iTunes, and Lotus Notes, as well as Microsoft Word, Excel, and PowerPoint viewers. (Support for later versions of these content formats may be available by the time you read this.) You can also install other multimedia plug-ins, as well as a variety of fonts to use with those plug-ins.

For some plug-ins, you will be prompted for where you want to put the plug-in. You can either install them so they are available to all users on the system or only to the current user. To add a plug-in for the current user only, place it in the `~/mozilla/plugins` directory. To have the plug-in available for all users who run Firefox on the system, put the plug-in in the `/usr/lib/mozilla/plugins` directory.

**NOTE**

When Firefox doesn't have a plug-in assigned to handle a particular data type, a pop-up window asks if you want to use the default application from your desktop environment to handle the data. For GNOME, the `/usr/share/applications/defaults.list` file defines system-wide default applications. For your own desktop, you can change the defaults used to open a particular file type as follows: Open the Nautilus File Manager; right-click on any file of the type you want to change; select Properties; select the "Open With" tab; and choose the application you want to use for that file type from the list. If the application you want to add is not on the list, click Add to add it to the list.

While plug-ins are available for playing select types of content, add-ons can be used to add features to the browser itself.

### Getting Add-Ons

To extend Firefox to handle content beyond what is delivered with CentOS, start from the Mozilla.org Firefox product page ([www.mozilla.com/en-US/firefox/](http://www.mozilla.com/en-US/firefox/)). From there, follow links to Firefox Add-ons. Here are some of the most popular add-ons to Firefox that are available from Mozilla.org:

**NOTE**

Some Firefox add-ons have been known to cause performance problems with Firefox, primarily from using excessive amounts of memory. If you are having poor performance with Firefox, close all Firefox windows, then restart Firefox in safe mode from a Terminal window by typing the following: **firefox -safe-mode**.

Refer to [http://kb.mozillazine.org/Safe\\_Mode](http://kb.mozillazine.org/Safe_Mode) for further information on using safe mode to debug Firefox problems.

- **Downloading Tool (FlashGot)** — If you like to download groups of files from your Web browser, FlashGot can be a very useful tool. With FlashGot installed, you can select to download an individual file, files identified by highlighting links on a web page, or all files linked from the current web page. There is also a Build Gallery feature that lets you identify a range of filenames to download at once. When FlashGot is installed, you can access it from Firefox by selecting Tools > FlashGot and then choosing a feature from the menu. In CentOS, FlashGot passes requests to KGet to complete the download. You can get other download tools to use instead of KGet, such as Wget.
- **Selectively Block Ads (Adblock Plus)** — Using Adblock Plus, you can selectively prevent ads from being displayed on the web pages you visit. With Adblock Plus installed, an Adblock Plus button appears on the upper-right corner of Firefox. Click on that button to see a window containing items on the current page you want to block. Right-click on an image and select “Adblock Image” to choose to block that image. Use an asterisk to block all content from a particular site (e.g., `www.example.com/*`). Open the Adblock Preferences window from Firefox (Tools > Adblock > Preferences) to see, edit, or remove blocked sites.
- **Access FTP Servers (FireFTP)** — Contains a useful client application that runs in Firefox for accessing with FTP servers. There is also a FireFTP button add-on for accessing FireFTP from the toolbar.
- **Block Flash Animations (Flashblock)** — Prevents Flash animations from playing in your Firefox browser window. Can be particularly useful for dial-up users who don’t want to take a performance hit when a visited site tries to play unrequested Flash content.
- **Improve Tab Browsing (Tabbrowser Preferences)** — Although Firefox already gives you some nice features for using tabs to keep multiple web pages open in the same Firefox window, Tabbrowser Preferences takes those features a step further. Select Edit > Preferences > Tabbed Browsing. The Tabbed Browsing selections let you refine how tabs work in Firefox. You can set what motion selects tabs (such as mouse-over as opposed to clicking), put tabs on the bottom instead of the top, or choose whether or not to load the home page in a new tab.
- **Watch Your Weather (ForecastFox)** — With ForecastFox, the latest weather for any region you select can be just a click away in Firefox. After you install ForecastFox and restart Firefox, a pop-up window enables you to configure ForecastFox options. Select at least Find Code, to choose the area in which you want to keep up on weather. Save your options, and a weather icon appears in the lower-right corner of Firefox. Move your mouse over that icon to see a quick view of the current weather. Double-click on the icon to have a more detailed weather report displayed from `www.weather.com`.

After you have installed an add-on, you need to restart Firefox for it to take effect. In some cases, a change to an add-on’s option will also require you to restart Firefox.

If you want to uninstall an add-on, change an add-on’s options, or get more add-ons, select Tools > Add-ons from Firefox. The window that appears shows you a list of installed add-ons and lets you change them. Select “Browse All Add-ons” to go directly to the Mozilla Firefox Add-ons page.

**NOTE**

On the Firefox Add-ons page, look for the Firefox Extensions RSS feed (an orange-striped icon in the Location box). You can use that RSS feed to be notified when new Firefox Add-ons become available.

## Changing Firefox Themes

There are several themes available for Firefox for changing the look and feel of your Firefox window. From the Mozilla update site (<https://addons.mozilla.org>), select Themes. When you download a theme for Firefox, it knows that it is a Firefox theme and, on the Download window, it gives you the option to install the theme by clicking on the “Use Theme” button.

To change a theme later or get more themes, select Tools > Add-ons > Themes. After you have installed a new theme and selected it as your current theme, you need to restart Firefox for the new theme to take effect. From the dialog window, you can click on the “Get More Themes” link to download other themes. The link takes you to the Mozilla update site.

## Securing Firefox

Security has been one of the strongest reasons for people to switch to Firefox. By prohibiting the most unsafe types of content from playing in Firefox and by warning you of potentially dangerous or annoying content before displaying it, Firefox has become the Web browser of choice for many security-conscious people. Here are some ways that Firefox helps make your Web browsing more secure:

- **ActiveX** — Because of major security flaws found in ActiveX, Firefox will simply not play ActiveX content. If you absolutely must be able to play ActiveX content, a plug-in is in development to provide controlled support for ActiveX. Follow the progress of this project at the Mozilla ActiveX Project home page ([www.iol.ie/~locka/mozilla/mozilla.htm](http://www.iol.ie/~locka/mozilla/mozilla.htm)). I don't recommend doing this, but it's up to you.
- **Pop-Ups** — Pop-up windows are disabled by default in Firefox. You can set preferences to enable all pop-ups or to enable only pop-ups from selected sites.
- **Privacy Preferences** — From the Privacy window in Firefox (select Edit > Preferences, and then click on the Privacy button), you can clear different categories of stored private information from your browser in a single click. This is a particularly good feature if you have just used a computer that is not yours to browse the Web. You can select to individually clear your History, information saved in forms you might have filled in, any passwords saved by the browser, history of what you have downloaded, cookies, and cached files. If you want all private data cleared, click on the Settings button, choose the categories you want cleared, and select OK. You could also select “Clear private data when closing Firefox” to have all data cleared when you exit Firefox.
- **Certificates** — In Firefox, you can install and manage certificates that can be used for validating a web site and safely performing encryption of communications to that site. Using the Preferences window (select Edit > Preferences, and then click on the Security button),

you can manage certificates under the Encryption Tab. Select “View Certificates” to display a window that lets you import new certificates or view certificates that are already installed. Firefox will check that certificates you encounter are valid (and warn you if they are not). See Chapter 13 for more information on using certificates.

Along with all the excellent security features built into Firefox, it’s important that you incorporate good security practices in your Web browsing. Download and install software only from sites that are secure and known to you to be safe. For any online transactions, make sure that you are communicating with a secure site (look for the `https` protocol in the location box and closed lock icon in the lower-right corner of the screen). Be careful about being re-directed to another web site when doing a financial transaction. An IP address in the site’s address or misspellings on a screen where you enter credit card information are warning signs that you may have been directed to an untrustworthy site.

Because new exploits are being discovered all the time, it’s important that you keep your Web browser up-to-date. That means that, at least, you need to get updates of Firefox from the CentOS project as they become available (see Chapter 5 for information on using `yum` to get the latest software). To keep up on the latest security news and information about Firefox and other Mozilla products, refer to the Mozilla Security Center ([www.mozilla.org/security](http://www.mozilla.org/security)).

## Tips for Using Firefox

There are so many nice features in Firefox, it’s hard to cover all of them. Just to point you toward a few more fun and useful features, here are some extra tips about Firefox you might enjoy:

- **Add Smart Keywords** — Many web sites include their own search boxes to allow you to look for information on their sites. With Firefox, you can assign a smart keyword to any search box on the Web, and then use that keyword from the Location bar in the Firefox browser to search that site.

For example, go to the Linux Documentation Project site (<http://tldp.org>). Right-click in the Search/Resources search box. Select “Add a Keyword for this Search” from the menu that appears. Add a name (**Linux Documentation**) and a keyword (**tldp**), and select Add to add the keyword to your Bookmarks.

After you have added the keyword, you can use it by simply entering the keyword and one or more search terms to the Firefox Location box (on the Navigation toolbar). For example, I entered **tldp Lego Mindstorms** and came up with a list of how-tos for using Lego Mindstorms in Linux. This list comes as if you had visited the site and typed in the text **Lego Mindstorms** into the search box on that site.

- **Check Config** — Firefox has hundreds of configuration preferences available to set as you please. You can see those options by typing **about:config** into the Location box. For true/false options, you can simply click the preference name to toggle it between the two values. For other preferences, click on the preference to enter a value into a pop-up box. While many of these values can be changed through the Preferences menu (Edit ► Preferences), some technical people prefer to look at settings in a list like the one shown on the `about:config` page. The `about:buildconfig` page lists the options used to build Firefox.

- **Multiple Home Pages** — Instead of just having one home page, you can have a whole set of home pages. When you start Firefox, a separate tab will open in the Firefox window for each address you identify in your home page list. To do this, create multiple tabs (File > New Tab) and enter the address for each page you want in your list of home pages. Then select Edit > Preferences > Main and click on the “Use Current Pages” button. The next time you open Firefox, it will start with the selected tabs open to the home pages you chose. (Clicking on the Home icon will open new tabs for all the home pages.)

There are many more things you can do with Firefox than I have covered in this chapter. If you have questions about Firefox features or you just want to dig up some more cool stuff about Firefox, I recommend checking out the MozillaZine forum for Firefox support (<http://forums.mozillazine.org/viewforum.php?f=38>). There is a sticky link there to Miscellaneous Firefox Tips and a good FAQ post.

## Using Text-Based Web Browsers

If you become a Linux administrator or power user, over time you will inevitably find yourself working on a computer from a remote login or where there is no desktop GUI available. At some point while you are in that state, you will probably want to check an HTML file or a web page. To solve the problem, CentOS includes several text-based Web browsers.

With text-based Web browsers, any HTML file available from the Web, your local file system, or a computer where you’re remotely logged in can be accessed from your shell. There’s no need to fire up your GUI or read pages of HTML markup if you just want to take a peek at the contents of a web page. Besides letting you call up web pages, move around those pages, and follow links to other pages, some of these text-based browsers even display graphics right in a Terminal window!

Which text-based browser you use is a matter of which you are more comfortable with. Browsers that are available include:

- **Links** — With Links (eLinks package), you can open a file or a URL, and then traverse links from the pages you open. Use search forward (*/string*) and back (*?string*) features to find text strings in pages. Use up and down arrows to go forward and back among links. Then press [Enter] to go to the current link. Use the right and left arrow keys to go forward and back among pages you have visited. Press [Esc] to see a menu bar of features to select from.

While Links doesn’t allow you to display images inline, if you select an image, it will be displayed on your desktop in the gThumb image viewer (by default). You also have the option of saving the image to your local hard disk.

- **Lynx** — The Lynx browser has a good set of Help files that come with it (press the ? key). Step through pages using the Spacebar. Although Lynx can display pages containing frames, it cannot display them in the intended positioning. Use the arrow keys to display

the selected link (right arrow), go back to the previous document (left arrow), select the previous link (up arrow), and select the next link (down arrow).

As with Links, Lynx lets you display a selected image. However, lynx uses ImageMagick instead of gThumb to display the image you choose.

- **w3m** — The w3m text-based Web browser can display HTML pages containing text, links, frames, and tables. It even tries to display images (that feature has improved a lot in recent releases). There are both English and Japanese Help files available (press **H** with w3m running). You can also use w3m to page through an HTML document in plaintext (e.g., `cat index.html | w3m -T text/html`). Use the [Page Up] and [Page Down] keys to page through a document. Press [Enter] on a link to go to that link. Press the **B** key to go back to the previous link. Search forward and back for text using **/** and **?** keys, respectively.

**NOTE**

You must install the `elinks` package to get Links, the `lynx` package to get Lynx, and the `w3m` package to get w3m. All of them are included with CentOS.

The w3m command seems the most sophisticated of these browsers. It features a nice default font selection and seems to handle frames neatly, and its use of colors also makes it easy to use. The Links browser lets you use the mouse to cut and paste text.

You can start any of these text-based Web browsers by giving it a filename, or if you have an active connection to the network, a web address. For example, to read the w3m documentation (which is in HTML format) with a w3m browser, you can type the following from a Terminal window or other shell interface:

```
$ w3m /usr/share/doc/w3m-0*/doc/MANUAL.html
```

An HTML version of the *W3M Manual* is displayed, or you can give w3m a URL to a web page, such as the following:

```
$ w3m www.handsonhistory.com
```

After a page is open, you can begin viewing the page and moving around to links included in the page. Start by using the arrow keys to move around and select links. Use the [Page Up] and [Page Down] keys to page through text.

## Communicating with E-Mail

---

Running a close second to Web browsers is the e-mail reader (referred to in network standards terms as a *Mail User Agent*, or *MUA*). Evolution is the recommended e-mail client for CentOS. However, Mozilla Thunderbird is the new kid on the block of e-mail clients.

Other e-mail options include the Sylpheed mail client and the KDE KMail program. There's also a groupware application that comes with KDE called Kontact that includes an e-mail client. Mail

programs that have been around in Linux and other UNIX systems since the time when most mail was plaintext include mutt, pine, and mail. In other words, there is no shortage of choices for e-mail clients in Linux.

Here are some pros and cons for different e-mail clients that are available for CentOS:

- **Evolution** — This is a full-featured e-mail client that also includes ways of managing your contacts, calendars, and tasks. Because it is so easy to use and rich in features, it provides one of the best ways to transition from Windows e-mail clients (such as Outlook). There are also features in Evolution for connecting to Microsoft Exchange and Novell GroupWise servers. The complaint I hear most often about Evolution is that it demands a lot of resources. So, with slow-processor and low-RAM systems, you would probably find other e-mail clients less frustrating to use over time.
- **Thunderbird** — As with Firefox in the browser arena, Thunderbird is the flagship mail client from the Mozilla project. It was designed from the ground up to be secure, fast, and loaded with important features. It also has versions available on Windows and Mac OS X, so you can use the same mail client on different platforms. Not much on the downside here: Because it is fairly new, they are still shaking out some of the bugs in Thunderbird. Also, it doesn't include a lot of the groupware features you get in Evolution. (However, you can check out the Calendar feature in the Thunderbird section of this chapter.)
- **KMail** — People who become frustrated with Evolution performance seem to often switch to KMail. Because KMail is a KDE desktop project, it integrates particularly well with the KDE desktop environment. However, many people insist that KMail runs well in GNOME, too. The look-and-feel is similar to Evolution (folders in the left column and message headers and message to the right). As with Evolution, KMail can easily integrate with clamav (antivirus software) and SpamAssassin (e-mail spam-checker software).
- **Sylpheed** — The Sylpheed mail client is good for low-end computers, where you still want to use a graphical mail client. Sylpheed is used on bootable business card Linux systems, such as Damn Small Linux. You can install Sylpheed simply by typing `yum install sylpheed`.
- **Text-Based Mail** — Many technical people who often work from the command line prefer to use a text-based mail reader as well. That way, they can do remote shell login or just not even fire up a GUI to read their mail. The mutt e-mail client will run in a shell, handle some more modern features well (such as attachments), and beat out any graphical e-mail client for performance by a wide margin. The downside is that the learning curve is bigger than you will have with point-and-click interfaces.

After covering some e-mail basics, this section leads you through the steps that allow you to use e-mail with Evolution and Thunderbird. If you are interested in text-based, command-driven mail tools, some of which have been around UNIX systems for many years, you will also find descriptions of many of those commands in this section.

## E-Mail Basics

E-mail is one of the oldest uses of computer networks — pre-dating the Web by more than 20 years. In fact, e-mail was one of the first applications used to transport information on the Internet, when the Internet consisted of only a few computers.

Today, there are millions of users around the world who have e-mail addresses. Although there are several different styles of e-mail addressing, by far the most popular e-mail address format is the domain style address (used with the Internet and other TCP/IP networks). The e-mail address consists of a username and domain name, separated by an @ sign. For example:

```
webmaster@handsonhistory.com
```

As someone using e-mail, you need an e-mail client (such as Evolution) that enables you to get your e-mail, manage your e-mail messages, and send messages. Although mail messages were originally only plaintext, and still are in most cases today, there are some newer features that let you enhance the kinds of content that you can send and receive, such as:

- **Attachments** — You can attach files to your mail messages. Attachments can contain data that you couldn't ordinarily keep in a mail message, such as a binary program, a word processing file, or an image. The recipient of the mail attachment can either save the file to a local hard disk or open it in a program designed to read the attachment.
- **HTML** — The same stuff used to create web pages can be included in mail messages you create with certain mail clients (including Evolution). This enables you to change fonts and colors, add backgrounds, insert images, or add HTML features.

### CAUTION

To people who use text-based mail clients, HTML content can't be interpreted (it shows up as a bunch of markers that overwhelm the text). In general, don't use HTML in messages that are being distributed to a large group of people (such as in a mailing list).

Also, e-mail was never intended to transport large attachments. For larger files, try copying to an FTP site instead of sending e-mail attachments.

Depending on the e-mail client you are using, e-mail management features let you direct incoming e-mail into different folders and sort messages by date, sender, or other attributes. E-mail sending features let you reply to messages, forward messages, and draw names from an address book or directory server.

### CROSS-REF

If you don't have an e-mail account, you can set up your own e-mail server using CentOS. For information on setting up a mail server, see Chapter 18.

If you want to change your default e-mail application from Evolution, select System > Preferences > Preferred Applications. When the Preferred Applications window appears, select your desired mail program in the Mail Reader section.



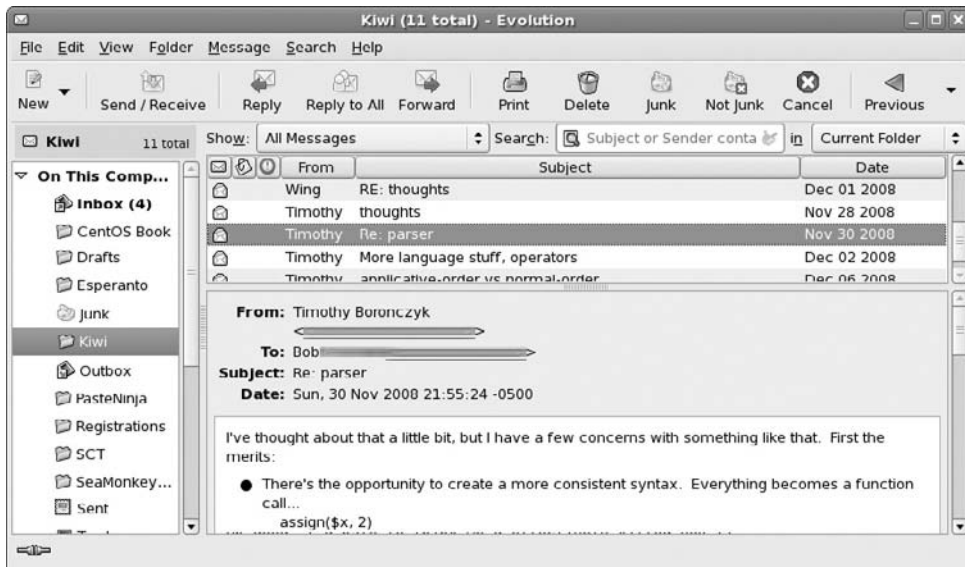
## Using Evolution E-Mail

Evolution is the preferred application for sending and managing e-mail on the default GNOME desktop for CentOS. CentOS developers gave it a prime spot on the desktop, just to the right of the System menu and Web browser icon. After you launch Evolution for the first time and run the Startup Assistant, the Evolution window appears, showing the different types of operations you can perform.

Figure 8-6 shows an example of the Evolution window.

**FIGURE 8-6**

Evolution can be used to manage your e-mail, appointments, and tasks.



Evolution is a groupware application, combining several types of applications that help groups of people communicate and work together. The features of Evolution include:

- **Mail** — Includes a complete set of features for getting, reading, managing, composing, and sending e-mail on one or more e-mail accounts.
- **Calendars** — Create and manage appointments on your personal calendar. You can e-mail appointment information to others and do keyword searches of your calendar.
- **Contacts** — Create contact information for friends and associates, such as names, addresses, and telephone numbers. A Categories feature helps you remember who gets birthday and anniversary gifts.

- **Tasks** — Organize ongoing tasks into folders.
- **Exchange** — Connects to an exchange server. If your organization gets its mail from an Exchange server, the Evolution Connector software (included with this version of Evolution) lets you configure this e-mail client to access that server.

In the next section, I focus on the Preferences and e-mail features of Evolution.

## Setting Evolution Preferences

To really make Evolution your own, you can set preferences that are particular to you, such as how your e-mail is gathered and sorted. You can change Mail Accounts settings by performing the following steps:

1. From the Evolution main window, select Edit ➤ Preferences.
2. Click “Mail Accounts” in the left column.
3. Select the mail account to change and click Edit. The Evolution Account Editor appears.
4. Here are a few items you may want to change for your e-mail account:
  - **Signature** — Have a signature appear on every e-mail message you send. Either click on the Default signature box and select Autogenerated (to use name and e-mail address as a signature) or click “Add New Signature” to create a signature in a text editor.
  - **Receiving Options** — By default, Evolution doesn’t check your mail server for your messages unless you ask it to. You can change that by clicking the “Automatically check for new mail every” box on the Receiving Options tab, to have Evolution check your mail server for your mail every 10 minutes. Once downloaded, each message is erased from the server. Select “Leave messages on server” to change that behavior.
  - **Automatic Copy** — You can have every message you send copied to one or more other users. This is a nice feature if you write important e-mail that you want to archive to a different e-mail account. Select the Defaults tab, and then click on the checkbox next to “Always Cc” or “Always Bcc.” Next, type the correct e-mail address.
  - **Security** — To help validate that you are who you say you are and keep your e-mail private, Evolution lets you use PGP/GPG (Pretty Good Privacy/GNU Privacy Guard) encryption keys. Click on the Security tab, and then enter your PGP/GPG Key ID. Choose settings for signing and encryption as appropriate.
5. Click OK to apply the changes.

## Receiving, Composing, and Sending E-Mail

Evolution offers a full set of features for sending, receiving, and managing your e-mail. The folder bar in the left part of the Evolution window makes it easy to create and use multiple mail folders.

Here are some tips for sending, reading, and receiving mail:

- **Read E-Mail** — Click Inbox in the Folder column. Your messages appear to the right.

- **Delete E-Mail** — After you have read a message, select it and press the [Delete] key. Click View ► Hide Deleted Messages to toggle whether or not you see deleted messages. Click Actions ► Expunge to permanently remove all messages marked for deletion in the current folder.
- **Send and Receive** — Click on the Send/Receive button to send any e-mail queued to be sent and receive any e-mail waiting for you at your mail server.
- **Compose E-Mail** — Click New ► Mail Message (or click on the New button in the toolbar). A “Compose a Message” window appears. Type the e-mail address, a message for the subject line, and the body of the message. Click Send when you are finished. Buttons on the Compose window let you add attachments, cut and paste text, choose a format (HTML or plaintext), and sign the message (if you have set up appropriate keys).
- **Create Folders** — If you like to keep old messages, you may want to save them outside your Inbox (so it won't get too crowded). Right-click on the Inbox, and then select “New Folder.” Type a folder name and click OK (to store it as a subfolder to your Inbox).
- **Sort Messages** — With new folders created, you can easily sort messages from your Inbox to another folder. The easiest way is to simply drag-and-drop each message (or a set of selected messages) from the message pane to the new folder.
- **Search Messages** — With your Inbox or other mail folder selected, type a keyword in the search box over your e-mail message pane and select whether to search your message subject lines, sender, recipient, or message body. Click “Find Now” to search for the keyword. After viewing the messages, click Clear to have the other messages reappear.
- **Filter Messages** — You can take action on an e-mail message before it even lands in your Inbox. Click Message ► Create Rule. A menu appears that lets you add filters to deal with incoming or outgoing messages. Select the type of filter you want. For example, you could have all messages from a particular sender, subject, date, status, or size sorted to a selected folder. Or you could have messages matching your criteria deleted, assigned a color, or respond by playing a sound clip.

**CROSS-REF** Refer to Chapter 18 for information on using SpamAssassin, along with Evolution filters, to sort out spam from your real e-mail messages. Evolution also includes built-in junk e-mail filtering, using Bayesian statistical analysis.

Besides the features mentioned in the previous sections, Evolution supports many common features, such as printing, saving, and viewing e-mail messages in various ways. The Help system that comes with Evolution (click on the Help button) includes a good manual, FAQ, and service for reporting bugs.

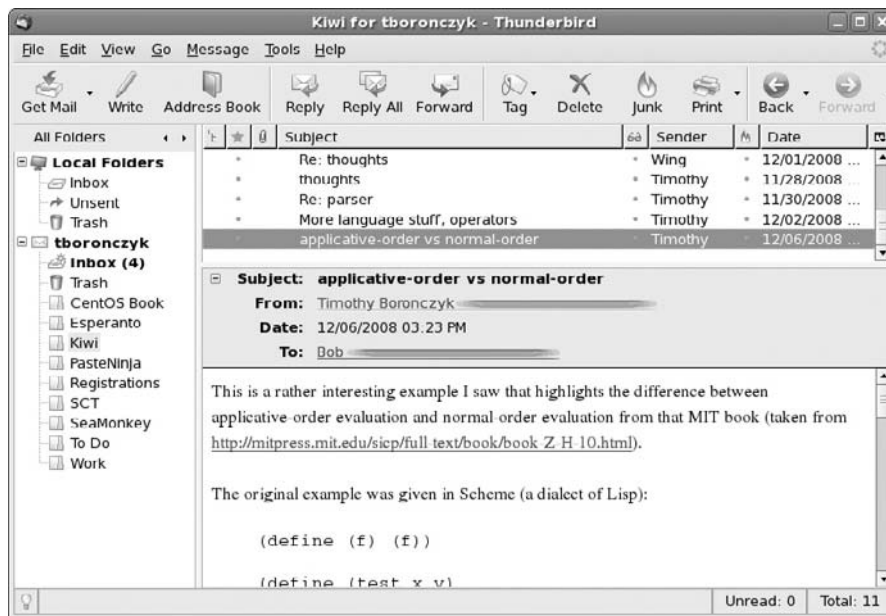
## Thunderbird Mail Client

As a companion to its Firefox Web browser, the Mozilla project created the Thunderbird e-mail client. If you installed Thunderbird (type **yum install thunderbird**), you can launch it from your Applications menu by selecting Internet ► Thunderbird Email.

The first time you run Thunderbird, an Import Wizard opens, allowing you to import preferences, account settings, address books, and other data from other e-mail clients. Have information about your e-mail account (username, incoming and outgoing servers, etc.) ready so that you can enter it before Thunderbird starts up. Figure 8-7 shows an example of the Thunderbird window.

**FIGURE 8-7**

Thunderbird is an efficient e-mail client that includes advanced junk mail and message filtering.



In many ways, the layout and selections in the Thunderbird client are similar to those in Evolution. In general, however, Thunderbird seems to offer better performance than Evolution. Here are some features of Thunderbird that may interest you:

- **Display Threads** — Click on a small callout icon (such as a cartoon speech bubble) in the Thunderbird message pane. Then, instead of simply sorting your messages by date, subject, or sender, messages are sorted by threads (so all messages created in response to a message are sorted together).
- **Junk Mail Controls** — Select **Edit** > **Preferences** and click on the **Privacy** tab to configure how Thunderbird deals with messages that appear to be junk mail. From the Preferences window, select to **Delete** or “**Move to the Junk folder**” any messages you mark as junk mail. To manage your junk mail, click in the junk mail column (a circle with a line through it) next to a message that comes into your mailbox that is junk mail. By marking

messages as junk mail, you can train Thunderbird's adaptive junk mail filter to learn when a message is junk mail and mark new messages that come in as such. Select Tools ► Run Junk Mail Controls on Folder to apply junk mail filtering to the current folder.

- **HTML Messages** — You have the option to create HTML markup in the mail messages you compose. When you write a mail message, from the Compose window you can choose what type of text to use, change font sizes, add bullets or numbers, set text justification, and add emoticons, to name a few features. (Note that in many news groups and mailing lists, you should not use HTML markup because some people like to use text-only mail clients to access those groups.)

After using the Thunderbird e-mail client, the biggest improvement over other graphical e-mail clients I have used is performance. Sorting and searching messages is much faster than I've experienced on other clients. Switching to different mail folders and opening messages also seems to work much faster.

## Text-Based Mail Programs

If you don't mind text-based interfaces or if you are a UNIX person who likes to sort, grep, troff, col, and cat your e-mail, there are still plenty of UNIX-like mail tools around. The mail command itself provides an easy-to-use interface for plaintext messages sent to other users on your UNIX system or on your LAN. There are text-based mail applications, such as the mutt command, that let you handle mail attachments.

Many text-based mail programs have been around for a long time, so they are full of features and have been well debugged. Because they are not used much anymore, however, don't expect them to have the latest spiffy features. As a group, text-based mail clients are not very intuitive. The following sections describe some text-based mail clients.

### TIP

Most of these programs use the value of your \$MAIL environment variable as your local mailbox. Usually, that location is /var/spool/mail/user, where user is your username. To set your \$MAIL so that it points to your Mozilla mailbox (so you can use a text-based mail program or graphical mail client), add the following line to one of your start-up files:

```
export MAIL=$HOME/.thunderbird/*.default/Mail/accountname/Inbox
```

If you usually use Thunderbird for mail, set this variable temporarily to try out some of these mail programs.

## Mail Readers and Managers

The mail readers described in the following sections are text-based and use the entire screen. Although some features are different, menu bars show available options right on the screen.

### Mutt Mail Reader

### NOTE

To use the Mutt mail reader, you must have the mutt software package installed from the DVD that comes with this book or over the network using yum.

The `mutt` command is a text-based, full-screen mail user agent for reading and sending e-mail. The interface is quick and efficient. Type **m** to start the mail program. Click the up and down arrow keys to select from your listed messages. Press [Enter] to see a mail message, and type **i** to return to the Main menu.

The menu bar indicates how to mark messages for deletion or undelete them, save messages to a directory, or reply to a message. Type **m** to compose a new message, and it opens your default editor (for me, `vi`) to create the message. Type **y** to send the message. If you want to read mail without having your fingers leave your keyboard, Mutt is a nice choice. (It even handles attachments!)

### Alpine Mail Reader

The Alpine mail reader is another full-screen mail reader, but it offers many more features than does Mutt. With Alpine, you can manage multiple mail folders. You can also manage newsgroup messages, as well as mail messages. As text-based applications go, Alpine is quite easy to use. It is developed by a group at the University of Washington for use by students on campus, but has become widely used in UNIX and Linux environments.

#### NOTE

The `alpine` package is not distributed with CentOS, but you can get Pine from the EPEL or RPMforge repositories.

Start this mail program by typing **alpine**. The following menu is displayed, from which you can select items by typing the associated letter or using up and down arrows and pressing [Enter]:

```

?  HELP                - Get help using Alpine
C  COMPOSE MESSAGE    - Compose and send a message
I  MESSAGE INDEX      - View messages in current folder
L  FOLDER LIST        - Select a folder to view
A  ADDRESS BOOK       - Update address book
S  SETUP              - Configure Alpine Options
Q  QUIT              - Leave the Alpine program

```

To read your e-mail, select either I or L. Commands are listed along the bottom of the screen and change to suit the content you are viewing. Left (←) and right (→) arrow keys let you step backward and forward among the alpine screens.

### Mail Reader

The `mail` command was the first mail reader for UNIX. It is text-based, but not screen-oriented. Type **mail** and you will see the messages in your mailbox. Because `mail` is not screen-oriented, you just get a prompt after message headings are displayed — you are expected to know what to do next. (You can use the [Enter] key to step through messages.) Type **?** to see which commands are available.

While in `mail`, type **h** to see mail headings again. Simply type a message number to see the message. Type **d#** (replacing # with a message number) to delete a message. To create a new message, type **m**. To respond to a message, type **r#** (replacing # with the message number). Type **man mail** to learn more about the `mail` command.

## Participating in Newsgroups

---

Usenet news is another feature that has been around almost as long as the Internet. Using a newsreader, and even many regular mail readers, you can select from literally thousands of topics and participate in discussions on those topics. To participate, you simply read the messages people have posted to the group, respond to those that you have something to say about, and send your own messages to start a discussion yourself.

To get started, you basically need a newsreader and access to a news server computer. The Thunderbird e-mail client includes support for accessing Usenet accounts. A popular newsreader that comes with CentOS is called Pan.

**TIP**

If you have never used a newsgroup before, check out the news.announce.newusers newsgroup. This newsgroup exists to answer questions from new users.

The Pan newsreader is a graphical application for reading, managing, and interacting with newsgroups. It is particularly adept at displaying attached pictures and downloading binaries. The interface is very intuitive and easy to use. A big benefit of using Pan instead of Thunderbird for accessing newsgroups is that Thunderbird combines and decodes split yEnc posts. You can install the pan package by typing **yum install pan**.

**TIP**

Although Pan was originally designed for the GNOME desktop, GNOME libraries are no longer required to run Pan. For that reason, Pan will now work on KDE, Window Maker, or other desktop environments without any special software.

To open the Pan newsreader, type **pan** from the shell. The first time you start Pan, the Pan Wizard runs to let you set up the newsreader. Have your e-mail address and your news server's name ready. When the Wizard is done, you can download the list of newsgroups available from your news server.

## Instant Messaging with Pidgin

---

Pidgin is the predominant instant messaging client in Linux. Originally based on the America Online (AOL) Open IM architecture ([www.aim.com](http://www.aim.com)), the project was originally named *GAIM* but changed its name to *Pidgin*. Pidgin now supports a wide variety of instant messaging protocols, including the following:

- **Oscar** — Because Oscar is the official AIM protocol created by AOL, it is the most popular one used for Pidgin. To work in Pidgin, Oscar had to be reverse-engineered because it is a proprietary protocol of AOL. So, not all features that you might find in AOL's own instant messenger are supported. Messaging is done over TCP-based networks (typically, the Internet), with all messages going through AOL servers, except in the case of direct connections (which are difficult to get working properly).

- **MSN Messenger** — This protocol was based originally on the MSN Messenger Service 1.0 protocol ([www.hypothetic.org/docs/msn/ietf\\_draft.txt](http://www.hypothetic.org/docs/msn/ietf_draft.txt)). That protocol has been *enhanced* so significantly by Microsoft since it was first published that the version included with Pidgin had to be reverse-engineered. To find out more about MSN Messenger (from Pidgin or otherwise), see the MSN Messenger Protocol Resources/Links page ([www.hypothetic.org/docs/msn/resources/links.php](http://www.hypothetic.org/docs/msn/resources/links.php)).
- **ICQ** — Pidgin uses the Open Source icqlib Library to implement the ICQ protocol. Because of recent changes to the ICQ protocol, it is usually recommended to use Oscar to connect to the ICQ network, rather than icqlib.
- **IRC** — The Internet Relay Chat protocol is based on the Internet standard RFC 1459. Although there are differences in implementation of that standard on different IRC servers, this TCP-based protocol should work fine on most IRC servers.
- **Yahoo! Messenger** — This allows you to communicate to others using Yahoo! Messenger servers.

There are other messaging protocols supported by Pidgin as well. These include Jabber (which is used by GoogleTalk and available from [www.jabber.org](http://www.jabber.org)), Napster (instant messaging and buddy lists, but not music downloads), Groupwise Messenger (Novell's instant messaging), Sametime (Lotus messaging from <http://meanwhile.sourceforge.net>), TOC (rarely used AOL AIM service for unofficial clients), and Zephyr (IM system from MIT). Pidgin not only supports multiple protocols, but also allows you to communicate over multiple protocols at the same time. There are also available Jabber servers you can get to run your own Jabber instant messaging server, such as ejabberd (<http://ejabberd.jabber.ru>). (Type **yum install ejabberd** to install this package.)

Install Pidgin by typing **yum install pidgin**. To start Pidgin from the Applications menu, choose Internet ➤ Instant Messenger. Figure 8-8 contains an example of the Pidgin Buddy List and other windows.

If you have never used instant messaging before, you can sign up for free accounts from AOL (<https://my.screenname.aol.com/>) or MSN (<http://messenger.msn.com>). Click Accounts from the initial Pidgin window and add your account. Select your account from the Account list, enter the password, and select “Sign on.”

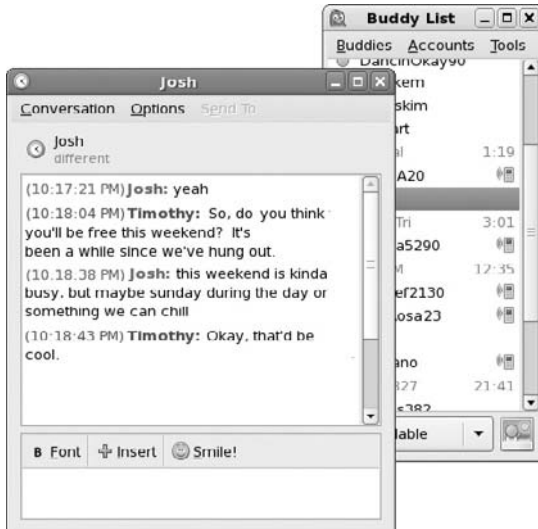
Once you are signed on, for example, to AOL, from the Buddy List that appears, select the IM button to connect to another IM user who is online. Or select Chat to enter the name of a chat room you want to enter. You can add buddies to your list as appropriate.

A small icon shaped like a yellow man appears in the system tray on your desktop when Pidgin is running. Click on that icon to have your Buddy List appear and disappear. Right-click on that icon, and a menu lets you choose to send a new message, join a chat, or work with Pidgin account and preference settings.



**FIGURE 8-8**

Chat with friends over the Internet with your AOL or other instant messaging account using Pidgin.



## Sharing Files with BitTorrent

*BitTorrent* is a tool for distributing software content to a large number of clients over a network. What makes BitTorrent so unique is that, as you download a file to your computer, someone else can be downloading the same file from your computer. In that way, the server originally offering the file doesn't get hammered, and a potentially unlimited number of people can get the file quickly.

BitTorrent is an excellent tool for the free and Open Source software community. For example, when a new release of CentOS comes out, using BitTorrent means you don't have to wait for days for traffic on the mirror servers to cool down. Likewise, someone who wants to share home videos with the world can do so without having an industrial-size server and bandwidth. Of course, there are also those who are concerned that BitTorrent makes it easy to share files people shouldn't share, such as commercial movies, music, and software.

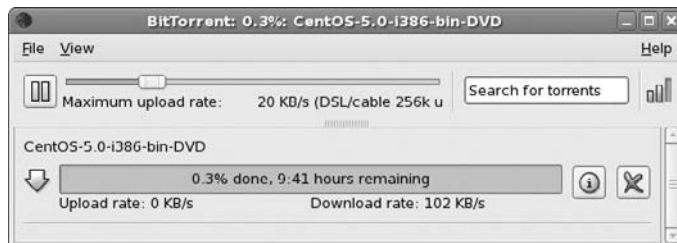
Both a text-based and a graphical (`bittorrent-gui`) BitTorrent client are available from the RPMforge repository. You can get both clients by typing the following as `root` user from a Terminal window:

```
# yum install bittorrent-gui
```

To use BitTorrent, visit a web site that offers software downloads and look for a link to a torrent file representing the software, video, or other type of file you want to download. Download the torrent file to your computer. Next open the BitTorrent Window (select Applications > Internet > BitTorrent Transfer Tool). Open the torrent file (look for a file with a .torrent extension) you downloaded by selecting File > Open torrent file. BitTorrent is shown in Figure 8-9.

**FIGURE 8-9**

Transfer large files with BitTorrent.



The slider on the BitTorrent window lets you control how much bandwidth you will allow for others to upload the files from you that you are downloading. The more you supply, the faster you will be allowed to download the file. You can continue to make the file available to others after you are finished downloading.

To create your own torrent file for a file or directory of files you want to share, select File > Make new torrent. While you can always publish your own torrent on a public server, your firewall may limit your ability to publish your own torrent to the Internet. For more information on BitTorrent, refer to the BitTorrent Introduction at [www.bittorrent.org/introduction.html](http://www.bittorrent.org/introduction.html).

## Using Remote Login, Copy, and Execution

This section describes some features for allowing users to use resources across a network. They are the `telnet`, `ssh`, `ftp`, and `wget` commands.

**CROSS-REF** Only the `ssh` service is turned on by default in CentOS because the other remote login, execution, and copy commands described here do not provide encrypted communications by default, and so they can represent significant security risks. For information on how to turn on the services described in this chapter on a CentOS server, refer to Chapter 13.

Two of the commands described in this section that are generally available are remote login and file transfer programs: `telnet` and `ftp`, respectively. Other commands for accessing FTP servers are `lftp` and `gFTP`. The `ssh` command is typically used as a secure remote login command, although it can be used for remote execution as well.

Two commands for copying files over the network are `wget` and `rsync`. Both of these tools can be used for efficiently downloading files that you can identify on the network. Note that `wget` requires a Web Server.

## Using Telnet for Remote Login

Telnet is a service provided by many different types of computer systems to enable remote users to log in to their machines over TCP/IP networks. The `telnet` command is the client program that you use to do the remote login. The most common way to use Telnet is with a hostname. The following is a typical Telnet session:

```
$ telnet sparky
Trying 10.0.0.11 ...
Connected to sparky.example.net 10.0.0.11
Escape character is '^]'.
CentOS release 5.2 (Final)
Kernel 2.6.18-92.1.22.el5 on an i686
login: mike
Password: *****
Last login: Mon Jun 16 13:15:57 from zarkov
[mike@sparky mike]$
```

This example shows what happens when the `telnet` command is used to log in from a computer named `zarkov` to a computer named `sparky` by typing `telnet sparky`. My computer tries to connect to the Telnet port on `sparky` (IP address `10.0.0.11`). Because `sparky` is also a CentOS system, once the connection is established, I see the standard `login:` prompt. I type the username (`mike`) and the password when prompted. When the login and password are accepted, I see the shell prompt for the user named `mike`.

The Telnet service is disabled by default on CentOS systems (as are most network services). You will need to explicitly enable it.

Here are a few useful options you can use with Telnet:

- `-a` — Automatic login. With this option, your computer attempts to log in to the remote computer using your local username. So, if you are logged in to your computer as `mike`, when you use `telnet` to log in to a remote computer, the remote computer assumes that you want to log in as `mike`. It simply prompts you for `mike`'s password.
- `-l user` — Username. This option is similar to the `-a` option, except that instead of using your current username, you can ask to log in using any username you choose.
- `-r` — rlogin-style interface. This option lets you use tilde (`~`) options. For example, to disconnect while in rlogin mode, type `~.` (tilde+dot), or to suspend the Telnet session,

type `~^z` (tilde+carat+z). Only use `~`. if your remote shell is hung (`exit` is a better way to quit normally). If you use `~^z` to suspend your Telnet session temporarily, you are returned to your local system shell. To get back to the suspended session, type **fg** to put Telnet back in the foreground.

Another way to use Telnet is in command mode. Instead of using a hostname, simply type the word **telnet**. You will see a `telnet` prompt as follows:

```
$ telnet
telnet>
```

At this point, there are several commands available to you. You are not yet connected to a remote host. To open a login session to a remote computer from the `telnet` prompt (e.g., to a computer named `sparky`), type:

```
telnet> open sparky
```

After you do connect to a remote computer, you can return to the Telnet session at any time by typing **[Ctrl]+**. Here are other options you can use during your Telnet session:

- `?` — Print Help information.
- `!` — Escape to the shell. (Type **exit** to leave the subshell and return to Telnet.)
- `close` — If you have an open connection, type **close** to close it.
- `display` — Shows the operating parameters that are in effect.
- `logout` — Logs you off any remote connection in this session and closes it.
- `mode` — Tries to enter line mode or character mode. (Type **mode ?** to see other options that go with the `mode` option.)
- `quit` — Close Telnet and exit.
- `z` — Suspend the current Telnet session. (Type **fg** to return to the suspended Telnet session.)

## Copying Files with FTP

As with Telnet, FTP is a protocol that is available on many different operating systems. Archives of files on the Internet are stored on what are called *FTP servers*. To connect to those servers from CentOS, you can either type the URL of that server into a Web browser or you can use the `ftp` command or graphical FTP windows such as `gFTP`.

### Using the `ftp` Command

The `ftp` command is available on CentOS, as well as every other Linux and UNIX system, for copying files to and from FTP servers. As with Telnet, FTP has a command mode or you (more typically) can use it to connect directly to a remote computer. For example:

```
$ ftp sparky
Connected to sparky.
220 (vsFTPd 2.0.6)
```

```
Name (sparky:mike): jake
331 Please specify the password.
Password: *****
230 Login successful.
Remote system type is UNIX.
Using binary mode to transfer files.
ftp>
```

In this example, `ftp` connects to a computer called `sparky` (`ftp sparky`). When I was prompted for a name, it assumed that I was going to use my current login name on `sparky` (`sparky:mike`). I could have pressed [Enter] to use the name `mike`, but instead I logged in as `jake` and typed the password when prompted. The password was accepted, and, after some information was printed, I was given an `ftp>` prompt.

Because FTP is used for public servers, you can often log in using the word `anonymous` as your username. By entering a valid e-mail address as your password, you can enter the anonymous FTP site and download files that the server makes available to the public. Sometimes the username and password `ftp` is also reserved for anonymous logins.

Unlike Telnet, instead of being in a regular UNIX shell after I logged in with FTP, I was placed in FTP command mode. Command mode with FTP includes a whole lot of commands for moving around the remote file system and for copying files (which is its main job).

**NOTE**

If you are behind a firewall and having trouble connecting to FTP servers, learn about active and passive FTP. Refer to the following: <http://slacksite.com/other/ftp.html>.

### ***FTP Directory Commands***

To get your bearings and move around the remote file system, you could use some of the following commands from the `ftp>` prompt. The commands are used to work with both the remote and local directories associated with the FTP connection.

- `passive` — Turns passive data transfer mode on and off. Passive mode may be required from behind firewalls that don't allow incoming connections.
- `pwd` — Shows the name of the current directory on the remote system.
- `ls` — Lists the contents of the current remote directory using the UNIX `ls` command. You can use any valid `ls` options with this command, provided that they are supported by the particular FTP server you are connected to.
- `dir` — Same as `ls`
- `cd` — Use the `cd` command to move to the named directory on the remote system.
- `cdup` — Moves up one directory in the file system.
- `lcd` — Use the `lcd` command to move to the named directory on the local system.

If you want to make changes to any of the remote files or directories, use the following commands:

- `mkdir` — Creates a directory on the remote system.
- `rename` — Renames a file or directory on the remote system.
- `rmdir` — Removes a remote directory.
- `delete` — Removes a remote file.
- `mdelete` — Removes multiple remote files.

Depending on how the FTP server is configured, you may or may not be able to execute some of the file and directory commands shown. In general, if you log in as the anonymous user, you will not be able to modify any files or directories. You will only be able to download files. If you have a real login account, you will typically have the same Read and Write permissions you have when you enter the computer using a standard login prompt.

### **FTP File Copying Commands**

Before you copy files between the remote and local systems, consider the type of transfer you want to do. The two types of transfer modes are:

- **Binary** — For transferring binary files (such as data files and executable commands). This is also referred to as an *image transfer*.
- **ASCII** — For transferring plaintext files.

The Linux `ftp` command seems to set the default to binary when you start FTP. Binary seems to work well for either binary or text files. However, binary transfers may not work when transferring ASCII files from non-UNIX systems. If you transfer an executable file in ASCII mode, the file may not work when you try to run it on your local system.

But, if you transfer a compressed file, such as a Zip or Gzip archive, an image file, or a word-processor document, you must use binary transfers or the files will get corrupted. To avoid this problem, type in the `binary` command prior to transferring files. Not using Binary mode is a common error.

Most file copying is done with the `get` and `put` commands. Likewise, you can use the `mget` and `mput` commands to transfer multiple files at once. Some FTP servers will even allow you to use matching characters (e.g., `mget abc*` to get all files beginning with the letters *abc*). Here are descriptions of those commands:

- `get file` — Copies a file from the current directory on the remote file system and copies it to the current directory on the local file system. You can use a full path along with the filename. Here are some examples:

```
ftp> get route
ftp> get /tmp/sting
```

The first example takes the file route from the current remote directory and copies it to the current local directory. The second example copies the file /tmp/sting from the remote system to the file tmp/sting relative to the current directory on the local system. So if your current directory were /home/jake, ftp would try to copy the file to /home/jake/tmp/sting.

- `put file` — Copies a file from the current local directory to the current remote directory. The usage of this command is essentially the same as the `get` command, except that files are copied from the local to the remote system.

**NOTE**

Anonymous FTP sites (described later) usually let you copy files *from* them, but not *to* them. If they do allow you to put files on their servers, it will usually be in a restricted area.

- `mget file . . .` — This command lets you download multiple files at once. You can specify multiple files either individually or by using metacharacters (such as the asterisk). If you run the `prompt` command (see below), FTP prompts you for each file to make sure you want to copy it.
- `mput file . . .` — This command lets you put multiple files on the remote computer. Like `mget`, `mput` can prompt you before transferring each file.

Another useful FTP command is the `prompt` command. After `prompt` is run, `mget` and `mput` commands will offer a prompt to ask if you want to download each file in the list you requested as it is ready to download.

### FTP Exiting Commands

While a connection is open to a remote computer from an FTP client in CentOS, you can use several commands to either temporarily or permanently exit from that connection. Here are some useful commands:

- `!` — This command temporarily exits you to the local shell. After you have done what you need to do, type `exit` to return to your FTP session. You can also use this command to run other local commands. For example, you can type `!pwd` to see what the current directory is on the local system, `!uname -a` to remind yourself of your local system name, or `!ls -l` to see the contents of your current directory.
- `close` — Closes the current connection.
- `bye` — Closes the connection and exits the `ftp` command. You can also use `quit` in place of `bye`.

### Using the `lftp` Command

By virtue of being an FTP client program, the `lftp` command supports all the standard commands you would expect to find in an FTP client (`get`, `put`, `ls`, `cd`, etc.). However, `lftp` has added features that make it more efficient and friendlier than some other FTP clients.

**NOTE**

You can install the `lftp` package by typing `yum install lftp`.

With `lftp`, you can connect to an FTP server in the same way you did with `ftp`. One convenient difference is that if you enter no username, `lftp` assumes that you want to use the anonymous username and just logs you in. To log in as a username other than `anonymous`, add a `-u user` option, where `user` is replaced by the name you want to log in as. Enter the password as prompted to continue.

After you are logged in with the `lftp` session running, there are a few nice features you can use that aren't available with other FTP clients. Here are some examples:

- **Bookmark** — If you are visiting a site that you want to return to, type the `bookmark` command and type a name to identify that site. The next time you start an `lftp` session, type the bookmark name as an option. Not only are you logged into the FTP site you bookmarked, but also you are taken to the directory where you set the bookmark.
- **Auto-Resume** — If you were disconnected in the middle of a large download, you will appreciate this feature. After a connection is broken during a download, reconnect to the FTP site and begin downloading the file again in the same local directory. The `lftp` command resumes downloading where it left off.
- **Tab Completion** — Press the [Tab] key to have `lftp` complete filenames and paths.

## Using the gFTP Window

If you prefer a more graphical interface for accessing FTP servers, you can use the gFTP window. Install gFTP by typing `yum install gftp`. You can open a gFTP window by typing `gftp`. Figure 8-10 shows an example of the gFTP window.

Unlike the `ftp` command, the gFTP window lets you simultaneously see the contents of the current remote and local directories. To transfer a file from one side to the other, simply double-click on it or drag-and-drop it to the other pane. (Normally, you will just be copying files from FTP sites, unless a site provides you with permission to write to it.)

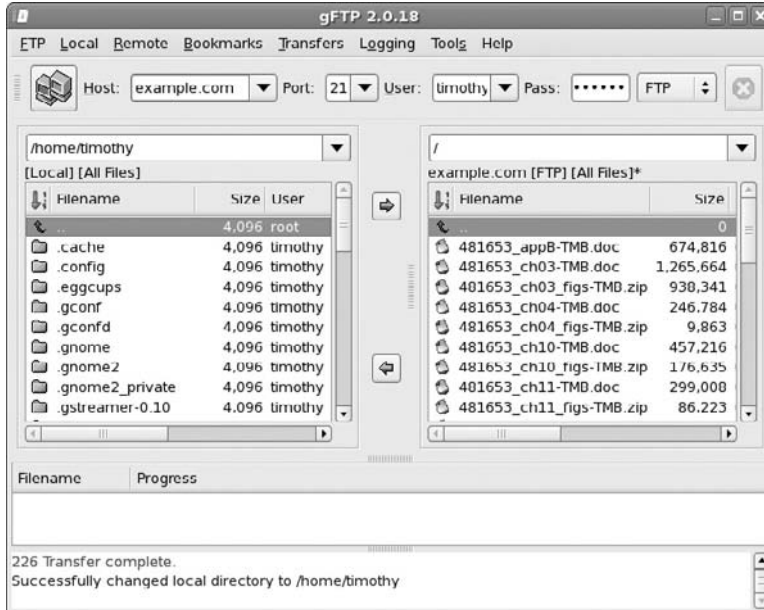
Follow this procedure to connect to an FTP site:

1. Type the name of the FTP server to which you want to connect (e.g., `ftp.example.com`) into the Host box.
2. Type the port number on the FTP server (you can leave this blank to use the default port number 21).
3. Type the username used to log in to the FTP server. Use the default `anonymous` if you don't have a specific username and the server is publicly accessible.
4. Type the password for the username you entered. The convention with anonymous FTP servers is to use your e-mail address as the password.
5. Click the icon displaying two little monitors to connect to the FTP site.



**FIGURE 8-10**

View local and remote files simultaneously from the gFTP window.



6. If you entered the information correctly, the bottom pane on the window should show that the transfer is complete, and the right pane should show the contents of the current directory of the FTP site. Here are some actions you can take once you are connected:
  - **Move Around** — Double-click on a directory to move to that directory or double-click on the two dots (..) to move up a level. You can do this on both the remote and local directories.
  - **Drag-and-Drop Files** — You can drag-and-drop files from the FTP site onto the left pane (representing your current local directory).
  - **Save This Site** — If you want to return to this site later, choose Bookmarks ➤ Add Bookmark. A pop-up window lets you name this site for the Bookmarks List. After you do, you can select that entry from the list at a later date to connect to that site. The gFTP window will have stored not only the hostname, but also the port, username, and password. So you are just one click away from connecting. This is one of the best features of graphical FTP programs such as gFTP.

A nice feature of gFTP is that it stores log information. Choose Logging ➤ View Log. A window appears showing you the conversations that have taken place between your computer and each FTP site. You can look at these messages to see what is wrong if you are unable to connect to a site or to remember where you have been and what you have done on an FTP site.

## Getting Files with wget

If you already know where a file is on the network, there are more efficient ways of downloading that file than opening an FTP session, moving around the FTP server, and running the `get` command. The `wget` command is a simple, efficient tool for doing non-interactive downloads of files over the Internet.

### NOTE

Another great command for copying files over the network is the `rsync` command. I often use `rsync` to do backups over the network. See Chapter 12 for descriptions on using `rsync` to do backups.

If there is a file you want to download from an FTP site or Web Server (HTTP) and you know exactly where the file is, `wget` is a good way to download. The `wget` command is very useful if you want to copy a whole site, recursively, from one computer to another (e.g., containing user home directories). When downloading from FTP sites, `wget` can let you just download as the anonymous user or add your own username and password to the command line.

### Downloading a Single File

Here is an example of using `wget` to get a file from a Web Server:

```
$ wget http://mirror.centos.org/centos/5.2/extras/i386/RPMS/
  Terminal-0.2.8-2.el5.centos.i386.rpm
--01:18:15-- http://mirror.centos.org/centos/5.2/extras/i386/RPMS/
  Terminal-0.2.8-2.el5.centos.i386.rpm
Resolving mirror.centos.org... 216.7.183.116
Connecting to mirror.centos.org|216.7.183.116|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 1645209 (1.6M) [application/x-rpm]
Saving to: 'Terminal-0.2.8-2.el5.centos.i386.rpm'

100%[=====>]
1,645,209   446K/s   in 4.0s

01:18:21 (404 KB/s) - 'Terminal-0.2.8-2.el5.centos.i386.rpm' saved
[1645209/1645209]
```

By the first part of the URL (`http://`), `wget` knows you are copying a file from an HTTP server to the current directory (`.`) on the local host. After resolving the address, `wget` connects to the site and transfers the file. As the file downloads, `wget` shows the progress of the download, and then exits.

### Downloading a File with Username and Password

If you are doing an FTP file copy and need to log in as a user other than `anonymous`, you can add that information to the command line or to a `.netrc` file in your home directory (type

**man netrc** to see the format of that file). Here is an example of adding the password to the command line:

```
$ wget ftp://joe:my67chevy@ftp.example.com/memo1.doc
```

**CAUTION**

Adding a password to a command line leaves the password exposed to onlookers. This practice is generally discouraged, except in cases in which no one can see your monitor or your history files or view your command line by running the `ps` command. You can add passwords to your `~/.wgetrc` file to keep your password from being seen. If you do so, ensure that no one else can read this file by running the `chmod 400 .wgetrc` command.

In the previous example, the user logs in as `joe` with the password `my67chevy`. The `wget` command then copies the file `memo1.doc` from the current directory on the host computer named `ftp.example.com`. That current directory is most likely `/home/joe`.

## Downloading a Whole Web Site

Using `wget`, you can download a large number of files from Web Servers as well. The `wget` command downloads files using the HTTP protocol, if file addresses begin with `http://`. Downloading a single file, you would use the same form as you would for an FTP file (e.g., `wget http://host/file`). The best `wget` option for HTTP downloads is `-r` (recursive).

A recursive download lets you choose a point at a web site and download all content below that point. Here is an example of a recursive download used to download the contents of the `www.example.com` web site.

```
$ wget -r http://www.example.com
```

In this example, the HTML pages, images, and other content on the `www.example.com` web site are copied below the current directory in a new directory named `www.example.com`. This is useful if you want to gather the contents of a web site but don't have login access to that site. Because content is taken by following links, if there is content in a directory at the web site that isn't in a link, it won't be downloaded.

Downloading an entire web site can result in a massive amount of data being downloaded. If you want only part of a web site, start from a point lower in the site's structure. Or, as an alternative, you can limit the number of levels that `wget` will go down the site structure. Using the `-l` option (*l* as in *level*), the following example gets two levels of HTML content:

```
$ wget -r -l 2 http://www.example.com
```

To mirror a site, you can use the `-m` option instead of `-r`. Using `wget -m http://site` is like asking to download an infinite number of levels recursively (`-r -l inf`), keep current time stamps (`-N`), and keep FTP directory listings (`-nr`). Note that `wget` will honor a web site's `robots.txt` file, which might restrict the ability of `wget` to recursively access multiple levels of links from a web site.

## Continuing a Download

In the old days, if you were downloading a particularly large file (such as an ISO image of a CD or DVD), if the download stopped for some reason (a disconnected network or errant reboot), you needed to start all over. With `wget`, you can choose to restart a download and have it continue right where it left off. This has been a lifesaver for me on many occasions.

Let's say that you were downloading a 4GB DVD ISO image named `mydvd.iso` from the site `ftp://ftp.example.com` and you killed the `wget` process by mistake after about 3 GB of download. Make sure that your current directory is the one that contains the partially downloaded ISO. Then run the same `wget` command you did originally, adding the `-c` (continue) option as follows:

```
$ wget -c ftp://ftp.example.com/mydvd.iso
```

If you had not used the `-c` option, in this case, a new download would have started using the filename `mydvd.iso.1` to download to.

### NOTE

Another command that you might be interested in, similar to `wget`, is the `curl` command. Like `wget`, `curl` can download files using the FTP or HTTP protocols. `curl` can also do multiple file transfers on the same connection.

## Using `ssh` for Remote Login/Remote Execution

Although the `telnet` and `rlogin` login commands and `rsh` remote execution command have been around much longer, the `ssh` command is the preferred tool for remote logins and executions. The reason is that `ssh` provides encrypted communication so you can use it securely over insecure, public networks between hosts that don't know each other.

In the following example, `ssh` is being used to log in to a computer named `sparky`. Because no user is specified, `ssh` tries to log in as the current user (which is the `root` user, in this case).

```
# ssh sparky
root@sparky's password:
```

If you wanted to log in as a different user, you could use the `-l` option. For example, to log in to the computer named `sparky` as the user named `jake`, you could type the following:

```
# ssh jake@sparky
jake@sparky's password:
```

The `ssh` command can also be used to execute a command on the remote computer. For example, if you wanted to monitor the messages file on a remote computer for a minute, you could type the following command:

```
# ssh root@sparky "tail -f /var/log/messages"
root@sparky's password:
```

After you typed the password in the preceding case, the last several lines of the `/var/log/messages` file on the remote computer would be displayed. As messages were received, they would continue to be displayed until you decided to exit (press `[Ctrl]+C` to exit the `tail` command).

**NOTE**

To learn how to use public keys for password-less login to ssh, refer to Chapter 13. Find out more about the ssh command from the SSH web site ([www.openssh.org](http://www.openssh.org)).

## Using scp for Remote File Copy

The `scp` command is a simple yet secure way of copying files among Linux systems. It uses the underlying `ssh` facility, so if `ssh` is enabled, so is `scp`. Here is an example of using `scp` to copy a file from one computer to another:

```
# scp myfile toys.linuxtoys.net:/home/chris
root@toys.linuxtoys.net's password: *****
```

In this example, the file `myfile` is copied to the computer named `toys.linuxtoys.net` in the `/home/chris` directory. If you don't provide a username, `scp` assumes that you are using the current username. Unlike some tools that provide remote login, `scp` and `ssh` do allow you to log in as the `root` user over the network, by default. (Many people turn off this feature for security reasons.)

To use `scp` with a different username, you can append the username with an `@` character. For example, `chris@toys.linuxtoys.net:/home/chris` would attempt to log in as the user named `chris` to do the file copy.

The first time you connect to a remote computer using `scp` or `ssh`, those commands try to establish the authenticity of the remote host. If it cannot establish the host's authenticity, `scp` will display the RSA key fingerprint and ask you if you want to continue. If you type **yes**, `scp` will not question the authenticity of that computer again for subsequent `scp` commands.

However, if the RSA key fingerprint should change in the future for the remote computer (which will happen if, e.g., the operating system is reinstalled on that computer), `scp` will refuse to let you connect to that remote computer. To override that refusal, you need to edit your `$HOME/.ssh/known_hosts` file and delete the entry for the remote computer. You can then verify the authenticity of the remote computer and continue to use `scp`.

The `sftp` command, which also communicates using secure `ssh` protocols, is a command for copying files from an FTP server. It is considered a more secure way of getting files from an FTP server that has an `sshd` server running. The `sftp` command can be disabled on the server by commenting out the `sftp` line in the `sshd_config` directory.

## Using the “r” Commands: `rlogin`, `rcp`, and `rsh`

The `rlogin`, `rcp`, and `rsh` commands all use the same underlying security mechanism to enable remote login, remote file copy, and remote execution, respectively, among computers. These commands are included with CentOS to be compatible with legacy UNIX systems. Because “r” commands are inherently insecure, however, most people use `ssh` and `scp` commands to provide the same functionality in a more secure way.

## Summary

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Most use of the World Wide Web centers on the Web browser. Firefox is fast becoming the most popular Web browser to use with CentOS and most other Linux systems and is accessible from a button on your desktop. Epiphany, Konqueror, and various text-based Web browsers are also available with CentOS.

Evolution, which can also be used for managing your e-mail, is now the preferred mail reader for CentOS. Thunderbird is the latest e-mail application from the Mozilla Project. There are also many text-based mail readers, such as Mutt, Alpine, and mail.

Command-line tools for downloading files include `wget`, `ftp`, and many others. A popular download tool, which offers both command-line and graphical interfaces, is BitTorrent. With BitTorrent, you not only download files, but also you can simultaneously upload the files you get to others.

Legacy remote login and file copy commands (`rlogin`, `rcp`, and `rsh`) are still available in CentOS. However, improved programs for remote login and file copy, such as `ssh`, `scp`, and `sftp`, are more often used today.



# Part III

# Administration

## IN THIS PART

**Chapter 9**  
**Understanding System Administration**

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**Chapter 10**  
**Setting up and Maintaining User Accounts**

---

**Chapter 11**  
**Automating System Tasks**

---

**Chapter 12**  
**Creating Backups and Restoring Data**

---

**Chapter 13**  
**Security**

---





# Chapter 9

## Understanding System Administration

CentOS, like other Linux and UNIX systems, is intended for use by more than one person at a time. Multiuser features allow many people to have accounts in Linux, with their data kept secure from others. Multitasking allows many people to use the computer at the same time. Sophisticated networking protocols and applications make it possible for a Linux system to extend its capabilities to network users and computers around the world. The person assigned to manage all of this stuff is referred to as the *system administrator*.

Even if you are the only person using a Linux system, system administration is still set up to be separate from other computer use. To do most administrative tasks, you need to be logged in as the *root* user (also referred to as the *super user*) or gain temporary root privilege. Other users cannot change, or in some cases, even see some of the configuration information for a Linux system. In particular, security features such as passwords are protected from general view.

This chapter describes the general principles of administering a CentOS system. In particular, this chapter covers some of the basic tools you need to administer your Linux system. It also helps you learn how to work with file systems and monitor the setup and performance of your Linux system.

Security Enhanced Linux (SELinux) adds another dimension to administering a CentOS system. Instead of giving the *root* user full control of the entire Linux system, access to data, programs, devices, and processes can be assigned to different roles. CentOS is delivered with only a limited set of SELinux features turned on, so the *root* user maintains most of its traditional role whether SELinux is off or on. SELinux is described at the end of this chapter.

### IN THIS CHAPTER

Using the root login

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Administrative commands, configuration files, and log files

---

Graphical administration tools

---

Working with the file system

---

Working with hardware devices

---

Monitoring system performance

---

Managing battery power on laptops

---

Using Security Enhanced Linux

---

## Using the root User Account

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The traditional role of the `root` user in Linux systems is to have complete control of the operation of your system. That user can open any file or run any program. The `root` user also installs software packages and adds accounts for other people who use the system.

During the CentOS installation process, you are required to add a password for the `root` user. You need to remember and protect this password. You will need it to log in as `root` or to obtain `root` permission while you are logged in as some other user.

The home directory for the `root` user is `/root`. The home directory and other information associated with the `root` user account is assigned in the `/etc/passwd` file. Here is what the `root` user's entry looks like in the `/etc/passwd` file:

```
root:x:0:0:root:/root:/bin/bash
```

This shows that for the user named `root`, the `x` indicates that the password is stored in `/etc/shadow`, the user ID is set to 0 (`root` user), and the group ID is set to 0 (`root` group). The home directory is `/root`, and the shell for that user is `/bin/bash`.

**CROSS-REF** It's best to make changes to `/etc/passwd` with the User Manager window or `usermod` command. See the section on setting up users in Chapter 10 for more information about the `/etc/passwd` file.

Among the defaults that are set for the `root` user are aliases for certain commands that could have dangerous consequences. Aliases for the `rm`, `cp`, and `mv` commands allow those commands to be run with the `-i` option. This prevents massive numbers of files from being removed, copied, or moved by mistake. The `-i` option causes each deletion, copy, or move to prompt you before removing or overwriting any files from those commands.

## Becoming the Super User (the `su` Command)

---

Although one way to become the super user is to log in as `root`, sometimes that is not convenient. For example, you may be logged into a regular user account and just want to make a quick administrative change to your system without having to log out and log back in. Or you may need to log in over the network to make a change to a Linux system but find that the system doesn't allow `root` users in from over the network (a common practice).

The answer is that you can use the `su` command.

**CAUTION** In general, it is safer to use the `sudo` command to run a single Linux command as the super user instead of running the `su` command. See the description of the `sudo` command later in this chapter.

From any Terminal window or shell, you can simply type:

```
$ su
Password: *****
#
```

When you are prompted, type in the `root` user's password. The prompt for the regular user (\$) will be changed to the super user prompt (#). At this point, you have full permission to run any command and use any file on the system. However, one thing that the `su` command doesn't do when used this way is read in the `root` user's environment. As a result, you may type a command that you know is available and get the message "command not found." To fix this problem, you can use the `su` command with the dash (-) option instead, as follows:

```
$ su -
Password: *****
#
```

You still need to type the password, but after you do that, everything that normally happens at login for the `root` user will happen after the `su` command is completed. Your current directory will be `root`'s home directory (probably `/root`), and things like the `root` user's `PATH` variable will be used. If you became the `root` user by just typing `su`, rather than `su -`, you would not have changed directories or the environment of the current login session.

**TIP**

When you become super user during someone else's session, a common mistake is to leave files or directories in the user's directories that are owned by `root`. If you do this, be sure to use the `chown` or `chmod` command to make the files and directories you modify open to the user that you want to own them. Otherwise, you will probably get a phone call in a short time, asking you to come back and fix it.

You can also use the `su` command to become another user than `root`. For example, to have the permissions of a user named `chum`, you could type the following:

```
$ su - chum
```

Even if you were `root` user before you typed this command, you would only have the permission to open files and run programs that are available to `chum`. As `root` user, however, after you type the `su` command to become another user, you don't need a password to continue. If you type that command as a regular user, you must type the new user's password.

When you are finished using super user permissions, return to the previous shell by exiting the current shell. Do this by pressing [Ctrl]+D or by typing **exit**.

**CAUTION**

If you are the administrator for a computer that is accessible to multiple users, don't leave a `root` shell open on someone else's screen (unless you want to let that person do anything they like to the computer)!

Besides opening a shell session using `su` (to run a bunch of commands as `root`), you can instead just apply `root` permission to a single command or window. This approach is considered more secure than leaving a shell open with `root` permission if you are just doing one administrative task. For example:

- **GUI Admin Tools** — When you run GUI administration tools as a regular user, you are usually prompted for the `root` user's password (as described the section “Using Graphical Administration Tools” later in this chapter). If a GUI administration tool fails and doesn't prompt you for a password, refer to the sidebar “Becoming Super User in X.”
- **sudo Command** — You can run the `visudo` command to configure a user in `/etc/sudoers` to be allowed to run administrative commands. After that is done, that user can run the `sudo` command, followed by a single administrative command, to run that command as `root` would. When that single command completes, the `root` permission to run that command ends as well. (See the description of the `sudo` command later in this chapter.)

## Learning about Administrative GUI Tools, Commands, Configuration Files, and Log Files

---

Linux systems have advanced enough in recent releases that you can now do most system administration from your desktop GUI, bypassing the shell altogether. Whether you administer Linux from the GUI or from a shell, however, underlying your activities are many administrative commands, configuration files, and log files.

Understanding where GUI administrative tools, commands, and files are located and how they are used will help you effectively maintain your Linux system. Although most administrative features are intended for the `root` user, other administrative users (described later in this section) have limited administrative capabilities.

### Using Graphical Administration Tools

The trend over the past few versions of CentOS has been to steer clear of the massive administrative interfaces and instead to offer graphical windows that perform individual administrative tasks. Instead of sharing one monolithic interface, they share common menus. Individual graphical windows for configuring a network, adding users, or setting up printers can be launched from those menus.

### Becoming the Super User in X

**T**here may be times when your desktop (and underlying X Window System) is running on Linux as a non-root user and you want to run a graphical administration program. In most cases, the GUI administration program will simply prompt you for the `root` user's password to continue.

*continued*

*continued*

However, if the program fails, saying that you don't have permission to run the command, here is what you can do:

1. First, open a Terminal window on the X desktop.
2. Then, export the display cookie to a temporary file using `xauth`.
3. Then, type the following and enter the `root` user's password when prompted, to become super user:

```
$ xauth extract cookie.dat $DISPLAY
```

```
$ su -  
Password: *****  
#
```

4. Next, merge the cookie into `root`'s authority file.
5. You can now safely delete the temporary file.

```
# xauth merge /path/to/cookie.dat
```

```
# rm /path/to/cookie.dat
```

If the value of the `DISPLAY` variable is something like `:0` or `:0.0`, any X command you run from that shell will appear on the console terminal for the computer. If you are at the console and that's what you see, then you can skip the next step. If you see no value (which is quite possible) or the wrong value, you must set the `DISPLAY` variable.

6. Type the following:

```
# export DISPLAY=:0
```

At this point, you can run any administrative X command (such as `neat` or `system-config-packages`) and have it appear on your X desktop. If you are running an administrative command from a remote computer and you want it to appear on your local desktop, you can set the `DISPLAY` to `host:0`, where `host` is replaced by the name of your computer.

When you are done, be sure to exit the application you are running.

To administer your CentOS system through the GNOME desktop, a common set of administrative tools is provided that are accessible from menu buttons on the panel. Selections for starting most graphical administration windows are available from the following menus:

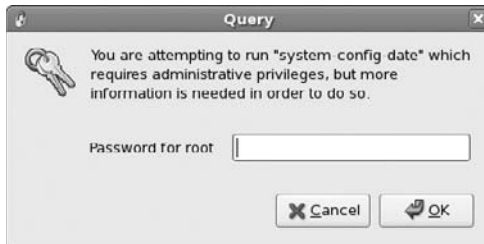
- **Administration** — Select System ➤ Administration from the GNOME desktop panel to select tools for configuring your system. These include tools for adding users, setting date and time, configuring your network, setting up printers, and getting sound cards and printers to work.

- **System Tools** — Select Applications > System Tools from the GNOME desktop panel to select tools to monitor and work with your system. These include tools for updating software, monitoring the system, and checking network activity.

Because these administrative tasks require root permission, if you are logged in as a regular user, you must enter the root password before the GUI application's window opens. For example, if you launch the Date & Time settings window (System > Administration > Date & Time) from the desktop panel as a regular user, you see the pop-up window shown in Figure 9-1.

**FIGURE 9-1**

Enter the root password to open system administration windows from a regular user's GUI.



After you have entered the root user's password, most of the system configuration tools will open without requiring you to retype the password during this login session. Authorization goes away after 5 minutes.

**NOTE**

As you configure different features on your CentOS system, you are asked to launch different individual graphical windows. In general, if you have a choice of tools for configuring a server or adding a feature, I recommend that you use the tool provided with your distribution. That's because the system-config-\* GUI tools more often integrate closely with the way CentOS systems store and manage their configuration information.

The following list describes administrative tools you can start from the Administration menu (System > Administration). The name of the package that must be installed to get the feature is shown in parentheses:

**Server Settings**

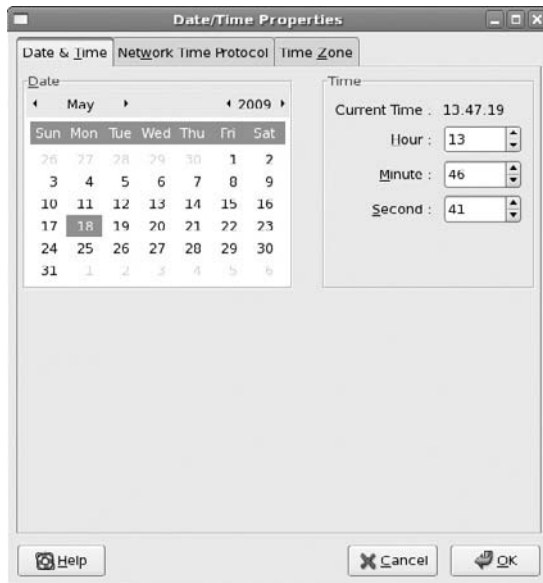
This submenu accesses the following server configuration windows:

- **Domain Name System (system-config-bind)** — Create and configure zones if your computer is acting as a DNS server.
- **FTP (system-config-vsftpd)** — Configure the vsftpd FTP server. You may also see this under the System Tools menu under the Applications menu.

- **HTTP (system-config-httpd)** — Configure your computer as an Apache Web server. You may also see this under the System Tools menu under the Applications menu.
- **NFS (system-config-nfs)** — Set up directories from your system to be shared with other computers on your network using the NFS service.
- **Authentication (authconfig-gtk)** — Change how users are authenticated on your system. Usually, Shadow Passwords and MD5 Passwords are selected. However, if your network supports LDAP, Kerberos, SMB, NIS, or Hesiod authentication, you can select to use any of those authentication types.
- **Boot Loader (system-config-boot)** — Configure the default boot entry and time-out value (in seconds) for your GRUB boot loader.
- **Date & Time (system-config-date)** — Set the date and time or choose to have an NTP server keep system time in sync. Figure 9-2 shows the Date/Time Properties window.

**FIGURE 9-2**

Choose an NTP server by clicking on the Network Time Protocol tab or set date and time in the Date/Time Properties window.



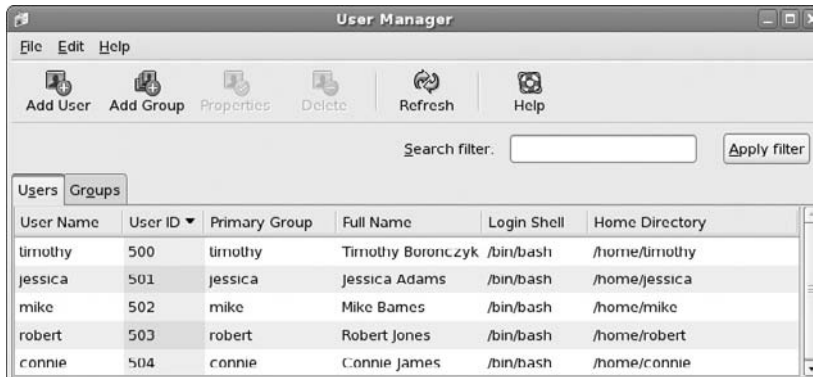
- **Display (system-config-display)** — Change the settings for your X desktop, including color depth and resolution for your display. You can also choose settings for your video card and monitor.
- **Firewall (system-config-firewall)** — Configure your firewall to allow or deny services to computers from the network.



- **Keyboard (system-config-keyboard)** — Choose the type of keyboard you are using, based on language.
- **Language (system-config-language)** — Select the default language used for the system.
- **Logical Volume Management (system-config-lvm)** — Display and manage logical volumes and related disk partitions.
- **Network (system-config-network)** — Manage your current network interfaces, as well as add interfaces.
- **Printing (system-config-printer)** — Configure local and network printers.
- **Root Password (system-config-rootpassword)** — Change the root password.
- **Samba (system-config-samba)** — Configure Windows (SMB) file sharing. (To configure other Samba features, you can use the SWAT window. SWAT is described in Chapter 17.)
- **Services (system-config-services)** — Display and change which services are running on your CentOS system at different run levels.
- **Users & Groups (system-config-users)** — Lets you add, display, and change user and group accounts for your CentOS system (see Figure 9-3).

**FIGURE 9-3**

Change user and group accounts with the User Manager window.



## System Tools

The following tools associated with system administration can be started from the System Tools menu (Applications ➤ System Tools):

- **Configuration Editor (gconf-editor)** — Change settings associated with your GNOME desktop system.

- **Disk Usage Analyzer (gnome-utils)** — Displays and analyzes data on the use of your computer's hard disks.
- **Hardware (hwbrowser)** — View information about your hard drives, network devices, sound cards, and other hardware. (Install the hwbrowser package to see this item.)
- **Kickstart (system-config-kickstart)** — Create a Kickstart configuration file that can be used to install multiple CentOS systems without user intervention.
- **System Log (gnome-system-log)** — Displays messages (by date) for log files stored in the `/var/log` directory.
- **System Monitor (frysk-gnome)** — Shows information about running processes and resource usage.

Procedures for using the various system graphical administrative tools are discussed throughout the book.

## Administrative Commands

Many commands are intended only for `root`. When you log in as `root`, your `$PATH` variable is set to include some directories that contain commands for the `root` user. These include the following directories:

- **/sbin** — This contains commands for modifying your disk partitions (such as `fdisk`), changing boot procedures (`grub`), and changing system states (`init`).
- **/usr/sbin** — This contains commands for managing user accounts (such as `useradd`) and checking network traffic (`wreshark`). Commands that run as daemon processes are also contained in this directory. (Look for commands that end in `d`, such as `sshd`, `pppd`, and `crond`.)

Some administrative commands are contained in regular user directories (such as `/bin` and `/usr/bin`). This is especially true of commands that have some options available to everyone. An example is the `/bin/mount` command, which anyone can use to *list* mounted file systems, but only `root` can use to *mount* file systems.

To find commands that are intended primarily for the system administrator, check out the Section 8 manual pages (usually in `/usr/share/man/man8`). They contain descriptions and options for most Linux administrative commands. For example, to see the man page for the `fdisk` command (`/usr/share/man/man8/fdisk.8.gz`), type:

```
$ man fdisk
```

Some third-party applications will add administrative commands to directories that are not in your `PATH`. For example, an application may put commands in `/usr/local/bin`. You may want to add other directories to your `PATH`.

## Administrative Configuration Files

Configuration files are another mainstay of Linux administration. Almost everything you set up for your particular computer — user accounts, network addresses, or GUI preferences — is stored in plaintext files. This has some advantages and some disadvantages.

The advantage of plaintext files is that it is easy to read and change them. Any text editor will do. On the downside, however, is that as you edit configuration files, no error checking is going on. You have to run the program that reads these files (such as a network daemon or the X desktop) to find out if you set up the files correctly. A comma or a quote in the wrong place can sometimes cause a whole interface to fail.

Throughout this book, I describe the configuration files you need to set up the different features that make up CentOS systems. In terms of a general perspective on configuration files, however, there are several locations in a CentOS file system where configuration files are stored. Here are some of the major locations:

- **\$HOME** — All users store information in their home directories that directs how their login accounts behave. Most configuration files in `$HOME` begin with a dot (`.`), so they don't appear as a user's directory when you use a standard `ls` command (you need to type `ls -a` to see them). There are dot files that define how each user's shell behaves, the desktop look and feel, and options used with your text editor. There are even files (such as `.ssh/*` and `.rhosts`) that can configure network permissions for each user.
- **/etc** — This directory contains most of the basic Linux system-configuration files. The following `/etc` configuration files are of interest:
  - **adjtime** — Holds data to adjust the hardware clock (see the `hwclock` man page).
  - **aliases** — Can contain distribution lists used by the Linux mail service.
  - **bashrc** — Sets system-wide defaults for `bash` shell users. (By default, it sets the shell prompt to include the current user name, hostname, current directory, and other values.)
  - **cdrecord.conf** — Contains defaults used for recording CDs.
  - **crontab** — Sets cron environment and times for running automated tasks.
  - **csch.cshrc (or cshrc)** — Sets system-wide defaults for `csch` (C shell) users.
  - **dovecot** — Contains information needed to support the dovecot IMAPv4/POP3 mail service.
  - **esd.conf** — Sets options used by the Enlightenment Sound Daemon to mix multiple audio streams into a single audio output.
  - **exports** — Contains a list of local directories that are available to be shared by remote computers using the Network File System (NFS).
  - **fstab** — Identifies the devices for common storage media (hard disk, floppy, CD-ROM, etc.) and locations where they are mounted in the Linux system. This is used by the `mount` command to choose which file systems to mount.

- **group** — Identifies group names and group IDs (GIDs) that are defined in the systems. Group permissions in Linux are defined by the second of three sets of `rwX` (Read, Write, Execute) bits associated with each file and directory.
- **gshadow** — Contains shadow passwords for groups.
- **host.conf** — Sets the locations in which domain names (e.g., `redhat.com`) are searched for on TCP/IP networks (such as the Internet). By default, the local hosts file is searched, then any nameserver entries in `resolv.conf`.
- **hosts** — Contains IP addresses and hostnames that you can reach from your computer. (Usually this file is used just to store names of computers on your LAN or small private network.)
- **hosts.allow** — Lists host computers that are allowed to use certain TCP/IP services from the local computer.
- **hosts.deny** — Lists host computers that are *not* allowed to use certain TCP/IP services from the local computer (doesn't exist by default).
- **inittab** — Contains information that defines which programs start and stop when Linux boots, shuts down, or goes into different states (runlevels) in between. This is the most basic configuration file for starting Linux.
- **issue** — Contains the lines that are displayed when a terminal is ready to let you log in to your system from a local terminal, or the console in text mode.
- **issue.net** — Contains login lines that are displayed to users who try to log in to the Linux system from a computer on the network using the telnet service.
- **mail.rc** — Sets system-wide parameters associated with using mail.
- **man.config** — Used by the `man` command to determine the default path to the location of man pages.
- **modprobe.conf** — Contains aliases and options related to loadable kernel modules used by your computer.
- **mtab** — Contains a list of file systems that are currently mounted.
- **mtools.conf** — Contains settings used by DOS tools in Linux.
- **named.conf** — Contains DNS settings if you are running your own DNS server.
- **ntp.conf** — Includes information needed to run the Network Time Protocol (NTP).
- **passwd** — Stores account information for all valid users for the system. Also includes other information, such as the home directory and default shell.
- **printcap** — Contains definitions for the printers configured for your computer.
- **profile** — Sets system-wide environment and start-up programs for all users. This file is read when the user logs in.
- **protocols** — Sets protocol numbers and names for a variety of Internet services.
- **redhat-release** — Contains a string identifying the current CentOS release.

- **resolv.conf** — Identifies the locations of DNS name server computers that are used by TCP/IP to translate Internet host.domain names into IP addresses.
- **rpc** — Defines remote procedure call names and numbers.
- **services** — Defines TCP/IP services and their port assignments.
- **shadow** — Contains encrypted passwords for users who are defined in the passwd file. (This is viewed as a more secure way to store passwords than the original encrypted password in the passwd file. The passwd file needs to be publicly readable, whereas the shadow file can be unreadable by all but the root user.)
- **shells** — Lists the shell command-line interpreters (bash, sh, csh, etc.) that are available on the system, as well as their locations.
- **sudoers** — Sets commands that can be run by users, who may not otherwise have permission to run the command, using the sudo command. In particular, this file is used to provide selected users with root permission.
- **syslog.conf** — Defines what logging messages are gathered by the syslogd daemon and what files they are stored in. (Typically, log messages are stored in files contained in the /var/log directory.)
- **termcap** — Lists definitions for character terminals, so that character-based applications know what features are supported by a given terminal. Graphical terminals and applications have made this file obsolete to most people. (Termcap was the BSD UNIX way of storing terminal information; UNIX System V used definitions in /usr/share/terminfo files.)
- **/etc/X11** — Contains subdirectories that each contain system-wide configuration files used by X and different X window managers available for Linux. The xorg.conf file (which makes your computer and monitor usable with X) and configuration directories containing files used by xdm and xinit to start X are in here.
- Directories relating to Window managers contain files that include the default values that a user will get if that user starts one of these Window managers on your system. Window managers that may have system-wide configuration files in these directories include Motif (mwm) and Twm (twm). The fs directory contains a file for configuring font server settings.

**NOTE**

Some files and directories in /etc/X11 are linked to other locations.

- **/etc/amanda** — Contains files and directories that allow the amanda facility to do network backups of other Linux and UNIX systems.
- **/etc/cron\*** — Directories in this set contain files that define how the crond utility runs applications on a daily (cron.daily), hourly (cron.hourly), monthly (cron.monthly), or weekly (cron.weekly) schedule.
- **/etc/cups** — Contains files that are used to configure the CUPS printing service.

- **/etc/default** — Contains files that set default values for various utilities. For example, the file for the `useradd` command defines the default group number, home directory, password expiration date, shell, and skeleton directory (`/etc/skel`) that are used when creating a new user account.
- **/etc/httpd** — Contains a variety of files used to configure the behavior of your Apache Web server (specifically, the `httpd` daemon process).
- **/etc/init.d** — Contains links to the run-level scripts. These scripts are linked from files in the `/etc/rc?.d` directories to have each service associated with a script started or stopped for the particular run level. The `?` is replaced by the run-level number (0 through 6).
- **/etc/mail** — Contains files used to configure your sendmail mail service.
- **/etc/pcmcia** — Contains configuration files that allow you to have a variety of PCMCIA cards configured for your computer. (PCMCIA slots are those openings on your laptop that allow you to have credit card–sized cards attached to your computer. You can attach such devices as modems and external CD-ROMs.)
- **/etc/postfix** — Contains configuration files for the postfix mail transport agent.
- **/etc/ppp** — Contains several configuration files used to set up Point-to-Point protocol (so that you can have your computer dial out to the Internet).
- **/etc/rc?.d** — There is a separate `rc?.d` directory for each valid system state: `rc0.d` (shutdown state), `rc1.d` (single-user state), `rc2.d` (multiuser state), `rc3.d` (multiuser plus networking state), `rc4.d` (user-defined state), `rc5.d` (multiuser, networking, plus GUI login state), and `rc6.d` (reboot state).
- **/etc/security** — Contains files that set a variety of default security conditions for your computer. These files are part of the `pam` (pluggable authentication modules) package.
- **/etc/skel** — Any files contained in this directory are automatically copied to a user's home directory when that user is added to the system. By default, most of these files are dot (`.`) files, such as `.kde` (a directory for setting KDE desktop defaults) and `.bashrc` (for setting default values used with the `bash` shell).
- **/etc/squid** — Contains configuration files for the Squid proxy caching server.
- **/etc/sysconfig** — Contains important system configuration files that are created and maintained by various system services (including `iptables`, `samba`, and most networking services).
- **/etc/uucp** — Contains configuration files used with Taylor UUCP (a nonstandard version of the `uucp` facility that is used to create modem, direct line, and other serial connections with other computers).
- **/etc/vsftpd** — Contains configuration files used to set up the `vsftpd` FTP server.
- **/etc/xinetd.d** — Contains a set of files, each of which defines a network service that the `xinetd` daemon listens for on a particular port. When the `xinetd` daemon process receives a request for a service, it uses the information in these files to determine which daemon processes to start to handle the request.

## Administrative Log Files

One of the things that Linux does well is keep track of itself. This is a good thing, when you consider how much can go wrong with a complex operating system. Sometimes you are trying to get a new facility to work and it fails without giving you the foggiest reason why. Other times you want to monitor your system to see if people are trying to access your computer illegally. In any of those cases, you can use log files to help track down the problem.

The main utilities for logging error and debugging messages for Linux are the `syslogd` and `klogd` daemons. General system logging is done by `syslogd`. Logging that is specific to kernel activity is done by `klogd`. Logging is done according to information in the `/etc/syslog.conf` file. Messages are typically directed to log files that are usually in the `/var/log` directory.

As root user, you can view log files with the `less` command or watch messages as they enter log file using the `tail` command (`tail -f /var/log/messages`).

## Using Other Administrative Logins

You don't hear much about other administrative logins (besides `root`) being used with Linux. It was a fairly common practice in UNIX systems to have several different administrative logins that allowed administrative tasks to be split among several users.

In any case, these administrative logins are available with Linux, so you may want to look into using them. At the very least, because individual software packages such as `bind`, `squid`, and `amanda` set up permissions for their log files and configuration files based on their administrative logins, maintaining those permissions can impede someone who hacks into one of those services from gaining control of the whole computer.

### TIP

Because most administrative features are expected to be administered by the root user, e-mail for other administrative accounts is routed to the root user. If you want other administrative users to receive their own e-mail, delete the aliases for those users from the `/etc/aliases` file.

## Understanding Administrative Logins

Here are some of the administrative logins that are configured automatically for Linux systems. By tradition, these logins are assigned UID numbers under 100. Here are examples:

### TIP

Most administrative logins have no passwords by default. They also typically have `/sbin/nologin` assigned as their shell, so if you try to log in as one of these users, you see a "This account is currently not available" message. That's why you can't use an administrative login separately until you assign it a password and shell (such as `/bin/bash`).

- `lp` — This user can control some printing features. Having a separate `lp` administrator allows someone other than the super user to do such things as move or remove `lp` logs and print spool files. The home directory for `lp` is `/var/spool/lpd`.

- `mail` — This user can work with administrative e-mail features. The `mail` group has group permissions to use mail files in `/var/spool/mail` (which is also the `mail` user's home directory).
- `uucp` — This user owns various `uucp` commands (once used as the primary method for dial-up serial communications). It is the owner of log files in `/var/log/uucp`, spool files in `/var/spool`, administrative commands (such as `uuchk`, `uucico`, `uuconv`, and `uuxqt`) in `/usr/sbin`, and user commands (`uucp`, `cu`, `uname`, `uustat`, and `uux`) in `/usr/bin`. The home directory for `uucp` is `/var/spool/uucp`.
- `bin` — This user owns many commands in `/bin` in traditional UNIX systems. This is not the case in CentOS because `root` tends to own most executable files. The home directory of `bin` is `/bin`.
- `news` — This user could do administration of Internet news services, depending on how you set permission for `/var/spool/news` and other news-related resources. The home directory for `news` is `/etc/news`.

## Using `sudo` for Assigning Administrative Privilege

One way to give full or limited root privileges to any non-`root` user is to set up the `sudo` facility. That simply entails adding the user to `/etc/sudoers` and defining what privilege you want that user to have. Then the user can run any command he or she is privileged to use by preceding that command with the `sudo` command.

The following is an example of how to use the `sudo` facility to cause any users that are added to the `wheel` group to have full root privileges:

1. As the `root` user, edit the `/etc/sudoers` file by running the `visudo` command:

```
# /usr/sbin/visudo
```

By default, the file is opened in `vi`, unless your `EDITOR` variable happens to be set to some other editor acceptable to `visudo` (e.g., `export EDITOR=gedit`). The reason for using `visudo` is that the command will lock the `/etc/sudoers` file and do some basic sanity-checking of the file to ensure it was edited correctly.

### NOTE

If you are stuck here, refer to the `vi` tutorial (“Using the `vi` Text Editor”) in Chapter 4 for information.

2. Uncomment the following line to allow users in the group named `wheel` to have full root privileges on the computer:

```
%wheel    ALL=(ALL)    ALL
```

The previous line causes the user to be prompted for a password to be allowed to use administrative commands. To allow users in the `wheel` group to have that privilege without using a password, uncomment the following line instead:

```
%wheel    ALL=(ALL)    NOPASSWD: ALL
```

3. Save the changes to the `/etc/sudoers` file.



4. Still as `root` user, open the `/etc/group` file in any text editor and add the users you want to have root privilege to the `wheel` line. For example, if you were to add the users `mary` and `jake` to the `wheel` group, the line would appear as follows:

```
wheel:x:10:root,mary,jake
```

At this point, the users `mary` and `jake` can run the `sudo` command to run commands, or parts of commands, that are normally restricted to the `root` user. The following is an example of a session by the user `jake` after he has been assigned `sudo` privileges:

```
[jake]$ sudo umount /mnt/win
```

We trust you have received the usual lecture from the local System Administrator. It usually boils down to these two things:

```
#1) Respect the privacy of others.
#2) Think before you type.
```

```
Password: *****
```

```
[jake]$ mount /mnt/win
```

```
mount: only root can mount /dev/sda1 on /mnt/win
```

```
[jake]$ sudo mount /mnt/win
```

```
[jake]$
```

In the preceding session, the user `jake` runs the `sudo` command so he can unmount the `/mnt/win` file system (using the `umount` command). He is given a warning and asked to provide his password (this is `jake`'s password, *not* the `root` user's password).

Notice that even after `jake` has given the password, he must still use the `sudo` command to run the command as `root` (the first `mount` fails, but the second succeeds). Notice that he was not prompted for a password for the second `sudo`. That's because after entering his password successfully, he can enter as many `sudo` commands as he wants for the next 5 minutes without having to enter it again. (You can change the time-out value from 5 minutes to however long you want by setting the `passwd_timeout` value in the `/etc/sudoers` file.)

The preceding example grants a simple all-or-nothing administrative privilege to everyone you put in the `wheel` group. However, the `/etc/sudoers` file gives you an incredible amount of flexibility in permitting individual users and groups to use individual applications or groups of applications. I recommend you refer to the `sudoers` and `sudo` man pages for information about how to tune your `sudo` facility.

## Administering Your Linux System

---

Your Linux system administrator duties don't end after you have installed CentOS. Your ongoing job as a Linux system administrator includes the following tasks:

- **Configuring Hardware** — Often when you add hardware to your CentOS computer, that hardware will be automatically detected and configured by tools such as HAL. In

those cases in which the hardware was not properly set up, you can use commands such as `lsmod`, `modprobe`, `insmod`, and `rmod` to configure the right modules to get the hardware working.

- **Managing File Systems and Disk Space** — You must keep track of the disk space being consumed, especially if your CentOS system is shared by multiple users. At some point, you may need to add a hard disk or track down what is eating up your disk space (you can use commands like `find`, `du`, and `df` to do this).
- **Monitoring System Performance** — You may have a runaway process on your system, or you may just be experiencing slow performance. Tools that come with CentOS can help you determine how much of your CPU and memory are being consumed.

The aforementioned administrative tasks are described in the rest of this chapter. Other chapters cover other administrative topics, such as managing user accounts (Chapter 10), automating system tasks (Chapter 11), system backups and restores (Chapter 12), and securing your system (Chapter 13). Tasks related to network and server administration are covered in Chapters 14 through 24. Ways of getting updates to your Linux software (using the Add/Remove Software window and `yum` command) are described in Chapter 5.

## Configuring Hardware

---

For many hardware items that you attach to your computer, Linux will simply detect them and configure them. During system boot time, the kernel will probe and identify your IDE drives, SCSI drives, PCI cards, and other hardware. After the Linux desktop is running, USB devices that you plug in (such as pen drives or digital cameras) will be detected, and any file systems they contain will be automatically mounted.

The following section describes how to add and reconfigure hardware in Linux. This includes sections on checking your hardware, using HAL (for detecting and configuring hardware) and commands for working with loadable modules when hardware isn't being detected and configured properly.

### Checking Your Hardware

Sometimes the fact that CentOS can't properly detect and configure your hardware may make it impossible for you to install Linux. In those cases, I suggest you try to determine what hardware you have before you install. See Chapter 2 for information on checking your hardware before installing CentOS.

### Managing Hardware with HAL

HAL, short for Hardware Abstraction Layer, maintains a list of devices on your system and provides a programming API for applications to access. A background process, `hal`, looks for changes to your installed hardware.

To see what HAL knows about your system, run the `lshal` command:

```
$ lshal
Dumping 96 device(s) from the Global Device List:
-----
udi = '/org/freedesktop/Hal/devices/computer'
  info.addons = {'hald-addon-cpufreq', 'hald-addon-acpi'} (string
  list)
...
  org.freedesktop.Hal.Device.SystemPowerManagement.method_names =
{'Suspend', 'SuspendHybrid', 'Hibernate', 'Shutdown', 'Reboot',
'SetPowerSave'} (string list)
  org.freedesktop.Hal.Device.SystemPowerManagement.method_
  signatures=
{'i', 'i', '', '', '', 'b'} (string list)
  power_management.acpi.linux.version = '20060707' (string)
  power_management.can_hibernate = true (bool)
  power_management.can_suspend = true (bool)
  power_management.can_suspend_hybrid = false (bool)
  power_management.can_suspend_to_disk = true (bool)
  power_management.can_suspend_to_ram = true (bool)
  power_management.is_powersave_set = false (bool)
  power_management.type = 'acpi' (string)
...
udi = '/org/freedesktop/Hal/devices/pci_8086_27c0'
  info.linux.driver = 'ata_piix' (string)
  info.parent = '/org/freedesktop/Hal/devices/computer' (string)
  info.product = '82801GB/GR/GH (ICH7 Family) SATA IDE Controller'
  (string)
  info.subsystem = 'pci' (string)
  info.udi = '/org/freedesktop/Hal/devices/pci_8086_27c0' (string)
  info.vendor = 'Intel Corporation' (string)
...
```

In the long-winded output, you can see all sorts of information about your system hardware, such as the SATA IDE disk controller in this example. You can learn more about HAL at [www.freedesktop.org/Software/hal](http://www.freedesktop.org/Software/hal) and [www.freedesktop.org/wiki/Software/HalFAQ](http://www.freedesktop.org/wiki/Software/HalFAQ).

## Reconfiguring Hardware with kudzu

When you added or removed hardware from your computer and rebooted in earlier versions of CentOS, a window appeared during the boot process advising that hardware has either been added or removed and asking if you wanted to reconfigure it. The program that detected and reconfigured your hardware is called `kudzu`.

The `kudzu` program is a hardware autodetection and configuration tool that runs automatically at boot time. If you like, you can also start `kudzu` while Linux is running. In either case, here is what `kudzu` does:

1. It checks the hardware connected to your computer.
2. It compares the hardware it finds to the database of hardware information stored in the `/etc/sysconfig/hwconf` file.
3. It prompts you to change your system configuration, based on new or removed hardware that was detected.

The following is a list of hardware that `kudzu` can detect (according to the `kudzu` README file), followed by a description of what `kudzu` does to configure the device. Other devices may be detected as well (such as USB devices).

- **Network Devices** — Adds an Ethernet interface alias (`eth0`, `eth1`, etc.) if necessary and either migrates the old device configuration or creates a new one.
- **SCSI** — Adds an alias for `scsi_hostadapter`.
- **Sound Card** — Runs the `sndconfig` command to configure and test the sound card.
- **Mouse** — Runs the `mouseconfig` command to configure and test the mouse.
- **Modem** — Links the new modem device to `/dev/modem`.
- **CD-ROM** — Links the CD-ROM device to `/dev/cdrom`.
- **Scanner** — Links the new scanner device to `/dev/scanner`.
- **Keyboard** — Runs the `kbdconfig` command to reconfigure the keyboard. Also, if you are using a serial console, it makes sure `/etc/inittab` and `/etc/securetty` are configured to be used by a serial console.

The following is a list of actions `kudzu` takes when a device is removed:

- **Network** — Removes the alias for the Ethernet interface (`eth0`, `eth1`, etc.).
- **SCSI** — Removes the alias for the SCSI host adapter (`scsi_hostadapter`).
- **Modem** — Removes the link to `/dev/modem`.
- **CD-ROM** — Removes the link to `/dev/cdrom`.
- **Scanner** — Removes the link to `/dev/scanner`.

To run `kudzu`, either reboot (during the reboot, `kudzu` is run automatically) or simply run the `kudzu` command (as `root` user from a shell). For any hardware that has been added or removed since the last time `kudzu` was run, you are asked if you want to configure it, not configure it, or do nothing.

**NOTE**

Removable devices, such as digital cameras, USB flash drives, and Webcams, are detected and configured on-the-fly using the `hald` daemon. The `hald` daemon relies on the Udev device management facility to dynamically create devices and mount points (if needed) when those types of devices are connected. See Chapter 7 for descriptions of how CDs and digital cameras are detected.

## Configuring Modules

In a perfect world, after installing and booting Linux, all of your hardware should be detected and available for access. While CentOS systems are rapidly moving closer to that world, there are times when you must take special steps to get your computer hardware working.

CentOS systems come with tools for configuring the drivers that stand between the programs you run (such as CD players and Web browsers) and the hardware they use (such as CD-ROM drives and network cards). The intention is to have only the most critical drivers your system needs built into the kernel; these are called *resident drivers*. Other drivers that are added dynamically as needed are referred to as *loadable modules*. The trend is to keep the basic kernel as lean as possible, so that each running system has only a few resident drivers and it can dynamically add what it needs.

### Listing Loaded Modules

To see which modules are currently loaded into the running kernel on your computer, you can use the `lsmod` command. Here's an example:

```
# lsmod
Module                Size  Used by
snd_seq_oss           38912  0
snd_seq_midi_event    9344   1 snd_seq_oss
snd_seq               67728  4 snd_seq_oss,snd_seq_midi_event
snd_seq_device        8328   2 snd_seq_oss,snd_seq
.
.
.
autofs                16512  0
ne2k_pci              9056   0
8390                  13568  1 ne2k_pci
ohci1394              41860  0
ieee1394             284464  1 ohci1394
floppy                65712  0
sg                    36120  0
scsi_mod             124600  1 sg
parport_pc            39724  0
parport               47336  1 parport_pc
ext3                  128424  2
jbd                   86040  1 ext3
```

This output shows a variety of modules that have been loaded on a Linux system. The modules loaded on this system include several to support sound, including some that provide OSS compatibility (`snd_seq_oss`).

To find information about any of the loaded modules, you can use the `modinfo` command. For example, you could type the following:

```
# modinfo snd-seq-oss
filename:          /lib/modules/2.6.18-92.el5/kernel/sound/core/seq/oss/
```

```

snd-seq-oss.ko
alias:          sound-service-?-8
alias:          sound-service-?-1
license:        GPL
description:    OSS-compatible sequencer module
author:         Takashi Iwai <tiwai@suse.de>
srcversion:     B37590B8403309A4C7CE5D7
depends:         snd-seq,snd-seq-midi-event,snd-seq-device,snd
vermagic:       2.6.18-92.e15 SMP mod_unload 686 REGPARM 4KSTACKS
                gcc-4.1
parm:          maxqlen:maximum queue length (int)
parm:          seq_oss_debug:debug option (int)
module_sig:     883f350484fb18d1f27370acbc602e11215d809c9bc2f87f8c01
                cc7bdecd16be
                9629ee1e0fa102809f402c2d3871d59b4c4b71129a229d8afd
                1a339a

```

This output tells you the location of the module (filename), the author, and description, among other information. The output describes `snd-seq-oss` as an OSS-compatible sequencer module. You can use the `-d` option to list just the description, the `-a` option to see the author of the module, or `-n` to see the object file representing the module. The author information often has the e-mail address of the driver's creator, so you can contact the author if you have problems or questions about it.

## Loading Modules

You can load any module that has been compiled and installed (to the `/lib/modules/<kernel version>` directory) into your running kernel using the `modprobe` command. The most common reasons for loading a module are that you want to use a feature temporarily (such as loading a module to support a special file system on a floppy you want to access) or to identify a module that will be used by a particular piece of hardware that could not be autodetected.

Here is an example of the `modprobe` command being used to load the `parport` module. The `parport` module provides the core functions to share parallel ports with multiple devices.

```
# modprobe parport
```

After `parport` is loaded, you can load the `parport_pc` module to define the PC-style ports available through the interface. The `parport_pc` module lets you optionally define the addresses and IRQ numbers associated with each device sharing the parallel port. For example:

```
# modprobe parport_pc io=0x3bc irq=auto
```

In the previous example, a device is identified as having an address of `0x3bc`. The IRQ for the device is autodetected.

The `modprobe` command loads modules temporarily. At the next system reboot, the modules you enter disappear. To ensure that the module is loaded each time your system boots up, add

an entry for it in `/etc/modprobe.conf`. The listing in `modprobe.conf` for the `parport_pc` module example (along with the address and IRQ options) would be:

```
alias parport_lowlevel parport_pc
options parport_lowlevel io=0x3bc irq=auto
```

For more information, read the `modprobe.conf` man page by typing **man modprobe.conf**.

**NOTE**

An alternative to using `modprobe` is the `insmod` command. The advantage of using `modprobe`, however, is that `insmod` will only load the module you request, while `modprobe` will try to load other modules that the one you requested is dependent on.

## Removing Modules

You can remove a module from a running kernel using the `rmmmod` command. For example, to remove the module `parport_pc` from the current kernel, type the following:

```
# rmmmod parport_pc
```

If the module is not currently busy, the `parport_pc` module is removed from the running kernel. (Instead of `rmmmod`, you can use `modprobe -r` to remove the module, plus related modules.)

**NOTE**

There are times when a piece of hardware is improperly detected and a module is loaded that is either the wrong module or is simply a broken module. In that case, you can consider adding the name of the offending driver to the `/etc/modprobe.d/blacklist` file, to prevent that module from being loaded. After that, you can consider loading the proper module manually or by adding an entry in `/etc/modprobe.conf`.

## Managing File Systems and Disk Space

---

File systems in Linux are organized in a hierarchy, beginning from root (`/`) and continuing downward in a structure of directories and subdirectories. As an administrator of a CentOS system, it is your duty to make sure that all the disk drives that represent your file system are available to the users of the computer. It is also your job to make sure that there is enough disk space in the right places in the file system for users to store what they need.

File systems are organized differently in Linux than they are in Microsoft Windows operating systems. Instead of drive letters (for example, `A:`, `B:`, `C:`) for each local disk, network file system, CD-ROM, or other type of storage medium, everything fits neatly into the directory structure. For hard drive partitions, it is up to an administrator to create a mount point in the file system and then connect the disk to that point in the file system. For removable media (such as CD, DVD, USB flash drives, or digital cameras), mount points are automatically created and connected (in the `/media` directory) when those items are connected or loaded.

**CROSS-REF** Chapter 2 provides instructions for using Disk Setup (formerly *Disk Druid*) to configure disk partitions. Chapter 4 describes how the Linux file system is organized.

The organization of your file system begins when you install Linux. Part of the installation process is to divide your hard disk (or disks) into partitions. Those partitions can then be assigned to:

- A part of the Linux file system
- Swap space for Linux

or

- Other file system types (perhaps containing other bootable operating systems)

For our purposes, I want to focus on partitions that are used for the Linux file system. To see what partitions are currently set up on your hard disk, use the `fdisk` command as follows:

```
# fdisk -l
Disk /dev/sda: 40.0 GB, 40020664320
255 heads, 63 sectors/track, 4825 cylinders
Units = cylinders of 16065 * 512 bytes = 8225280 bytes

   Device Boot      Start         End      Blocks   Id  System
/dev/sda1  *           1           13         104     b   Win95 FAT32
/dev/sda2                84           89        48195    83   Linux
/dev/sda3                90          522       3478072+  83   Linux
/dev/sda4             523          554        257040     5   W95 Ext'd (LBA)
/dev/sda5             523          554       257008+   82   Linux swap / Solaris
```

This output shows the disk partitioning for a computer able to run both Linux and Microsoft Windows. You can see that the Linux partition on `/dev/sda3` has most of the space available for data. There is a Windows partition (`/dev/sda1`) and a Linux swap partition (`/dev/sda5`). There is also a small `/boot` partition (46 MB) on `/dev/sda2`. In this case, the root partition for Linux has 3.3 GB of disk space and resides on `/dev/sda3`.

Next, to see what partitions are actually being used for your Linux system, you can use the `mount` command (with no options). The `mount` command can show you which of the available disk partitions are actually mounted and where they are mounted.

```
# mount
/dev/sda3 on / type ext3 (rw)
/dev/sda2 on /boot type ext3 (rw)
/dev/sda1 on /mnt/win type vfat (rw)
none on /proc type proc (rw)
none on /sys type sysfs (rw)
none on /dev/pts type devpts (rw,gid=5,mode=620)
none on /dev/shm type tmpfs (rw)
```



```
none on /proc/sys/fs/binfmt_misc type binfmt_misc (rw)
/dev/scd0 on /media/cdrecorder_ type iso9660
(ro,nosuid,nodev,uhelper=hal)
```

**NOTE**

You may notice that `/proc`, `/sys`, `/dev/pts`, `/proc/sys/fs/binfmt_misc`, `/dev/shm`, and other entries not relating to a partition are shown as file systems. This is because they represent different file system types (`proc` and `devpts`, etc.). The word *none*, however, indicates that they are not associated with a separate physical partition.

The mounted Linux partitions in this case are `/dev/sda2`, which provides space for the `/boot` directory (which contains data for booting Linux), and `/dev/sda3`, which provides space for the rest of the Linux file system beginning from the root directory (`/`). This particular system also contains a Windows partition that was mounted in the `/mnt/win` directory.

Mount points for removable media (CDs, DVDs, USB pen drives, etc.) are in the `/media` directory. In this example, an IDE combination CDRW/DVD-ROM drive was mounted on `/media/cdrecorder`. With most GUI interfaces, the CD or DVD is typically mounted automatically when you insert it. In this example, the `uhelper` (unprivileged unmount request helper) is assigned to the `hal` daemon user `hal` so that the `hal` facility can unmount the CD as an otherwise non-privileged user.

**NOTE**

See a description of the GNOME Volume Manager in Chapter 3 for information about how removable media are handled in the current CentOS release.

After the word `type`, you can see the type of file system contained on the device. (See the description of different file system types in the next section of this chapter.) Particularly on larger Linux systems, you may have multiple partitions for several reasons:

- **Multiple Hard Disks** — You may have several hard disks available to your users. In that case, you would have to mount each disk (and possibly several partitions from each disk) in different locations in your file system.
- **Protecting Different Parts of the File System** — If you have many users on a system and the users consume all of the file system space, the entire system can fail. For example, there may be no place for temporary files to be copied (so the programs writing to temporary files may fail), and incoming mail may fail to be written to mail boxes. With multiple mounted partitions, if one partition runs out, others can continue to work.
- **Backups** — There are some fast ways to back up data from your computer that involve copying the entire image of a disk or partition. If you want to restore that partition later, you can simply copy it back (bit by bit) to a hard disk. With smaller partitions, this approach can be done fairly efficiently.
- **Protecting from Disk Failure** — If one disk (or part of one disk) fails, by having multiple partitions mounted on your file system, you may be able to continue working and just fix the one disk that fails.

When a disk partition is mounted on the file system, all directories and subdirectories below that mount point are then stored on that partition. So, for example, if you were to mount one

partition on / and one on /usr, everything below the /usr mount point would be stored on the second partition while everything else would be stored on the first partition. If you then mounted another partition on /usr/local, everything below that mount point would be on the third partition, while everything else below /usr would be on the second partition.

**TIP**

What if a remote file system is unmounted from your computer and you go to save a file in that mount point directory? What happens is that you will write the file to that directory, and it will be stored on your local hard disk. When the remote file system is remounted, however, the file you saved will seem to disappear. To get the file back, you will have to unmount the remote file system (causing the file to reappear), move the file to another location, remount the file system, and copy the file back there.

Mount points that are often mentioned as being candidates for separate partitions include /, /boot, /home, /usr, and /var. The root file system (/) is the catchall for directories that aren't in other mount points. The root file system's mount point (/) is the only one that is required. The /boot directory holds the images needed to boot the operating system. The /home file system is where all the user accounts are typically stored. Applications and documentation are stored in /usr. Below the /var mount point is where log files, temporary files, server files (Web, FTP, etc.), and lock files are stored (i.e., items that need disk space for your computer's applications to keep running).

**CROSS-REF**

See Chapter 2 for further information on partitioning techniques.

The fact that multiple partitions are mounted on your file system is invisible to people using your Linux system. The only times they will care will be if a partition runs out of space or if they need to save or use information from a particular device (such as a floppy disk or remote file system). Of course, any user can check this by typing the `mount` command.

## Mounting File Systems

Most of your hard disk partitions are mounted automatically for you. When you installed CentOS, you were asked to create partitions and indicate the mount points for those partitions. When you boot CentOS, all Linux partitions residing on hard disk should typically be mounted. For that reason, this section focuses mostly on how to mount other types of devices so that they become part of your Linux file system.

Besides being able to mount other types of devices, you can also use `mount` to mount other kinds of file systems on your Linux system. This means that you can store files from other operating systems or use file systems that are appropriate for certain kinds of activities (such as writing large block sizes). The most common use of this feature for the average Linux user, however, is to allow that user to obtain and work with files from floppy disks or CD-ROMs.

### Supported File Systems

To see file system types that are currently available to be used on your system, type `cat /proc/filesystems`. The following file system types are supported in Linux, although they may

not be in use at the moment, or they may not be built into your current kernel (so they may need to be loaded as modules):

- **adfs** — This is the acorn disc file system, which is the standard file system used on RiscOS operating systems.
- **befs** — This is the file system used by the BeOS operating system.
- **cifs** — The Common Internet File System (CIFS) is the virtual file system used to access servers that comply with the SNIA CIFS specification. CIFS is an attempt to refine and standardize the SMB protocol used by Samba and Windows file sharing.
- **ext3** — The ext file systems are the most common file systems used with Linux. The ext3 file system is currently the default file system type in many Linux systems (including CentOS). The root file system (/) is typically ext3 (although you can use other file systems as well). The ext3 file system is also referred to as the Third Extended file system. The ext3 file system includes journaling features that improve a file system's ability to recover from crashes, as compared to ext2 file systems.
- **ext4** — An enhancement to ext3, this type of file system performs and scales better to larger numbers of files, but ext4 is still considered experimental.
- **ext2** — The default file system type for versions of older CentOS releases. Features are the same as ext3, except that ext2 doesn't include journaling features.
- **ext** — This is the first version of the ext file system. It is not used very often anymore, and I recommend that you don't use it.
- **iso9660** — This file system evolved from the High Sierra file system (which was the original standard used on CD-ROM). Extensions to the High Sierra standard (called *Rock Ridge extensions*), allow iso9660 file systems to support long filenames and UNIX-style information (such as file permissions, ownership, and links). This file system type is used when you mount a CD-ROM.
- **kafs** — This is the AFS client file system. It is used in distributed computing environments to share files with Linux, Windows, and Macintosh clients.
- **minix** — This is the Minix file system type, used originally with the Minix version of UNIX. It only supports filenames of up to 30 characters.
- **msdos** — This is an MS-DOS file system. You can use this type to mount floppy disks that come from Microsoft operating systems.
- **vfat** — This is the Microsoft extended FAT (VFAT) file system.
- **umsdos** — This is an MS-DOS file system with extensions to allow features that are similar to UNIX (including long filenames).
- **proc** — This is not a real file system, but rather a file-system interface to the Linux kernel. You probably won't do anything special to set up a proc file system. However, the /proc mount point should be a proc file system. Many utilities rely on /proc to gain access to Linux kernel information.

- **swap** — This is used for swap partitions. Swap areas are used to hold data temporarily when RAM is currently used up. Data is swapped to the swap area, then returned to RAM when it is needed again.
- **nfs** — This is the Network File System (NFS) type of file system. File systems mounted from another computer on your network use this type of file system.

**CROSS-REF** Information on using NFS to export and share file systems over a network is contained in Chapter 17.

- **hpfs** — This file system is used to do Read Only mounts of an OS/2 HPFS file system.
- **nepfs** — This relates to Novell NetWare file systems. NetWare file systems can be mounted over a network.
- **ntfs** — Many people who set up dual-boot computers want to be able to access the Windows (ntfs) drives. To add NTFS file system support to CentOS, you need to install the fuse and fuse-ntfs-3g packages available from the RPMForge repository.
- **affs** — This file system is used with Amiga computers.
- **reiserfs** — This is a journaling file system that used to be the default file system for some other Linux distributions (including SUSE, Slackware, and Linspire). Reiserfs is not considered to be well-supported in CentOS systems.
- **ufs** — This file system is popular on Sun Microsystems operating systems (i.e., Solaris and SunOS).
- **xenix** — This was added to be compatible with Xenix file systems (one of the first PC versions of UNIX). The system is obsolete and will probably be removed eventually.
- **xfs** — This is a journaling file system that is useful in high-performance environments. It includes full 64-bit addressing. An xfs file system can scale up to systems that include multiple terabytes of data that transfer data at multiple gigabytes per second. The CentOSPlus repository contains the `kmod-xfs` and `xfsprogs` RPMs you need to implement xfs easily on CentOS.
- **jfs** — This file system is based on the JFS file system IBM used for OS/2 Warp. It became an Open Source project in 2000. JFS is most suited for enterprise systems. Like XFS, JFS is tuned for large file systems and high-performance environments.
- **xiafs** — This file system supports long filenames and larger inodes than file systems such as minux.
- **squashfs** — This is a compressed file system, where files are uncompressed on the fly as they are requested. It is often used with live CDs.
- **fuse** — Fuse behaves like a user-space remote file system. A local user can use ssh tools to mount a remote file system locally, without the remote file system being made available, purely on the basis of the permissions of the user you log in as. A very cool way to mount a remote file system without administrative intervention on the remote side!

The ext4 file system is the latest version of the ext file system (with ext3 being the current standard). An ext4 file system can be mounted as an ext3 file system. However, if you want to use new ext4 features (called extents), mount it as an ext4 device (`mount -t ext4dev`). See the Ext4 FAQ for information on creating and working with ext4 file systems:

```
http://ext4.wiki.kernel.org/index.php/Frequently_Asked_Questions
```

A how-to document helps you get started with ext4 file systems:

```
http://ext4.wiki.kernel.org/index.php/Ext4_Howto
```

You can convert an ext3 file system to ext4 by using a command like the following:

```
# tune2fs -O extents -E test_fs /dev/DEV
```

And, you can adjust the inode setting, for example, from 128 to 256, to improve efficiency with a command like the following:

```
# tune2fs -I 256 /dev/DEV
```

Encrypted file systems can be used to protect your data if your computer should become lost or stolen. In particular, this feature was created with laptops in mind. Someone stealing your laptop would not be able to mount or access data on an encrypted file system without your password. The `cryptsetup` command from the `cryptsetup-luks` package is used to create cryptographic volumes. Any file system, other than root (`/`), can be encrypted.

In addition, you can use encryption on hotpluggable file systems. A handy getting-started document appears at <http://flyn.org/easycrypto/easycrypto.html>. Another document relating directly to encrypting your file system on CentOS can be found at <http://wiki.centos.org/HowTos/EncryptedFilesystem>.

You can use `dm-crypt`, short for *device mapper encryption*, to provide transparent encryption to block devices, such as disks. By *transparent*, this means that programs don't need to worry that the contents of your disk are encrypted, as the mapping layer adds this feature. This allows you to work with word processors, text editors, drawing programs, and so on, without messing with encryption. But your files are stored safely protected (well, as safe as current encryption technology can be).

To use `dm-crypt`, you must have a 2.6 or higher Linux kernel with `dm-crypt` support. For more on `dm-crypt`, see [www.saout.de/misc/dm-crypt/](http://www.saout.de/misc/dm-crypt/).

## Using the `fstab` File to Define Mountable File Systems

The hard disks on your local computer and the remote file systems you use every day are probably set up to mount automatically when you boot Linux. The definitions for which of these file systems are mounted are contained in the `/etc/fstab` file. Here's an example of an `/etc/fstab` file:

```
/dev/VolGroup00/LogVol100 /          ext3      defaults    1 1
LABEL=/boot                /boot    ext3      defaults    1 2
```

```

/dev/devpts          /dev/pts           devpts   gid=5,mode=620  0 0
/dev/shm             /dev/shm           tmpfs    defaults         0 0
/dev/proc            /proc              proc     defaults         0 0
/dev/sys             /sys               sysfs    defaults         0 0
/dev/VolGroup00/LogVol101 swap              swap     defaults         0 0
/dev/sda1            /mnt/win           vfat     noauto          0 0

```

All file systems listed in this file are mounted at boot time, except for those set to `noauto` in the fourth field. In this example, the root (`/`) and swap hard disk partitions are configured as logical volume management (LVM) volumes. This means that they may consist of multiple hard disk partitions. You can use the `pvdisplay` command to see what physical volumes make up each logical volume. An advantage of LVM volumes is that, if you run out of space in a logical volume, you can simply attach a new physical volume (such as a disk partition) to extend its size. You don't have to resize or create a new partition.

The `/proc`, `/sys`, `/dev/shm`, and `/dev/pts` file systems are not associated with particular devices. The floppy disk and CD-ROM drive entries are no longer included in the `/etc/fstab` file by default. That's because those media types are now handled by the `hald` daemon and are mounted automatically when they are inserted. The actual mount points will change based on the CD or DVD's volume name (implanted on that medium itself).

I also added one additional line for `/dev/sda1`, which allows me to mount the Windows (vfat in this case, but ntfs support can be added) partition on my computer so I don't have to always boot Windows to get at the files on my Windows partition.

## NOTE

To access the Windows partition described previously, I must first create the mount point (by typing `mkdir /mnt/win`). I can then mount it when I choose by typing (as root) `mount /mnt/win`.

You find the following in each field of the `fstab` file:

- **Field 1** — The name of the device representing the file system. The word `none` is often placed in this field for file systems (such as `/proc` and `/dev/pts`) that are not associated with special devices. Notice that this field can now include the `LABEL` or `UUID` options. Using `UUID`, you can indicate a universally unique identifier (UUID). `LABEL` indicates a volume label instead of a device name. The advantage to the `LABEL` approach is that, since the partition is identified by volume name, you can move a volume to a different device name and not have to change the `fstab` file.
- **Field 2** — The mount point in the file system. The file system contains all data from the mount point down the directory tree structure, unless another file system is mounted at some point beneath it.
- **Field 3** — The file system type. Valid file system types are described in the “Supported File Systems” section earlier in this chapter.
- **Field 4** — Options to the `mount` command. In the preceding example, the `noauto` option prevents the indicated file system from being mounted at boot time. Also, `ro` says

to mount the file system Read Only (which is reasonable for a CD-ROM drive). Commas must separate options. See the `mount` command manual page (under the `-o` option) for information on other supported options.

**TIP**

Normally, only the `root` user is allowed to mount a file system using the `mount` command. However, to allow any user to mount a file system (such as a file system on a floppy disk), you could add the `user` or `owner` option to Field 4 of `/etc/fstab`.

- **Field 5** — The number in this field indicates whether or not the indicated file system needs to be backed up by a backup system called `dump`. A number 1 assumes that the file system needs to be backed up, or *dumped*. A number 0 assumes that the file system doesn't need to be dumped. Note that most Linux users do not use the `dump` program for backups.
- **Field 6** — The number in this field indicates whether or not the indicated file system needs to be checked with `fsck`. A zero indicates that the file system should not be checked. A number 1 assumes that the file system needs to be checked first (this is used for the root file system). A number 2 assumes that the file system can be checked at any point after the root file system is checked.

If you want to add an additional local disk or an additional partition, you can create an entry for the disk or partition in the `/etc/fstab` file. To get instructions on how to add entries for an NFS file system, see Chapter 17.

## Using the `mount` Command to Mount File Systems

Your CentOS system automatically runs `mount -a` (mount all file systems) each time you boot. For that reason, you would typically only use the `mount` command for special situations. In particular, the average user or administrator uses `mount` in two ways:

- To display the disks, partitions, and remote file systems that are currently mounted
- To temporarily mount a file system

Any user can type the `mount` command (with no options) to see what file systems are currently mounted on the local Linux system. The following is an example of the `mount` command. It shows a single hard disk partition (`/dev/sda1`) containing the root (`/`) file system, and `proc` and `devpts` file system types mounted on `/proc` and `/dev`, respectively. The last entry shows a floppy disk, formatted with a standard Linux file system (`ext3`) mounted on the `/media/floppy` directory.

```
$ mount
/dev/mapper/VolGroup00-LogVol100 on / type ext3 (rw)
/dev/proc on /proc type proc (rw)
/dev/sys on /sys type sysfs (rw)
/dev/devpts on /dev/pts type devpts(rw,gid=5,mode=620)
/dev/sda3 on /boot type ext3 (rw)
/dev/shm on /dev/shm type tmpfs (rw)
/dev/fd0 on /media/floppy type ext3 (rw)
```

The most common devices to mount by hand are your floppy disk and your CD-ROM. However, by default now in CentOS and other Linux systems, CD-ROMs and floppy disks are mounted for you automatically when you insert them. (In some cases, the autorun program may also run automatically. For example, autorun may start a CD music player or software package installer to handle the data on the medium.)

### Mounting Removable Media

If you want to mount a file system manually, the `/etc/fstab` file helps make it simple to mount a file system from any disk partition, floppy disk, or a CD-ROM. Although CentOS no longer automatically adds entries for CDs and floppy disks to the `/etc/fstab` file, you could add entries manually, if you wanted to mount those media in different locations. Here are examples of entries you could add to your `/etc/fstab` file:

```
/dev/cdrom /mnt/cdrom auto noauto,user,exec,ro 0 0
/dev/fd0 /mnt/floppy auto noauto,owner 0 0
```

The `/mnt` directory is the location traditionally used to mount removable or temporary file systems in Linux. If you are adding mount points manually, it's best to use a location such as `/mnt`, instead of the newer `/media` directory, so you don't conflict with any file systems the HAL service (`hal` daemon) mounts automatically in the `/media` directory.

With entries added such as those just shown, you can use the `mount` command with a single option to indicate what you want to mount, and information is taken from the `/etc/fstab` file to fill in the other options. The following are cases in which you could mount a CD or floppy disk file system using a single option (based on the `/etc/fstab` file shown above):

- **CD-ROM** — If you are mounting a CD-ROM that is in the standard ISO 9960 format (as most software CD-ROMs are), you can mount that CD-ROM by placing it in your CD-ROM drive and typing the following:

```
# mount /mnt/cdrom
```

By default, your CD-ROM is mounted on a point in the `/media` directory. The command just shown, however, mounts the `/dev/cdrom` device on the `/mnt/cdrom` directory.

- **Floppy Disk** — If you are mounting a floppy disk that is in the standard Linux file system format (`ext3`), based on the `/etc/fstab` file entry shown above, you can mount that floppy disk by inserting it in your floppy drive and typing the following:

```
# mount /mnt/floppy
```

The file system type (`ext3`), device (`/dev/fd0`), and mount options are filled in from the `/etc/fstab` file. You should be able to change to the floppy disk directory (`cd /mnt/floppy`) and list the contents of the floppy's top directory (`ls`).

#### NOTE

In both of the two previous cases, you could give the device name (`/dev/cdrom` or `/dev/fd0`, respectively) instead of the mount point directory to get the same results.



Of course, it is possible that you may get floppy disks you want to use that are in all formats. Someone may give you a floppy containing files from a Microsoft operating system (in MS-DOS format). Or you may get a file from another UNIX system. In those cases, you can fill in your own options, instead of relying on options from the `/etc/fstab` file. In some cases, Linux autodetects that the floppy disk contains an MS-DOS (or Windows vfat) file system and mounts it properly without additional arguments. However, if it doesn't, here is an example of how to mount a floppy containing MS-DOS files:

```
# mount -t msdos /dev/fd0 /mnt/floppy
```

This shows the basic format of the `mount` command you would use to mount a floppy disk. You could change `msdos` to any other supported file system type (described earlier in this chapter) to mount a floppy of that type. Instead of using floppy drive A: (`/dev/fd0`), you could use drive B: (`/dev/fd1`) or any other accessible drive. Instead of mounting on `/mnt/floppy`, you could create any other directory and mount the floppy there.

Here are some other useful options you could add along with the `mount` command:

- `-t auto` — If you aren't sure exactly what type of file system is contained on the floppy disk (or other medium you are mounting), use the `-t auto` option to indicate the file system type. The `mount` command will query the disk to try to guess what type of data it contains.
- `-r` — If you don't want to make changes to the mounted file system (or can't because it is a Read Only medium), use this option when you mount it. This will mount it Read Only.
- `-w` — This mounts the file system with Read/Write permission.

### Mounting CD or DVD Images

Another valuable way to use the `mount` command has to do with ISO disk images. If you download a CD, DVD, or floppy disk image from the Internet and you want to see what it contains, you can do so without burning it to CD or floppy. With the image on your hard disk, create a mount point and use the `-o loop` option to mount it locally. Here's an example of what to type (as root user):

```
# mkdir /mnt/mycdimage  
# mount -o loop whatever-i386-disc1.iso /mnt/mycdimage
```

In this example, the disk image file (`whatever-i386-disc1.iso`) residing in the current directory is mounted on the `/mnt/mycdimage` directory I just created. I can now `cd` to that directory, view the contents of it, and copy or use any of its contents. This is useful for downloaded CD images that you want to install software from without having to burn the image to CD. When you are done, just type **`umount /mnt/mycdimage`** to unmount it.

Other options to mount are available only for a specific file system type. See the `mount` manual page for those and other useful options.

## Using the `umount` Command to Unmount a File System

When you are done using a temporary file system, or you want to unmount a permanent file system temporarily, you can use the `umount` command. This command detaches the file system from its mount point in your Linux file system. To use `umount`, you can give it either a directory name or a device name. For example:

```
# umount /mnt/floppy
```

This unmounts the device (probably `/dev/fd0`) from the mount point `/mnt/floppy`. You could also have done this using the form:

```
# umount /dev/fd0
```

In general, it's better to use the directory name because the `umount` command will fail if the device is mounted in more than one location.

If you get a message that the “device is busy,” the `umount` request has failed. The reason is that either a process has a file open on the device or that you have a shell open with a directory on the device as a current directory. Stop the processes or change to a directory outside of the device you are trying to unmount for the `umount` request to succeed.

An alternative for unmounting a busy device is the `-l` option. With `umount -l` (a lazy unmount), the unmount happens as soon as the device is no longer busy. To unmount a remote NFS file system that is no longer available (e.g., the server went down), you can use the `umount -f` option to forcibly unmount the NFS file system.

## Using the `mkfs` Command to Create a File System

It is possible to create a file system, for any supported file system type, on a disk or partition that you choose. This is done with the `mkfs` command. While this is most useful for creating file systems on hard disk partitions, you can create file systems on floppy disks or re-writable CDs as well.

Here is an example of using `mkfs` to create a file system on a floppy disk:

```
# mkfs -t ext3 /dev/fd0
mkfs 1.39, (29-May-2006)
Filesystem label=
OS type: Linux
Block size=1024 (log=0)
Fragment size=1024 (log=0)
184 inodes, 1440 blocks
72 blocks (5.00%) reserved for the super user
First data block=1
1 block group
8192 blocks per group, 8192 fragments per group
184 inodes per group
```

```
Writing inode tables: done
```

```
Filesystem too small for a journal
```

```
Writing superblocks and filesystem accounting information: done
```

```
The filesystem will be automatically checked every 23 mounts or  
180 days, whichever comes first. Use tune2fs -c or -i to override.
```

You can see the statistics that are output with the formatting done by the `mkfs` command. The number of inodes and blocks created are output. Likewise, the number of blocks per group and fragments per group are also output. You could now mount this file system (`mount /mnt/floppy`), change to it as your current directory (`cd /mnt/floppy`), and create files on it as you please.

## Adding a Hard Disk

Adding a new hard disk to your computer so that it can be used by Linux requires a combination of steps described in previous sections. The general steps are as follows:

1. Install the hard disk hardware.
2. Identify the partitions on the new hard disk.
3. Create the file systems on the new hard disk.
4. Mount the file systems.

The easiest way to add a hard disk to Linux is to have the entire hard disk devoted to a single Linux partition. You can have multiple partitions of different sizes, however, and assign them each to different types of file systems and different mount points, if you like. The following procedure describes how to add a hard disk containing a single Linux partition. Along the way, however, it also notes which steps you need to repeat to have multiple file systems with multiple mount points.

### NOTE

This procedure assumes that CentOS is already installed and working on the computer. If this is not the case, follow the instructions for adding a hard disk on your current operating system. Later, when you install CentOS, you can identify this disk when asked to partition your hard disk(s).

1. Install the hard disk into your computer. Follow the manufacturer's instructions for physically installing and connecting the new hard disk. If, presumably, this is a second hard disk, you may need to change jumpers on the hard disk unit itself to have it operate as a slave hard disk. You may also need to change the BIOS settings.
2. Boot your computer to Linux.
3. Determine the device name for the hard disk. As `root` user from a shell, type:

```
# dmesg | less
```

From the output, look for an indication that the new hard disk was found. For example, if it is a second hard disk, you should see `sdb` : in the output. Be sure you identify the right disk or you will erase all the data from disks you probably want to keep!

**NOTE**

In the past, IDE hard drives began with `/dev/hd` and SCSI drives began with `/dev/sd`. Now, both IDE and SCSI drives begin with `/dev/sd` in CentOS, as in `/dev/sda` and `/dev/sdb`.

4. Use the `fdisk` command to create partitions on the new disk. For example, if you are formatting the second hard disk (`sdb`), you could type the following:

```
# fdisk /dev/sdb
```

5. If the disk had existing partitions on it, you can change or delete those partitions now. Or, you can simply reformat the whole disk to blow everything away. Use `p` to view all partitions and `d` to delete a partition.
6. To create a new partition, type the following:

```
n
```

You are asked to choose an extended or primary partition.

7. To choose a primary partition, type the following:

```
p
```

You are asked the partition number.

8. If you are creating the first partition (or for only one partition), type the number **1**:

```
1
```

You are asked to enter the first cylinder number (with 1 being the default).

9. To begin at the second cylinder, type the number **2** as follows:

```
2
```

You are asked to enter the last cylinder.

10. If you are using the entire hard disk, use the last cylinder number shown. Otherwise, choose the ending cylinder number or indicate how many megabytes the partition should have.
11. To create more partitions on the hard disk, repeat Steps 6 through 10 for each partition. You will need to change the partition number, cylinder numbers, and so on as appropriate.
12. Type `w` to write changes to the hard disk. At this point, you should be back at the shell.

13. To make a file system on the new disk partition, use the `mkfs` command. By default, this command creates an ext2 file system, which is useable by Linux. To create an ext3 file system on the first partition of the second hard disk, type the following:

```
# mkfs -t ext3 /dev/sdb1
```

If you created multiple partitions, repeat this step for each partition (such as `/dev/sdb2`, `/dev/sdb3`, etc.).

**NOTE**

If you don't use `-t ext3` as shown above, an ext2 file system is created by default. Use other commands, or options to this command, to create other file system types. For example, use `mkfs.vfat` to create a VFAT file system, `mkfs.msdos` for DOS, or `mkfs.reiserfs` for Reiser file system type. The `tune2fs` command, described later in this section, can be used to change an ext2 file system to an ext3 file system.

14. Once the file system is created, you can have the partition permanently mounted by editing the `/etc/fstab` and adding the new partition. Here is an example of a line you might add to that file:

```
/dev/sdb1          /abc          ext3          defaults      1 1
```

In this example, the partition (`/dev/sdb1`) is mounted on the `/abc` directory as an ext3 file system. The `defaults` keyword causes the partition to be mounted at boot time. The numbers `1 1` cause the disk to be checked for errors. Add one line like the one shown above for each partition you created.

15. Create the mount point. For example, to mount the partition on `/abc` (as shown in the previous step), type the following:

```
# mkdir /abc
```

Create your other mount points if you created multiple partitions. The next time you boot Linux, the partition will be automatically mounted on the `/abc` directory, as will any other partitions you added.

After you have created the file systems on your partitions, a nice tool for adjusting those file systems is the `tune2fs` command. Using `tune2fs`, you can change volume labels, how often the file system is checked, and error behavior. You can also use `tune2fs` to change an ext2 file system to an ext3 file system so the file system can use journaling. For example:

```
# tune2fs -j /dev/sdb1
tune2fs 1.39 (29-May-2006)
Creating journal inode: done
This filesystem will be automatically checked every 38 mounts or
180 days, whichever comes first. Use tune2fs -c or -i to override.
```

By adding the `-j` option to `tune2fs`, you can either change the journal size or attach the file system to an external journal block device. After you have used `tune2fs` to change your file system type, you will need to correct your `/etc/fstab` file to include changing the file system type from ext2 to ext3.

## Using RAID Disks

RAID (Redundant Arrays of Independent Disks) spreads the data used on a computer across multiple disks, while appearing to the operating system as if it is dealing with a single disk partition. Using the different RAID specifications, you can achieve the following advantages:

- **Improved Disk Performance** — RAID0 uses a feature called *striping*, in which data is striped across multiple RAID partitions. Striping can improve disk performance by spreading the hits on a computer's file system across multiple partitions, which are presumably on multiple hard disks. However, striping does not provide redundancy. If one disk fails, all the data is lost (not only the data on that disk).
- **Mirroring** — RAID1 uses partitions from multiple hard disks as mirrors. That way, if one of the partitions becomes corrupted or the hard disk goes down, the data exists on a partition from another disk because it has continuously maintained an exact mirror image of the original partition.
- **Parity** — Although striping can improve performance, it can increase the chance of data loss, since any hard-disk crash in the array can potentially cause the entire RAID device to fail. Using a feature called *parity*, information about the layout of the striped data is kept so that data can be reconstructed if one of the disks in the array crashes. RAID3, 4, and 5 implement different levels of parity.

During installation of CentOS, you can use the Disk Setup window to create RAID0, RAID1, and RAID5 disk arrays. The following procedures describe how to set up RAID disks during installation.

Before you begin creating RAID partitions when you install CentOS, you will probably want to start with a computer that has two or more hard disks. The reason is that, if you don't have multiple hard disks, you won't get the performance gains that come from spreading the hits on your computer among multiple disks. Likewise, mirroring will be ineffective if all RAID partitions are on the same disk because the failure of a single hard disk would still potentially cause the mirrored partitions to fail as well.

For example, you might begin with 30 GB of free disk space on your first hard disk (`/dev/sda`) and 30 GB of free disk space on your second hard disk (`/dev/sdb`). During the CentOS installation procedure, select to partition your disk with Disk Setup. Then follow this procedure:

1. From the Disk Setup window, click on the RAID button. A RAID Options window appears.
2. Select "Create a Software RAID Partition," and click OK. The Add Partition window appears.
3. With "Software RAID" selected as the File System Type, choose the drive you want to create the partition on and choose the size (in megabytes). Then click OK.
4. Repeat Steps 2 and 3 (presumably creating software RAID partitions on different hard disks until you have created all the RAID partitions you want to use).

5. Click on the RAID button again. Select “Create a RAID Device [default=/dev/md0]” and click OK.
6. You need to select the following information about your RAID device and click OK:
  - **Mount Point** — The point in the file system associated with the RAID device. You might be creating the RAID device for a part of the file system for which you expect there to be a lot of hits on the hard disk (such as the /var partition).
  - **File System Type** — For a regular Linux partition, choose ext3. You can also select LVM, swap, or VFAT as the file system type.
  - **RAID Device** — The first RAID device is typically md0 (for /dev/md0).
  - **RAID Level** — Allowable RAID levels are RAID0, RAID1, and RAID5. RAID0 is for striping (essentially dividing the RAID device into stripes across RAID partitions you have selected). RAID1 is for mirroring so that the data is duplicated across all RAID partitions. RAID5 is for parity, so there is always one back-up disk if a disk goes bad. You need at least three RAID partitions to use RAID5.
  - **RAID Members** — From the RAID partitions you created, select which ones are going to be members of the RAID device you are creating.
  - **Number of Spares** — Select how many spares are available to the RAID device.
7. The new RAID Device should appear on the Disk Setup window. Click Next to continue with installation.

Once installation is complete, you can check your RAID devices by using a variety of tools that come with CentOS. Commands for working with RAID partitions come in the `dmraid` package. Using `dmraid` commands, you can list and reconfigure your RAID partitions.

## Checking System Space

Running out of disk space on your computer is not a happy situation. Using tools that come with CentOS, you can keep track of how much disk space has been used on your computer, and you can keep an eye on users who consume a lot of disk space.

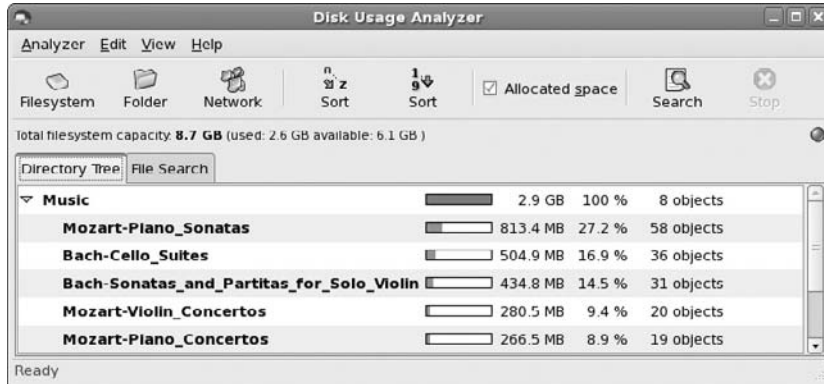
### Checking Disk Space with Disk Usage Analyzer

The Disk Usage Analyzer, which is part of the `gnome-utils` package, provides an easy way to see how much and where space is being consumed on your hard disk. To start Disk Usage Analyzer from the GNOME desktop, select Applications > System Tools > Disk Usage Analyzer.

At first, Disk Usage Analyzer displays only the size of the hard disk and amount of space that has been consumed on that disk. However, you can see how much disk space is consumed by files in a particular folder (and its subfolders) by selecting the Folder button and browsing for the folder that interests you. Figure 9-4 shows an example of a music folder containing several subfolders of music. You can sort each subfolder alphabetically or by disk space consumed.

FIGURE 9-4

Find where disk space is being used with the Disk Usage Analyzer.



## Displaying System Space with df

You can display the space available in your file systems using the `df` command. To see the amount of space available on all of the mounted file systems on your Linux computer, type `df` with no options:

```
$ df
Filesystem 1k-blocks    Used   Available Use%    Mounted on
/dev/sda1  30645460 2958356  26130408  11%    /
/dev/sda2    46668     8340    35919    19%    /boot
/dev/fd0     1412      13      1327     1%    /mnt/floppy
```

The output here shows the space available on the hard disk partition mounted on the root partition (`/dev/sda1`), `/boot` partition (`/dev/sda2`), and the floppy disk mounted on the `/mnt/floppy` directory (`/dev/fd0`). Disk space is shown in 1-K blocks. To produce output in a more human-readable form, use the `-h` option as follows:

```
$ df -h
Filesystem      Size  Used Avail Use% Mounted on
/dev/sda1      29G   2.9G  24G   11% /
/dev/sda2       46M   8.2M  25M   19% /boot
/dev/fd0       1.4M   13k  1.2M   1% /mnt/floppy
```

With the `df -h` option, output appears in a friendlier megabyte or gigabyte listing. Other options with `df` let you:

- Print only file systems of a particular type (`-t type`).
- Exclude file systems of a particular type (`-x type`).
- Include file systems that have no space, such as `/proc` and `/dev/pts` (`-a`).



- List only available and used inodes (`-i`).
- Display disk space in certain block sizes (`--block-size=#`).

## Checking Disk Usage with `du`

To find out how much space is being consumed by a particular directory (and its subdirectories), you can use the `du` command. With no options, `du` lists all directories below the current directory, along with the space consumed by each directory. At the end, `du` produces the total disk space used within that directory structure.

The `du` command is a good way to check how much space is being used by a particular user (`du /home/user1`) or in a particular file system partition (`du /var`). By default, disk space is displayed in 1-K block sizes. To make the output more friendly (in kilobytes, megabytes, and gigabytes), use the `-h` option as follows:

```
$ du -h /home/jake
114k   /home/jake/httpd/stuff
234k   /home/jake/httpd
137k   /home/jake/uucp/data
701k   /home/jake/uucp
1.0M   /home/jake
```

The output shows the disk space used in each directory under the home directory of the user named `jake` (`/home/jake`). Disk space consumed is shown in kilobytes (k) and megabytes (M). The total space consumed by `/home/jake` is shown on the last line. To avoid listing all the subdirectories and see a total for all files and directories below a certain directory, add the `-s` option as follows:

```
$ du -sh /home/jake
1.0M   /home/jake
```

## Finding Disk Consumption with `find`

The `find` command is a great way to find file consumption of your hard disk using a variety of criteria. You can get a good idea of where disk space can be recovered by finding files that are over a certain size or were created by a particular person.

### NOTE

You must be the `root` user to run this command effectively, unless you are just checking your personal files.

In the following example, the `find` command searches the root file system (`/`) for any files owned by the user named `jake` (`-user jake`) and prints the filenames. The output of the `find` command is then listed with a long listing in size order (`ls -ldS`). Finally, that output is sent to the file `/tmp/jake`. When you read the file `/tmp/jake`, you will find all of the files that are owned by the user `jake`, listed in size order. Here is the command line:

```
# find / -xdev -user jake -print | xargs ls -ldS > /tmp/jake
```

**TIP**

The `-xdev` option prevents file systems other than the selected file system from being searched. This is a good way to cut out a lot of junk that may be output from the `/proc` file system. It could also keep large, remotely mounted file systems from being searched.

The next example is similar to the previous one, except that instead of looking for a user's files, this command line looks for files that are larger than 1,000 KB (`-size +1000k`):

```
# find / -xdev -size +1000k -print | xargs ls -ldS > /tmp/size
```

You can save yourself a lot of disk space by just removing some of the largest files that are no longer needed. Open the `/tmp/size` file in this example, and large files are sorted by size.

## Monitoring System Performance

---

If your Linux system is being used as a multiuser computer, sharing the processing power of that computer can be a major issue. Likewise, any time you can stop a runaway process or reduce the overhead of an unnecessary program running, your Linux server can do a better job serving files, Web pages, or e-mail to the people who rely on it.

Utilities are included with Linux that can help you monitor the performance of your Linux system. The kinds of features you want to monitor in Linux include CPU usage, memory usage (RAM and swap space), and overall load on the system. The following sections describe tools for monitoring Linux.

### Watch Computer Usage with System Monitor

If you like visual representations of your system use, the System Monitor provides a great way to see how much your system is being used. To open the System Monitor from the Applications menu on the GNOME panel, select System Tools ➤ System Monitor. Figure 9-5 shows the System Monitor window with the Resources tab selected.

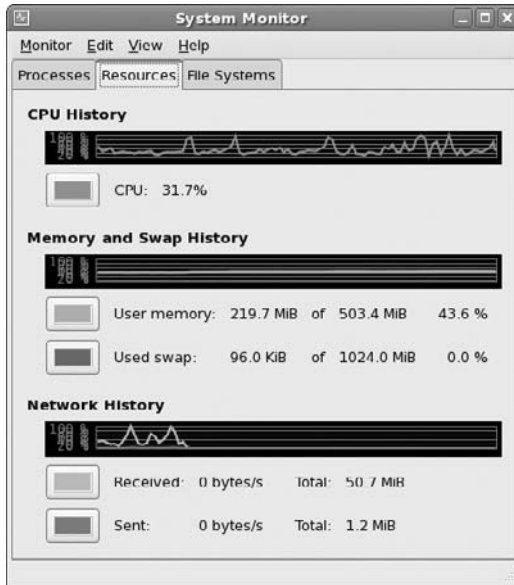
On the Resource Monitor window, lines scroll from right to left, indicating the percentage of your CPU being used as it rises and falls. You can also see how much of your total memory (RAM) is being used at the moment (and over time), as well as the amount of swap space being used. The bar at the bottom of the window shows the amount of data being sent and received over your computer's network interfaces.

Click on the Processes tab to see a listing of processes that are running for the current user. Click on the columns in that tab to sort processes by name, memory use, percentage of CPU being consumed by the process, and process ID. There are also columns showing the security context of the process (if SELinux is enabled) and the arguments associated with the process.

Click on the File Systems tab to see the storage devices (hard disk partitions, CD, USB flash drive, or other) that are currently mounted on your computer. Click columns to sort the devices by device name, directory name, file system type, total disk space, free disk space, or used disk space.

**FIGURE 9-5**

System Monitor graphically displays your system's CPU and memory usage.



The example in Figure 9-5 shows a computer that is running with 512 MB of RAM. Since there isn't a fair amount of activity on the System Monitor in this example, there is still User memory available. However, if on your system User memory is running near the maximum, it would indicate the likely occurrence of performance problems as RAM fills up and data has to be moved to swap space. The CPU used is only about 31 percent, which indicates that the CPU is currently keeping up with the demand.

## Monitoring CPU Usage with `top`

Start the `top` utility in a Terminal window, and it displays the top CPU consuming processes on your computer. Every 5 seconds, `top` will determine which processes are consuming the most CPU time and display them in descending order on your screen.

By adding the `-S` option to `top`, you can have the display show you the cumulative CPU time that the process, as well as any child processes that may already have exited, has spent. If you want to change how often the screen is updated, you can add the `-d secs` option, where `secs` is replaced by the number of seconds between updates.

By default, processes are sorted by CPU usage. You can sort processes numerically by PID (press **N**), by age (press **A**), by resident memory usage (press **M**), by time (press **T**), or back to CPU

usage (press **P**). The following output shows an example of `top` running, with information sorted by memory use. The system shown is running a GNOME desktop, with OpenOffice.org Writer, Firefox Web browser, and several other applications active. Notice that the amount of memory free is very low. To get good performance out of a CentOS desktop system, 256 MB may not be enough once you start running a lot of big applications.

```
top - 16:11:41 up 10:27, 2 users, load average: 1.60, 0.51, 0.18
Tasks: 107 total, 2 running, 103 sleeping, 0 stopped, 2 zombie
Cpu(s): 16.6%us, 6.5%sy, 0.0%ni, 0.0%id, 76.9%wa, 0.0%hi, 0.0%si, 0.0%st
Mem: 252424k total, 249224k used, 3200k free, 2360k buffers
Swap: 1020088k total, 14240k used, 1005848k free, 86820k cached

  PID USER      PR  NI  VIRT  RES  SHR  S  %CPU  %MEM    TIME+  COMMAND
 4242 timothy  18   0 183m  37m  25m  R  19.9  15.0   0:05.86  writer.bin
 4217 timothy  15   0 137m  31m  17m  S   0.0  12.9   0:07.27  firefox-bin
 4244 timothy  15   0 39148 18m  7684  S   0.0   7.6   0:04.94  beagled-helper
 4138 timothy  15   0 101m  14m  9.8m  S   0.0   5.9   0:06.87  baobab
```

## Monitoring Power Usage on Laptop Computers

To effectively use a laptop computer, you need to be able to monitor and manage the laptop's power usage. Using tools provided in CentOS, you can configure your laptop to:

- Monitor the battery level.
- Notify you when the battery is low.
- Notify you when the battery is fully charged.
- Show when the laptop is plugged in.
- Suspend the current session.

CentOS offers the ACPI facility to handle power management. ACPI can also do thermal control, motherboard configuration, and change power states.

Many older laptops do not include support for ACPI in the BIOS, while for some newer laptops, ACPI may be required. To check whether ACPI is supported on your CentOS system, you can use the `dmesg` command after a reboot. For example, type:

```
# dmesg | less
```

Page through the output looking for lines beginning with ACPI. On a computer where ACPI wasn't working, I saw the message "ACPI: System description tables not found."

The following procedure was performed on a laptop that used ACPI to manage power events. It describes how to use the GNOME Power Manager applet on the desktop to monitor your battery.

**NOTE**

If it seems that ACPI is interfering with the proper operation of your laptop, you can turn it off when you boot your computer. Add `acpi=off` to the end of the kernel line (from the GRUB boot screen or the `/boot/grub/grub.conf` file) to turn off ACPI.

### Using `acpi_listen` to Monitor ACPI Events

If ACPI is running on your system, you can monitor ACPI events using the `acpi_listen` command. As the root user, type the following from a Terminal window:

```
# acpi_listen
ac_adapter AC 00000080 00000000
processor CPU 00000080 00000000
processor CPU 00000081 00000000
battery BAT0 00000080 00000001
ac_adapter AC 00000080 00000001
processor CPU 00000080 00000000
processor CPU 00000081 00000000
battery BAT0 00000080 00000001
button/lid LID 00000080 00000001
button/lid LID 00000080 00000002
```

The message above appeared when the AC power was disconnected, the power was reconnected, the laptop's lid was closed, and the lid was again opened.

## Using Security Enhanced Linux

---

Security Enhanced Linux (SELinux) is a security model that offers the potential to compartmentalize and secure every component of a Linux system (processes, files, directories, users, devices, etc.). Instead of the all-or-nothing, either-you-have-root-privilege-or-you-don't approach to security in traditional Linux and UNIX systems, SELinux allows much finer granularity in how permissions to run and alter components on the computer are handed out. With SELinux, you can drastically limit the damage caused by a person who cracks one part of a Linux system.

When you first install CentOS, you have the opportunity to enable or disable SELinux. If enabled, the targeted policy is used by default. Targeted policies focus on services with vulnerable daemon processes, as well as the resources the services can access.

Targeted policies limit the impact that an attack on the following services can have on your server as a whole: Apache (Web server), Samba (Windows file and print sharing), FTP (file transfer protocol), NFS (network file system), and others. The targeted set of policies is practical today and provides further boundaries around what are already quite secure features. In most cases, you can use this policy set without modification.

This section sets out to give you an understanding of what SELinux is. It describes how to turn on SELinux in CentOS. Then it provides an overview of how CentOS's targeted policy is set up for you and describes how you can modify the targeted SELinux policies to personalize your SELinux policy settings.

# Understanding Security Enhanced Linux

---

With traditional UNIX and Linux systems, when a user got root access to your computer, she owned the machine. The `root` user (or whoever took over as `root` user) could override ownership, Read/Write/Execute permissions, and processor scheduling priorities. Likewise, an attack on a Web server (`httpd` daemon) could allow an attacker full privileges of the `apache` user account, instead of limiting the attack to a single set of virtual host resources.

Organizations such as the United States National Security Agency (NSA) recognized the need to have operating systems in secure environments be able to separate information in terms of confidentiality and data integrity. The standard security model made Linux and UNIX systems unacceptable for highly secure environments, where the risk of one exploit taking down the whole operating system was unacceptable. The mechanism that NSA recommended to implement highly secure systems is referred to as *Mandatory Access Control* (MAC).

The SELinux project aims at providing MAC functionality into the Linux kernel. By implementing rules for what all operating system components can and can't do, an application that has security flaws or has been taken over for malicious intent can be contained. In other words, gaining control of one component of a system doesn't allow a cracker to take over the entire computer.

Despite the fact that SELinux is complex, many of the bugs have been worked out of it in recent releases, and the default settings are quite easy to work with. I would recommend enabling SELinux on a server you are testing, to prepare to one day enable SELinux to protect your Internet servers.

## Types and Roles in SELinux

The mechanisms for implementing security rules in SELinux are referred to as *policies*. Any system that implements SELinux selects a particular policy (strict, targeted, etc.) that results in a consistent set of rules that meet the level of security required on the system.

Using policy configuration files, SELinux implements two different security models: *Type Enforcement* (TE) and *Role-Based Access Control* (RBAC).

- **Type Enforcement (TE)** — Under the TE model, every object in the operating system is bound to a security attribute called a *type*. Every process is bound to a security attribute called a *domain*. This approach allows for very tight control of every object in the operating system. Every user is allowed to access objects in the operating system based on the domain in which he or she is allowed to operate.
- **Role-Based Access Control (RBAC)** — Using the RBAC model, SELinux lets each user operate in a specific role. The roles are arranged in a hierarchy, with specific permissions associated with each role provided by type enforcement.

In traditional Linux, a user is assigned a specific user ID (UID) and group ID (GID), which affords that user certain access to system resources. For instance, it gives the user certain rights to read, write, or execute files and directories based on whether that user owns the file or directory or is part of a group assigned to that file or directory.

In SELinux, a data file, directory, or application can have many more attributes associated with it. Those attributes might actually give more permissions to access the component than were available in traditional Linux security. At the same time, having access to the component wouldn't necessarily give that user control of that component in a way that could be exploited beyond what the security policies allow the user to do.

## Users in SELinux

The model that SELinux uses to define the rights that users have on a SELinux-enabled system can coexist with the existing Linux user model, rather than replace it. With SELinux enabled, Linux users still have their accounts defined through definitions in the `/etc/passwd` file. A user who is also assigned a role in SELinux is referred to as a *defined user*.

Special user identities in SELinux include the `system_u` (which is the user identity assigned to system processes) and `user_u` (which is the assignment used to indicate if general users, in particular those without specific user identities, are allowed to use the feature in question). There is also a `root` identity, which is retained to allow compatibility with existing file contexts. This allows existing files to remain valid if they have `root` as their user identity.

## Policies in SELinux

As noted earlier, with CentOS you have the choice of either turning off SELinux or turning it on. The values set in the `/etc/selinux/config` file determine which type of policy is on (only the targeted policy is available by default; however, a strict policy is also available) and whether or not SELinux is:

- **Enforcing** — The current SELinux policy is turned on and its policies are enforced.
- **Permissive** — The current SELinux policy is on, but not enforced (so you only see warning messages describing how the policy would be enforced).
- **Disabled** — SELinux is off, so only standard Linux permissions are enforced (as they always were on systems not including SELinux).

CentOS contain a compiled policy file for the targeted policy they deliver. For example, in the current version of CentOS, `/etc/selinux/targeted/policy/policy.21` is the compiled policy set used when that policy is active.

## Tools in SELinux

Tools available with SELinux let you work with and change policy settings in SELinux. Many of these tools come in the `selinux-policy`, `selinux-policycoreutils` and `setroubleshoot-server` packages. Tools include the following:

- **SELinux Troubleshooter** — The SELinux Troubleshooter will start an icon in the desktop panel when SELinux detects something that violates SELinux policy. Click that icon to display the setroubleshoot browser window to see descriptions and potential fixes for the problem. You can also start the setroubleshoot browser directly by selecting Applications > System Tools > SELinux Troubleshooter.
- **SELinux Policy Generation Tool** — Graphical tool for generating your own SELinux policy framework. Application developers or systems administrators can use this tool to confine users or applications to only access those resources they need.
- **SELinux Administration Window** — Open the SELinux Administration window (select System > Administration > SELinux Management) to change the status of SELinux (Enabled, Disabled, or Enforcing) or change the default policy type (targeted by default). You can also modify SELinux settings for users, files and directories, policy modules, and network ports.
- **SELinux Commands** — A set of command-line tools can be used to modify SELinux policies. These commands include `chcon` (to label files and directories) and `setsebool` (to turn on and off SELinux attributes). To get information on how specific daemon processes are being handled in SELinux, refer to various SELinux policy man pages (`ftpd_selinux`, `httpd_selinux`, `kerberos_selinux`, `named_selinux`, `nfs_selinux`, `nis_selinux`, `rsync_selinux`, and `ybind_selinux`).

## Using SELinux in CentOS

---

If you use the targeted SELinux policy (which is delivered and on by default), you can still administer Linux as you always have. The following procedure describes the software packages you need to use SELinux and starts you off working with the default targeted policy. If you need additional information, visit [http://selinuxproject.org/page/Main\\_Page](http://selinuxproject.org/page/Main_Page) to find a plethora of useful SELinux documentation.

### SELinux

Support for SELinux is built into the Linux 2.6 kernel. In fact, SELinux is on by default in the latest release of CentOS. If you prefer to have SELinux off, after you boot the desktop, you can open the SELinux Administration window (select System > Administration > SELinux Management) and set the “Enforcing Current” selection to Permissive. Permissive causes SELinux to check and note where SELinux would fail, but doesn’t actually fail.

With SELinux enabled, you might also want the following software packages installed:

- **checkpolicy** — Contains the SELinux policy compiler named `checkpolicy`. Use this package to build or check policies for SELinux. Using `checkpolicy`, you create binary policy files from policy configurations and parameters in a `policy.conf` file. (Type **man checkpolicy** to read about `checkpolicy`.)



- **libselinux** — Contains the application programming interface for SELinux applications. It includes components used by application programs to check SELinux status.
- **policycoreutils** — Contains basic utilities needed to operate an SELinux system. Commands include `fixfiles` (to check and possibly correct security attributes on file systems), `restorecon` (to set security attributes for selected files), `audit2allow` (to translate messages from `/var/log/messages` to rules that SELinux can use), `newrole` (to open a shell in a new role), `load_policy` (to load a policy file), `run_init` (to run an init script using the correct context), `sestatus` (to check whether SELinux is currently enabled), and `setfiles` (to set the security contexts of files).
- **selinux-policy-mls** — Contains the multilevel security translation table for SELinux.
- **selinux-policy-targeted** — Contains the sample policy file used to incorporate the targeted SELinux policy into a running Linux system, as well as context files and the `booleans` file needed to make runtime changes to SELinux.
- **setools** — Contains tools for managing parts of a running policy that define what access users have to different components of the Linux system.

## Checking Whether SELinux Is On

After CentOS is installed, you can check the `/etc/selinux/config` file (which is linked to `/etc/sysconfig/selinux`) to see if SELinux is enabled and, if so, which policies are in effect. That file sets two critical variables for a CentOS system configured to use SELinux:

- **SELinux State** — The `SELINUX` variable sets the state of SELinux. If you enable SELinux during CentOS installation, this starts out as `SELINUX=enforcing` (which causes security policies for SELinux to be enforced). If SELinux is disabled during installation, `SELINUX=disabled` is set instead. A third choice is to set `SELINUX=permissive`, which prints warnings based on the policies you have set, instead of enforcing them.
- **SELinux Policy Type** — The `SELINUXTYPE` variable indicates the type of policy to use. `SELINUX=targeted` protects only selected network daemons (as set in files located in the `/etc/selinux/targeted` directory).

For most practical purposes, if you use SELinux, you will want to enable the SELinux-targeted policy (which is the default). While not locking down all CentOS components under SELinux, the targeted policy does lock down those daemon processes that are most critical to protect from attacks. Standard Linux security protects everything else in the operating system.

You can override your default settings to place SELinux into permissive mode from the Linux boot prompt by adding the following to the end of the kernel line from the GRUB screen when you boot CentOS:

```
setenforce 0
```

With SELinux in Permissive mode (`setenforce 0`), you can still log in and use the system, with any potentially devastating permission failures simply resulting in error messages.

If SELinux is in Permissive mode, you can likewise return SELinux to Enforcing mode from the boot prompt by typing **setenforce 1**. You can change the SELinux state permanently, using the SELinux Administration window.

## Checking SELinux Status

There are many tools for checking the status of SELinux on your CentOS system. To check whether or not SELinux is enabled, type the following:

```
# sestatus -v
SELinux status:      disabled
```

The output shows that SELinux is not enforced on the current system. If SELinux were set to Permissive, the output would look more like the following:

```
SELinux status:      enabled
SELinuxfs mount:    /selinux
Current mode:        enforcing
Mode from config file:  enforcing
Policy version:      21
Policy from config file: targeted
```

To see and change basic SELinux settings from a graphical interface, you can open the SELinux Administration window. From the GNOME Desktop, select System > Administration > SELinux Management. From that window, you can set whether SELinux is Disabled, Enforcing, or Permissive. You can also set the SELinux policy to use (targeted is the default).

Changing the policy type or turning the SELinux service from off to on requires that you also relabel the entire file system. Changing policy should never be done lightly. If you do decide to change policy through the SELinux Administration window, that change also requires that the file system be relabeled. By changing the policy through this window, the file system will be relabeled automatically the next time you reboot your computer (or you can select the checkbox to prevent relabeling the file system on the next reboot).

### NOTE

Relabeling the file system can be a long and time-consuming activity. Again, remember that changing policies is a major change to your operating system. The more nodes there are in your file system, the longer it will take to relabel your file system the next time you boot your computer.

You can check the security context in which you are operating using the `id` command with the `-Z` option. The following example shows that your current context is the `root` user, your role is the `system_r` role, and the type is `unconfined_t`.

```
# id -Z
unconfined_u:unconfined_r:unconfined_t:s0-s0:c0.c1023
```

SELinux is capable of turning out a lot of error messages. By default, those messages are directed to the `/var/log/audit/audit.log` file. Because the file contains messages from many different services, you can use the `seAudit` window (type **seaudit** from a Terminal window) to view messages strictly related to SELinux.

## Summary

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Although you may be using CentOS as a single-user system, many of the tasks you must perform to keep your computer running are defined as administrator tasks. A special user account called the `root` user is needed to do many of the things necessary to keep a Linux system working as you would like it to. If you are administering a Linux system that is used by lots of people, the task of administration becomes even larger. You must be able to add and support users, maintain the file systems, and ensure that system performance serves your users well.

To help the administrator, CentOS comes with a variety of command-line utilities and graphical windows for configuring and maintaining your system.

Commands such as `mkfs` and `mount` let you create and mount file systems, respectively. Tools like System Monitor and `top` let you monitor system performance.

SELinux adds a new layer of security on top of existing Linux security methods. As a systems administrator, you can choose whether or not to turn on SELinux. You can also choose which of your system services are protected by SELinux.

# Chapter 10

## Setting up and Maintaining User Accounts

One of the more fundamental and important tasks of administering a Linux system is setting up and supporting user accounts. Computers, after all, are tools to be used by people. Apocalyptic science fiction plots aside, computers have no purpose without users.

When you install CentOS, you are required to create the `root` (administrator) user account. The first time you boot the system, you are asked to create a regular user account, using any name you choose. Several other administrative user accounts that you will probably never use directly are set up automatically, such as `apache`, `rpm`, and `lp`.

**CROSS-REF** For a description of the `root` user account and how to use it, see Chapter 9.

This chapter discusses the basics of setting up user accounts and offers tips on easing the burden of supporting a large number of Linux users.

### Creating User Accounts

---

Every person who uses your CentOS system should have a separate user account. Having a user account provides each person with an area in which to securely store files. A user account also defines which files and directories a user is permitted to create, modify, or delete throughout the computer's file system.

Some user accounts are already there when you install your Linux system. Administrative users (user IDs 0–499 are used) are created to maintain

#### IN THIS CHAPTER

Creating user accounts

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Setting user defaults

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Creating portable desktops

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Deleting user accounts

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Checking disk quotas

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Sending mail to all users

---

separate control of system files and services from a regular user. Of the administrative user accounts, you will probably only use `root` when some system administration is required.

Regular user accounts are created using any names you choose, starting by default with a user ID (UID) of 500. Regular users you add to your CentOS system typically fall into one of two categories:

- **Desktop Users** — A desktop user is one that you expect to use your computer via a graphical interface. Create this kind of user account for yourself and anyone else you want to log in directly to the computer or from a thin client over the network. Most of this section describes how to add this type of user.
- **Server Users** — If you are configuring CentOS as a server (Web, mail, FTP, etc.), you may want to add accounts for users who have limited access to your system. You may want those users to be able to add content to a Web Server or access a mail server, but have only a shell login account (or possibly no login account). See the section “Adding User Accounts to Servers” later in this chapter for information on adding these types of accounts.

**CROSS-REF** If you have multiple users, you’ll also need to be concerned about back-up and recovery issues for those users. See Chapter 12 for more information.

You can add user accounts to your CentOS system in several ways. This chapter describes how to use the `useradd` command to add user accounts to CentOS from the command line and how to use the User Manager window to add users from the desktop.

## Adding Users with `useradd`

The most straightforward method for creating a new user from the shell is with the `useradd` command. After opening a Terminal window with root permission, you simply invoke the `useradd` command at the command prompt, with details of the new account as parameters.

The only required parameter to `useradd` is the login name of the user, but you will probably want to include some additional information. Each item of account information is preceded by a single-letter option code with a dash in front of it. Table 10-1 lists the options that are available with the `useradd` command.

As an example, create an account for a new user named *Robert Jones* with a login name of `robert`. First, log in as `root`, and then type the following command:

```
# useradd -c "Robert Jones" -m robert
```

### TIP

When you choose a username, don’t begin with a number (e.g., `09rjones`). Also, it is best to use all lowercase letters, no control characters or spaces, and a maximum of eight characters. The `useradd` command allows up to 32 characters, but some applications can’t deal with usernames that long. Tools such as `ps` display UIDs instead of names if the username is more than eight characters long. Having users named `Rjones` and `rjones` can cause confusion with programs like `sendmail` that don’t distinguish case. Also, some very old applications may not be able to handle usernames with more than eight characters.

TABLE 10-1

## useradd Command Options

Option	Description
-c " <i>comment</i> "	Provide a description of the new user account. Usually just the person's full name. Replace <i>comment</i> with the name of the user account. If the comment contains multiple words, use quote marks.
-d <i>home_dir</i>	Set the home directory to use for the account. The default is to name it the same as the login name and to place it beneath /home. Replace <i>home_dir</i> with the directory name to use.
-D	Rather than create a new account, save the supplied information as the new default settings for any new accounts that are created.
-e <i>expire_date</i>	Assign the expiration date for the account in MM/DD/YYYY or MM-DD-YYYY format. Replace <i>expire_date</i> with the expiration date to use. This is best used with temporary employees whom you know only need the account for a limited time.
-f <i>inactivity</i>	Set the number of days after a password expires until the account is permanently disabled. Setting this to 0 disables the account immediately after the password has expired. Setting it to -1 disables the option, which is the default behavior. Replace <i>inactivity</i> with the number to use.
-g <i>group</i>	Set the primary group (as listed in the /etc/group file) that the new user will be in. Replace <i>group</i> with the group name to use. The default is to assign the username as the group name.
-G <i>grouplist</i>	Add the new user to the supplied comma-separated list of groups.
-k <i>skel_dir</i>	Set the skeleton directory containing initial configuration files and login scripts that should be copied to a new user's home directory. This parameter can only be used in conjunction with the -m option. Replace <i>skel_dir</i> with the directory name to use.
-m	Automatically create the user's home directory and copy the files in the skeleton directory (/etc/skel) to it.
-M	Do not create the new user's home directory, even if the default behavior is set to create it.
-n	Turn off the default behavior of creating a new group that matches the name and user ID of the new user.
-o	Use with -u <i>uid</i> to create a user account that has the same UID as another username. This effectively lets you have two different users with authority over the same set of files and directories.

*continued*

**TABLE 10-1** (continued)

Option	Description
-p <i>passwd</i>	Enter a password for the account you are adding. This must be an encrypted password. Instead of adding an encrypted password here, you can simply use the <code>passwd</code> command later to add a password for the user. The user should be asked to immediately change the password you set.
-r	Allows you to create a new account with a user ID in the range reserved for system accounts.
-s <i>shell</i>	Specify the command shell to use for this account. Replace <i>shell</i> with the command shell.
-u <i>user_id</i>	Specify the user ID number for the account. The default behavior is to automatically assign the next available number. Replace <i>user_id</i> with the ID number.

Next, set Robert's initial password using the `passwd` command. The `passwd` command prompts you to type the password twice. Asterisks are shown here to represent the password you type. Nothing is actually displayed when you type the password.

```
# passwd robert
Changing password for user robert.
New password: *****
Retype new password: *****
```

**CROSS-REF** Refer to Chapter 13 for tips on picking good passwords.

In creating the account for Robert, the `useradd` command performs several actions:

- Reads the `/etc/login.defs` file to get default values to use when creating accounts.
- Checks command-line parameters to find out which default values to override.
- Creates a new user entry in the `/etc/passwd` and `/etc/shadow` files based on the default values and command-line parameters.
- Creates any new group entries in the `/etc/group` file.
- Creates a home directory based on the user's name and places it in the `/home` directory.
- Copies any files located within the `/etc/skel` directory to the new home directory. This usually includes login and application start-up scripts.

The preceding example uses only two of the available `useradd` options. Most account settings are assigned using default values. Here's an example that uses a few more options:

```
# useradd -m -g users -G wheel,sales -s /bin/tcsh -c "Connie James"
connie
```

In this case, the `useradd` command is told to create a home directory for the user `connie` (`-m`), make users the primary group she belongs to (`-g`), add her to the groups `wheel` and `sales` (`-G`), and assign `tcsh` as her primary command shell (`-s`). Note that the `wheel` and `sales` groups must already exist for this example to work. This results in a line similar to the following being added to the `/etc/passwd` file:

```
connie:x:502:100:Connie James:/home/connie:/bin/tcsh
```

In the `/etc/passwd` file, each line represents a single user account record. Each field is separated from the next by a colon (`:`) character. The field's position in the sequence determines what it is. As you can see, the login name is first. The password field contains an `x` because CentOS is using a shadow password file in which to store encrypted password data. The user ID selected by the `useradd` command was 502. The primary group ID is 100, which corresponds to the `users` group in the `/etc/group` file. The comment field was correctly set to *Connie James*, the home directory was automatically assigned as `/home/connie`, and the command shell was assigned as `/bin/tcsh`, exactly as specified with the `useradd` options.

When you leave out many of the options (as I did in the first `useradd` example), default values are assigned in most cases. For example, by not using `-g users` or `-G wheel,sales`, a group named `connie` would have been created and assigned to the new user. Likewise, excluding `-s /bin/tcsh` causes `/bin/bash` to be assigned as the default shell.

The `/etc/group` file holds information about the different groups on your CentOS system and the users who belong to them. Groups are useful for allowing multiple people to share access to the same files while denying access to others. If you peek at the `/etc/group` file, you should find something similar to this:

```
bin:x:1:root,bin,daemon
daemon:x:2:root,bin,daemon
sys:x:3:root,bin,adm
adm:x:4:root,adm,daemon
tty:x:5:
disk:x:6:root
lp:x:7:daemon,lp
mem:x:8:
kmem:x:9:
wheel:x:10:root,robert,connie
.
.
.
nobody:x:99:
users:x:100:
timothy:x:500
robert:x:501
sales:x:601:robert,jessica,frankie
```

Each line in the group file contains the name of a group, the group ID number associated with it, and a list of users in that group. By default, each user is added to his or her own group, beginning with GID 500. Note that `connie` was added to the `wheel` and `sales` groups instead of having her own group.



It is actually rather significant that `connie` was added to the `wheel` group. By doing this, you grant her the ability to use the `sudo` command to run commands as the `root` user, provided that the `wheel` line is uncommented from the `/etc/sudoers` file, which it is not by default.

**TIP**

Type **`man sudo`** in a Terminal window to learn more about the `sudo` command, and **`man sudoers`** to learn more about the `sudoers` file.

In this example, we used the `-g` option to assign `connie` to the `users` group. If you leave off the `-g` parameter, the default behavior is for `useradd` to create a new group with the same name and ID number as the user (assuming a group with the same ID does not already exist), which is assigned as the new user's primary group. For example, look at the following `useradd` command:

```
# useradd -m -G wheel,sales -s /bin/tcsh -c "Connie James" connie
```

It would result in an `/etc/passwd` line like this:

```
connie:x:502:502:Connie James:/home/connie:/bin/tcsh
```

It would also result in a new group line like this:

```
connie:x:502:
```

Note that the user ID and group ID fields now have the same number. If you set up all of your users this way, you will have a unique group for every user on the system, which allows for increased flexibility in the sharing of files among your users.

## Adding Users with User Manager

If you prefer a graphical window for adding, changing, and deleting user accounts, you can use the User Manager window. To open the window from the GNOME desktop, click on System ➤ Administration ➤ Users and Groups (or type **`system-config-users`** from a Terminal window as root). Figure 10-1 shows an example of that window.

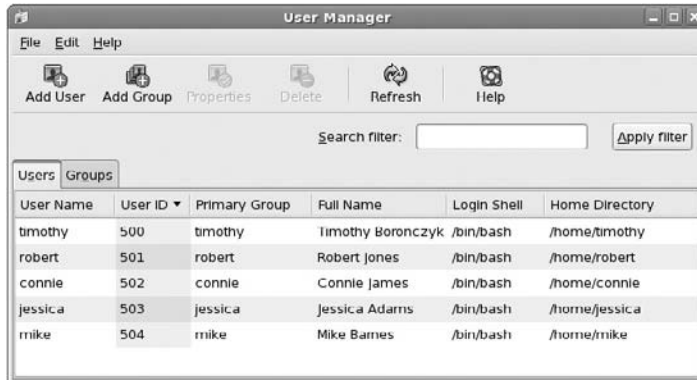
When you open the User Manager window, you see a list of all regular users who are currently added to your computer. Administrative users (UID 1–499) are not displayed. For each user, you can see the username, UID, primary group, full name, login shell, and home directory. Click any of those headings to sort the users by that information.

To add a new user from the User Manager window, do the following:

1. Click on the Add User icon to open the Create New User window (see Figure 10-2).
2. Type the requested information in the following fields:
  - **“User Name”** — A single word to describe the user. Typically, the username is eight characters, all lowercase, containing the user's real first name, last name, or more often a combination of the two.

**FIGURE 10-1**

Manage users from the User Manager window.

**FIGURE 10-2**

The Create New User window



- **“Full Name”** — The user’s full name. This name is typically just used for display, so using uppercase and lowercase is fine.
- **“Password”** — The user’s initial password. Ask the user to change this password the first time he or she logs in to the new account, which the user can do by running the `passwd` command.
- **“Confirm Password”** — Type the password again, to make sure you entered it correctly.

- **“Login Shell”** — The default shell that the user sees when first logging in to CentOS from a character display
  - **“Create home directory”** — By default, this box is selected and the user’s home directory is created automatically.
  - **“Home Directory”** — By default, the user is given a home directory of the user’s name in the /home directory. For example, the user `jessica` would be assigned /home/jessica as her home directory. Change this field if you want to assign the user to a different home directory.
  - **“Create a private group for the user”** — Check this box if you want a group by the same name as the user, created for this user. The name is added to the /etc/group file. This feature is referred to as *user private groups* (UPGs).
  - **“Specify user ID manually”** — Typically, you would not check this box, so that the UID for the new user would be assigned automatically. New UIDs for regular users start at 500. However, if you want to assign a particular UID for a user (e.g., if you want to match the UID with the user’s UID from another computer on your network), select this box and type the number you want to use in the UID box.
3. Click OK when you are done. The new user is added to the /etc/passwd and /etc/group files. The user account is now available for that user to log in.

**NOTE**

Using user private groups (UPGs) can be a benefit for sharing a directory of files among several users. Here’s an example:

```
# useradd -m projectx
# mkdir /usr/local/x
# chown root.projectx /usr/local/x
# chmod 2775 /usr/local/x
# ls -ld /usr/local/x
drwxrwsr-x 2 root projectx 4096 May 12 04:31 /usr/local/x
# gpasswd -a nextuser projectx
```

In this example, you create a user named `projectx` (with a group named `projectx`). Create a /usr/local/x directory and have it owned by root user and `projectx` group. Set the `setgid` bit to be on for the group (2), open full Read/Write/Execute permissions for user and group (77), and open Read and Execute permissions for everyone else (5). Add each user to the group that you want to be able to write to the `projectx` directory (replace `nextuser` with the user you want to add). After that, regardless of a user’s primary group, any file created in the /usr/local/x directory by a user can be read or modified by anyone in the `projectx` group.

## Setting User Defaults

---

The `useradd` command and User Manager window both determine the default values for new accounts by reading the /etc/login.defs file. You can modify those defaults by either editing that

file manually with a standard text editor or by running the `useradd` command with the `-D` option. If you choose to edit the file manually, here is what you face:

```
# *REQUIRED*
#   Directory where mailboxes reside, _or_ name of file, relative to the
#   home directory.  If you _do_ define both, MAIL_DIR takes precedence.
#   QMAIL_DIR is for Qmail
#
#QMAIL_DIR      Maildir
MAIL_DIR        /var/spool/mail
#MAIL_FILE      .mail

# Password aging controls:
#
#   PASS_MAX_DAYS   Maximum number of days a password may be used.
#   PASS_MIN_DAYS   Minimum number of days allowed between password changes.
#   PASS_MIN_LEN    Minimum acceptable password length.
#   PASS_WARN_AGE   Number of days warning given before a password expires.
#
PASS_MAX_DAYS   99999
PASS_MIN_DAYS   0
PASS_MIN_LEN    5
PASS_WARN_AGE   7

#
# Min/max values for automatic uid selection in useradd
#
UID_MIN          500
UID_MAX          60000

#
# Min/max values for automatic gid selection in groupadd
#
GID_MIN          500
GID_MAX          60000

#
# If defined, this command is run when removing a user.
# It should remove any at/cron/print jobs etc. owned by
# the user to be removed (passed as the first argument).
#
#USERDEL_CMD     /usr/sbin/userdel_local

#
# If useradd should create home directories for users by default
# On RH systems, we do. This option is overridden with the -m flag on
# useradd command line.
```

```

#
CREATE_HOME      yes

# The permission mask is initialized to this value. If not specified,
# the permission mask will be initialized to 022.
UMASK           077

# This enables userdel to remove user groups if no members exist.
#
USERGROUPS_ENAB yes

# Use MD5 or DES to encrypt password? Red Hat use MD5 by default.
MD5_CRYPT_ENAB yes

```

Blank lines and comments beginning with a pound sign (`#`) are ignored. All other lines contain keyword/value pairs. For example, the keyword `MAIL_DIR` is followed by some white space and the value `/var/spool/mail`. This tells `useradd` that the initial user e-mail mailbox is created in that directory. Following that are lines that enable you to customize the valid range of automatically assigned user ID numbers or group ID numbers. A comment section that explains that keyword's purpose precedes each keyword. Altering a default value is as simple as editing the value associated with that keyword and then saving the `login.defs` file.

If you want to view the defaults, type the `useradd` command with the `-D` option as follows:

```

# useradd -D
GROUP=100
HOME=/home
INACTIVE=-1
EXPIRE=
SHELL=/bin/bash
SKEL=/etc/skel
CREAT_MAIL_SPOOL=yes

```

You can also use the `-D` option to change defaults. When run with this flag, `useradd` refrains from actually creating a new user account; instead, it saves any additionally supplied options as the new default values in `/etc/login.defs`. Not all `useradd` options can be used in conjunction with the `-D` option. You can use only the five options listed in Table 10-2.

To set any of the defaults, give the `-D` option first; then add any of the defaults you want to set. For example, to set the default home directory location to `/home/everyone` and the default shell to `/bin/tcsh`, type the following:

```

# useradd -D -b /home/everyone -s /bin/tcsh

```

Besides setting up user defaults, an administrator can create default files that are copied to each user's home directory for use. These files can include login scripts and shell configuration files, such as `.bashrc`. The following sections describe some of these files.

TABLE 10-2

## useradd Options for Changing User Defaults

Options	Description
<code>-b default_home</code>	Set the default directory in which user home directories will be created. Replace <code>default_home</code> with the directory name to use. Usually this is <code>/home</code> .
<code>-e default_expire_date</code>	Set the default expiration date on which the user account is disabled. The <code>default_expire_date</code> value should be replaced with a date in the form <code>MM/DD/YYYY</code> — for example, <code>10/15/2009</code> .
<code>-f default_inactive</code>	Set the number of days after a password has expired before the account is disabled. Replace <code>default_inactive</code> with a number representing the number of days.
<code>-g default_group</code>	Set the default group that new users will be placed in. In CentOS, <code>useradd</code> creates a new group with the same name and ID number as the user, so this value is ignored. To set a different group primary group for a user, you must set it explicitly with the <code>-g</code> option on the command line.
<code>-s default_shell</code>	Set the default shell for new users. Typically this is <code>/bin/bash</code> . Replace <code>default_shell</code> with the full path to the shell that you want as the default for new users.

## Supplying Initial Login Scripts

Many Linux applications, including the command shell itself, read a configuration file at startup. It is traditional practice that these configuration files are stored in the users' home directories. In this way, each user can customize the behavior of the command shell and other applications without affecting that behavior for other users. In this way, global defaults can be assigned from `/etc/profile`, and then those settings can be enhanced by a user's personal files.

The `bash` command shell, for example, looks for a file called `.bashrc` in the current user's home directory whenever it starts up. Similarly, the `tcsh` command shell looks for a file called `.tcshrc` in the user's home directory. You may see a repeating theme here. Start-up scripts and configuration files for various applications usually begin with a dot (`.`) character and end in the letters `rc` (which stands for "run commands"). You can supply initial default versions of these and other configuration files by placing them in the `/etc/skel` directory. When you run the `useradd` command, these scripts and configuration files are copied to the new user's home directory.

## Supplying Initial `.bashrc` and `.bash_profile` Files

By supplying your users with initial `.bashrc` and `.bash_profile` files, you give them a starting point from which they can further customize their shell environment. Moreover, you can be sure that files are created with the appropriate access permissions so as not to compromise system security without the user's knowledge.

The `.bash_profile` script is run each time the user starts a new `bash` shell and, in turn, runs the `.bashrc` script. So, security is a concern. The `.bash_profile` file sets the original `PATH` used by the user, so it is a good place to add directories containing binaries you want the user to be able to run at your location. You can also add other start-up programs you want to run automatically for every user. Here's an example of the `.bash_profile` file:

```
# .bash_profile

# Get the aliases and functions
if [ -f ~/.bashrc ]; then
    . ~/.bashrc
fi

# User specific environment and startup programs

PATH=$PATH:$HOME/bin
export PATH
```

The `.bashrc` file is a good place to supply useful command aliases and additions to the command search path. Here's an example of a `.bashrc` file:

```
# .bashrc

# Source global definitions
if [ -f /etc/bashrc ]; then
    . /etc/bashrc
fi
# User specific aliases and functions
alias rm='rm -i'
alias cp='cp -i'
alias mv='mv -i'
```

This sample `.bashrc` executes `/etc/bashrc` if it exists to read any further global `bash` values. Next, the file creates aliases for the `rm`, `cp`, and `mv` commands that result in a `-i` option always being used unless overridden with the `-f` option. This protects against the accidental deletion of files.

## Supplying an Initial `.tcshrc` File

The following example `.tcshrc` file does basically the same thing as the preceding `.bashrc` example. However, this file (which is for the `root` user) has the additional task of setting the appearance of the command prompt:

```
# .tcshrc

# User specific aliases and functions

alias rm 'rm -i'
alias cp 'cp -i'
alias mv 'mv -i'

setenv PATH "$PATH:/usr/bin:/usr/local/bin"

set prompt='[%n@%m %c]# '
```

Instead of using the `export` command to set environment variables, the `tcsh` shell uses the `setenv` command. In the example, `setenv` is used to set the `PATH` variable. The shell prompt is set to include your username (`%n`), your computer name (`%m`), and the name of the current directory (`%c`). So, if you were to use the `tcsh` shell as the `root` user on a computer named `zarkov` with `/tmp` as your current directory, your prompt would appear as follows:

```
[root@zarkov /tmp]#
```

The `.tcshrc` file can also be named `.cshrc`. The `tcsh` shell is really an extended version of the `csh` shell. In fact, you can invoke it by the `csh` name. When a `tcsh` shell is started, it first looks for a `.tcshrc` file in the current user's home directory. If it can't find a file by that name, it looks for the other name, `.cshrc`. Thus, either name is appropriate.

## Configuring System-Wide Shell Options

Allowing individually customizable shell start-up files for each user is a very flexible and useful practice. But sometimes you need more centralized control than that. You may have an environment variable or other shell setting that you want set for every user, without exception. If you add that setting to each individual shell, the user has the ability to edit that file and remove it. Furthermore, if that setting must be changed in the future, you must change it in every single user's shell start-up file.

### Configuring System-Wide Bash Options

Fortunately, there is a better way. There are default start-up files that apply to all users of the computer that each command shell reads before reading the user-specific files. In the case of the `bash` command shell, it reads the `/etc/bashrc` file before doing anything else.

#### NOTE

While you can put system-wide options in the `/etc/bashrc` file, users can override these settings.



## Configuring System-Wide tcsh Options

Similarly, the tcsh shell reads the `/etc/csh.cshrc` file before processing the `.cshrc` or `.tcshrc` file found in the user's home directory. Here is a partial listing of the contents of the `/etc/csh.cshrc` file that ships with CentOS:

```
# /etc/cshrc
#
# csh configuration for all shell invocations.

# by default, we want this to get set.
# Even for non-interactive, non-login shells.
    umask 022

if ($?prompt) then
    if ($?tcsh) then
        set promptchars='##'
        set prompt='%u@m %c]## '
        set autolist
    else
        set prompt='\[$user@'hostname -s']\$\
    endif
endif
```

The `/etc/csh.cshrc` and `/etc/bashrc` files set a variety of shell environment options. If you want to modify or add to the shell environment supplied to every single user on the system, the `/etc/bashrc` or `/etc/csh.cshrc` file is the place to do it.

## Setting System Profiles

Some of the most basic information assigned to each user is added from the `/etc/profile` file. So, if you want to change any of the following information, you can start from `/etc/profile`. The contents of the `/etc/profile` file is sourced into each user's shell only to the initial login shell. Here are some values contained in `/etc/profile`:

- **PATH** — Assigns the default PATH for the root user and for all other users. You might change this value to add paths to local directories containing applications all users need.
- `ulimit -S -c 0` — The `-c 0` option to `ulimit` prevents core files typically created when a process crashes from being created. The `-S` makes this a “soft” option, so the user has the ability to turn on the core file feature if he or she chooses.
- **Environment Variables** — Shell environment variables that are needed for standard operation are assigned in this file. These include `USER` (set by the `id -un` command), `LOGNAME` (same as `USER`), `MAIL` (set to `/var/spool/mail/$USER`), `HOSTNAME` (set to the output of the command `/bin/hostname`), and `HISTSIZE` (which sets shell command history to 1,000 items).

- **INPUTRC** — Sets keyboard mappings for particular situations, based on the contents of the `/etc/inputrc` file. In particular, the `inputrc` file makes sure that the Linux console and various Terminal windows (`xterm` and `rxvt`) all behave sanely.

The last thing that the `/etc/profile` file does is look at the contents of the `/etc/profile.d` directory and source in the files that it finds. Each file contains settings that define environment variables or aliases that affect how users can use the shell. For example, the `lang.sh` and `lang.csh` files identify the locations of foreign language files. The `vim` files create aliases that cause `vim` to be used when `vi` is typed. The `which-2.sh` file defines a set of options used by the `which` command. You can modify the `profile.d` files or add your own to have environment variables and aliases set for all of your users.

## Adding User Accounts to Servers

When you set up a server, you often want to allow people to either upload files to it or download files or messages from it. However, you may not want to allow those people access to the entire server. You can begin limiting access to those users when you first create their user accounts.

To prevent a remote user from logging in and accessing a shell via `ssh` or another login service, you can set the default shell for a user to `nologin`. For example:

```
# useradd -s /sbin/nologin jason
```

With the shell set to `nologin`, this user would not be able to log in to the server to open a shell. However, the user could still use this account to log in to an FTP service on the server if the service is available and the user has a password. By default, the user's home directory in this example when he logged in via FTP would be `/home/jason`. (See Chapter 19 for ways in which you can restrict this user to access only his home directory in a `chroot` environment.)

Another approach to FTP-only access to a server is to use `/usr/libexec/openssh/sftp-server` as a user's login shell. While this allows users access to the entire file system that is available to the user account, it restricts them to access the server via secured FTP only.

A common practice with Web hosting is to allow a user to place content on the server, often in that user's `/home/username/public_html` directory, using FTP (but no shell login). However, the administrator could choose to assign the location for the Web content to be any directory, including the system-wide Web Server directory. The following command assigns the user named `webuser` to use `/var/www/html` as his home directory (you should also change ownership of the files to belong to `webuser` for this to work):

```
# useradd -s /sbin/nologin -d /var/www/html webuser
```

If you were adding a user for mail service access only, you might choose to prevent any access to FTP as well. One way to do that is to point the user's home directory to `/dev/null`. For example:

```
# useradd -s /sbin/nologin -d /dev/null jason
```

Once you have set up a limited user account, you can further define what your server's users can and cannot access, using features associated with the particular service.

## Creating Portable Desktops

---

Since Linux is an operating system that was born on the Internet, it is not surprising that it has strong networking capabilities. This makes Linux an excellent server, but it also allows Linux to be an excellent desktop workstation, especially in a highly networked environment. CentOS lets you easily set up your users with a portable desktop that follows them from computer to computer. With other leading desktop operating systems, it is not nearly as easy.

Typically, a Linux user's home directory is located within the `/home` directory. As an alternative, within the `/home` directory, you can create a directory named after the system's hostname. Within that directory, create the users' home directories. Thus, on a Linux system named `flashg`, the user `connie` would have a home directory of `/home/flashg/connie` instead of `/home/connie`. There is a very good reason for doing this.

If you are logged into the Linux system `zarkov` and would like to access your home directory on `flashg` as if it were stored locally, the best approach is to use Network File System (NFS) to mount `flashg's /home` directory on the `/home` on `zarkov`. This results in having the same contents of your home directory available to you no matter which machine you log in to.

**CROSS-REF** You can read more about NFS in Chapter 17.

To mount `flashg's /home` directory as described, you would add a line similar to the following in `zarkov's /etc/fstab` file:

```
flashg:/home /home nfs defaults,_netdev 0 0
```

You would also add an entry such as the following in `flashg's /etc/exports` directory:

```
/home zarkov
```

Now, when `zarkov` boots up, it automatically mounts `flashg's` home partition over the network. This enables you to treat the remote files and directories on `flashg's /home` as if they are locally stored on `zarkov`. Unfortunately, this has the side effect of “covering up” `zarkov's` actual `/home` directory.

This is where the extra directory level based on the system name comes to the rescue. With all of `flashg's` home directories located in `/home/flashg` and all of `zarkov's` home directories located in `/home/zarkov`, you can remove the danger of one system covering up the home directories of another. In fact, let's take this example one step further: Imagine a scenario in which the systems `flashg`, `zarkov`, and `dale` all have portable desktops that are shared with the other systems. The `/etc/fstab` and `/etc/exports` files for each system should have the following lines added to them as indicated.

The `/etc/exports` and `/etc/fstab` files for `flashg` are as follows:

---

**`/etc/exports` file**

```
/home/flashg zarkov,dale
```

---

**`/etc/fstab` file**

```
zarkov:/home/zarkov /home/zarkov nfs defaults,_netdev 0 0
dale:/home/dale /home/dale nfs defaults,_netdev 0 0
```

The `/etc/exports` and `/etc/fstab` files for `zarkov` are:

---

**`/etc/exports`**

```
/home/zarkov flashg,dale
```

---

**`/etc/fstab`**

```
flashg:/home/flashg /home/flashg nfs defaults,_netdev 0 0
dale:/home/dale /home/dale nfs defaults,_netdev 0 0
```

The `/etc/exports` and `/etc/fstab` files for `dale` are:

---

**`/etc/exports`**

```
/home/dale zarkov,flashg
```

---

**`/etc/fstab`**

```
zarkov:/home/zarkov /home/zarkov nfs defaults,_netdev 0 0
flashg:/home/flashg /home/flashg nfs defaults,_netdev 0 0
```

As you can see, each system uses NFS to mount the home directories from the other two systems. A user can travel from server to server and see exactly the same desktop on each system.

---

## Providing Support to Users

Creating new user accounts is just one small administrative task among many. No single chapter can adequately discuss all the tasks that are involved in the ongoing support of users. But I share with you a few hints and procedures to ease that burden.

## Creating a Technical Support Mailbox

E-mail is a wonderful communication tool, especially for the overworked system administrator. People usually put more thought and effort into their e-mail messages than into the voice messages that they leave. A text message can be edited for clarity before being sent, and important details can be cut and pasted from other sources. This makes e-mail an excellent method for Linux users to communicate with their system administrators.

In an office with only a few users, you can probably get away with using your personal mailbox to send and receive support e-mails. In a larger office, however, you should create a separate mailbox reserved only for technical support issues. This has several advantages over the use of your personal mailbox:

- Support messages will not be confused with personal, non-support-related messages.
- Multiple people can check the mailbox and share administrative responsibility without needing to read each other's personal e-mail.
- Support e-mail is easily redirected to another person's mailbox when you go on vacation. Your personal e-mail continues to go to your personal mailbox.

One easy solution is to simply create a support e-mail alias that redirects messages to an actual mailbox or list of mailboxes. For example, suppose you want to create a support alias that redistributes e-mail to the user accounts for support staff members Joe, Connie, and Bob. You would log in as `root`, edit the `/etc/aliases` file, and add lines similar to the following:

```
# Technical support mailing list
support: joe, connie, bob
```

After saving the file, you need to run the `newaliases` command to recompile the `/etc/aliases` file into a database format. Now your users can send e-mail to the support e-mail address, and the message will be automatically routed to everyone on the list. When a member of the list responds to that message, he or she should use the "Reply To All" option so that the other support staff members also see the message. Otherwise, multiple people may attempt to solve the same problem, resulting in wasteful duplication of effort.

You may also choose to create a support user account. The technical support staff would log in to this account to check messages and send replies. In this manner, all replies are stamped with the support login name and not the personal e-mail address of a staff member.

## Resetting a User's Password

Probably the most common problem that your users will encounter is the inability to log in because:

- They have the [Caps Lock] key on.
- They have forgotten the password.
- The password has expired.

If the [Caps Lock] key is not on, then you probably need to reset the user's password. You can't look up the password because Linux stores hashed forms of passwords. Instead, use the `passwd` command to assign a new password to the user's account. Give the user the new password (preferably in person), but then set the password to expire soon so that he or she must choose one (let's hope one that is more easily remembered).

If you must reset a user's password, do so with the `passwd` command. While logged in as `root`, type **passwd** followed by the login name you are resetting. You are prompted to enter the password twice. For example, to change the password for `connie`, type:

```
# passwd connie
```

After resetting the password, set it to expire so that the user is forced to change it the next time she logs in. You can use the `chage` command to set an expiration period for the password and to trick the system into thinking that the password is long overdue to be changed.

```
# chage -M 30 -d 0 connie
```

The `-M 30` option tells the system to expire Connie's password every 30 days. The `-d 0` option tricks the system into thinking that her password has not been changed since January 1, 1970. Keep in mind that using `chage` activates password aging for any account on which it is used. Adding a `-l` to the `chage` command line disables password aging.

**CROSS-REF** Administrators who support multiple users might want to consider some newer technologies that make life easier, such as centralized e-mail address books using LDAP. See Chapter 21 for more information.

## Modifying Accounts

---

Occasionally, a user needs more done to an account than just a resetting of the password. You may need to change the groups that a user is in, the drive that a home directory resides on, or a person's name changes with new marital status. The following sections explain how to modify user accounts using one of two methods: `usermod` or the User Manager window.

### Modifying User Accounts with `usermod`

The `usermod` command is similar to the `useradd` command and even shares some of the same options. However, instead of adding new accounts, it enables you to change various details of existing accounts. When invoking the `usermod` command, you must provide account details to change followed by the login name of the account. Table 10-3 lists the available options for the `usermod` command.

Assume that a new employee named *Mike Barnes* will be taking over Connie's job. We want to convert the `connie` account to a new name (`-l mike`), new comment (`-c "Mike Barnes"`), and home directory (`-d /home/mike`). You can do that with the following command:

```
# usermod -l mike -c "Mike Barnes" -m -d /home/mike connie
```

TABLE 10-3

## usermod Options for Changing Existing Accounts

Options	Description
-c " <i>comment</i> "	Change the description field of the account. Non- <code>root</code> users can use the <code>chfn</code> command to change this field for themselves. Replace <i>comment</i> with a name or other description of the user account. Because the comment can contain multiple words, the quotes are necessary.
-d <i>home_dir</i>	Change the home directory of the account to the specified new location. If the <code>-m</code> option is included, copy the contents of the home directory as well. Replace <i>home_dir</i> with the full path to the new directory.
-e <i>expire_date</i>	Assign a new expiration date for the account, replacing <i>expire_date</i> with a date in the YYYY-MM-DD format.
-f <i>inactivity</i>	Set the number of days after a password expires until the account is permanently disabled. Setting <i>inactivity</i> to 0 disables the account immediately after the password has expired. Setting it to -1 disables the option, which is the default behavior.
-g <i>group</i>	Change the primary group (as listed in the <code>/etc/group</code> file) that the user is in. Replace <i>group</i> with the name of the new group.
-G <i>grouplist</i>	Set the list of groups that user belongs to. Replace <i>grouplist</i> with a list of groups. If the user already is in a group that is not in the group list, he will be removed from that group.
-l <i>login_name</i>	Change the login name of the account to the name supplied after the <code>-l</code> option. Replace <i>login_name</i> with the new name. This does not automatically change the name of the home directory; use the <code>-d</code> and <code>-m</code> options for that.
-m	This option is used only in conjunction with the <code>-d</code> option. It causes the contents of the user's home directory to be copied to the new directory.
-o	This option is used only in conjunction with the <code>-u</code> option. It removes the restriction that user IDs must be unique.
-s <i>shell</i>	Specify a new command shell to use with this account. Replace <i>shell</i> with the full path to the new shell.
-u <i>user_id</i>	Change the user ID number for the account. Replace <i>user_id</i> with the new user ID number. Unless the <code>-o</code> option is used, the ID number must not be in use by another account.

Furthermore, if after converting the account you learn that Mike prefers the `tcsh` shell, you can make that change with the `-s` option (`-s /bin/tcsh`):

```
# usermod -s /bin/tcsh mike
```

Or, you can use the `chsh` command to change the shell. The following is an example:

```
$ chsh -s /bin/tcsh mike
```

The `chsh` command is handy because it enables a regular user to change his or her own shell setting to any shell listed in the `/etc/shells` file. The `root` user can change his or her own shell to any command he or she chooses. Simply leave the username parameter off when invoking the command, and `chsh` assumes the currently logged-in user as the account to change.

Users can also change their own user information using the `chfn` command. This information is stored in the `/etc/passwd` file and displayed when you type the `finger` command (e.g., `finger mike`). In this example, the full name, office name, office phone, home phone, and work phone are set by the user `mike`:

```
$ chfn -f "Michael Barnes" -o "A-111" -p 555-1212 -h 555-2323 mike
```

Users can also add information about themselves into the `.plan`, `.project`, `.forward`, and `.pgpkey` files in their home directory. That information will then be picked up by the `finger` command.

**NOTE**

The `finger` command opens potential security issues. Fingering gives out personal information that can be useful to those who want to crack your system. In addition, malicious users can flood your servers with `finger` requests.

## Modifying User Accounts with User Manager

To use the desktop to change an existing account, you can use the User Manager. Here's how to add a new user from the User Manager window:

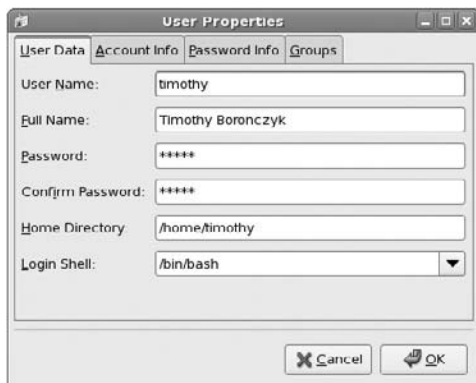
1. Select **System** > **Administration** > **Users and Groups** (or type **system-config-users** from a Terminal window as `root`). The main User Manager window appears.
2. Select the username of the account you want to modify, and then click on the **Properties** button to open the User Properties window (see Figure 10-3).
3. There are four tabs of information you can modify for the user you selected:
  - **User Data** — This tab contains the user information you created when you first added the user account.
  - **Account Info** — Select the “Enable Account Expiration” checkbox, and then type a date if you want the account to become inaccessible after a particular date. Select the “Local Password is Locked” checkbox if you want to prevent access to the account but not delete it. The latter is a good technique when an employee is leaving the company



or if you want to lock out a customer whose account is temporarily disabled. The information isn't removed; it just isn't accessible.

**FIGURE 10-3**

Choose Properties to modify an existing user account.



- **Password Info** — Select “Enable Password Expiration” if you want to control expiration of the user’s password. By default, passwords don’t expire. Here are your options:
    - “Days before change allowed” forces the user to keep the password for at least a set number of days before it can be changed.
    - “Days before change required” allows the user to keep the same password for at least the set number of days.
    - “Days warning before change” sets how many days before the password expiration day that the user is warned to change the password.
    - “Days before account inactive” sets the number of days after which the account is deactivated.
  - **Groups** — Select from the list of available groups to add the user to one or more of those groups.
4. Click OK to apply the changes to the user account.

## Deleting User Accounts

Occasionally, it is necessary to remove a user account from your Linux system. This can be done with either the `userdel` command or the User Manager window.

## Deleting User Accounts with `userdel`

The `userdel` command takes a single argument, which is the login name of the account to delete. If you supply the optional `-r` option, it also deletes the user's home directory and all the files in it. To delete the user account with login name `connie`, you would type this:

```
# userdel connie
```

To wipe out her home directory along with her account, type this:

```
# userdel -r connie
```

Files owned by the deleted user but not located in the user's home directory will not be deleted. The system administrator must search for and delete those files manually. The `find` command comes in very handy for this type of task. I won't describe all the capabilities of the `find` command (that would take a very fat chapter of its own). I do, however, provide a few simple examples of how to use `find` to locate files belonging to a particular user, even when those files are scattered throughout a file system. You can even use the `find` command to delete or change the ownership of files as they are located. Table 10-4 has a few examples of the `find` command in action.

**TABLE 10-4**

### Using `find` to Locate and Change User Files

Find Command	Description
<code>find / -user connie</code>	Search the entire file hierarchy (starting at <code>/</code> ) for all files and directories owned by <code>connie</code> and print the filenames to the screen.
<code>find /home -user connie -exec rm -i {} \;</code>	Search for all files and subdirectories under <code>/home</code> owned by <code>connie</code> . Run the <code>rm</code> command interactively to delete each file.
<code>find / -user connie -exec chown mike {} \;</code>	Search for all files and subdirectories under <code>/home</code> that are owned by user <code>connie</code> and run the <code>chown</code> command to change each file so that it is owned by <code>mike</code> instead.
<code>find / -uid 500 -exec chown mike {} \;</code>	This command is basically the same as the previous example, but it uses the user ID number instead of the username to identify the matching files. This is useful if you have deleted a user before converting her files.

There are a few common things about each invocation of the `find` command. The first parameter is always the directory to start the recursive search in. After that come the file attributes to

match. You can use the `-exec` parameter to run a command against each matching file or directory. The `{}` characters act as a placeholder that designates where the matching filename should be filled in when `find` runs the `-exec` option. The `\;` at the end simply tells Linux where the command ends. These are only a few of `find`'s capabilities. I encourage you to read the online man page to learn more about `find`. Type **man find** to view the page.

## Deleting User Accounts with User Manager

To delete a user from the User Manager window, simply click on the line representing the user account, and then click on the Delete button.

- The information about the user is removed from the `/etc/passwd` file; thus, the user can no longer log in.
- The home directory and all files owned by the user will still exist. However, a listing of files previously owned by that user (`ls -l`) will show only the former user's UID, but no name, as the owner.

See the description in the previous section for information about how to find and remove files previously owned by the user.

## Checking Disk Quotas

---

Limited disk space can be another source of user support calls. CentOS offer the `quotas` software package for limiting and displaying the amount of disk space that a user can consume. You can also use the `du` command to see how much disk space has been used in a particular directory and related subdirectories. To automate the process of checking for disk space, you can create your own script. The following sections describe these ways of dealing with potential disk space problems.

### Using Quota to Check Disk Usage

A careless or greedy user can gobble up all the space on your hard disk and, possibly, bring your computer to a halt. By using disk quotas, you can limit the amount of disk resources a user or group can use up.

The quota package contains a set of tools that lets you limit the amount of disk space (based on disk blocks) and files (based on inodes) that a user can consume. Using quotas, you can limit the amount of usage on a per-user and per-group basis for each file system on your computer. The general steps for setting disk quotas are:

1. Edit the `/etc/fstab` file.
2. Create quota files.
3. Create and start a quota start-up script.

4. Create quota rules.
5. Check quotas.

You set quotas on file systems listed in your `/etc/fstab` file. For computers that are shared by many users, there might be a separate `/home` or `/var` partition where users are expected to put all their data. That kind of partition boundary can prevent an entire disk from being consumed by one user. Quotas on the `/home` or `/var` partition can make sure that the space within those partitions is shared fairly among your computer's users.

**NOTE**

When you begin setting user disk quotas, keep track of the total amount of disk space that can be consumed by the users you assign. Although quotas can limit how much each user can consume, it doesn't prevent your system from running out of disk space when the total amount of disk space allocated exceeds the total amount available.

The procedure that spans the next few sections assumes that you have a separate `/home` partition on your computer for which you want to create quotas. You could use any partition, not just the `/home` partition shown in the procedure. For example, if you have only one partition mounted at the root of the file system (`/`), you could set quotas for your entire file system by replacing `/home` with `/` in the following example.

### Editing the `/etc/fstab` File

You need to add quota support to the file system. To do that, edit the `/etc/fstab` file and add the `usrquota` option to field number four of the partition for which you want to set quotas. Here is an example of a line from `/etc/fstab`:

```
/dev/sda2 /home ext3 defaults,usrquota,grpquota 1 2
```

Here, the `/home` file system is used to allow disk quotas for all users' home directories under the `/home` directory.

Before the `usrquota` option can take effect, the file system must be remounted. This happens automatically when you reboot, which you will have to do if you are setting quotas for the root (`/`) file system. Otherwise, you might be able to use the `umount` and `mount` commands to cause the `usrquota` option to take effect or run `mount` with the `remount` option.

### Creating Quota Files

You need to have `aquota.user` and/or `aquota.group` files in the root directory of the partition on which you want to establish disk quotas. To add quotas based on individual users, you need an `aquota.user` file, while `aquota.group` is needed to set quotas based on groups. One way to create these files is with the `quotacheck` command. Here's an example of the `quotacheck` command to create an initial `aquota.user` file:

```
# quotacheck -c /home
```

A `/home/aquota.user` file is created from the previous command. To create an initial `aquota.group` file, type **touch /home/aquota.group**. Next, you must create the disk usage table for the partition. Here's an example of how to do that:

```
# quotacheck -vug /home
```

The `quotacheck` command in this example looks at the file system partition mounted on `/home` and builds a table of disk usage. The `-v` option produces verbose output from the command, the `-u` option causes user quotas to be examined, and the `-g` option causes group quotas to be examined.

### Creating a Quota Start-Up Script

Because the quota package doesn't include a start-up script with the current CentOS distribution, you need to create your own. You want this script to check quotas (`quotacheck` command), start the quota service (`quotaon` command), and turn off the service (`quotaoff` command).

Open a new file called `/etc/init.d/quota` as root user, using any text editor. Here is an example of the content you can add to that file:

```
#!/bin/bash

# init file for quota
#
# description: Checks disk quotas
#
# processname: quota
# chkconfig: - 90 90
# source function library
. /etc/rc.d/init.d/functions

case "$1" in
    start)
        echo -n "Checking quotas: "
        daemon /sbin/quotacheck -avug
        echo
        echo -n "Starting quotas: "
        daemon /sbin/quotaon -avug
        echo
        ;;
    stop)
        echo -n "Shutting down quotas: "
        daemon /sbin/quotaoff -a
        echo
        ;;
    restart)
        $0 stop
```

```

        $0 start
        ;;
    *)
        echo "Usage: quota {start|stop|restart}"
        exit 1
    esac

    exit 0

```

The quota script, when started, first runs the `quotacheck` command to check all file systems for which quota checking is on. Then it turns on quota checking with the `quotaon` command. The line `# chkconfig: - 90 90` identifies the names assigned to the start-up script (`S90quota` or `K90quota`) when it is added to the individual run-level directories. When you run `chkconfig --add quota` in the next step, those scripts are automatically put in the correct run-level directories.

### Turn on the Quota Start-up Script

If you created a quota file, as described in the previous step, you need to make it executable and set it to start automatically when you start CentOS. To do those things, type the following as root user:

```

# chmod 755 /etc/init.d/quota
# chkconfig --add quota
# chkconfig quota on

```

At this point, links are created so that your quota script starts when your system boots.

### Creating Quota Rules

You can use the `edquota` command to create quota rules for a particular user or group. Valid users and groups are listed in the `/etc/passwd` and `/etc/group` files, respectively. Here is an example of an `edquota` command to set quotas for a user named `john`:

```

# edquota -u john
Disk quotas for user john (uid 501)
  Filesystem            blocks    soft    hard    inodes    soft    hard
  /dev/sda2              596        0        0         1         0        0
  ~
  ~
  ~
"/tmp//EdP.aBY1zYC" 3L, 215C

```

#### NOTE

The `edquota` command uses the `vi` text editor to edit your quota files. To use a different editor, change the value of the `EDITOR` or `VISUAL` environment variable before running `edquota`. For example, to use the `emacs` editor, type the following before running `edquota`:

```

# export EDITOR=emacs

```

This example shows that user quotas can be set for the user `john` on the `/dev/sda2` partition (which is `/home` in my example). Currently, `john` has used 596 blocks (a block equals 1 K on this `ext3` file system). One file was created by `john` (represented by 1 inode). To change the disk usage limits, you can edit the zeros (unlimited use) under the soft and hard heading for blocks and inodes.

Soft limits set limits that you don't want a user or group to exceed. Hard limits set the boundaries that you will not let a user or group exceed. After a set grace period that a soft limit is exceeded, which is 7 days by default, the soft limit becomes a hard limit. Type **edquota -t** to check and change the grace periods that you have set.

Here is an example of how the line in the previous `edquota` example could be changed:

```
/dev/sda2          596    512000  716800    1      800  1000
```

In this example, the soft limit on the number of blocks that the user `john` could consume on the `/dev/sda2` device (`/home`) is 512,000 blocks (or 500 MB); the hard limit is 716,800 blocks (or 700 MB). Soft and hard limits on inodes are 800 and 1,000, respectively. If either of the soft limits is exceeded by the user `john`, he has 7 days to get back under the limit or he will be blocked from using any more disk space or inodes.

Further attempts to write to a partition after the hard limit has been exceeded result in a failure to write to the disk. When this happens, the user who tries to create the file that exceeds his limit will see a message like the following:

```
ide0(3,2): write failed, user block limit reached.
cp: writing 'abc.doc': Disk quota exceeded
```

Exceeding disk quota can also prevent that user from logging in again because logging in from some graphical user interfaces requires being able to write to a user's home directory.

Instead of assigning quotas to users, you can assign quotas to any group listed in the `/etc/group` file. Instead of the `-u` option to `edquota`, use the `-g` options followed by a group name.

## Updating Quota Settings

After you have changed quota settings for a user, you should rerun the `quotacheck` command. You should also run the `quotacheck` command periodically, to keep the quota records up to date. One way to do that is to run the `quotacheck` command weekly using a `cron` entry. See Chapter 11 for more information on the `cron` facility.

## Checking Quotas

To report on how much disk space and how many inodes each user on your computer for which you have set quotas has consumed, use the `repquota` command. Here's an example of the `repquota` command for reading quota data relating to all partitions that are using quotas:

```
# repquota -a
*** Report for user quotas on device /dev/sda2
Block grace time: 7days: Inode grace time: 7days

User          used      soft    hard  grace    used    soft    hard  grace
root  --    1973984      0      0      grace    2506    0      0
john  --      1296      700    1700    6days     3      0      0
```

In this example, john has exceeded his soft limit of 700 blocks. He currently has 6 days left in his grace period to remove enough files so that the soft limit does not become the hard limit.

## Using du to Check Disk Use

You can discover the most voracious consumers of disk space using the `du` command. Invoke `du` with the `-s` option and give it a list of directories; it reports the total disk space used by all the files in each directory. Add the `-h` option to display disk space used in numbers, followed by kilobytes (K), megabytes (M), or gigabytes (G). The `-c` option adds a total of all requested directories at the end. The following checks disk usage for several home directories:

```
# du -hcs /home/robert /home/keith /home/graham /home/samantha
```

This should result in a list of all of your users' home directories preceded by the number of kilobytes (K), megabytes (M), or gigabytes (G) that each directory structure uses. It looks something like this:

```
339M    /home/robert
81M     /home/keith
31M     /home/graham
44K     /home/samantha
451M    total
```

## Removing Temp Files Automatically

Some potential disk-consumption problems are set up to take care of themselves. For example, directories for storing temporary files used by applications (such as `/tmp` and `/var/tmp`) can consume lots of disk space over time. To deal with the problem, CentOS includes the `tmpwatch` facility. The `tmpwatch` command runs from the `cron` file `/etc/cron.daily/tmpwatch` to delete unused temporary files. Here's what that file could contain (the actual file that ships with CentOS is slightly different from this example, but this sample highlights additional options that are available to `tmpwatch`):

```
flags=-umc
/usr/sbin/tmpwatch "$flags" -x /tmp/.X11-unix -x /tmp/.XIM-unix \
-x /tmp/.font-unix -x /tmp/.ICE-unix \
-x /tmp/.Test-unix 10d /tmp
/usr/sbin/tmpwatch "$flags" 30d /var/tmp
```



```
/usr/sbin/tmpwatch 720 /var/tmp
for d in /var/{cache/man,catman}/{cat?,X11R6/cat?,local/cat?}; do
    if [ -d "$d" ]; then
        /usr/sbin/tmpwatch "$flags" -f 30d $d
    fi
done
```

Each day, this `tmpwatch` script runs to delete temporary files that haven't been used for some time. The flags (`-umc`) indicate that time access is based on the file's access time (`u`), modification time (`m`), and inode change time (`c`). It starts by identifying files that are not to be deleted (`tmpwatch -x`). Files such as those in the `/tmp/.X11-unix` directory represent sockets for active X servers and would make an active GUI inaccessible if they were deleted. All other files from the `/tmp` and `/var/tmp` directories are removed after 10 and 30 days of not being accessed, respectively. Temporary man page files stored in `/var/cache` subdirectories are also checked and deleted after 30 days of disuse.

## Sending Mail to All Users

---

Occasionally, you need to send messages to all users on your system. Warning users of planned downtime for hardware upgrades is a good example. Sending e-mail to each user individually is extremely time-consuming and wasteful; this is precisely the kind of task that e-mail aliases and mailing lists were invented for. Keeping a mailing list of all the users on your system can be problematic, however. If you are not diligent about keeping the mailing list current, it becomes increasingly inaccurate as you add and delete users. Also, if your system has many users, the mere size of the alias list can become unwieldy.

The following script, called `mailfile`, provides a simple method of working around these problems. It grabs the login names from the `/etc/passwd` file and sends e-mail to all users.

### NOTE

Because regular user accounts begin with UID 500 in CentOS, the script excludes all UIDs under 500 that are typically administrative accounts. It also skips UID 65,534, which is the anonymous NFS user account.

```
#!/bin/bash
# mailfile: This script mails the named file to all regular
#           users of the system. It skips all administrative
#           accounts (accounts under UID 500) as well as the
#           anonymous NFS user (UID 65534).
#
# USAGE: mailfile "Subject goes here" filename.txt

# Check for a subject
#
# Get the subject of the message
subject=$1
```

```
# Check for a filename
filename=$2

# Loop through all login names, skipping accounts under 500
# as well as the anonymous NFS account (65534)

for x in $(cut -d ":" -f 1,3 /etc/passwd)
do
    USER=$(echo $x | cut -d ":" -f1)
    ID=$(echo $x | cut -d ":" -f2)

    if [[ $ID -gt 499 && $ID -lt 65534 ]]; then

        # Mail the file
        echo Mailing to $USER
        mail -s "$subject" $USER < $filename

        # Sleep for a few seconds so we don't overload the mailer
        # On fast systems or systems with few accounts, you can
        # probably take this delay out.
        sleep 2
    fi
done
```

The script accepts two parameters. The first is the subject of the e-mail message, which is enclosed in quotes. The second is the name of the file containing the text message to send. Thus, to send an e-mail message to all users warning them about an upcoming server hardware upgrade, I may do something similar to the following:

```
mailfile "System upgrade at 5:00pm" upgrade.txt
```

The file `upgrade.txt` contains the text of the message to be sent to each user. The really useful thing about this approach is that I can save this text file and easily modify and resend it the next time I upgrade the system.

**TIP**

If your users log in to your system using text-based logins instead of graphical logins, you can add messages to the `/etc/motd` file to have them reach your users. Any text in that file will be displayed on each user's screen after the user logs in and before the first shell prompt appears.

## Summary

---

It is not uncommon for a Linux system to be used as a single-task server with no actual users. It sits quietly in a server room, serving web pages or handling domain name service, never crashing, and rarely needing attention. This is not always the case, however. You may have to support

users on your Linux system, and that can be the most challenging part of your system administration duties.

CentOS provides a variety of tools that help you with your user administrative chores. The `useradd`, `usermod`, and `userdel` commands enable easy command-line manipulation of user account data. Furthermore, you can lighten your load even more by creating a support mailbox and building shell scripts to automate repetitive tasks. CentOS builds on top of the rich history of UNIX and provides an ideal platform to support the diverse needs of your users.

# Chapter 11

## Automating System Tasks

**Y**ou'd never get any work done if you typed every command that needs to be run on your CentOS system when it starts. Likewise, you could work more efficiently if you grouped together sets of commands that you run all the time. Shell scripts can handle these tasks.

A *shell script* is a group of commands, functions, variables, or just about anything else you can use from a shell. These items are typed into a plain-text file. That file can then be run as a command. CentOS uses system initialization shell scripts during system startup to run commands needed to get things going. You can create your own shell scripts to automate the tasks you need to do regularly.

This chapter provides a rudimentary overview of the inner workings of shell scripts and how they can be used. You learn how shell scripts are responsible for the messages that scroll by on the system console during booting and how simple scripts can be harnessed to a scheduling facility (such as `cron` or `at`) to simplify administrative tasks.

You also learn to fine-tune your machine to start at the most appropriate run level and to run only services you need. With that understanding, you'll be able to personalize your computer and cut down on the amount of time you spend repetitively typing the same commands.

### Understanding Shell Scripts

---

Have you ever had a task that you needed to do over and over that took a lot of typing on the command line? Do you ever think to yourself, “Wow,

#### IN THIS CHAPTER

Understanding shell scripts

System initialization

System startup and shutdown

Scheduling system tasks

I wish there was just one command I could type to do all this of this”? Maybe a shell script is what you’re after.

Shell scripts are the equivalent of batch files in MS-DOS and can contain long lists of commands, complex flow control, arithmetic evaluations, user-defined variables, user-defined functions, and sophisticated condition testing. Shell scripts are capable of handling everything from simple one-line commands to something as complex as starting up your CentOS system.

In fact, as you will read in this chapter, CentOS does just that. It uses shell scripts (`/etc/rc.d/rc.sysinit` and `/etc/rc`) to check and mount all your file systems, set up your consoles, configure your network, launch all your system services, and eventually provide you with your login screen. While there are nearly a dozen different shells available in CentOS, the default shell is called `bash`, the *Bourne-Again SHell*.

## Executing and Debugging Shell Scripts

One of the primary advantages of shell scripts is that they can be opened in any text editor to see what they do. A big disadvantage is that large or complex shell scripts often execute more slowly than compiled programs. There are two basic ways to execute a shell script:

- The filename is used as an argument to the shell (as in `bash myscript`). In this method, the file does not need to be executable; it just contains a list of shell commands. The shell specified on the command line is used to interpret the commands in the script file. This is most common for quick, simple tasks.
- The shell script may also have the name of the interpreter placed in the first line of the script preceded by `#!` (as in `#!/bin/bash`), and have its execute bit set (using `chmod +x`). You can then run your script just like any other program in your path simply by typing the name of the script on the command line.

**CROSS-REF** See Chapter 4 for more details on `chmod` and Read/Write/Execute permissions.

When scripts are executed in either manner, options to the program may be specified on the command line. Anything following the name of the script is referred to as a *command-line argument*.

As with writing any software, there is no substitute to clear and thoughtful design and lots of comments. The pound sign (`#`) prefaces comments and can take up an entire line or exist on the same line after script code. It’s best to implement more complex shell scripts in stages, making sure the logic is sound at each step before continuing. Here are a few good, concise tips to make sure things are working as expected during testing:

- Place an `echo` statement at the beginning of lines within the body of a loop. That way, rather than executing the code, you can see what will be executed without making any permanent changes.
- To achieve the same goal, you could place dummy `echo` statements throughout the code. If these lines get printed, you know the correct logic branch is being taken.

- You could use `set -x` near the beginning of the script to display each command that is executed or launch your scripts using `bash -x myscript`.
- Because useful scripts have a tendency to grow over time, keeping your code readable as you go along is extremely important. Do what you can to keep the logic of your code clean and easy to follow.

## Understanding Shell Variables

Often within a shell script, you want to reuse certain items of information. During the course of processing the shell script, the name or number representing this information may change. To store information used by a shell script in such a way that it can be easily reused, you can set variables. Variable names within shell scripts are case-sensitive and can be defined in the following manner:

```
NAME=value
```

The first part of a variable is the variable name, and the second part is the value set for that name. Be sure that the `NAME` and `value` touch the equal sign, without any spaces. Variables can be assigned from constants, such as text or numbers. This is useful for initializing values or saving lots of typing for long constants. Here are examples where variables are set to a string of characters (`CITY`) and a numeric value (`PI`):

```
CITY="Springfield"  
PI=3.14159265
```

Variables can contain the output of a command or command sequence. You can accomplish this by preceding the command with a dollar sign and open parenthesis, and following it with a closing parenthesis. For example, `MYDATE=$(date)` assigns the output from the `date` command to the `MYDATE` variable. Enclosing the command in backticks (```) has the same effect, although using backticks has been deprecated in favor of `$()`.

### NOTE

Keep in mind that characters such as dollar sign (`$`), backtick (```), asterisk (`*`), exclamation point (`!`), and others have special meaning to the shell, as you will see as you proceed through this chapter. To use those characters in an option to a command, and not have the shell use its special meaning, you need to precede that character with a backslash (`\`) or surround it in quotes. One place you will encounter this is in files created by Windows users that might include spaces, exclamation points, or other characters. In Linux, to properly interpret a file named `my big! file!`, you either need to surround it in double quotes or type `my\ big\! file\!`.

These are great ways to get information that can change from computer to computer or from day to day. The following example sets the output of the `uname -n` command to the `MACHINE` variable. Then I use parentheses to set `NUM_FILES` to the number of files in the current directory by piping (`|`) the output of the `ls` command to the word count command (`wc -l`).

```
MACHINE='uname -n'  
NUM_FILES=$(/bin/ls | wc -l)
```

Variables can also contain the value of other variables. This is useful when you have to preserve a value that will change so you can use it later in the script. Here `BALANCE` is set to the value of the `CurBalance` variable.

```
BALANCE="$CurBalance"
```

**NOTE**

When assigning variables, use only the variable name (e.g., `BALANCE`). When referenced, meaning you want the *value* of the variable, precede it with a dollar sign (as in `$CurBalance`). The result of the latter is that you get the value of the variable, and not the variable name itself.

## Special Shell Variables

There are special variables that the shell assigns for you. The most commonly used variables are called the *positional parameters* or *command-line arguments* and are referenced as `$0`, `$1`, `$2`, `$3` ... `$n`. `$0` is special and is assigned the name used to invoke your script; the others are assigned the values of the parameters passed on the command line. For instance, if the shell script named `myscript` were called as:

```
myscript foo bar
```

the positional parameter `$0` would be `myscript`, `$1` would be `foo`, and `$2` would be `bar`.

Another variable, `$#`, tells you how many parameters your script was given. In our example, `$#` would be 2. Another particularly useful special shell variable is `$?`, which receives the exit status of the last command executed. Typically, a value of zero means everything is OK, and anything other than zero indicates an error of some kind. For a complete list of special shell variables, refer to the `bash` man page.

## Parameter Expansion in Bash

As mentioned earlier, if you want the value of a variable, you precede it with a `$` (e.g., `$CITY`). This is really just shorthand for the notation `${CITY}`; curly braces are used when the value of the parameter needs to be placed next to other text without a space. Bash has special rules that allow you to expand the value of a variable in different ways. Going into all the rules is probably a little overkill for a quick introduction to shell scripts, but Table 11-1 presents some common constructs that you're likely to see in `bash` scripts you find on your CentOS box.

Try typing the following commands from a shell to test how parameter expansion works:

```
$ THIS="Example"
$ THIS=${THIS:-"Not Set"}
$ THAT=${THAT:-"Not Set"}
$ echo $THIS
Example
$ echo $THAT
Not Set
```

TABLE 11-1

## Examples of Bash Parameter Expansion

Construction	Meaning
<code>\${var:-value}</code>	If variable is unset or empty, expand this to <i>value</i> .
<code>\${var#pattern}</code>	Chop the shortest match for <i>pattern</i> from the front of <i>var</i> 's value.
<code>\${var##pattern}</code>	Chop the longest match for <i>pattern</i> from the front of <i>var</i> 's value.
<code>\${var%pattern}</code>	Chop the shortest match for <i>pattern</i> from the end of <i>var</i> 's value.
<code>\${var%%pattern}</code>	Chop the longest match for <i>pattern</i> from the end of <i>var</i> 's value.

In the examples here, the `THIS` variable is initially set to the word `Example`. In the next two lines, the `THIS` and `THAT` variables are set to their current values or to `Not Set`, if they are not currently set. Notice that because I just set `THIS` to the string `Example`, when I echo the value of `THIS`, it appears as `Example`. However, since `THAT` was not set, it appears as `Not Set`.

**NOTE**

For the rest of this section, I show how variables and commands may appear in a shell script. To try out any of those examples, however, you can simply type them into a shell as shown in the previous example.

In the following example, `MYFILENAME` is set to `/home/timothy/myfile.txt`. Next, the `FILE` variable is set to `myfile.txt` and `DIR` is set to `/home/timothy`. In the `NAME` variable, the filename is cut down to simply `myfile`, then in the `EXTENSION` variable the file extension is set to `txt`. (To try these out, you can type them at a shell prompt as in the previous example, then echo the value of each variable to see how it is set.)

```
MYFILENAME="/home/timothy/myfile.txt"
FILE=${MYFILENAME##*/}           #FILE becomes "myfile.txt"
DIR=${MYFILENAME%/*}            #DIR becomes "/home/timothy"
NAME=${FILE%.*}                 #NAME becomes "myfile"
EXTENSION=${FILE#*.}            #EXTENSION becomes "txt"
```

## Performing Arithmetic in Shell Scripts

Bash uses *untyped* variables, meaning it normally treats variables as strings or text, but can change them on the fly if you want it to. Unless you tell it otherwise with `declare`, your variables are just a bunch of letters to Bash. But when you start trying to do arithmetic with them, Bash will convert them to integers if it can. This makes it possible to do some fairly complex arithmetic in Bash.

Integer arithmetic can be performed using the built-in `let` command or through the external `expr` or `bc` commands. After setting the variable `BIGNUM` value to 1024, the three commands



that follow would all store the value 64 in the `RESULT` variable. The last command gets a random number between 0 and 10 and echoes the results back to you.

```
BIGNUM=1024
let RESULT=$BIGNUM/16
RESULT='expr $BIGNUM / 16'
RESULT='echo "$BIGNUM / 16" | bc -l'
let foo=$RANDOM%10; echo $foo
```

## NOTE

While most elements of shell scripts are relatively freeform (where white space, such as spaces or tabs, is insignificant), both `let` and `expr` are particular about spacing. The `let` command insists on no spaces between each operand and the mathematical operator, whereas the syntax of the `expr` command requires white space between each operand and its operator. In contrast to those, `bc` isn't picky about spaces but can be trickier to use because it does floating-point arithmetic.

To see a complete list of the kinds of arithmetic you can perform using the `let` command, type **help let** at the Bash prompt.

## Using Programming Constructs in Shell Scripts

One of the features that make shell scripts so powerful is that their implementation of looping and conditional execution constructs is similar to those found in more complex scripting and programming languages. You can use several different types of loops, depending on your needs.

### The `if . . . then` Statements

The most commonly used programming construct is conditional execution, or the `if` statement. It is used to perform actions only under certain conditions. There are several variations, depending on whether you're testing one thing, or want to do one thing if a condition is true, but another thing if a condition is false, or if you want to test several things one after the other.

The first `if . . . then` example tests if `VARIABLE` is set to the number 1. If it is, then the `echo` command is used to say that it is set to 1. The `fi` then indicates that the `if` statement is complete, and processing can continue.

```
VARIABLE=1
if [ $VARIABLE -eq 1 ] ; then
echo "The variable is 1"
fi
```

Instead of using `-eq`, you can use the equals sign (`=`), as shown in the following example. The `=` is used for comparing string values, while `-eq` is used for comparing numbers.

Using the `else` statement, different words can be echoed if the criterion of the `if` statement isn't met (`$STRING = "Friday"`). Keep in mind that it's good practice to put strings in double quotes.

```

STRING="Friday"
if [ $STRING = "Friday" ] ; then
echo "WhooHoo. Friday."
else
echo "Will Friday ever get here?"
fi

```

You can also reverse tests with an exclamation mark (!). In the following example, if `STRING` is not Monday, then "At least it's not Monday" is echoed.

```

STRING="Friday"
if [ "$STRING" != "Monday" ] ; then
    echo "At least it's not Monday"
fi

```

In the following example, `elif` (which stands for "else if") is used to test for an additional condition (is filename a file or a directory).

```

filename="$HOME"

if [ -f "$filename" ] ; then
    echo "$filename is a regular file"
elif [ -d "$filename" ] ; then
    echo "$filename is a directory"
else
    echo "I have no idea what $filename is"
fi

```

As you can see from the preceding examples, the condition you are testing is placed between square brackets [ ]. When a test expression is evaluated, it will return either a value of 0, meaning that it is true, or a 1, meaning that it is false. Notice that the `echo` lines are indented. This is optional and done only to make the script more readable.

Table 11-2 lists the conditions that are testable and is quite a handy reference. (If you're in a hurry, you can type **help test** on the command line to get the same information.)

There is also a special shorthand method of performing tests that can be useful for simple *one-command* actions. In the following example, the two pipes (|) indicate that if the directory being tested for doesn't exist (`-d $dirname`), then make the directory (`mkdir $dirname`).

```

# [ test ] || {action}
# Perform simple single command {action} if test is false
dirname="/tmp/testdir"
[ -d "$dirname" ] || mkdir "$dirname"

```

Instead of pipes, you can use two ampersands (&&) to test if something is true. In the following example, a command is being tested to see if it includes at least three command-line arguments.

```

# [ test ] && {action}
# Perform simple single command {action} if test is true
[ $# -ge 3 ] && echo "There are at least 3 command line arguments."

```

TABLE 11-2

## Operators for Test Expressions

Operator	What Is Being Tested?
<code>-a file</code>	Does the file exist? (same as <code>-e</code> )
<code>-b file</code>	Is the file a special block device?
<code>-c file</code>	Is the file character special (e.g., a character device)? Used to identify serial lines and terminal devices.
<code>-d file</code>	Is the file a directory?
<code>-e file</code>	Does the file exist? (same as <code>-a</code> )
<code>-f file</code>	Does the file exist, and is it a regular file (e.g., not a directory, socket, pipe, link, or device file)?
<code>-g file</code>	Does the file have the set-group-id bit set?
<code>-h file</code>	Is the file a symbolic link? (same as <code>-L</code> )
<code>-k file</code>	Does the file have the sticky bit set?
<code>-L file</code>	Is the file a symbolic link?
<code>-n string</code>	Is the length of the string greater than 0 bytes?
<code>-O file</code>	Do you own the file?
<code>-p file</code>	Is the file a named pipe?
<code>-r file</code>	Is the file readable by you?
<code>-s file</code>	Does the file exist, and is it larger than 0 bytes?
<code>-S file</code>	Does the file exist, and is it a socket?
<code>-t fd</code>	Is the file descriptor connected to a terminal?
<code>-u file</code>	Does the file have the set-user-id bit set?
<code>-w file</code>	Is the file writable by you?
<code>-x file</code>	Is the file executable by you?
<code>-z string</code>	Is the length of the string 0 (zero) bytes?
<code>expr1 -a expr2</code>	Are both the first expression and the second expression true?
<code>expr1 -o expr2</code>	Is either of the two expressions true?
<code>file1 -nt file2</code>	Is the first file newer than the second file (using the modification time stamp)?

**TABLE 11-2** (continued)

Operator	What Is Being Tested?
<i>file1 -ot file2</i>	Is the first file older than the second file (using the modification time stamp)?
<i>file1 -ef file2</i>	Are the two files associated by a link (a hard link or a symbolic link)?
<i>var1 = var2</i>	Is the first variable equal to the second variable?
<i>var1 -eq var2</i>	Is the first variable equal to the second variable?
<i>var1 -ge var2</i>	Is the first variable greater than or equal to the second variable?
<i>var1 -gt var2</i>	Is the first variable greater than the second variable?
<i>var1 -le var2</i>	Is the first variable less than or equal to the second variable?
<i>var1 -lt var2</i>	Is the first variable less than the second variable?
<i>var1 != var2</i>	Is the first variable not equal to the second variable?
<i>var1 -ne var2</i>	Is the first variable not equal to the second variable?

## The case Command

Another frequently used construct is the case command. Similar to a switch statement in programming languages, this can take the place of several nested if statements. A general form of the case statement is as follows:

```
case "VAR" in
    Result1)
        { body };;
    Result2)
        { body };;
    *)
        { body } ;;;
esac
```

One use for the case command might be to help with your backups. The following case statement tests for the first three letters of the current day (case 'date +%a' in). Then, depending on the day, a particular backup directory (BACKUP) and tape drive (TAPE) is set.

```
# Our VAR doesn't have to be a variable,
# it can be the output of a command as well
# Perform action based on day of week
case 'date +%a' in
    "Mon")
        BACKUP=/home/myproject/data0
        TAPE=/dev/rft0
```

```

# Note the use of the double semi-colon to end each option
;;
# Note the use of the "|" to mean "or"
"Tue" | "Thu")
    BACKUP=/home/myproject/data1
    TAPE=/dev/rft1
;;
"Wed" | "Fri")
    BACKUP=/home/myproject/data2
    TAPE=/dev/rft2
;;
# Don't do backups on the weekend.
*)
    BACKUP="none"
    TAPE=/dev/null
;;
esac

```

The asterisk (\*) is used as a catchall, similar to the default keyword in the C programming language. In this example, if none of the other entries are matched on the way down the loop, the asterisk is matched, and the value of BACKUP becomes none. Note the use of `esac`, or `case` spelled backwards, to end the case statement.

## The for . . . do Loop

Loops are used to perform actions over and over again until a condition is met or until all data has been processed. One of the most commonly used loops is the `for . . . do` loop. It iterates through a list of values, executing the body of the loop for each element in the list. The syntax and a few examples are presented here:

```

for VAR in LIST
do
    { body }
done

```

The `for` loop assigns the values in LIST to VAR one at a time. Then for each value, the body in braces between `do` and `done` is executed. VAR can be any variable name, and LIST can be composed of pretty much any list of values or anything that generates a list.

```

for NUMBER in 0 1 2 3 4 5 6 7 8 9
do
    echo The number is $NUMBER
done

for FILE in '/bin/ls'
do
    echo $FILE
done

```

You can also write it this way, which is somewhat cleaner:

```
for NAME in John Paul Ringo George ; do
    echo $NAME is my favorite Beatle
done
```

Each element in the LIST is separated from the next by white space. This can cause trouble if you're not careful because some commands, such as `ls -l`, output multiple fields per line, each separated by white space. The string `done` ends the `for` statement.

If you're a die-hard C programmer, Bash allows you to use C syntax to control your loops:

```
LIMIT=10
# Double parentheses, and no $ on LIMIT even though it's a variable!
for ((a=1; a <= LIMIT ; a++)) ; do
    echo "$a"
done
```

## The while . . . do and until . . . do Loops

Two other possible looping constructs are the `while . . . do` loop and the `until . . . do` loop. The structure of each is presented here:

```
while condition          until condition
do                       do
    { body }             { body }
done                     done
```

The `while` statement executes while the condition is true. The `until` statement executes until the condition is true, in other words, while the condition is false.

Here is an example of a `while` loop that will output the number 0123456789:

```
N=0
while [ $N -lt 10 ] ; do
    echo -n $N
    let N=$N+1
done
```

Another way to output the number 0123456789 is to use an `until` loop as follows:

```
N=0
until [ $N -eq 10 ] ; do
    echo -n $N
    let N=$N+1
done
```

## Some Useful External Programs

`bash` is great and has lots of built-in commands, but it usually needs some help to do anything really useful. Some of the most common useful programs you'll see used are `grep`, `cut`, `tr`, `awk`, and `sed`. As with all the best UNIX tools, most of these programs are designed to work with standard input and standard output, so you can easily use them with pipes and shell scripts.

### The General Regular Expression Parser (`grep`)

The name *general regular expression parser* sounds intimidating, but `grep` is just a way to find patterns in files or text. Think of it as a useful search tool. Getting really good with regular expressions is quite a challenge, but many useful things can be accomplished with just the simplest forms.

For example, you can display a list of all regular user accounts by using `grep` to search for all lines that contain the text `/home` in the `/etc/passwd` file as follows:

```
grep /home /etc/passwd
```

Or you could find all environment variables that begin with `HO` using the following command:

```
env | grep ^H0
```

To find a list of options to use with the `grep` command, type **man grep**.

### Extract Sections from Lines of Text (`cut`)

The `cut` command can extract specific fields from a line of text or from files. It is very useful for parsing system configuration files into easy-to-digest chunks. You can specify the field separator you want to use and the fields you want, or you can break up a line based on bytes.

The following example lists all home directories of users on your system. Using an earlier example of the `grep` command, this line pipes a list of regular users from the `/etc/passwd` file, then displays the sixth field (`-f6`) as delimited by a colon (`-d ':'`). The hyphen at the end tells `cut` to read from standard input (from the pipe).

```
grep /home /etc/passwd | cut -f6 -d ':' -
```

### Translate or Delete Characters (`tr`)

The `tr` command is a character-based translator that can be used to replace one character or set of characters with another or to remove a character from a line of text.

The following example translates all uppercase letters to lowercase letters and displays the words “mixed upper and lower case” as a result:

```
F00="Mixed UPpEr aNd LoWeR cAsE"  
echo $F00 | tr [A-Z] [a-z]
```

In the next example, the `tr` command is used on a list of filenames to rename any files in that list so that any tabs or spaces (as indicated by the `[:blank:]` option) contained in a filename are translated into underscores. Try running the following code in a test directory:

```
for file in * ; do
    f='echo $file | tr [:blank:] [_]'
```

```
[ -e "$f" ] || mv -i "$file" "$f"
```

```
done
```

## The Stream Editor (sed)

The `sed` command is a simple scriptable editor, and as such can perform only simple edits, such as removing lines that have text matching a certain pattern, replacing one pattern of characters with another, and other simple edits. To get a better idea of how `sed` scripts work, there's no substitute for the online documentation, but here are some examples of common uses.

You can use the `sed` command to essentially do what I did earlier with the `grep` example: search the `/etc/passwd` file for the word *home*. Here the `sed` command searches the entire `/etc/passwd` file, searches for the word *home*, and prints any line containing the word *home*.

```
sed -n '/home/p' /etc/passwd
```

In this example, `sed` searches the file `somefile.txt` and replaces every instance of the string *Mac* with *Linux*. Notice that the letter `g` is needed at the end of the substitution command to cause every occurrence of *Mac* on each line to be changed to *Linux*. (Otherwise, only the first instance of *Mac* on each line is changed.) The output is then sent to the `fixed_file.txt` file. The output from `sed` goes to standard output, so this command re-directs the output to a file for safekeeping.

```
sed 's/Mac/Linux/g' somefile.txt > fixed_file.txt
```

You can get the same result using a pipe:

```
cat somefile.txt | sed 's/Mac/Linux/g' > fixed_file.txt
```

By searching for a pattern and replacing it with a null pattern, you delete the original pattern. This example searches the contents of the `somefile.txt` file and replaces extra blank spaces at the end of each line (`s/ *$`) with nothing (`//`). Results go to the `fixed_file.txt` file.

```
cat somefile.txt | sed 's/ *$//' > fixed_file.txt
```

## Trying Some Simple Shell Scripts

Sometimes the simplest of scripts can be the most useful. If you type the same sequence of commands repetitively, it makes sense to store those commands in a file. Here are a couple of simple, but useful, shell scripts.



## A Simple Telephone List

This idea has been handed down from generation to generation of old UNIX hacks. It's really quite simple, but it employs several of the concepts just introduced.

```
#!/bin/bash
# (@)/ph
# A very simple telephone list
# Type "ph new name number" to add to the list, or
# just type "ph name" to get a phone number

PHONELIST=~/.phonelist.txt

# If no command line parameters ($#), there
# is a problem, so ask what they're talking about.
if [ $# -lt 1 ] ; then
    echo "Whose phone number did you want? "
    exit 1
fi

# Did you want to add a new phone number?
if [ $1 = "new" ] ; then
    shift
    echo $* >> $PHONELIST
    echo $* added to database
    exit 0
fi

# Nope. But does the file have anything in it yet?
# This might be our first time using it, after all.
if [ ! -s $PHONELIST ] ; then
    echo "No names in the phone list yet! "
    exit 1
else
    grep -i -q "$*" $PHONELIST # Quietly search the file
    if [ $? -ne 0 ] ; then      # Did we find anything?
        echo "Sorry, that name was not found in the phone list"
        exit 1
    else
        grep -i "$*" $PHONELIST
    fi
fi
exit 0
```

So, if you created the file `ph` in your current directory, you could type the following from the shell to try out your `ph` script:

```
$ chmod 755 ph
$ ./ph new "Mary Jones" 608-555-1212
```

```
Mary Jones 608-555-1212 added to database
$ ./ph Mary
Mary Jones 608-555-1212
```

The `chmod` command makes the `ph` script executable. The `./ph` command runs the `ph` command from the current directory with the `new` option. This adds *Mary Jones* as the name and *608-555-1212* as the phone number to the database (`$HOME/.phone.txt`). The next `ph` command searches the database for the name *Mary* and displays the phone entry for *Mary*. If the script works, add it to a directory in your `PATH` (such as `$HOME/bin`).

## A Simple Backup Script

Because nothing works forever and mistakes happen, backups are just a fact of life when dealing with computer data. This simple script backs up all the data in the home directories of all the users on your CentOS system.

```
#!/bin/bash
# (@)/my_backup
# A very simple backup script
#

# Change the TAPE device to match your system.
# Check /var/log/messages to determine your tape device.
# You may also need to add scsi-tape support to your kernel.
TAPE=/dev/rft0

# Rewind the tape device $TAPE
mt $TAPE rew

# Get a list of home directories
HOMES=$(grep /home /etc/passwd | cut -f6 -d':')
# Backup the data in those directories
tar cvf $TAPE $HOMES
# Rewind and eject the tape.
mt $TAPE rewoffl
```

**CROSS-REF** See Chapter 12 for details on backing up and restoring.

## System Initialization

---

When you turn on your computer, a lot happens even before CentOS starts up. Here are the basic steps that occur each time you boot up your computer to run CentOS:

- 1. Boot Hardware** — Based on information in the computer's Read Only memory (referred to as the *BIOS*), your computer checks and starts up the hardware. Some of that information tells the computer which devices (floppy disk, CD, hard disk, etc.) to check to find the bootable operating system.

- 2. Start Boot Loader** — After checking that no bootable operating system is ready to boot in your floppy, CD, or DVD drive, typically, the BIOS checks the master boot record on the primary hard disk to see what to load next. With CentOS installed, the GRUB boot loader is started, allowing you to choose to boot CentOS or another installed operating system.
- 3. Boot the Kernel** — Assuming that you selected to boot CentOS, the Linux kernel is loaded. That kernel mounts the basic file systems and transfers control to the `init` process. The rest of this section describes what happens after the kernel hands off control of system startup to the `init` process.

## Starting `init`

In the boot process, the transfer from the kernel phase (the loading of the kernel, probing for devices, and loading drivers) to `init` is indicated by the following lines:

```
Welcome to CentOS release 5.3 (Final)
Press "I" to enter interactive startup.
```

The `init` program, part of the `SysVinit` RPM package, is now in control.

The output from `ps` always lists `init` (known as *the father of all processes*) as PID (process identifier) 1.

In CentOS, a special script, `/etc/inittab`, directs the actions of the `init` program.

## The `inittab` File

The following example shows the contents of the `/etc/inittab` file as it is delivered with CentOS:

```
#
# inittab      This file describes how the INIT process should set up
#              the system in a certain run-level.
#
# Author:      Miquel van Smoorenburg, <miquels@drinkel.nl.mugnet.org>
#              Modified for RHS Linux by Marc Ewing and Donnie Barnes
#

# Default runlevel. The runlevels used by RHS are:
# 0 - halt (Do NOT set initdefault to this)
# 1 - Single user mode
# 2 - Multiuser, without NFS (The same as 3, if you do not have
#    networking)
# 3 - Full multiuser mode
# 4 - unused
# 5 - X11
# 6 - reboot (Do NOT set initdefault to this)
#
id:5:initdefault:

# System initialization.
```

```

si::sysinit:/etc/rc.d/rc.sysinit

10:0:wait:/etc/rc.d/rc 0
11:1:wait:/etc/rc.d/rc 1
12:2:wait:/etc/rc.d/rc 2
13:3:wait:/etc/rc.d/rc 3
14:4:wait:/etc/rc.d/rc 4
15:5:wait:/etc/rc.d/rc 5
16:6:wait:/etc/rc.d/rc 6

# Trap CTRL-ALT-DELETE
ca::ctrlaltdel:/sbin/shutdown -t3 -r now

# When our UPS tells us power has failed, assume we have a few minutes
# of power left. Schedule a shutdown for 2 minutes from now.
# This does, of course, assume you have powerd installed and your
# UPS connected and working correctly.
pf::powerfail:/sbin/shutdown -f -h +2 "Power Failure; System Shut-
ting Down"

# If power was restored before the shutdown kicked in, cancel it.
pr:12345:powerokwait:/sbin/shutdown -c "Power Restored; Shutdown Can-
celled"

# Run gettys in standard runlevels
1:2345:respawn:/sbin/mingetty tty1
2:2345:respawn:/sbin/mingetty tty2
3:2345:respawn:/sbin/mingetty tty3
4:2345:respawn:/sbin/mingetty tty4
5:2345:respawn:/sbin/mingetty tty5
6:2345:respawn:/sbin/mingetty tty6

# Run xdm in runlevel 5
x:5:respawn:/etc/X11/prefdm -nodaemon

```

The plaintext `inittab` file consists of several colon-separated fields in the format:

```
id:runlevels:action:command
```

The `id` field is a unique identifier, one to four alphanumeric characters in length, that represents a particular action to take during system startup. The `runlevels` field contains a list of run levels in which the command will be run. Common run levels are 0, 1, 2, 3, 4, 5, and 6 (s and S represent single-user mode, which is equivalent to 1). Run levels 7, 8, and 9 can also be used as the special run levels associated with the on-demand action (a, b, and c, which are equivalent to A, B, and C). The next field represents the type of action to be taken by `init` (valid actions and the results of those actions are listed in Table 11-3), and the last field is the actual command that is to be executed.

TABLE 11-3

Valid `init` Actions

Action	How the Command Is Run
<code>once</code>	The command is executed once when entering the specified run level.
<code>wait</code>	The same as <code>once</code> , but <code>init</code> waits for the command to finish before continuing with other <code>inittab</code> entries.
<code>respawn</code>	The process is monitored, and a new instance is started if the original process terminates.
<code>powerfail</code>	The command is executed upon receiving a <code>SIGPWR</code> signal from software associated with a UPS unit. This assumes that a few minutes of power are left so, by default, the system can shut down the system in 2 minutes.
<code>powerwait</code>	The same as <code>powerfail</code> , but <code>init</code> waits for the command to finish.
<code>powerokwait</code>	The command is executed upon receiving a <code>SIGPWR</code> signal if the <code>/etc/powerstatus</code> file contains the word <code>OK</code> . This is generally accomplished by the UPS software and indicates that a normal power level has been restored.
<code>powerfailnow</code>	The local system may be able to detect that an external UPS is running out of power and is about to fail almost immediately.
<code>ondemand</code>	The command is executed when <code>init</code> is manually instructed to enter one of the special run levels <code>a</code> , <code>b</code> , or <code>c</code> (equivalent to <code>A</code> , <code>B</code> , and <code>C</code> , respectively). No change in run level actually takes place. The program is restarted if the original process terminates.
<code>sysinit</code>	The command is executed during the system boot phase; the <code>runlevels</code> field is ignored.
<code>boot</code>	The command is executed during the system boot phase, after all <code>sysinit</code> entries have been processed; the <code>runlevels</code> field is ignored.
<code>bootwait</code>	The same as <code>boot</code> , but <code>init</code> waits for the command to finish before continuing with other <code>inittab</code> entries; the <code>runlevels</code> field is also ignored.
<code>initdefault</code>	The run level to enter after completing the <code>boot</code> and <code>sysinit</code> actions
<code>off</code>	Nothing happens (perhaps useful for testing and debugging).
<code>ctrlaltdel</code>	Traps the <code>[Ctrl]+[Alt]+[Del]</code> key sequence and is typically used to gracefully shut down the system.
<code>kbrequest</code>	Used to trap special key sequences, as interpreted by the keyboard handler

Because the `inittab` file is a configuration file, not a sequential shell script, the order of lines is not significant. Lines beginning with a hash (`#`) character are comments and are not processed.

The first non-commented line in the preceding sample `inittab` file sets the default run level to 5. A default of 5 (which is the common run level for desktop systems) means that, following the completion of all commands associated with the `sysinit`, `boot`, and `bootwait` actions, run level 5 is entered (booting to a GUI-based login).

The other common `initdefault` level is run level 3 (often used for servers that boot up in text mode and often have no GUI). Table 11-4 describes each of the run levels and helps you choose the run level that is best suited as the default in your environment.

**NOTE**

If there is no `initdefault` specified in the `inittab` file, the boot sequence will be interrupted, and you will be prompted to specify a default run level into which the machine will boot.

The next line in the `inittab` file instructs `init` to execute the `/etc/rc.d/rc.sysinit` script before entering the default run level. This script performs many initialization routines such as choosing a keymap file, checking and mounting `root` and `proc` file systems, setting the clock and hostname, configuring swap space, cleaning up temp files, and loading modules.

The seven following lines control the commands executed within each major run level. In each, the `/etc/rc.d/rc` script is called, using the desired run level as an argument. In turn, it descends into the appropriate directory tree (e.g., the `/etc/rc3.d` directory is entered for run level 3).

The `ctrlaltdel` action in the `inittab` file tells `init` to perform exactly what PC users would expect if the [Ctrl], [Alt], and [Delete] keys were pressed simultaneously. The system reboots itself in an orderly fashion (a switch to run level 6) after a 3-second delay.

The next two lines (with their comments) deal with graceful shutdowns if you have an uninterruptible power supply (UPS) and software installed. The first line initiates a halt (a switch to run level 0) 2 minutes after receiving a signal from the UPS indicating a power failure. The second line cancels the shutdown in the event that power is restored.

The six `getty` lines start up virtual consoles to allow logins. These processes are always running in any of the multiuser run levels. When someone connected to a virtual console logs out, that `getty` process dies, and then `respawn` action tells `init` to start a new `getty` process. You can switch between virtual consoles by pressing [Ctrl]+[Alt]+[F1], [Ctrl]+[Alt]+[F2], and so on.

The last line indicates that as long as the system is in run level 5, the “preferred display manager” [`xdm`, `gdm` (Gnome), `kdm` (KDE), etc.] will be running.

This presents a graphical login prompt rather than the usual text-based login and eliminates the need to run `startx` to start the GUI.

TABLE 11-4

## Possible Run Levels

Run Level	What Happens in This Run Level
0	All processes are terminated, and the machine comes to an orderly halt. As the <code>inittab</code> comments point out, this is not a good choice for <code>initdefault</code> because as soon as the kernel, modules, and drivers are loaded, the machine halts.
1, s, S	This is single-user mode, frequently used for system maintenance and instances where it may be preferable to have few processes running and no services activated. In single-user mode, the network is nonexistent, the X server is not running, and it is possible that some file systems are not mounted.
2	Multuser mode. Multiple user logins are allowed, all configured file systems are mounted, and all processes except X, the <code>at</code> daemon, the <code>xinetd</code> daemon, and NIS/NFS are started. If your machine doesn't have (or perhaps doesn't need) a permanent network connection, this is a good choice for <code>initdefault</code> .
3	Multuser mode with network services. Run level 3 is the typical value for <code>initdefault</code> on a CentOS server.
4	Run level 4 is available as a user-defined run level. It is nearly identical to run level 3 in a default CentOS configuration.
5	Multuser mode with network services and X. This run level starts the X server and presents a graphical login window, visually resembling any of the more expensive UNIX-based workstations. This is a common <code>initdefault</code> value for a CentOS workstation or desktop system.
6	All processes are terminated, and the machine is gracefully rebooted. Again, the comments in the <code>inittab</code> file mention that this is not a good choice for <code>initdefault</code> , perhaps even worse than run level 0. The effect is a possibly infinite cycle of booting, followed by rebooting.
7, 8, 9	Generally unused and undefined, these run levels have the potential to meet any needs not covered by the default options.
a, b, c, A, B, C	Used in conjunction with the <code>ondemand</code> action. These don't really specify a run level but can launch a program or daemon "on demand" if so instructed.

## System Startup and Shutdown

During system startup, a series of scripts is run to start the services that you need. These include scripts to start network interfaces, mount directories, and monitor your system. Most of these scripts are run from subdirectories of `/etc/rc.d`. The program that starts most of these

services when you boot and stops them when you shut down is the `/etc/rc.d/rc` script. The following sections describe run-level scripts and what you can do with them.

## Starting Run-Level Scripts

As previously mentioned, the `/etc/rc.d/rc` script is integral to the concept of run levels. Any change of run level causes the script to be executed, with the new run level as an argument. Here's a quick rundown of what the `/etc/rc.d/rc` script does:

- **Checks That Run-Level Scripts Are Correct** — The `rc` script checks to find each run-level script that exists and excludes those that represent backup scripts left by `rpm` updates.
- **Determines Current and Previous Run Levels** — Determines the current and previous run levels to know which run-level scripts to stop (previous level) and start (current level).
- **Decides Whether to Enter Interactive Startup** — If the `confirm` option is passed to the boot loader at boot time, all server processes must be confirmed at the system console before starting.
- **Kills and Starts Run-Level Scripts** — Stops run-level scripts from the previous level, then starts run-level scripts from the current level.

In CentOS, most of the services that are provided to users and computers on the network are started from run-level scripts.

## Understanding Run-Level Scripts

A software package that has a service to start at boot time (or when the system changes run levels) can add a script to the `/etc/init.d` directory. That script can then be linked to an appropriate run-level directory and run with either the `start` or `stop` option (to start or stop the service).

Table 11-5 lists many of the typical run-level scripts that are found in `/etc/init.d` and explains their functions. Depending on the CentOS software packages you installed on your system, you may have dozens more run-level scripts than you see here. (Later, I describe how these files are linked into particular run-level directories.)

Each script representing a service that you want to start or stop is linked to a file in each of the run-level directories. For each run level, a script beginning with `K` stops the service, whereas a script beginning with `S` starts the service.

The two digits following the `K` or `S` in the filename provide a mechanism to select the priority in which the programs are run. For example, `S12syslog` is run before `S90crond`. However, the file `S110my_daemon` is run before `S85gpm`, even though you can readily see that 85 is less than 110. This is because the ASCII collating sequence orders the files, which simply means that one positional character is compared to another. Therefore, a script beginning with the characters `S110` is executed between `S10network` and `S15netfs` in run level 3.



TABLE 11-5

## Run-Level Scripts Contained in /etc/init.d

Run-Level Scripts	What Does It Do?
acpid	Controls the Advanced Configuration and Power Interface daemon, which monitors events in the kernel and reports them to user level.
anacron	Runs <code>cron</code> jobs that were not run at their intended times because of the system being down.
atd	Starts or stops the <code>at</code> daemon to receive, queue, and run jobs submitted via the <code>at</code> or <code>batch</code> commands. (The <code>anacron</code> run-level script runs <code>at</code> and <code>batch</code> jobs that were not run because the computer was down.)
autofs	Starts and stops the <code>automount</code> daemon, for automatically mounting file systems (so, e.g., a CD can be automatically mounted when it is inserted).
bluetooth	Starts services such as authentication, discovery, and human interface devices for communicating with Bluetooth devices.
crond	Starts or stops the <code>cron</code> daemon to periodically run routine commands.
cups	Controls the printer daemon ( <code>cupsd</code> ) that handles spooling printing requests.
dhcpd	Starts or stops the <code>dhcpd</code> daemon, which automatically assigns IP addresses to computers on a LAN.
dovecot	Starts the <code>dovecot</code> IMAP server, which allows e-mail clients to request and view their mail messages from the mail server.
firstboot	Checks to see if <code>firstboot</code> needs to be run and, if so, runs it. This is typically done after CentOS is first installed.
gpm	Controls the <code>gpm</code> daemon, which allows the mouse to interact with console- and text-based applications.
haldaemon	Starts the <code>hal</code> daemon to discover and set up hardware. Used to mount removable media, manage power, or auto-play multimedia.
halt	Terminates all processes, writes out accounting records, removes swap space, unmounts all file systems, and either shuts down or reboots the machine (depending on how the command was called).
hplip	Starts the HP Linux Imaging and Printing (HPLIP) service for running HP multifunction peripherals.
httpd	Starts the <code>httpd</code> daemon, which allows your computer to act as an HTTP server (i.e., to serve web pages).
iptables	Loads the defined firewall rules from <code>/etc/sysconfig/iptables</code> .

**TABLE 11-5** (continued)

Run-Level Scripts	What Does It Do?
keytable	Loads the predefined keyboard map.
killall	Shuts down any subsystems that may still be running prior to a shutdown or reboot.
ldap	Starts the Lightweight Directory Access Protocol daemon ( <code>slapd</code> ), which listens for LDAP requests from the network.
mysqld	Runs the MySQL database daemon ( <code>mysqld</code> ) to listen for requests to MySQL databases.
named	Starts and stops the BIND DNS server daemon ( <code>named</code> ) to listen for and resolve domain name system requests.
netfs	Mounts or unmounts network (NFS, SMB, and NCP) file systems.
network	Starts or stops all configured network interfaces and initializes the TCP/IP and IPX protocols.
NetworkManager	Switches automatically to the best available network connections.
nfs	Starts or stops the NFS-related daemons ( <code>rpc.nfsd</code> , <code>rpc.mountd</code> , <code>rpc.statd</code> , and <code>rpc.rquotad</code> ) and exports shared file systems.
ntpd	Runs the Network Time Protocol daemon ( <code>ntpd</code> ), which synchronizes system time with Internet standard time servers.
portmap	Starts or stops the <code>portmap</code> daemon, which manages programs and protocols that use the Remote Procedure Call (RPC) mechanism.
routed	Starts or stops the <code>routed</code> daemon, which controls dynamic-routing table updates via the Router Information Protocol (RIP).
rwhod	Starts or stops the <code>rwhod</code> daemon, which enables others on the network to obtain a list of all currently logged-in users.
sendmail	Controls the <code>sendmail</code> daemon, which handles incoming and outgoing SMTP (Simple Mail Transport Protocol) mail messages.
single	Terminates running processes and enters run level 1 (single-user mode).
smb	Starts or stops the <code>smbd</code> and <code>nmbd</code> daemons for allowing access to Samba file and print services.
snmpd	Starts or stops the <code>snmpd</code> (Simple Network Management Protocol) daemon, which enables others to view machine-configuration information.
spamassassin	Starts and stops the <code>spamd</code> daemon to automate the process of checking e-mail messages for spam.

*continued*

**TABLE 11-5** (continued)

Run-Level Scripts	What Does It Do?
<code>squid</code>	Starts or stops the <code>squid</code> service, which enables proxy service to clients on your network.
<code>sshd</code>	Runs the secure shell daemon ( <code>sshd</code> ), which listens for requests from <code>ssh</code> clients for remote login or remote execution requests.
<code>syslog</code>	Starts or stops the <code>klogd</code> and <code>syslogd</code> daemons that handle logging events from the kernel and other processes, respectively.
<code>vsftpd</code>	Runs the Very Secure FTP server ( <code>vsftpd</code> ) to provide FTP sessions to remote clients for downloading and uploading files.
<code>xf86</code>	Regenerates font lists and starts and stops the X font server.
<code>xinetd</code>	Sets the machine's hostname, establishes network routes, and controls <code>xinetd</code> , the network services daemon that listens for incoming TCP/IP connections to the machine.
<code>yum-updatesd</code>	Starts the <code>yum-updatesd</code> daemon, which periodically checks for software updates.

All of the programs within the `/etc/rcX.d` directories (where `X` is replaced by a run-level number) are symbolic links, usually to a file in `/etc/init.d`. The `/etc/rcX.d` directories include the following:

- `/etc/rc0.d` — Run level 0 directory
- `/etc/rc1.d` — Run level 1 directory
- `/etc/rc2.d` — Run level 2 directory
- `/etc/rc3.d` — Run level 3 directory
- `/etc/rc4.d` — Run level 4 directory
- `/etc/rc5.d` — Run level 5 directory
- `/etc/rc6.d` — Run level 6 directory

In this manner, `/etc/rc0.d/K05atd`, `/etc/rc1.d/K05atd`, `/etc/rc2.d/K05atd`, `/etc/rc3.d/S95atd`, `/etc/rc4.d/S95atd`, `/etc/rc5.d/S95atd`, and `/etc/rc6.d/K05atd` are all symbolic links to `/etc/init.d/atd`. Using this simple, consistent mechanism, you can customize which programs are started at boot time.

## Understanding What Start-Up Scripts Do

Despite all the complicated `rcXs`, `Ss`, and `Ks`, the form of each startup script is really quite simple. Because they are in plaintext, you can just open one with a text editor to take a look at what it does. For the most part, a run-level script can be run with a `start` option, a `stop`

option, and possibly a restart option. For example, the following lines are part of the contents of the `smb` script that defines what happens when the script is run with different options to start or stop the Samba file and print service:

```
#!/bin/sh
#
# chkconfig: - 91 35
# description: Starts and stops the Samba smbd daemon \
#              used to provide SMB network services.
.
.
.
start() {
    KIND="SMB"
    echo -n $"Starting $KIND services: "
    daemon smbd $SMBDOPTIONS
    RETVAL=$?
    echo

    [ $RETVAL -eq 0 -a $RETVAL2 -eq 0 ] && touch /var/lock/
        subsys/smb || \
        RETVAL=1
    return $RETVAL
}

stop() {
    KIND="SMB"
    echo -n $"Shutting down $KIND services: "
    killproc smbd
    RETVAL=$?
    echo
    [ $RETVAL -eq 0 -a $RETVAL2 -eq 0 ] && rm -f /var/lock/
        subsys/smb
    return $RETVAL
}

restart() {
    stop
    start
}

.
.
.
```

To illustrate the essence of what this script does, I skipped some of the beginning and end of the script (where it checked if the network was up and running and set some values). Here are the actions `smb` takes when it is run with `start` or `stop`:

- `start` — This part of the script starts the `smbd` server when the script is run with the `start` option.
- `stop` — When run with the `stop` option, the `/etc/init.d/smb` script stops the `smbd` server.

The `restart` option runs the script with a `stop` option followed by a `start` option. If you want to start the `smb` service yourself, type the following command (as `root` user):

```
# service smb start
Starting SMB services:          [ OK ]
```

To stop the service, type the following command:

```
# service smb stop
Shutting down SMB services:    [ OK ]
```

The `smb` run-level script is different from other run-level scripts in that it supports several options other than `start` and `stop`. For example, this script has options (not shown in the example) that allow you to reload the `smb.conf` configuration file (`reload`) and check the status of the service (`status`).

## Changing Run-Level Script Behavior

Modifying the start-up behavior of any such script merely involves opening the file in a text editor.

For example, the `atd` daemon queues jobs submitted from the `at` and `batch` commands. Jobs submitted via `batch` are executed only if the system load is not above a particular value, which can be set with a command-line option to the `atd` command.

The default *limiting load factor* value of 0.8 is based on the assumption that a single-processor machine with less than 80 percent CPU utilization could handle the additional load of the batch job. However, if you were to add another CPU to your machine, 0.8 would only represent 40 percent of the computer's processing power. So you could safely raise that limit without affecting overall system performance.

You can change the limiting load factor from 0.8 to 1.6 to accommodate the increased processing capacity. To do this, simply modify the following line (in the `start` section) of the `/etc/init.d/atd` script:

```
daemon /usr/sbin/atd
```

Replace it with this line, using the `-l` argument to specify the new minimum system load value:

```
daemon /usr/sbin/atd -l 1.6
```

After saving the file and exiting the editor, you can reboot the machine or just run any of the following three commands to begin using the new batch threshold value:

```
# service atd reload
# service atd restart
# service atd stop ; service atd start
```

**NOTE**

Always make a copy of a run-level script before you change it. Also, keep track of changes you make to run-level scripts before you upgrade the packages they come from. You need to make those changes again after the upgrade.

If you are uncomfortable editing start-up scripts and you simply want to add options to the daemon process run by the script, there may be a way of entering these changes without editing the start-up script directly. Check the `/etc/sysconfig` directory and see if there is a file by the same name as the script you want to modify. If there is, that file probably provides values that you can set to pass options to the start-up script. Sysconfig files exist for `arpwatch`, `dhcpd`, `ntpd`, `samba`, `squid`, and others.

## Reorganizing or Removing Run-Level Scripts

There are several ways to deal with removing programs from the system start-up directories, adding them to particular run levels, or changing when they are executed. From a Terminal window, you can use the `chkconfig` command. From a GUI, use the Service Configuration window.

**CAUTION**

You should never remove the run-level file from the `/etc/init.d` directory. Because no scripts are run from the `/etc/init.d` directory automatically, it is OK to keep them there. Scripts in `/etc/init.d` are only accessed as links from the `/etc/rcX.d` directories. Keep scripts in the `init.d` directory so you can add them later by relinking them to the appropriate run-level directory.

To reorganize or remove run-level scripts from the GUI, use the Service Configuration window. Either select `System > Administration > Services` or log in as `root` user and type the following command in a Terminal window:

```
# system-config-services &
```

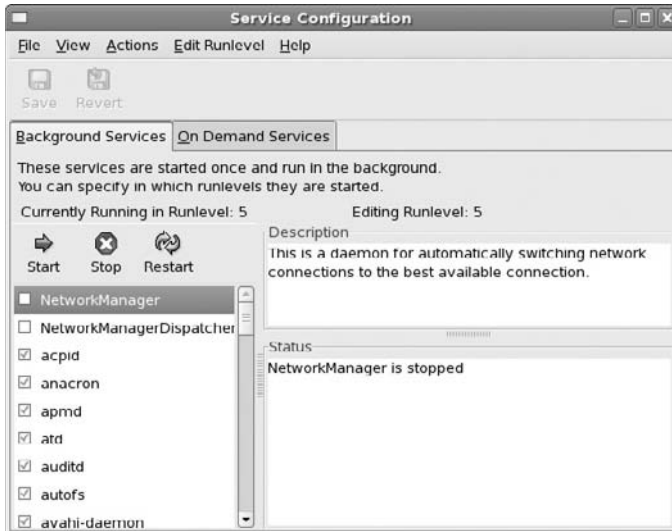
Figure 11-1 shows an example of the Service Configuration window.

The Service Configuration window enables you to reconfigure services for run levels 2, 3, 4, and 5. Icons next to each service indicate whether the service is currently enabled (green) or disabled (red) for the current run level and whether or not the service is currently running. Select a service to see a description of that service. Here is what you can do from this window:

- **Enable** — With a service selected, click on the Enable button to enable the service to start when you start your computer (run levels 2, 3, 4, and 5).
- **Disable** — With a service selected, click Disable if you do not want it to start when you boot your computer (or otherwise enter run levels 2, 3, 4, or 5).

**FIGURE 11-1**

Reorganize, add, and remove run-level scripts from the Service Configuration window.



- **Customize** — With a service selected, click Customize and select the run levels at which you want the service to start.
- **Start** — Click a service on the list. Select Start to request the service to start immediately.

Some administrators prefer text-based commands for managing run-level scripts and for managing other system services that start automatically. The `chkconfig` command can be used to list whether services that run-level scripts start, as well as services that the `xinetd` daemon starts, are on or off. To see a list of all system services, with indications that they are on or off, type the following:

```
# chkconfig --list | less
```

You can then page through the list to see those services. If you want to view the status of an individual service, you can add the service at the end of the `list` option. For example, to see whether the NFS service starts in each run level, type the following:

```
# chkconfig --list nfs
nfs      0:off  1:off  2:off  3:on   4:on   5:on   6:off
```

This example shows that the NFS service is set to be on for run levels 3, 4, and 5, but that it is set to off for run levels 0, 1, 2, and 6.

Another tool that can be run from the shell to change which services start and do not start at various levels is the `ntsysv` command. Type the following as `root` user from the shell:

```
# ntsysv
```

A screen appears with a list of available services. Use the up and down arrow keys to locate the service you want. With the cursor on a service, press the Spacebar to toggle the service on or off. Press the [Tab] key to highlight the OK button, and press the Spacebar to save the change and exit. The `ntsysv` tool only changes services for the current run level. You can run `ntsysv` with the `--level #` option, where `#` is replaced by the run level for which you want to change services.

## Adding Run-Level Scripts

Suppose you want to create and configure your own run-level script. For example, after installing the binaries for the fictitious `my_daemon` program, it needs to be configured to start up in run levels 3, 4, and 5 and terminated in any other run level. You can add the script to the `/etc/init.d` directory, then use the `chkconfig` command to configure it.

To use `chkconfig`, ensure that the following lines are included in the `/etc/init.d/my_daemon` script:

```
# chkconfig: 345 82 28
# description: Does something pretty cool - you really \
#   have to see it to believe it!
# processname: my_daemon
```

### NOTE

The line `chkconfig: 345 82 28` sets the script to start in run levels 3, 4, and 5. It sets start scripts to be set to 82 for those run levels. It sets stop scripts to be set to 28 in all other levels.

With those lines in place, simply run the following command:

```
# chkconfig --add my_daemon
```

Appropriate links are created automatically. This can be verified with the following command:

```
# chkconfig --list my_daemon
```

The resulting output should look like this:

```
my_daemon 0:off 1:off 2:off 3:on 4:on 5:on 6:off
```

The script names that are created by `chkconfig` to make this all work are:

```
/etc/rc0.d/K28my_daemon
/etc/rc1.d/K28my_daemon
/etc/rc2.d/K28my_daemon
```



```
/etc/rc3.d/S82my_daemon
/etc/rc4.d/S82my_daemon
/etc/rc5.d/S82my_daemon
/etc/rc6.d/K28my_daemon
```

## Managing xinetd Services

There are a bunch of services, particularly network services, that are not handled by separate run-level scripts. Instead, a single run-level script called `xinetd` (formerly `inetd`) is run to handle incoming requests for these services. For that reason, `xinetd` is sometimes referred to as the *super-server*. The `xinetd` run-level script (along with the `xinetd` daemon that it runs) offers the following advantages:

- **Fewer Daemon Processes** — Instead of one (or more) daemon processes running on your computer to monitor incoming requests for each service, the `xinetd` daemon can listen for requests for many different services. As a result, when you type `ps -ax` to see what processes are running, dozens of fewer daemon processes will be running than there would be if each service had its own daemon.
- **Access Control and Logging** — By using `xinetd` to oversee the management of services, consistent methods of access control (such as PAM) and consistent logging methods (such as the `/var/log/messages` file) can be used across all of the services.

When a request comes into your computer for a service that `xinetd` is monitoring, `xinetd` uses the `/etc/xinetd.conf` file to read configuration files contained in the `/etc/xinetd.d` directory. Then, based on the contents of the `xinetd.d` file for the requested service, a server program is launched to handle the service request (provided that the service is not disabled).

Each server process is one of two types: single-thread or multithread. A single-thread server handles only the current request, whereas a multithread server handles all incoming requests for the service as long as there is still a client holding the process open. Then the multithread server closes and `xinetd` begins monitoring that service again.

The following are a few examples of services that are monitored by `xinetd`. The daemon process that is started up to handle each service is also listed.

- `eklogind` (`/usr/kerberos/sbin/klogind`) — Kerberos-related login daemon
- `finger` (`/usr/sbin/in.fingerd`) — Handles incoming finger requests for information from remote users about local users.
- `gssftp` (`/usr/kerberos/sbin/ftpd`) — Kerberos-related daemon for handling file transfer requests (FTP)
- `ntalk` (`/usr/sbin/in.ntalkd`) — Daemon for handling requests to set up chats between a remote user and a local one (using the `talk` command)
- `rlogind` (`/usr/sbin/in.rlogind`) — Daemon for responding to remote login requests (from a remote `rlogin` command)

- `rsh (/usr/sbin/in.rshd)` — Handles requests from a remote client to run a command on the local computer.

**NOTE**

You should normally not run `finger`, `rlogin`, or `rsh` because of security concerns with these commands.

Other services that can be launched by requests that come to `xinetd` include services for remote Telnet requests, Samba configuration requests (`swat`), and Amanda network backups. A short description of each service is included in its `/etc/xinetd.d` file. Many of the services handled by `xinetd` are legacy services, including `rlogin`, `rsh`, and `finger`, that are considered insecure by today's security standards because they use clear-text passwords.

## Manipulating Run Levels

Aside from the run level chosen at boot time (usually 3 or 5) and the shutdown or reboot levels (0 and 6, respectively), you can change the run level at any time while you're logged in (as `root` user). The `telinit` command (really just a symbolic link to `init`) enables you to specify a desired run level, causing the termination of all system processes that shouldn't exist in that run level, and starting all processes that should be running.

**NOTE**

The `telinit` command is also used to instruct `init` to reload its configuration file, `/etc/inittab`. This is accomplished with either the `telinit q` or the `telinit Q` commands.

For example, if you encountered a problem with your hard disk upon startup, you may be placed in single-user mode (run level 1) to perform system maintenance. After the machine is stable, you can execute the command as follows:

```
# telinit 5
```

The `init` command handles terminating and starting all processes necessary to present you with a graphical login window.

## Determining the Current Run Level

You can determine the machine's current run level with the aptly named `runlevel` command. Using the previous example of booting into single-user mode and then manually changing the run level, the output of the `runlevel` command would be:

```
# runlevel
S 5
```

This means that the previous run level was `S` (for single-user mode) and the current run level is `5`. If the machine had booted properly, the previous run level would be listed as `N` to indicate that there really wasn't a previous run level.

## Changing to a Shutdown Run Level

Shutting down the machine is simply a change in run level. With that in mind, other ways to change the run level include the `reboot`, `halt`, `poweroff`, and `shutdown` commands. The `reboot` command, which is a symbolic link to the `halt` command, executes a `shutdown -r now`, terminating all processes and rebooting the machine. The `halt` command executes `shutdown -h now`, terminating all processes and leaving the machine in an idle state (but still powered on).

Similarly, the `poweroff` command, which is also a link to the `halt` command, executes a change to run level 0, but if the machine's BIOS supports ACPI, it will switch off the power to the machine.

### NOTE

A time must be given to the `shutdown` command, either specified as `+m` (representing the number of minutes to delay before beginning shutdown) or as `hh:mm` (an absolute time value, where `hh` is the hour and `mm` is the minute that you would like the shutdown to begin). Alternatively, `now` is commonly used to initiate the shutdown immediately.

## Scheduling System Tasks

---

Frequently, you need to run a process unattended or at off-hours. The `at` facility is designed to run such jobs at specific times. Jobs you submit are spooled in the directory `/var/spool/at`, awaiting execution by the `at` daemon `atd`. The jobs are executed using the current directory and environment that was active when the job was submitted. Any output or error messages that haven't been re-directed elsewhere are e-mailed to the user who submitted the job.

The following sections describe how to use the `at`, `batch`, and `cron` facilities to schedule tasks to run at specific times. These descriptions also include ways of viewing which tasks are scheduled and deleting scheduled tasks that you don't want to run anymore.

### Using `at.allow` and `at.deny`

There are two access control files designed to limit which users can use the `at` facility. The file `/etc/at.allow` contains a list of users who are granted access, and the file `/etc/at.deny` contains a similar list of those who may not submit `at` jobs. If neither file exists, only the super-user is granted access to `at`. If a blank `/etc/at.deny` file exists (as in the default configuration), all users are allowed to use the `at` facility to run their own `at` jobs. If you use either `at.allow` or `at.deny`, you aren't required to use both.

### Specifying When Jobs Are Run

There are many different ways to specify the time at which an `at` job should run (most of which look like spoken commands). Table 11-6 has a few examples. These are not complete commands — they only provide an example of how to specify the time that a job should run.

TABLE 11-6

### Samples for Specifying Times in an at Job

Command Line	When the Command Is Run
<code>at now</code>	The job is run immediately.
<code>at now + 2 minutes</code>	The job will start 2 minutes from the current time.
<code>at now + 1 hour</code>	The job will start 1 hour from the current time.
<code>at now + 5 days</code>	The job will start 5 days from the current time.
<code>at now + 4 weeks</code>	The job will start 4 weeks from the current time.
<code>at now next minute</code>	The job will start in exactly 60 seconds.
<code>at now next hour</code>	The job will start in exactly 60 minutes.
<code>at now next day</code>	The job will start at the same time tomorrow.
<code>at now next month</code>	The job will start on the same day and at the same time next month.
<code>at now next year</code>	The job will start on the same date and at the same time next year.
<code>at now next fri</code>	The job will start at the same time next Friday.
<code>at teatime</code>	The job will run at 4 p.m. The keywords <code>noon</code> and <code>midnight</code> can also be used.
<code>at 16:00 today</code>	The job will run at 4 p.m. today.
<code>at 16:00 tomorrow</code>	The job will run at 4 p.m. tomorrow.
<code>at 2:45pm</code>	The job will run at 2:45 p.m. on the current day.
<code>at 14:45</code>	The job will run at 2:45 p.m. on the current day.
<code>at 11:11 Dec 23 2012</code>	The job will begin at 11:11 a.m. on December 23, 2012.
<code>at 11:11 12/23/12</code>	The job will begin at 11:11 a.m. on December 23, 2012.

## Submitting Scheduled Jobs

The `at` facility offers a lot of flexibility in how you can submit scheduled jobs. There are three ways to submit a job to the `at` facility:

- Piped in from Standard Input** — For example, the following command will attempt to build the Perl distribution from source in the early morning hours while the machine is likely to be less busy, assuming the Perl sources are stored in `/tmp/perl`:

```
echo "cd /tmp/perl; make ; ls -al" | at 2am tomorrow
```

An ancillary benefit to this procedure is that a full log of the compilation process will be e-mailed to the user who submitted the job.

- **Read as Standard Input** — If no command is specified, `at` will prompt you to enter commands at the special `at>` prompt, as shown in the following example. You must indicate the end of the commands by pressing `[Ctrl]+D`, which signals an End of Transmission (`<EOT>`) to `at`.

```
$ at 23:40
at> cd /tmp/perl
at> make
at> ls -al
at> <Ctrl-d>
```

- **Read from a File** — When the `-f` command-line option is followed by a valid filename, the contents of that file are used as the commands to be executed, as in the following example:

```
$ at -f /root/bin/runme now + 5 hours
```

This runs the commands stored in `/root/bin/runme` in 5 hours. The file can either be a simple list of commands or a shell script to be run in its own subshell (i.e., the file begins with `#!/bin/bash` or the name of another shell).

## Viewing Scheduled Jobs

You can use the `atq` command (effectively the same as `at -l`) to view a list of your pending jobs in the `at` queue, showing each job's sequence number, the date and time the job is scheduled to run, and the queue in which the job is being run.

The two most common queue names are `a` (which represents the `at` queue) and `b` (which represents the `batch` queue). All other letters (uppercase and lowercase) can be used to specify queues with lower priority levels. If the `atq` command lists a queue name as `=`, it indicates that the job is currently running. Here is an example of output from the `atq` command:

```
# atq
2    2009-09-02 00:51 a
3    2009-09-02 00:52 a
4    2009-09-05 23:52 a
```

Here you can see that there are three `at` jobs pending (job numbers 2, 3, and 4, all indicated as `a`). After the job number, the output shows the date and hour each job is scheduled to run.

## Deleting Scheduled Jobs

If you decide that you'd like to cancel a particular job, you can use the `atrm` command (equivalent to `at -d`) with the job number (or more than one) as reported by the `atq` command. For example, using the following output from `atq`:

```
# atq
18      2009-09-01 03:00 a
19      2009-09-29 05:27 a
20      2009-09-30 05:27 a
21      2009-09-14 00:01 a
22      2009-09-01 03:00 a
```

you can remove the jobs scheduled to run at 5:27 a.m. on September 29 and September 30 from the queue with the following command:

```
# atrm 19 20
```

## Using the batch Command

If system resources are at a premium on your machine, or if the job you submit can run at a priority lower than normal, the `batch` command (equivalent to `at -q b`) may be useful. It is controlled by the same `atd` daemon, and it allows job submissions in the same format as `at` submissions (although the time specification is optional).

However, to prevent your job from usurping already-scarce processing time, the job will run only if the system load average is below a particular value. The default value is 0.8, but specifying a command-line option to `atd` can modify this. This was used as an example in the earlier section describing startup and shutdown. Here is an example of the `batch` command:

```
$ batch
at> du -h /home > /tmp/duhome
at> <Ctrl+d>
```

In this example, after I type the `batch` command, the `at` facility is invoked to enable me to enter the command(s) I want to run. Typing the `du -h /home > /tmp/duhome` command line has the disk usages for everything in the `/home` directory structure output to the `/tmp/duhome` file. On the next line, pressing `[Ctrl]+D` ends the batch job. As soon as the load average is low enough, the command is run. (Run the `top` command to view the current load average.)

## Using the cron Facility

Another way to run commands unattended is via the `cron` facility. Part of the `vixie-cron rpm` package, `cron` addresses the need to run commands periodically or routinely (at least, more often than you'd care to manually enter them) and allows lots of flexibility in automating the execution of the command.

As with the `at` facility, any output or error messages that haven't been re-directed elsewhere are e-mailed to the user who submitted the job. Unlike using `at`, however, `cron` jobs are intended to run more than once and at a regular interval (even if that interval is only once per month or once per year).

Also like the `at` facility, `cron` includes two access control files designed to limit which users can use it. The file `/etc/cron.allow` contains a list of users who are granted access, and the file `/etc/cron.deny` contains a similar list of those who may not submit `cron` jobs. If neither file exists (or if `cron.deny` is empty), all users are granted access to `cron`.

There are four places where a job can be submitted for execution by the `cron` daemon `crond`:

- **The `/var/spool/cron/username` File** — This method, in which each individual user (indicated by *username*) controls his or her own separate file, is the method used on UNIX System V systems.
- **The `/etc/crontab` File** — This is referred to as the *system crontab file*, and was the original crontab file from BSD UNIX and its derivatives. Only `root` has permission to modify this file.
- **The `/etc/cron.d` Directory** — Files placed in this directory have the same format as the `/etc/crontab` file. Only `root` is permitted to create or modify files in this directory.
- **The `/etc/cron.hourly`, `/etc/cron.daily`, `/etc/cron.weekly`, and `/etc/cron.monthly` Directories** — Each file in these directories is a shell script that runs at the times specified in the `/etc/crontab` file (by default, at 1 minute after the hour every hour; at 4:02 a.m. every day; Sunday at 4:22 a.m.; and 4:42 a.m. on the first day of the month, respectively). Only `root` is allowed to create or modify files in these directories.

The standard format of an entry in the `/var/spool/cron/username` file consists of five fields specifying when the command should run: minute, hour, day of the month, month, and day of the week. The sixth field is the actual command to be run.

The files in the `/etc/cron.d` directory and the `/etc/crontab` file use the same first five fields to determine when the command should run. However, the sixth field represents the name of the user submitting the job (because it cannot be inferred by the name of the file as in a `/var/spool/cron/username` directory), and the seventh field is the command to be run. Table 11-7 lists the valid values for each field common to both types of files.

The latest version of `cron` (`vixie-cron` and `crontabs` packages) includes the ability to indicate that a `cron` job be run at boot time. Refer to the `crontab` man page (type **man 5 crontab**) for information on using the `reboot` option to have a command run once at start-up time.

An asterisk (\*) in any field indicates all possible values for that field. For example, an asterisk in the second column is equivalent to 0, 1, 2, . . . , 22, 23, and an asterisk in the fourth column means Jan, Feb, Mar, . . . , Nov, Dec. In addition, lists of values, ranges of values, and increments can be used. For example, to specify the days Monday, Wednesday, and Friday, the fifth field could be represented as the list `Mon, Wed, Fri`. To represent the normal working hours in a day, the range `9-17` could be specified in the second field. Another option is to use an increment, as in specifying `0-31/3` in the third field to represent every third day of the month, or `*/5` in the first field to denote every 5 minutes.

Lines beginning with a `#` character in any of the `crontab`-format files are comments, which can be very helpful in explaining what task each command is designed to perform. It is also

possible to specify environment variables (in Bourne shell syntax, e.g., `NAME="value"`) within the `crontab` file. Any variable can be specified to fine-tune the environment in which the job runs, but one that may be particularly useful is `MAILTO`. The following line sends the results of the cron job to a user other than the one who submitted the job:

```
MAILTO=otheruser
```

**TABLE 11-7**

### Valid `/etc/crontab` Field Values

Field Number	Field	Acceptable Values
1	minute	Any integer between 0 and 59
2	hour	Any integer between 0 and 23
3	day of the month	Any integer between 0 and 31
4	month	Any integer between 0 and 12, or an abbreviation for the name of the month (Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec)
5	day of the week	Any integer between 0 and 7 (where both 0 and 7 can represent Sunday, 1 is Monday, 2 is Tuesday, etc.), or abbreviation for the day (Sun, Mon, Tue, Wed, Thu, Fri, Sat)

If the following line appears in a `crontab` file, all output and error messages that haven't already been re-directed will be discarded:

```
MAILTO=
```

### Modifying Scheduled Tasks with `crontab`

The files in `/var/spool/cron` should not be edited directly. They should only be accessed via the `crontab` command. To list the current contents of your own personal `crontab` file, type the following command:

```
$ crontab -l
```

All `crontab` entries can be removed with the following command:

```
$ crontab -r
```

Even if your personal `crontab` file doesn't exist, you can use the following command to begin editing it:

```
$ crontab -e
```



The file automatically opens in the text editor that is defined in your EDITOR or VISUAL environment variables, with vi as the default. When you're done, simply exit the editor. Provided there were no syntax errors, your crontab file will be installed. For example, if your username is jsmith, you have just created the file /var/spool/cron/jsmith. If you add a line (with a descriptive comment, of course) to remove any old core files from your source code directories, that file may look similar to this:

```
# Find and remove core files from /home/jsmith/src
5 1 * * Sun,Wed find /home/jsmith/src -name core.[0-9]*
    -exec rm {} \; > /dev/
    null 2>&1
```

Because core files in CentOS consist of the word *core*, followed by a dot (.) and process ID, this example will match all files beginning with *core.* and followed by a number. The root user can access any user's individual crontab file by using the *-u username* option to the crontab command.

**NOTE**

cron jobs are started with a very basic environment that only has a limited PATH. Programs within a job should either be entered with their full path, or there should be a PATH definition at the beginning of the crontab file.

**Understanding cron Files**

Separate cron directories are set up to contain cron jobs that run hourly, daily, weekly, and monthly. These cron jobs are all set up to run from the /etc/crontab file. The default /etc/crontab file looks like this:

```
SHELL=/bin/bash
PATH=/sbin:/bin:/usr/sbin:/usr/bin
MAILTO=root
HOME=/

# run-parts
01 * * * * root run-parts /etc/cron.hourly
02 4 * * * root run-parts /etc/cron.daily
22 4 * * 0 root run-parts /etc/cron.weekly
42 4 1 * * root run-parts /etc/cron.monthly
```

The first four lines initialize the run-time environment for all subsequent jobs (the subshell in which jobs run, the executable program search path, the recipient of output and error messages, and that user's home directory). The next five lines execute (as the user root) the run-parts program that controls programs that you may want to run periodically.

run-parts is a shell script that takes a directory as a command-line argument. It then sequentially runs every program within that directory (shell scripts are most common, but binary executables and links are also evaluated). The default configuration executes programs in /etc/cron.hourly at 1 minute after every hour of every day; /etc/cron.daily at 4:02 a.m. every day;

`/etc/cron.weekly` at 4:22 a.m. on Sundays; and `/etc/cron.monthly` at 4:42 a.m. on the first day of each month.

Here are examples of files that are installed in `cron` directories for different software packages:

- **`/etc/cron.daily/logrotate.cron`** — Automates rotating, compressing, and manipulating system log files.
- **`/etc/cron.daily/makewhatis.cron`** — Updates the `whatis` database (contains descriptions of man pages), which is used by the `man -k`, `apropos`, and `whatis` commands to find man pages related to a particular word.
- **`/etc/cron.daily/slocate.cron`** — Updates the `/var/lib/slocate/slocate.db` database (using the `updatedb` command), which contains a searchable list of files on the machine.
- **`/etc/cron.daily/tmpwatch`** — Removes files from `/tmp`, `/var/tmp`, and `/var/catman` that haven't been accessed in 10 days.

The `makewhatis.cron` script installed in `/etc/cron.weekly` is similar to the one in `/etc/cron.daily`, but it completely rebuilds the `whatis` database, rather than just updating the existing database.

Finally, in the `/etc/cron.d` directory are files that have the same format as `/etc/crontab` files.

## NOTE

If you are not comfortable working with `cron` from the command line, there is a KCron Task Scheduler window that comes in the `kdeadmin` package for managing `cron` tasks. To launch KCron, type **`kcron`** from a Terminal window.

## Summary

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Shell scripts are an integral part of a CentOS system for configuring, booting, administering, and customizing CentOS. They are used to eliminate typing repetitive commands. They are frequently executed from the scheduling facilities within CentOS, allowing much flexibility in determining when and how often a process should run. They also control the startup of most daemons and server processes at boot time.

The `init` daemon and its configuration file, `/etc/inittab`, also factor heavily in the initial startup of your CentOS system. They implement the concept of run levels that is carried out by the shell scripts in `/etc/rc.d/init.d`, and they provide a means by which the machine can be shut down or rebooted in an orderly manner.

To have shell scripts configured to run on an ongoing basis, you can use the `cron` facility. `cron` jobs can be added by editing `cron` files directly or by running commands such as `at` and `batch` to enter the commands to be run.



# Chapter 12

## Creating Backups and Restoring Data

If you've ever suffered a hard drive crash, you know just how aggravating it can be. You can lose irreplaceable data. You likely spend countless hours reinstalling your operating system and applications. It is not a fun experience. It need happen only once for you to learn the importance of making regular backups of your critical data.

Today, larger and faster backup media can simplify the process of backing up your data. CentOS supports many different types of media — such as writable CD (CD-R and CD-RW), DVD (DVD-R, DVD+R, DVD+RW, and DVD-RW), and magnetic tape — for creating backups. Using tools such as `cron`, you can configure backups to run unattended at scheduled times.

This chapter describes how to create a backup strategy and how to select media for backing up data on your CentOS system. It tells you how to do automated backups and backups over a network. It also describes how to restore individual files, or entire file systems, using tools such as the `restore` command.

### Making a Simple Backup Archive

---

Improvements in the GNOME desktop for handling removable media (CDs, DVDs, USB flash drives, etc.) can help you to do a quick backup of your personal data. With the GNOME desktop running on your CentOS system, use the following procedure to back up all the data in your home directory:

#### IN THIS CHAPTER

Doing a simple backup

Selecting a backup strategy

Selecting a backup medium

Backing up to a hard drive

Backing up files with `dump`

Automating backup with `cron`

Restoring backed-up files

Backing up over the network with `Amanda`

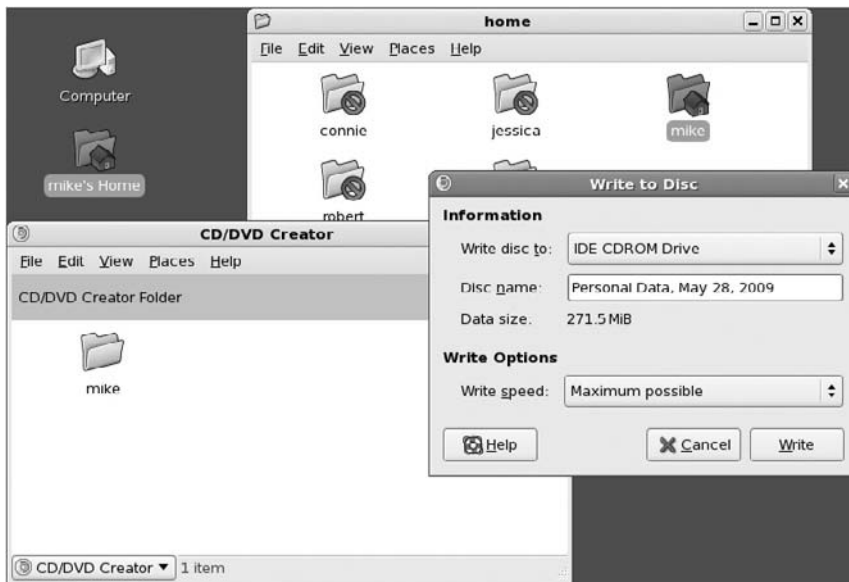
Performing network backups with multiple computers

Using the `pax` archiving utility

1. Insert a blank CD or DVD into your computer's drive. An icon appears on the desktop indicating that a blank disk is ready to be used.
2. Double-click on the "Blank Disc" icon to see the CD/DVD Creator window. Or, select CD/DVD Creator from the window that pops up.
3. Open the folder icon representing your home directory (such as mike's Home) on the desktop, and browse to the /home folder.
4. Drag-and-drop your home directory from the /home folder onto the CD/DVD Creator window.
5. Add other files and folders you want to back up to the CD/DVD Creator window in the same way.
6. When all the files and folders you want to back up are copied to the CD/DVD Creator window, click "Write to Disc" and the "Write to Disc" pop-up window appears.
7. Type a disk name for the backup medium, and optionally choose the Write speed. The disk name will be used as the name of the mount point if you later open the CD/DVD on the GNOME desktop. Figure 12-1 shows the "Write to Disc" pop-up and the CD/DVD Creator window (with the home folder of the user `mike` dragged into that folder).

**FIGURE 12-1**

Drag-and-drop files and folders on the CD/DVD Creator window for a simple backup. Click Write to have the files and folders written to the disk.



This procedure results in a standard ISO9660 image with Rock Ridge extensions being burned to the CD or DVD. That disk can be read from Linux, Windows, or other systems that support

that ISO standard. While the procedure is a quick way to save your critical files, you should consider using other backup tools described in this chapter for more flexible and powerful backup methods.

## Doing a Simple Backup with `rsync`

---

Cheap hard-disk space, fast networks, and some really neat new tools have given Linux users some nice backup alternatives to the old reliable removable media such as tapes and CDs. To back up your personal data or the data from a small office computer, the examples in this section provide fairly simple ways of creating usable backups of your data.

To do this procedure, you need to have hard-disk space on a computer that is at least slightly larger than the hard disk you are backing up. That hard-disk space could be on:

- **A Different Partition** — By backing up to a separate disk partition, you are protected in case the partition you are backing up becomes corrupted. However, you are not protected if your hard disk goes bad.
- **A Different Hard Disk** — Backing up to a separate hard disk can protect from a corrupted disk, but won't help you if your computer is hit by lightning, a flood, or other acts of God.
- **A Different Computer** — By backing up over the network, you can back up to another computer that is as far away from the source of your data as makes you feel comfortable. You can back up to the computer down the hall or one across the country.

To do the actual backup, you use the `rsync` command. In essence, `rsync` lets you copy files from one location to another. However, it also has some nice features that enable you to do the following:

- **Transfer Differences Only** — If you transfer a file that was transferred during an earlier backup, `rsync` uses a checksum-search algorithm to determine the differences between the old file and the new one. Then it sends only the data needed to account for the differences between the two files.
- **Transfer Data Securely** — `rsync` combines with `ssh` (or another remote shell) to encrypt the data, so it can travel securely across a network.
- **Maintain Ownership** — The transferred files can keep their same permissions, ownership, time stamps, and group designations. (Because ownership is based on numeric UIDs and GIDs, matching user and group accounts must be set up between machines for the files to appear to be owned by the same users and groups after the files are copied.)

The following sections show examples of the `rsync` command at work.

### Backing Up Files Locally

The first example shows a simple backup of a user's personal files. Here I'm copying the `/home/timothy` directory (including all its files and subdirectories) to another directory on

the local computer. That directory (`/mnt/backup/homes`) could be on a separate partition (see Chapter 2 for creating separate partitions), hard disk (see Chapter 9 to add a hard disk), or a remote NFS file system (see Chapter 17 to mount an NFS file system).

```
# rsync -av /home/timothy /mnt/backup/homes/
```

**NOTE**

Notice that there's no trailing slash after `/home/timothy` (so it's not `/home/timothy/`). Without that trailing slash, `rsync` will copy files from that directory to a target directory named `timothy` (`/mnt/backup/homes/timothy`). With a trailing slash, all files from `/home/timothy/` are copied directly to the `homes` directory (`/mnt/backup/homes/`).

In this example, the entire contents of the `/home/timothy` directory structure are added to the `/mnt/backup/homes/timothy` directory. All files, subdirectories, links, devices, and other file types are copied. By using the archive option (`-a`), all ownership, permissions, and creation times are maintained on the copied files. Using the `-a` option saves you from having to enter the following options individually: `-r` (recursive), `-l` (copy symbolic links), `-p` (preserve permissions), `-t` (preserve times), `-g` (preserve group), `-o` (preserve owner), and `-D` (preserve devices and special files). The verbose option (`-v`) results in more messages being displayed as `rsync` progresses.

If `/mnt/backup/homes` is on a separate disk, you now have your entire `/home/timothy` directory copied in two places on the same machine. If the `/mnt/backup/homes` directory is an NFS shared directory, the files are now backed up to another machine.

Because the example is a backup of personal files that don't change too often, after a few days of changes to the files, you might want to run the exact same command again:

```
# rsync -av /home/timothy /mnt/backup/homes/
```

This time, any new files are copied to the target directory, and the changes to any files you modified are applied to the original backup files. Any files you deleted from the home directory will still be in the target directory since `rsync` doesn't remove deleted files unless you specifically tell it to. The result is, again, a complete copy of the `/home/timothy` directory at the moment the `rsync` command is run, plus any files that have been deleted from any `/home/timothy` directories.

**NOTE**

If you want files that were deleted from the sending directory to be likewise deleted from the target directory, you can add the `--delete` option to `rsync`.

## Backing Up Files Remotely

While the previous example was a quick, informal backup method, with more critical data, you want to make sure that the data is being backed up to another computer and that the backup is done at regular intervals. This can be accomplished by using `rsync` in concert with `ssh` and `cron`.

Having `ssh` as the transport mechanism ensures that data will be encrypted when it is transferred. Also, because the SSH service (`sshd`) is enabled by default on CentOS systems, you need

only a username and password to the remote system to do the backup. As long as you can use `ssh` to connect to the remote machine, port number 873 is open in your firewall, and `rsync` is installed remotely, you can use the `rsync` command to transfer files there. Here's an example:

```
# rsync -azv -e ssh /home/timothy flashg:/mnt/backup/homes/  
root@flashg's password: *****  
building file list ... done
```

In this example, I identify the remote computer (named `flashg` in this case) by putting it before the remote directory name, separated with a colon. I use some different options as well. To the archive (`-a`) and verbose (`-v`) options, I add the `-z` option to compress the data (making it more efficient to transfer). I also use the `-e ssh` option to have `rsync` use an `ssh` remote shell to transfer data. The password prompt you see is the `ssh` login prompt. The `-a` option is important if you want to be able to restore files exactly as they were copied, because it recursively copies a whole directory structure as it preserves ownership, date/time stamps, and permissions.

You can repeat this command each time you want to back up your files. However, the more efficient way to do this is to set up this command to run as a `cron` job so that the backups happen automatically at set intervals.

To have `rsync` run automatically, you can't have it prompt you for a password. To have the `rsync` command run without prompting for a password, follow this procedure:

1. Set up SSH to do no-password logins for the user who is going to perform the backup.

**CROSS-REF** See the section, "Using `ssh`, `scp`, and `sftp` without Passwords," in Chapter 13 for information on how to do this.

2. Decide how often you want the backup to run. For example, if you want to run the `rsync` command once each day, as `root` user you could create a file called `/etc/cron.daily/mybackup`.
3. Set permissions to be executable:

```
# chmod 755 /etc/cron.daily/mybackup
```

4. Add the command line to the `mybackup` file that you want to use:

```
rsync -azv -e ssh /home/timothy timothy@flashg:/mnt/backup/homes/
```

Notice that I added the username `timothy` as the login user name on the remote computer (`flashg`). For you, this will be the name of the person for whom you set up a no-password login in Step 1.

At this point, a backup will be done once each day to the machine specified.

**NOTE** With the simple backup command just shown, you can build on more complex features. In particular, you might want to think about building in a snapshot feature. Snapshots allow you to go back to a particular date and time to restore



a backed-up file. Mike Rubel has an excellent procedure for doing `rsync` snapshots at [www.mikerubel.org/computers/rsync\\_snapshots](http://www.mikerubel.org/computers/rsync_snapshots) entitled “Easy Automated Snapshot-Style Backups with Linux and Rsync.”

Another useful feature is the `--bwlimit` option, which can prevent `rsync` commands from consuming too much of the available network bandwidth. For example, `--bwlimit=100` would limit the maximum transfer rate to 100 KB/s (kilobytes per second).

## Choosing Backup Tools

---

While the `rsync` command is one of the best choices for doing backups, it is by no means the only tool available. Many Linux systems administrators use a variety of commands for doing backups, often writing scripts to combine commands to work together. They might group together files in a single archive using `tar` or `cpio`, compress files to backup using `bzip2` or `gzip`, or write whole directory structures of files using `mkisofs`.

Descriptions of backup tools in this chapter focus on those that are particularly designed for backups. The `dump` and `restore` commands are traditional UNIX commands for backing up and restoring files. The `mkisofs` and `cdrecord` commands can combine to gather a file system into an ISO image and copy that image to CD or DVD. As for networked backup features, the Amanda facility is described later in this chapter. The `pax` facility provides a means of creating `cpio` and `tar` archives.

If the tools for backing up files described in this chapter are not exactly what you are looking for, there are many Open Source backup facilities that you can add to your CentOS system. Here are a few examples:

- **Bacula** ([www.bacula.org](http://www.bacula.org)) — Bacula is a tool for managing network backups. It includes features to make it easy to recover files that have been lost or damaged. Support for backup media includes tape, CD, and hard-disk media.
- **Mondo Rescue** ([www.mondorescue.org](http://www.mondorescue.org)) — Mondo supports backups from LVM, RAID, `ext2`, `ext3`, JFS, XFS, ReiserFS, and VFAT file systems. Backups can be done to CD-R, CD-RW, NFS, or hard disk.
- **BackupPC** (<http://backuppc.sourceforge.net>) — BackupPC is useful for backing up both Linux and Windows systems over a network. Using BackupPC, you can extract backups using Samba, `tar` (over `ssh`, `rsh`, or `nfs`), or `rsync`.

## Selecting a Backup Strategy

---

While it is tempting to do the quick-and-easy backup, backing up important data requires more planning and forethought. There are several approaches you can take to backing up your data.

You need to ask yourself a few questions to decide which approach is best for you. Some things that you should consider are:

- In the event of a crash, how much downtime can I tolerate?
- Will I need to recover older versions of my files, or is the most recent revision sufficient?
- Do I need to back up files for just one computer or for many computers on a network?

Your answers to these questions will help you decide how often to do full backups and how often to do incremental backups. If the data is particularly critical, you may even decide that you need to have your data duplicated constantly, using a technique called *disk mirroring*. The following sections describe different backup methods.

## Full Backup

A *full backup* is one that stores every file on a particular disk or partition. If that disk should ever crash, you can rebuild your system by restoring the entire backup to a new disk. Whatever backup strategy you decide on, some sort of full backup should be part of it. You may perform full backups every night or perhaps only once every week; it depends on how often you add or modify files on your system, as well as the capacity of your backup equipment.

## Incremental Backup

An *incremental backup* is one that contains only those files that have been added or modified since the last time a more complete backup was performed. You may choose to do incremental backups to conserve your backup media.

Incremental backups also take less time to complete because they only back up data that has changed since the most recent backup (full or incremental). Incremental and other partial backup types can be important when systems are in high use during the workweek and running a full backup would degrade system performance. Full backups can be reserved for the weekend when the system is not in use.

## Disk Mirroring

Full and incremental backups can take time to restore, and sometimes you just can't afford that downtime. By duplicating your operating system and data on an additional hard drive, you can greatly increase the speed with which you can recover from a server crash.

With disk mirroring, it is usually common for the system to continuously update the duplicate drive with the most current information. In fact, with a type of mirroring called *RAID1* (described in Chapter 9), the duplicate drive is written to at the same time as the original, and if the main drive fails, the duplicate can immediately take over. This is called *fault-tolerant behavior*, which is a must if you are running a mission-critical server of some kind.

You can tailor different RAID levels to use features other than mirroring. Other RAID levels use striping and can be tuned for performance, data redundancy, and cost. Software RAID is

supported in the Linux kernel, and several hardware vendors have RAID controller cards for SATA, IDE, and SCSI disk configurations that work well in Linux. Vendors include LSI Logic ([www.lsillogic.com](http://www.lsillogic.com)), Promise ([www.promise.com](http://www.promise.com)), and 3Ware ([www.3ware.com](http://www.3ware.com)). See <http://tldp.org/HOWTO/Software-RAID-HOWTO.html> for further information on RAID in Linux.

**NOTE**

**Do not rely on RAID as a backup means. RAID only helps to protect you from data loss when one of your disks malfunctions. It does not prevent you from accidentally overwriting or deleting data.**

## Network Backup

All of the preceding backup strategies can be performed over a network. This is good because you can share a single backup device with many computers on a network. This is much cheaper and more convenient than installing a tape drive or other backup device in every system on your network. If you have many computers, however, your backup device will require a lot of capacity. In such a case, you might want to consider a mechanical tape loader, DVD-RW drive, or CD or DVD jukebox (which is capable of recording multiple CDs or DVDs without operator intervention).

It is even possible to do a form of disk mirroring over the network. For example, a Web Server may store a duplicate copy of its data on another server. If the first server crashes, a simple TCP/IP hostname change can redirect the Web traffic to the second server. When the original server is rebuilt, it can recover all of its data from the backup server and be back in business.

## Selecting a Backup Medium

---

Armed with a backup strategy in mind, it's time to select a backup medium. Several types of backup hardware and media are available for use with CentOS. Each type has its advantages and disadvantages.

The type of medium you choose depends largely on the amount of data you need to archive, how long you will store backups, how often you expect to recover data from your backups, and how much you can afford to spend. Table 12-1 compares the most common backup media.

The following sections describe how to use magnetic tape, writable DVDs, and writable CDs as backup media. Using additional hard drives as backup media is described later in this chapter.

### Magnetic Tape

Magnetic tape was for years the most common medium used for backing up large amounts of computer data. Tapes provide a low-cost, convenient way to archive your files. Today's high-capacity tape drives can back up many gigabytes of data on an amazingly small tape, allowing vast amounts of information to be safely stored. Tapes are also easy to transport offsite so that data will be secure in case of fires, hurricanes, or other disasters.

TABLE 12-1

### Comparison of Common Backup Media

Backup Medium	Advantages	Disadvantages
Magnetic tape	High capacity, low cost for archiving massive amounts of data	Sequential access medium, so recovery of individual files can be slow
Writable CDs	Random access medium, so recovery of individual files is easier. Backups can be restored from any CD-ROM drive.	Limited storage space (up to 700 MB per CD).
Writable DVDs	Random access medium (like CDs). Large capacity (4.7 GB, although the actual capacity you can achieve might be less). DVDR-9 and DVD-9 DVDs can store up to 8.5 GB of data.	DVD-RW drives and DVD-R disks are relatively expensive (although they are coming down in price). As more manufacturers add DVD writers to their PCs, DVDs will eventually replace CDs as the most common removable media drives.
Additional hard drive	Allows faster and more frequent backups. Fast recovery from crashes. No media to load. Data can be located and recovered more quickly. You can configure the second disk to be a virtual clone of the first disk, so that you can boot off the second disk if the first disk crashes.	Data cannot be stored offsite; thus there is a risk of data loss if the entire server is destroyed. This method is not well suited to keeping historical archives of the many revisions of your files. The hard drive will eventually fill up. By using removable hard drives, you can overcome this limitation by removing the backup drive when it is full and moving it to a secure location.

The primary disadvantage of magnetic tape is that it is a *sequential access medium*. This means that tapes are read or written from beginning to end, and searching for a particular file can be time-consuming. For this reason, tape is a good choice for backing up and restoring entire file systems, but not the ideal choice to recover individual files on a regular basis.

CentOS can use a wide variety of tape drives. Most SCSI tape drives will work without loading special modules. Even many IDE tape drives are now supported natively, without requiring the drive to operate in an “SCSI emulation” mode. Some drives, however, may require installation of additional software and kernel modules.

## Writable CD Drives

Another backup medium that is gaining popularity is the writable CD drive. Writable CD drives have several advantages over tape, the primary one being that CDs are a *random access medium*. This means that the CD drive can quickly locate a particular file on the CD without sequentially scanning through the entire disk. This is useful when you need to keep a revision history of frequently changing data files (such as source code for a software project or drafts of legal documents).

Although people used to believe that CDs had a very long life span, that belief has recently come into question. CDs are probably still a good choice if the backup will be needed for two years or less. For longer time periods, a tape backup will generally last longer than a writable CD. If your backups are intended for short-term storage, you should probably consider a rewritable or CD-RW CD drive. A rewritable CD (unlike plain writable CDs) can be reformatted and used to store new backups.

The biggest drawback is that a CD can store, at most, about 700 MB of data. In contrast, DVDs can store 4.7 GB of data (or about 8.5 GB for dual-layer CDs), and many tape drives can store multiple gigabytes of data. For example, DAT DDS-3 tapes can hold up to 24 GB of compressed data, while 8mm AIT-2 tapes can hold up to 100 GB of compressed data.

### Getting `cdrecord` for Writable CDs

To write CDs with CentOS, you can use the `cdrecord`, `cdparanoia`, and `mkisofs` packages, which are installed by default.

### Writing to CDs

Because the data written to a CD-R or CD+R disk becomes permanent once it is written, you need to format the CD and copy files to it all in one step. If you formatted it first, you would end up with an empty file system on a CD that can no longer be written to.

#### NOTE

Using a command called `growisofs` (described later in this chapter), you can write to a CD in such a way that the session is not closed. Later, you can add more data, in multiple sessions, before you finally close the CD. The `cdrecord` command itself also now supports a `-multi` option, which can keep the session open for further writing. Not all CD drives will support multisession writing (which requires that the hardware support CD-ROM XA mode 2 form 1).

The first step is to create an image of the CD file system as a file on your computer. You do this with the `mkisofs` command. The second step is to burn the image to CD or DVD using a tool such as the `cdrecord` command.

As an example, imagine that you want to back up the home directory for user `connie`. You would invoke the `mkisofs` command and pass it the name of the file system image file to create, followed by the directory to base it on:

```
$ mkisofs -R -o /var/tmp/connie.iso /home/connie
```

This creates an ISO9660 file system image in a file named `connie.iso` located in the `/var/tmp` directory. The `-R` option causes Linux-specific file ownership and long filenames to be used. If your `/var` partition does not have enough room for the image, choose a different location.

**TIP**

By default, `mkisofs` preserves the ownership and access rights of files and directories when it creates the file system image. This is appropriate when you are making a backup, but not when you are creating a software distribution CD. In such a case, add the `-r` option instead of `-R` as the first parameter to `mkisofs`. It will then store all files as publicly readable and, where appropriate, executable.

If you have an ATAPI CD drive, you no longer need an SCSI ID for that drive to be able to record to it. You could enter the device name instead of the SCSI ID (e.g., `dev=/dev/cdrom`). However, if you have an SCSI CD drive, before you can write the image file to a CD, you must first discover the SCSI bus number, device ID number, and Logical Unit Number (LUN) of the CD drive. You can find out which SCSI device ID the CD drive is using. Invoke the `cdrecord` command with the single parameter `-scanbus`:

```
# cdrecord -scanbus
```

You should see a response similar to the following:

```
scsibus0:
  0,0,0    0) 'IDE-CD ' 'R/RW 4x4x24 ' '1.04' Removable CD-ROM
  0,0,1    1) *
  0,0,2    2) *
  0,0,3    3) *
  0,0,4    4) *
  0,0,5    5) *
  0,0,6    6) *
  0,0,7    7) *
```

This tells you that the CD drive is using SCSI ID zero. The Logical Unit Number in this case should always be zero, so you now have all three numbers. You supply them to `cdrecord` as part of the `dev` parameter.

The SCSI bus number is listed first; it is followed by the ID number, and then by the LUN. The entire command should look similar to this:

```
# cdrecord -v speed=2 dev=0,0,0 -data /var/tmp/connie.iso
```

For an ATAPI CD drive, with the CD drive as `/dev/cdrom`, your command line might appear as follows instead:

```
# cdrecord -v speed=2 dev=/dev/cdrom -data /var/tmp/connie.iso
```

Several additional parameters are included in the command. The `-v` parameter tells `cdrecord` to supply verbose output to the screen. The `speed` parameter tells `cdrecord` what speed to record at (in this case X2). You might choose to leave off `speed=2` and let `cdrecord`

autodetect the record speed of your CD burner. The `-data` parameter tells `cdrecord` to burn WAV or AU files as data, instead of audio tracks. Without that option, those file types are burned as audio tracks, while all other files are burned as data.

Before running `cdrecord live`, you might consider adding the `-dummy` option, which runs through the CD burn process without actually turning on the laser. You can add the `-eject` parameter to eject the CD when it is done. As it works, `cdrecord` should display status messages that look similar to the following:

```
cdrecord: No write mode specified.
cdrecord: Assuming -tao mode.
cdrecord: Future versions of cdrecord may have drive dependent
defaults.
cdrecord: Continuing in 5 seconds...
Cdrecord-Clone 2.01-dvd (i686-pc-linux-gnu) Copyright (C) 1995-2004
Jörg Schilling
TOC Type: 1 = CD-ROM
scsidev: '/dev/cdrom'
devname: '/dev/cdrom'
scsibus: -2 target: -2 lun: -2
Warning: Open by 'devname' is unintentional and not supported.
Linux sg driver version: 3.5.27
Using libscg version 'schily-0.8'.
SCSI buffer size: 64512
atapi: 1
Device type      : Removable CD-ROM
Version         : 0
Response Format: 1
Vendor_info      : 'IDE-CD  '
Identifikation  : 'R/RW 4x4x24  '
Revision        : '1.04'
Device seems to be: Generic mmc CD-RW.
Using generic SCSI-3/mmc CD-R/CD-RW driver (mmc_cdr).
Driver flags    : MMC SWABAUDIO
Supported modes: TAO PACKET RAW/R16
Drive buf size  : 1572864 = 1536 KB
FIFO size       : 4194304 = 4096 KB
Track 01: data   0 MB
Total size:      0 MB (00:04.02) = 302 sectors
Lout start:      1 MB (00:06/02) = 302 sectors
Current Secsize: 2048
ATIP info from disk:
  Indicated writing power: 5
  Is not unrestricted
  Is not erasable
  Disk sub type: Medium Type B, low Beta category (B-) (4)
```

```
ATIP start of lead in: -12369 (97:17/06)
ATIP start of lead out: 359849 (79:59/74)
Disk type: Short strategy type (Phthalocyanine or similar)
Manuf. index: 69
Manufacturer: Moser Baer India Limited
Manufacturer is guessed because of the orange forum embargo.
The orange forum likes to get money for recent information.
The information for this media may not be correct.
Blocks total: 359849 Blocks current: 359849 Blocks remaining: 359547
Starting to write CD/DVD at speed 4 in real TAO mode for single session.
Last chance to quit, starting real write 0 seconds. Operation starts.
Waiting for reader process to fill input buffer ... input buffer ready.
trackno=0
Performing OPC...
Starting new track at sector: 0
Track 01: 322 of 322 MB written (fifo 100%) [buf 99%] 2.0x.
Track 01: Total bytes read/written: 338395136/338395136 (165232 sectors).
Writing time: 1110.710s
Average write speed 2.0x.
Fixating...
Fixating time: 126.108s
cdrecord: fifo had 5331 puts and 5331 gets.
cdrecord: fifo was 0 times empty and 5262 times full, min fill
was 96%.
```

After `cdrecord` finishes writing the CD and your shell prompt returns, delete the file system image file `/var/tmp/connie.iso`. Label the CD appropriately and store it in a safe place.

If you need any files that were copied to the CD, just return the CD to the CD drive. If it doesn't automatically open a window displaying the contents of the CD, type **`mount /media/cdrecorder`**. Open `/media/cdrecorder` in a folder window and copy the files you want.

Note that the mount point name for the CD drive may be something other than `/media/cdrecorder`. The way that the `udev` facility works is to use generic names such as `cdrecorder`, `disk`, or `cdrom` for CDs or DVDs that include no volume ID. However, if a volume ID was added to the CD header when the CD was created, that name will be used as the mount point. For example, a game CD with a volume ID of `GAMEDISK` would be mounted as `/media/GAMEDISK`.

**CROSS-REF** See Chapter 7 for more information on `cdrecord`. You can also learn more about installing and troubleshooting writable CD drives from the `CD-Writing-HOWTO`. If you are using a desktop CentOS system, you might want to use a graphical CD writer instead. Chapter 7 also describes the K3B graphical tool for copying and burning CDs and DVDs.



## Writable DVD Drives

cdrecord can be used to write both CDs and DVDs. Using a writable DVD drive and the cdrecord command, you can back up your data to DVD-R, DVD-RW, DVD+R, and DVD+RW disks.

### NOTE

DVD-R is a write-once DVD format with a capacity of about 4.7 GB. Disks in the DVD-RW format can be written and rewritten many times. DVD+RW is a read-write format that provides for faster writing of data, and DVD+R is a similar write-once format. Typically, a DVD-burning drive will support the plus (DVD+RW, DVD+R) or the minus (DVD-RW, DVD-R) formats. Some drives support both. It is important that you purchase disks compatible with your hardware.

The first trick with recording to DVDs in Linux is to make sure that you have a drive that supports DVD writing. You can check by removing any disks in the CD/DVD drive and typing the following:

```
$ cdrecord -prcap -dev=/dev/cdrom | less
Cdrecord-Clone 2.01-dvd (i686-pc-linux-gnu)
.
.
.
Device type      : Removable CD-ROM
Version          : 0
Response Format: 2
Capabilities     :
Vendor_info      : 'PIONEER '
Identifikation  : 'DVD-RW  DVR-105 '
Revision        : '1.30'
Device seems to be: Generic mmc2 DVD-R/DVD-RW.
```

Drive capabilities, per MMC-3 page 2A:

```
Does read CD-R media
Does write CD-R media
Does read CD-RW media
Does write CD-RW media
Does read DVD-ROM media
Does read DVD-R media
Does write DVD-R media
Does not read DVD-RAM media
Does not write DVD-RAM media
Does support test writing
.
.
.
```

In the preceding output, you can see that this drive supports reading and writing of both CDs and DVDs. Use the Spacebar to page through the output (and **q** to quit). Near the end of the

output, you should see read and write speeds supported by the drive. Note that those are maximum *possible* speeds, so the actual maximum write speeds will depend on the CD or DVD media you are using.

The procedure for writing to DVDs is almost identical to backing up data onto a CD disk, with the following exceptions:

- Each backup disk can hold a lot more data (4.7 GB for single-layer and 8.5 GB for dual-layer DVD, as compared to 700 MB for CDs).
- Both the DVD writer and medium are more expensive than the CD counterparts, although the cost of DVD writers has come down drastically in the past few years.

**NOTE**

When manufacturers say 4.7 GB, they are talking about 1,000 MB per GB, not 1,024 MB. Therefore, you can really only store up to about 4.3 GB of data on a DVD (or, more precisely, 4,294,967,296 bytes).

There are also a few other issues you should be aware of that relate to using DVD media to record from Linux:

- While most new writable DVD drives today support both DVD-R and DVD+R formats, some older drives may not support DVD+R.
- DVD+RW media that have not been formatted must be formatted before you can write to them. However, you can use `cdrecord` on an unformatted DVD+RW because it will automatically detect and format an unformatted disk. To force a format, you can use the `-format` option to `cdrecord`. There is also a `dvd+rw-format` that you can use to format a DVD drive (just run `dvd+rw-format` with your DVD device as the option).
- You don't need to reformat DVD-RW media more than once. Multiple reformats can make the DVD-RW media unusable.

Follow the procedure in the “Writable CD Drives” section to create a file system image file (using `mkisofs`) and determine the location of your DVD-R driver. Then use the `cdrecord` command to actually burn the DVD. Here is an example of a `cdrecord` command line that burns a file system image called `bigimage.iso`:

```
# cdrecord -v speed=2 dev=/dev/cdrom -data bigimage.iso
```

## Writing CDs or DVDs with `growisofs`

Instead of doing separate `mkisofs` and `cdrecord` commands, as just shown, you can use the `growisofs` command to combine the function of those two commands. The `growisofs` command is particularly useful for mastering of large ISO images (such as those for double-layer DVD recording). That's because instead of copying the ISO image you create to a file (as `mkisofs` does), `growisofs` sends the ISO image directly to the CD or DVD to be burned.

The `growisofs` command is also nice for backups because it has simple options for doing multisession DVDs. For example, if you want to back up your `/home/timothy` directory today, then back up your `/var/www` directory later, you start the first backup as follows:

```
$ growisofs -Z /dev/cdrom -R -J /home/timothy
```

The `-Z` indicates that this is an initial session being written to the CD or DVD. The device of the CD/DVD drive is `/dev/cdrom`. The `-R` and `-J` options allow longer Linux filenames on ISO9660 images (so the disk can be read by other operating systems, yet still retain Linux extensions). The last option (in this case, `/home/timothy`) is whatever directories or files you want to copy to DVD.

When you are ready to write more to the CD or DVD, use the `-M` option instead, to indicate that you are adding on to an existing CD or DVD. Here is an example:

```
$ growisofs -M /dev/cdrom -R -J /var/www
```

Here, the `-M` indicates to add a new session to the existing session on the CD or DVD. The content of the `/var/www` directory (and its subdirectories) is written to the media. You can mount the media between sessions. Just be sure to unmount it before you try to write to it again (using the `umount` command).

## Backing Up to a Hard Drive

---

As noted in the simple backup procedure in the beginning of this chapter, removable media such as tapes, DVDs, and CDs are not the only choice for backing up your data. You may find it useful to install a second hard drive in your system and use that drive for backups. This has several advantages over other backup media:

- Data can be backed up quickly and throughout the day; thus, backed-up data will be more current in the event of a crash.
- There's no medium to load. Data can be located and recovered more quickly.
- You can configure the second disk to be a virtual clone of the first one. If the first disk crashes, you can simply boot off the second disk rather than installing new hardware. With disk mirroring software, this process can even be automated. The downside to this approach is that a mirrored drive that is online all the time is more prone to error than would be the case when copying files to removable media, and then removing the media to a safe location.
- With new, cost-effective removable hard drives (including those connected via USB and FireWire), you have the convenience of removable media with what was once usually thought of as non-removable media.

There are also some disadvantages to backing up to a hard drive. For example, the hard-drive backup method is not well suited to keeping historical archives of the many revisions of your files because the hard drive will eventually fill up. This problem can be reduced substantially, however, by using `rsync` snapshots, which store changes that are applied to modified files.

The simplest form of second-hard-drive backup is to simply copy important files to the other drive using the `cp` or `tar` command. The most sophisticated method is to provide fault-tolerant disk mirroring using RAID software.

A method in-between RAID and a simple `cp` command is to add an `rsync` command to a `cron` file so that backups are done automatically as often as you please. For example, you can add a script that does your `rsync` backup to `/etc/cron.hourly`, `/etc/cron.daily`, `/etc/cron.weekly`, or `/etc/cron.monthly`, to have your backup run automatically each hour, day, week, or month, respectively. Keep in mind that you would have to catch any problems within the set time frame (an hour, a day, etc.) before the bad data overwrites the backup. (I describe how to use the `cron` facility to do backups with `dump` later in this chapter.)

## Backing Up Files with `dump`

The `dump` command was historically one of the most commonly used tools for performing backups on UNIX systems. This command traces its history back to the early days of UNIX and thus is a standard part of nearly every version of UNIX. Likewise, the `dump` package is included in CentOS.

### NOTE

The `dump` and `restore` commands, while widely used for many years, are not considered to be particularly reliable or robust backup and restore tools these days. Also, they can be used only on `ext2` and `ext3` file system types, and it is safest to use `dump` and `restore` on unmounted file systems. Descriptions of those tools are included here to support those with legacy backup media and automated scripts that still use those commands.

The `dump` package actually consists of several commands. You can read online man pages for more information about them. Table 12-2 provides a short description of the programs.

**TABLE 12-2**

### Programs in the `dump` Package

Command	Description
<code>dump</code>	Creates backup archives of whole disk partitions or selected directories.
<code>restore</code>	Can be used to restore an entire archive or individual files from an archive to the hard drive.
<code>rmt</code>	A program used by the <code>dump</code> and <code>restore</code> commands to copy files across the network. You should never need to use this command directly.

## Creating a Backup with dump

When making a file system backup using the `dump` command, you must supply parameters specifying the dump level, the backup media, and the file system to back up. You can also supply optional parameters to specify the size of the backup media, the method for requesting the next tape, and the recording of file system dump times and status.

The first parameter to `dump` is always a list of single-letter option codes. This is followed by a space-separated list of any arguments needed by those options. The arguments appear in the same order as the options that require them. The final parameter is always the file system or directory being backed up.

```
# dump options arguments filesystem
```

Table 12-3 lists the various one-letter option codes for the `dump` command.

Thus, a typical `dump` command may look similar to the following:

```
# dump 0uBf 500000 /dev/qst0 /dev/sda6
```

This command results in `dump` performing a level zero (full) backup of the `/dev/sda6` file system, storing the backup on the tape drive `/dev/qst0`, and recording the results in `/etc/dumpdates`. The `B` option is used to increase the expected tape block count to 500,000; otherwise, `dump` would prompt for a new tape far earlier than required. The `dump` command prints status messages to the screen, letting you know how far along the backup has progressed and estimating how much time it will take to complete. The output looks similar to this:

```
DUMP: Date of this level 0 dump: Sat Aug 23 23:33:37 2003
DUMP: Dumping /dev/sda6 (/home) to /dev/qst0
DUMP: Exclude ext3 journal inode 8
DUMP: Label: /home
DUMP: mapping (Pass I) [regular files]
DUMP: mapping (Pass II) [directories]
DUMP: estimated 93303 tape blocks on 0.19 tape(s).
DUMP: Volume 1 started with block 1 at: Sat Aug 23 23:33:47
DUMP: dumping (Pass III) [directories]
DUMP: dumping (Pass IV) [regular files]
DUMP: Closing /dev/qst0
DUMP: Volume 1 completed at: Sat Aug 23 23:35:35 2003
DUMP: Volume 1 94360 tape blocks (92.15MB)
DUMP: Volume 1 took 0:01:48
DUMP: Volume 1 transfer rate: 873 kB/s
DUMP: 94360 tape blocks (92.15MB) on 1 volume(s)
DUMP: finished in 108 seconds, throughput 873 kBytes/sec
DUMP: Date of this level 0 dump: Sat Aug 23 23:33:37 2003
DUMP: Date this dump completed: Sat Aug 23 23:35:35 2003
DUMP: Average transfer rate: 873 kB/s
DUMP: DUMP IS DONE
```

TABLE 12-3

## Options to dump

Dump Options	Description
0-9	The dump level. Selecting a dump level of 0 backs up all files (a full dump). A higher number backs up only those files modified since the last dump of an equal or lower number (in essence, an incremental dump). The default dump level is 9.
-a	Data is written until an “end-of-media” is returned. This should work with any modern drive and bypasses all media length or size calculations.
-B <i>records</i>	The number of dump records per volume. Basically, the amount of data you can fit on a tape. This option takes a numeric argument.
-b <i>kbperdump</i>	The number of kilobytes per dump record. Useful in combination with the -B option. This option takes a numeric argument.
-h <i>level</i>	Files can be marked with a nodump attribute. This option specifies the dump level at or above which the nodump attribute is honored. This option takes a numeric argument of 1-9.
-f <i>file</i>	The name of the file or device to write the dump to. This can even be a file or device on a remote machine.
-d <i>density</i>	Sets the tape density. The default is 1,600 bits per inch. This option takes a numeric argument.
-n	When a dump needs attention (such as to change a tape), dump will send a message to all of the users in the operator group. This option takes no arguments.
-s <i>feet</i>	Specifies the length in feet of the dump tape. This calculation is dependent on tape density (option d) and the dump record (options B and b). This option takes a numeric argument.
-u	Record this backup in the /etc/dumpdates file. It is a good idea to use this option, especially if you create incremental backups.
-t <i>date</i>	Specify a date and time on which to base incremental backups. Any files modified or added after that time will be backed up. This option causes dump to ignore the /etc/dumpdates file. It takes a single argument, a date in the format specified by the <code>ctime</code> man page.
-W	This option causes dump to list the file systems that need to be backed up. It does this by looking at the /etc/dumpdates file and the /etc/fstab file.
-w	This works like the W option but lists the individual files that should be backed up.

## Understanding Dump Levels

The dump command can back up all files on a file system, or it can selectively back up only those files that have changed recently. The dump level parameter is used to specify this behavior. A dump level of 0 results in a full backup of all files on the file system. Specifying a higher number (1-9) backs up only those files that have been changed or added since the most recent dump of the same or lower dump level. I recommend that you use dump levels to implement a full and incremental backup schedule similar to the one shown in Table 12-4.

**TABLE 12-4**

### Recommended Dump Schedule

Day of Week	Dump Level
Sunday	Level 0 (full dump). Eject the tape when done.
Monday	Level 9 (incremental dump)
Tuesday	Level 8 (incremental dump)
Wednesday	Level 7 (incremental dump)
Thursday	Level 6 (incremental dump)
Friday	Level 5 (incremental dump)
Saturday	Level 4 (incremental dump)

Note that after the full backup on Sunday, a Level 9 incremental dump is done the next day, and a successively lower dump level is done each day after that. This results in all the files that have changed since Sunday being backed up on every single incremental backup. Each incremental backup is thus larger than the previous one; the backup contains all of the files from the previous incremental backup plus any files that have changed since then. This may seem wasteful of storage space on the backup tape, but it will save a lot of time and effort should there be a need to restore the file system. (This is referred to as a *differential backup*.)

For example, imagine that your hard drive crashed on Friday. After replacing the hard drive, you can restore the entire file system in two steps: Restore the full backup from the prior Sunday, and then the most recent incremental backup from Thursday. You can do this because Thursday's backup contains all of the files from Monday, Tuesday, and Wednesday's tape as well as the files that changed after that. If the dump levels had progressed in positive order (Level 1 for Monday, Level 2 for Tuesday, etc.), *all* of the incremental backups would have to be restored in order to restore the file system to its most current state.

## Automating Backups with cron

---

You can automate most of your backups with shell scripts and the cron daemon. Use the `su` command to become root, and then `cd` to the `/usr/local/bin` directory. Use any text editor to create a shell script called `backups.sh`, which looks similar to the following:

```
#!/bin/sh
#
# backups.sh - A simple backup script, by Thad Phetteplace
#
# This script takes one parameter, the dump level.
# If the dump level is not provided, it is
# automatically set to zero. For level zero (full)
# dumps, rewind and eject the tape when done.
#
if [ $1 ]; then
    level=$1
else
    #
    # No dump level was provided, so set it
    # to zero
    #
    level="0"
fi

/sbin/dump $level'uf' /dev/nst0 /
/sbin/dump $level'uf' /dev/nst0 /home
/sbin/dump $level'uf' /dev/nst0 /var
/sbin/dump $level'uf' /dev/nst0 /usr

#
# If we are doing a full dump, rewind and eject
# the tape when done.
#
if [ $level = "0" ]; then
    /bin/mt -f /dev/nst0 rewind
    /bin/mt -f /dev/nst0 offline
fi
```

You might have to change the partitions being backed up to match your setup, but this script should otherwise work quite well for you. After saving and exiting the editor, change the permissions on the file so that it is executable and readable only by root:

```
# chmod 700 backups.sh
```



You can now back up your entire system by running the `backups.sh` script when logged in as `root`. The script accepts the dump level as its only parameter. If you leave the parameter off, it will automatically assume a Level 0 dump. Thus, the following two commands are equivalent:

```
# backups.sh
# backups.sh 0
```

You may need to customize this script for your situation. For example, I am using the tape device `/dev/nst0`. You might be using a different tape device. Whatever device you use, you should probably use the version of its device name that begins with the letter *n*. That tells the system that after it finishes copying data to the tape, it should *not* rewind the tape. For example, I used `/dev/nst0` instead of `/dev/st0` in the preceding script. If I had used `/dev/st0`, each successive incremental backup would have overwritten the previous one.

Other things that you may change in this script include the partitions being backed up and the dump level at which the tape is ejected. It is common practice to eject the tape after the last incremental backup just before performing a full backup.

The most useful thing about this script is that you can easily configure your system to run it automatically. Simply add a few lines to the root crontab file, and the `cron` daemon will invoke the script on the days and times specified. While logged in as `root`, enter the `crontab` command with the `-e` option:

```
# crontab -e
```

This opens the root crontab file in an editor. Add the following lines at the end of the file:

```
0 22 * * 0 /usr/local/bin/backup.sh 0
0 22 * * 1 /usr/local/bin/backup.sh 9
0 22 * * 2 /usr/local/bin/backup.sh 8
0 22 * * 3 /usr/local/bin/backup.sh 7
0 22 * * 4 /usr/local/bin/backup.sh 6
0 22 * * 5 /usr/local/bin/backup.sh 5
0 22 * * 6 /usr/local/bin/backup.sh 4
```

Save and exit the file. The `cron` daemon will now run the backup script at 10:00 p.m. (22:00 in military time) every day of the week. This example implements the dump schedule outlined earlier. A full dump is performed on Sunday, and the tape is ejected when it is done. A new tape should be loaded on Monday, and then incremental backups will be written to that same tape for the rest of the week. The next full dump will be written to the end of that tape, unless someone is around on Sunday to eject and replace the tape before 10:00 p.m. Keep in mind that the person set to receive e-mail for the `root` user will be the one to be notified of the actions of this, or any, `root`-owned `cron` script.

## Restoring Backed-Up Files

---

The `restore` command is used to retrieve files from a backup tape or other medium that was created by `dump`. You can use `restore` to recover an entire file system or to interactively select individual files. It recovers files from the specified media and copies them into the current

directory (the one you ran the `recover` command in), re-creating subdirectories as needed. Much as with the `dump` command, the first parameter passed to the `restore` command is a list of single-character option codes, as shown in Table 12-5.

TABLE 12-5

### restore Command Options

Restore Options	Description
-r	Restore the entire dump archive.
-C	Compare the contents of the dump file with the files on the disk. This is used to check the success of a restore.
-R	Start the restore from a particular tape of a multtape backup. This is useful for restarting an interrupted restore.
-X <i>filelist</i>	Extract only specific files or directories from the archive. This option takes one argument, a list of files or directories to extract.
-T <i>file</i>	List the contents of the dump archive. If a file or directory is given as an argument, list only the occurrence of that file, directory, or anything within the directory.
-i	Restore files in interactive mode.
-b <i>blocksize</i>	Specify the block size of the dump in kilobytes. This option takes a numeric argument.
-D <i>filesystem</i>	Specify the name of the file system to be compared when using the -C option. The file system name is passed as an argument.
-F <i>script</i>	Specify the name of the dump archive to restore from. This option takes an alphanumeric argument.
-h	If this option is specified, <code>restore</code> re-creates directories marked for extraction but will not extract their contents.
-m	Files are extracted by inode number instead of name. This is generally not very useful.
-N	Instead of extracting files, print their names.
-s <i>file#</i>	Specify the dump file to start with on a multiple file tape. This takes a numeric argument.
-T <i>directory</i>	Tells <code>restore</code> where to write any temporary files. This is useful if you booted from a floppy disk (which has no space for temporary files).
-v	Run in verbose mode. This causes <code>restore</code> to print information about each file as it restores it.
-y	The <code>restore</code> command will always continue when it encounters a bad block, rather than asking you if you want to continue.

## Restoring an Entire File System

Let's return to our earlier example of the Friday disk crash. You installed a shiny new hard drive, and your backup tapes are in hand. It is time to restore the files. For the purposes of this example, I assume that the crashed drive contained only the /home partition and that the Linux operating system is still intact. If the crashed drive had contained the Linux operating system, you would first have to reinstall Linux before restoring the backup.

With your new disk installed, run the `fdisk` command to partition the disk, as described in Chapter 2 in the section on partitioning your hard disks.

Before any files can be recovered to your new hard drive, an empty file system must be created on it. You use the `mkfs` command to do this. The `mkfs` command can accept a variety of parameters, but usually you need to supply only the name of the device to create the file system on. Thus, to prepare the new hard drive, type:

```
# mkfs -t ext3 /dev/sdb1
```

Alternatively, because your /home drive is listed in the `/etc/fstab` file, you can simply specify the /home mount point, and `mkfs` will figure out the correct device. Thus, the preceding command could be replaced with this:

```
# mkfs /home
```

### CAUTION

You should, of course, exercise extreme caution when using the `mkfs` command. If you specify the wrong device name, you could unintentionally wipe out all data on an existing file system.

After creating a file system on your new disk, mount the partition to a temporary mount point.

```
# mkdir /mnt/test
# mount /dev/sdb1 /mnt/test
```

This connects the new file system to the `/mnt/test` directory. Now change into the directory (`cd /mnt/test`) and use the `restore` command to recover the entire file system off your backup tape. Of course, it is assumed that you have loaded the tape into the tape drive.

```
# cd /mnt/test
# restore rf /dev/nst0
```

When the restore is finished, you can unmount the partition and remount it to the appropriate mount point. If you have restored the file system to a different physical partition from that it was originally on, be sure to modify the `/etc/fstab` file appropriately so that the correct partition is mounted next time the system is rebooted.

## Recovering Individual Files

The `restore` command can also be used to recover individual files and directories. By using `restore` in interactive mode, you can type a series of `restore` commands to selectively restore files. To run `restore` in interactive mode, use the `i` parameter instead of `r`:

```
# restore if /dev/nst0
```

The `restore` command will then read the file index from the backup tape and present you with a `restore` prompt. At this prompt, you can type the commands that enable you to select which directories and files to recover. You can navigate the directory structure of the backup index much the same way that you navigate an actual file system using a shell prompt. The interactive `restore` command even has its own version of the familiar `cd` and `ls` commands, as shown in Table 12-6.

**TABLE 12-6**

### Interactive restore Commands

Command	Description
<code>add</code>	Add a file or directory to the list of files to be extracted. If a directory is marked for extraction, all of the directories and files within it will also be extracted.
<code>cd</code>	Change the current directory being viewed within the dump archive. Works much like the <code>cd</code> command used at a shell prompt.
<code>delete</code>	Delete a file or directory from the list of files to be extracted. Deleting a directory from the list results in all of the files and directories within it also being deleted from the list of files to be extracted.
<code>extract</code>	Extract all of the marked files and directories from the archive, and write them back to the file system.
<code>help</code>	List the available commands.
<code>ls</code>	List the contents of the current directory. If a directory name is provided as an argument, list the contents of that directory. Files or directories marked for extraction have a <code>*</code> character in front of them.
<code>pwd</code>	Print the full pathname of the current directory of the dump archive.
<code>quit</code>	Exit the interactive restore program.
<code>setmodes</code>	Do not restore the files; instead, set the modes of already existing files on the target disk to match the modes recorded in the dump file. This is useful for recovering from a <code>restore</code> that was prematurely aborted.
<code>verbose</code>	Toggles verbose output versus quiet output during the restore process. Verbose output mode will echo information to the screen for every file that is restored.

As an example, pretend that the user `mike` has accidentally deleted his `Mail` subdirectory from his home directory. Mike happens to be your boss, so it is urgent that you recover his files. Here is how you can go about it.

Load the appropriate tape into the tape drive and log in as `root`. Use the `cd` command to go to the top of the `/home` partition, and then run the `restore` program in interactive mode:

```
# cd /home
# restore if /dev/nst0
```

Verify that you have the backup tape for the `/home` partition by entering the `ls` command. You should see something like the following list of directories, representing users who have home directories in `/home`:

```
restore > ls
.:
connie/      jessica/    mike/       lost+found/ robert/     timothy/
```

Yes, this is the home partition. Now change the current directory to Mike's home directory using the `cd` command. Type `ls` again to view the contents of his home directory.

```
restore > cd mike
restore > ls
./mike:
.mozilla/      Desktop/      report.html
.tcshrc        Mail/         letter.txt
.xinitrc       News/         www/
```

Now mark the `Mail` directory for extraction using the `add` command:

```
restore > add Mail
```

If you use the `ls` command again, you see that the `Mail` directory is preceded with an asterisk (\*) character, which means that it has been marked for extraction.

```
restore > ls
./mike:
.mozilla/      Desktop/      report.html
.tcshrc        *Mail/        letter.txt
.xinitrc       News/         www/
```

Now use the `extract` command to begin the extraction process. `restore` will prompt you for the number of the tape to start with. This is a single-tape backup, so just enter the number **1**. When it prompts you to set owner/mode for `'.'`?, answer yes by typing **y** and pressing [Enter]. `restore` will then restore the file permissions (if necessary) of the directory it is restoring to. This isn't critical when extracting individual files like this, but you should always answer **yes** to this prompt when doing a full restore. Anyway, your screen should now contain the following:

```
restore > extract
You have not read any tapes yet.
Unless you know which volume your file(s) are on you
```

```

should start with the last volume and work toward the first.
Specify next volume #: 1
set owner/mode for '.'? [yn] y
restore >

```

At this point, the files have been recovered, and you can exit the `restore` program by issuing the `quit` command. That's all there is to it. You now know the basics of using the `dump` and `restore` commands.

## Configuring Amanda for Network Backups

Using Amanda (the Advanced Maryland Automatic Network Disk Archiver), you can use a single large-capacity tape drive on a server to back up files from multiple computers over a network. The Amanda packages (`amanda`, `amanda-client`, and `amanda-server`) include a variety of commands. The online man page for Amanda describes the commands as shown in Table 12-7.

**TABLE 12-7**

### Backup Commands Used with Amanda

Command	Description
<code>amdump</code>	Do automatic Amanda backups. This command is normally run by <code>cron</code> on a computer called the <i>tape server host</i> and requests backups of file systems located on backup clients. <code>amdump</code> backs up all disks in the <code>disklist</code> file to tape or, if there is a problem, to a special holding disk. After all backups are done, <code>amdump</code> sends mail reporting failures and successes.
<code>amflush</code>	Flush backups from the holding disk to tape. <code>amflush</code> is used after <code>amdump</code> has reported it could not write backups to tape. When this happens, backups stay in the holding disk. After the tape problem is corrected, run <code>amflush</code> to write backups from the holding disk to the tape.
<code>amcleanup</code>	Clean up after an interrupted <code>amdump</code> . This command is needed only if <code>amdump</code> was unable to complete for some reason, usually because the tape server host crashed while <code>amdump</code> was running.
<code>amrecover</code>	Provide an interactive interface to browse the Amanda index files and select which tapes to recover files from. <code>amrecover</code> can also run <code>amrestore</code> and the system restore program (such as <code>tar</code> ) sometimes.
<code>amrestore</code>	Read an Amanda tape, searching for requested backups. <code>amrestore</code> is suitable for everything from interactive restores of single files to a full restore of all partitions on a failed disk.

*continued*

**TABLE 12-7** (continued)

Command	Description
<code>amlabel</code>	Write an Amanda format label onto a tape. All Amanda tapes must be labeled with <code>amlabel</code> . <code>amdump</code> and <code>amflush</code> will not write to an unlabeled tape.
<code>amcheck</code>	Verify that the correct tape is in the tape drive and that all file systems on all backup client systems are ready to be backed up. Can optionally be run by <code>cron</code> before <code>amdump</code> , so someone will get mail warning that backups will fail unless corrective action is taken.
<code>amadmin</code>	Take care of administrative tasks, such as finding out which tapes are needed to restore a file system, forcing hosts to do full backups of selected disks, and looking at schedule balance information.
<code>amtape</code>	Take care of tape changer control operations, such as loading particular tapes, ejecting tapes, and scanning the tape rack.
<code>amverify</code>	Check Amanda backup tapes for errors (GNU tar format backups only).
<code>amrmtape</code>	Delete a tape from the tape list and from the Amanda database.
<code>amstatus</code>	Give the status of a running <code>amdump</code> .

The `amdump` command is the one that you will use the most, but before you can get started, you need to configure a few things on both the backup server (the system with the tape drive) and the backup clients (the systems being backed up). On Amanda clients, you need to install the `amanda` package. On the Amanda server, you need to install the `amanda-server` package as well.

## Creating Amanda Directories

You need to create some directories to hold the Amanda configuration files and to provide a location to write Amanda log files. The configuration files go in the `/etc/amanda` directory, and the log files go in `/var/lib/amanda`. In both cases, you should log in as the `amanda` user and create subdirectories within those directories, one subdirectory for each backup schedule that you intend to run and an index file, as shown in the following example.

### NOTE

For security reasons, you should do all Amanda administration as the `amanda` user. To do this, the root user can create a password for `amanda` by typing `passwd amanda` and entering the new password. A better alternative, however, might be to lock the `amanda` user account, and then simply type `su - amanda` (as in the following example) to do Amanda tasks as root user without an extra password. The rest of this procedure assumes that you are logged in as the `amanda` user.

```
# su - amanda
$ mkdir -p /var/lib/amanda/normal/index
$ mkdir -p /etc/amanda/normal
```

For the purpose of this example, I have created only a normal backup configuration that backs up the data drives on several machines. You may also decide to create an upgrade backup configuration that backs up the operating system partitions. You could then run that backup before you perform any operating system upgrades.

You also need to specify a holding disk that Amanda can use to spool backups temporarily before it writes them to disk. This directory should have a lot of free space. I have a large /home partition on my server, so I created an *amanda* directory there to use as a holding disk:

```
# mkdir /home/amanda
# chmod 700 /home/amanda
# chown amanda /home/amanda
# chgrp disk /home/amanda
```

## Creating the amanda.conf file

Next, as the *amanda* user, you must create two configuration files for Amanda and store them in the `/etc/amanda/normal` directory: *amanda.conf* and *disklist*. You can start by copying samples of these files from the `/etc/amanda/DailySet1` directory as follows:

```
$ cd /etc/amanda/DailySet1
$ cp amanda.conf disklist /etc/amanda/normal
```

The *amanda.conf* file sets a variety of general configuration values, and the *disklist* file defines which machines and partitions to back up. The *amanda.conf* file can be rather complicated, but, fortunately, most of its values can be left at their default values. Here is a simplified *amanda.conf* file with some comments embedded in it to help explain things:

```
#
# amanda.conf - sample Amanda configuration file. This started
# life as
#           the actual config file in use at CS.UMD.EDU.

org "EXAMPLE"      # your organization name for reports
mailto "amanda"    # space separated list of operators at your site
dumpuser "amanda" # the user to run dumps under

# Specify tape device and/or tape changer. If you don't have a tape
# changer, and you don't want to use more than one tape per run of
# amdump, just comment out the definition of tpchanger.

runtapes 1          # number of tapes to be used in a single
                    # run of amdump
tapedev "/dev/nst0" # the no-rewind tape device to be used
rawtapedev "/dev/rst0" # the raw device to be used (ftape only)

tapetype HP-DAT    # what kind of tape it is
                    # (see tapetypes below)
```



```

labelstr "~normal[0-9][0-9]*$" # label constraint all
                                # tapes must match

# Specify holding disks. These are used as a temporary
# staging area for dumps before they are written to tape and
# are recommended for most sites.

holdingdisk hd1 {
    comment "main holding disk"
    directory "/home/amanda" # where the holding disk is
    use 290Mb # how much space can we use on it
    chunksize -1 # size of chunk
}

# Note that, although the keyword below is infofile, it is
# only so for historic reasons, since now it is supposed to
# be a directory (unless you have selected some database
# format other than the 'text' default)

infofile "/var/lib/amanda/normal/curinfo" # database DIRECTORY
logdir "/var/lib/amanda/normal" # log directory
indexdir "/var/lib/amanda/normal/index" # index directory

# tapetypes

# Define the type of tape you use here, and use it in "tapetype"
# above. Some typical types of tapes are included here. The
# tapetype tells amanda how many MB will fit on the tape, how
# big the filemarks are, and how fast the tape device is.

define tapetype HP-DAT {
    comment "DAT tape drives"
    # data provided by Rob Browning <rlb@cs.utexas.edu>
    length 1930 mbytes
    filemark 111 kbytes
    speed 468 kbytes
}

# dumptypes
#
# These are referred to by the disklist file.

define dumptype global {
    comment "Global definitions"
    # This is quite useful for setting global parameters, so you
    # don't have to type them everywhere.
}

```

```
define dumptype always-full {
    global
    comment "Full dump of this filesystem always"
    compress none
    priority high
    dumpcycle 0
}
```

This example `amanda.conf` file was trimmed down from a larger example I copied from the `/etc/amanda/DailySet1` directory. The example `amanda.conf` file provides additional information on the available configuration options. Also, the online man page for Amanda should be helpful (type **man amanda** to read it). You can find more instructions in the `/usr/share/doc/amanda-server*` directory. Generally, you have to do the following:

- Modify the org name for reports.
- Change the device names set for `tapedev` and `rawtapedev` to match your tape device.
- Select a tape type entry that is appropriate for your tape drive.
- Change the name of the directory specified in the holding disk section to match the directory you created earlier.

## Creating a disklist File

You also must create a `disklist` file in the `/etc/amanda/normal` directory. This simply contains a list of the systems and disk partitions to back up. The qualifier `always-full` is included on each entry to tell Amanda what type of backup to perform. It means to use full, rather than incremental, backups.

```
# sample Amanda2 disklist file
#
# File format is:
#
#      hostname diskdev dumptype [spindle [interface]]
#
# where the dumptypes are defined by you in amanda.conf.

dexter sda5 always-full
dexter sda6 always-full
dexter sda7 always-full
dexter sda8 always-full

daffy sda5 always-full
daffy sda6 always-full
daffy sda7 always-full
daffy sdb1 always-full
daffy sdb2 always-full
```

This example file backs up two systems, `dexter` and `daffy`. The order of the systems and the partitions is selected so that the most important data is backed up first. This way, if a tape drive becomes full, you have still managed to back up the most important data.

## Adding Amanda Network Services

Amanda is designed to perform backups over a network. The following `amanda` services are defined in the `/etc/services` file:

```
amanda      10080/udp
amanda      10080/tcp
amandaidx   10082/tcp
amidxtape   10083/tcp
```

### On the Amanda Server

To offer these services to the network in CentOS, you need to configure the `xinetd` daemon to listen for those services. You do this by enabling the `amandaidx` and `amidxtape` services by typing the following (as `root` user):

```
# chkconfig amidxtape on
# chkconfig amandaidx on
```

This enables Amanda to accept requests from the client system and to start the backup process without any user intervention. You need to tell the `xinetd` daemon to reload the `/etc/xinetd.d` files before this change takes effect. You can do this by typing the following as `root` user:

```
# /etc/init.d/xinetd reload
```

### On Each Amanda Client

Next you need to configure the `.amandahosts` file in the `/var/lib/amanda` directory on each computer (client) that the Amanda server will back up from. This file should contain the fully qualified host and domain name of any backup servers that will connect to this client. When you begin, only your `localhost` is defined in this file as your backup server. To add another computer as a backup server, type the following (replacing `amandahost` with the name of the backup server, while you are logged in as the `amanda` user):

```
$ echo amandahost >> /var/lib/amanda/.amandahosts
```

You also need to make sure that the Amanda client daemon is configured to run on the client. You do this by enabling the `amanda` service by typing the following (as `root` user):

```
# chkconfig amanda on
```

This enables the Amanda client to communicate with the Amanda server. You need to tell the `xinetd` daemon to reload the `/etc/xinetd.d` files before this change takes place. Do this by typing the following as `root` user:

```
# /etc/init.d/xinetd reload
```

## Performing an Amanda Backup

Now that everything is configured, you are ready to perform an Amanda backup. Before running the actual backup, you should run `amcheck` to check your drive and configuration. While logged in as `root`, type the following commands:

```
# /usr/sbin/amcheck DailySet1
# /usr/sbin/amdump normal
```

This runs the `amdump` command and tells it to read the configuration files it finds in the `/etc/amanda/normal` directory created earlier. It then works its way down the list of systems and partitions in the `disklist` file, backing up each partition in the order it occurs. The results of the `amdump` are written to the `/var/lib/amanda/normal` directory. Read the files you find there to check on the results of the backup. (See the previous section on how to create a `disklist` file to understand the process that `amdump` goes through.)

You can, of course, automate this process with `cron`. To create an `amdump` schedule similar to the regular `dump` schedule discussed in an earlier section, do the following. While logged in as `root`, enter the `crontab` command with the `-e` option:

```
# crontab -e
```

This opens the root `crontab` file in an editor. Add the following lines to the end of the file:

```
0 22 * * 0 /usr/sbin/amdump normal
0 22 * * 1 /usr/sbin/amdump incremental
0 22 * * 2 /usr/sbin/amdump incremental
0 22 * * 3 /usr/sbin/amdump incremental
0 22 * * 4 /usr/sbin/amdump incremental
0 22 * * 5 /usr/sbin/amdump incremental
0 22 * * 6 /usr/sbin/amdump incremental
```

Save and exit the file. The `cron` daemon will now run `amdump` at 10:00 p.m. (22:00 in military time) every day of the week. This example assumes that a second incremental configuration has been created. You can do this by creating a subdirectory named `incremental` under `/etc/amanda` and populating it with appropriately modified `amanda.conf` and `disklist` files. You must also create a subdirectory named `incremental` under `/var/lib/amanda` so that `amanda` has somewhere to write the log files for this configuration.

It may be a bit of work to get it all in place, but when you do, Amanda can make your network backups much easier to manage. It may be overkill for a small office, but in a large enterprise network situation, it enables CentOS to act as a powerful backup server.

## Using the pax Archiving Tool

Over the years, a variety of UNIX operating systems have arisen, resulting in a variety of similar but incompatible file archiving formats. Even tools that go by the same name may use slightly

different storage formats on different systems. This can lead to big problems when trying to archive and retrieve data in a multiplatform environment. Fortunately, there is a solution.

The `pax` program is a POSIX standard utility that can read and write a wide variety of archive formats. An RPM package for `pax` is included with CentOS. If it is not already installed, type the following as `root` user to get the latest version of `pax` (provided you have an Internet connection):

```
# yum install pax
```

The `pax` command takes a variety of command-line options. The last parameter is usually the file or directory to archive. You may use wildcard characters such as `*` or `?` to specify multiple files or directories. The options you will use most often include the `-r` and `-w` parameters for specifying when you are reading or writing an archive. These are usually used in conjunction with the `-f` parameter, which is used to specify the name of the archive file.

By using `pax` parameters in different combinations, it is possible to extract an archive, create an archive, list the contents of an archive, or even copy an entire directory hierarchy from one location to another. Table 12-8 shows a few examples of the `pax` command in action.

**TABLE 12-8**

### Examples of `pax` Use

The <code>pax</code> Command	Description
<code>pax -f myfiles</code>	List the contents of the archive named <i>myfiles</i> .
<code>pax -r -f myfiles</code>	Extract the contents of the archive named <i>myfiles</i> .
<code>pax -w -f myfiles /etc</code>	Create an archive named <i>myfiles</i> containing everything within the <code>/etc</code> directory.
<code>pax -w -f myfiles *.txt</code>	Archive all of the files in the current directory that have a <code>.txt</code> file extension.
<code>pax -r -w /olddir /newdir</code>	Copy the entire contents of the directory <code>/olddir</code> into a new directory called <code>/newdir</code> .
<code>pax -w -B 1440000 -f /dev/fd0 *</code>	Archive the contents of the current directory onto multiple floppy disks.
<code>pax -w -x cpio -f myfiles *</code>	Archive the contents of the current directory into an archive file named <i>myfiles</i> using the <code>cpio</code> format.
<code>pax -r -U connie -f backups</code>	Extract all of the files owned by user <i>connie</i> from the archive named <i>backups</i> .

Note that by leaving off both the `-r` and `-w` options, you cause `pax` to simply list the contents of the archive. If you specify both the `-r` and `-w` options, then you should leave off the `-f` option and supply source and destination directories instead. This will cause the source directory to be completely cloned in the specified destination directory.

You can use additional parameters to further modify the `pax` command's behavior. For example, you can use the `-x` option in conjunction with the `-w` option to specify the specific archive type to create, or you can use the `-B` option to specify the number of bytes to write to each volume of a multivolume archive.

Table 12-9 describes the many optional parameters to the `pax` command.

**TABLE 12-9**

### Options to `pax`

Options to <code>pax</code>	Description
<code>-r</code>	Read files from an archive.
<code>-w</code>	Write files to an archive.
<code>-a</code>	Append files to a previously created archive.
<code>-b <i>blocksize</i></code>	Specify the archive's data block size. It must be a multiple of 512.
<code>-c <i>pattern</i></code>	Match all files except those that match the specified pattern.
<code>-d</code>	Match filename wildcards against file or directory names only, not the complete path.
<code>-f <i>archive</i></code>	Specify the name of the archive.
<code>-i</code>	Interactively rename files when archiving.
<code>-k</code>	Do not overwrite existing files.
<code>-l</code>	Link files with hard links when in copy mode ( <code>-r -w</code> ).
<code>-n <i>pattern</i></code>	Match only the first file that matches the supplied pattern.
<code>-o <i>options</i></code>	Extra options specific to the archiving format used
<code>-p <i>string</i></code>	Specify the file characteristics to retain when archiving or copying. Read the <code>pax</code> man page for more information on this option.
<code>-s <i>replstr</i></code>	Modify the archived filenames using the supplied regular expression.
<code>-t</code>	Preserve the access times of archived files.
<code>-u</code>	Do not overwrite files with older versions.

*continued*

**TABLE 12-9** (continued)

Options to <code>pax</code>	Description
<code>-v</code>	Provide verbose output when running.
<code>-x format</code>	Specify the format of the archive. Valid formats include <code>cpio</code> , <code>bcpio</code> , <code>sv4cpio</code> , <code>sv4crc</code> , <code>tar</code> , and <code>ustar</code> . The default is to use <code>ustar</code> when creating an archive. The <code>pax</code> command will automatically determine the correct file type when reading an archive.
<code>-z</code>	Indicates that <code>gzip</code> should be used to compress and decompress the archive.
<code>-B bytes</code>	Specify the number of bytes per archive volume. Use this option to create multivolume archives on removable media.
<code>-D</code>	Do not overwrite existing files with files that have an older inode modification time.
<code>-E limit</code>	Limit the number of times <code>pax</code> will retry upon encountering a Read or Write error.
<code>-G group</code>	Select files based on a group name or GID. To select by GID, place a <code>#</code> sign in front of the group number.
<code>-H</code>	Follow only command-line symbolic links while performing a physical file system traversal.
<code>-L</code>	Follow all symbolic links when traversing a directory hierarchy.
<code>-P</code>	Do not follow symbolic links. This is the default.
<code>-T time</code>	Select files based on their modification time. Read the <code>pax</code> man page for complete discussion of this parameter's syntax.
<code>-U user</code>	Select files based on the owner's username, or by UID with a <code>#</code> sign in front of it.
<code>-X</code>	Do not traverse into directories that reside on a different device.
<code>-Y</code>	This option is the same as the <code>-D</code> option, except that the inode change time is checked using the pathname created after all the filename modifications have completed.
<code>-Z</code>	This option is the same as the <code>-u</code> option, except that the modification time is checked using the pathname created after all the filename modifications have completed.

As you can see, `pax` is a very flexible and powerful archiving tool. It can be particularly helpful in migrating data from older legacy systems to your new Linux system. When you are faced with the task of recovering archived data from an antiquated or even nonfunctioning UNIX system, the multiple file format support of `pax` can be a literal lifesaver.

## Summary

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I hope that you never experience a major hard drive crash, but if you do, the effort of making backups will repay itself many times over. A variety of low-cost backup hardware is available to use with your CentOS system. The traditional tape drive is an excellent choice for backing up large amounts of data or data that you need to keep for years. However, simply copying your /home directories to another medium offers some level of protection for your data.

For convenience, a writable DVD or CD drive is a good choice. As for the tools you choose to do your backups, the `dump` and `restore` commands are old favorites, dating back to the early UNIX days (although they are considered somewhat unreliable these days). The Amanda backup facility is excellent for network backups. If you are dealing with backups in several different formats, the `pax` command might be helpful.





# Chapter 13

## Security

**W**ith the growth of the Internet, computer and network security has become more important than ever. Assaults on your CentOS system can come in many forms, such as denial-of-service attacks, break-in attempts, or hijacking your machine as a spam relay, to name a few.

In many cases, good practices for setting and protecting passwords, monitoring log files, and creating good firewalls will keep out many would-be intruders. Keeping up with critical security software updates will help patch vulnerabilities as they become known. The addition of SELinux adds another layer of protection on your Linux system. Sometimes, more proactive approaches are needed to respond to break-ins. This chapter will familiarize you with the dangers that exist and the tools necessary to protect your system.

### Linux Security Checklist

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While Linux offers all the tools you need to secure your computer, if you are careless, someone can (and probably will) harm your system or try to steal your data. The following checklist covers a range of security measures to protect your Linux desktop or server.

- **Add Users and Passwords** — Creating separate user accounts, each with a good password, is your first line of defense in keeping your data secure. Users are protected from each other, as well as from an outsider who takes over one user account. Setting up group

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accounts can extend the concept of ownership to multiple users. See “Using Password Protection” later in this chapter, as well as Chapter 10, for more on setting up user accounts.

- **Read, Write, and Execute Permissions** — Every item in a Linux file system, including files, directories, applications, and devices, can be restricted by Read, Write, and Execute permissions for that item’s owner and group, as well as by all others. In this way, for example, you can let other users run a command or open a file, allowing them to change it. See Chapter 4 for information on setting file and directory permissions.
- **Protect root** — In standard Linux systems, the `root` users (as well as other administrative user accounts such as `apache`) have special abilities to use and change your Linux system. Protect the `root` account’s password, and don’t use the `root` account when you don’t need to. An open shell or desktop owned by the `root` user can be a target for attack. Running `system-config-*` windows as a regular user and then entering the `root` password as prompted and running administrative commands using `sudo` can reduce exposure to attacks on your `root` account. See Chapter 9 for information on handling the `root` user account.
- **Use Trusted Software** — While there are no guarantees with any Open Source software, you have a better chance of avoiding compromised software by using an established Linux distribution, such as CentOS. Software repositories where you get add-on packages or updates should likewise be scrutinized. Using valid GPG public keys that use signatures and encryption, you can ensure that the software you install comes from a valid vendor. And, of course, always be sure of the source of data files you receive before opening them in a Linux application.
- **Get Software Updates** — As vulnerabilities and bugs are discovered in software packages, every major Linux distribution offers tools for getting and installing those updates. Be sure to get those updates, especially if you are using CentOS as a server. See Chapter 5 for information on using `yum` to get software updates.
- **Use Secure Applications** — Even with software that is valid and working, some applications offer better protection from attack or invasion than others. For example, if you want to log in to a computer over the Internet, the secure shell service (`ssh`) is considered more secure than `rlogin` or `telnet` services. Also, some services that are thought to be insecure if you expose them on the Internet (such as Samba and NFS) can be used more securely over the Internet through virtual private network (VPN) tunnels (such as IPsec or CIPE).
- **Use Restrictive Firewalls** — A primary job of a firewall is to accept requests for services from a network that you want to allow and turn away requests that you don’t (primarily based on port numbers requested). A desktop system should refuse requests that come in on most ports. A server system should allow requests for a controlled set of ports. This chapter describes how to set up a firewall using `iptables`.
- **Enable Only Services You Need** — To offer services in Linux such as Web, file, or mail services, a daemon process will listen on a particular port number. Don’t enable services you don’t need. In fact, you shouldn’t even install server software you don’t need. See Chapter 11 for information on using system services.

**NOTE**

A program that runs quietly in the background handling service requests (such as `sendmail`) is called a *daemon*. Usually, daemons are started automatically when your system boots up, and they keep running until your system is shut down. Daemons may also be started on an as-needed basis by `xinetd`, a special daemon that listens on a large number of port numbers and then launches the requested process.

- **Limit Access to Services** — You can restrict access for a service you want to have to a particular host computer, domain, or network interface. For example, a computer with interfaces to both the Internet and a local area network (LAN) might limit access to a service such as NFS to computers on the LAN, but not offer those same services to the Internet. Services may limit access in their own configuration files or using TCP/IP wrappers (described later in this chapter).
- **Check Your System** — Linux has many tools available for checking the security of your system. After you install CentOS, you can check access to its ports using `nmap` or watch network traffic using `Wireshark`. You can also add popular security tools such as `Nessus`, to get a more complete view of your system security.
- **Monitor Your System** — You can log almost every type of activity on your Linux system. System log files, using the `rsyslogd` and `klogd` facilities, can be configured to track as much or as little of your system activity as you choose. The `logwatch` facility provides an easy way to have the potential problem messages forwarded to your administrative e-mail account. Linux logging features are described later in this chapter. You can get add-on packages such as `tripwire` and `portsentry`, to check your system for tampering and deal with someone scanning your ports, respectively.
- **Use SELinux** — SELinux (Security Enhanced Linux) is an extraordinarily rich and complex facility for managing the access of nearly every aspect of a Linux system. It addresses the “if I get root access I own your box” shortcomings of Linux and UNIX systems for highly secure environments. CentOS offers a useful, limited set of SELinux policies that are turned on by default. Despite improvements, however, many Linux system administrators still just turn off SELinux because they find it difficult to use. Chapter 9 provides an overview of SELinux, along with explanations of how it is implemented in CentOS.

This checklist should give you a good starting point with many aspects of security in Linux. Each of these topics is covered in greater depth throughout this chapter and in the other chapters throughout this book that I have just referenced. However, computer security is an ongoing battle, so I recommend you check out the following web sites to get a deeper, continuing experience with Linux security:

- **CERT** ([www.cert.org](http://www.cert.org)) — The CERT Coordination Center follows computer security issues. Check their home page for the latest vulnerability issues. The site has articles on security practices ([www.cert.org/search\\_pubs/search.php](http://www.cert.org/search_pubs/search.php)). It also has recommendations on what you should do if your computer has been compromised ([www.cert.org/tech\\_tips/win-UNIX-system\\_compromise.html](http://www.cert.org/tech_tips/win-UNIX-system_compromise.html)), although this is now considered somewhat dated.

- **The centos-announce List** (<http://lists.centos.org/>) — The centos-announce mailing list offers you a way to receive security alerts and notifications for package updates conveniently via e-mail.
- **Red Hat Security Alerts** ([www.redhat.com/security](http://www.redhat.com/security)) — For RHEL security issues (that typically relate to CentOS systems as well), you should check out the resources available from this site. From here you can look for and read about available updates. You can also get information on security training and consulting from Red Hat, Inc.

## Using Password Protection

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Passwords are the most fundamental security tool of any modern operating system and, consequently, the most commonly attacked security feature. It is natural to want to choose a password that is easy to remember, but very often this means choosing a password that is also easy to guess. Crackers know that on any system with more than a few users, at least one person is likely to have an easily guessed password.

By using the “brute force” method of attempting to log in to every account on the system and trying the most common passwords on each of these accounts, a persistent cracker has a good shot of finding a way in. Remember that a cracker will automate this attack, so thousands of login attempts are not out of the question. Obviously, choosing good passwords is the first and most important step to having a secure system.

Here are some things to avoid when choosing a password:

- Do not use any variation of your login name or your full name. Even if you use varied case, append, or prepend numbers or punctuation, or type it backwards, this will still be an easily guessed password.
- Do not use a dictionary word, even if you add numbers or punctuation to it.
- Do not use proper names of any kind.
- Do not use passwords based on a contiguous line of letters or numbers on the keyboard (such as *qwerty*, *1q2w3e4r*, or *asdfg*).

## Choosing Good Passwords

A good way to choose a strong password is to take the first letter from each word of an easily remembered sentence. The password can be made even better by adding numbers, punctuation, and varied case. The sentence you choose should have meaning only to you, and should not be publicly available (choosing a sentence on your personal web page is a bad idea). Table 13-1 lists examples of strong passwords and the tricks used to remember them.

TABLE 13-1

## Ideas for Good Passwords

Password	How to Remember It
Mrci7yo!	My rusty car is 7 years old!
2emBp1ib	2 elephants make BAD pets, 1 is better.
ItMc?Gib	Is that MY coat? Give it back.

The passwords look like gibberish but are actually rather easy to remember. As you can see, I can place emphasis on words that stand for capital letters in the password. You set your password using the `passwd` command. Type the `passwd` command within a command shell, and it will enable you to change your password. First, it will prompt you to enter your old password. To protect against someone *shoulder surfing* and learning your password, the password will not be displayed as you type.

As long as you type your old password correctly, the `passwd` command will prompt you for the new password. When you type in your new password, the `passwd` command checks the password against `cracklib` to determine if it is a *good* or *bad* password. Non-`root` users will be required to try a different password if the one they have chosen is not a good password. The `root` user is the only user who is permitted to assign *bad* passwords. Once the password has been accepted by `cracklib`, the `passwd` command will ask you to enter the new password a second time to make sure there are no typos (which are hard to detect when you can't see what you are typing). When running as `root`, it is possible to change a user's password by supplying that user's login name as a parameter to the `passwd` command. Typing this:

```
# passwd mike
```

results in the `passwd` command prompting you for `mike`'s new password. It does not prompt you for his old password in this case. This allows `root` to reset a user's password when that user has forgotten it (an event that happens all too often).

## Using a Shadow Password File

In early versions of UNIX, all user account and password information was stored in a file that all users could read, although only `root` could write to it. This was generally not a problem because the password information was encrypted. The password was encrypted using a *trapdoor algorithm*, meaning that the non-encoded password could be encoded into a scrambled string of characters, but the string could not be translated back to the non-encoded password.

How does the system check your password in this case? When you log in, the system encodes the password you entered, compares the resulting scrambled string with the scrambled string

that is stored in the password file, and grants you access only if the two match. Have you ever asked a system administrator what the password on your account was only to be told that the system administrator doesn't know? If so, this is why: The administrator really doesn't have the password, only the encrypted version. The non-encoded password exists only at the moment you type it.

## Breaking Encrypted Passwords

There is a problem with people being able to see encrypted passwords, however. Although it may be difficult, or even impossible, to reverse the encryption of a trapdoor algorithm, it is very easy to encode a large number of password guesses and compare them to the encoded passwords in the password file. This is, in order of magnitude, more efficient than trying actual login attempts for each username and password. If a cracker can get a copy of your password file, the cracker has a much better chance of breaking into your system.

Fortunately, Linux and all modern UNIX systems support a shadow password file by default. The file is a special version of the `passwd` file that only `root` can read. It contains the encrypted password information, so passwords can be left out of the `passwd` file, which any user on the system can read. CentOS supports the older, single password file method as well as the newer, shadowed password file configuration. You should always use the shadow password file (it is used by default).

## Checking for the shadow Password File

The password file is named `passwd` and can be found in the `/etc` directory. The shadowed password file is named `shadow` and is also located in `/etc`. If your `/etc/shadow` file is missing, then it is likely that your system is storing the password information in the `/etc/passwd` file instead. Verify this by displaying the file with the `less` command:

```
# less /etc/passwd
```

Something similar to the following should be displayed if your system is not using shadowed passwords:

```
root:DkkS6Uke799fQ:0:0:root:/root:/bin/bash
bin:*:1:1:bin:/bin:
daemon:*:2:2:daemon:/sbin:
.
.
.
timothy:KpRUp2ozmY5TA:500:100:Timothy Boronczyk:/home/timothy:/bin/sh
robert:0sXrzvKnQaksI:501:100:Robert Jones:/home/robert:/bin/sh
connie:ptNoiueYEjwX.:502:100:Connie James:/home/connie:/bin/sh
jessica:Ju2vY7A0X6Kzw:503:100:Jessica Adams:/home/jessica:/bin/sh
```

Each line in this listing corresponds to a single user account on the Linux system. Each line is made up of seven fields separated by colon (`:`) characters. From left to right, the fields are the

login name, the encrypted password, the user ID, the group ID, the description (usually a person's name), the home directory, and the default shell. Looking at the first line, you see that it is for the root account and has an encrypted password of `DkkS6Uke799fQ`. You can also see that root has a user ID of zero, a group ID of zero, and a home directory of `/root`, and root's default shell is `/bin/sh`.

All of these values are quite normal for a root account, but seeing that encrypted password should set off alarm bells in your head. It confirms that your system is not using the shadow password file. At this point, you should immediately convert your password file so that it uses `/etc/shadow` to store the password information. You do this by using the `pwconv` command. Simply log in as `root` (or use the `su` command to become root) and enter the `pwconv` command at a prompt. It will print no messages, but when your shell prompt returns, you should have a `/etc/shadow` file and your `/etc/passwd` file should now look like this:

```
root:x:0:0:root:/root:/bin/bash
bin:x:1:1:bin:/bin:
daemon:x:2:2:daemon:/sbin:
.
.
.
timothy:x:500:100:Mary Smith:/home/mary:/bin/sh
robert:x:501:100:Robert Jones:/home/robert:/bin/sh
connie:x:502:100:Connie James:/home/connie:/bin/sh
jessica:x:503:100:Jessica Adams:/home/jessica:/bin/sh
```

Encrypted password data is replaced with an `x`. Password data has been moved to `/etc/shadow`.

To check the type of password authentication your system is using, open the Authentication window (System ► Administration ► Authentication from the GNOME desktop). This tool lets you choose to use MD5 passwords, LDAP authentication, Kerberos 5, or other authentication methods.

To work with passwords for groups, you can use the `grpconv` command to convert passwords in `/etc/groups` to shadowed group passwords in `/etc/gshadow`. If you change `passwd` or group passwords and something breaks so you are unable to log in to the accounts, you can use the `pwunconv` and `grpunconv` commands, respectively, to reverse password conversion.

So, now you are using the shadow password file and picking good passwords. You have made a great start toward securing your system. You may also have noticed by now that security is not just a one-time job. It is an ongoing process, as much about policies as programs. Keep reading to learn more.

## Securing Linux with iptables Firewalls

---

What is a firewall? In the non-computer world, a firewall is a physical barrier that keeps a fire from spreading. *Computer firewalls* serve a similar purpose, but the “fires” that they attempt



to block are attacks from crackers on the Internet. In this context, a firewall, also known as a *packet filter*, is a physical piece of computer hardware that sits between your network and the Internet, regulating and controlling the flow of information.

The most common types of firewalls used today are filtering firewalls. A *filtering firewall* filters the traffic flowing between your network and the Internet, blocking certain things that may put your network at risk. It can limit access to and from the Internet to specific computers on your network. It can also limit the type of communication, selectively permitting or denying various Internet services.

For CentOS to act as a filtering firewall, you can use the iptables features. This chapter describes the iptables facility and the Firewall Configuration window for starting out with a simple firewall.

## Using the Security Level Configuration Window

When you first installed your CentOS system, you were given the opportunity to create a basic firewall for your system. Using the Security Level Configuration window, you can see those settings and modify them further.

If you are not familiar with firewalls in general, or iptables in particular, it can be a bit daunting to start out. To make your start with iptables easier for new users, CentOS systems offer the Firewall Configuration window. Look through the settings on this window, and then refer to other iptables descriptions that follow for more details on each feature.

To open the Security Level Configuration window, from the System menu select Administration > Security Level and Firewall (or type **system-config-securitylevel**). Figure 13-1 shows an example of this window.

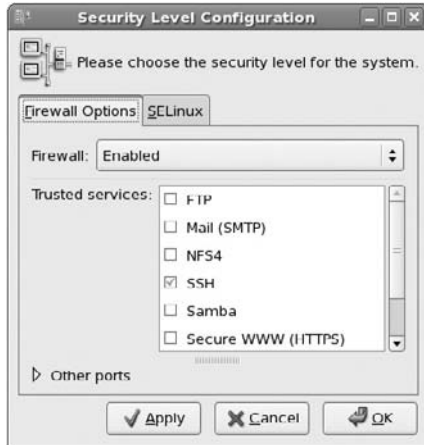
You can enable or disable the firewall using the Firewall select list on the Firewall Options tab. If you are connected to the Internet or other public network, I strongly suggest that you enable your firewall. Even if you are on a trusted LAN, you should turn the firewall on, but possibly open some services you might want to expose to the Internet (such as NFS and Samba). If the firewall is enabled, select from the following topics in the left column to configure your firewall:

- **Trusted Services** — You can open access to ports associated with your network interfaces to provide the services you want to make available from your system. Some services, such as Samba, require that multiple ports be open.

Services that are selected (open) by default include Multicast DNS, Network Printing (IPP client and server), and SSH (Secure Shell). Other services available from this screen include DNS, FTP, Mail (SMTP), NFS4, RADIUS, Samba, secure Web services (HTTPS), and standard Web service (HTTP). Selecting a service opens the common port(s) associated with that service, for the appropriate protocol in your firewall, but does not configure the service itself.

**FIGURE 13-1**

Set up a basic firewall using the Security Level Configuration window.

**NOTE**

If you need more information about what a particular service is used for, hover your mouse over the service name in this window that interests you, for a further description.

- **Other Ports** — You can allow access to any other port numbers by adding them to the “Other ports” box. Select Add and then select the protocol type (TCP or UDP) and port number pair you want to allow. About 1,000 ports are available to select from. To enable different ports, select the “User Defined” box, type the port number, and select the protocol you want to enable. Click OK when you are done. A listing of which ports are used by different services can be found in `/etc/services` (the `/etc/services` file and ports are discussed more later in this chapter).

Before clicking Apply to save your settings, consider that doing so will overwrite your existing firewall rules. If you have done any hand editing of the configuration file (`/etc/sysconfig/iptables`), those changes will be overwritten. Make a backup copy of that file before continuing.

Configuring `iptables` to set up logging, port forwarding, network address translation, and other features can all be done manually, as described in the next sections.

## Configuring an iptables Firewall

The remaining sections on `iptables` in this chapter describe a more manual way of working with your `iptables` firewall in Linux. I also cover how to implement special features that are not available from the Firewall Configuration window, such as port forwarding and NAT.

## Turning on iptables

The iptables firewall feature, also referred to as *netfilter*, is the default firewall software when you install CentOS.

This section describes how to turn on iptables and set up firewall rules for several different types of situations. It also tells how to turn on features related to firewalls that allow your firewall to do Network Address Translation (NAT), IP masquerading, port forwarding, and transparent proxies.

### NOTE

The CentOS start-up scripts will *punch a hole* through your firewall if you use certain services, and will therefore work even if they are not explicitly enabled in your iptables configuration. For example, NTP (which sets your system time from a network time server) and DNS resolution (which lets you contact a DNS server to resolve addresses) both open the ports they need in your firewall.

The following procedure describes how to get iptables going on your CentOS system.

1. Set the iptables script to start automatically at boot time:

```
# chkconfig iptables on
```

2. Before you can start iptables, you must have a working set of rules that has been placed in your `/etc/sysconfig/iptables` file. To create those rules, refer to the examples in the following sections. (Without the configuration file in place, iptables fails silently.)

### TIP

If you are new to iptables, you can start with a workable set of default values by configuring your firewall during the CentOS installation. I recommend selecting to enable the firewall and enabling only those services you are ready to offer. The resulting `/etc/sysconfig/iptables` file will let you study how CentOS creates its firewalls rules.

3. If you are doing NAT or IP Masquerading, turn on IP packet forwarding. One way to allow this is to change the value of `net.ipv4.ip_forward` to 1 in the `/etc/sysctl.conf` file. Open that file as root user with any text editor and change the line to appear as follows:

```
net.ipv4.ip_forward = 1
```

4. Restart your network interfaces to have IP packet forwarding take effect.

```
# /etc/init.d/network restart
```

5. Once the rules file is in place, start up iptables:

```
# /etc/init.d/iptables start
```

6. At this point, iptables is installed as your firewall. You can check to see that the modules used by iptables are loaded by using the `lsmod` command. Here are some examples:

```
# lsmod |less
Module                Size  Used by
nf_conntrack_ftp      10656  0
```

```

ipt_REJECT                6784  3
nf_conntrack_ipv4        11396 6
nf_conntrack              51264 4
    nf_conntrack_ftp,nf_conntrack_ipv4,xt_state
iptables_filter           6528  1
ip_tables                 13840 1 iptable_filter
x_tables                  15380 7
    xt_tcpudp,ipt_REJECT,xt_state,ip_tables

```

7. If you want to allow passive FTP or IRC connections from computers on your LAN, you may need to load those modules by adding them to the `/etc/modprobe.conf` file. The basic connection tracking module, `ip_conntrack`, should be loaded by default already. See the description of passive FTP and IRC after the `firewall-example` sections.

If there is an error in your `/etc/sysconfig/iptables` file, you can make a copy of that file and then try to make a workable configuration by running `system-config-firewall` and setting up a basic firewall. You can then make changes to your firewall to add the features that you need.

### TIP

As you add `iptables` rules, more modules will have to be loaded. Appropriate modules should be loaded automatically when a new rule is entered. Run `lsmod | less` again after you have added a few rules to see which modules were added. Note that these modules will not be unloaded if you decide to stop `iptables`. They will stay loaded until the next reboot or until you remove them (`modprobe -r`).

The following sections contain examples of `iptables` firewall rules.

## Creating iptables Firewall Rules

One way to configure `iptables` is to start by adding and deleting rules to your kernel from the command line. Then when you get a set of rules that you like, you save the rules that are currently running on your system. The tools you use to create your firewall rules and then make them permanent are as follows:

- `iptables` — Use this command to append (`-A`), delete (`-D`), replace (`-R`), or insert (`-I`) a rule. Use the `-L` option to list all current rules.
- `service iptables save` — Use this command to save the rules from the kernel and install them in the configuration file.
- `/etc/sysconfig/iptables` — This is the configuration file that contains the rules that were saved from the `service iptables save` command.
- `/etc/sysconfig/iptables-config` — You can add settings for managing your `iptables` rules to the `iptables-config` file. For example, any `iptables` modules, such as `ip_conntrack` and others described later in this chapter, can be added to the `IPTABLES_MODULES` line to be loaded automatically. You can also set whether the `iptables` table in your running kernel is saved to a file when `iptables` stops.
- `/etc/init.d/iptables` — This is the `iptables` start-up script that must run automatically each time CentOS reboots. When it starts, it clears all `iptables` rules and counters and

installs the new rules from the `/etc/sysconfig/iptables` file. You can also use this script with different options from the command line to check the status of `iptables` (`status`) or to run `iptables -save` for you to save the current rules (`save`).

To get you started with `iptables`, I'm providing a sample set of rules along with descriptions of how you might change those rules for different situations. Here's how you could load and save any of the sets of rules described in the following example:

1. Stop `iptables` and clear all existing rules:

```
# /etc/init.d/iptables stop
```

2. Add the rules shown in the following example to a file, using any text editor. Modify the rules to suit your situation and save the file.
3. As `root` user, run the file as a shell script. For example, if you named the file `firescript`, you could run it as follows:

```
# sh firescript
```

4. See how the rules were loaded into the kernel:

```
# iptables -L
```

5. If everything looks OK, save the rules that are now in the kernel into the `/etc/sysconfig/iptables` file:

```
# cp /etc/sysconfig/iptables /etc/sysconfig/iptables-old  
# service iptables save
```

6. Start `iptables`:

```
# /etc/init.d/iptables start
```

From now on, the rules will be read each time you reboot or restart `iptables`. Save a copy of the script you used to create the rules, in case you ever need it again.

### **EXAMPLE 1: Firewall for Shared Internet Connection (Plus Servers)**

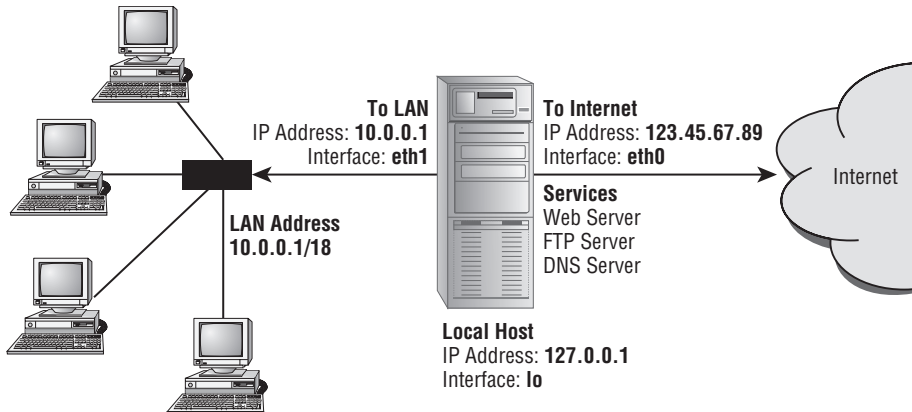
Because firewall configurations can be vastly different depending on what you are trying to achieve, I've illustrated how to configure firewalls based on several different example setups. These setups combine different levels of security requirements.

This example features a home- or small-office LAN with a CentOS system acting as an `iptables` firewall between the LAN and the Internet. The firewall computer also acts as a Web Server, FTP server, and DNS server. Figure 13-2 shows this configuration.

If you want to use the sample firewall script that follows, you must change the following information to match your configuration:

**FIGURE 13-2**

Using iptables as a firewall between the Internet and a LAN



### Firewall Computer

The firewall computer is set up as follows:

- **Local Host** — 127.0.0.1 (IP address) and lo (interface). You shouldn't need to change these.
- **Connection to the Internet** — 123.45.67.89 (IP address) and eth0 (interface). Replace them with the static IP address and interface name associated with your connection to the Internet, respectively.
- **Connection to the LAN** — 10.0.0.1 (IP address) and eth1 (interface). Replace 10.0.0.1 and eth1 with the static IP address and interface name associated with your connection to your LAN, respectively.
- **Computers on the LAN** — Each computer on the LAN in the example has an IP address from 10.0.0.2 to 10.0.0.254. Change 10.0.0.255 to a number that matches your LAN's range of addresses.

Here is an example of a script to load firewall rules that could be used for the configuration shown in Figure 13-2:

```
# (1) Policies (default)
iptables -P INPUT DROP
iptables -P OUTPUT DROP
iptables -P FORWARD DROP

# (2) User-defined chain for ACCEPTed TCP packets
iptables -N okay
```

```
iptables -A okay -p TCP --syn -j ACCEPT
iptables -A okay -p TCP -m state --state ESTABLISHED,RELATED -j
ACCEPT
iptables -A okay -p TCP -j DROP

# (3) INPUT chain rules

# Rules for incoming packets from LAN
iptables -A INPUT -p ALL -i eth1 -s 10.0.0.0/24 -j ACCEPT
iptables -A INPUT -p ALL -i lo -s 127.0.0.1 -j ACCEPT
iptables -A INPUT -p ALL -i lo -s 10.0.0.1 -j ACCEPT
iptables -A INPUT -p ALL -i lo -s 123.45.67.89 -j ACCEPT
iptables -A INPUT -p ALL -i eth1 -d 10.0.0.255 -j ACCEPT

# Rules for incoming packets from the Internet

# Packets for established connections
iptables -A INPUT -p ALL -d 123.45.67.89 -m state --state \
ESTABLISHED,RELATED -j ACCEPT

# TCP rules
iptables -A INPUT -p TCP -i eth0 --destination-port 21 -j okay
iptables -A INPUT -p TCP -i eth0 --destination-port 22 -j okay
iptables -A INPUT -p TCP -i eth0 --destination-port 53 -j okay
iptables -A INPUT -p TCP -i eth0 --destination-port 80 -j okay
iptables -A INPUT -p TCP -i eth0 --destination-port 113 -j okay
# UDP rules
iptables -A INPUT -p UDP -i eth0 --destination-port 53 -j ACCEPT
iptables -A INPUT -p UDP -i eth0 --destination-port 2074 -j ACCEPT
iptables -A INPUT -p UDP -i eth0 --destination-port 4000 -j ACCEPT

# ICMP rules
iptables -A INPUT -p ICMP -i eth0 --icmp-type 3 -j ACCEPT
iptables -A INPUT -p ICMP -i eth0 --icmp-type 8 -j ACCEPT
iptables -A INPUT -p ICMP -i eth0 --icmp-type 11 -j ACCEPT

# (4) FORWARD chain rules
# Accept the packets we want to forward
iptables -A FORWARD -i eth1 -j ACCEPT
iptables -A FORWARD -m state --state ESTABLISHED,RELATED -j ACCEPT

# (5) OUTPUT chain rules
# Only output packets with local addresses (no spoofing)
iptables -A OUTPUT -p ALL -s 127.0.0.1 -j ACCEPT
iptables -A OUTPUT -p ALL -s 10.0.0.1 -j ACCEPT
iptables -A OUTPUT -p ALL -s 123.45.67.89 -j ACCEPT

# (6) POSTROUTING chain rules
iptables -t nat -A POSTROUTING -o eth0 -j SNAT --to-source
123.45.67.89
```

I divided the commands in the preceding script into six sections. The following text describes each of those sections.

### (1) Policies

The `iptables -P` commands set the default policies for INPUT, OUTPUT, and FORWARD chains. By assigning each of those policies to DROP, any packet that isn't matched is discarded. In other words, for a packet to get through, it has to be specifically matched and ACCEPTed by one of the other rules in the script.

### (2) User-Defined Chain

A user-defined chain I call `okay` is created to do a few more checks on packets requesting certain TCP services that I'm going to allow through (Web, FTP, and DNS services). The `-N okay` option creates the `okay` chain. The next line says that a SYN packet (`--syn`), which requests a new connection, is fine to let through. The next line allows through packets associated with an ESTABLISHED connection (one that has already had traffic pass through the interface) or a RELATED connection (one that is starting a new connection related to an already established connection). The final line in this set tells iptables to DROP packets that don't meet one of those checks.

### (3) INPUT Chain Rules

The bulk of the packet filtering is done in the INPUT chain. The first set of input rules indicates to iptables when to always accept packets from the Internet and from the LAN. The next three sets determine which requests for specific protocols (TCP, UDP, and ICMP) are accepted:

- **Packets from LAN** — Because you want the users on your LAN and the firewall computer itself to be able to use the Internet, this set of rules lets through packets that are initiated from those computers. The first line tells iptables to accept packets for ALL protocols for which the source is an acceptable address on your LAN (`-s 10.0.0.0/24`, which represents IP numbers 10.0.0.1 through 10.0.0.254). The next three lines allow packets that come from all valid IP addresses on the firewall computer itself (`-s 127.0.0.1, 10.0.0.1 and 123.45.67.89`). The last line accepts broadcast packets (`-d 10.0.0.255`) on the LAN.
- **Packets from Internet (Already Connected)** — This line is split in two (I just used the backslash to join the lines because the page wasn't wide enough to show it as one line). It ACCEPTs packets that are both associated with connections that are already established (`--state ESTABLISHED, RELATED`) and are requested directly to the firewall's IP address (123.45.67.89).
- **TCP Rules (New Connections)** — Here is where you open up the ports for the TCP services you want to provide to anyone from the Internet. In these lines you open ports for FTP service (`--destination-port 21`), secure shell service (22), DNS if you need to offer zone transfers (53), Web Service (80), and IDENTD authentication (113), the last of which might be necessary for protocols such as IRC. Instead of accepting these requests immediately, you jump to the `okay` chain you defined to further check that the packets were formed properly.



**CAUTION**

You want to ensure that the services on the ports to which you are allowing access are properly configured before you allow packets to be accepted to them.

- **UDP Rules (New Connections)** — These lines define the ports where connection packets are accepted from the Internet for UDP services. In this example, I chose to accept requests for DNS service (`--destination-port 53`) because the computer is set up as a DNS server. The example also illustrates lines that accept requests for a couple of other optional ports. Port 2074 is needed by some multimedia applications the users on your LAN might want to use, and port 4000 is used by the ICQ protocol (for online chats).
- **ICMP Rules** — ICMP messages are really more for reporting conditions of the server than for actually providing services. Packets from the Internet that are accepted for ICMP protocol requests in our example are those for ICMP Types 3, 8, and 11. Type 3 service is needed when doing Path MTU Discovery (PMTUD). One of the answers of Type 3 is “Fragmentation needed but Don’t Fragment was set,” which is sent back to the origin host so that this host can then reduce its packet size. Type 8 service, which allows your computer to accept echo request messages, makes it possible for people to ping your computer to see if it is available. Type 11 service relates to packets whose time to live (TTL) was exceeded in transit, and for which you are accepting a “Time Exceeded” message that is being returned to you. (You need to accept Type 11 messages to use the `traceroute` command to find broken routes to hosts you want to reach.)

#### (4) FORWARD Chain Rules

Because this firewall is also acting as a router, FORWARD rules are needed to limit what the firewall will and will not pass between the two networks (Internet and local LAN). The first line forwards everything from the local LAN (`-A FORWARD -i eth1`). The second line forwards anything from the Internet that is associated with an established connection (`--state ESTABLISHED,RELATED`).

#### (5) OUTPUT Chain Rules

These rules basically exist to prevent anyone from your local computer from *spoofing* IP addresses (i.e., from saying packets are coming from somewhere that they are not). According to these three rules, each packet output from your firewall must have as its source address one of the addresses from the firewall computer’s interfaces (127.0.0.1, 10.0.0.1, or 123.45.67.89).

#### (6) POSTROUTING Chain Rules

The POSTROUTING chain defines rules for packets that have been accepted, but need additional processing. This is where the actual Network Address Translation (NAT) work takes place. For the NAT table (`-t nat`), in the POSTROUTING chain, all packets that go out to the Internet have their addresses translated to that of the firewall’s external interface (`--to-source 123.45.67.89`). In this case, I used the Source Network Address Translation (SNAT) chain because I have a static IP address (123.45.67.89) associated with my Internet connection. If I were using a dynamic IP address (via DHCP), I would use MASQUERADE instead of SNAT. I

would also have to change any references to `-d 123.45.67.89` to `-i eth0`. (Of course, you would be using a different IP address and possibly a different Ethernet interface.)

### **EXAMPLE 2: Firewall for Shared Internet Connection (No Servers)**

In this scenario, the firewall is protecting a Linux system (firewall) and several systems on the LAN that are only used to connect to the Internet. No servers are behind this firewall, so you want to prevent people from the Internet from requesting services.

You could use the same script shown in Example 1, but not use lines that request TCP services. So you could drop the user-defined chain in Section 2 and drop the TCP rules from Section 3. You could also remove the ICMP rules, if you don't want your firewall to be visible to ping requests (Type 8) and if you don't care about receiving messages when your packets exceed their TTL values (Type 11), such as when a packet runs into a broken router.

### **EXAMPLE 3: Firewall for Single Linux System with Internet Connection**

In this example, there is one network interface, connecting your CentOS system to the Internet. You are not sharing that connection with other computers, and you are not offering any services from your computer.

In this case, you could cut Sections 2, 4, and 6. From Section 3, you could cut all rules relating to incoming requests from the LAN and all TCP services. As I mentioned in Example 2, you could also remove the Type 8 ICMP rule to make your firewall invisible to ping requests from the Internet and the Type 11 ICMP rule to not accept messages about failed TTL packets.

## **Understanding iptables**

Now that you've seen something about what iptables rules look like and how you can get them going, step back a bit and see how iptables works.

The iptables feature works by having IP packets (i.e., network data) that enter or leave the firewall computer traverse a set of chains that define what is done with the packet. Each rule that you add essentially does both of the following:

- Checks whether a particular criterion is met (such as that a packet requests a particular service or comes from a particular address).
- Takes an action (such as dropping, accepting, or further processing a packet).

Different sets of rules are implemented for different types of tables. For example, tables exist for filtering (`filter`), network address translation (`nat`), and changing packet headers (`mangle`). Depending on the packet's source and destination, it traverses different chains. Most of the rules you create will relate to the `filter` table, which is implied if no other table is given.

The chains associated with the `filter` table are `INPUT`, `OUTPUT`, and `FORWARD`. You can add user-defined chains as well. You will probably be most interested in adding or removing particular TCP and UDP services using the basic rules shown in the previous example. Assign `ACCEPT`

to packets you want to go through and DROP to those you want to discard. You can also assign REJECT to drop a packet but return a message to the sender, or LOG to neither drop nor accept the message but to log information about the packet.

Many great features are built into iptables. The following descriptions tell you about some cool things you can do with iptables and give you some tips on using it.

### ***Allowing FTP and IRC Services through an iptables Firewall***

With passive FTP, the FTP client sends its IP address and the port number on which it will listen for data to the server. If that client is on a computer that is behind your firewall for which you are doing NAT, that information must be translated as well or the FTP server will not be able to communicate with the client.

iptables uses connection-tracking modules to track connections. Using this feature, it can look inside the data area of each FTP packet (i.e., not in the IP packet header) to get the information it needs to do NAT (remember that computers from the Internet can't talk directly to your private IP addresses). To do FTP connection tracking (to allow passive FTP connections to the clients on your LAN), you need to have the following modules loaded:

- `nf_ip_conntrack`
- `nf_ip_conntrack_ftp`
- `nf_ip_nat_ftp`

The same is true for chats and DCC sends, used to establish and monitor direct connections to IRC chat sessions. Addresses and port numbers are stored within the IRC protocol packets, so those packets must be translated, too. To allow clients on your LAN to use IRC services, you need to load the following modules:

- `nf_ip_conntrack_irc`
- `nf_ip_nat_irc`

The default port for IRC connections is 6667. If you don't want to use the default, you can add different port numbers when you load the connection-tracking modules:

```
modprobe nf_ip_conntrack_irc ports=6668,6669
```

### ***Using iptables to Do SNAT or IP Masquerading***

As noted in the iptables example, you can use Source Network Address Translation (SNAT) or IP Masquerading (MASQUERADE) to allow computers on your LAN with private IP addresses to access the Internet through your iptables firewall. Choose SNAT if you have a static IP address for your Internet connection and MASQUERADE if the IP address is assigned dynamically.

When you create the MASQUERADE or SNAT rule, it is added to the NAT table and the POSTROUTING chain. For MASQUERADE, you must provide the name of the interface, such

as `eth0`, `ppp0`, or `slip0`, to identify the route to the Internet or other outside network. For SNAT you must also identify the actual IP address of the interface. Here is an example of a MASQUERADE rule:

```
# iptables -t nat -A POSTROUTING -o eth0 -j MASQUERADE
```

Here is an example of a SNAT rule:

```
# iptables -t nat -A POSTROUTING -o eth0 -j SNAT --to-source  
12.12.12.12
```

You can add several source addresses if you have multiple addresses that provide a route to the Internet (e.g., `--to-source 12.12.12.12.1-12.12.12.12.254`). Although MASQUERADE uses some additional overhead, you probably need to use it instead of SNAT if you have a dial-up or other Internet connection for which the IP address changes on each connection.

Remember that you need to make sure that IP forwarding is turned on in the kernel. It is off by default. To turn it on permanently, edit the `/etc/sysctl.conf` file as described earlier. To turn it on temporarily, you can do the following:

```
# echo 1 > /proc/sys/net/ipv4/ip_forward
```

In common cases in which you don't know the IP address when you first establish the connection to the Internet through a dial-up, DSL, or cable modem connection, and you require dynamic IP addressing, turn on that service:

```
# echo 1 > /proc/sys/net/ipv4/ip_dynaddr
```

### **Using iptables as a Transparent Proxy**

With the REDIRECT target, you can cause traffic for a specific port on the firewall computer to be directed to a different one. Using this feature, you can direct host computers on your local LAN to a proxy service on your firewall computer without those hosts knowing it.

The following is an example of a set of command-line options to the `iptables` command that causes a request for Web Service (port 80) to be directed to a proxy service (port 3128):

```
# iptables -t nat -A PREROUTING -p tcp --dport 80 -j REDIRECT --to-  
ports 3128
```

You can use REDIRECT targets in PREROUTING and OUTPUT chains only within a `nat` table. You can also give a range of port numbers to spread the re-direction across multiple port numbers.

### **Using iptables to Do Port Forwarding**

What if you have only one static IP address, but you want to use a computer other than your firewall computer to provide Web, FTP, DNS, or some other service? You can use the Destina-

tion Network Address Translation (DNAT) feature to direct traffic for a particular port on your firewall to another computer.

For example, if you want all requests for Web Service (port 80) that are directed to the firewall computer (-d 15.15.15.15) to be directed to another computer on your LAN (such as 10.0.0.25), you can use the following `iptables` command:

```
# iptables -t nat -A PREROUTING -p tcp -d 15.15.15.15 --dport 80 \  
-j DNAT --to-destination 10.0.0.25
```

Note that the preceding example should actually appear on one line. The backslash indicates continuation on the next line.

You can also spread the load for the service you are forwarding by providing a range of IP addresses (e.g., `--to-destination 10.0.0.1-10.0.0.25`). Likewise, you can direct the request to a range of ports as well.

### Using Logging with IP Tables

Using the `LOG` target, you can log information about packets that meet the criteria you choose. In particular, you might want to use this feature to log packets that seem like they might be improper in some way. In other words, if you don't want to drop a packet for some reason, you can just log its activity and decide later if something needs to be corrected.

The `LOG` target directs log information to the standard tools used to do logging in CentOS: `dmesg` and `rsyslogd`. Here's an example of a rule using a `LOG` target:

```
-A FORWARD -p tcp -j LOG --log-level info
```

Instead of `info`, you could use any of the following log levels available with `rsyslog`: `emerg`, `alert`, `crit`, `err`, `warning`, `notice`, `info`, or `debug`. Using the `--log-prefix` option as follows, you could also add information to the front of all messages produced from this logging action:

```
-A FORWARD -p tcp -j LOG --log-level info --log-prefix "Forward  
INFO "
```

### Enhancing Your IP Tables Firewall

You can modify or expand on the IP Tables examples given in this chapter in many ways. `iptables` is tremendously flexible.

When you actually create your own IP Tables firewall, you should refer to the `iptables` man page (type **man iptables**) for detailed descriptions of options, ways of matching, ways of entering addresses, and other details. I also recommend an excellent `iptables` tutorial by Oskar Andreasson (<http://iptables-tutorial.frozentux.net>).

Here are a few tips for using `iptables` features:

- **Reduce Rules** — Try to improve performance by reducing the number of rules. Using subchains can keep a packet from seeing rules that don't apply to it.

- **Deal with Fragments** — Use the `-f` option to refer to the second and subsequent packets of a packet that was split into fragments. In general, it is safe to not drop second and third fragments for which you don't have a first packet fragment because they won't be reassembled. If you use NAT, the fragments are assembled before filtering, so you shouldn't have problems with unfiltered fragments being sent through.
- **Opposite** — To make a rule its opposite, use an exclamation mark (!).
- **All Interfaces** — To match all interfaces of a type, use a plus sign (+), as in `eth+`.
- **Blocking Connections** — Use the `--syn` option to block SYN packets (i.e., those packets requesting connections). This option applies only to TCP packets.
- **Limiting** — Use the `--limit` option to restrict the rate of matches that result in log messages. This option allows matches to produce messages only a limited number of times per second (the default is three per hour with bursts of five).
- **Denial of Service (DOS) Attacks** — You can use the `--limit` option to reduce the impact of DOS attacks, but it still won't stop them altogether. As long as the traffic is directed at your server, your network bandwidth is being leached away, and the machine still uses resources to ignore the data.
- **Table Types** — The default table type is `filter`. The other types of tables are `nat` (for IP Masquerading) and `mangle` (for altering packets). To use a table other than `filter`, you must add a `-t table_type` option, where `table_type` is either `nat` or `mangle`.

## Controlling Access to Services with TCP Wrappers

---

Completely disabling an unused service is fine, but what about the services that you really need? How can you selectively grant and deny access to these services? In the current version of CentOS, TCP wrapper support has been integrated into `xinetd`. `xinetd` will look at the files `/etc/hosts.allow` and `/etc/hosts.deny` to determine when a particular connection should be granted or refused for services such as `rlogin`, `rsh`, `telnet`, `finger`, and `talk`. TCP wrappers are also enabled by default for other services, such as a `vsftpd` FTP server (with `tcp_wrappers=YES` in your `vsftpd.conf` file).

When a service is requested that relies on TCP wrappers, the `hosts.allow` and `hosts.deny` files are scanned and checked for an entry that matches the IP address of the connecting machine. These checks are made when connection attempts occur:

- If the address is listed in the `hosts.allow` file, the connection is allowed and `hosts.deny` is not checked.
- If the address is in `hosts.deny` (but not the `hosts.allow` file), the connection is denied.
- If the address is in neither file, the connection is allowed.

It is not necessary (or even possible) to list every single address that may connect to your computer. The `hosts.allow` and `hosts.deny` files enable you to specify entire subnets and groups of addresses. You can even use the keyword `ALL` to specify all possible addresses. You can also restrict specific entries in these files so that they apply only to specific network services. Look at an example of a typical pair of `hosts.allow` and `hosts.deny` files. Here's the `/etc/hosts.allow` file:

```
#
# hosts.allow This file describes the names of the hosts which are
#             allowed to use the local INET services, as decided
#             by the '/usr/sbin/tcpd' server.
#

cups-lpd: 199.170.177.
in.telnetd: 199.170.177., .linuxtoys.net
vsftpd: ALL
```

Here's the `/etc/hosts.deny` file:

```
#
# hosts.deny This file describes the names of the hosts which are
#            *not* allowed to use the local INET services, as
#            decided by the '/usr/sbin/tcpd' server.
#

ALL: ALL
```

The preceding example is a rather restrictive configuration. It allows connections to the `cups-lpd` and `telnet` services from certain hosts, but then denies all other connections. It also allows connections to the FTP service (`vsftpd`) to all hosts. Let's examine the files in detail.

As usual, lines beginning with a `#` character are comments and are ignored by `xinetd` when it parses the file. Each non-comment line consists of a comma-separated list of daemons followed by a colon (`:`) character and then a comma-separated list of client addresses to check. In this context, a client is any computer that attempts to access a network service on your system.

A client entry can be a numeric IP address (such as `199.170.177.25`) or a hostname (such as `jukebox.linuxtoys.net`), but is more often a wildcard variation that specifies an entire range of addresses. A client entry can take four different forms. The online manual page for the `hosts.allow` file describes them as follows:

- **“A string that begins with a dot (.) character”** — A hostname is matched if the last components of its name match the specified pattern. For example, the pattern `.tue.nl` matches the hostname `wzv.win.tue.nl`.
- **“A string that ends with a dot (.) character”** — A host address is matched if its first numeric fields match the given string. For example, the pattern `131.155.` matches the address of (almost) every host on the Eindhoven University network (`131.155.x.x`).

- **“A string that begins with an at (@) sign is treated as an NIS netgroup name”** — A hostname is matched if it is a host member of the specified netgroup. Netgroup matches are not supported for daemon process names or for client user names.
- **“An expression of the form *n.n.n.n/m.m.m.m* is interpreted as a *net/mask pair*”** — A host address is matched if *net* is equal to the bitwise *and* of the address and the mask. For example, the *net/mask* pattern `131.155.72.0/255.255.254.0` matches every address in the range `131.155.72.0` through `131.155.73.255`.

The example `host.allow` contains the first two types of client specification. The entry `199.170.177.` will match any IP address that begins with that string, such as `199.170.177.25`. The client entry `.linuxtoys.net` will match hostnames such as `jukebox.linuxtoys.net` or `picframe.linuxtoys.net`.

Let's examine what happens when a host named `jukebox.linuxtoys.net` (with IP address `199.170.179.18`) connects to your CentOS system using the Telnet protocol:

1. `xinetd` receives the connection request.
2. `xinetd` begins comparing the address and name of `jukebox.linuxtoys.net` to the rules listed in `/etc/hosts.allow`. It starts at the top of the file and works its way down the file until finding a match. Both the daemon (the program handling the network service on your CentOS box) and the connecting client's IP address or name must match the information in the `hosts.allow` file. In this case, the second rule that is encountered matches the request:  

```
in.telnetd: 199.170.177., .linuxtoys.net
```
3. `Jukebox` is not in the `199.170.177` subnet, but it is in the `linuxtoys.net` domain. `xinetd` stops searching the file as soon as it finds this match.

**CAUTION**

While Telnet acts as a convenient example with `xinetd`, you should not run the Telnet service because of security concerns. Enable `ssh` instead for remote logins. See the later section on using the secure shell package for more on `ssh`.

How about if `jukebox` connects to your box using the `CUPS-lpd` protocol? In this case, it matches none of the rules in `hosts.allow`; the only line that refers to the `lpd` daemon does not refer to the `199.170.179` subnet or to the `linuxtoys.net` domain. `xinetd` continues on to the `hosts.deny` file. The entry `ALL: ALL` matches anything, so `tcpd` denies the connection.

The `ALL` wildcard was also used in the `hosts.allow` file. In this case, we are telling `xinetd` to permit absolutely any host to connect to the FTP service on the Linux box. This is appropriate for running an anonymous FTP server that anyone on the Internet can access. If you are not running an anonymous FTP site, you probably should not use the `ALL` flag.

A good rule of thumb is to make your `hosts.allow` and `hosts.deny` files as restrictive as possible and then explicitly enable only those services that you really need. Also, grant access only to those systems that really need access. Using the `ALL` flag to grant universal access to a particular



service may be easier than typing in a long list of subnets or domains, but better a few minutes spent on proper security measures than many hours recovering from a break-in.

**TIP**

You can further restrict access to services using various options within the `/etc/xinetd.conf` file, even to the point of limiting access to certain services to specific times of the day. Read the manual page for `xinetd` (by typing `man xinetd` at a command prompt) to learn more about these options.

## Checking Log Files

---

Preparing your system for a cracker attack is only part of the battle. You must also recognize a cracker attack when it is occurring. Understanding the various log files in which CentOS records important events is critical to this goal. The log files for your CentOS system can be found in the `/var/log` directory.

Because the system logs are plaintext files, you can view the contents of logs directly using any text editor or paging command (such as `less` or `more`). The `logwatch` facility that comes with CentOS sends daily highlights from your log files in an e-mail message to the root user. You can also add packages, such as `logsenry`, to monitor your log files.

## Replacing the `syslogd` Package

The default logging service in CentOS is `syslogd`. However, the newer `rsyslogd` is more flexible and powerful than its predecessor. I suggest that you install and use `rsyslogd`, and uninstall `syslogd`. You can do this at a Terminal window as root user:

```
# yum install rsyslog && yum remove syslogd
```

The `&&` is very important because removing the `syslogd` package without having a `syslog` replacement will remove most of your system!

After the `rsyslog` package has been installed with `yum`, you need to enable it with `chkconfig` and start the service.

```
# service rsyslog start  
# chkconfig rsyslog on
```

## Understanding the `rsyslogd` Service

Most of the files in the `/var/log` directory are maintained by the `rsyslogd` service. The `rsyslogd` daemon is the System Logging Daemon and acts as an extension of a previous logging system called `syslogd`. It accepts log messages from a variety of other programs and writes them to the appropriate log files. This is better than having every program write directly to its own log file because it allows you to centrally manage how log files are handled. It is possible to

configure `rsyslogd` to record varying levels of detail in the log files. It can be told to ignore all but the most critical message, or it can record every detail.

The `rsyslogd` daemon can even accept messages from other computers on your network. This is particularly handy because it enables you to centralize the management and reviewing of the log files from many systems on your network. There is also a major security benefit to this practice. If a system on your network is broken into, the cracker cannot delete or modify the log files because those files are stored on a separate computer.

It is important to remember, however, that those log messages are not, by default, encrypted. Anyone tapping into your local network will be able to eavesdrop on those messages as they pass from one machine to another. Also, although the cracker may not be able to change old log messages, she will be able to affect the system such that any new log messages should not be trusted.

It is not uncommon to run a dedicated `loghost`, a computer that serves no other purpose than to record log messages from other computers on the network. Because this system runs no other services, it is less likely that it will be broken into. This makes it nearly impossible for the cracker to erase her tracks. It does not, however, mean that all of the log messages are accurate after a cracker has broken into a machine on your network.

## Re-Redirecting Logs to a `loghost` with `rsyslogd`

To re-direct your computer's log files to another computer's `rsyslogd`, you must make some changes to your local `rsyslogd`'s configuration file. The file that you need to work with is `/etc/rsyslog.conf`. If you are not already `root`, become `root` and then open the `/etc/rsyslog.conf` file in a text editor (such as `vi`). You should see something similar to this:

```
# Log all kernel messages to the console.
# Logging much else clutters up the screen.
#kern.* /dev/console

# Log anything (except mail) of level info or higher.
# Don't log private authentication messages!
*.info;mail.none;authpriv.none;cron.none /var/log/messages

# The authpriv file has restricted access.
authpriv.* /var/log/secure

# Log all the mail messages in one place.
mail.* -/var/log/maillog

# Log cron stuff
cron.* /var/log/cron

# Everybody gets emergency messages
*.emerg *
```

```
# Save news errors of level crit and higher in a special file.
uucp,news.crit                               /var/log/spooler

# Save boot messages also to boot.log
local7.*                                       /var/log/boot.log
```

The lines beginning with a # character are comments. Other lines contain two columns of information, separated by spaces or tabs. The left field is a semicolon-separated list of message types and message priorities. The right field is the log file to which those messages should be written.

**NOTE**

Notice the dash (-) before the `/var/log/maillog` file. Normally, each log file is synced after every logging. A dash preceding the full path to the log file indicates that the file is not synced after each logging. While this might result in lost information if your machine crashes before the log is written, it can result in better performance on your system if you run verbose logging.

To send the messages to another computer (the `loghost`) instead of a file, simply replace the log filename with the @ character followed by the name of the `loghost`. For example, to re-direct the output normally sent to the `messages`, `secure`, and `maillog` log files, make these changes to the previous file:

```
# Log anything (except mail) of level info or higher.
# Don't log private authentication messages!
*.info;mail.none;authpriv.none;cron.none           @loghost

# The authpriv file has restricted access.
authpriv.*                                         @loghost

# Log all the mail messages in one place.
mail.*                                             @loghost
```

The messages will now be sent to the `rsyslogd` running on the computer named `loghost`. The name `loghost` was not an arbitrary choice. It is customary to create such a hostname and make it an alias to the actual system acting as the `loghost`. That way, if you ever need to switch the `loghost` duties to a different machine, you need to change only the `loghost` alias; you do not need to re-edit the `rsyslog.conf` file on every computer.

## Understanding the Messages Log File

Because of the many programs and services that record information to the messages log file, it is important that you understand the format of this file. Examining this file often gives you a good early warning of problems developing on your system. Each line in the file is a single message recorded by some program or service. Here is a snippet of an actual messages log file:

```
Feb 25 11:04:32 toys network: Bringing up loopback interface:
succeeded
Feb 25 11:04:35 toys network: Bringing up interface eth0: succeeded
Feb 25 13:01:14 toys vsftpd(pam_unix)[10565]: authentication failure;
```

```
logname= uid=0 euid=0 tty= ruser= rhost=10.0.0.5 user=chris
Feb 25 14:44:24 toys su(pam_unix)[11439]: session opened for
user root by chris(uid=500)
```

This is really very simple when you know what to look for. Each message is divided into five main parts. From left to right they are:

- The date and time that the message was logged
- The name of the computer that the message came from
- The program or service name that the message pertains to
- The process number (enclosed in square brackets) of the program sending the message
- The actual text message itself

Let's examine the previous file snippet. In the first two lines, you can see that I restarted the network. The next line shows that I tried to log in as the user named `chris` to get to the FTP server on this system from a computer at address `10.0.0.5`. (I typed the wrong password, and authentication failed.) The last line shows that I used the `su` command to become `root` user.

By occasionally reviewing the messages file and the secure file, it is possible to catch a cracking attempt before it is successful. If you see an excessive number of connection attempts for a particular service, especially if they are coming from systems on the Internet, you may be under attack.

## Tracking Log Messages with `logwatch`

Another way to keep up with the contents of your log files is with the `logwatch` facility. `logwatch` flags messages that might reflect a problem with your system and forwards them each day in an e-mail message to your system's `root` user. When you install CentOS, the `logwatch` package is installed and configured to watch your log files and report suspicious activities to your system administrator. Based on the `logwatch` cron file (`/etc/cron.daily/0logwatch`), the `logwatch` facility will:

- Run each morning at 4:00 a.m.
- Choose which log files to scan and where to send the e-mail message, based on the configuration file `/etc/logwatch/conf/logwatch.conf`. (The defaults are listed in `/usr/share/logwatch/default.conf`.)
- Send an e-mail message to the local computer's `root` user that reports potentially suspicious activity on your system, based on the contents of your log files.
- Report on administrative activities that could reflect a problem with the system.

The kind of information `logwatch` reports on includes users and groups that have been deleted, packages installed or uninstalled, and disk space consumed. The daily messages also show login activity through `ssh` over the network and file transfer activities. Failure messages are flagged and reported for each log file scanned.

Review the `/usr/share/logwatch/default.conf/logwatch.conf` file to see the options you have for configuring your `logwatch` service. To change any options, you can add them to the `/etc/logwatch/conf/logwatch.conf` file. Here are examples of some `logwatch` settings:

```
LogDir = /var/log
TmpDir = /var/cache/logwatch
MailTo = root
MailFrom = Logwatch
Print = No
Service = "-zz-network"      # Prevents execution of zz-network ser-
                             # vice, which
                             # prints useful network configura-
                             # tion info.
Service = "-zz-sys"         # Prevents execution of zz-sys ser-
                             # vice, which
                             # prints useful system configura-
                             # tion info.
Service = "-eximstats"      # Prevents execution of eximstats ser-
                             # vice, which
                             # is a wrapper for the eximstats program.
Range = yesterday
Detail = Low
Service = All
mailer = "sendmail -t"
```

`LogDir` sets the log file directory as `/var/log` (so any log files listed are shown as relative to that directory). The `/var/cache/logwatch` directory is used to hold temporary files. The daily e-mail report is sent to the `root` user on the local system (you can change `MailTo` to any valid e-mail address), with the sender (`MailFrom`) listed as `Logwatch`. You can change the `Print` value to `Yes` to have the report sent to standard output, instead of being mailed to the `MailTo` recipient. The `Range` is set to `yesterday`, which causes `logwatch` to search log files for the past day only. You can change the `Range` to `All` to search all past files available for a particular log file, as in `messages`, `messages.1`, `messages.2`, and so on. To increase the amount of detail (which is set to `Low` by default), you can identify `Detail` as `Medium` or `High` (or a number from 0 to 10). The mail application used to send the report is `sendmail`.

Most of the action that takes place by `logwatch` is based on the value of the `Service` entry. With `Service` set to `All`, all files in the `/usr/share/logwatch/conf/services` directory are used to produce the `logwatch` report. Files in this directory are each related to a service that is checked by `logwatch` and defines the type of information that is gathered for that service. Precede any service name that you want to disable with a dash (`-`). (By default, `zz-network`, `zz-sys`, and `eximstats` are disabled.)

## Using the Secure Shell Package

---

The Secure Shell package (SSH) provides shell services similar to other remote execution, remote copy, and remote login commands (such as the old UNIX `rsh`, `rnp`, and `rlogin`

commands), but encrypts the network traffic. It uses private-key cryptography, so it is ideal for use with Internet-connected computers. CentOS contains the following client and server software packages for SSH: `openssh`, `openssh-clients`, and `openssh-server` packages.

## Starting the SSH Service

If you have installed the `openssh-server` software package, the SSH server is automatically configured to start. The SSH daemon is started from the `/etc/init.d/sshd` start-up script. To make sure the service is set up to start automatically, type the following (as `root` user):

```
# chkconfig --list sshd
sshd      0:off  1:off  2:on   3:on   4:on   5:on   6:off
```

This shows that the `sshd` service is set to run in system states 2, 3, 4, and 5 (normal boot-up states) and set to be off in all other states. You can turn on the SSH service, if it is off, for your default run state, by typing the following as `root` user:

```
# chkconfig sshd on
```

This line turns on the SSH service when you enter run levels 2, 3, 4, or 5. To start the service immediately, type the following:

```
# /etc/init.d/sshd start
```

### NOTE

If you aren't able to connect to the `sshd` service from another computer, check that the firewall is open on your server to allow access to `tcp` port 22. That's the default port on which `sshd` listens for requests.

## Using the `ssh`, `sftp`, and `scp` commands

Three commands you can use with the SSH service are `ssh`, `sftp`, and `scp`. Remote users use the `ssh` command to log in to your system securely. The `scp` command lets remote users copy files to and from a system. The `sftp` command provides a safe way to access secure SFTP sites.

Like the normal remote shell services, secure shell looks in the `/etc/hosts.equiv` file and in a user's `.rhosts` file to determine whether it should allow a connection. It also looks in the SSH-specific files `/etc/shosts.equiv` and `.shosts`. Using the `shosts.equiv` and the `.shosts` files is preferable because it avoids granting access to the non-encrypted remote shell services. The `/etc/ssh/shosts.equiv` and `.shosts` files are functionally equivalent to the traditional `hosts.equiv` and `.rhosts` files, so the same instructions and rules apply. (Type **man hosts.equiv** for further information.)

Now you are ready to test the SSH service. From another computer upon which SSH has been installed (or even from the same computer if another is not available), type the `ssh` command followed by a space and the name of the system you are connecting to. For example, to connect to the system `ratbert.glaci.com`, type:

```
$ ssh ratbert.glaci.com
```

If this is the first time you have ever logged in to that system using the `ssh` command, it will ask you to confirm that you really want to connect. Type **yes** and press [Enter] when it asks this:

```
The authenticity of host 'ratbert.glaci.com (199.170.177.18)
' can't be established.
RSA key fingerprint is xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:
xx:xx.
Are you sure you want to continue connecting (yes/no)? yes
```

**CAUTION**

If you see an auth request a second time, this could possibly be a man-in-the-middle attack.

If you don't specify a username when you start the `ssh` connection, the SSH daemon assumes you want to use the username you are logged in as from the client. If you want to log in as a different username (e.g., `chris`), you could type the following:

```
$ ssh chris@ratbert.glaci.com
```

or

```
$ ssh -l chris ratbert.glaci.com
```

Once you are logged in, a shell prompt appears, and you can begin using the remote system as you would from a local shell.

The `scp` command is similar to the `rcp` command for copying files to and from Linux systems. Here is an example of using the `scp` command to copy a file called `memo` from the home directory of the user named `sally` to the `/tmp` directory on a computer called `flashg`:

```
$ scp /home/sally/memo flashg:/tmp
sally@flashg's password: *****
memo          100%|*****| 153  0:00
```

Enter the password for your username (if a password is requested). If the password is accepted, the remote system indicates that the file has been copied successfully.

Similarly, the `sftp` command starts an interactive FTP session with an FTP server that supports SSH connections. Many security-conscious people prefer `sftp` to other `ftp` clients because it provides a secure connection between you and the remote host. Here's an example:

```
$ sftp ftp.handsonhistory.com
Connecting to ftp.handsonhistory.com
sally@ftp.handsonhistory.com's password: *****
sftp>
```

At this point, you can begin an interactive FTP session. You can use `get` and `put` commands on files as you would using any FTP client, but with the comfort of knowing that you are working on a secure connection.

**TIP**

The `sftp` command, as with `ssh` and `scp`, requires that the SSH service be running on the server. If you can't connect to an FTP server using `sftp`, the SSH service may not be available.

## Using SSH, SCP, and SFTP without Passwords

For machines that you use a great deal, it is often helpful to set them up so that you do not have to use a password to log in. The following procedure shows you how to do that.

These steps will take you through setting up password-less authentication from one machine to another. In this example, the local user is named `george` on a computer named `host1`. The remote user is also `george` on a computer named `host2`.

1. Log in to the local computer. (In this example, I log in as `george` to `host1`.)

**NOTE**

Run Step 2 only once as local user on your local workstation. Do not run it again unless you lose your `ssh` keys. When configuring subsequent remote servers, skip right to Step 4.

2. Type the following to generate the `ssh` key:

```
$ ssh-keygen -t dsa
Generating public/private dsa key pair.
Enter file in which to save the key
(/home/george/.ssh/id_dsa): <Enter>
Enter passphrase (empty for no passphrase): <Enter>
Enter same passphrase again: <Enter>
Your identification has been saved in /home/george/.ssh/id_dsa.
Your public key has been saved in /home/george/.ssh/id_dsa.pub.
The key fingerprint is:
3b:c0:2f:63:a5:65:70:b7:4b:f0:2a:c4:18:24:47:69 george@host1
```

3. Accept the default key file location by pressing [Enter]. Then press [Enter] again (twice) to assign a blank passphrase. (If you enter a passphrase, you will be prompted for that passphrase and won't be able to log in without it.)
4. You must secure the permissions of your authentication keys by closing permissions to your home directory, `.ssh` directory, and authentication files as follows:

```
$ chmod go-w $HOME
$ chmod 700 $HOME/.ssh
$ chmod go-rwx $HOME/.ssh/*
```

5. Type the following to copy the key to the remote server (replace `george` with the remote username and `host2` with the remote hostname):

```
$ cd ~/.ssh
$ scp id_dsa.pub george@host2:/tmp
george@host2's password: *****
```



6. Type the following to add the `ssh` key to the remote user's authorization keys (the code should be on one line, not wrapped):

```
$ ssh george@host2 'cat /tmp/id_dsa.pub >>
/home/george/.ssh/authorized_keys'
```

**NOTE**

The previous two steps will ask for passwords. This is OK.

7. In order for the `sshd` daemon to accept the `authorized_keys` file you created, your home directories and authentication files must have secure permissions. To secure those files and directories, type the following (note that the double quotes are needed to prevent the `*` from being interpreted by the local shell):

```
$ ssh chester@host2 chmod go-w $HOME
$ ssh george@host2 chmod 700 $HOME/.ssh
$ ssh george@host2 "chmod go-rwx $HOME/.ssh/*"
```

8. Type the following to remove the key from the temporary directory:

```
$ ssh george@host2 rm /tmp/id_dsa.pub
```

It is important to note that once you have this working, it will work regardless of how many times the IP address changes on your local computer. IP address has nothing to do with this form of authentication.

## Securing Linux Servers

---

Opening up your system as a server on a public network creates a whole new set of challenges when it comes to security. Instead of just turning away nearly all incoming requests, your computer will be expected to respond to requests for supported services (such as Web, FTP, or mail service) by supplying information or possibly running scripts that take in data.

Entire books have been filled with information on how to go about securing your servers. Many businesses that rely on Internet servers assign full-time administrators to watch over the security of their servers. So, think of this section as an overview of some of the kinds of attacks to look out for and some tools available to secure your server.

## Understanding Attack Techniques

Attacks on computing systems take on different forms, depending on the goal and the resources of the attacker. Some attackers want to be disruptive, while others want to infiltrate your machines and use the resources for their own nefarious purposes. Still others are targeting your data for financial gain or blackmail. Here are three major categories of attacks:

- **Denial of Service (DOS)** — The easiest attacks to perpetrate are denial-of-service attacks. The primary purpose of these attacks is to disrupt the activities of a remote site by overloading it with irrelevant data. DOS attacks can be as simple as sending thousands of page requests per second at a web site. These types of attacks are easy to perpetrate and easy to protect against. Once you have a handle on where the attack is coming from, a simple phone call to the perpetrator's ISP will get the problem solved.
- **Distributed Denial of Service (DDOS)** — More advanced DOS attacks are called *distributed denial-of-service attacks*. DDOS attacks are much harder to perpetrate and nearly impossible to stop. In this form of attack, an attacker takes control of hundreds or even thousands of weakly secured Internet-connected computers. The attacker then directs them in unison to send a stream of irrelevant data to a single Internet host. The result is that the power of one attacker is magnified thousands of times. Instead of an attack coming from one direction, as is the case in a normal DOS, it comes from thousands of directions at once. The best defense against a DDOS attack is to contact your ISP to see if it can filter traffic at its border routers.

Many people use the excuse, "I have nothing on my machine anyone would want," to avoid having to consider security. The problem with this argument is that attackers have a lot of reasons to use your machine. The attacker can turn your machine into an agent for later use in a DDOS attack. More than once, authorities have shown up at the door of a dumbfounded computer user asking questions about threats originating from their computer. By ignoring security, the owners have opened themselves up to a great deal of liability.

- **Intrusion Attacks** — To use the resources of a target machine remotely, attackers must first look for an opening to exploit. In the absence of inside information such as passwords or encryption keys, they must scan the target machine to see what services are offered. Perhaps one of the services is weakly secured, and the attacker can use some known exploit to finagle his way in.

A tool called *nmap* is generally considered the best way to scan a host for services (note that *nmap* is a tool that can be used for good and bad). Once the attacker has a list of the available services running on his target, he needs to find a way to trick one of those services into letting him have privileged access to the system. Usually, this is done with a program called an *exploit*.

While DOS attacks are disruptive, intrusion-type attacks are the most damaging. The reasons are varied, but the result is always the same. An uninvited guest is now taking up residence on your machine and is using it in a way you have no control over.

## Protecting against Denial-of-Service Attacks

As explained earlier, a denial-of-service attack attempts to crash your computer or at least degrade its performance to an unusable level. There are a variety of denial-of-service exploits. Most try to overload some system resource, such as your available disk space or your Internet connection. Some common attacks and defenses are discussed in the following sections.

## Mailbombing

*Mailbombing* is the practice of sending so much e-mail to a particular user or system that the computer's hard drive becomes full. There are several ways to protect yourself from mailbombing. You can use the Procmail e-mail-filtering tool or configure your `sendmail` daemon.

**CROSS-REF** See Chapter 18 for a more complete description of `sendmail`.

### Blocking Mail with *procmail*

The Procmail e-mail-filtering tool is installed by default with CentOS and is tightly integrated with the `sendmail` e-mail daemon; thus, it can be used to selectively block or filter out specific types of e-mail. You can learn more about Procmail at the Procmail web site: [www.procmail.org](http://www.procmail.org).

To enable Procmail for your user account, create a `.procmailrc` file in your home directory. The file should be mode 0600 (readable by you but nobody else). Type the following, replacing *evilmail* with the actual e-mail address that is mailbombing you:

```
# Delete mail from evilmail
:0
* ^From.*evilmail
/dev/null
```

The Procmail recipe looks for the `From` line at the start of each e-mail to see if it includes the string *evilmail*. If it does, the message is sent to `/dev/null` (effectively throwing it away).

### Blocking Mail with *sendmail*

The Procmail e-mail tool works quite well when only one user is being mailbombed. If, however, the mailbombing affects many users, you should probably configure your `sendmail` daemon to block all e-mail from the mailbomber. Do this by adding the mailbomber's e-mail address or system name to the access file located in the `/etc/mail` directory.

Each line of the access file contains an e-mail address, hostname, domain, or IP address followed by a tab and then a keyword specifying what action to take when that entity sends you a message. Valid keywords are `OK`, `RELAY`, `REJECT`, `DISCARD`, and `ERROR`. Using the `REJECT` keyword will cause a sender's e-mail to be bounced back with an error message. The keyword `DISCARD` will cause the message to be silently dropped without sending an error back. You can even return a custom error message by using the `ERROR` keyword.

Thus, an example `/etc/mail/access` file may look similar to this:

```
# Check the /usr/share/doc/sendmail/README.cf file for a description
# of the format of this file. (search for access_db in that file)
# The /usr/share/doc/sendmail/README.cf is part of the sendmail-doc
# package.
```

```
#
# by default we allow relaying from localhost...
localhost.localdomain      RELAY
localhost                   RELAY
127.0.0.1                   RELAY
#
# Senders we want to Block
#
evilmailer@yahoo.com      REJECT
stimp.y.giaci.com         REJECT
cyberpromo.com            DISCARD
199.170.176.99            ERROR:"550 Die Spammer Scum!"
199.170.177               ERROR:"550 Email Refused"
```

As with most Linux configuration files, lines that begin with a pound (#) sign are comments. Our list of blocked spammers is at the end of this example file. Note that the address to block can be a complete e-mail address, a full hostname, a domain only, an IP address, or a subnet.

To block a particular e-mail address or host from mailbombing you, log in to your system as root, edit the `/etc/mail/access` file, and add a line to DISCARD mail from the offending sender.

After saving the file and exiting the editor, you must convert the access file into a hash-indexed database called `access.db`. The database is updated automatically the next time `sendmail` starts. Or you can convert the database immediately, as follows:

```
# cd /etc/mail
# make
```

`sendmail` should now discard e-mail from the addresses you added.

## Spam Relaying

Another way in which your e-mail services can be abused is by having your system used as a spam relay. *Spam* refers to the unsolicited junk e-mail that has become a common occurrence on the Internet. Spammers often deliver their annoying messages from a normal dial-up Internet account. They need some kind of high-capacity e-mail server to accept and buffer the payload of messages. They deliver the spam to the server all in one huge batch and then log off, letting the server do the work of delivering the messages to the many victims.

Naturally, no self-respecting Internet service provider (ISP) will cooperate with this action, so spammers resort to hijacking servers at another ISP to do the dirty work. Having your mailserver hijacked to act as a spam relay can have a devastating effect on your system and your reputation. Fortunately, open mail relaying is deactivated by default on CentOS installations. Open mail relaying is one security issue that you will not have to worry about.

You can allow specific hosts or domains to relay mail through your system by adding those senders to your `/etc/mail/access` file with keyword RELAY. By default, relaying is allowed only

from the local host. Refer to Chapter 18, as well as the `sendmail` documentation, for more information.

**TIP**

One package you might consider using to filter out spam on your mail server is `spamassassin`. SpamAssassin examines the text of incoming mail messages and attempts to filter out messages that are determined to be spam. SpamAssassin is described in Chapter 18. You should also check out The Spamhaus Project ([www.spamhaus.org](http://www.spamhaus.org)), which maintains the Spamhaus Block List to help you block verified spam sources and spam operations.

## Smurf Amplification Attack

*Smurfing* refers to a particular type of denial-of-service attack aimed at flooding your Internet connection. It can be a difficult attack to defend against because it is not easy to trace the attack to the attacker. Here is how smurfing works.

The attack makes use of the ICMP protocol, a service intended for checking the speed and availability of network connections. Using the `ping` command, you can send a network packet from your computer to another computer on the Internet. The remote computer will recognize the packet as an ICMP request and echo a reply packet to your computer. Your computer can then print a message revealing that the remote system is up and telling you how long it took to reply to the ping.

A *smurfing attack* uses a malformed ICMP request to bury your computer in network traffic. The attacker does this by bouncing a ping request off an unwitting third party in such a way that the reply is duplicated dozens or even hundreds of times. An organization with a fast Internet connection and a large number of computers is used as the relay. The destination address of the ping is set to an entire subnet instead of a single host. The return address is forged to be your machine's address instead of the actual sender. When the ICMP packet arrives at the unwitting relay's network, every host on that subnet replies to the ping! Furthermore, they reply to your computer instead of to the actual sender. If the relay's network has hundreds of computers, your Internet connection can be quickly flooded.

The best fix is to contact the organization being used as a relay and inform them of the abuse. Usually, they need only to reconfigure their Internet router to stop any future attacks. If the organization is uncooperative, you can minimize the effect of the attack by blocking the ICMP protocol on your router. This will at least keep the traffic off your internal network.

## Protecting against Distributed DOS Attacks

DDOS attacks are much harder to initiate and nearly impossible to stop. A DDOS attack begins with the penetration of hundreds or even thousands of weakly secured machines. These machines can then be directed to attack a single host based on the whims of the attacker.

With the advent of DSL and the cable modem, millions of people are enjoying Internet access with virtually no speed restrictions. In their rush to get online, many of those people neglect to implement even the most basic security. Because the vast majority of these people run Microsoft

operating systems, they tend to get hit with worms and viruses rather quickly. After the machine has been infiltrated, quite often the worm or virus installs a program on the victim's machine that instructs it to quietly *call home* and announce that it is now ready to do *the master's bidding*.

At the whim of the master, the infected machines can now be used to focus a concentrated stream of garbage data at a selected host. In concert with thousands of other infected machines, a *scriptkiddie* (someone, often a youngster, who doesn't have the knowledge to create worms or viruses, but has the inclination and small bit of skill needed to find and launch them) now has the power to take down nearly any site on the Internet.

Detecting a DDOS is similar to detecting a DOS attack. One or more of the following signs are likely to be present:

- Sustained saturated data link
- No reduction in link saturation during off-peak hours
- Hundreds or even thousands of simultaneous network connections
- Extremely slow system performance

To determine if your data link is saturated, the act of pinging an outside host can tell much of the story. Much higher than usual latency is a dead giveaway. Normal ping latency (i.e., the time it takes for a ping response to come back from a remote host) looks like the following:

```
# ping www.example.com
PING www.example.com (192.0.34.166) from 10.0.0.11: 56(84) bytes of
data
64 bytes from 192.0.34.166: icmp_seq=1 ttl=49 time=40.1 ms
64 bytes from 192.0.34.166: icmp_seq=2 ttl=49 time=42.5 ms
64 bytes from 192.0.34.166: icmp_seq=3 ttl=49 time=39.5 ms
64 bytes from 192.0.34.166: icmp_seq=4 ttl=49 time=38.4 ms
64 bytes from 192.0.34.166: icmp_seq=5 ttl=49 time=39.0 ms

--- www.example.com ping statistics ---
5 packets transmitted, 5 received, 0% loss, time 4035ms
rtt min/avg/max/mdev = 38.472/39.971/42.584/1.432 ms
```

In the preceding example, the average time for a ping packet to make the round trip was about 39 thousandths of a second.

A ping to a nearly saturated link will look like the following:

```
# ping www.example.com
PING www.example.com (192.0.34.166): from 10.0.0.11: 56(84)bytes of
data
64 bytes from 192.0.34.166: icmp_seq=1 ttl=62 time=1252 ms
64 bytes from 192.0.34.166: icmp_seq=2 ttl=62 time=1218 ms
64 bytes from 192.0.34.166: icmp_seq=3 ttl=62 time=1290 ms
64 bytes from 192.0.34.166: icmp_seq=4 ttl=62 time=1288 ms
```

```
64 bytes from 192.0.34.166: icmp_seq=5 ttl=62 time=1241 ms

--- www.example.com ping statistics ---
5 packets transmitted, 5 received, 0% loss, time 5032ms
rtt min/avg/max/mdev = 1218.059/1258.384/1290.861/28.000 ms
```

In this example, a ping packet took, on average, 1.3 seconds to make the round trip. From the first example to the second example, latency increased by a factor of 31! A data link that goes from working normally to slowing down by a factor of 31 is a clear sign that link utilization should be investigated.

For a more accurate measure of data throughput, a tool such as `ttcp` can be used. To test your connection with `ttcp`, you must have installed the `ttcp` RPM package on machines inside *and* outside of your network. (The `ttcp` package comes on the DVD included with this book.) If you are not sure whether the package is installed, simply type **ttcp** at a command prompt. You should see something like the following:

```
# ttcp
Usage: ttcp -t [-options] host [ < in ]
      ttcp -r [-options > out]
Common options:
  -4      Use IPv4
  -6      Use IPv6
  -l ###  length of bufs read from or written to network (default 8192)
  -u      use UDP instead of TCP
  -p ###  port number to send to or listen at (default 5001)
  -s      -t: source a pattern to network
          -r: sink (discard) all data from network
  -A      align the start of buffers to this modulus (default 16384)
  -O      start buffers at this offset from the modulus (default 0)
  -v      verbose: print more statistics
  -d      set SO_DEBUG socket option
  -b ###  set socket buffer size (if supported)
  -f X    format for rate: k,K = kilo{bit,byte}; m,M = mega; g,G = giga
Options specific to -t:
  -n ###  number of source bufs written to network (default 2048)
  -D      don't buffer TCP writes (sets TCP_NODELAY socket option)
  -w ###  number of microseconds to wait between each write
Options specific to -r:
  -B      for -s, only output full blocks as specified by -l (for TAR)
  -T      "touch": access each byte as it's read
  -I      if Specify the network interface (e.g. eth0) to use
```

The first step is to start up a receiver process on the server machine:

```
# ttcp -rs
ttcp-r: buflen=8192, nbuf=2048, align=16384/0, port=5001 tcp
ttcp-r: socket
```

The `-r` flag denotes that the server machine will be the receiver. The `-s` flag, in conjunction with the `-r` flag, tells `ttcp` that you want to ignore any received data.

The next step is to have someone outside of your data link, with a network link close to the same speed as yours, set up a `ttcp` sending process:

```
# ttcp -ts server.example.com
ttcp-t: buflen=8192, nbuf=2048, align=16384/0, port=5001 tcp ->
server.example.com
ttcp-t: socket
ttcp-t: connect
```

Let the process run for a few minutes and then press [Ctrl]+C on the transmitting side to stop the testing. The receiving side will then take a moment to calculate and present the results:

```
# ttcp -rs
ttcp-r: buflen=8192, nbuf=2048, align=16384/0, port=5001 tcp
ttcp-r: socket
ttcp-r: accept from 64.223.17.21
ttcp-r: 2102496 bytes in 70.02 real seconds = 29.32 KB/sec +++
ttcp-r: 1226 I/O calls, msec/call = 58.49, calls/sec = 17.51
ttcp-r: 0.0user 0.0sys 1:10real 0% 0i+0d 0maxrss 0+2pf 0+0csw
```

In this example, the average bandwidth between the two hosts was 29.32 KB/s. On a link suffering from a DDOS, this number would be a mere fraction of the actual bandwidth the data link is rated for.

If the data link is indeed saturated, the next step is to determine where the connections are coming from. A very effective way of doing this is with the `netstat` command, which is included as part of the base CentOS installation. Type the following to see connection information:

```
# netstat -tupn
```

Table 13-2 describes each of the `netstat` parameters used here.

**TABLE 13-2**

### netstat Parameters

Parameter	Description
<code>-t, --tcp</code>	Show TCP socket connections.
<code>-u, --udp</code>	Show UDP socket connections.
<code>-p, --program</code>	Show the PID and name of the program to which each socket belongs.
<code>-n, --numeric</code>	Show numerical address instead of trying to determine symbolic hostnames, ports, or usernames.



The following is an example of what the output might look like:

```
Active Internet connections (w/o servers)
Proto Recv-Q Send-Q Local Address      Foreign Address    State      PID/
                                     Program name
tcp      0      0 65.213.7.96:22    13.29.132.19:12545 ESTABLISHED 32376/
                                     sshd
tcp      0      224 65.213.7.96:22    13.29.210.13:29250 ESTABLISHED 13858/
                                     sshd
tcp      0      0 65.213.7.96:6667  13.29.194.190:33452 ESTABLISHED 1870/
                                     ircd
tcp      0      0 65.213.7.96:6667  216.39.144.152:42709 ESTABLISHED 1870/
                                     ircd
tcp      0      0 65.213.7.96:42352 67.113.1.99:53    TIME_WAIT  -
tcp      0      0 65.213.7.96:42354 83.152.6.9:113    TIME_WAIT  -
tcp      0      0 65.213.7.96:42351 83.152.6.9:113    TIME_WAIT  -
tcp      0      0 127.0.0.1:42355   127.0.0.1:783     TIME_WAIT  -
tcp      0      0 127.0.0.1:783    127.0.0.1:42353   TIME_WAIT  -
tcp      0      0 65.213.7.96:42348 19.15.11.1:25     TIME_WAIT  -
```

The output is organized into columns defined as follows:

- **Proto** — Protocol used by the socket
- **Recv-Q** — The number of bytes not yet copied by the user program attached to this socket
- **Send-Q** — The number of bytes not acknowledged by the host
- **Local Address** — Address and port number of the local end of the socket
- **Foreign Address** — Address and port number of the remote end of the socket
- **State** — Current state of the socket. Table 13-3 provides a list of socket states.
- **PID/Program Name** — Process ID and program name of the process that owns the socket

During a DOS attack, the foreign address is usually the same for each connection. In this case, it is a simple matter of typing the `whois` command, followed by the foreign IP address, to determine who owns the IP address of the machine causing the attack.

During a DDOS attack, the foreign address will likely be different for each connection. In this case, it is impossible to track down all of the offenders because there will likely be thousands of them. The best way to defend yourself is to contact your ISP and see if it can filter the traffic at its border routers.

## Protecting against Intrusion Attacks

Crackers have a wide variety of tools and techniques to assist them in breaking into your computer. Intrusion attacks focus on exploiting weaknesses in your security, so the crackers can take

more control of your system (and potentially do more damage) than they could from the outside.

**TABLE 13-3**

### Socket States

State	Description
ESTABLISHED	Socket has an established connection.
SYN_SENT	Socket is actively trying to establish a connection.
SYN_RECV	Connection request is received from the network.
FIN_WAIT1	Socket is closed and shutting down.
FIN_WAIT2	Socket is waiting for remote end to shut down.
TIME_WAIT	Socket is waiting after closing to handle packets still in the network.
CLOSED	Socket is not being used.
CLOSE_WAIT	The remote end has shut down, waiting for the socket to close.
LAST_ACK	The remote end has shut down, and the socket is closed, waiting for acknowledgment.
LISTEN	Socket is waiting for an incoming connection.
CLOSING	Both sides of the connection are shut down, but not all of your data has been sent.
UNKNOWN	The state of the socket is unknown.

Fortunately, there are many tools and techniques for combating intrusion attacks. This section discusses the most common break-in methods and the tools available to protect your system. Although the examples shown are specific to CentOS systems, the tools and techniques are generally applicable to any other Linux or UNIX-like operating system.

### Evaluating Access to Network Services

CentOS and its UNIX kin provide many network services, and with them many avenues for cracker attacks. You should know these services and how to limit access to them..

What do I mean by a *network service*? Basically, I am referring to a resource or facility that a remote user can request of the server machine, such as a login, file sharing, instant messaging, or other service. Routing e-mail is a network service. So is serving web pages. Your Linux box

has the potential to provide thousands of services. Many of them are listed in the `/etc/services` file. Look at a snippet of that file:

```
# /etc/services:
# service-name port/protocol [aliases ...] [# comment]
chargen      19/tcp      ttytst source
chargen      19/udp      ttytst source
ftp-data     20/tcp
ftp-data     20/udp
# 21 is registered to ftp, but also used by fsp
ftp          21/tcp
ftp          21/udp      fsp fspd
ssh         22/tcp      # SSH Remote Login Protocol
ssh         22/udp      # SSH Remote Login Protocol
telnet      23/tcp
telnet      23/udp
# 24 - private mail system
smtp        25/tcp      mail
```

After comment lines, you will notice three columns of information. The left column contains the name of each service. The middle column defines the port number and protocol type used for that service. The rightmost field contains an optional alias or list of aliases for the service.

As an example, examine the last entry in the file snippet. It describes the SMTP (Simple Mail Transfer Protocol) service, which is the service used for delivering e-mail over the Internet. The middle column contains the text `25/tcp`, which tells us that the SMTP protocol uses port 25 and uses the Transmission Control Protocol (TCP) as its protocol type.

What exactly is a *port number*? It is a unique number that has been set aside for a particular network service. It allows network connections to be properly routed to the software that handles that service. For example, when an e-mail message is delivered from some other computer to your Linux box, the remote system must first establish a network connection with your system. Your computer receives the connection request, examines it, sees it labeled for port 25, and thus knows that the connection should be handed to the program that handles e-mail (which happens to be `sendmail`).

I mentioned that SMTP uses the TCP protocol. Some services use UDP, the User Datagram Protocol. All you really need to know about TCP and UDP (for the purpose of this security discussion) is that they provide different ways of packaging the information sent over a network connection. A TCP connection provides error detection and retransmission of lost data. UDP doesn't check to ensure that the data arrived complete and intact; it is meant as a fast way to send non-critical information.

## Disabling Network Services

Although there are hundreds of services (listed in `/etc/services`) that potentially could be available and subject to attack on your CentOS system, in reality, only a few dozen services are installed,

and only a handful of those are on by default. Most network services are started by either the `xinetd` process or by a start-up script in the `/etc/init.d` directory.

`xinetd` is a daemon that listens on a great number of network port numbers. When a connection is made to a particular port number, `xinetd` automatically starts the appropriate program for that service and hands the connection to it. The `xinetd` daemon improves on its predecessor, `inetd`, by offering features that include more flexible access control, more logging settings, and denial-of-service prevention.

The configuration file `/etc/xinetd.conf` is used to provide default settings for the `xinetd` server. The directory `/etc/xinetd.d` contains files telling `xinetd` what ports to listen on and what programs to start. Each file contains configuration information for a single service, and the file is usually named after the service it configures. For example, to enable the `rsync` service, edit the `rsync` file in the `/etc/xinetd.d` directory, and look for a section similar to the following:

```
service rsync
{
    disable = yes
    socket_type      = stream
    wait            = no
    user            = root
    server          = /usr/bin/rsync
    server_args     = --daemon
    log_on_failure  += USERID
}
```

Note that the first line of this example identifies the service as `rsync`. This exactly matches the service name listed in the `/etc/services` file, causing the service to listen on port 873 for TCP and UDP protocols. You can see that the service is off by default (`disable = yes`). To enable the services, change the line to read like this:

```
disable = no
```

**NOTE**

The `rsync` service is a nice one to turn on if your machine is an FTP server. It allows people to use an `rsync` client (which includes a checksum-search algorithm) to download files from your server. With that feature, users can restart a disrupted download without having to start from the beginning.

Because most services are disabled by default, your computer is only as insecure as you make it. You can double-check that insecure services, such as `rlogin` and `rsh` (which are included in the `rsh-server` package), are also disabled by making sure that `disabled = yes` is set in the `/etc/xinetd.d/rlogin` and `rsh` files.

**TIP**

You can make the remote login service active but disable the use of the `/etc/host.equiv` and `.rhosts` files, requiring `rlogin` to always prompt for a password. Rather than disabling the service, locate the server line in the `rsh` file (`server = /usr/sbin/in.rshd`) and add a space followed by `-L` at the end. Of course, that doesn't change the fact that your password and data will still be sent unencrypted over the network.

You now need to send a signal to the `xinetd` process to tell it to reload its configuration file. The quickest way to do that is to reload the `xinetd` service. As the `root` user, type the following from a shell:

```
# service xinetd reload
Reloading configuration:      [ OK ]
```

That's it — you have enabled the `rsync` service. Provided that you have properly configured your FTP server (see Chapter 19), clients should now be able to download files from your computer via the `rsync` protocol and be able to restart interrupted downloads.

## Securing Servers with SELinux

Although SELinux can be used to lock down every aspect of a Linux system, the targeted policy included with the CentOS implementation of SELinux focuses on securing those services that are most vulnerable to attacks. The boundaries set in those policies help prevent a cracker who has compromised a service from compromising the rest of the system as well.

After you have opened a port in your firewall so others can request a service and then started that service to handle requests, SELinux can be used to set up walls around that service. As a result, its daemon process, configuration files, and data can't access resources they are not specifically allowed to access. The rest of your computer, then, is safer.

As SELinux developers continue to work out the kinks in SELinux, there has been a tendency for users to experience SELinux failures and just disable SELinux. If you have tried SELinux in the past and turned it off when you had a problem, consider that SELinux has improved quite a bit in recent versions and it might be time for you to try it again.

If you do encounter a failure related to SELinux, try to find out if SELinux should have caused the failure. In other words, maybe you were doing something that was unsafe and SELinux was right to fail. However, if the failure you encounter turns out to be a bug with SELinux, file a bug report to <http://bugzilla.redhat.com> and help make the service better.

See Chapter 9 for a more in-depth description of SELinux in CentOS.

## Protecting Web Servers with Certificates and Encryption

Previous sections told you how to lock the doors to your CentOS system to deny access to crackers. The best dead-bolt lock, however, is useless if you are mugged in your own driveway and have your keys stolen. Likewise, the best computer security can be for naught if you are sending passwords and other critical data unprotected across the Internet.

A savvy cracker can use a tool called a *protocol analyzer* or a *network sniffer* to peek at the data flowing across a network and pick out passwords, credit card data, and other juicy bits of information. The cracker does this by breaking into a poorly protected system on the same network

and running software, or by gaining physical access to the same network and plugging in her own equipment.

You can combat this sort of theft by using encryption. The two main types of encryption in use today are *symmetric cryptography* and *public-key cryptography*.

## Symmetric Cryptography

*Symmetric cryptography*, also called *private-key cryptography*, uses a single key to both encrypt and decrypt a message. This method is generally inappropriate for securing data that will be used by a third party, because of the complexity of secure key exchange. Symmetric cryptography is generally useful for encrypting data for one's own purposes.

A classic use of symmetric cryptography is for a personal password vault. Anyone who has been using the Internet for any amount of time has accumulated a quantity of usernames and passwords for accessing various sites and resources. A personal password vault lets you store this access information in an encrypted form. The end result is that you have to remember only one password to unlock all of your access information.

Until recently, the U.S. Government was standardized on a symmetric encryption algorithm called DES (Data Encryption Standard) to secure important information. Because there is no direct way to crack DES-encrypted data, to decrypt DES-encrypted data without a password, you would have to use an unimaginable amount of computing power to try to guess the password. This is also known as the *brute-force method* of decryption.

As personal computing power has increased nearly exponentially, the DES algorithm has had to be retired. In its place, after a very long and interesting search, the U.S. Government has accepted the Rijndael algorithm as what it calls the Advanced Encryption Standard (AES). Although the AES algorithm is also subject to brute-force attacks, it requires significantly more computing power to crack than the DES algorithm does.

For more information on AES, including a command-line implementation of the algorithm, you can visit <http://aescrypt.sourceforge.net/>.

## Public-Key Cryptography

*Public-key cryptography* does not suffer from key distribution problems, and that is why it is the preferred encryption method for secure Internet communication. This method uses two keys, one to encrypt the message and another to decrypt the message. The key used to encrypt the message is called the *public key* because it is made available for all to see. The key used to decrypt the message is the *private key* and is kept hidden. The entire process works like this:

Imagine that you want to send me a secure message using public-key encryption. Here is what we need:

1. I must have a public and private key pair. Depending on the circumstances, I may generate the keys myself (using special software) or obtain the keys from a key authority.

2. You want to send me a message, so you first look up my public key (or more accurately, the software you are using looks it up).
3. You encrypt the message with the public key. At this point, the message can only be decrypted with the private key (the public key cannot be used to decrypt the message).
4. I receive the message and use my private key to decrypt it.

## Secure Sockets Layer

A classic implementation of public-key cryptography is with Secure Sockets Layer (SSL) communication. This is the technology that enables you to securely submit your credit card information to an online merchant. The elements of an SSL-encrypted session are as follows:

- SSL-enabled Web browser (Firefox, Mozilla, Internet Explorer, Opera, Konquerer, etc.)
- SSL-enabled Web Server (Apache)
- SSL certificate

To initiate an SSL session, a Web browser first makes contact with a Web Server on port 443, also known as the HTTPS port (Hypertext Transport Protocol Secure). After a socket connection has been established between the two machines, the following occurs:

1. The server sends its SSL certificate to the browser.
2. The browser verifies the identity of the server through the SSL certificate.
3. The browser generates a symmetric encryption key.
4. The browser uses the SSL certificate to encrypt the symmetric encryption key.
5. The browser sends the encrypted key to the server.
6. The server decrypts the symmetric key with its private key counterpart of the public SSL certificate.
7. The browser and server can now encrypt and decrypt traffic based on a common knowledge of the symmetric key.

Secure data interchange can now occur.

## Creating SSL Certificates

In order to be able to use SSL certificates for secure HTTP data interchange, you must have an SSL-capable Web Server. The Apache Web Server (`httpd` and `mod_ssl` packages), which comes with CentOS, is SSL-capable.

Here are some of the files you will need to create your own SSL certificates for the Apache Web Server:

- `/etc/httpd/conf/httpd.conf` — Web Server configuration file
- `/etc/pki/tls/certs/Makefile` — Certificate building script
- `/etc/httpd/conf.d/ssl.conf` — Primary Web Server SSL configuration file

Now that you're familiar with the basic components, take a look at the tools used to create SSL certificates:

```
# cd /etc/pki/tls/certs
# make
This makefile allows you to create:
  o public/private key pairs
  o SSL certificate signing requests (CSRs)
  o self-signed SSL test certificates
```

```
To create a key pair, run "make SOMETHING.key".
To create a CSR, run "make SOMETHING.csr".
To create a test certificate, run "make SOMETHING.crt".
To create a key and a test certificate in one file, run "make SOME-
THING.pem".
```

```
To create a key for use with Apache, run "make genkey".
To create a CSR for use with Apache, run "make certreq".
To create a test certificate for use with Apache, run "make
testcert".
```

```
To create a test certificate with serial number
other than zero, add SERIAL=num
```

```
Examples:
make server.key
make server.csr
make server.crt
make stunnel.pem
make genkey
make certreq
make testcert
make server.crt SERIAL=1
make stunnel.pem SERIAL=2
make testcert SERIAL=3
```

The `make` command uses the `Makefile` to create SSL certificates. (The `make` command is used for a variety of software tasks with C and C++ programming.) Without any arguments, the `make` command simply prints the information listed above. The following defines each argument you can give to `make`:

- `make server.key` — Creates generic public/private key pairs.
- `make server.csr` — Generates a generic SSL certificate service request.
- `make server.crt` — Generates a generic SSL test certificate.
- `make stunnel.pem` — Generates a generic SSL test certificate, but puts the private key in the same file as the SSL test certificate.
- `make genkey` — Same as `make server.key` except it places the key in the `ssl.key` directory



- `make certreq` — Same as `make server.csr` except it places the certificate service request in the `ssl.csr` directory
- `make testcert` — Same as `make server.crt` except it places the test certificate in the `ssl.crt` directory
- `make server.crt SERIAL=1` — Generate the keys mentioned above using keys serial numbers other than zero.

### Using Third-Party Certificate Signers

In the real world, I know who you are because I recognize your face, your voice, and your mannerisms. On the Internet, I cannot see these things and must rely on a trusted third party to vouch for your identity. To ensure that a certificate is immutable, it has to be signed by a trusted third party when the certificate is issued and validated every time an end-user taking advantage of your secure site loads it. The following is a list of the trusted third-party certificate signers:

- **GlobalSign** — [www.globalsign.com/](http://www.globalsign.com/)
- **GeoTrust** — [www.geotrust.com/](http://www.geotrust.com/)
- **VeriSign** — [www.verisign.com/](http://www.verisign.com/)
- **RapidSSL.com** — [www.rapidssl.com/](http://www.rapidssl.com/)
- **Thawte** — [www.thawte.com/](http://www.thawte.com/)
- **Entrust** — [www.entrust.com/](http://www.entrust.com/)
- **ipsCA** — [www.ipsca.com/](http://www.ipsca.com/)
- **COMODO Group** — [www.comodogroup.com/](http://www.comodogroup.com/)

#### NOTE

Because of the fluid nature of the certificate business, some of these companies may not be in business when you read this, while others may have come into existence.

To get a more current list of certificate authorities, from your Mozilla Firefox browser select **Edit** > **Preferences**. From the Preferences window that appears, select **Advanced** > **Encryption** > **View Certificates**. From the Certificate Manager window that appears, refer to the **Authorities** tab to see **Certificate Authorities** from which you have received certificates. Consider using well-known certificate authorities for your publicly accessible resources.

Each of these certificate authorities has gotten a chunk of cryptographic code embedded into nearly every Web browser in the world. This chunk of cryptographic code allows a Web browser to determine whether or not an SSL certificate is authentic. Without this validation, it would be trivial for crackers to generate their own certificates and dupe people into thinking they are giving sensitive information to a reputable source.

Certificates that are not validated are called *self-signed certificates*. If you come across a site that has not had its identity authenticated by a trusted third party, your Web browser will display a message similar to the one shown in Figure 13-3.

**FIGURE 13-3**

A Page window alerts you when a site is not authenticated.



This does not necessarily mean that you are encountering anything illegal, immoral, or fattening. Many sites opt to go with self-signed certificates, not because they are trying to pull a fast one on you, but because there may not be any reason to validate the true owner of the certificate and they do not want to pay the cost of getting a certificate validated. Some reasons for using a self-signed certificate include:

- **The Web Site Accepts No Input** — In this case, you as the end-user have nothing to worry about. There is no one trying to steal your information because you aren't giving out any information. Most of the time this is done simply to secure the Web transmission from the server to you. The data in and of itself may not be sensitive, but, being a good *netizen*, the site has enabled you to secure the transmission to keep third parties from sniffing the traffic.
- **The Web Site Caters to a Small Clientele** — If you run a web site that has a very limited set of customers, such as an Application Service Provider, you can simply inform your users that you have no certificate signer and that they can browse the certificate information and validate it with you over the phone or in person.
- **Testing** — It makes no sense to pay for an SSL certificate if you are just testing a new web site or Web-based application. Use a self-signed certificate until you are ready to go live.

### Creating a Certificate Service Request

To create a third-party validated SSL certificate, you must first start with a Certificate Service Request (CSR). To create a CSR, do the following on your Web Server:

```
# cd /etc/pki/tls/certs
# make certreq
/usr/bin/openssl
```

You are about to be asked to enter information that will be incorporated into your certificate request.

What you are about to enter is what is called a Distinguished Name or a DN.

There are quite a few fields but you can leave some blank

For some fields there will be a default value,

If you enter '.', the field will be left blank.

-----

```
Country Name (2 letter code) [GB]:US
State or Province Name (full name) [Berkshire]: Connecticut
Locality Name (eg, city) [Newbury]: Mystic
Organization Name (eg, company) [My Company Ltd]:Acme Marina, Inc.
Organizational Unit Name (eg, section) []:InfoTech
Common Name (eg, your name or your server's hostname)
 []:www.acmemarina.com
Email Address []: webmaster@acmemarina.com
```

To complete the process, you will be asked if you want to add any extra attributes to your certificate. Unless you have a reason to provide more information, you should simply press [Enter] at each of the following prompts to leave them blank:

```
Please enter the following 'extra' attributes
to be sent with your certificate request
A challenge password []:
An optional company name []:
```

### Getting the CSR Signed

Once your CSR has been created, you need to send it to a signing authority for validation. The first step in this process is to select a signing authority. Each signing authority has different deals, prices, and products. Check out each of the signing authorities listed in the “Using Third-Party Certificate Signers” section earlier in this chapter to determine which works best for you. The following are areas where signing authorities differ:

- Credibility and stability
- Pricing
- Browser recognition

- Warranties
- Support
- Certificate strength

After you have selected your certificate signer, you have to go through some validation steps. Each signer has a different method of validating identity and certificate information. Some require that you fax articles of incorporation, while others require a company officer be made available to talk to a validation operator. At some point in the process, you will be asked to copy and paste the contents of the CSR you created into the signer's Web Form.

```
# cd /etc/pki/tls/certs
# cat localhost.csr
-----BEGIN CERTIFICATE REQUEST-----
MIIB6jCCAAMCAQAwgaxCzAJBgNVBAYTA1VTMRQwEgYDVoQIIEwTDb25uZWNOaWN1
dDEPMA0GA1UEBxMGTX1zdG1jMRowGAYDVQQKEzFhY211IE1hcm1uYSwgSW5jLjER
MA8GA1UECmISW5mb1RlY2gxGzAZBgNVBAMTEnd3dy5hY211bWYyaW5hLmNvbTEn
MCUGCSqGS1b3DQEJARYYd2VibWFzdGVyQGZjbWVtYXJpbnEuY29tMIGfMA0GCsqG
SIb3DQEBAQUAA4GNADCBiQKBgQDcYH4pjMxKMLdyXRmcoz8uBV0vw1NZHyRWw8ZG
u2eCbvji6w4wXuHwaDuxbuDBmw//Y9DMI2MXg4wDq4xmPi35Es010fw4ytZJn1yW
aU6cJVQro460nXyaqXZOPiRCxUSnGRU+0nsqKgf7LPpXv29S3QvMIBTYWzCkNnc
gWBwwwIDAQABoAAwDQYJKoZIhvcNAQEEBQADgYEANv6eJ0aJZGzopNR5h2YkR9Wg
78oB13mgoPH60Sccw3pWsoW4qb0Wq7on8dS/++Q0CZWZ1IgefgaSQMInKZ1II7Fs
YIwYBgpPTMC4bp0ZZtURCyQWrKIDXQBxw7B1U/3A25nvkRY7vgNL9Nq+7681EJ8
W9AJ3PX4vb2+ynttcBI=
-----END CERTIFICATE REQUEST-----
```

You can use your mouse to copy and paste the CSR into the signer's Web Form.

After you have completed the information validation, paid for the signing, and answered all of the questions, you have completed most of the process. In 48 to 72 hours you should receive an e-mail with your shiny new SSL certificate in it. The certificate will look similar to the following:

```
-----BEGIN CERTIFICATE-----
MIIEFjCCA3+gAwIBAgIQMI26Z2d6njZgN97tJAVF0DANBgkqhkiG9w0BAQFADCB
ujEfMBOGA1UEChMWVmVyaVNpZ24gVHJ1c3QgTmV0d29yaXZEXMBUeG1UECm0VmVy
aVNpZ24sIE1uXy4xMzAxBgNVBAsTK1Zlcm1TaWduIE1udG9ybmF0aW9uYWwgU2V5
dmV5IENBIC0gZ2Zhc3MgMzFJMEcG10rY2g0Dd3d3LnZlcm1zaWduLmNvbS9DUFMg
SW5jb3JwLmJ1Fj1Zi4gTE1BQk1MSVRZIEUR4oYyk5NyBwZjJpU21nbjAeFw0w
MzAxMTUwMDAwMDBaFw0wNDAxMTUyMzU5NT1aMIGuMQswCQYDVQGEwJVUzETMBEG
A1UECBMKV2FzaG1uZ3RvHiThErE371UEBxQLRmVkJXJhbcBXYXkxGzAZBgNVBAoU
Ek1ETSBTXJ2aWMLcywgSW5jLjEMMAoGA1UECmQDd3d3MTMwMQYDVQQLFCpUZXJt
cyBvZiB1c2UgYXQgd3d3LnZlcm1zaWduLmNvbS9ycGEgKGMpMDAxFDASBgNVBAMU
C21kbXN1cnYuY29tMIGfMA0GCsqGS1b3DQEBAQUAA4GNADCBiQKBgQDahSk+uzOf
7jjDFEnqT8UBa1L3yFILXFjhj3XpMXLgWzLmkDmdJjXsa4x7AhEpr1ubuVnHJVIO
FnLDopsx4pyr4n+P8FyS4M5grbcQzy2YnkM2jyqVF/7y0W2pD130t4eacYYaz4Qg
q9pTxxUzjEG4twvKCAFwfuheoGu1CMV2qQ1DAQABo4IBJTCCASewCQYDVROTBaiw
ADBEBgNVHSAEPTA7MDkGC2CGSAGG+EUBBxcDMC0wKAYIKwYBBQUHAGewHGH0dHBz
Oi8vd3d3LnZlcm1zaWduLmNvbS9ycGEwCwYDVRRPBAQDAGWgMcGA1UdJQohMB8G
```

```
CWCGSAGG+EIEM00c0wIYBQUHAwEGCCsGAQUFBwMCMDDQGCCsGAQUFBwEBBCgwJjAk
BggrBgEFBQcwAYYYaHR0cDovL29jc2AudmVyaXNpZ24uY29tL0NsYXNzM01udGVybmFOaW9u
O6A5oDeGNWh0dHA6Ly9jcmwudmVyaXNpZ24uY29tL0NsYXNzM01udGVybmFOaW9u
YWxTZXJ2ZXIuY3JsMBkGCmCGSAGG+E+f4Nfc3zYJ0DA5NzMWMTeyMA0GCSqGSIB3
DQEBBAUAA4GBAJ/PsVttm1DkQa i5nLeudLceb1F4isXP17B68wXLkIeRu4Novu13
81LZXnaR+acHeStR01b3rQPjgv2y1mwjkPmC1WjoeYfdxH7+Mbg/6fomnK9auWAT
WFOiFW/+a8OWRYQJLMA2VQOVhX4znjpGcVNY9AQSHm1UiESJy7vtd1iX
-----END CERTIFICATE-----
```

Copy and paste this certificate into an empty file called *server.crt*, which must reside in the */etc/pki/tls/certs* directory, and restart your Web Server:

```
# service httpd restart
```

Assuming your web site was previously working fine, you can now view it in a secure fashion by placing an *s* after the *http* in the web address. So if you previously viewed your web site at <http://www.acmemarina.com>, you can now view it in a secure fashion by going to <https://www.acmemarina.com>.

### Creating Self-Signed Certificates

Generating and running a self-signed SSL certificate is much easier than having a signed certificate. To generate a self-signed SSL certificate, do the following:

1. Remove the key and certificate that currently exist:

```
# rm /etc/pki/tls/certs/localhost.crt
# rm /etc/pki/tls/private/localhost.key
```

2. Create your own server key:

```
# make genkey
```

3. Create the self-signed certificate by typing the following:

```
# make testcert
umask 77 ; \
/usr/bin/openssl req -new -key /etc/httpd/conf/ssl.key/server.key
    -x509 -days 365 -out /etc/httpd/conf/ssl.key/server.crt
.
.
.
```

At this point, it is time to start adding some identifying information to the certificate. Before you can do this, you must unlock the private key you just created. Do so by typing the password you typed earlier. Then follow this sample procedure:

```
You are about to be asked to enter information that will be
    incorporated into your certificate request.
What you are about to enter is what is called
```

```

a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [GB]:US
State or Province Name (full name) [Berkshire]: Ohio
Locality Name (eg, city) [Newbury]: Cincinnati
Organization Name (eg, company) [My Company Ltd]:Industrial Press,
Inc.
Organizational Unit Name (eg, section) []:IT
Common Name (eg, your name or your server's hostname) []
:www.industrialpressinc.com
Email Address []: webmaster@industrialpressinc.com

```

The preceding generation process places all files in the proper place. All you need to do is restart your Web Server and add https instead of http in front of your URL. Don't forget: You'll get a certificate validation message from your Web browser, which you can safely ignore.

### ***Restarting Your Web Server***

By now, you've probably noticed that your Web Server requires you to enter your certificate password every time it is started. This is to prevent someone from breaking into your server and stealing your private key. Should this happen, you are safe in the knowledge that the private key is a jumbled mess. The cracker will not be able to make use of it. Without such protection, a cracker could get your private key and easily masquerade as you, appearing to be legitimate in all cases.

If you just cannot stand having to enter a password every time your Web Server starts and are willing to accept the increased risk, you can remove the password encryption on your private key. Simply do the following:

```

# cd /etc/pki/tls/private
# /usr/bin/openssl rsa -in localhost.key -out localhost.key

```

## **Exporting Encryption Technology**

**F**or many years, the U.S. Government treated encryption technology like munitions. As a result, anyone wanting to export encryption technology had to get an export license from the Commerce Department. This applied not only to encryption software developed within the United States, but also to software obtained from other countries and then re-exported to another country (or even

*continued*

*continued*

to the same country you got it from). Thus, if you installed encryption technology on your Linux system and then transported it out of the country, you were violating federal law! Furthermore, if you e-mailed encryption software to a friend in another country or let him or her download it from your server, you violated the law.

In January 2000, the U.S. export laws relating to encryption software were relaxed considerably. However, often the U.S. Commerce Department's Bureau of Export Administration requires a review of encryption products before they can be exported. U.S. companies are also still not allowed to export encryption technology to countries classified as supporting terrorism.

### **Troubleshooting Your Certificates**

The following tips should help if you are having problems with your SSL certificate:

- It's usual to use one SSL certificate per IP address. If you want to add more than one SSL-enabled web site to your server, you usually bind another IP address to the network interface. Now, however, you can do SSL-enabled name-based virtual hosting, where multiple hosts share the same IP address and port, using the Apache `mod_gnutls` module. If that interests you, refer to this site:

[www.g-loaded.eu/2007/08/10/  
ssl-enabled-name-based-apache-virtual-hosts-with-mod\\_gnutls/](http://www.g-loaded.eu/2007/08/10/ssl-enabled-name-based-apache-virtual-hosts-with-mod_gnutls/)

- Make sure you aren't blocking port 443 on your Web Server. All HTTPS requests come in on port 443. If you are blocking it, you will not be able to get secure pages.
- The certificate lasts for only one year. When that year is up, you have to renew your certificate with your certificate authority. Each certificate authority has a different procedure for doing this; check the authority's web site for more details.
- Make sure that you have the `mod_ssl` package installed. If it is not installed, you will not be able to serve any SSL-enabled traffic.

## **Summary**

---

With the rise of the Internet, security has become a critical issue for nearly all computer users. Properly using passwords, securely configuring network services, and monitoring log files are critical ways of keeping your computer secure. Using encryption keys, you can help verify the authenticity of those you communicate with, as well as make the data you transmit more secure. By following the recommendations in this chapter, you can begin to learn the techniques and tools that are available for keeping your CentOS systems secure.

# Part IV

# Networking

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**Making Servers Public with DNS**

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# Chapter 14

## Setting Up Network Connections and LANs

**W**ith computers becoming more mobile and wireless networks more common, setting up network connections is more diverse than in the days when most computers were at fixed locations and addresses. But, whether you are connecting to your own local area network (LAN) or a public wireless network, CentOS includes tools to set up the kind of network connections you want.

To allow you to manage your network connections interactively, CentOS includes NetworkManager. NetworkManager is described here for choosing and connecting to a wireless LAN because it includes an easy-to-use desktop applet that detects available wireless LANs and lets you choose the one you want to connect to.

In the home or in a small business, CentOS can help you connect to other Linux, Windows, and Mac computers so that you can share your computing equipment (files, printers, and devices). Add a connection to the Internet and routing among multiple LANs (described in Chapter 15), and CentOS can serve as a focal point for network computing in a larger enterprise. For times when you need more manual configuration for your LAN connections, this chapter describes how to use the Network Configuration window.

### Connecting to the Network with NetworkManager

---

NetworkManager is designed to make your network connections “just work.” It finds your network interface cards, then connects to the network

#### IN THIS CHAPTER

**Using NetworkManager for network connections**

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**Understanding local area networks**

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**Connecting to a LAN with NetworkManager**

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**Setting up a wired Ethernet LAN**

---

**Setting up a wireless LAN**

---

**Troubleshooting your LAN**

---

(when possible) or gives you easy choices to let you choose your network connection. If you change network connections, NetworkManager will likewise try to change attributes of your connection, such as IP addresses, DNS servers, and routes.

In most cases with NetworkManager, connecting to an existing network is simple:

- **Wired Network** — If a wired network interface is available and a DHCP server is found, CentOS will automatically connect you to that interface and use it as your default route.
- **Wireless Network** — If a wireless network interface is available, the NetworkManager applet menu shows all wireless networks that your wireless card can find. You simply choose the network you want and authenticate as needed.

If the NetworkManager service is enabled, you should see the connection icon on the desktop top panel, as shown in Figure 14-1.

**FIGURE 14-1**

The NetworkManager applet icon (upper left) shows that NetworkManager is running.



If you see the NetworkManager applet icon, you can immediately start using NetworkManager. If it is not displayed, check that NetworkManager is installed and start the service, as follows:

1. **Check for NetworkManager** — Type the following from a Terminal window to see if NetworkManager packages are installed:

```
$ rpm -qa NetworkManager*
NetworkManager-gnome-0.6.4-8.e15
NetworkManager-0.6.4-8.e15
NetworkManager-glib-0.6.4-8.e15
```

2. **Install NetworkManager** — If NetworkManager packages are not installed, type the following as root user from a Terminal window:

```
# yum install NetworkManager-gnome NetworkManager-glib
```

3. **Start NetworkManager** — Type the following commands (as root) to start the NetworkManager service immediately (`service`), and set it to start on every reboot:

```
# service NetworkManager start
# chkconfig NetworkManager on
```

With NetworkManager installed and running, you can begin using the NetworkManager applet on your GNOME desktop to manage your network interfaces.

With the NetworkManager service started, you can manage your network connections from the NetworkManager applet icon. With NetworkManager, you can work with wireless and wired Ethernet connections, as well as select to set up a virtual private network (VPN) from those connections.

## Connecting to a Wireless Network

To see wireless networks detected by your computer, click on the NetworkManager applet icon in the top panel. Provided that CentOS has a working driver for your wireless card, you will see a list of wireless networks that have been detected.

### NOTE

Although support for wireless LAN cards has dramatically improved in recent releases, there are still many wireless cards that are not supported out-of-the-box. If your wireless card is not properly detected, refer to the “Getting Wireless Drivers” section later in this chapter for descriptions of how to get and load appropriate wireless drivers.

Assuming that the network you want to connect to shows up under the “Wireless Networks” heading, you can click on that network. Type a password or encryption key and click Connect when you see the Wireless Network Secrets Required window.

If the password is correct, NetworkManager will use your new wireless connection as the default network route from your computer (disconnecting any wired Ethernet connection you may have).

Here are some other ways to work with wireless networks from the NetworkManager applet:

- **Existing Wireless Network** — If your wireless card is working, but the network you want doesn’t appear, click on the NetworkManager icon and select “Connect to Other Wireless Network” to select a different wireless network by name.
- **New Wireless Network** — To create your own wireless network, click on the NetworkManager icon and select “Create New Wireless Network.” When prompted, enter the network name and select the type of Wireless Security you want. You can then enter the passphrase that others would use to connect to your new wireless network.
- **Disable Wireless Network** — Right-click on the NetworkManager applet icon and uncheck the “Enable Wireless” box (so the checkbox disappears).

After you have established a connection, you can check information about that connection by right-clicking on the NetworkManager icon and selecting “Connection Information.” You will see the interface name, connection speed, driver name, IP address, and locations of DNS servers (among other information).

## Connecting to a Wired Network

As noted earlier, with your wired network plugged in and a DHCP server on the line, you probably don’t have to do anything to start your wired Ethernet network interface. However, if you

want to configure static IP addressing instead, I recommend that you use the Network Configuration window, described later in this chapter.

Once a wired network connection is working, however, you can use the NetworkManager applet to enable and disable the interface. To do that, right-click on the NetworkManager applet icon and select Enable Networking. That will toggle the network interface on and off.

## Setting Up a Virtual Private Network Connection

The NetworkManager applet offers some simple graphical tools for configuring your CentOS system to connect to a virtual private network (VPN). The following procedure describes how to configure NetworkManager to communicate with a remote `openvpn` server.

Sometimes the people and offices that have to work closely together are not physically close together. For example, you may have:

- Two branch offices that need to constantly share sales databases

or

- An employee who needs to access office computers, printers, and files from home

Rather than purchase expensive leased lines from a phone company, you want to use an inexpensive network medium, like the Internet, to let the two sides communicate. The problem is that you don't want to open up access to file sharing, print sharing, and other private services to the Internet. You also don't want communication between these sites to be exposed to anyone who is watching Internet traffic. One solution is to set up a VPN.

A VPN provides a way to set up secure communications over an otherwise insecure network. With a VPN connection in place, the two sides of a connection can communicate as safely as they do on the same corporate LAN. To do this, a VPN usually offers the following features:

- **Authentication** — Using passwords or other techniques, two ends of a communication can prove that they are who they say they are before accepting a connection. After the connection is in place, communications can flow in both directions across it.
- **Encryption** — By encrypting all data being sent between the two points on the public network, you can be assured that even if someone could see the packets you send, they couldn't read them. Creating a connection between two public network addresses to use for exchanging encrypted data is known as *tunneling*.

Before you can set up a VPN connection with NetworkManager, the basic service needs to be installed and running. Also, make sure the `NetworkManager-openvpn` and `openvpn` packages are installed from the EPEL (Extra Packages for Enterprise Linux) repository.

The following procedure assumes that NetworkManager is running and you can reach a computer on your network that has an active `openvpn` service. (See Chapter 15 for information on setting up a VPN server with `openvpn`.)

Click on the NetworkManager applet icon, then select VPN Connections ➤ Configure VPN. A VPN Connections window appears.

1. Select Add to see the “Create VPN Connection” window, and select Forward to continue.
2. For this example, select “OpenVPN Client” (Cisco VPN client is also available), and click Forward. You are asked to enter VPN connection information.
3. Fill in the following information for your openvpn client connection:
  - **Connection Name** — Name the connection anything you like.
  - **Gateway Address** — The name or IP address of the openvpn server that is acting as the gateway for your VPN connection
  - **Connection Type** — Select the default X.509 Certificates (if you are using the example server from Chapter 15). You can also select “Pre-shared key,” “Password Authentication,” or “X.509 with Password Authentication.”
  - **CA File** — Identify the location of the root CA certificate you copied from the key server (possibly to `/etc/openvpn/keys/ca.crt`).
  - **Certificate** — Identify the location of the client certificate you copied from the key server (possibly to `/etc/openvpn/keys/client01.crt`).
  - **Key** — Identify the location of the client key you copied from the key server (possibly to `/etc/openvpn/keys/client01.key`).Select Forward to continue.
4. If everything looks correct, select Apply to apply your new vpn connection.
5. If the openvpn server is up and running, you can try your new VPN connection. Select the NetworkManager applet. Then choose “VPN Connections” and select the name of the new VPN connection you just configured.

NetworkManager is still a work in progress, so the automated features may not extend as far as you would like. For example, when you change between wired and wireless interfaces, besides just bringing VPN interfaces up or down, you may also want to unmount and mount shared file systems. Work is under way in this area but has not yet been included in any formal release.

## Understanding Local Area Networks

---

Connecting the computers in your organization via a local area network (LAN) can save you a lot of time and money. Putting a small amount of money into networking hardware, even in a small configuration (less than five or six users), can save you from buying multiple printers, backup media, and other hardware. Add a single, shared Internet connection, and you no longer need multiple modems and Internet accounts.

With a LAN, you don't have to run down the hall anymore with your file on a disk or USB thumb drive to print it on your friend's printer. Information that had to wait for the mailroom to make the rounds can be sent in an instant to anyone (or everyone) on your LAN.

With a LAN, you begin to open the greatest potential of Linux — its ability to act as a server on a network. Adding it to your LAN can provide a focal point to workstations that could use Linux as a file server, a mail server, a print server, or a boot server. Those features are described later in this book.

Creating and configuring a LAN consists of these steps:

1. **Planning, Getting, and Setting Up LAN hardware** — This entails choosing a network topology, purchasing the equipment you need, and installing it (adding cards and connecting wires or using wireless antennas).
2. **Configuring TCP/IP** — To use most of the networking applications and tools that come with Linux, you must have TCP/IP configured. TCP/IP lets you communicate not only with computers on your LAN, but also with any computers that you can reach on your LAN, modem, or other network connection (particularly via the Internet).

## Planning, Getting, and Setting Up LAN Hardware

Even with a simple LAN, you must make some decisions about network topology (i.e., how computers are connected). You must also make some decisions about network equipment (network interface cards, wires, switches, etc.).

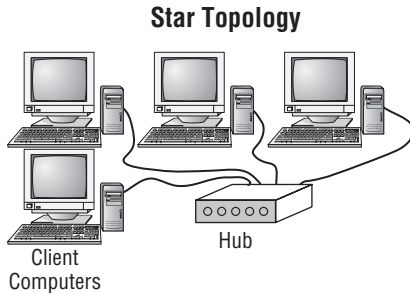
### LAN Topologies

Most small office and home LANs connect computers together in one of the following topologies:

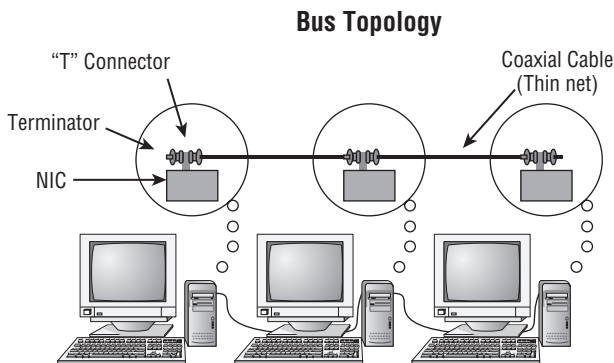
- **Star Topology** — The star topology is by far the most popular LAN topology. In this arrangement, each computer contains a Network Interface Card (NIC) that connects with a cable to a central network switch or hub. The cabling is typically Category 5 (unshielded twisted pair) wiring with RJ-45 connectors. Other equipment, such as printers and fax machines, can also be connected to the hub in a star topology. Figure 14-2 is an example of a star topology.
- **Bus Topology** — Instead of using switches or hubs, the bus topology connects computers in a chain from one to the next. The cabling usually used is referred to as *coaxial*, or *Thin Ethernet cable*. A T-connector attaches to each computer's NIC, then to two adjacent computers in the chain. At the two ends of the chain, the T-connectors are terminated. Figure 14-3 illustrates an example of a bus topology.
- **Ring Topology** — This is a less popular topology than star and bus topologies. In a ring topology, computers connect to a ring of wires on which tokens are taken and passed by computers that want to send information on the network. This type of topology typically uses IBM's token ring protocols.

**FIGURE 14-2**

In a star topology, machines on the network connect to a central switch or hub.

**FIGURE 14-3**

A bus topology chains computers together without using a hub.



You can configure a wireless Ethernet LAN in several different topologies, depending on how you want to use the LAN. With a wireless LAN, each computer broadcasts in the air rather than across wires. Here are some examples of wireless topologies:

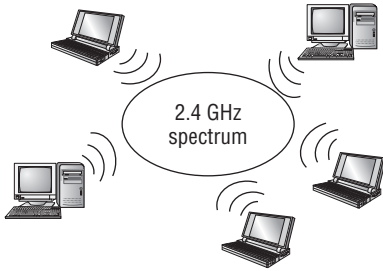
- **Wireless Peer-to-Peer** — In this topology, frames of data are broadcast to all nodes within range, but are consumed only by the computers for which they are intended. This arrangement is useful if you are sharing file and print services among a group of client computers. Figure 14-4 shows an example of a peer-to-peer wireless LAN.
- **Wireless Access Point** — A wireless interface can act as an access point for one or more wireless clients. Clients can be configured to communicate directly with the access point, instead of with every client that is within range. This arrangement is useful for point-to-point connections between two buildings, where the access point is acting as a



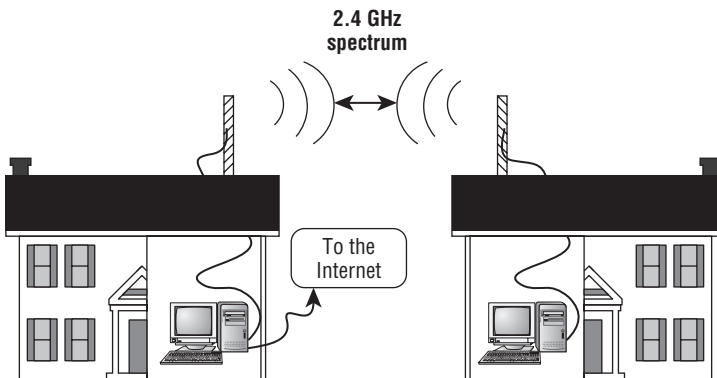
gateway to the Internet or, for example, a campus intranet. It is also the most popular topology for home wireless LANs. Figure 14-5 depicts a point-to-point wireless LAN.

**FIGURE 14-4**

Wireless LANs can communicate as peers by broadcasting data.

**FIGURE 14-5**

Wireless communication can go through an access point.



- **Multiple Wireless Access Points and Roaming** — Each wireless network can be configured as a separate cell. Multiple cells can be joined together in what is called a *Managed Wireless LAN*. In this arrangement, each cell's access point acts as a bridge (in fact, its actions are referred to as *bridging*) by passing all data from the cell to other cells without changing any node's MAC address. In other words, the managed wireless LAN masks the fact that there are multiple wireless cells invisible to the clients on those cells. This arrangement allows users to roam among cells as they come in and out of range without losing continuity of communication.

**NOTE**

Although Linux does not support any wireless LAN cards that can act as a bridging wireless access point, you can have the Linux system act as a client to a bridging access point. Set your card to Managed mode, and identify the MAC address for your wireless LAN's access point. For information on the current state of wireless Ethernet bridging, refer to the Bridging page at the OSDL web site (<http://linux-net.osdl.org/index.php/Bridge>).

For our purposes, we focus on star (wired) and peer-to-peer (wireless) topologies. Common to both of these topologies is the protocol used to send data over those wired and wireless media — the Ethernet protocol.

## LAN Equipment

The equipment that you need to connect your LAN can include some or all of the following:

**CROSS-REF**

For a complete description of wireless hardware, see the “Choosing Wireless Hardware” section later in this chapter.

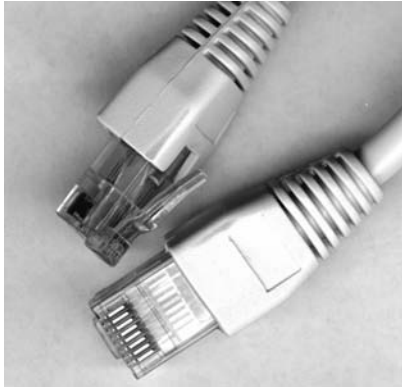
- **Network Interface Card (NIC)** — Typically, one of these cards goes into a slot in each computer. For wired Ethernet networks, the cards can transmit data at 10 Mbps (megabits per second) or 100 Mbps. Gigabit (1,000 Mbps) NICs are also available and have recently dropped quite a bit in price. An 802.11b wireless NIC card can operate at speeds of up to 11 Mbps but is more expensive than a wired NIC card. Recently, 802.11g cards have become much more popular, as well as coming down drastically in price.
- **Cables** — For star topologies, cables are referred to as *twisted-pair*. Category 5e wiring, which contains four twisted-pair sets per wire, is the most common type of wiring used for LANs today. A connector at each end of the cable is an RJ-45 plug, similar to those used on telephone cables. Ethernet interfaces are either 10Base-T (10-Mbps speeds) or 100Base-TX (100-Mbps speeds). These cables plug into the computer's NIC at one end and the hub at the other.

Figure 14-6 shows an example of a twisted-pair cable with an RJ-45 connector used for star topologies.

- **Hubs** — With the star topology, hubs were once the most popular way to connect computers. With low-cost network switches becoming more popular, however, hubs are now less often used. Sometimes hubs are also referred to as *repeaters* because they receive signals from the nodes connected to them and send the signals on to other nodes.
- **Switches** — Switches are now more commonly used than hubs. Switches let you divide a LAN that is getting too large into segments that are more manageable. A switch can reduce network traffic by directing messages intended for a specific computer directly to that computer. This is as opposed to a hub, which broadcasts all data to all nodes. Because switches have come down so much in price, in most cases, you should just pay a few extra dollars and get a switch instead of a hub. Besides the common 10/100-Mbps switches, Gigabit switches (1,000 Mbps) are now available for economical prices.

**FIGURE 14-6**

A star topology's twisted-pair cables have RJ-45 connectors (similar to telephone-cable connectors).



One piece of equipment that I won't go into yet is a router. A *router* is used to direct information from the LAN to other LANs or the Internet.

**CROSS-REF** Machines that carry out routing functions are described in Chapter 15.

### LAN Equipment Setup

With an Ethernet NIC, appropriate cables, and a hub or switch, you are ready to set up your wired Ethernet LAN. Most new computers include built-in Ethernet ports. If your computer doesn't have one, most PCI Ethernet cards you can purchase for only a few dollars can be used with Linux. The steps for setting up an Ethernet LAN are:

1. Power down each computer and physically install the NIC card (following the manufacturer's instructions). Note that many systemboards already include a NIC. You may not need to install any card in your computer.
2. Using cables appropriate for your NIC cards and switch, connect each NIC to the network switch.
3. Power up each computer.
4. If CentOS is not installed yet, install the software and reboot (as instructed). Chapter 2 tells you how to configure your Ethernet card while installing Linux.
5. If CentOS is already installed, refer to the section "Configuring TCP/IP for Your LAN" for information on configuring your Ethernet cards.
6. When the system comes up, your Ethernet card and interface (`eth0`) should be ready to use.

For most wired Ethernet cards, Linux will properly detect the card and load the module needed for that card to start communicating. Wireless cards, however, often require special firmware to be installed on your CentOS system. If your card is not immediately detected and configured, descriptions later in this chapter will help you get the firmware and drivers you need.

If your card is working, you can continue on to configure TCP/IP for that card. If not, refer to the section, “Troubleshooting Your LAN,” later in this chapter to learn how to check your Ethernet connection.

## Configuring TCP/IP for Your LAN

When you install CentOS, you are given the opportunity to add your TCP/IP hostname and IP address, as well as some other information, to your computer or choose to have that information automatically provided using Dynamic Host Configuration Protocol (DHCP). You also can set up a way to reach other computers on your LAN by name. With very small LANs, that can be done by adding computer names and IP addresses to your `/etc/hosts` file (as described here) or (with more than a few machines) using a DNS server.

**CROSS-REF** DNS is discussed in Chapter 15. Configuring your own DNS server is described in Chapter 24.

If you did not configure your LAN connection during installation of Linux, you can either use NetworkManager (described earlier) to connect to your wired or wireless networks or the Network Configuration window (run the `system-config-network` command to start it). Using the Network Configuration window, the IP address and hostnames can be assigned statically to an Ethernet interface or retrieved dynamically at boot time from a DHCP server.

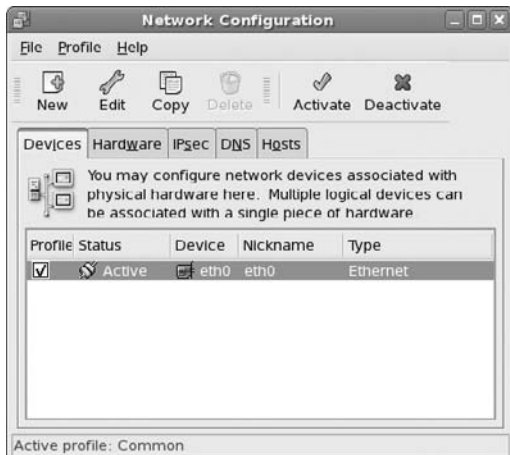
**NOTE** A computer can have more than one IP address because it can have multiple network interfaces. Each network interface connected to the network must have an IP address (even if the address is assigned temporarily). So, if you have two Ethernet cards (`eth0` and `eth1`), each needs its own IP address. Also, the address `127.0.0.1` represents the local host, so users on the local computer can access services in loopback.

To use the Network Configuration window to define your IP address for your Ethernet interface, follow this procedure:

1. Start the Network Configuration. From the top panel, click **System** > **Administration** > **Network** or, as `root` user from a Terminal window, type **system-config-network**. The Network Configuration window appears as shown in Figure 14-7.
2. Click on the Devices tab. A listing of your existing network interfaces appears.
3. Double-click on the `eth0` interface (representing your first Ethernet card). A pop-up window appears, enabling you to configure your `eth0` interface. Figure 14-8 shows the pop-up Ethernet Device window configuring `eth0`.

**FIGURE 14-7**

Configure your LAN interface using the Network Configuration window.

**FIGURE 14-8**

Configure your eth0 interface using the Ethernet Device window.



4. On the Ethernet Devices window that appears, you can enter the following information:
  - **“Activate device when computer starts”** — Check here to have `eth0` start at boot time.
  - **“Allow all users to enable and disable the device”** — Check to let non-root users enable and disable the network interface.
  - **“Enable IPv6 configuration for this interface”** — Check here if you are connected to an IPV6 network. (Most networks are still IPV4.)
5. On the same window, you must choose whether to get your IP addresses from another computer at boot time or enter the addresses yourself:
  - **“Automatically obtain IP address settings with . . . ”** — Select this checkbox if you have a DHCP or BOOTP server on the network from which you can obtain your computer’s IP address, netmask, and gateway. DHCP is the most common way to connect to your ISP. You should consider setting up your own DHCP server if you have more than just a few computers on your LAN. (See Chapter 24 for how to set up a DHCP server.) You can, optionally, set your own hostname, which can be just a name (such as `zarkov`) or a fully qualified domain name (such as `zarkov.example.com`).
  - **“Statically set IP addresses”** — If there is no DHCP, or other boot server, on your LAN, you can add necessary IP address information statically by selecting this option and adding the following information:
    - **“Address”** — Type the IP address of this computer into the Address box. This number must be unique on your network. For your private LAN, you can use private IP addresses (see the section, “Understanding IP Addresses,” later in this chapter).
    - **“Subnet mask”** — Enter the netmask to indicate what part of the IP address represents the network. (Netmask is described later in this chapter.)
    - **“Default gateway address”** — If a computer or router connected to your LAN is providing routing functions to the Internet or other network, type the IP address of the computer into this box. (Chapter 15 describes how to use NAT or IP masquerading and use CentOS as a router.)
  - **“Set MTU to . . . ”** — The maximum transfer unit (MTU) sets the number of 8-bit bytes that are available to the Internet Protocol in a link-layer frame. Click the checkbox and enter a number to change from the default 1,500 MTU used by default for Ethernet interfaces in Linux. Lower rates can result in fewer packets being dropped on unreliable networks (some gamers like to lower the rate slightly, so fewer small actions are dropped). Higher rates can improve performance of large data transfers on reliable networks. In most cases, you don’t need to modify this.
6. Click OK in the Ethernet Device window to save the configuration and close the window.
7. Click File ➤ Save to save the information you entered.
8. Click Activate in the Network Configuration window to start your connection to the LAN.

## Identifying Other Computers (Hosts and DNS)

Each time you use a name to identify a computer, as when browsing the Web or using an e-mail address, the computer name must be translated into an IP address. To resolve names to IP addresses, CentOS goes through a search order (based on the contents of three files in the `/etc` directory: `resolv.conf`, `nsswitch.conf`, and `host.conf`). By default, it checks:

- Hostnames you add yourself (which end up in the `/etc/hosts` file)
- Hosts available via NIS (if an NIS server is configured as described in Chapter 22)
- Hostnames available via DNS

You can use the Network Configuration window to add:

- **Hostnames and IP Addresses** — You might do this to identify hosts on your LAN that are not configured on a DNS server.
- **DNS Search Path** — By adding domain names to a search path (e.g., `example.com`), you can browse to a site by its hostname (such as `zarkov`) and have Linux search the domains you added to the search path to find the host you are looking for (e.g., `zarkov.example.com`).
- **DNS Name Servers** — A DNS server can resolve addresses for the domains it serves and contact other DNS servers to get addresses for all other DNS domains.

### NOTE

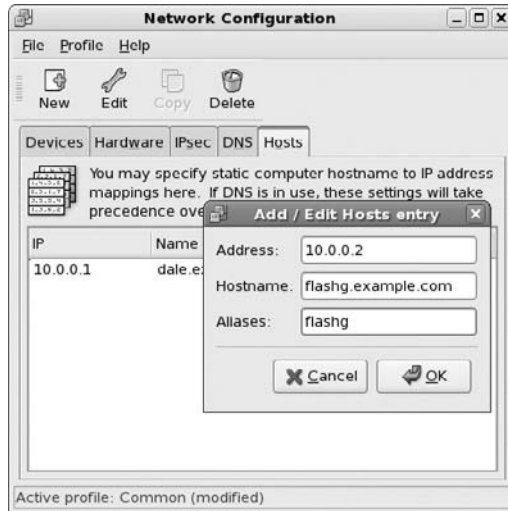
If you are configuring a DNS server, you can use that server to centrally store names and IP addresses for your LAN. This saves you the trouble of updating every computer's `/etc/hosts` file every time you add or change a computer on your LAN. Refer to Chapter 24 to learn how to set up a DNS server.

To add hostnames, IP addresses, search paths, and DNS servers, do the following:

1. Start the Network Configuration. As `root` user from a Terminal window, type **system-config-network** or from the Desktop menu, click System Settings > Network. The Network Configuration window appears.
2. Click on the Hosts tab. A list of IP addresses, hostnames, and aliases appears.
3. Click New. A pop-up window appears asking you to add the IP address, hostname, and aliases for a host that you can reach on your network. Figure 14-9 shows the Network Configuration window and the pop-up window for adding a host.
4. Type in the IP address number, hostname, and, optionally, the host alias.
5. Click OK.
6. Repeat this process until you have added every computer on your LAN.
7. Click on the DNS tab.
8. Type the IP address of the computers that serve as your Primary and Secondary DNS servers. You get these IP addresses from your ISP or, if you created your own DNS server, you can enter that server's IP address.

**FIGURE 14-9**

Add hosts to `/etc/hosts` using the Network Configuration window.



9. Type the name of the domain (probably the name of your local domain) to be searched for hostnames into the DNS “Search Path” box.
10. Select File ➤ Save to save the changes.
11. Select File ➤ Quit to exit.

Now, when you use programs such as `ftp`, `ssh`, or other TCP/IP utilities, you can use any hostname that is identified on your local computer, exists in your search path domain, or can be resolved from the public Internet DNS servers.

**NOTE**

Strictly speaking, you don't have to set up your `/etc/hosts` file. You could use IP addresses as arguments to TCP/IP commands, but names are easier to work with.

## Setting Up a Wireless LAN

Sometimes it's not convenient to run wires to all the computers on your network. Pulling Ethernet cables through existing walls can be a pain. Dragging wires into your garden so you can sit in a lounge chair and surf the Internet can ruin the ambience. With the inexpensive, high-speed wireless equipment available today, a wireless LAN is an economical solution.

Although you can use wireless LAN cards with other computer systems, you may want to use Linux systems for one or more nodes in your wireless network. For example, the features in



Linux can eliminate the need to buy other types of equipment. Some additional features that make Linux a valuable asset on a wireless LAN include:

- **Internet Access** — You don't need a separate router or gateway machine to attach your wireless LAN to the Internet. Having wired and wireless Ethernet LAN cards on a Linux system enables your wireless clients to access the Internet through your Linux system.
- **Firewall** — Owing to some inherent security weaknesses with wireless encryption protocols, you may want to add an extra measure of security to your network by configuring firewalls. With a Linux firewall (iptables) at the boundary between your wireless LAN and your larger network, you still have a measure of protection for your larger network if someone cracks your wireless LAN.
- **Monitoring and Logging** — All the tools you use for monitoring and logging activity on your wired networks in Linux are also available for your wireless network.

**NOTE**

Keep in mind that you don't have to use CentOS to provide Internet access, firewalls, and monitoring. There are several Linux firewall distributions that were created specifically for this purpose that can run from live CDs or even floppy disks.

Support for different wireless cards and tools for connecting to wireless networks have improved tremendously. In most cases, to connect to a wireless network, you can just use NetworkManager (as described earlier in this chapter), and you can skip this section altogether. However, in cases in which your wireless card isn't properly detected or configured, this section should help you find the drivers you need and do any manual configuration necessary.

This section describes how to use wireless LAN equipment on computers running CentOS to create a wireless Ethernet LAN. It focuses on configuring two Linux systems for wireless communication; however, once you configure these nodes, you can add Windows, Linux, or other types of systems to your wireless LAN by installing compatible wireless cards on each system.

## Understanding Wireless Networks

Wireless LANs are most appropriate in environments where wires are impractical. Despite some challenges such as security and interference, a wireless LAN provides these advantages:

- You don't have to run wires in places that are hard to reach. In many cases, a single wireless LAN can extend your network throughout a building or to another building without the need for wires between each node.
- For the price of a wireless card, you can save the expense of wires, network switches (the air is your switch), and wall repairs (to fix the holes from pulling wires through).
- You can freely move computers around within the transmission range that your environment allows (distances being limited by such variables as antenna power, obstacles, and rates of transmission).

Although several different wireless networking standards exist, this chapter focuses on the installation of relatively low-cost, standard IEEE 802.11b and 802.11g wireless-networking equipment. An 802.11b or 802.11g wireless network uses space in the spectrum available to the

public (in other words, you use space in the air for which no special license is required). The 802.11 standards are often referred to as the *Wi-Fi*, or *Wireless Fidelity*, standard.

An 802.11 network is characterized by the following:

- It provides transmission rates of up to 11 Mbps (802.11b) or up to 54 Mbps (802.11g). Transmission rates can also be set (or autodetected) to lower rates for each standard.
- It uses the 2.4-GHz band of the spectrum. Microwave ovens, Bluetooth devices, and some high-end mobile phones also use this band. (Check local regulations if you are setting up an 802.11 network outside the United States.) To reduce congestion, 14 separate channels have been made available within the 2.4-GHz range.
- It allows transmission over distances as short as a desktop away to as long as several miles away (using special antennas). Greater distances can be gained at lower transmission speeds.
- It makes connections between multiple clients or clients and a base station (usually referred to as an *access point*). On the clients, the wireless LAN cards run in Ad hoc mode, while the base station uses infrastructure mode (also called *Managed mode*).

Other 802.11 standards exist (such as 802.11a, which can operate at higher speeds), but for the most part wireless-equipment manufacturers originally rallied around the 802.11b standard and now rally around the 802.11g standard (which can communicate at lower speeds with 802.11b equipment as well). Prices of 802.11b and 802.11g equipment are so close these days that, in most cases, you will want the 802.11g equipment.

**CROSS-REF** To see a complete list of Wi-Fi–certified products, visit the WECA web site ([www.wirelessethernet.org](http://www.wirelessethernet.org)) and click “Wi-Fi Certified Products.” Although these products should be able to communicate with one another, they do not all have drivers that are compatible with Linux.

After your wireless network has been configured, you can use the wireless connections as you would a regular wired Ethernet connection. For example, you can configure TCP/IP on top of your wireless network so that it acts as a gateway to your network’s Internet connection. If you are using Linux as a wireless network client as well, you can take full advantage of firewall, masquerading, network proxy, or other networking features to protect and make full use of your wireless network.

## Choosing Wireless Hardware

Wireless LAN card manufacturers have not shown much interest in providing Linux drivers. Most wireless card drivers that are native to Linux were created without the help of those manufacturers. Also, in many cases, Linux drivers are not available at all.

Another issue related to purchasing a wireless LAN card is that manufacturers often change their hardware without notice. Wireless cards with the same name and model number may include different wireless chipsets. While this may not be a problem for Windows users (because the vendor will include a Windows driver to match), the card may fail on your Linux machine despite that fact that others using a card of the same name in Linux swear it is working just fine.

So, now that you know that your wireless card may not work once you get it home, let's talk about how to have the best chance of picking a card that will work. Here are some places to begin looking:

- **Native Linux Driver** — Some wireless cards have drivers that were created specifically for Linux systems. Cards with those drivers have a good chance of being detected automatically and working after you install the wireless card. A project called Madwifi (<http://madwifi.org>) has additional Linux wireless drivers, created specifically for wireless LAN cards that use chipsets from Atheros ([www.atheros.com](http://www.atheros.com)). Select the Compatibility List from the Madwifi wiki (<http://madwifi.org/wiki/Compatibility>) to see supported wireless cards.
- **Windows Driver** — In cases in which no native Linux driver is available, it's sometimes possible to use an Open Source driver called *NDISwrapper* along with the Windows driver to use a wireless card in Linux. To see which cards are supported by NDISwrapper, refer to the list of NDISwrapper-supported cards. Go to the NDISwrapper project page (<http://ndiswrapper.sourceforge.net/>).

Table 14-1 shows a list of network cards that have Linux-specific Open Source drivers included with CentOS.

**NOTE**

It's possible that even if your wireless card isn't listed in Table 14-1 that it might still work with drivers included with CentOS. Some wireless cards that include the same chipset (and therefore work with the same driver) may be referred to by different names. Rather than try to keep track of all the various acquisitions and name changes in the wireless industry, I refer you to the *Linux Wireless LAN HowTo* ([www.hp1.hp.com/personal/Jean\\_Tourrilhes/Linux](http://www.hp1.hp.com/personal/Jean_Tourrilhes/Linux)). The *Drivers* section provides more insight into which drivers work with which cards.

## Selecting Antennas

If you are setting up your wireless LAN among several computers in close proximity to each other, you may not need an additional antenna. To deal with obstructions and longer distances, however, you can add indoor or outdoor antennas to your wireless hardware.

In the sections that follow, I illustrate different types of indoor and outdoor antennas that are compatible with those cards.

### Using Indoor Antennas

The antennas that are built into wireless LAN cards often work well enough to enable communication among computers in an open area. Additional indoor antennas are useful if the direct line of sight between the wireless LAN cards is blocked. A computer may be locked in a storage closet or stuck under a desk. A pile of papers might inhibit transmission, or a sheet of metal might stop it dead. A small antenna that draws the transmission away from the card might be the answer to these problems.

TABLE 14-1

## Supported Wireless Network Adapters and Modules

Wireless Network Adapter	Module
350 Series Wireless LAN Adapter (Cisco Systems)	airo_cs.ko
ADMtec ADM8211 wireless	adm8211.ko
Aironet PC4500 (Cisco Systems)	airo_cs.ko
Aironet PC4800 (Cisco Systems)	airo_cs.ko
AT&T WaveLAN Adapter	wavelan_cs.ko
Atheros 802.11 wireless	ath5k.ko
Atmel AT76C50X wireless	atmel_cs.ko
Atmel AT76C50X wireless (PCI version)	atmel_pci.ko
Broadcom 43xx wireless	bcm43xx.ko
Cabletron RoamAbout 802.11 DS	wvlan_cs.ko
Compaq WL100 11 Mbps Wireless Adapter	orinoco_cs.ko
Digital RoamAbout/DS	wavelan_cs.ko
ELSA AirLancer MC-11	wvlan_cs.ko
Intel PRO/Wireless 2100 Network Connection mini PCI adapters	ipw2100.ko
Intel PRO/Wireless 2915ABG and 2200BG Network Connection mini PCI adapters	ipw2200.ko
Intel PRO/Wireless 3945ABG Network Connection adapter	iwlwifi.ko
Intel Wireless WiFi Link 4965AGN	iwlwifi.ko
Lucent Technologies WaveLAN Adapter	wavelan_cs.ko
Intersil PRISM2 11 Mbps Wireless Adapter	wvlan_cs.ko
Lucent Technologies WaveLAN/IEEE Adapter	orinoco_cs.ko
MELCO WLI-PCM-L11	orinoco_cs.ko
MELCO WLI-PCM-L11G	orinoco_cs.ko
NCR WaveLAN Adapter	wavelan_cs.ko
Orinoco PC Cards	orinoco_cs.ko
PLANEX GeoWave/GW-CF110	orinoco_cs.ko

*continued*

**TABLE 14-1** (continued)

Wireless Network Adapter	Module
Planet WL3501	wl3501_cs.ko
Prism54 PCI wireless	prism54pci.ko
Prism54 USB wireless	prism54usb.ko
Realtek RTL8187 USB wireless	rtl8187.ko
Xircom CreditCard Netwave	netwave_cs.ko
ZCOMAX AirRunner/XI-300	orinoco_cs.ko
ZyDAS ZD1201 wireless LAN USB sticks	zd1201.ko
ZyDAS ZD1211 wireless LAN USB sticks	zd1211rw.ko

While most wireless LAN cards don't require a completely unobstructed line of sight, an obstacle can certainly slow reception. To get around this problem, an antenna such as the Orinoco IEEE range-extender can plug directly into an Orinoco Gold or Silver wireless LAN card. A 1.5-meter extension cable can bring the signal out from behind a closed door or out on top of a desk.

When you set up the antenna, it is recommended that it be:

- Placed in a central location
- Mounted vertically
- Located away from obstructions (metal surfaces in particular, and, to a lesser extent, solid objects such as concrete walls or stacks of papers)

Refer to the instructions that come with your antenna for specific guidelines regarding placing and mounting the antenna.

### **Using Outdoor Antennas**

Choosing and setting up outdoor antennas for your wireless LAN can be more difficult and expensive than setting them up indoors. Once the outdoor antennas are in place, however, you can save money because you won't need multiple Internet access accounts (monthly fees, DSL/cable modems, etc.).

Although a complete description of the use of outside antennas with your wireless LAN is outside the scope of this chapter, here are some tips that will help you choose the best antennas for your wireless LAN.

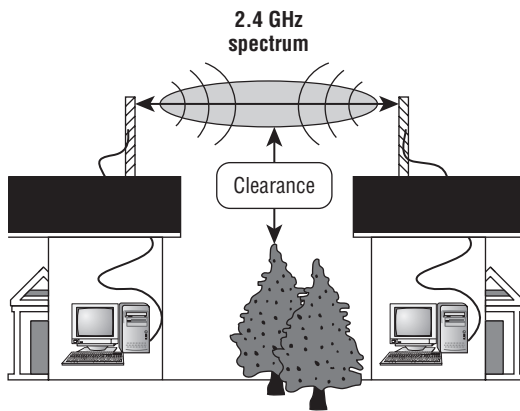
- **Point-to-Point versus Multipoint** — If you are creating a point-to-point link between two outdoor locations (e.g., to share an Internet connection between two buildings), a directional antenna can help you achieve greater distance and transmission speeds. However, if your antenna is providing multipoint access for several other outdoor antennas or

wireless clients (such as students working from laptops on the campus lawn), an omnidirectional antenna may be more appropriate.

- **Clearance** — The clearer the line of sight between outdoor antennas, the greater the distance and transmission speed you can achieve. Placing antennas at the highest possible points can prevent diminished performance caused by trees, cars, buildings, and other objects. The amount of distance between obstacles and the coverage area of your wireless transmission is referred to as the *clearance factor* (see Figure 14-10).

**FIGURE 14-10**

The distance of obstructive objects from the wireless signal is called the *clearance*.



- **Distance** — Although the actual distances over which antennas can send and receive data vary greatly based on different factors, you can achieve distances of many miles with outdoor antennas. For example, two Orinoco 24 dBi directional parabolic-grid antennas can theoretically achieve distances of up to 52 miles at an 11-Mbps transmission speed with a 180-meter clearance. Reduce that transmission rate to 1 Mbps, and you can achieve distances of up to 149 miles with a 1,200-meter clearance. Shorter distances are achieved with less expensive equipment, such as the Orinoco 14 dBi directional antenna, which can achieve distances of up to 5.3 miles at 11 Mbps with a 13-meter clearance.
- **Cable Factor** — The distances that transmissions travel on the cables between the wireless cards and the antennas can be a factor in choosing the right antenna. The shorter the cables, the greater the distance and speed you will get on your antenna.

The power of an antenna is rated in terms of *gain*. Gain is measured in decibels, based on a *theoretical isotropic radiator* (or dBi). Higher gains offer opportunities for reaching greater distances at greater speeds. However, the ability of the antenna to focus that power (directional vs. omnidirectional) greatly affects the speeds and distances that can be achieved. If you want to see some interesting home-made antennas, search the Web for the word *cantenna*.

## Getting Wireless Drivers

If you are using a wireless card that includes a supported driver in CentOS, the system might detect that card and load the proper driver, so that you will be able to configure it as described later in this section. In other cases, you will need to install the associated firmware for the driver that comes with the hardware (usually intended for Windows systems). If the driver you need for your wireless card is not included with CentOS, you may be able to use NDISwrapper and a Windows driver to configure your wireless card. The following procedure contains an example of configuring NDISwrapper with a Linksys 802.11g wireless PCI adapter card:

**NOTE**

If you find you need further information about using NDISwrapper, refer to the NDISwrapper project page at <http://ndiswrapper.sourceforge.net/>.

1. Determine the kind of wireless card you are using. If you have a PCI card, type:

```
# lspci -v | less
00:0a.0 Network controller: Broadcom Corporation BCM4306 802.11b/
g Wireless LAN Controller (rev 03)
Subsystem: Linksys: Unknown device 0014
Flags: bus master, fast devsel, latency 64, IRQ 5
Memory at ee000000 (32-bit, non-prefetchable) [size=8K]
```

In this example, the PCI card is a BCM4306 802.11b/g Wireless Controller from Broadcom Corporation. (If your wireless card is a USB device, type the `lsusb` instead.)

2. Check the following list of wireless card drivers known to run under NDISwrapper, as mentioned previously.
3. If your card is supported, download the driver recommended. I used the Linksys WMP54GS Wireless-G PCI Adapter (which was reflected by the chipset BCM4306 802.11g, rev 03 shown in the preceding `lspci` output). So I downloaded the driver as follows:

```
# mkdir wireless
# cd wireless/
# wget ftp://ftp.linksys.com/pub/network/wpc54g_v2_driver_
utility_v2.0.zip
```

4. After the file is done downloading, unzip the driver file. For the example, I typed:

```
# unzip wpc54g_v2_driver_utility_v2.0.zip
```

5. Install the `kernel-devel` and `gcc` packages. Then link the `kernels` directory to the `modules` directory or your current kernel (replacing `<kernel-version>` with the version of your kernel development package and current kernel, where shown):

```
# yum install kernel-devel gcc
# ln -s /usr/src/kernels/<kernel-version> /lib/modules/
<kernel-version>/build
```

6. Get the NDISwrapper source code by downloading it to your CentOS system from the following site: <http://sourceforge.net/projects/ndiswrapper>.
7. With the NDISwrapper source code package in the current directory, unzip and untar it as follows:

```
# tar xvfz ndiswrapper-*.tar.gz
```

8. As root user, change to the NDISwrapper directory and run the make command as follows:

```
# cd ndiswrapper*
# make install
```

9. Get the INF file from the unzipped driver package. From our example, the file we needed was `lsbcmnds.inf`. Then run the `ndiswrapper -i` command to install the driver. For example, with the `lsbcmnds.inf` file in the current directory, I ran:

```
# ndiswrapper -i lsbcmnds.inf
```

10. Check that the driver is now available and the hardware is available:

```
# ndiswrapper -l
lsbcmnds          driver present, hardware present
```

11. To load the NDISwrapper module, type the following:

```
# modprobe ndiswrapper
```

12. Type the following command to see your wireless LAN (WLAN) entry:

```
# iwconfig
```

13. Type the following to see your access point:

```
# iwlist wlan0 scan
```

14. Create an alias for your wireless device to `wlan0`, so that the interface is loaded automatically at boot time:

```
# ndiswrapper -m
```

15. To check that the NDISwrapper module loaded properly, you can check the `/var/log/messages` file. These messages appeared after the module was loaded:

```
Nov  2 20:28:53 toys kernel: ndiswrapper version 1.42 loaded
                    (preempt=no,smp=no)
Nov  2 20:28:53 toys kernel: ACPI: PCI interrupt
0000:00:0a.0[A] ->
                    GSI 5 (level, low) -> IRQ 5
Nov  2 20:28:53 toys kernel: ndiswrapper: using irq 5
Nov  2 20:28:54 toys udev: creating device node '/dev/ndiswrapper'
Nov  2 20:28:54 toys kernel: wlan0: ndiswrapper ethernet
                    device 00:0f:66:6f:b9:0a using driver lsbcmnds
```



```
Nov  2 20:28:54 toys kernel: wlan0: encryption modes supported:
      WEP, WPA with TKIP, AES/CCMP
Nov  2 20:28:54 toys kernel: ndiswrapper: driver lsbcmnds
      (The Linksys Group, Inc.,07/17/2003, 3.30.15.0) added
```

From the output, you can see that the NDISwrapper module was loaded, that it found the wireless PCI card, and that the `wlan0` interface was assigned to that device using the `lsbcmnds` driver. With the card properly detected, you can configure TCP/IP to use that card.

## Installing Wireless Linux Software

For most CentOS installation types, the software packages you need to create your wireless LAN will already be installed. Drivers and modules needed to support PCMCIA cards and wireless cards should be in your system. Besides the wireless drivers, the following software packages contain tools for configuring and working with your wireless LAN cards:

- **pcmciautils** — Contains commands and configuration files to support your wireless card if it happens to be a PCMCIA card.
- **wireless-tools** — Contains commands for setting extensions for your wireless LAN interface. Commands include `iwconfig` (for configuring your wireless interface) and `iwlist` (for listing wireless statistics).

After you have established a wireless LAN interface, you can use a variety of Linux software to monitor and control access to that interface. You will need to install the appropriate software packages as well. Here are some examples of other wireless software packages that you might find useful:

- **aircrack-ng** — Can be used to audit wireless networks
- **wifi-radar** — Scans for available wireless networks.
- **kismet** — Sniffing 802.11 wireless networks
- **wifiroamd** — Lets you search for the best available access point.
- **airsnort** — Has tools for checking the strength of your wireless encryption keys

## Configuring the Wireless LAN

Before you begin testing the distances you can achieve with your wireless Linux LAN, I recommend that you configure wireless cards on two computers within direct sight of each other. After the two computers are communicating, you can change wireless settings to tune the connection and begin experimenting with transmission distances.

The following sections describe the steps you need to take to set up a wireless LAN between two Linux systems. Although only two nodes are described, you can add more computers to your wireless LAN once you know how. This procedure describes how to operate your wireless Linux LAN in two different modes:

- **Ad Hoc** — All the computers in your wireless LAN are gathered into a single virtual network made up of only one cell. A single cell means that you cannot roam among

different groups of wireless nodes and continue your communication invisibly. To do that requires a managed network.

- **Managed** — As I noted earlier, many wireless cards supported in Linux cannot operate as access points. A Linux wireless card, however, can operate as a node in a managed network. The wireless configuration tools that come with CentOS let you identify the access point for Linux to use by indicating the access point's MAC address.

Install your wireless cards per the manufacturer's instructions. Then configure the interface for each card as described in the following procedure.

## Configuring the Wireless Interface

The Network Configuration window (`system-config-network` command) can be used to configure wireless Ethernet card interfaces, as well as regular wired Ethernet cards. The following procedure describes how to configure a wireless Ethernet card using the Network Configuration window:

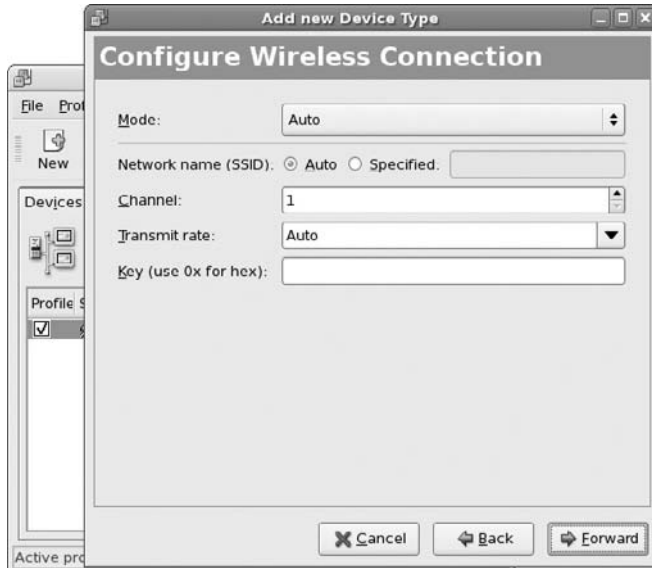
### NOTE

If your wireless card driver does not appear on the list, you may need to configure your wireless card manually, as described later in this chapter. Step through this procedure, and if you are not able to activate the wireless card, refer to the description of the `ifcfg-eth1` file.

1. Start the Network Configuration. From the Desktop menu, click System > Administration > Network, or, as `root` user from a Terminal window, type **`system-config-network`**. The Network Configuration window appears.
2. Click on the New button. The Select Device Type window appears.
3. Click “Wireless connection” and Forward. The Select Wireless Device window appears.
4. Select your wireless card from the list of cards shown, and click Forward. The Configure Wireless Connection window appears, as shown in Figure 14-11.
5. Add the following information and click Forward:
  - **Mode** — Indicates the mode of operation for the wireless LAN card. Because I am setting up a wireless LAN consisting of only one cell (in other words, with no roaming to cells set up in other areas), I could set the mode to Ad hoc. Ad hoc mode allows the card to communicate directly with each of its peers. You can use Managed mode if you have multiple cells, requiring your card to communicate directly to an access point. You can also use Managed mode for a point-to-point network.
  - **“Network name (SSID)”** — The network name (or Network ID) that identifies cells that are part of the same network. If you have a group of cells (which might include multiple nodes and repeaters among which a client could roam), this name can identify all of those cells as falling under one virtual network. Choose any name you like, and then use that name for all computers in your virtual network. (*SSID* stands for “Service Set ID.”)

**FIGURE 14-11**

Add a wireless interface using the Network Configuration window.



- **Channel** — Choose a channel between 1 and 14. You can begin with Channel 1; if you get interference on that channel, try changing to other channels.
- **“Transmit rate”** — Choose the rate of transmission from the following rates: “11M,” “5.5M,” “2M,” “1M,” or “Auto.” Choosing “Auto” allows the interface to automatically ramp down to lower speeds as needed. Lower speeds allow the interface to transmit over greater distances and deal with noisy channels.
- **Key** — You need the same encryption key for all wireless LAN cards that are communicating with each other. It is critical to get this value right. This key is used to encrypt all data transmitted and decrypt all data received on the wireless interface. You can enter the number (up to 40 bits, depending on what is supported by your card) as XXXXXXXXXXXX or XXXX-XXXX-XX (where each X is a number from 0 to 9 or letter between A and F). For 64-bit encryption, the key must be 10 hexadecimal characters; for 128-bit encryption, the key must be 32 hexadecimal characters.

A Configure Network Settings window appears.

6. You can enter the following information:
  - **“Automatically obtain IP address settings with . . . ”** — If you want to get your IP address from a DHCP server, click this box and the rest of the information is obtained automatically. Otherwise, set the IP address statically using the other options.

- **“Hostname”** — If you are using DHCP, you can optionally add a hostname to identify this network interface. If none is entered here, the output from the `/bin/hostname` command is used.
  - **“Statically set IP addresses”** — Click here to manually set your IP addresses.
  - **“Address”** — If you selected static IP addresses, type the IP address of this computer into the Address textbox. This number must be unique on your wireless network.
  - **“Subnet Mask”** — Enter the netmask to indicate what part of the IP address represents the network. (Netmask is described later in this chapter.)
  - **“Default Gateway Address”** — If a computer on your wireless LAN is providing routing to the Internet or other network, type the IP address of the computer here.
7. Click Forward to see a listing of the information you just entered.
  8. Click Apply to complete the new wireless network interface.
  9. Select File ➤ Save (on the main window) to save the interface.

This procedure creates an interface configuration file in your `/etc/sysconfig/network-scripts` directory. The name of the configuration file is `ifcfg-` followed by the interface name (`eth0`, `eth1`, etc.). So, if your wireless card is providing your only network interface, it might be called `ifcfg-eth0`.

Using any text editor, open the `ifcfg-eth?` file (replacing `?` with the interface number) as root user. The following is an example of an `ifcfg-eth1` file:

```
# Please read /usr/share/doc/initscripts-*/sysconfig.txt
# for the documentation of these parameters.
ONBOOT=no
USERCTL=no
PEERDNS=no
GATEWAY=10.0.0.1
TYPE=Wireless
DEVICE=eth1
HWADDR=00:02:2d:2e:8c:a8
BOOTPROTO=none
NETMASK=255.255.255.0
IPADDR=10.0.1.1
DOMAIN=
ESSID=
CHANNEL=1
MODE=Ad-Hoc
RATE=11Mb/s
NETWORK=10.0.1.0
BROADCAST=10.0.1.255
```

In this example, the wireless card's hardware (MAC) address is automatically set to `00:02:2d:2e:8c:a8`. (Your MAC address will be different.) The interface is not yet set

to come up at boot time (`ONBOOT=no`). The interface device is `eth1` (which matches the interface filename `ifcfg-eth1`), because this particular computer has another Ethernet card on the `eth0` interface. The interface type is set to `Wireless`.

Other information in the file sets standard TCP/IP address information. The netmask is set to `255.255.255.0` and the IP address for the card is set to `10.0.1.1`. The broadcast address is `10.0.1.255`.

You can also set many options that are specific to your wireless network in this file. The following list explains some additional options that you might want to set:

- **NWID** — Identifies the name of this particular computer on the network. The computer's hostname (determined from the `uname -n` command) is used by default if you don't set it with `NWID`.
- **FREQ** — You can choose a particular frequency in which to transmit. No value is required because selecting a channel implies a certain frequency. If you do enter a frequency, the value must be a number followed by a *k* (kiloHertz), *M* (megaHertz), or *G* (gigaHertz). The default values for the channels you select range from `2.412G` (Channel 1) to `2.484G` (Channel 14), with other channels occurring at increments of 0.005 GHz. The default is `2.422G`.
- **SENS** — You can select the sensitivity level of the access point. `SENS` can be set to 1 (low density), 2 (medium density), or 3 (high density). The default is 1. The `sensitivity threshold` has an impact on roaming.

**CAUTION**

The encryption algorithm used with 802.11 networks is the Wired Equivalent Privacy (WEP) algorithm. Although using the encryption key is more secure than not using it, experts feel that WEP has some inherent flaws that might allow a drive-by hacker to decrypt your wireless LAN traffic. For that reason, I strongly recommend using additional techniques to protect your wireless LANs, such as firewalls and diligent log-checking. See the "Wireless Security" sidebar for further information. (If your wireless card supports WPA encryption standards, use those as they are more secure than WEP.)

Besides those options just shown, you can also pass any valid options to the `iwconfig` command (which actually interprets these values), by adding an `IWCONFIG` option to the configuration file. Display the `iwconfig` man page (type **man iwconfig**) to see all wireless options. Also view the `/etc/sysconfig/network-scripts/ifup-wireless` script to see how the options you just added are processed.

**NOTE**

On the computer that is acting as a gateway from your wireless network to the Internet, you need to turn on IP packet forwarding. Change the value of `net.ipv4.ip_forward` to 1 in `/etc/sysctl.conf`. Open that file as the root user with a text editor, and change the line as follows:

```
net.ipv4.ip_forward = 1
```

Repeat the configuration procedure for each wireless CentOS computer on your LAN. At this point, your wireless network should be ready to go. Restart your network, as described in the following steps, to make sure that it is working:

## Wireless Security

The Wireless Ethernet Compatibility Alliance (WECA) has recommended changes in response to security concerns about wireless networks. They did this because, unlike wired networks, which can often be physically protected within a building, wireless networks often extend beyond physical boundaries that can be protected.

The Wired Equivalent Privacy (WEP) standard adds encryption to the 802.11 wireless standard. WECA refers to WEP as its way of providing *walls* that make wireless Ethernet as secure as wired Ethernet. However, you need to implement WEP, as well as other security methods that would apply to any computer network, in order to make your wireless network secure. Here are WECA's suggestions:

- Change the default WEP encryption key on a regular basis (possibly weekly or even daily). This prevents casual drive-by hackers from reading your encrypted transmissions.
- Use password protection on your drives and folders.
- Change the default Network Name (SSID).
- Use session keys, if available in your product (session keys are not supported in current Linux wireless drivers).
- Use MAC address filtering (supported in a limited way in Linux).
- Don't broadcast from the access point, if possible.
- Use a VPN (Virtual Private Network) system, which can add another layer of encryption beyond that which is available on your wireless network.

For larger organizations requiring greater security, WECA suggests such features as firewalls and user-verification schemes (such as Kerberos). As I mentioned earlier in this chapter, features for protecting from intrusions and restricting services are already built into CentOS. Refer to the descriptions of security tools in Chapters 13, 14, and 15 for methods of securing your network, its computers, and their services. In particular, you could consider adding a VPN to further secure all data sent on your wireless LAN.

Wi-Fi Protected Access (WPA) features are available for wireless cards in Linux. Wireless cards for Linux that support WPA include Cisco Aironet 802.11a/b/g, Linksys Dual-Band Wireless A+G, Proxim Gold 11a/b/g Combo card (8480-WD), and Netgear Dual Band WAG511. WPA-Supplicant software is available with the `wpa_supplicant` and `wpa_supplicant-gui` packages.

## Activating the Wireless Interfaces

To immediately activate the wireless interface you just configured, select the Wireless entry on the Network Configuration window and click on the Activate button. After a few seconds, the Status should appear as Active.

To have the interface start when you reboot your computer, click on the wireless interface from the Network Configuration window and select Edit. From the Wireless Device Configuration window that appears, click on the box next to “Activate device when computer starts.”

If you want to explicitly enter a Network Name (SSID), click on the Wireless Settings tab on the Wireless Device Configuration window. From there, select Specified, type the network name (any name you choose to match others on your wireless network), and click OK.

Be sure to save your changes on the Network Configuration window by clicking File ➤ Save.

## Checking Your Wireless Connection

Your wireless LAN interface should be operating at this point. If another wireless computer is available on your wireless network, try communicating with it using the `ping` command and its IP address (as described in the section, “Can You Reach Another Computer on the LAN?” later in this chapter).

If you are not able to communicate with other wireless nodes or if transmission is slow, you may have more work to do. For example, if you see messages that say “Destination Host Unreachable,” instead of the output shown earlier, refer to the section on “Troubleshooting a Wireless LAN” for help.

## Testing Distances

Although you may be thrilled to have a wireless LAN working between two computers, you will probably want these computers to be located some distance from each other to make the LAN useful. Getting your wireless LAN to work at the desired distances can be quite a challenge. See the section, “Selecting Antennas,” earlier in this chapter for suggestions on selecting and using antennas to configure the type of wireless LAN you are interested in.

## Setting Wireless Extensions

After the wireless module is loaded, you can change wireless extensions using the `iwconfig` command. The `iwconfig` command is the command that is actually used to set the options added to the `ifcfg` configuration script (e.g., for the `eth1` interface, the script would be `/etc/sysconfig/network-scripts/eth1`).

Some of the same options that you set when the module was loaded can be reset using the `iwconfig` command. The `iwconfig` command can be useful for testing different settings on an active wireless LAN. The syntax of the `iwconfig` command is as follows:

```
# iwconfig interface parameter value
```

The *interface* is the name of the wireless interface you want to change, such as `eth1` or `wlan0`. The *parameter* is the name of the option, and the *value* is replaced by its value. For example, to set your network name (ESSID) to *GalaxyBureau*, you could type the following as root user:

```
# iwconfig eth0 essid "GalaxyBureau"
```

Table 14-2 contains a list of available options for the `iwconfig` command. Refer back to the “Configuring the Wireless Interface” section for further details on these options.

The best place to add `iwconfig` options permanently in CentOS is the configuration file for your wireless interface in the `/etc/sysconfig/network-scripts` directory.

Options to `iwconfig` are added to the wireless interface file (such as `ifcfg-eth0` or `ifcfg-eth1`) using the `IWCONFIG` parameter. For example, to add an encryption-key value of `1234-1234-12` for your wireless LAN card, you could add the following line to your wireless-interface file:

```
IWCONFIG="key 1234-1234-12"
```

## Understanding Internet Protocol Addresses

---

Whether you are using a wired or a wireless network, each computer you communicate with (including yours) must have a unique address on the network. In TCP/IP, each computer must be assigned an Internet Protocol (IP) address. This section gives you some background in IP addresses.

There are two basic ways to assign a hostname and an IP address to a network interface in Linux:

- **Static Addresses** — With static IP addresses, each computer has an IP address that doesn't change each time the computer reboots or restarts its network interface. Its IP address can be entered manually because it's not assigned on-the-fly. You can do this at installation time or later using the Network Configuration window.
- **Dynamic Addresses** — With dynamic addresses, a client computer gets its IP address assigned from a server on the network when the client boots. The most popular protocol for providing dynamic addresses is called the *Dynamic Host Configuration Protocol* (DHCP). With this method, a client computer may not have the same IP address each time it boots.

### TIP

If you expect to add and remove computers regularly from your LAN or if you have a limited number of IP addresses, you should use DHCP to assign IP addresses.

Chapter 22 describes how to set up a DHCP server.



TABLE 14-2

Options for the `iwconfig` Command

Option	Description
<code>essid name</code>	Indicates the network name.
<code>ap address</code>	Indicates that the access point is at a particular MAC address. For low-quality connections, the client driver may return to trying to automatically detect the access point. This setting is useful in Managed mode only.
<code>channel #</code>	Picks the channel number to operate on.
<code>frag frag_size</code>	Sets the fragmentation threshold for splitting up packets before they are transmitted.
<code>freq 2.4??G</code>	Sets the frequency of the channel to communicate on.
<code>key xxxx-xxxx-xx</code>	Sets the key used for WEP encryption.
<code>mode option</code>	Sets the mode used for communications to Ad hoc, Managed, Master, Repeater, Secondary, or Auto.
<code>nick name</code>	Sets the station name to define this particular computer.
<code>rate XM</code>	Defines the transmission rate to use.
<code>rts number</code>	Sets the RTS/CTS threshold for packet transmission.
<code>retry number</code>	For cards that support MAC retransmissions, you can use this option to determine how many retries are made before the transmission fails. The value can be a number (indicating the number of seconds allotted for retries), or a number followed by an <i>m</i> (for milliseconds) or <i>u</i> (for microseconds). Instead of a number, you can set a number of retries using the limit parameter. For example: <code>retry limit 100</code> indicates that the transmission can retry up to 100 times.
<code>sens number</code>	Sets the lowest possible sensitivity threshold for which the wireless interface will try to receive a packet. Raising this level can help block out interference from other wireless LANs that might weakly encroach on your transmission area.

An IP address is a four-part number, with each part represented by a number from 0 to 255 (256 numbers total). Part of that IP address represents the network the computer exists on, while the remainder identifies the specific host on that network. Here's an example of an IP address:

```
192.168.35.121
```

Originally, IP addresses were grouped together and assigned to an organization that needed IP addresses, based on IP address classes. These days, a more efficient method, referred to as *Classless Inter-Domain Routing* (CIDR), is used to improve routing and waste fewer IP addresses. These two IP address methods are described in the following sections.

## IP Address Classes

Unfortunately, it's not so easy to understand which part of an IP address represents the network and which represents the host without explaining how IP addresses are structured. IP addresses are assigned in the following manner. A network administrator is given a pool of addresses. The administrator can then assign specific host addresses within that pool as new computers are added to the organization's local network. There were originally three basic classes of IP addresses, each representing a different-size network:

- **Class A** — Each Class A address has a number between 0 and 127 as its first part. Host numbers within a Class A network are represented by any combination of numbers in the next three parts. A Class A network therefore contains millions of host numbers ( $\sim 256 \times 256 \times 256$ , with a few special numbers being invalid). A valid Class A network number is:

24 .

- **Class B** — A Class B IP address has a number between 128 and 191 in its first part. With a Class B network, however, the second part also represents the network. This enables a Class B network to have more than 64,000 host addresses ( $256 \times 256$ ). A valid Class B network number is:

135 .84

- **Class C** — A Class C IP address begins with a number between 192 and 223 in its first part. With a Class C network, the first three parts of an IP address represent the network, while only the last part represents a specific host. Thus, each Class C network can have 254 numbers (the numbers 0 and 255 can't be assigned to hosts). Here is an example of a Class C network number:

194 .122 .56

To tell your computer which part of a network address is the network and which is the host, you must enter a number that masks the network number. That number is referred to as the *netmask*.

## Understanding Netmasks

Suppose you are assigned the Class B address 135.84, but you are only given the pool of numbers available to the address 135.84.118. How do you tell your network that every address beginning with 135.84.118 represents a host on your network, but that other addresses beginning with 135.84 should be routed to another network? You can do it with a netmask.

The *netmask* essentially identifies the network number for a network. When you assign the IP address that is associated with your computer's interface to the LAN (`eth0`), you are asked for a netmask. By default, your computer fills in a number that masks the part of your IP address that represents the class of your network. For example, the default netmasks for Class A, B, and C networks are the following:

- Class A netmask: 255.0.0.0
- Class B netmask: 255.255.0.0
- Class C netmask: 255.255.255.0

Now, if your network was assigned the network number 135.84.118, to tell your computer that 135.84.118 is the network number and not 135.84 (as it normally would be for a Class B address), add a netmask of 255.255.255.0. So you could use host numbers from 1 to 254 (which would go into the fourth part of the number).

To further confuse the issue, you could mask only one or more bits that are part of the IP address. Instead of using the number 255, you could use any other numbers between 0 and 255, including 128, 192, 224, 240, 248, 252, and 254, to mask only part of the numbers in that part of the address.

**NOTE**

The reason that only the numbers just mentioned are valid netmasks is that each part is represented by eight binary numbers, but all ones that are included must be to the left. So 240 would be allowed (11110000), but 242 would not (11110010). This limitation is what leads to the creation of CIDR (see the next section).

## Classless Inter-Domain Routing

The class method of allocating IP addresses had several major drawbacks. First, few organizations fell neatly into one class or another. For most organizations, a Class C address (up to 256 IP addresses) was too small, and a Class B address (up to 65,534 IP addresses) was too big. The result was a lot of wasted numbers in a world where IP addresses were running short. Second, IP classes resulted in too many routing table entries. As a result, routers were becoming overloaded with information.

The Classless Inter-Domain Routing (CIDR) addressing scheme set out to deal with these problems. The scheme is similar to IP address classes, but offers much more flexibility in assigning how much of the 32-bit IP address is the network identifier. Instead of the first 8, 16, or 32 bits identifying the network, 0 to all 32 bits could identify the network. As a result, groups of assigned IP addresses could contain from 1 to about 4,294,967,296 host addresses.

To indicate the network identifier, a CIDR IP address is followed by a slash (/) and then a number from 0 to 32. A smaller number indicates a network containing more hosts. Here's an example of an IP address that uses the CIDR notation:

```
128.8.27.18/16
```

In this example, the first 16 bits (128.8) represent the network number, and the remainder (27.18) represent the specific host number. This network number can contain up to 65,536 hosts (the same as a Class B address). The following list shows how many hosts can be represented in networks using different numbers to identify the network:

```
/0 4,294,967,296 hosts
/1 2,147,483,648 hosts
/2 1,073,741,824 hosts
/3 536,870,912 hosts
/4 268,435,456 hosts
/5 134,217,728 hosts
/6 67,108,864 hosts
/7 33,554,432 hosts
/8 16,777,216 hosts
/9 8,388,608 hosts
/10 4,194,304 hosts
/11 2,097,152 hosts
/12 1,048,576 hosts
/13 524,288 hosts
/14 262,144 hosts
/15 131,072 hosts
/16 65,536 hosts
/17 32,768 hosts
/18 16,382 hosts
/19 8,192 hosts
/20 4,096 hosts
/21 2,048 hosts
/22 1,024 hosts
/23 512 hosts
/24 256 hosts
/25 128 hosts
/26 64 hosts
/27 32 hosts
/28 16 hosts
/29 8 hosts
/30 4 hosts
/31 2 hosts
/32 1 host
```

The CIDR addressing scheme also helps reduce the routing overload problem by having a single, high-level route represent many lower-level routes. For example, an ISP could be assigned a single /13 IP network and assign the 500,000-plus addresses to its customers. Routers outside the ISP would only need to know how to reach the ISP for those half-million addresses. The ISP would then be responsible for maintaining routing information for all of the host routes with that network address.

## Getting IP Addresses

So, what is the impact of assigning IP addresses for the computers on your LAN? Your choice of which IP addresses to use depends on your situation. If you are part of a large organization, you should get addresses from your network administrator. Even if you don't connect to other LANs in your organization at the moment, having unique addresses can make it easier to connect to them in the future.

If you are setting up a network for yourself (with no other networks to consider in your organization), you can use private addresses. However, if you need to connect computers to the Internet as servers, apply for your own domain name (from an Internet domain registrar) and IP addresses (from your ISP).

**CROSS-REF** Refer to Chapter 24 for information about getting the IP addresses and domain names you need to configure a public server on the Internet.

If you don't need to have your LAN accessible from the Internet, choose IP addresses from the set of available general-purpose IP addresses. Using these private IP addresses, you can still access the Internet from your LAN for such things as Web browsing and e-mail by using IP masquerading or Network Address Translation (NAT), as described in Chapter 15. Table 14-3 lists the private IP addresses not used on any public part of the Internet.

**TABLE 14-3**

### Private IP Addresses

Network Class	Network Numbers	Addresses per Network Number
Class A	10.0.0.0	167,777,216
Class B	172.16.0.0 to 172.31.0.0	65,536
Class C	192.168.0.0 to 192.168.255.255	256

So, for a small private LAN, the following numbers are examples of IP addresses that could be assigned to the host computers on your network. (You could use any of the network numbers, plus host numbers, from the table. These are just examples.)

- 192.168.1.1
- 192.168.1.2
- 192.168.1.3
- 192.168.1.4
- 192.168.1.5

You could continue that numbering up to 192.168.1.254 on this network (.255 is reserved for the broadcast address), and you could use a network mask of 255.255.255.0.

## Troubleshooting Your LAN

---

After your LAN has been set up, your Ethernet cards installed, and hostnames and addresses added, there are several methods you can use to check that everything is up and working. Some troubleshooting techniques are shown in the following sections.

### Did Linux Find Your Ethernet Driver at Boot Time?

Type the following right after you boot your computer to verify whether Linux found your card and installed the Ethernet interface properly:

```
dmesg | grep eth
```

The `dmesg` command lists all the messages that were output by Linux at boot time. The `grep eth` command causes only those lines that contain the word `eth` to be printed. The first message shown below appeared on my laptop computer with the NETGEAR card. The second example is from my computer with the EtherExpress Pro/100 card:

```
eth0: NE2000 Compatible: port 0x300, irq3, hw_addr 00:80:C8:8C:8E:49
eth0: OEM i82557/i82558 10/100 Ethernet at 0xccc0, 00:90:27:4E:67:35,
IRQ 17.
```

The message in the first example shows that a card was found at IRQ3 with a port address of 0x300 and an Ethernet hardware address of 00:80:C8:8C:8E:49. In the second example, the card is at IRQ 17, the port address is 0xccc0, and the Ethernet address is 00:90:27:4E:67:35.

#### NOTE

If the `eth0` interface is not found but you know that you have a supported Ethernet card, check that your Ethernet card is properly seated in its slot.

### Can You Reach Another Computer on the LAN?

Try communicating with different network interfaces on your LAN. The `ping` command can be used to send a packet to another computer or local network interface and to ask for a packet in return. You could give `ping` either a hostname or an IP address. The following is a succession of `ping` commands you can use to test your local network interfaces and connections to other computers (your external and router IP addresses will probably be different):

```
# ping localhost           Local loopback
# ping 10.0.0.10          Local external interface
# ping 10.0.0.1           Local router to Internet
# ping 208.77.188.166     Remote server
# ping example.com       Remote server by name
```

If you are able to ping a remote server by name, you know that both name service and routing are working. If the remote server can be reached, the output will look similar to the following:

```
PING example.com (208.77.188.166): 56(84) bytes of data.  
64 bytes from www.example.com (208.77.188.166): icmp_seq=1 ttl=255  
time=0.351 ms  
64 bytes from www.example.com (208.77.188.166): icmp_seq=2 ttl=255  
time=0.445 ms  
64 bytes from www.example.com (208.77.188.166): icmp_seq=3 ttl=255  
time=0.409 ms  
64 bytes from www.example.com (208.77.188.166): icmp_seq=4 ttl=255  
time=0.457 ms  
64 bytes from www.example.com (208.77.188.166): icmp_seq=5 ttl=255  
time=0.401 ms  
64 bytes from www.example.com (208.77.188.166): icmp_seq=6 ttl=255  
time=0.405 ms  
64 bytes from www.example.com (208.77.188.166): icmp_seq=7 ttl=255  
time=0.443 ms  
64 bytes from www.example.com (208.77.188.166): icmp_seq=8 ttl=255  
time=0.384 ms  
64 bytes from www.example.com (208.77.188.166): icmp_seq=9 ttl=255  
time=0.365 ms  
64 bytes from www.example.com (208.77.188.166): icmp_seq=10 ttl=255  
time=0.367 ms  
  
--- example.com ping statistics ---  
10 packets transmitted, 10 packets received, 0% packet loss, time  
9011ms  
rtt min/avg/max/mdev = 0.351/0.402/0.457/0.042 ms, pipe 2
```

A line of output is printed each time a packet is sent and received in return. It shows how much data was sent and how long it took for each package to be received. After you have watched this for a while, press [Ctrl]+C to stop the ping. At that point, you will see statistics on how many packets were transmitted, received, and lost.

If you don't see output that shows packets have been received, it means that you are not contacting the other computer. Try to verify that the names and addresses of the computers that you want to reach are in your `/etc/hosts` file or that your DNS server is accessible. Next, confirm that the names and IP addresses you have for the other computers you are trying to reach are correct (the IP addresses are the most critical).

## Is Your Ethernet Connection Up?

Using the `ifconfig` command, you can determine whether your Ethernet (and other network interfaces) is up and running. Type the following command:

```
# ifconfig
```

The output that appears is similar to the following:

```
eth0 Link encap:Ethernet HWaddr 00:90:27:4E:67:35
      inet addr:10.0.0.10 Bcast:10.0.0.255 Mask:255.255.255.0
      UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
      RX packets:156 errors:0 dropped:0 overruns:0 frame:0
      TX packets:104 errors:0 dropped:0 overruns:0 carrier:0
      collisions:0 txqueuelen:100
      RX bytes:20179 (19.7 Kb)  TX bytes:19960 (19.4 Kb)
      Interrupt:11 Base address:0xe000 Memory:ff8ff000-ff8ff038

lo   Link encap:Local Loopback
      inet addr:127.0.0.1 Mask:255.0.0.0
      UP LOOPBACK RUNNING MTU:3924 Metric:1
      RX packets:56 errors:0 dropped:0 overruns:0 frame:0
      TX packets:56 errors:0 dropped:0 overruns:0 carrier:0
      collisions:0 txqueuelen:0
      RX bytes:3148 (3.0 Kb)  TX bytes:3148 (3.0Kb)
```

In this example, two network interfaces are up on the current computer. The first section shows your Ethernet interface (`eth0`), and its Ethernet hardware address, IP address (`inet addr`), broadcast address, and netmask. The next lines provide information on packets that have been sent, along with the number of errors and collisions that have occurred.

## NOTE

The `lo` entry is for loopback. This enables you to run TCP/IP commands on your local system without having a physical network up and running.

If your `eth0` interface does not appear, it may still be configured properly but not running at the moment. Try to start the `eth0` interface by typing the following:

```
# ifconfig eth0 up
```

After this, type **ifconfig** again to see if `eth0` is now running. If it is, it may be that `eth0` is simply not configured to start automatically at boot time. You can change it so that Ethernet starts at boot time (which I recommend), using the Network Configuration window described earlier in this chapter.

## TIP

If your network interfaces are not running at all, you can try to start them from the network initialization script. This interface reads parameters and basically runs `ifconfig` for all network interfaces on your computer. Type the following to restart your network:

```
# /etc/init.d/network restart
```

Another way to see statistics for your Ethernet driver is to list the contents of the process pseudo-file system for network devices. To do that, type the following:

```
# cat /proc/net/dev
```



The output should look like this:

```

Inter-|   Receive                                     |Transmit
face  |bytes packets errs drop fifo frame compressed multicast|bytes
  lo: 5362   64  0  0  0  0      0    0   5362   64  0  0  0  0
  sit0:    0    0  0  0  0  0      0    0    0   0  0  0  0  0
  eth0: 3083   35  0  0  0  0      0    0   3876   31  0  0  0  0

```

The output is a bit hard to read. (This book isn't wide enough to show it without wrapping around, so the output was truncated at the right.) With this output, you can see Receive and Transmit statistics for each interface. This output also shows you how many Receive and Transmit errors occurred in communication. (Transmit information is cut off in this example.)

For a more detailed look at your network, you can use the Wireshark window. Wireshark is described in the section, "Watching LAN Traffic with Wireshark," later in this chapter.

## NOTE

The `sit0` network interface (which stands for "Simple Internet Transition") can be used to encapsulate IPv6 packets into an IPv4 network. This allows IPv6 network communications to be routed across IPv4 networks. You would only use this interface if you have IPv6 networking enabled.

## Troubleshooting a Wireless LAN

If you set up your two (or more) wireless LAN cards to enable CentOS systems to communicate and they are not communicating, you can troubleshoot the problem in several different ways.

### Checking Wireless Settings

You can use the `iwlist` and `iwconfig` commands to check your wireless settings. The `iwconfig` command provides a quick overview of your wireless settings, while the `iwlist` command shows you information about parameters that you specify.

Use the `iwconfig` command, along with the name of the wireless LAN interface, to see information about that interface. For example, if the wireless interface were `eth1`, you could type the following:

```

# iwconfig eth1
eth0      IEEE 802.11-DS  ESSID:"GalaxyBureau"  Nickname:"zarkov"
          Mode:Ad-Hoc  Frequency:2.412GHz  Cell: 02:02:2D:2D:3B:30
          Bit Rate=11Mb/s  Tx-Power=15 dBm  Sensitivity:1/3
          RTS thr:off  Fragment thr:off
          Encryption key:7365-6375-31
          Power Management:off
          Link Quality:0/92  Signal level:-102 dBm  Noise level:-102
dBm
          Rx invalid nwid:0  invalid crypt:0  invalid misc:0

```

With `iwconfig`, you can see details about the wireless aspects of the Ethernet interface. In this example, the network name (ESSID) is `GalaxyBureau`, and the station name (`Nickname`) is `zarkov`. The interface is operating in Ad hoc mode on Channel 1 (frequency of 2.412 GHz). Transmission rates are at the maximum speed of 11 Mbps. The encryption key that must be used by every node the card connects with is `7365-6375-31`. Other settings describe the link and signal quality.

The `iwlist` command lets you request specific information about the wireless LAN interface. The syntax is to follow the `iwlist` command with the interface name and the information you are interested in. For example:

```
# iwlist eth1 freq
eth0      11 channels in total; available frequencies :
          Channel 01 : 2.412 GHz
          Channel 02 : 2.417 GHz
          Channel 03 : 2.422 GHz
          Channel 04 : 2.427 GHz
          Channel 05 : 2.432 GHz
          Channel 06 : 2.437 GHz
          Channel 07 : 2.442 GHz
          Channel 08 : 2.447 GHz
          Channel 09 : 2.452 GHz
          Channel 10 : 2.457 GHz
          Channel 11 : 2.462 GHz
          Current Frequency:2.412 GHz (Channel 1)
```

The `freq` parameter displays the available frequencies (and channels) available for communication. Note that all the available frequencies are in the 2.4-GHz range.

```
# iwlist eth0 rate
eth0      12 available bit-rates :
          1 Mb/s
          2 Mb/s
          5.5 Mb/s
          6 Mb/s
          9 Mb/s
          11 Mb/s
          12 Mb/s
          18 Mb/s
          24 Mb/s
          36 Mb/s
          48 Mb/s
          54 Mb/s
          Current Bit Rate=54 Mb/s
```

The preceding `rate` parameter displays the transmission rates available for the wireless interface. You can see that 1, 2, 5.5, 6, 9, and 11 Mbps and other rates are available for the current interface. The current bit-rate is 54 Mbps.

```
# iwlist eth0 key
eth0      2 key sizes : 40, 104bits
          4 keys available :
            [1] 7365-6375-31 (40 bits)
            [2] off
            [3] off
            [4] off
          Current Transmit Key: [1]
```

The `key` parameter lets you see the encryption keys available with the interface. It also shows the key sizes currently available. Because the card reflected in the preceding example supports 64- and 128-bit encryption, the key sizes available are 40 and 104 bits. (The encryption algorithm automatically generates the last 24 bits of each key.)

If you are troubleshooting your wireless LAN connection, some settings are more likely than others to cause problems. It is important to set the following wireless LAN settings properly — if you don't, they may keep your network from working:

- **Network ID (ESSID)** — You may not be able to communicate among peer computers if the Network ID (ESSID) doesn't match on each of them. Network IDs are case-sensitive — for example, *Mylan* is not the same as *MyLAN*.
- **Encryption Key** — Having encryption keys that don't match is like trying to log in to Linux with the wrong password. Check that all nodes are using the same key. (If nodes were unable to connect, check the encryption key first, because typing long hexadecimal keys can be prone to error.)
- **Mode** — If you are communicating through an access point, your mode should be set to Managed and you must provide the MAC address for that access point. In most single-cell networks, you should set all nodes to Ad hoc. The Ad hoc mode allows all nodes to communicate directly to each other as peers.
- **Channel or Frequency** — The channel and frequency options are just two different means of setting the same value. For example, setting the channel to 1 is the same as setting the frequency to 2.412G (GHz). Make sure that the nodes on your network are able to communicate on the same frequency.

## Checking TCP/IP

To ensure that your wireless LAN is communicating with its peers, use the `ping` command (as described earlier in this chapter). If you believe that your cards are working properly but the `ping` command continues to give you a `Network Unreachable` message, you may have a problem with your TCP/IP configuration. Here are some items you can check from the Network Configuration window:

- **IP Address** — Know the correct IP address of the peer you are trying to reach.
- **Hostname** — If you `ping` the peer computer by name, make sure that your computer can properly resolve that name into the correct IP address, or have the peer's hostname

and IP address properly listed in the `/etc/hosts` file locally. The former option will probably require that you have one or more DNS servers identified to resolve the name.

If you can reach another computer on the wireless LAN but not computers outside of that LAN (such as Internet addresses), check that you have properly identified the location of your gateway. If the gateway address is correct and you can reach that gateway, it may be that the gateway itself is not configured to allow packet forwarding.

If you found that any of the preceding information needed to be changed and you changed it, you should restart the wireless LAN interface. One way to do that is to restart the PCMCIA interface and the network interfaces as follows:

```
# /etc/init.d/pcmcia restart
# /etc/init.d/network restart
```

## Adapting to Poor Reception

Your wireless LAN might be working fine while your two wireless computers are sitting on the same desk. But if performance degrades when you separate the computers, you may need to identify any potential obstructions. Then you must decide how to get around them. For desktop systems, a small indoor antenna can bring the signal out from under a desk or out of a closet. For adjacent buildings, a roof antenna might be the answer.

In cities or other congested areas, many people and pieces of equipment can be competing for the 2.4-GHz range. You may want to move a microwave oven or high-end remote phone that may be interfering with your wireless LAN. These settings might help adapt to poor reception:

- **Reduce Transmission Rate** — Instead of using 11 Mbps, you can explicitly ramp down to 5.5, 2, or 1 Mbps. Slower rates can mean more efficient operation in noisy places.
- **Use Smaller Fragment Sizes** — Although there is more total overhead to transmitting packets broken up into smaller fragments, they can often provide better overall performance in noisy environments. Change the `frag` parameter to reduce fragment sizes.
- **Use Different Frequencies** — By specifically requesting that certain frequencies (or channels) be used for transmission, you can avoid congested channels.

## Use Debugging Tools

Because most wireless LAN cards were created for Windows systems, debugging tools from the manufacturers are available only on those systems. If your computer is a dual-boot system (Windows and Linux), try booting in Windows to test the quality of your wireless network.

In CentOS, you can use many of the tools you use for wired Ethernet networks and other TCP/IP network interfaces. Here are a couple of examples:

- **Wireshark** — The Wireshark window (type **wireshark** as the `root` user from a Terminal window) lets you watch Ethernet frames being sent and received by your wireless LAN interface. For example, the output of Wireshark can tell you whether a failed connection reflects a lack of reception or rejected requests. (Wireshark is described in the next section.)

- **/var/log/messages** — When the wireless LAN interface starts up, messages related to that startup are sent to the `/var/log/messages` file. In some cases, these messages will reflect improper options being set for the wireless LAN module.

## Watching LAN Traffic with Wireshark

If you really want to understand the coming and going of information on your LAN, you need a tool that analyzes network traffic. Wireshark (formerly called *Ethereal*) is a graphical tool for capturing and displaying the packets being sent across your network interfaces. Using filters to select particular hosts, protocols, or direction of data, you can monitor activities and track problems on your network.

In addition to reading Ethernet packet data gathered by Wireshark, the Wireshark window can be used to display captured files from Lanalyzer, Sniffer, Microsoft Network Monitor, Snoop, and a variety of other tools. These files can be read from their native formats or after being compressed with gzip (.gz).

Wireshark can track more than 100 packet types (representing different protocols). It can also display specific fields related to each protocol, such as various data sizes, source and destination addresses, port numbers, and other values.

### Starting Wireshark

To start Wireshark from the Applications menu, select Internet ➤ Wireshark Network Analyzer. Or type the following (as `root` user) from a Terminal window:

```
# wireshark &
```

The Wireshark window, shown in Figure 14-12, appears. (If the `wireshark` command is not found, the package is probably not installed. You can install the `wireshark` and `wireshark-gnome` packages from the Internet by typing `yum install wireshark wireshark-gnome`, or you can use the `rpm` command to install them from the installation DVD.)

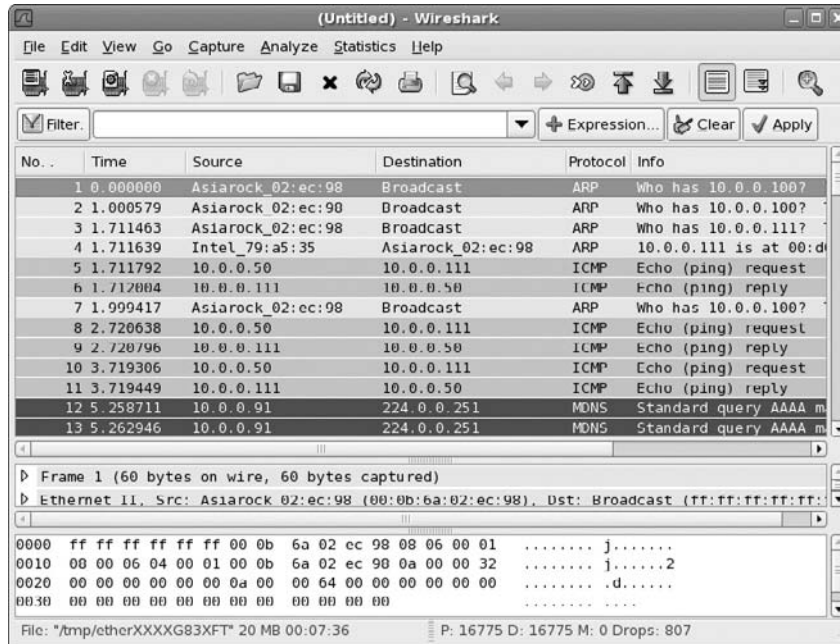
The primary function of Wireshark is to take a snapshot of the packets coming across your network interfaces and display that data in the Wireshark window. You can filter the data based on a variety of filter primitives. When the capture is done, you can step through and sort the data based on the values in different columns. Optionally, you can save the captured data to a file to study the data at a later time.

#### TIP

If you can't use Wireshark because you don't have a GUI available, you can use the `tcpdump` command from the shell. It is not as friendly as Wireshark, but it supports the same filtering syntax. Because `tcpdump` can produce a lot of output, you will probably want to use some form of filtering or direct the output of the command to a file. (Type `man tcpdump` for information on filter options.)

FIGURE 14-12

Wireshark captures and displays packets on a network interface.



## Capturing Ethernet Data

With the Wireshark window displayed, you can capture data relating to packet activities on any of your Ethernet network interfaces by doing the following:

1. Click Capture > Interfaces. You will see a list of network interfaces available on your computer.
2. Click Prepare next to the interface you want to capture from (probably eth0 for a wired Internet or wlan0 for a wireless interface). A Wireshark Capture Options window appears.
3. Choose options relating to what data is captured:
  - **“Limit each packet to”** — Limits the size of each packet to a maximum number of bytes.
  - **“Capture packets in promiscuous mode”** — Any computer on a LAN can see all packets that traverse the LAN, except those packets intended for switched portions of the LAN. With this on, all packets seen by your network interface are captured. With this mode off, only packets intended specifically for your network interface (including multicast and broadcast packets) are captured. In other words, turn on Promiscuous mode to monitor the whole LAN, and turn it off to monitor only your interface.

- **Capture Filter** — This optional field lets you enter a filter that can be used to filter capture data. You can type in filters individually or click on the Filter button to use a filter you have stored earlier.

**CROSS-REF**

Filtering is one of the most powerful features of Wireshark. See the sidebar, “Using Wireshark Filters,” for further information on how to enter filters into the Filter field.

- **“Capture file(s)”** — Enter the name of a file in which you want to capture the data gathered. If you don’t enter a filename, the information will be displayed on the Wireshark window without being saved to a file.
  - **“Ring buffer (Number of files)”** — Select this option to have packets captured in a set number of files. To use this feature, you must also specify a filename (such as */tmp/abc*) and a file size. Data will be put into files you chose, named from the `root` filename you have provided. Once the files fill up, Wireshark will go back and write to the first file again and continue filling up the files. When you stop the capture, you are left with the number of capture files you chose, containing the most recent data.
  - **“Update list of packets in real time”** — Select this option to have packet information appear in the Wireshark window as each packet crosses the interface. With this option off, the information is displayed after you stop capturing it.
  - **“Automatic scrolling in live capture”** — If you are updating packets in real time, select this option to have packet information scroll up after the screen fills. With this off, you just see the first screen of packets and have to scroll down manually to see the rest.
  - **“Hide capture info dialog”** — Prevents the “Capture Info” box from appearing to display the number and types of packets being captured.
  - **“Stop Capture after . . . ”** — By default, Wireshark will capture data from the moment you click OK until you click Stop (with this value set to 0). Or, select one of the three “Stop Capture” fields, and type a number to capture only that number of packets; a number to stop capture after a set number of bytes, kilobytes, megabytes, or gigabytes of data; or a number to indicate the number of seconds, minutes, hours, or days to capture data. When the limit is reached, capture stops and the file is stored in */tmp/etherXXXX??????*, where *??????* is replaced by a string of characters.
  - **“Enable MAC/network/transport name resolution”** — With any of these three options on, names are displayed instead of addresses (if possible). For example, for transport names, Source and Destination IP addresses are displayed as hostnames (if they can be resolved from */etc/hosts* or DNS). With this option off, IP addresses appear in the Source and Destination columns.
4. Click Capture. Wireshark begins gathering data on packets encountered by the interface. The Wireshark Capture window displays information on how many incoming and outgoing packets have crossed the interface since the capture began. The number of packets that are associated with each protocol Wireshark monitors is displayed, along with the percentage of total packets associated with each protocol.

5. Click Stop (or the capture might stop automatically, if it has reached a size or time limit set by you). The snapshot of data you just took will appear on the Wireshark window. Packets are displayed in the order in which they traversed the interface.
6. You can choose to save the data to your hard disk by selecting File ➤ Save As.

At this point, you can start interpreting the data.

## Interpreting Captured Ethernet Data

With the captured data displayed in your Wireshark window, you can get a detailed view of the network traffic that your computer is exposed to. The Wireshark window is divided into three parts. The top part contains a scrollable list of packets. The protocol tree for the current packet appears in the middle part of the display. A hexadecimal dump of the entire contents of the packet appears in the bottom part.

You can sort data in different ways from the top part of the window by clicking on the column headings. To see more details relating to different items in the protocol tree for the current packet, you can click on the triangle-shaped icon next to the protocol information that interests you.

## Using Wireshark Filters

If you are monitoring a busy server or a busy network, Wireshark can gather so much data that it can become almost unusable. If you know what you are looking for, however, you can filter what packets are captured based on values you enter.

Filters in Wireshark are implemented using the pcap library (type **man pcap** to read about it). The filter expressions you can use with Wireshark are described on the **tcpdump** man page. Here are some examples of filters that you could enter into the Filter box when you capture Ethernet data with Wireshark:

```
host 10.0.0.15
```

The **host** primitive lets you capture only packets that are either to or from a particular host computer (by IP address or hostname). By preceding **host** with **src** or **dst**, you can indicate that you only want packages sent from a particular source or to a particular destination host.

```
tcp port 80
```

You can enter a protocol name (such as **tcp**, **ether**, **udp**, or **ip**) to limit captured packets to those that are assigned to that protocol. As shown in the previous example, with **tcp** you could also indicate a port number (such as **80**, to monitor traffic to and from your Web Server).

*continued*



*continued*

You can filter for certain special activities on the network, using the gateway, broadcast, or multicast primitives. Entering gateway host lets you find packets sent to a gateway host that is neither a Source nor a Destination for the packet (which is determined because the Ethernet address doesn't match either of those IP addresses). Enter **ether broadcast** to monitor broadcast packets on your Ethernet network, such as announcements from name servers announcing availability. Likewise, you could filter for multicast packets on ether or IP protocols (**ether multicast**).

The following tips will help you interpret what the data means:

- The Source and Destination columns show where each packet came from and where it went. If the “Enable name resolution” option is on (which is recommended), the hostname associated with IP packets is displayed. This makes it much easier to see which computer is communicating with you.
- To see all activity associated with a particular location, click on the Source or Destination column. Packets will be sorted alphabetically, making it easier for you to scroll through the activity list for the location that interests you.
- If you are trying to debug a particular feature, click on the Protocol column to gather activities based on protocol. For example, if you were trying to get Samba to work (for Windows file or printer sharing), sorting by protocol would enable you to see all NetBIOS and NBNS (NetBIOS name server) requests that came to your computer.
- To mark a packet of interest to you, click the middle mouse button. This will highlight the packet, making it easier to find later. (If you have only a two-button mouse and you indicated during installation that it should emulate a three-button mouse, you can click both mouse buttons together to emulate the middle mouse button.)

The Info column gives you details about the intention of the packet. For example, you can see the type of service that was requested (such as HTTP for Web Service or FTP for file transfer). You can see what information is being broadcast and determine when attempts to find particular host computers are failing. If you believe that someone is using your network improperly, you can see which sites they are visiting and the services they are requesting.

Another handy option is one that lets you follow the stream of TCP information. Click Tools ➤ Follow TCP Stream. The Contents of TCP stream window that appears lets you see the total output of the HTTP, SMTP, or other protocol being used. Of course, viewing data being transmitted by protocols is useful only if it is in plaintext. Although the fact that more and more data and service requests are being encrypted makes it more difficult to debug using Wireshark, it also makes it harder for bad guys on your network to steal your data.

## Summary

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Linux is at its best when it is connected to a network. Configuring a LAN enables you to share resources with other computers in your home or organization. These resources can include files, printers, CD-ROM drives, and backup media.

This chapter describes how to connect to wired and wireless networks and create a LAN with a CentOS system being used on one of the computers on that LAN. It helps you determine the kind of equipment you need to obtain and the layout (topology) of the network. In particular, the chapter describes how to use NetworkManager for making network connections, and Network Configuration for manually configuring your network interfaces.

If something isn't working with your network interface to the LAN, you can use utilities such as `ifconfig` to check that your Ethernet interface is configured and running properly. You can also check that Linux found and installed the proper driver for your Ethernet card. After an Ethernet interface is working, you can use the Wireshark window to monitor the packets coming and going across the interface between your computer and the network.

If a wired network is not possible or convenient, Linux includes support for wireless LAN cards. A wireless LAN can be an effective means of extending your network to areas that are difficult or expensive to reach with wired connections. Using NDISwrapper, you can also get drivers working for many Windows wireless cards.



# Chapter 15

## Setting Up an Internet Connection

This chapter demonstrates how to connect CentOS to any TCP/IP-based network, such as the Internet, a private LAN, or a company WAN. The differences in how you connect have more to do with the network medium you use (i.e., telephone lines, LAN router, etc.) than they do with whether you are connecting to the public Internet or a company's private network.

Connections to the Internet described in this chapter include a simple dial-up connection from your own Linux system. The most popular protocol for making dial-up connections to the Internet is the Point-to-Point Protocol (PPP). It also builds on the procedures in Chapter 14 for creating your own local area network (LAN) by teaching you how to connect your LAN to the Internet.

This chapter first provides an overview of the structure of the Internet, including descriptions of domains, routing, and proxy services. It then discusses how to connect your Linux system to the Internet using PPP dial-up connections. For those who want to connect a LAN to the Internet, it describes how to use Linux as a router and set it up to do IP masquerading to protect your private LAN addresses. Finally, it describes how to configure Linux as a proxy server, including how to configure client applications such as Firefox.

### Understanding How the Internet Is Structured

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In order to operate, the Internet relies on maintaining a unique set of names and numbers. The names are domain names and hostnames, which enable the computers connected to the Internet to be identified

#### IN THIS CHAPTER

**Understanding how the Internet is structured**

---

**Using dial-up connections to the Internet**

---

**Connecting your LAN to the Internet**

---

**Setting up Linux as a router**

---

**Configuring a virtual private network**

---

**Setting up Linux as a proxy server**

---

**Setting up proxy clients**

---

in a hierarchy. The numbers are Internet Protocol (IP) addresses and port numbers, which enable computers to be grouped together into interconnected sets of subnetworks, yet remain uniquely addressable by the Internet.

An Internet service provider (ISP) will give you the information you need to set up a connection to the Internet. You plug that information into the programs used to create that connection, such as scripts to create a PPP connection over telephone lines. See the section, “Using Dial-Up Connections to the Internet,” later in this chapter for descriptions of the information needed from your ISP and the procedures for configuring PPP to connect to the Internet. With a broadband connection and the default DHCP configuration, you might just be able to plug in your Ethernet card and go.

The following list describes the basic Internet structure in more detail:

- **IP Addresses** — These are the numbers that uniquely define each computer known to the Internet. Internet authorities assign pools of IP addresses (along with network masks, or *netmasks*) so that network administrators can assign addresses to each individual computer that they control. An alternative to assigned addresses is to use a reserved set of private IP addresses, so multiple computers in your home or business can share a single public IP address.
- **Port Numbers** — Port numbers provide access points to particular services. Port numbers are like channels on a television. While all ports are inherently the same, many ports are associated with a particular service. A server computer will listen on the network for packets that are addressed to its IP address, along with one or more port numbers. For example, a Web Server listens to port 80 to respond to requests for HTTP content. A Web browser will know, by default, to make its request for HTTP service (in other words, a web page) to port 80 on the server.

**NOTE**

In reality, you can assign any service to any port you choose. In fact, system administrators sometimes assign services to unusual ports for the express purpose of keeping most outsiders from finding them. If you decide to use a non-standard port for a service, you should try to avoid port numbers that are already assigned for common services, since those ports might end up being scanned by an intruder anyway. A client of your service would have to know to request that port specifically. For example, `www.example.com:4863` would request content from port 4863 from the host `www.example.com`.

- **Domain Names** — On the Internet, computer names are organized in a hierarchy of domain names and host names. If you want to have and maintain your own Internet domain, you need to be assigned one that fits into one of the top-level domains (such as `.com`, `.org`, `.net`, `.edu`, `.info`, etc.).
- **Hostnames** — If a domain name is assigned to your organization, you are free to create your own hostnames within that domain, sometimes called *subdomains*. This is a way of associating a name (hostname) with an address (IP address). When you use the Internet, you use a fully qualified domain name to identify a host computer. For example, in the

domain `handsonhistory.com`, a host computer named `baskets` would have a fully qualified domain name of `baskets.handsonhistory.com`.

Within an organization, you should choose a hostnaming scheme that makes sense to you. For example, for `handsonhistory.com`, you could have hostnames dedicated to different crafts (`baskets`, `decoys`, `weaving`, etc.). Some organizations use the names from Norse mythology such as Thor, Odin, and Loki; beer brands such as Summit, Jamespage, Guinness; or names of fictional characters such as Flash, Dale, Zarkov, and so on.

**TIP**

For some naming schemes, see <http://c2.com/cgi/wiki?NamesGivenToComputers>.

- **Routers** — If you have a LAN or other type of network in your home or organization that you want to connect to the Internet, you can share an Internet connection. You do this by setting up a router. The router connects to both your network and the Internet, providing a route for data to pass between your network and the Internet. This is especially useful if you connect to the Internet over a dial-up or broadband connection, since your Linux box can act as a router and you can share the connection among all your computers.
- **Firewalls and IP Masquerading** — To keep your private network somewhat secure yet still allow some data to pass between it and the Internet, you can set up a firewall. The firewall restricts the kinds of data packets or services that can pass through the boundary between the private and public networks. If your network uses private addresses or if you just want to protect the addresses of computers behind your firewall, you can use techniques like Network Address Translation (NAT) or IP masquerading.

**NOTE**

Although you can set up a firewall to filter packets on any computer on your private network, firewalls are typically configured most stringently on the machine that routes packets between the public and private networks. In this way, intruders can be stopped before they get on your private network, and security can be relaxed somewhat between your computers behind the firewall.

- **Proxies** — You can bypass some of the configuration required to allow the computers on your LAN to communicate directly with the Internet by configuring a proxy server. A proxy server can store (referred to as *caching*) Internet objects such as data from Web and FTP servers so that clients of that proxy server don't have to contact the server originating that data each time it is requested. With a proxy server, a computer on your LAN can also run Internet applications such as a Web browser and have them appear to the Internet as if they are actually running on the proxy server.

**CROSS-REF**

You can read about firewalls in Chapter 13. IP masquerading and proxy servers are described in the sections, “Enable Forwarding and Masquerading” and “Setting Up Linux as a Proxy Server,” later in this chapter.

## Internet Domains

You can't read a magazine, watch a TV commercial, or open a cereal box these days without coming across a “*something.com*.” When a company, organization, or person wants you to

connect to them on the Internet, it relies on the uniqueness of its particular domain name. However, within that domain name, the company or organization to which it has been assigned can arrange its content however it chooses.

Internet domains are organized in a structure called the *Domain Name System* (DNS). At the top of that structure is a set of *top-level domains* (or TLDs). Some of the top-level domains are used commonly in the United States, although they are available for worldwide use. TLDs such as `edu` for colleges and universities, `gov` for United States government sites, and `mil` for United States military sites were among the most used TLDs in the early Internet. In more recent years, `com` for commercial sites has experienced the most growth.

The `us` domain was added to include U.S. institutions, such as local governments and elementary schools, as well as to individuals within a geographical region of the United States. Recently, new domains such as `info` for people and businesses to publish information about themselves and `biz` (an alternative to `com`) for businesses have been added.

To facilitate the entry of other countries to the Internet, the International Organization for Standardization (ISO) has defined a set of two-letter codes that are assigned to each country; examples include codes such as `cz` for Czech Republic, `de` for Germany, and `pe` for Peru. Within each country are naming authorities responsible for organizing the subdomains. Some subdomains are organized by categories, whereas others are structured by geographic location. Some locales have offered their domain names for general use, including the `cc` domain from the Cocos Keeling Islands territory of Australia, `tv` for Tuvalu, and `ws` representing Western Samoa.

Domain names are hierarchical, which means that there can be subdomains beneath second-level domains, as well as host computers. (*Second-level domains* are the names directly below the TLDs that are assigned to individual people and organizations.) Each subdomain is separated by a dot (`.`), starting with the top-level domain on the right and with the second-level domain and each subsequent subdomain appearing to the left, and finally ending with a dot (the trailing dot is usually omitted except in nameserver configurations). Here is an example of a *fully qualified domain name* for a host:

```
baskets.crafts.handsonhistory.com.
```

In this example, the top-level domain is `.com`. The second-level domain name assigned to the organization that controls the domain is `handsonhistory`. Within that domain is a subdomain, or third-level domain, called `crafts`. The last name (`baskets`) refers to a particular computer within that third-level domain. From other hosts in the third-level domain, the host can be referred to simply as `baskets`. From the Internet, you would refer to it as `baskets.crafts.handsonhistory.com`.

**CROSS-REF**

For more details on how the domain-name system is structured and for information on how to set up your own DNS server in Linux, see Chapter 24.

**TIP**

Several RFCs (Request for Comments) define the domain-name system. RFC 1034 covers domain-name concepts and facilities. RFC 1035 is a technical description of how DNS works. RFC 1480 describes the us domain. For a more general description of DNS, there is RFC 1591. You can view RFCs at the RFC Database ([www.rfc-editor.org/rfc.html](http://www.rfc-editor.org/rfc.html)).

## Hostnames and IP Addresses

In the early days of the Internet, every known host computer name and address was collected into a file called HOSTS.TXT and distributed throughout the Internet. This quickly became cumbersome because of the size of the list and the constant changes being made to it. The solution was to distribute the responsibility for resolving hostnames into IP addresses to many DNS servers throughout the Internet.

To make the domain names friendly, the names contain no network addresses, routes, or other information needed to deliver messages. Instead, each computer must rely on some method to translate domain names and hostnames into IP addresses. The DNS server is the primary means of resolving the names to addresses. If you request a service from a computer using a fully qualified domain name (including all domains and subdomains), the request will go to a DNS server to resolve that name into an IP address. It will gather that information either directly from the DNS server that owns that information or, which is more likely, from another DNS server along the way that has gathered that information.

If you have a private LAN or other network, you can keep your own list of hostnames and IP addresses. For the computers you work with all the time, it's easier to type **baskets** than **baskets.crafts.handsonhistory.com**. There are a couple of ways besides DNS that your computer can resolve the IP address for computers for which you give only the hostname:

- **Check the /etc/hosts File** — In your computer's /etc/hosts file, you can place the IP addresses and names for the computers on your local network. In this way, your computer doesn't need to query the DNS server to get the address, which may not be there anyway if you are on a private network and don't have your own DNS server. Another use of the /etc/hosts file is to override an address that a DNS server is giving you, for example, if it is giving you an errant IP address for that host.
- **Check Specified Domains** — You can specify that if the hostname requested doesn't include a fully qualified domain name and the hostname is not in your /etc/hosts file, then your computer should check certain specified domain names. You can do this in the /etc/resolv.conf file.

On your Linux system, when you make a request to resolve a hostname into an IP address, the contents of the /etc/resolv.conf file will most likely determine where your computer searches for that information. That file can specify your local domain, an alternative list of domains, and the location of one or more DNS servers. Here is an example of an /etc/resolv.conf file:

```
domain crafts.handsonhistory.com
search crafts.handsonhistory.com handsonhistory.com
```



```
nameserver 10.0.0.10
nameserver 10.0.0.12
```

In this example, the local domain is `crafts.handsonhistory.com`. If you try to contact a host by giving only its hostname (with no domain name), your computer can check in both `crafts.handsonhistory.com` and `handsonhistory.com` domains to find the host. If you give the fully qualified domain name, it can contact the name servers (first `10.0.0.10` and then `10.0.0.12`) to resolve the address. (You can specify up to six name servers that your computer will query in order until the address is resolved. The total search line is limited to 256 characters, however.)

If your system uses DHCP, in which another server on your network assigns your Linux system an IP address, your `/etc/resolv.conf` file can look more like the following:

```
; generated by /sbin/dhclient-script
search cel.client2.big_isp.com
nameserver 10.0.0.10
nameserver 10.0.0.12
```

In this example, the `/etc/resolv.conf` file was created by the DHCP client code, based on information from the DHCP server. Note that `big_isp.com` is an alias for a large communications company.

**TIP**

**Your resolver knows to check your `/etc/hosts` file first because of the contents of the `/etc/host.conf` and `/etc/nsswitch.conf` files. By default, the `nsswitch.conf` file has your resolver check local files first, followed by DNS to resolve addresses. The `host.conf` file indicates that local files (`hosts`) be checked first for the address, followed by the DNS system (`bind`). You can change that behavior by modifying those files. See the `resolv.conf` man page for further information.**

## Routing

Knowing the IP address of the computer you want to reach is one thing; being able to reach that IP address is another. Even if you connect your computers on a LAN, to have full connectivity to the Internet there must be at least one node (i.e., a computer or dedicated device) through which you can route network traffic that is destined for locations outside your LAN. That is the job of a router.

A *router* is a device that has interfaces connected to at least two networks and is able to route network traffic between the two networks. In my example of a small business that has a LAN that it wants to connect to the Internet, the router would have a connection and IP address on the LAN, as well as a connection and IP address to a network that provides access to the Internet.

A computer running Linux can act as a router between any two TCP/IP interfaces, for example, if the computer has two LAN cards or if it has a network interface card and a modem for a dial-up connection to the Internet. Alternatively, you can purchase a dedicated router, such as

Cisco ADSL routers, that can exclusively perform routing between your LAN and the Internet or network service provider.

**TIP**

Unlike regular dial-up modems, xDSL routers or bridges have several different standards that are not all compatible. Before purchasing an xDSL modem, check with your ISP. If your ISP supports xDSL, it can tell you the exact models of xDSL modems you can use to get xDSL service.

## Proxies

Instead of having direct access to the Internet as you do with routing, you can have indirect access via the computers on your LAN by setting up a *proxy server*. With a proxy server, you don't have to configure and secure every computer on the LAN for Internet access. When, for example, a client computer tries to access the Internet from a Web browser, the request goes to the proxy server. The proxy server then makes that request to the Internet. A proxy server can also be used to filter undesirable web sites from being accessed by users on your local network.

With a proxy server, Internet access is fairly easy to set up and quite secure to use. Linux can be configured as a proxy server using several different projects, including Squid (as described later in this chapter).

## Using Dial-Up Connections to the Internet

---

Although high-speed Internet connections have become widely available, if no high-speed connection is available, modems and telephone lines may be your only option. An external modem typically connects to a serial port (COM1, COM2, etc.) or USB port on your computer and then into a telephone wall jack. Then your computer dials a modem at your ISP or business that has a connection to the Internet.

The most common protocol for making dial-up connections to the Internet (or other TCP/IP network) is the Point-to-Point Protocol (PPP). This section describes how to use the PPP protocol to connect to the Internet.

## Getting Information

To establish a PPP connection, you need to get some information from the administrator of the network that you are connecting to. This is either your ISP when you sign up for Internet service or the person in your workplace who walks around carrying cables, two or more cellular phones, and a couple of beepers. (When a network goes down, these people are in demand!) Here is the kind of information you need to set up your PPP connection:

- **Telephone Number** — This telephone number gives you access to the pool of modems at the ISP. If it is a national ISP, make sure that you get a local or toll-free telephone number. Otherwise, you will rack up long-distance fees on top of your ISP fees.

- **Account Name and Password** — This information is used to verify that you have an Internet account with the ISP. This is referred to as an *account name* when you connect to a Linux or other UNIX system. (When connecting to an NT server, the account name may be referred to as a *system name*.)
- **An IP Number** — Most ISPs use Dynamic IP numbers, which means that you are assigned an IP number temporarily when you are connected. Your ISP assigns a permanent IP number if it uses static IP addresses. If your computer or all the computers on your LAN need to have a more permanent presence on the network, you may be given one static IP number or a set of static IP addresses to use.
- **DNS Server IP Addresses** — Your computer translates Internet hostnames to IP addresses by querying a Domain Name System (DNS) server. Your ISP should give you at least one IP address for a preferred (and possibly alternate) DNS server.
- **PAP or CHAP Secrets** — You may need a Password Authentication Protocol (PAP) ID or Challenge Handshake Authentication Protocol (CHAP) ID and a secret, instead of a login and password when connecting to a Windows NT system at your ISP. These features are used with authentication on Microsoft operating systems, as well as other systems. Linux and other UNIX servers don't typically use this type of authentication, although they support PAP and CHAP on the client side.

Besides providing an Internet connection, your ISP typically also provides services for use with your Internet connection. Although you don't need this information to create your connection, you will need it soon afterward to configure these useful services. Here is some information you should acquire:

- **Mail Server** — If your ISP is providing you with an e-mail account, you must know the address of the mail server, the type of mail service (such as Post Office Protocol or POP3), and the authentication password for the mail server in order to get your e-mail.
- **News Server** — To enable you to participate in newsgroups, the ISP may provide the name of a news server. If the server requires you to log on, you will also need a password.

After you have gathered this information, you are ready to set up your connection to the Internet. To configure CentOS to connect to your ISP, follow the PPP procedure described in the section that follows.

## Setting Up Dial-Up PPP

Point-to-Point Protocol (PPP) is used to create Internet Protocol (IP) connections over serial lines. Most often, the serial connection is established over a modem; however, it will also work over serial cables (null modem cables) or digital lines (including ISDN and DSL).

Although one side must dial out while the other side must receive the call to create a PPP connection over a modem, after the connection is established, information can flow in both directions. For the sake of clarity, however, I refer to the computer placing the call as the *client* and the computer receiving the call as the *server*.

To simplify the process of configuring PPP and other network interfaces, CentOS lets you configure dial-up by using either the Network Configuration window or another tool, such as `kppp`:

- **Network Configuration Window** — From the GNOME desktop panel, choose System > Administration > Network. From the Network Configuration window, select New. The Select Device Type window that appears lets you configure and test your dial-up PPP modem connection.
- **KPPP Window** — Select Applications > Internet > KPPP, or from a Terminal window run the `kppp` command. From the KPPP window, you can set up a PPP dial-up connection and launch it. (You must have the `kdenetwork` package installed to get KPPP.)

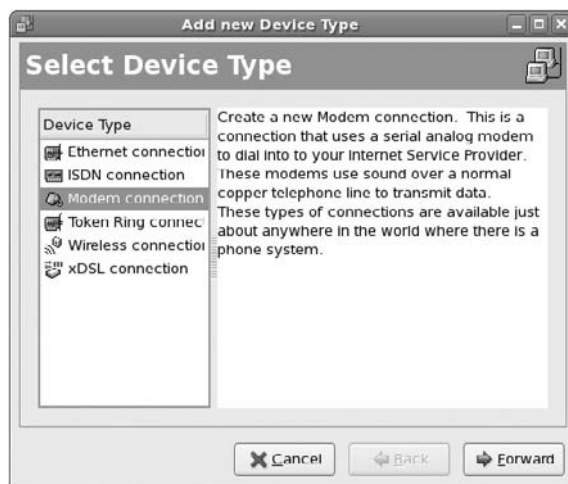
Before you begin either of the two dial-up procedures, physically connect your modem to your computer, plug it in, and connect it to your telephone line. If you have an internal modem, you will probably see a telephone port on the back of your computer that you need to connect. If your modem isn't detected, you can reboot your computer or run `wvdialconf create` as described later in this chapter to have it detected.

## Creating a Dial-Up Connection with the Network Configuration Window

You can use the Network Configuration window to set up dial-up networking. To start it, choose System > Administration > Network from the desktop panel. Select New and a Select Device Type window appears to help you select the device for your Internet connection (a dial-up modem, in this case), as shown in Figure 15-1.

**FIGURE 15-1**

The Network Configuration window helps you set up a PPP Internet connection.



Follow the procedure below from the first Select Device Type window.

1. From the Select Device Type window that appears, select Modem connection and click Forward. The utility searches for a modem and the Select Modem window appears.
2. Select the following modem properties:
  - **Modem Device** — If the modem is connected to your first serial port (COM1) you can select `/dev/ttyS0`; for the second serial port (COM2), choose `/dev/ttyS1`.
  - **Baud Rate** — This is the rate at which the computer talks to the modem, which is typically considerably faster than the modem can talk over the phone lines. The default is 115200. For dial-up connections, the value of 57600 is probably fine.
  - **Flow Control** — Check the modem documentation to see if the modem supports hardware flow control (CRTSCTS). If it doesn't, select software flow control (XON/XOFF).
  - **Modem Volume** — This is off by default because the modem noise can be annoying. However, I usually select medium while I am setting up the modem. Then I turn it off once everything is working. The sound can give you a sense of where things are stopping if you can't get a connection.
  - **Use Touch-Tone Dialing** — Leave this checkbox on in most cases. If for some reason your phone system doesn't support touch-tone dialing, you can turn it off. Click Forward. The Select Provider window appears.
3. Enter the following provider information:
  - **Internet Provider** — If you are using Internet service in any of the countries shown in the Internet Provider window, select the plus sign next to that country name. If your Internet provider appears under the National list, select it. Information is automatically filled in for that provider. Otherwise, you need to fill in the rest of the dialog window. Click Forward.
  - **Phone Number** — Enter the telephone number of the ISP you want to dial into. An optional prefix is available in case you need to dial 9 or some other number to get an outside dial tone.
  - **Provider Name** — The name of the Internet service provider. You could use `ppp0` here as the provider name, to identify the interface. For multiple dial-up accounts, use `ppp1`, `ppp2`, and so on.
  - **Login Name** — The login name assigned to you from the ISP. The ISP may have called the login name a login ID or something similar.
  - **Password** — The password associated with the login nameClick Forward, and the IP Settings window appears.
4. With a dial-up connection, you would typically select "Automatically obtain IP address settings." However, if the ISP has assigned a static IP address that you can use, click on the "Statically set IP addresses" checkbox, and then enter your IP address, Subnet Mask, and Default Gateway Address. Then click Forward to continue.

The Create Dialup Connection window appears, displaying information you just entered.

5. If all the information looks correct, click Apply. The window closes.
6. The Network Configuration window appears, with a new PPP connection of modem type appearing in the window.
7. Click on the new dial-up entry so it is highlighted.
8. Click File ➤ Save to save the new dial-up configuration you just created.
9. Click on the PPP device name and click on the Activate button. The Internet dialer starts up and dials your ISP. If you have sound turned on, you should hear your modem dialing out.

If everything is working properly, you should see your login and password accepted and the PPP connection completed. Try opening a Web browser and see if you can access a web site on the Internet. If this doesn't work the first time, don't be discouraged. There are many things to check to get your dial-up PPP connection working. If your dial-up connection isn't working yet, skip ahead to the "Checking Your PPP Connection" section.

## Launching Your PPP Connection

Although your dial-up connection should now be configured (as described in the previous section), it is not set to connect automatically. One way to start the connection is to set it up to launch from the desktop panel. Here's how:

From the KDE desktop (after installing the `kppp` package):

1. Right-click the panel and then choose Add Application to Panel ➤ Internet ➤ KPPP.
2. Select the KPPP icon from the panel (and type the root password, if prompted). A KPPP window appears.
3. Select the dial-up interface you added and click Connect to connect.

From this point forward, icons will appear on your desktop that you can select to connect immediately to your ISP over the dial-up connection you configured.

## Launching Your PPP Connection on Demand

Instead of starting a dial-up PPP connection manually each time you want to contact the Internet, you can set your dial-up connection to start automatically when an application (such as a Web browser or e-mail program) tries to use the connection. On-demand dialing is particularly useful if:

- The dial-up connection on your Linux system is acting as the gateway for other computers in your home or office. You don't have to run over to your Linux box to start the connection when another computer needs the dial-up connection.
- You run programs at off hours that require an Internet connection (like remote backups).

- You don't want to be bothered clicking an extra icon when you just want to browse the Web a bit.

The risk of on-demand dialing is that dial-up connections can start up when you don't want them to because the connection starts automatically (some people get worried when their computer starts dialing by itself in the middle of the night).

Here is an example of settings you can add to your dial-up configuration file (`/etc/sysconfig/network-scripts/ifcfg-xxx` where `xxx` is replaced by your provider name) to configure on-demand dialing:

```
ONBOOT=yes
DEMAND=yes
IDLETIMEOUT=600
RETRYTIMEOUT=30
```

The `ONBOOT=yes` starts the `pppd` daemon but doesn't immediately begin dialing because `DEMAND` is set to `yes`. Also, because `DEMAND=yes`, a dial-up connection attempt is made any time traffic tries to use your dial-up connection. With `IDLETIMEOUT` set to 600, the connection is dropped after 600 seconds (10 minutes) with no traffic on the connection. With `RETRYTIMEOUT` set to 30, a dropped connection is retried after 30 seconds unless the connection was dropped by an idle time-out, in which case there is no retry. You can change the time-out values as it suits you.

**NOTE**

Because it can take time for dial-up connections to be established, operations may fail while dialing occurs. In particular, DNS requests can time out in 30 seconds, which may not be long enough to establish a dial-up connection. If you have three DNS servers configured for each client, you have a 90-second time-out period. As a result, the modem connection may be running before the request fails.

## Checking Your PPP Connection

To debug your PPP connection or simply to better understand how it works, you can run through the steps below. They will help you understand where information is being stored and how tools can be used to track this information.

### Checking That Your Modem Was Detected

It is possible that your modem is not supported under Linux. If that is the case, your PPP connection might be failing because the modem was not detected at all. To scan your serial ports to see where your modem might be, type the following as `root`:

```
$ wvdialconf /etc/wvdial.conf.new
```

The `wvdialconf` command is really made to build a configuration file (`/etc/wvdial.conf`) that is used by the dialer command (`wvdial`). If it succeeds, you can copy the `wvdial.conf.new` file to the `/etc/wvdial.conf`. Its first action, however, is to scan the serial ports on your computer and

report where it finds modems. If it tells you that no modem was detected, it's likely that either your modem isn't connected properly or no driver is available to support the modem.

If the modem wasn't detected, you should determine whether or not it is a modem supported in Linux. You can do this by finding out what type of chipset is used in the modem. This is even more important than finding out the manufacturer of the modem because the same manufacturer can use chips from different companies. This applies primarily to internal, software-based modems because most external serial modems, internal PCI controller-based modems, and many USB modems are supported in Linux.

After you have determined the chipset being used, check the web site `linmodems.org`. This site contains information on so-called Win-modems. Search for the chipset on your modem from this site. It will tell you if there is a driver available for your modem.

A nice tool for determining what type of Win-modem you have and how to get it working is `scanModem`. If you have access to the Internet from another machine, you can download `scanModem` from `http://linmodems.technion.ac.il/packages/scanModem.gz`.

Because you probably don't have a working Internet connection yet, find a way to copy `scanModem.gz` to your Linux system. As `root` user from a Terminal window, type these commands, with that file in the current directory:

```
# gunzip scanModem.gz
# chmod 755 scanModem
# ./scanModem
```

The result is a Modem directory containing text files describing your modem and what you can do to configure it.

## NOTE

If you are a new Linux user with a Win-modem and you are still baffled after referring to the `linmodems.org` site, you might consider getting a serial or USB modem. To try to get your Win-modem working, you might need to download, compile, and load a modem driver. Especially with some older Win-modems, drivers have not been updated to work with the latest kernels. Picking up a cheap serial modem from a used computer store can save hours of frustration that may still result in failure.

## Checking That Your PPP Interface Is Working

One way to check that the PPP interface is working is with the `ping` command. From the Terminal window, type `ping` along with any Internet address you know. For example:

```
$ ping www.handsonhistory.com
PING handsonhistory.com (198.60.22.8) from 192.168.0.43 : 56(84)
 bytes of data.
64 bytes from handsonhistory.com (198.60.22.8): icmp_seq=0 ttl=240
 time=120 msec
64 bytes from handsonhistory.com (198.60.22.8): icmp_seq=1 ttl=240
 time=116 msec
64 bytes from handsonhistory.com (198.60.22.8): icmp_seq=2 ttl=240
 time=120 msec
```



```

--- www.handsonhistory.com ping statistics ---
4 packets transmitted, 3 packets received, 25% packet loss
round-trip min/avg/max/mdev = 116.816/119.277/120.807/1.779 ms

```

Press [Ctrl]+C to end the ping command. The previous lines show the responses from `www.handsonhistory.com`. It sent back packets from the IP address `198.60.22.8` in response to each one it received. You can see the sequence of packets (`icmp_seq`) and the time it took for each response in milliseconds. If you receive packets in return, you will know two things: first, that your connection is working, and second, that your name to address translation from the DNS addresses in `/etc/resolv.conf` is working.

## Checking the Default Route

After starting a dial-up connection, check that the default route is set using `route -n`, as shown in the following example:

```

# /sbin/route -n
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
198.62.1.1 0.0.0.0 255.255.255.255 UH 0 0 0 ppp0
10.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 eth0
169.254.0.0 0.0.0.0 255.255.0.0 U 0 0 0 eth0
127.0.0.0 0.0.0.0 255.0.0.0 U 0 0 0 lo
0.0.0.0 198.62.1.1 0.0.0.0 UG 0 0 0 ppp0

```

This shows that the gateway was set to the remote PPP server (`198.62.1.1`), as well as showing the other interfaces running on my computer. There are two `ppp0` entries. The first shows the destination as a host (UH). The second shows the destination as a gateway (UG). The address entry `169.254.0.0` indicates that all addresses for subnetwork `169.254` should be directed to the local network. Microsoft clients that can't get an IP address via DHCP or other means will assign themselves IP addresses in this range. All addresses that can't be resolved on the local LAN are directed to the gateway address.

## Checking That the Name Servers Are Set

If you are able to ping a remote computer by IP address but are not able to resolve any addresses, your DNS servers may not be set correctly. As `root` user from a Terminal window, open the `/etc/resolv.conf` file and check that there are lines identifying one or more DNS servers in this file. These should be supplied to you by your ISP, unless you run your own DNS server.

Try using the ping command to make sure that the name servers are live.

### NOTE

When you connect to your ISP using DHCP, it's possible that during the connection process, new name server information will appear in your `/etc/resolv.conf` file and old entries will be lost. This can be a problem if you are relying on your own server for providing DNS service and its entry is erased.

## Checking the CHAP-Secrets or PAP-Secrets File

PPP supports two authentication protocols in CentOS: Challenge Handshake Authentication Protocol (CHAP) and Password Authentication Protocol (PAP). Here is what each protocol does to authenticate:

- **CHAP** — The server sends the client a challenge packet that includes the server name. The client sends back a response that includes its name and a value that combines the secret and the challenge. The client name and secret are stored in your `/etc/ppp/chap-secrets` file.
- **PAP** — The client sends its name and a password (in clear text) for authentication. The client name and secret are stored in your `/etc/ppp/pap-secrets` file.

By default, PPP will authenticate if the server requests it, unless it has no secrets to share. If it has no secrets, PPP (or, more specifically, the PPP daemon `pppd`) will refuse authentication. It is likely that you will find the usernames and passwords you provided when you set up your PPP connection in both of these files. (PPP assumes that you may be using CHAP or PAP authentication.)

The CHAP-secret and PAP-secret formats are the same. Each authentication line can contain the client name, the server name, and the secret. The server name can be represented by an `*` (to allow this secret to be used to authenticate any server). This is useful if you don't know what the server name will be. Also, remember that case is significant (i.e., `Myserver` is not the same as `myserver`).

### TIP

For more about PAP and CHAP in PPP for Linux, type `man pppd` to see the `pppd` man page.

In any case, here's an example of what a CHAP-secrets file may look like:

```
# Secrets for authentication using CHAP
# client          server      secret                IP addresses
#####
##### redhat-config-network will overwrite this part!!! (begin)
#####
"abcusername"    "ppp0"      "MySecretPassword"
```

### WARNING

The `PAP-secrets` and `CHAP-secrets` files should not be accessible by anyone but the root user. Anyone gaining this information could use it to access your Internet account. By default, permissions are closed to all but the root user. To close permission, type `chmod 600 /etc/ppp/*-secrets`.

## Looking at the ifcfg File

The `ifcfg` file for your PPP connection is stored in a filename that includes the provider name you entered, such as `/etc/sysconfig/network-scripts/ifcfg-ATT`. That file contains options that are passed to the `pppd` daemon for features that are negotiated with the remote PPP server.

Most of the problems that can occur with your PPP connection result from getting some of the options wrong, particularly asking for features the server can't or won't provide.

Here is an example of the `ifcfg-???` file (in this case named `ifcfg-ATT`) used to connect to a Windows NT PPP server:

```
DEVICE=ppp0
PROVIDER=ATT
MODEMPORT=/dev/ttyS0
LINESPEED=115200
PAPNAME=guest
ONBOOT=yes
DEFROUTE=yes
DEMAND=yes
```

The device name is `ppp0`. The `PROVIDER` is the name you assigned to the connection (which is associated with the configuration file, e.g., `ifcfg-ATT`). `MODEMPORT` is the device name associated with the port the modem is connected to (in this case, `COM1`). `LINESPEED` sets the speed, in bits per second, between the computer and the modem (not the dial-up speed, which is typically slower). `PAPNAME` is the username that you log in with, assuming that you are using PAP authentication.

`ONBOOT` is set to `yes` to start the `pppd` daemon at boot time but not dial out yet, since `DEMAND=yes` is set. `DEFROUTE=yes` sets the default route to be this PPP connection. `DEMAND=yes` causes the link to be initiated only when traffic is present.

**TIP**

If you want to see the exact options set by each of these parameters, look at the contents of the `/etc/sysconfig/network-scripts/ifup-ppp` script. For example, if `DEFROUTE=yes`, then the option `defaultroute` is sent to the `pppd` daemon. Type **man pppd** to see the `pppd` man page for a description of each option, or read the text file at `/usr/share/doc/initscripts-8.45.19.1.EL/sysconfig.txt`.

You can add a `PPPOPTIONS` line to set any additional options you want passed to the `pppd` daemon process. There are some cases in which the ISP will require other values that are not included here. Likewise, there are some options that you should not put in this file when connecting to certain types of servers. Here are some suggestions of values that either should not be in this file or should be (in some cases) for some Windows NT servers. For descriptions of these options, see the `pppd` man page:

- `remotename=remotename` — You may need this value for PAP authentication, but it should not be entered for CHAP authentication. For CHAP, the remote PPP server sends you its name.
- `require-chap, require-pap, auth, noauth` — It's a nice idea to ask a Windows NT server to authenticate itself (which is what `require-chap` and `require-pap` do for their respective protocols). The `auth` value requires the server to authenticate itself before packets can be sent or received. However, I'm told on good authority that Windows NT will not let you do any of this. Authentication will fail, and you will not get a connection.

You may need to indicate explicitly that the server is not required to authenticate itself by entering the `noauth` option.

- `default-asynmap` — PAP can fail to authenticate because of “link transparency problems.” If authentication fails and you are sure you have the authentication information correct, try adding this value.
- `ipcp-accept-local`, `ipcp-accept-remote` — Sometimes a server will request your local IP address, even if it wants to assign one itself. The same is true of the remote address. Try adding these lines to the options file:

```
192.168.0.1:192.168.0.2
ipcp-accept-local
ipcp-accept-remote
demand
```

This gives temporary local and remote addresses and tells the remote server that it can replace those values. Instead of using private IP addresses as shown here, you could use `0.0.0.0` instead.

- `bsdcomp`, `deflate` — Certain kinds of compression are not supported with Windows NT PPP servers, so you should not request BSD compression (`bsdcomp`) or Deflate compression (`deflate`). In some cases, you may want to prohibit those types of compression: `nobsdcomp`, `nodeflate`, and `noccp` (for no compression control protocol).

As noted earlier, the best place for descriptions of `pppd` options is the `pppd` man page. For a sample options file, look in `/usr/share/doc/ppp*/sample`.

## NOTE

Additional scripts for dial-up connections, particularly if you are using the newer IPv6 addresses, are contained in the `/etc/ppp` directory.

## Running Debugging

If your modem is working but you are not getting connected at all, the first thing to do is turn on logging for PPP. This will help you track down the problem. If you are still stumped after looking at the logging output, have an expert review the log file. Make sure that debugging is turned on by setting `DEBUG=yes` in the `ifcfg-???` file.

## TIP

If you can get on the Internet from another machine, I recommend posting your failed PPP output to the `comp.protocol.ppp` newsgroup, where some very smart PPP experts can help answer your questions. Before you post, however, read a few days' worth of messages from the group. Chances are that someone has already run into the same problem and has a solution. Also, post only the parts of the log file that are relevant. You can also ask your local Linux user group for help.

To have debugging directed to a separate log file for PPP, add these lines to the `/etc/rsyslog.conf` file:

```
daemon.*      /var/log/pppmsg
local2.*      /var/log/pppmsg
```

After this, restart the `rsyslogd` daemon process (as `root` user) by typing the following:

```
# service rsyslog restart
```

It's best to try to do this debugging process from the desktop because it helps to have several Terminal windows open (I would suggest at least three). From the first window, start a command that lists the contents of the log file we just defined above (`pppmsg`) as debug messages come in:

```
# tail -f /var/log/pppmsg
```

In the next window, start the PPP interface. Assuming that it is the `ppp0` interface, use the following command as `root` user:

```
# ifup ppp0
```

Here is a partial listing of the output:

```
Apr  6 15:43:51 maple pppd[1282]: pppd 2.4.1 started by root, uid 0
Apr  6 15:43:51 maple ifup-ppp: pppd started for ppp0 on /dev/modem
      at 115200
Apr  6 15:43:52 maple chat[1285]: abort on (BUSY)
Apr  6 15:43:52 maple chat[1285]: abort on (ERROR)
Apr  6 15:43:52 maple chat[1285]: abort on (NO CARRIER)
Apr  6 15:43:52 maple chat[1285]: abort on (NO DIALTONE)
Apr  6 15:43:52 maple chat[1285]: abort on (Invalid Login)
Apr  6 15:43:52 maple chat[1285]: abort on (Login incorrect)
Apr  6 15:43:52 maple chat[1285]: send (ATZ^M)
Apr  6 15:43:52 maple chat[1285]: expect (OK)
Apr  6 15:43:53 maple chat[1285]: ATZ^M^M
Apr  6 15:43:53 maple chat[1285]: OK
Apr  6 15:43:53 maple chat[1285]: -- got it
Apr  6 15:43:53 maple chat[1285]: send (ATDT5551212^M)
Apr  6 15:43:53 maple chat[1285]: expect (CONNECT)
Apr  6 15:43:53 maple chat[1285]: ^M
Apr  6 15:44:10 maple chat[1285]: ATDT5551212^M^M
Apr  6 15:44:10 maple chat[1285]: CONNECT
Apr  6 15:44:10 maple chat[1285]: -- got it
Apr  6 15:44:10 maple chat[1285]: send (\d)
Apr  6 15:44:14 maple pppd[1282]: Serial connection established.
Apr  6 15:44:14 maple pppd[1282]: Using interface ppp0
Apr  6 15:44:14 maple pppd[1282]: Connect: ppp0 <--> /dev/modem
      .
      .
      .
Apr  6 15:44:17 maple pppd[1282]: local  IP address 222.62.137.121
Apr  6 15:44:17 maple pppd[1282]: remote IP address 222.62.1.105
Apr  6 15:44:17 maple pppd[1282]: primary  DNS address 111.222.111
      .253
Apr  6 15:44:17 maple pppd[1282]: secondary DNS address 111.222.111
      .254
```

This output shows starting the PPP connection on `/dev/modem`. After verifying that the modem is working, the chat script sends the telephone number. The connection is made, and the PPP interface is started. After some parameter negotiations, the server assigns IP addresses to both sides of the communication, and the connection is ready to use.

If you do get connected, but none of your applications (Web browser, FTP, etc.) seem to work, check that your PPP interface is noted as the default route (`/sbin/route -n`). If it is, check that you have the DNS servers specified correctly in your `/etc/resolv.conf` file. Use the `ping` command on those DNS servers' IP addresses to make sure that you can get through.

## Connecting Your LAN to the Internet

---

The users on your LAN are happy that you made it so that they can share files and printers with each other. With your users already connected on a LAN, the next logical step is to set up a connection to the Internet that everyone can share. The advantages of doing this are as follows:

- **Save on Modems** — Instead of each computer having its own modem, you can have one high-speed device such as a DSL router or cable modem that routes all traffic to the Internet.
- **Save on Telephone Lines** — Instead of using a telephone line for each person who wants to get to the Internet, you can use one line to your ISP. In the case of DSL, the telephone company will even let you use the same telephone line for both analog voice and high-speed digital data.
- **Central Maintenance** — If information related to your Internet connection (such as your dial-out number or name server addresses) changes, you can administrate those changes in one location instead of having to change them on every computer.
- **Central Security** — You can better control the Internet traffic that comes into and goes out of your network.

The procedures in this section assume that you have already set up a LAN, as described in Chapter 14. It is also assumed that you have an outgoing connection from your Linux system to the Internet that all traffic between the computers on your LAN and the Internet can pass through. That outgoing connection may be dial-up or may come through another LAN card connected to a DSL router or other LAN. This section describes two ways to set up your Linux system so clients on the LAN can access the Internet:

- **As a Router** — By configuring Linux as a router, it can route IP packets from clients on the LAN to the Internet through the dial-up connection.
- **As a Proxy Server** — You can configure Linux as a proxy server. In this way, client computers on your LAN can access the Internet as though the connection were coming from the Linux computer.

## Setting Up Linux as a Router

---

There are several different ways to set up routing from your LAN to the Internet. You can have a dedicated router, or you can have a computer already connected to your LAN that will act as a router. This section describes how to use your Linux system as a router.

A computer may have several network interfaces, such as a loopback, an Ethernet LAN, a direct line to another computer, or a dial-up interface. For a client computer to use a router to reach the Internet, it may have a private IP address assigned to it on the LAN. A connection to a routing computer would act as the gateway to all other addresses.

Here's an example of Linux being used as a router between a LAN and the Internet:

- The Linux system has at least two network interfaces: one to the office LAN and one to the Internet. The interface to the Internet may be a dial-up PPP connection or, more likely these days, a higher-speed DSL or cable modem connection.
- Packets on the LAN that are not addressed to a known computer on the LAN are forwarded to the router (i.e., the Linux system acting as a router). Therefore, each client identifies that Linux system as the gateway system.
- The Linux router/firewall is set up to receive packets from the local LAN, then forwards those packets to its other interface (possibly a PPP connection to the Internet). If the LAN uses private IP addresses, the firewall is also configured to use IP masquerading or Network Address Translation.

The following sections describe how to set up the Linux router, as well as the client computers from your LAN that will use this router. Using Linux as a router also provides an excellent opportunity to improve the security of your Internet connection by setting up a firewall to filter traffic and hide the identity of the computers on your LAN (IP masquerading).

### Configuring the Linux Router

To configure your Linux computer as a router, you need to have a few things in place. Here's what you need to do before you set up routing:

- **Connect to Your LAN** — Add a network card and configure the computers on your LAN as described in Chapter 14.
- **Connect to the Internet** — Set up a dial-up or other type of connection from your Linux computer to your ISP. This is described earlier in this chapter in the section on setting up outgoing PPP connections.
- **Configure Your Linux Computer as a Router** — See the rest of this section.

## Selecting IP Addresses

The type of IP addresses you are using on your LAN will have an impact on a couple of steps in this procedure. Here are the differences:

- **Private IP Addresses** — If the computers on your LAN use private IP addresses (described in Chapter 14), you need to set up Linux as a firewall to do IP masquerading or NAT (as described in Chapter 13). Because those numbers are private, they must be hidden from the Internet when the Linux router forwards their requests. Packets forwarded with masquerading or NAT look to the outside world as though they came from the Linux computer forwarding the packets.
- **Valid IP Addresses** — If your LAN uses addresses that were officially assigned by your ISP or other registration authority, you don't need to do IP masquerading or NAT. Actually, for any machine you want to expose to the world, such as a public server, you will want to have a valid, public IP address.

In most cases in which you are not configuring the computers on your LAN as servers, you will probably want to use private IP addresses.

## Enable Forwarding and Masquerading

With your Linux computer's LAN and Internet interfaces in place, use the following procedure to set up Linux as a router. After this procedure is completed, any client computer on your LAN can identify your Linux computer as its gateway so it can use Linux to get to the Internet.

1. Open the `/etc/sysconfig/network` file in a text editor as the `root` user. Then add either a default gateway or default gateway device as described below.

Your default gateway is where traffic destined for networks outside of your own is sent. This is where you would identify your Internet connection. Here is how you choose which one to enter:

- **Default Gateway** — If there is a static IP address you use to reach the Internet, enter that IP address here. For example, if your Internet connection goes through a DSL modem connected to your NIC card at address `192.168.0.1`, enter that address as follows:

```
GATEWAY=192.168.0.1
```

- **Default Gateway Device** — If you reach the Internet using a dynamic address that is assigned when you connect to a particular interface, enter that interface here. For example, if you had a dial-up interface to the Internet on the first PPP device, you would enter `ppp0` as the default gateway device as follows:

```
GATEWAYDEV=ppp0
```

When you are done, the contents of this file should look similar to the following:

```
NETWORKING=yes  
HOSTNAME='maple.handsonhistory.com'
```



```
DOMAINNAME='handsonhistory.com'
#GATEWAY=
GATEWAYDEV=ppp0
```

In this case, the computer is configured to route packets over a dial-up connection to the Internet (ppp0).

2. Turn on IP packet forwarding. One way to do this is to change the value of `net.ipv4.ip_forward` to 1 in the `/etc/sysctl.conf` file. Open that file as root user with any text editor and change the line to appear as follows:

```
net.ipv4.ip_forward = 1
```

**NOTE**

You can restart your network for this change to take effect (service network restart). To have the change take place without a network restart, type **echo 1 > /proc/sys/net/ipv4/ip\_forward**.

3. If the computers on your LAN have valid IP addresses, skip ahead to the “Configuring Network Clients” section. If your computers have private IP addresses, continue with this procedure.

**CAUTION**

The lines shown below for configuring your iptables firewall to do IP masquerading should be used in addition to your other firewall rules. They do not, in themselves, represent a secure firewall, but merely describe how to add masquerading to your firewall. See Chapter 13 for details about how to configure a more complete firewall and when to use NAT versus IP masquerading.

4. To get IP masquerading going on your Linux router, you need to define which addresses will be masqueraded and forwarded, using iptables.

The following examples assume that you are masquerading all computers on your private LAN 10.0.0 (i.e., 10.0.0.1, 10.0.0.2, etc.) and routing packets from that LAN to the Internet over your dial-up (ppp0) interface.

Type the following as root user:

```
# iptables -t nat -A POSTROUTING -o ppp0 -j MASQUERADE
# iptables -A FORWARD -s 10.0.0.0/24 -j ACCEPT
# iptables -A FORWARD -d 10.0.0.0/24 -j ACCEPT
# iptables -A FORWARD -s ! 10.0.0.0/24 -j DROP
```

The previous commands turn on masquerading in the NAT table by appending a POSTROUTING rule (`-A POSTROUTING`) for all outgoing packets on the first dial-up PPP interface (`-o ppp0`). The next two lines accept forwarding for all packets from (`-s`) and to (`-d`) the 10.0.0 network (10.0.0.0/24). The last line drops packets that don't come from the 10.0.0 network.

The previous lines add rules to your running iptables firewall in the Linux kernel. To make the current rules permanent, save them as follows:

```
# service iptables save
```

This copies all the current rules to the `/etc/sysconfig/iptables` file, from which the rules are read each time you reboot your system. If the new rules don't work, just copy the `iptables.save` file back to the original `iptables` file.

5. At this point, you may want to restart your network as follows:

```
# /etc/init.d/network restart
```

6. Then, to restart your firewall, type the following:

```
# /etc/init.d/iptables restart
```

7. To see if your new rules have gone into effect, type **iptables -L**. To view NAT rules, type **iptables -L -t nat**.

If the route to the Internet from Linux is being provided by a dial-up connection, you probably want to turn on on-demand dialing (as described earlier in this chapter).

## Configuring Network Clients

In this example, there are a variety of Linux and Windows operating system clients on a LAN. One Linux computer has a connection to the Internet and is set up to act as a router between the Internet and the other computers on the LAN (as described previously). To be able to reach computers on the Internet, each client must be able to do the following:

- Resolve the names it requests (e.g., `www.centos.org`) into IP addresses.
- Find a route from the local system to the remote system, using its network interfaces.

Each Linux client computer knows how to find another computer's address based on the contents of the `/etc/host.conf`, `/etc/hosts`, and `/etc/resolv.conf` files. The contents of the `host.conf` file, by default, are the following:

```
order hosts,bind
```

This tells your system to check for any hostnames (`hosts`) that you request by first checking the contents of the `/etc/hosts` file and then checking with name servers that are identified in the `/etc/resolv.conf` file. In our case, we will put the addresses of the few hosts we know about on our private network (whether on the LAN, direct connection, or other network interface) in the `/etc/hosts` file. Then, the system knows to resolve addresses using a DNS server (`bind`) based on addresses of name servers we add to the `/etc/resolv.conf` file.

Next, each client machine must know how to get to the Internet. Do this by adding a default route, sometimes called a *gateway*, to each client. To permanently add a default route on the client Linux system, do the following:

1. Set the default route to point to the router. This entails setting the `GATEWAY` or `GATEWAY-DEV` value in the `/etc/sysconfig/network` file as described in the previous procedure. This time, the address will point to the LAN interface of the router.

- Restart your network interfaces by typing the following as root user:

```
# /etc/init.d/network restart
```

- When the computer comes back up, type the following:

```
# netstat -r
Kernel IP routing table
Destination Gateway Genmask Flags MSS Window irtt Iface
10.0.0.0 * 255.255.255.0 U 0 0 0 eth0
169.254.0.0 0.0.0.0 255.255.0.0 U 0 0 0 eth0
default 10.0.0.1 0.0.0.0 UG 0 0 0 eth0
```

You can see that the default gateway was set to the host at the IP address 10.0.0.1 on the eth0 Ethernet interface. Assuming that the router is ready to route your packets to the Internet, your Linux client is now ready to use that router to find all IP addresses that you request that you do not already know where to find. The `netstat -r` command provides the same output as the `/sbin/route` command.

## Configuring a Virtual Private Network Connection

There are several ways of going about setting up VPN connections in Linux:

- **Internet Protocol SECURITY (IPsec)** — IPsec is a standard developed by the Internet Engineering Task Force (IETF) as the required method of encryption when the IP version 6 becomes the standard Internet protocol (IPv4 is currently the standard). There are several implementations of IPsec over IPv4 in Linux these days. Linux includes IPsec support by including the Linux 2.6 kernel and offering an administrative interface for configuring it via the `ipsec-tools` package.
- **PPP over OpenSSH** — With this method, using software that is already in Linux, you can configure a PPP interface (as you would a regular dial-up connection) to use SSH to encrypt all data that goes across the PPP interface. While this method is not too difficult to configure, it can provide poor performance (there's a good discussion on this at <http://sites.inka.de/~W1011/devel/tcp-tcp.html>). To see how to create a PPP over OpenSSH VPN, refer to the VPN PPP-SSH HOWTO (search [www.tldp.org](http://www.tldp.org)).
- **OpenVPN** — With OpenVPN (<http://openvpn.net>), you can use all OpenSSL encryption and authentication features to create a tunnel to remote systems over public networks such as the Internet. An OpenVPN package for CentOS is available from the RPMforge repository.
- **Openswan** — The Openswan project ([www.openswan.org](http://www.openswan.org)) produces an implementation of IPsec that was originally based on code from the FreeS/WAN project ([www.freeswan.org](http://www.freeswan.org)). Openswan is included in the CentOS software repository (to install it, type `yum install openswan`).

- **Crypto IP Encapsulation (CIPE)** — Using this method, IP packets are routed across selected IP interfaces as encrypted UDP packets. CIPE is easy to set up and carries less overhead than PPP over OpenSSH, so you should get better performance. One drawback is that, because it is not a standard VPN, CIPE is not available on all platforms and was dropped from CentOS.

Chapter 14 explained the basic idea behind using a VPN and described how to configure NetworkManager to communicate with a remote OpenVPN server. In this chapter, I provide an overview of the features and tools in IPsec and a detailed description of configuring an OpenVPN server in CentOS.

## Understanding IPsec

To provide more secure transmission of TCP/IP data in the new Internet Protocol version 6 (IPv6) standard, developers of that standard created the Internet Protocol Security (IPsec) architecture. With IPsec, encrypted communication is possible right at the IP level, and methods for providing access control, data integrity, authentication, and traffic flow confidentiality are standardized as well.

In practical terms, organizations that have computers which need to communicate on public networks in ways that are secure and private can create VPNs with IPsec. Unlike other VPN implementations (such as CIPE), which require a manual exchange of keys to work, IPsec offers an automated way of creating security associations between communications endpoints and managing keys.

With slow adoption of IPv6, IPsec has been backported into the IPv4 protocol, which is still the most common IP version used on the Internet. That backport was added into the IP protocol included with the Linux 2.6 kernel. The Internet standard RFC2401 document describes the IPsec architecture.

## Using IPsec Protocols

IPsec consists of two primary protocols: Authentication Header (AH) and Encapsulating Security Payload (ESP). Look in the `/etc/protocols` file and you'll see that AH is assigned to protocol number 50 and ESP is assigned to protocol number 51.

To authenticate peer computers and exchange symmetric keys, IPsec uses the Internet Key Exchange (IKE) protocol. At the beginning of communication between two host computers using IPsec, IKE does the following:

- Authenticates that the peer computers are who they say they are.
- Negotiates security associations.
- Chooses secret symmetric keys (using Diffie-Hellmann key exchange).

The security associations established by IKE are stored in a Security Association Database (SAD). A security association holds information about the communications endpoints (possibly public Internet IP addresses), whether AH or ESP protocols are being used with IPsec, and the secret key/algorithm being used.

IPsec itself has two possible modes of operation: Tunnel mode and Transport mode.

- **Tunnel Mode** — The entire IP datagram is encapsulated into the new IP datagram by IPsec. This protects both the data and the control information from being seen by anyone except the communications endpoint that is allowed to decrypt the communication.
- **Transport Mode** — Only the data (the payload intended for the client receiving the data) is encrypted. To do this, IPsec inserts its own header between the Internet Protocol header and the protocol header for the upper layer.

Included in the protocol header of each packet transmitted is information referred to as Hash Message Authentication Codes (HMAC). Including these codes with transmitted data in IPsec offers the following advantages:

- **Data Integrity** — By using a hash algorithm to create a hash from a secret key and the data in the IP datagram, the resulting HMAC is added to the IPsec protocol header. The receiver can then check that the HMAC is correct using its own copy of that secret key. Supported authentication algorithms include MD5, SHA1, and SHA2 (256, 384, and 512).
- **Data Privacy** — By using symmetric encryption algorithms (such as DES, NULL, AES, 3DES, and Blowfish), datagrams are encrypted so their contents cannot be seen by outsiders.

By recording a sequence of packets during data communications, an intruder can attempt denial-of-service attacks by replaying that sequence of packets. IPsec combats that type of attack by accepting packets that are within a *sliding window* of sequence numbers or higher. Packets using older sequence numbers are dropped.

## Using IPsec in CentOS

Using IPsec in CentOS, you can configure VPNs between CentOS and other systems that support IPsec. It is important that hosts at both ends of the IPsec VPN are configured in the same way. In fact, you may have the best results by using the same operating system version and IPsec software. In CentOS, you have the choice of using OpenVPN, Openswan, or IPsec-Tools.

By default, the necessary modules to use IPsec are already available in CentOS. If you choose to use IPsec, all the tools you need to configure a VPN are contained in the `ipsec-tools` packages. You set up IPsec in the kernel in much the same way that you set up firewalls with `iptables`: You run commands that load settings into the kernel, either from command-line options or from a file containing your pre-configured options.

The commands you use to set up a VPN with IPsec include the following:

- `setkey` — Use this command to load the data about your VPN connections into the kernel. It can add, change, flush, or dump information in the Security Association Database (SAD) and the Security Policy Database (SPD) for your IPsec VPN. Typically, you would create a configuration file in the format described on the `setkey` man page, then run `setkey -f filename` to load that data into the kernel.
- `racoon` — Use this command to create IKE security associations between host computers communicating together over an IPsec VPN. Security data are loaded into `racoon` from the `/etc/racoon/racoon.conf` file, unless that file is overridden from the `racoon` command line using the `-f` option.

Sample configuration files to use with `setkey` are available from the IPsec-howto ([www.ipsec-howto.org](http://www.ipsec-howto.org)). A sample `racoon.conf` file is included with the `ipsec-tools` package (in the `/usr/share/doc/ipsec-tools-*` directory). For an in-depth description of the tools used with IPsec, refer to the Kame Project web site ([www.kame.net](http://www.kame.net)).

## Configuring an OpenVPN Server

Virtual private networks were created to allow computer systems to have secure connections using insecure public networks. Setting up an OpenVPN server at your place of business can provide an inexpensive way for branch offices or telecommuters to securely access your company's private network.

Because VPN technologies, such as OpenVPN, provide encrypted connections between two transport-level network interfaces, any applications communicating between those two systems are secure. This is as opposed to user-space applications, such as SSL, that must implement features from every application they want to offer to users.

For Linux systems, OpenVPN provides a very good choice of software for configuring a VPN server. The following are some of the features of OpenVPN:

- A single port can provide access to up to 128 clients.
- The server can control client setup, doing tasks such as pushing configuration data to clients through the VPN tunnel.
- You can use Telnet to access the server.
- OpenVPN includes TUN/TAP virtual network interface drivers at the networking layer, with device names like `/dev/tunX` and `/dev/tapX`. Applications can use the TUN devices as virtual point-to-point interfaces to VPN partners (routed mode). TAP devices provide a virtual Ethernet adapter, so daemons listening on TAP can capture Ethernet frames.

The OpenVPN procedure in this chapter describes how to set up an OpenVPN server. This includes:

- Setting up information needed to create certificate authority certificates and keys. In the process you create a root RSA Private Key (`ca.key`) that you need to keep confidential and a root certificate (`ca.crt`) that you share.
- Setting up configuration files and starting the OpenVPN service.

## Decisions before Configuring OpenVPN

The decisions you need to make before setting up your OpenVPN connection include the following:

- **Do You Want a Public Key Infrastructure or Static Key?** — If you have a single VPN client connection to a single server, you can use a static key. That way you don't have to maintain a key infrastructure. See the OpenVPN how-to for more information at <http://openvpn.net/index.php/documentation/howto.html#examples>.
- **Will Your VPN Do Routing or Bridging?** — Routing, where data is routed from the VPN server to the LAN (instead of just being passed through), is usually a better choice than bridging. Routing is easier to set up and provides more control for specific client features.

The following assumes that you decided to set up a public key infrastructure and are using a routing OpenVPN server. For information on using OpenVPN to do bridging, refer to the Ethernet Bridging FAQ at <http://openvpn.net/index.php/documentation/faq.html#bridge1>.

## Create a Public Key Infrastructure

Using certificates and private keys, you can create a safe environment for allowing multiple clients to access your private networks over the Internet. The following procedure is done on a CentOS system that doesn't necessarily have to be the same one that you use for your VPN server. In this example, however, the entire procedure is run on the OpenVPN server.

To begin setting up your public key infrastructure, open a Terminal window as `root` and do the following:

### 1. Copy the Sample Configuration Files:

```
# cp -r /usr/share/doc/openvpn-2.0.9/easy-rsa/ /etc/openvpn/  
# cd /etc/openvpn/easy-rsa/2.0
```

### 2. Change Permissions — Because of a bug in the package, several scripts are not set with the appropriate permissions for you to execute them. You need to issue this command to fix this:

```
# chmod +x build-* clean-all inherit-inter list-crl pktool  
revoke-full \  
sign-req whichopensslcnf
```

- 3. Choose Variables** — Edit the vars file. In this example, the vars file is located in `/etc/openssl/easy-rsa/2.0`. Most of the defaults will work, as long as you work from this configuration directory. However, you need at least to set the key values that are placed in your certificate. Replace the examples in quotes with your own values:

```
export KEY_COUNTRY="US"
export KEY_PROVINCE="WI"
export KEY_CITY="Madison"
export KEY_ORG="Reedsburg-LUG"
export KEY_EMAIL="chris@linuxtoys.net"
```

In the vars file, you can also change such values as the default key size (1024) and days to certificate expiration (3,650 days).

- 4. Set Variables** — Export the variables in the vars file to the current shell so they can be used by the later commands you run:

```
# source ./vars
```

- 5. Prepare to Create New Keys** — If there are any keys in your `KEY_DIR` (probably named `keys/` in the current directory), this command removes them and creates `index.txt` and serial files in that directory:

```
# ./clean-all
```

Next, you will create the server certificates and keys.

- 6. Build Root Certificate Authority Certificate and Key** — Run the following commands, which, in turn, will use the `pktool` command to create a 1,024-bit RSA private key:

```
# ./build-ca
Generating a 1024 bit RSA private key
.....++++++
....++++++
writing new private key to 'ca.key'
.
.
.
Country Name (2 letter code) [US]:
State or Province Name (full name) [WI]:
Locality Name (eg, city) [Madison]:
Organization Name (eg, company) [Reedsburg-LUG]:
Organizational Unit Name (eg, section) []:
Common Name (eg, your name or your server's hostname) [Reedsburg-
LUG CA]:
Email Address [chris@linuxtoys.net]:
```

You should have two new files in the keys directory. The `ca.key` file holds the private key and the `ca.crt` key holds the new certificate generated from your KEYS values.



7. **Create Parameters for SSL/TLS** — Type the following to build the server-side Diffie-Hellman parameters needed for SSL/TLS connection:

```
# ./build-dh
Generating DH parameters, 1024 bit long safe prime, generator 2
This is going to take a long time
.....+.....+.....+
```

This creates a file named *dh1024.pem* in the keys directory.

8. **Create Server Keys and Certificates** — Run the following command to create the keys and certificates needed on the OpenVPN server, replacing *server1* with your server's hostname or other common name to identify it:

```
# ./build-key-server server1
Generating a 1024 bit RSA private key
..+++++
.....+++++
writing new private key to 'server.key'
.
.
.
A challenge password []: chzypassw77
An optional company name []:
Using configuration from /etc/openvpn/easy-rsa/2.0/openssl.cnf
.
.
.
Sign the certificate? [y/n]:y
1 out of 1 certificate requests certified, commit? [y/n] y
Write out database with 1 new entries
Data Base Updated
```

The command just run produces the *server.crt*, *server.csr*, and *server.key* files in the keys directory. The *server.key* file must be kept secret!

Next, you need to create client certificates and keys for each client you want to connect to your OpenVPN server.

9. **Create Client Certificates and Keys** — Run the *build-key* (or *build-key-pass*) script for every client that you want to use the OpenVPN server. Here are examples running the *build-key* script for two clients, named *client01* and *client02*:

```
# ./build-key client01
.
.
.
A challenge password []: my67ChvyB
Sign the certificate? [y/n] y
```

```

1 out of 1 certificate requests certified, commit? [y/n] y
# ./build-key client02
.
.
.

```

After you have run `build-key` for every client, you will have a `crt` (`client01.crt`), `csr` (`client01.csr`), and `key` (`client01.key`) file in the `keys` directory for each client. The next step is to make sure each of those keys is transported to the appropriate computer.

For this example, we will copy the keys to a directory on the CentOS client machine we are calling `client01` in the `/etc/openvpn/keys/` directory on that machine. (See the “Create OpenVPN Client Configuration” section later in this chapter.)

### Create OpenVPN Server Configuration

Before starting the OpenVPN service on the server, you need to create a `server.conf` file in the `/etc/openvpn` directory. You can do this by copying a sample `server.conf` file and editing it. Here is an example of one you can use:

```

# cd /usr/share/doc/openvpn-2.0.9/sample-config-files
# cp server.conf /etc/openvpn/

```

As root user, open the `server.conf` file in any text editor. This is an example for a multi-client server that is doing routing (not bridging). The locations of key files should match those you created in the key server section earlier. Many of the comments have been left out of this example, although you should read them in the `server.conf` file to guide your configuration.

```

port 1194
proto udp
dev tun

ca /etc/openvpn/easy-rsa/2.0/keys/ca.crt
cert /etc/openvpn/easy-rsa/2.0/keys/server.crt
key /etc/openvpn/easy-rsa/2.0/keys/server.key # This file should be
kept secret
dh /etc/openvpn/easy-rsa/2.0/keys/dh1024.pem

server 10.8.0.0 255.255.255.0

keepalive 10 120
comp-lzo

persist-key
persist-tun

```

```
status openvpn-status.log  
  
verb 3
```

In this configuration, the OpenVPN server listens on port 1194, UDP protocol, as a routing VPN server (dev tun). You can use a different port number to make the service more obscure, but the clients must use that port number as well. The private network that OpenVPN clients will be able to reach from this VPN connection is on the subnetwork 10.8.0 (identified by 10.8.0.0 255.255.255.0). With the configuration file completed, you can start the OpenVPN service on the server by typing the following:

```
# service openvpn start
```

The last step you need to take to make your OpenVPN server ready to accept connections is to open your firewall to accept connections on port 1194 and to allow your system to route packets to your private subnetwork. In this example, we used a private subnetwork with IP addresses of 10.8.0.1 through 10.8.0.254. See the “Firewall” section of Chapter 13 for details.

## Create OpenVPN Client Configuration

To configure an OpenVPN client to connect to the OpenVPN server you just configured, you need to copy the key files to the client, create a client configuration file, and start the service. Here is an example of how you might copy the keys from the server:

```
# cd /etc/openvpn  
# mkdir keys  
# scp root@server1:/etc/openvpn/easy-rsa/2.0/keys/ca.crt keys  
# scp root@server1:/etc/openvpn/easy-rsa/2.0/keys/client01.crt keys  
# scp root@server1:/etc/openvpn/easy-rsa/2.0/keys/client01.key keys
```

Copy a client configuration file to your /etc/openvpn directory and edit it as appropriate. For example, type the following:

```
# cd /usr/share/doc/openvpn-2.0.9/sample-config-files  
# cp client.conf /etc/openvpn/
```

Here is an example of an edited client.conf file:

```
client  
  
dev tun  
proto udp  
  
ns-cert-type server  
  
remote example.com 1194  
  
resolv-retry infinite
```

```
nobind

persist-key
persist-tun

ca /etc/openvpn/keys/ca.crt
cert /etc/openvpn/keys/client01.crt
key /etc/openvpn/keys/client01.key

comp-lzo
verb 3
```

To test that your VPN client configuration is working, type the following:

```
# openvpn --config client.conf
```

The output you see from this command will help you debug any problems you have connecting to the OpenVPN server. If you use a GUI interface to start your OpenVPN client, be sure to identify the location of your client configuration file and keys.

## Setting Up Linux as a Proxy Server

---

You have a LAN set up, and your Linux computer has both a connection to the LAN and a connection to the Internet. One way to provide Web-browsing services to the computers on the LAN without setting up routing is to configure Linux as a proxy server.

The Squid proxy caching server software package comes with CentOS. In a basic configuration, you can get the software going very quickly. However, the package is full of features that let you adapt it to your needs. You can control which hosts have access to proxy services, how memory is used to cache data, how logging is done, and a variety of other features. Here are the basic proxy services available with Squid:

- **HTTP** — Allowing Hypertext Transfer Protocol (HTTP) proxy services is the primary reason to use Squid. This is what lets client computers access web pages on the Internet from their browsers (through your Linux computer). In other words, HTTP proxy services will find and return the content to you for addresses that look similar to this: `www.ab.com`.
- **FTP** — This represents File Transfer Protocol (FTP) proxy services. When you enable HTTP for a client, you enable anonymous FTP from the browser automatically as well (e.g., `ftp://ftp.ab.com`).
- **Gopher** — The Gopher protocol proxy service was one of the first mechanisms for organizing and searching for documents on the Internet. It predates the Web by more than a decade. Nobody uses Gopher anymore; however, it is automatically supported when you enable HTTP for a client.

Besides allowing proxy services, Squid can also be part of an Internet cache hierarchy. Internet caching occurs when Internet content is taken from the original server and copied to a caching server that is closer to you. When you, or someone else in the caching hierarchy, request that content again, it can be taken from the caching server instead of from the original server.

You don't have to cache Internet content for other computers to participate in caching with Squid. If you know of a parent caching computer that will allow you access, you can identify that computer in Squid and potentially speed your Web browsing significantly.

Caching services in Squid are provided through your Linux system's ICP port. Besides ICP services, you can also enable Simple Network Management Protocol (SNMP) services. SNMP lets your computer provide statistics and status information about itself to SNMP agents on the network. SNMP is a feature for monitoring and maintaining computer resources on a network.

**CAUTION**

SNMP poses a potential security risk if it is not configured properly. Use caution when configuring SNMP with Squid.

The squid daemon process (`/usr/sbin/squid`) can be started automatically at system boot time. After it is set up, most of the configuration for Squid is done in the `/etc/squid/squid.conf` file. The `squid.conf` file contains lots of information about how to configure Squid. (The file contains more than 4,300 lines of comments and examples, although there are only 35 lines of active settings.)

For further information about the Squid proxy server, refer to the Squid Web Proxy Cache home page ([www.squid-cache.org](http://www.squid-cache.org)).

## Starting the Squid Daemon

When you install CentOS, you have an opportunity to install Squid (`squid` package). If you are not sure whether or not Squid was installed, type the following:

```
# rpm -q squid
squid-2.6.STABLE6-5.el5_1.3
```

If Squid is not installed, you can install it from the DVD that comes with this book or by typing **yum install squid** to install it over the network. Next, you can check whether or not Squid is configured to run. To do that, type the following:

```
# chkconfig --list squid
squid          0:off  1:off  2:off  3:off  4:off  5:off  6:off
```

If the Squid service is off for run levels 3, 4, and 5 (it's off at all run levels by default), you can set it to start automatically at boot time. To set up the `squid` daemon to start at boot time, type the following:

```
# chkconfig squid on
```

At this point, the `squid` daemon should start automatically when your system boots. By default, the `squid` daemon will run with the `-D` option. The `-D` option enables Squid to start without having an active Internet connection. If you want to add other options to the `squid` daemon, you can edit the `/etc/sysconfig/squid` configuration file. Look for the line that looks similar to the following:

```
SQUID_OPTS="-D"
```

You can add any options, along with the `-D` option, between the quotes. Most of these options are useful for debugging Squid:

- `-a port#` — Substitute for `port#` a port number that will be used instead of the default port number (3128) for servicing HTTP proxy requests. This is useful for temporarily trying out an alternative port.
- `-f squidfile` — Use this option to specify an alternative `squid.conf` file (other than `/etc/squid/squid.conf`). Replace `squidfile` with the name of the alternative `squid.conf` file. This is a good way to try out a new `squid.conf` file before you replace the old one.
- `-d level` — Change the debugging level to a number indicated by `level`. This also causes debugging messages to be sent to `stderr`.
- `-X` — Use this option to check that the values are set properly in your `squid.conf` file. It turns on full debugging while the `squid.conf` file is being interpreted.

You can restart the `squid` service by typing `/etc/init.d/squid restart`. While the `squid` daemon is running, there are several ways you can run the `squid` command to change how the daemon works, using these options:

- `squid -k reconfigure` — Causes Squid to again read its configuration file.
- `squid -k shutdown` — Causes Squid to exit after waiting briefly for current connections to exit.
- `squid -k interrupt` — Shuts down Squid immediately, without waiting for connections to close.
- `squid -k kill` — Kills Squid immediately, without closing connections or log files. Use this option only if other methods don't work.

With the `squid` daemon ready to run, you need to set up the `squid.conf` configuration file.

## Using a Simple `squid.conf` File

You can use the `/etc/squid/squid.conf` file that comes with Squid to get started. Although the file contains lots of comments, the actual settings in that file are quite manageable. The following paragraphs describe the contents of the default `squid.conf` file:

```
http_port 3128
```

The `http_port` tag identifies the port on which Squid listens for HTTP client requests. The default port to use is 3128. Optionally, you can add a hostname (e.g., `example.com:3128`) or IP address (e.g., `10.0.0.1:3128`) to limit allowed incoming requests to those made to a particular hostname or IP address.

```
hierarchy_stoplist cgi-bin ?
```

The `hierarchy_stoplist` tag indicates that when a certain string of characters appears in a URL, the content should be obtained from the original server and not from a cache peer. In this example, requests for the string `cgi-bin` and the question mark character (`?`) are all forwarded to the originating server.

```
acl QUERY urlpath_regex cgi-bin \?
cache deny QUERY
```

The preceding two lines can be used to cause URLs containing certain characters to never be cached. These go along with the previous line by not caching URLs containing the same strings (`cgi-bin` and `?`) that are always sought from the original server.

```
acl apache rep_header Server ^Apache
acl all src 0.0.0.0/0.0.0.0
acl manager proto cache_object
acl localhost src 127.0.0.1/255.255.255.255
```

The `acl` tags are used to create access control lists. The first line in the preceding code creates an access control list called *apache* and assigns any response headers containing `Server ^Apache` to the `apache` `acl`. After that, the `all` `acl` is defined to include all IP addresses. The next `acl` line assigns the `manager` `acl` to handle the `cache_object` protocol. The `localhost` source is assigned to the IP address of `127.0.0.1`.

```
access_log /var/log/squid/access.log squid
```

The preceding line identifies the location of the Squid `access.log` file. As the name implies, this file contains messages about requests to access the Squid server.

Squid includes default settings for how long different types of content in cache are still considered to be fresh. The following `refresh_pattern` values are included in the `squid.conf` file:

```
refresh_pattern ^ftp:      1440      20%    10080
refresh_pattern ^gopher:   1440      0%     1440
refresh_pattern .          0         20%    4320
```

In the code just shown, all lines that begin (`^`) with `ftp` or `gopher` are set to expire in 1,440 minutes. The percentage of the object's age during which it is considered to be fresh is shown in the next column (20%, 0%, and 20%). The last column indicates the maximum number of

minutes during which the object will be considered fresh. The next several entries define how particular ports are handled and how access is assigned to HTTP and ICP services.

```
acl SSL_ports port 443
acl Safe_ports port 80          # http
acl Safe_ports port 21         # ftp
acl Safe_ports port 443       # https
acl Safe_ports port 70        # gopher
acl Safe_ports port 210       # wais
acl Safe_ports port 1025-65535 # unregistered ports
acl Safe_ports port 280       # http-mgmt
acl Safe_ports port 488       # gss-http
acl Safe_ports port 591       # filemaker
acl Safe_ports port 777       # multiling http
acl CONNECT method CONNECT
http_access allow manager localhost
http_access deny manager
http_access deny !Safe_ports
http_access deny CONNECT !SSL_ports
http_access allow localhost
http_access deny all
http_reply_access allow all
icp_access allow all
```

The following sections describe these settings in more detail, as well as other tags you might want to set in your `squid.conf` file. By default, no clients can use the Squid proxy server, so you at least want to define which computers can access proxy services.

To make sure that this simple Squid configuration is working, follow this procedure:

1. On the Squid server, restart the `squid` daemon. To do this, type `/etc/init.d/squid restart`. (If Squid isn't running, use `start` instead of `restart`.)
2. On the Squid server, start your connection to the Internet if it is not already up.
3. On a client computer on your network, set up a Web browser to use the Squid server as a proxy server (described later in this chapter). In Firefox, select `Edit > Preferences > Advanced` and click on the `Network` tab, then choose `Settings`. From the `Connection Setting` window that pops up, select "Manual proxy configuration." Then add the Squid server's computer name and, by default, port 3128 to each protocol. You can also check the "Use this proxy server for all protocols" option to use the same proxy for all service requests from the browser.
4. On the client computer, try to open any web page on the Internet with the browser you just configured.

If the web page doesn't appear, see the "Debugging Squid" section for how to fix the problem.



## Modifying the Squid Configuration File

If you want to set up a more complex set of access permissions for Squid, you should start with the default `squid.conf` configuration file (described earlier).

To begin, open the `/etc/squid/squid.conf` file (as the `root` user). You will see a lot of information describing the values that you can set in this file. Most of the tags that you need to configure Squid are used to set up caching and provide host access to your proxy server.

**TIP**

**Don't change the `squid.conf.default` file! If you really mess up your `squid.conf` file, you can start again by making another copy of this file to `squid.conf`. If you want to recall exactly what changes you have made so far, type the following from the `/etc/squid` directory:**

```
# diff squid.conf squid.conf.default | less
```

This will show you the differences between your actual `squid.conf` and the version you started with.

## Configuring Access Control in `squid.conf`

To protect your computing resources from being used by anyone, Squid requires that you define which host computers have access to your HTTP (Web) services. By default, all hosts are denied access to Squid HTTP services except for the local host. With the `acl` tag, you can create access lists. Then, with the `http_access` tag, you can authorize access to HTTP (Web) services for the access lists you create.

The form of the access control list tag (`acl`) is:

```
acl name type string
acl name type file
```

The *name* is any name you want to assign to the list. A *string* is a string of text, and *file* is a file of information that applies to the particular *type* of `acl`. Valid `acl` types include `dst`, `src`, `dstdomain`, `srcdomain`, `url_path_pattern`, `url_pattern`, `time`, `port`, `proto`, `method`, `browser`, and `user`.

Several access control lists are set up by default. You can use these assigned `acl` names to assign permissions to HTTP or ICP services. You can also create your own `acl` names to assign to those services. Here are the default `acl` names from the `/etc/squid/squid.conf` file that you can use or change:

```
acl all src 0.0.0.0/0.0.0.0
acl manager proto cache_object
acl localhost src 127.0.0.1/255.255.255.255
acl SSL_ports port 443 563
acl Safe_ports port 80          # http
acl Safe_ports port 21         # ftp
```

```
acl Safe_ports port 443 563      # https, snews
acl Safe_ports port 70          # gopher
acl Safe_ports port 210         # wais
acl Safe_ports port 1025-65535  # unregistered ports
acl Safe_ports port 280         # http-mgmt
acl Safe_ports port 488         # gss-http
acl Safe_ports port 591         # filemaker
acl Safe_ports port 777         # multiling http
acl CONNECT method CONNECT
```

When Squid tries to determine which class a particular computer falls in, it goes from top to bottom. In the first line, all host computers (address/netmask are all zeros) are added to the acl group `all`. In the second line, you create a manager group called `manager` that has access to your `cache_object` (the capability to get content from your cache). The group `localhost` is assigned to your loopback address. Secure Socket Layer (SSL) ports are assigned to the numbers 443 and 563, whereas `Safe_ports` are assigned to the numbers shown above. The last line defines a group called `CONNECT` that you can use to allow access to SSL ports.

To deny or enable access to HTTP services on the Squid computer, the following definitions are set up:

```
http_access allow manager localhost
http_access deny manager
http_access deny !Safe_ports
http_access deny CONNECT !SSL_ports
http_access allow localhost
http_access deny all
```

These definitions are quite restrictive. The first line allows someone requesting cache objects (`manager`) from the local host to do so, but the second line denies anyone else making such a request. Access is not denied to ports defined as safe ports. Also, secure socket connections via the proxy are denied on all ports, except for SSL ports (`!SSL_ports`). HTTP access is permitted only from the local host and is denied to all other hosts.

To allow the client computers on your network access to your HTTP service, you need to create your own `http_access` entries. You probably want to do something more restrictive than simply saying `http_access allow all`. Here is an example of a more restrictive acl group and how to assign that group to HTTP access:

```
acl ourlan src 10.0.0.1-10.0.0.100
http_access allow ourlan
```

In the previous example, all computers at IP addresses 10.0.0.1 through 10.0.0.100 are assigned to the `ourlan` group. Access is then allowed for `ourlan` with the `http_access` line.

## Configuring Caching in squid.conf

*Caching*, as it relates to a proxy server, is the process of storing data on an intermediate system between the Web Server that sent the data and the client that received it. The assumption is that later requests for the same data can be serviced more quickly by not having to go all the way back to the original server. Instead, the proxy server can simply send you the content from its copy in cache. Another benefit of caching is that it reduces demands on network resources and on the information servers.

You can arrange caching with other caching proxy servers to form a cache hierarchy. The idea is to have a *parent cache* exist close to an entry to the Internet backbone. When a *child cache* requests an object, if the parent doesn't have it, the parent goes out and gets the object, sends a copy to the child, and keeps a copy itself. That way, if another request for the data comes to the parent, it can probably service that request without making another request to the original server. This hierarchy also supports *sibling caches*, which can, in effect, create a pool of caching servers on the same level.

### CAUTION

Caching can consume a lot of your hard disk space if you let it. If you have separate partitions on your system, make sure that you have enough space in /var to handle the added load.

Here are some cache-related tags that you should consider setting:

- `cache_peer` — If there is a cache parent whose resources you can use, you can add the parent cache using this tag. You would need to obtain the parent cache's hostname, the type of cache (parent), proxy port (probably 3128), and ICP port (probably 3130) from the administrator of the parent cache. If you have no parent cache, you don't have to set this value. Here's an example of a `cache_peer` entry:

```
cache_peer parent.handsonhistory.com parent 3128 3130
```

You can also add options to the end of the line, such as `proxy-only`, so that what you get from the parent isn't stored locally, and `weight=n` (where *n* is replaced by a number above 1 to indicate that the parent should be used above other parents). Add `default` if the parent is used as a last resort when all other parents don't have the requested data.

- `cache_mem` — Specifies the amount of cache memory (RAM) used to store in-transit objects (ones that are currently being used), hot objects (ones that are used often), and negative-cached objects (recent failed requests). The default is 8 MB, although you can raise that value. To set `cache_mem` to 16 MB, enter the following:

```
cache_mem 16 MB
```

### NOTE

Because Squid will probably use a total of three times the amount of space you give it for all its processing, Squid documentation recommends that you use a `cache_mem` size one-third the size of the space that you actually have available for Squid.

- `cache_dir` — Specifies the directory (or directories if you want to distribute the cache across multiple disks or partitions) in which cache swap files are stored. The default is

the `/var/spool/squid` directory. You can also specify how much disk space to use for the cache in megabytes (100 is the default), the number of first-level directories to create (16 is the default), and the number of second-level directories (256 is the default). Here's an example:

```
cache_dir ufs /var/spool/squid 100 16 256
```

**NOTE**

The cache directory must exist. Squid won't create it for you. It will, however, create the first- and second-level directories.

- `cache_mgr` — Add the e-mail address of the user who should receive e-mail if the cache daemon dies. By default, e-mail is sent to `root`. To explicitly set `cache_mgr` to the root user, use the following:

```
cache_mgr root
```

- `cache_effective_user` — After the squid daemon process is started as `root`, subsequent processes are run as `squid` user and group (by default). To change that subsequent user to a different name (e.g., to `nobody`), set the `cache_effective_user` as follows:

```
cache_effective_user nobody
```

**NOTE**

When I changed the `cache_effective_user` name so that a user other than `squid` ran the squid daemon, the messages log recorded several failed attempts to initialize the Squid cache before the process exited. When I changed the username back to `squid`, the process started properly. To use the `cache_effective_user` feature effectively, you must change ownership of `/var/spool/squid` and its subdirectories.

## Configuring Port Numbers in `squid.conf`

When you configure client computers to use your Squid proxy services, the clients need to know your computer's name or IP address and the port numbers associated with the services. For a client wanting to use your proxy to access the Web, the HTTP port is the needed number. Here are the tags that you use to set port values in Squid for different services, along with their default values:

- `http_port 3128` — The `http_port` is set to 3128 by default. Client workstations need to know this number to access your proxy server for HTTP services.
- `icmp_port 3130` — ICP requests are sent to and from neighboring caches through port 3130 by default.
- `htcp_port 4827` — ICP sends HTCP requests to and from neighboring caches on port 4827 by default.

## Debugging Squid

If Squid isn't working properly when you set it up or if you just want to monitor Squid activities, there are several tools and log files to help you.

## Checking the squid.conf File

By running the squid daemon with the `-X` option (described earlier), you can check what is being set from the squid.conf file. You can add an `-X` option to the `SQUID_OPTS` line in the `/etc/init.d/squid` file. Then run `/etc/init.d/squid restart`. A whole lot of information is output, which details what is being set from squid.conf. If there are syntax errors in the file, they appear here.

## Checking Squid Log Files

Squid log files are stored in the `/var/log/squid` directory by default in CentOS. The following are the log files created there, descriptions of what they contain, and descriptions of how they might help you debug potential problems:

- `access.log` — Contains entries that describe each time the cache has been hit or missed when a client requests HTTP content. Along with that information is the identity of the host making the request (IP address) and the content they are requesting. Use this information to find out when content is being used from the cache and when the remote server must be accessed to obtain the content. Here is what some of the access result codes mean:
  - `TCP_DENIED` — Squid denied access for the request.
  - `TCP_HIT` — Cache contained a valid copy of the object.
  - `TCP_IMS_HIT` — A fresh version of the requested object was still in cache when the client asked if the content had changed.
  - `TCP_IMS_MISS` — An If-Modified-Since request was issued by the client for a stale object.
  - `TCP_MEM_HIT` — Memory contained a valid copy of the object.
  - `TCP_MISS` — Cache did not contain the object.
  - `TCP_NEGATIVE_HIT` — The object was negatively cached, meaning that an error was returned (such as the file not being found) when the object was requested.
  - `TCP_REF_FAIL_HIT` — A stale object was returned from the cache because of a failed request to validate the object.
  - `TCP_REFRESH_HIT` — A stale copy of the object was in cache, but a request to the server returned information that the object had not been modified.
  - `TCP_REFRESH_MISS` — A stale cache object was replaced by new, updated content.
  - `TCP_SWAPFAIL` — An object could not be accessed from the cache, despite the belief that the object should have been there.
- `cache.log` — Contains valuable information about your Squid configuration when the squid daemon starts up. You can see how much memory is available (Max Mem), how much swap space (Max Swap), the location of the cache directory (`/var/spool/squid`), the types of connections being accepted (HTTP, ICP, and SNMP), and the port upon which connections are being accepted. You can also see a lot of information about cached objects (such as how many are loaded, expired, or canceled).

- `store.log` — Contains entries that show when content is being swapped out from memory to the cache (SWAPOUT), swapped back into memory from the cache (SWAPIN), or released from the cache (RELEASE). You can see where the content comes from originally and where it is being placed in the cache. Time is logged in this file in raw UNIX time (in milliseconds).

You might also be interested in another log file: `/var/log/messages`. This file contains entries describing the start-up and exit status of the `squid` daemon.

### Using the `top` Command

Run the `top` command to see information about running processes, including the Squid process. If you are concerned about performance hits from too much Squid activity, type **M** from within the `top` window. The **M** option displays information about running processes, sorted by the percent of memory each process is using. If you find that Squid is consuming too large a percentage of your system memory, you can reduce the memory usage by resetting the `cache_mem` value in your `squid.conf` file.

## Setting Up Proxy Clients

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For your Linux proxy server to provide Web-browsing access (HTTP) to the Windows and Linux client computers on your network, each client needs to do a bit of setup within the Web browser. The beauty of using proxy servers is in what your client computers don't need to know, such as the following:

- Addresses of DNS servers
- Telephone numbers of ISPs
- Chat scripts to connect to the ISP

There are probably other things that clients don't need to know, but you get the idea. After the proxy server has a connection to the Internet and has allowed a client computer on the LAN access to that service, all the client needs to know is the following:

- **Hostname** — The name or IP address of the proxy server. This assumes that the client can reach the proxy over the LAN or other IP-based network.
- **Port Numbers** — The port number of the HTTP service (3128 by default). That same port number can be used for FTP service as well.

How you go about setting up proxy service on the client has more to do with the browser you are using than with the operating system you are using. Follow the procedures outlined in the following sections for setting up Firefox, Microsoft Internet Explorer, Mosaic, or Lynx browsers.

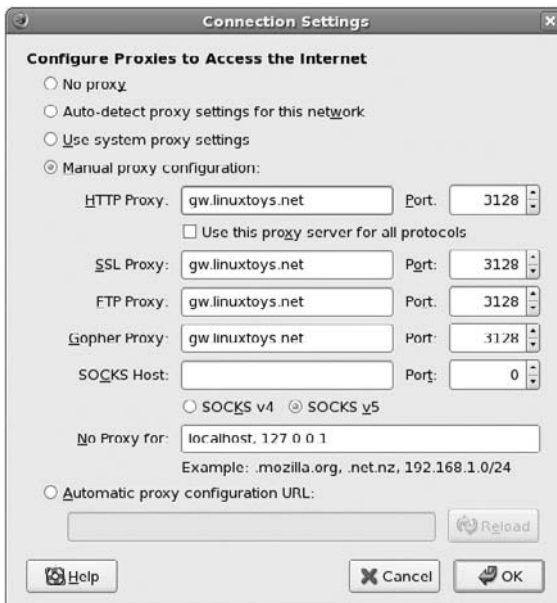
## Configuring Firefox to Use a Proxy

Normally, you would set up Firefox to browse the Web directly over a TCP/IP connection to the Internet over telephone lines or via a router on your LAN. Follow this procedure to change Firefox to access the Web through your proxy server:

1. Open Firefox.
2. Choose Edit ► Preferences. The Preferences window appears.
3. Select the Advanced category and select the Network tab.
4. Click on the Settings button. The Connection Settings window appears.
5. Click “Manual proxy configuration” to enable proxy configuration (see Figure 15-2 for an example of the Firefox Connection Settings page).
6. Type the proxy server’s name or IP address in the address boxes for HTTP, FTP, and Gopher services.

**FIGURE 15-2**

The Preferences window identifies proxy servers and port numbers in Firefox.



7. Type the port number for HTTP services on your proxy server (probably 3128) in the Port boxes for HTTP, FTP, and Gopher services. You can just fill in the information for the HTTP Proxy and check the “Use this proxy server for all protocols” option to have those other services filled in automatically.
8. Click OK.

The next time you request a web address from Firefox, it will contact the proxy server to try to obtain the content.

## Configuring Other Browsers to Use a Proxy

There are different methods for indicating a proxy server to other browsers available with Linux. To have a Mosaic or Lynx browser use a proxy server to access the Internet, add an environment variable to the shell where the browser will run. Here’s how you would set the environment variables for HTTP and FTP proxy services to a proxy computer named `maple` using a `csh` or `tcsh` shell:

```
setenv http_proxy http://maple:3128/  
setenv ftp_proxy http://maple:3128/
```

If you are using a `ksh` or `bash` shell, type the following:

```
export http_proxy=http://maple:3128  
export ftp_proxy=http://maple:3128
```

You can add any of these values to your start-up scripts. Or, to make them available on a system-wide basis, you could add them to a system configuration file, such as `/etc/profile` or `/etc/skel/.bash_profile`.

For the `elinks` and `links` browsers, you can indicate to use a proxy server in the `/etc/elinks.conf` file. For example, here are the lines you would add to the `/etc/elinks.conf` file to have `elinks` and `links` use the computer named `maple` act as a proxy for FTP and HTTP services:

```
protocol.ftp.proxy.host maple:3128  
protocol.http.proxy.host maple:3128
```

## Summary

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Connecting to the Internet opens a whole world of possibilities for your CentOS system. Using your system as a public Web Server, mail server, or FTP server depends on its capability to connect to the Internet. Likewise, if your computers are already connected in a LAN, adding an Internet connection can provide Internet access to everyone on the LAN in one stroke.



In this chapter, descriptions of how Internet domains are organized built on the coverage of IP addresses in the previous chapter. Creating dial-up connections to the Internet focused on descriptions of PPP. This chapter also discussed several different techniques for connecting your LAN to the Internet. You can set up your Linux computer as a router or as a Squid proxy server.

To use your Internet connection to transport sensitive data to another location in your company's private network, you can configure a VPN. This chapter describes how to use IPsec in CentOS to create a VPN connection between two locations.

# Chapter 16

## Setting Up Printers and Printing

Sharing printers is a good way to save money and make your printing more efficient. Very few people need to print all the time, but when they do want to print something, they usually need it quickly. Setting up a print server can save money by eliminating the need for a printer at every workstation. Some of those savings can be used to buy printers that can output more pages per minute or have higher-quality output.

You can attach printers to your CentOS system to make them available to users of that system or to other computers on the network. You can configure your CentOS printer as a remote CUPS printer or Samba printer. With Samba, you are emulating a Windows print server.

This chapter describes configuring and using printers in CentOS. It focuses on Common UNIX Printing Service (CUPS), which is the recommended print service for the current versions of CentOS. To configure CUPS printers, this chapter focuses on the Printer Configuration window (`system-config-printer` command).

When a local printer is configured, print commands (such as `lpr`) are available for carrying out the actual printing. Commands also exist for querying print queues (`lpq`), manipulating print queues (`lpc`), and removing print jobs (`lprm`). A local printer can also be shared as a print server to users on other computers on your network.

### IN THIS CHAPTER

**Understanding printing in Linux**

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**Setting up printers**

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**Using printing commands**

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**Managing document printing**

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**Sharing printers**

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## Common UNIX Printing Service

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CUPS has become the standard for printing from Linux and other UNIX-like operating systems. Instead of being based on older, text-based line printing technology, CUPS was designed to meet today's needs for standardized printer definitions and sharing on IP-based networks (as most computer networks are today). Here are some features of CUPS:

- **IPP** — At its heart, CUPS is based on the Internet Printing Protocol (IPP) ([www.pwg.org/ipp](http://www.pwg.org/ipp)), a standard that was created to simplify how printers can be shared over IP networks. In the IPP model, printer servers and clients who want to print can exchange information about the model and features of a printer using the HTTP protocol. A server can also broadcast the availability of a printer, so a printing client can easily find a list of locally available printers.
- **Drivers** — CUPS also standardized how printer drivers are created. The idea was to have a common format that could be used by printer manufacturers that could work across all different types of UNIX systems. That way, a manufacturer had to create the driver only once to work for Linux, Mac OS X, and a variety of UNIX derivatives.
- **Printer Classes** — Using printer classes, you can create multiple print server entries that point to the same printer or one print server entry that points to multiple printers. In the first case, multiple entries could each allow different options (such as pointing to a particular paper tray or printing with certain character sizes or margins). In the second case, you could have a pool of printers so that printing is distributed. This would decrease the occurrence of congested print jobs, caused by a malfunctioning printer or a printer that is dealing with very large documents.
- **UNIX Print Commands** — To integrate into Linux and other UNIX environments, CUPS offers versions of standard commands for printing and managing printers that have been traditionally offered with UNIX systems.

The Printer Configuration window (`system-config-printer` command) lets you configure printers in CentOS that use the CUPS facility. However, CUPS also offers a Web-based interface for adding and managing printers. Configuration files for CUPS are contained in the `/etc/cups` directory. In particular, you might be interested in the `cupsd.conf` file (which identifies permission, authentication, and other information for the printer daemon) and `printers.conf` (which identifies addresses and options for configured printers).

## Setting Up Printers

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Most parallel printers and USB printers can be detected and set up using the Printer Configuration window. However, the Printer Configuration window also lets you configure CentOS so that you can use printers that are available on your LAN as a Windows printer (Samba), Apple-socket or HP JetDirect, Internet Printing Protocol (IPP) printer, or UNIX printer (LPD or LRP daemons).

## Choosing a Printer

If you are choosing a new printer to use with your CentOS system, look for one that is PostScript-compatible. The PostScript language is the preferred format for Linux and UNIX printing and has been for many years. Every major word and image processing application that runs on Linux and UNIX systems supports PostScript printing.

If you get a PostScript printer and it is not explicitly shown in the list of supported printers, simply select the PostScript filter when you install the printer locally. No special drivers are needed. Your next best choice is to choose a printer that supports PCL (Hewlett Packard's Printer Control Language). In either case, make sure that the PostScript or PCL is implemented in the printer hardware and not in the Windows driver.

When selecting a printer, avoid those that are referred to as *Winprinters*. These printers use nonstandard printing interfaces (those other than PostScript or PCL). Support for these low-end printers is hit-or-miss. For example, some low-end HP DeskJet printers use the `pnm2ppa` driver to print documents in Printing Performance Architecture (PPA) format. Some Lexmark printers use the `pbm217k` driver to print. Although drivers are available for many of these Winprinters, many of them are not fully supported.

Ghostscript may also support your printer; if it does, you can use that tool to do your printing. Ghostscript ([www.ghostscript.com](http://www.ghostscript.com)) is a free PostScript and PDF file interpreter program. It can convert that content to output that can be interpreted by a variety of printers. With the `ghostscript` package installed, type `gs -h` to see a list of available output device formats.

You'll find an excellent list of printers supported in Linux at the Free Standards Group OpenPrinting site ([www.linux-foundation.org/en/OpenPrinting](http://www.linux-foundation.org/en/OpenPrinting)). I strongly recommend that you visit that site before you purchase a printer to work with Linux. The site offers a Printer Compatibility database, so you can find out if your printer is supported and, if so, what print driver is needed to get your printer working in Linux. For useful information on purchasing a printer that will work in Linux, refer to the "Supported Printers" section of the Printing HOWTO ([www.tldp.org/HOWTO/Printing-HOWTO/printers.html](http://www.tldp.org/HOWTO/Printing-HOWTO/printers.html)).

## Using the Printer Configuration Window

To install a printer from your desktop, use the Printer Configuration window (`system-config-printer` command). This tool enables you to add printers, delete printers, and edit printer properties. It also lets you send test pages to those printers to make sure that they are working properly.

The key here is that you are configuring printers that are managed by your print daemon (`cupsd` for the CUPS service). After a printer is configured, users on your local system can use it. Following that, you can refer to the "Configuring Print Servers" section to learn how to make the server available to users from other computers on your network.

The printers that you set up can be connected locally to your computer (as on a parallel or USB port) or to another computer on the network (e.g., from another UNIX system, Windows system, or NetWare server).

### Configuring Local Printers

Add a local printer (in other words, a printer connected directly to your computer) with the Printer Configuration window using the following procedure. (See the “Choosing a Printer” sidebar if you don’t yet have a printer.)

#### TIP

You should connect your printer before starting this procedure. With the printer connected, the Printer Configuration window might be able to scan for the printer to determine the printer’s location and to test the printer immediately when you have finished adding it.

### Adding a Local Printer

To add a local printer, follow these steps as root user:

1. Make sure that the CUPS service (`cupsd` daemon) is running. Just to make sure, type the following:

```
# service cups restart
```

2. To open the Printer Configuration window, either select System > Administration > Printing from the panel or type the following from a Terminal window:

```
# system-config-printer &
```

The Printer Configuration window appears. Note that printers detected on the local LAN appear under the “Remote Printers” heading.

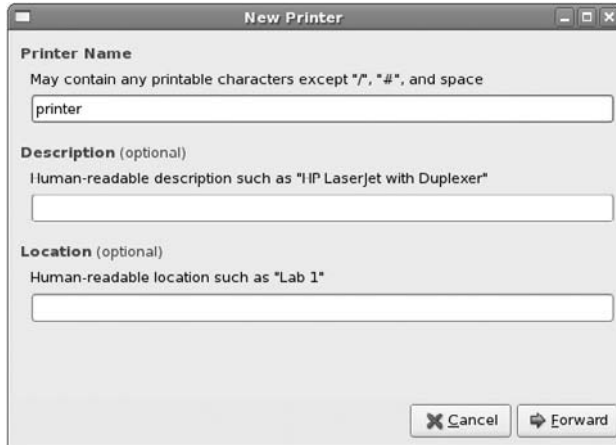
3. Click “New Printer.” A New Printer window appears, as shown in Figure 16-1.
4. If the printer you want to configure is detected, simply select it and click Forward. If it is not detected, choose the device to which the printer is connected (`LPT #1` and `Serial Port #1` are the first parallel and serial ports, respectively) and click Forward. (Type `/usr/sbin/lpinfo -v | less` in a shell to see all available ports.)

You are asked to identify the printer’s driver.

5. To use an installed driver for your printer, choose “Select Printer From Database,” and then choose the manufacturer of your printer. As an alternative, you could select “Provide PPD File” and supply your own PPD file (e.g., if you have a printer that is not supported in Linux and you have a driver that was supplied with the printer). PPD stands for “PostScript Printer Description.” Select Forward to see a list of printer models from which you can choose.
6. Select the printer model for your printer. If there are multiple drivers available for the model, you can choose which one you want from the Drivers box.

**FIGURE 16-1**

Begin the process of adding a printer with the New Printer window.

**TIP**

If your printer doesn't appear on the list but supports PCL (which is HP's Printer Control Language), select from one of several generic PCL drivers. If your printer supports PostScript, you can select "PostScript printer" from the list. Selecting "Raw Print Queue" enables you to send documents to the printer that are already formatted for that printer type.

7. With your printer model selected, click on the Printer, Driver, or PPD buttons at the bottom of the screen. In many cases, you will see good information from the Linux Printing Database about how your printer is configured and how to tune it further. Click Forward to continue.
8. Add the following information and then click Forward:
  - **Printer Name** — Add the name you want to give to identify the printer. The name must begin with a letter, but after the initial letter, it can contain a combination of letters, numbers, dashes (-), and underscores (\_).
  - **Description** — Add a few words describing the printer, such as its model name and features.
  - **Location** — Indicate its location (e.g., "in Room 205 under the coffee pot").In this example, my HP LaserJet 2100 and HP DeskJet 5550 printers were detected (as you will see later). One is detected on the computer's parallel port (HP Laserjet 2100), and one is detected on a USB port (HP DeskJet 5550).
9. If the information looks correct, click Apply to create the entry for your printer. You are returned to the Printer Configuration main window, with the new printer listed under Local Printers.

- Click on the name of the printer you just added, and then click “Print Test Page.” (Click OK when told the test page has printed.) This test page will tell you interesting information about your printer, such as the resolution and the type of interpreter used (such as PostScript).

To further configure the printer, using the tabs that appear to the right of the selected printer, continue to the “Editing a Local Printer” section.

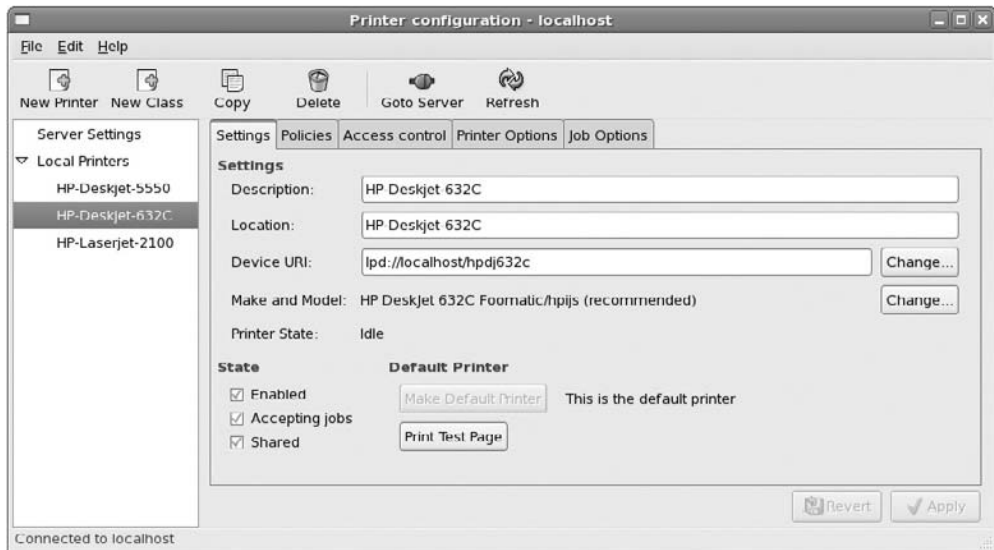
Printing should be working at this point for users who are printing from your local computer. (If you want to share this printer with other computers on your network, refer to the “Configuring Print Servers” section of this chapter.)

### Editing a Local Printer

After you have added a local printer, you can edit the printer definitions to change how that printer behaves. Select the printer you want to edit from the left-hand pane to access the property, as shown in Figure 16-2.

**FIGURE 16-2**

Change printer settings, policies, and access from the Printer Properties window.



With the printer you want to configure selected, choose from the following sections on the left to change its configuration:

- Settings** — The Description, Location, Device URI, and Make and Model information you created earlier are displayed on this pane.

- **Print Test Page** — Although this isn't technically an option, it lets you send a test page to the printer.
- **Policies** — Click on the Policies item. From this pane, you can set the following items:
  - **State** — Select checkboxes to indicate whether the printer will print jobs that are in the queue (“Enabled”), accept new jobs for printing (“Accepting jobs”), or be available to be shared with other computers that can communicate with your computer (“Shared”). You also must select Server Settings and click on the “Share published printers connected to this system” checkbox before the printer will accept print jobs from other computers.
  - **Policies** — In case of error, the stop-printer selection causes all printing to that printer to stop. You can also select to have the job discarded (abort-job) or retried (retry-job) in the event of an error condition.
  - **Banner** — Add banner pages at the beginning or end of a job. This is good practice for a printer that is shared by many people. The banner page helps you sort who gets which print job. The standard banner page shows the ID of the print job, the title of the file, the user that requested the print job, and any billing information associated with it.
- **Access Control** — If your printer is a shared printer, you can select this item to create a list of users who are either allowed access to the printer (with all others denied) or denied access to the printer (with all others allowed).
- **Printer Options** — Click “Printer Options” to set defaults for options related to the printer driver. The available options are different for different printers. Many of these options can be overridden when someone prints a document. Here are a few of the options you might have available to set:
  - **Watermark** — There are several Watermark settings that let you add and change watermarks on your printed pages. By default, Watermark and Overlay are off (None). By selecting Watermark (behind the text) or Overlay (over the text), you can set the other Watermark settings to determine how watermarks and overlays are done. Watermarks can go on every page (“All”) or only the first page (“First Only”). Select “Watermark Text” to choose what words are used for the watermark or overlay (Draft, Copy, Confidential, Final, etc.). You can then select the font type, size, style, and intensity of the watermark or overlay.
  - **Resolution Enhancement** — You can use the printer's current settings or choose to turn resolution enhancement on or off.
  - **Page Size** — The default is U.S. letter size (depending on the language settings of your GNOME session), but you can also ask the printer to print legal size, envelopes, ISO A4 standard, or several other page sizes.
  - **Media Source** — Choose which tray to print from. Select Tray 1 to insert pages manually.



- **Levels of Gray** — Choose to use the printer’s current levels of gray or have enhanced or standard gray levels turned on.
- **Resolution** — Select the default printing resolution (such as 300, 600, or 1,200 dots per inch). Higher resolutions result in better quality but take longer to print.
- **EconoMode** — Either use the printer’s current setting or choose a mode where you save toner or one where you have the highest possible quality.
- **Job Options** — Click on the “Job Options” item to set common default options that will be used for this printer if the application printing the job doesn’t already set them. These include Common Options (number of copies, orientation, scale to fit, and pages per side), Image Options (scaling, saturation, hue, and gamma), and Text Options (characters/inch, lines/inch, and margin settings).

**NOTE**

For a description of other driver options, refer to the *CUPS Software User Manual* (`/usr/share/doc/cups-*/sum.html`) under the “Standard Printer Options” heading.

Click Apply when you are satisfied with the changes you made to the local printer.

## Configuring Remote Printers

To use a printer that is available on your network, you must identify that printer to your CentOS system. Supported remote printer connections include Networked CUPS (IPP) printers, Networked UNIX (LPD) printers, Networked Windows (SMB) printers, Networked Novell (NCP) printers, and JetDirect printers. (Of course, both CUPS and UNIX print servers can be run from Linux systems, as well as other UNIX systems.)

In each case, you need a network connection from your CentOS system that enables you to reach the servers to which those printers are connected. To use a remote printer, of course, requires that someone set up that printer on the remote server computer. See the section “Configuring Print Servers” later in this chapter for information on how to do that in CentOS.

You can use the Printer Configuration window to configure each of the remote printer types:

1. From the GNOME desktop, select System > Administration > Printing.
2. Click “New Printer.” The New Printer window appears.
3. Besides the local ports listed (LPT and Serial ports), you can select one of the following types of network printers:
  - **AppleSocket/HP JetDirect** — For a JetDirect printer
  - **Internet Printing Protocol (IPP)** — For a CUPS or other IPP printer
  - **LPD/LPR Host or Printer** — For a UNIX printer
  - **Windows Printer via SAMBA** — For a Windows system printer
4. Continue following the steps in whichever of the following sections as appropriate.

### ***Adding a Remote CUPS Printer***

After choosing to add an IPP CUPS printer from the Select Connection window, you must add the following information to the window that appears:

- **Host** — The host of the computer to which the printer is attached (or otherwise accessible). This can be an IP address or TCP/IP hostname for the computer. (The TCP/IP name is typically accessible from your `/etc/hosts` file or through a DNS name server.)
- **Queue** — The printer name on the remote CUPS print server, which might look something like `/printers/HP722C`. CUPS supports the concept of printer instances, which allows each printer to have several sets of options. So, if the remote CUPS printer is configured this way, you might be able to choose a particular path to a printer, such as `hp/300dpi` or `hp/1200dpi`. A slash character separates the print queue name from the printer instance.

I suggest that you fill in the hostname and select “Find Queue,” to find the available IPP printers from that host. After selecting the printer from a list, the Host and Queue information are automatically filled in. Click on the Verify button to make sure that the printer is accessible. Click Forward and complete the rest of the procedure as you would for a local printer.

### ***Adding a Remote UNIX Printer***

After you have selected to add an LPD/LPR (UNIX) host or printer from the Select Connection window, you must add the following information to the window that appears:

- **Host** — The hostname of the computer to which the printer is attached (or otherwise accessible). This is the IP address or TCP/IP name for the computer (the TCP/IP name is typically accessible from your `/etc/hosts` file or through a DNS name server). The host computer might be a UNIX or Linux print server running the `lpd` print daemon. If you know the hostname but not the printer name, type the hostname and select the Probe button. Available LPD printers from the host will appear in a list in the Queue field.
- **Queue** — The printer name on the remote UNIX computer

Although CUPS is the more popular printing system for Linux and UNIX systems today, some UNIX-like systems still use the Berkeley LPR print spooler system (see RFC1179). Some early Linux systems included LPRng print spooling software to provide this same interface for managing print servers (`lpd` daemon). So, to print to a really old Linux system at your location, you might need to identify a printer there as a UNIX printer. For older clients, CUPS can also act like an LPD print spooler (see the bullet on enabling LPD-style printing in the “Configuring a Shared CUPS Printer” section later in this chapter).

Click Forward and complete the configuration as you would for a local printer.

#### **TIP**

If the print job is rejected when you send it to test the printer, the print server computer may not have allowed you access to the printer. Ask the remote computer’s administrator of the UNIX printer to add your hostname to the `/etc/lpd.perms` file. Type `lpq -P printer` to see the status of your print job.

### ***Adding a Windows (SMB) Printer***

Enabling your computer to access an SMB printer (the Windows printing service) involves adding an entry for that printer in the Select Connection window.

#### **NOTE**

Before you can add an SMB printer queue to Linux, you must first have configured that printer to work on the Windows machine. You must also indicate that the printer can be shared and is accessible to your Linux machine on your LAN.

After you have selected Windows Printer via SAMBA to the Select Connection window (described previously), you can browse for computers on your network that offer SMB services (file or printing service) by clicking on the Browse button. When the SMB Browser List appears, you can:

- Select the group (click the arrow next to the group you want).
- Select the server (click the arrow next to the server you want).
- Select the printer from the list of available printers shown.

Alternatively, you could identify a server that does not appear on the list of servers. Type a server name and share into the `smb://` box at the top of the page. For example, you could type:

```
smb://MYGROUP/EINSTEIN/hp2100m
```

Next, select the “Authentication required” box to enter a username and password, if that is required to access the shared printer:

- **Username** — The username is the name required by the SMB server system to give you access to the SMB printer. A username is not necessary if you are authenticating the printer based on share-level, rather than user-level, access control. With share-level access, you can add a password for each shared printer or file system.
- **Password** — The password associated with the SMB username or the shared resource, depending on the kind of access control being used. Click on the Verify button to check that the username and password are correct.

#### **CAUTION**

When you enter a username and password for SMB, that information is stored unencrypted in the `/etc/cups/printers.conf` file. Be sure that the file remains readable only by root.

Click Forward and complete the configuration as you would for a local printer.

If everything is set up properly, you should be able to use the standard `lpr` command to print the file to the printer. With this example, you could use the following form for printing:

```
$ cat file1.ps | lpr -P hp2100m
```

**TIP**

If you are receiving failure messages, make sure that the computer to which you are printing is accessible. For the previous example, you could type `smbclient -L NS1 -U jwilson`. Type the password (`my9passwd`, in this case). If you get a positive name query response after you enter a password, you should see a list of shared printers and files from that server. Check the names, and try printing again.

### Adding a JetDirect Printer

A JetDirect printer (AppSocket/HP JetDirect) is one that is connected directly to your Ethernet network via a JetDirect device. You typically use port 9100 to print to a JetDirect printer, although additional interfaces may use ports 9101, 9102, and so on. To use a JetDirect printer from CentOS, enter the following information:

- **Host** — Enter the name of the JetDirect printer.
- **Port Number** — Enter the port number (typically 9100) to identify the interface to the JetDirect printer.

## Using Web-Based CUPS Administration

The Printer Configuration window effectively hides the underlying CUPS facility. There may be times, however, when you want to work directly with the tools and configuration files that come with CUPS. The following sections describe how to use some special CUPS features.

**CAUTION**

Plaintext configuration files are at the base of the CUPS printing facility. When different tools, such as the CUPS Web-based interface and the Printer Configuration window, manipulate the same config files, those files can become unusable by the other tools. When possible, you should use the `system-config-printer` (Printer Configuration window) to work with printers in CentOS. You will see warnings to this effect if you start to use the CUPS interface.

Although the preferred way to configure CUPS printing in CentOS is with the Printer Configuration window, CUPS offers its own Web-based administrative tool.

If CUPS is already running on your computer, you can immediately use CUPS Web-based administration from your Web browser. If CUPS is not running yet, refer to the following section describing the `cupsd` daemon for information on starting it.

CUPS listens on port 631 to provide access to the CUPS Web-based administrative interface. On the local computer, type the following into your Web browser's location box:

```
http://localhost:631/admin
```

A screen similar to the one shown in Figure 16-3 appears.

By default, Web-based CUPS administration is available only from the local host. To access Web-based CUPS administration from another computer, you must change the `/admin` section

in the `/etc/cups/cupsd.conf` file. As recommended in the text of this file, you should limit access to CUPS administration from the Web. Also keep in mind that passwords are passed as clear text, so someone sniffing your network could see your password. Consider accessing this service through an SSH tunnel if you want to do CUPS administration over an insecure network.

**FIGURE 16-3**

CUPS enables Web-based administration via port 631.



In the following example, I tell CUPS to listen on its LAN interface for outside connections (in this example, the IP address of `eth0` is `10.0.0.20`). I changed `BrowseAllow` to `ALL`. I then added `Allow` lines to allow access from a host from IP address `10.0.0.5` for the root of the server (`/`), `/admin`, and `/admin/conf`, as shown in the following example.

```
Listen 10.0.0.20
BrowseAllow ALL

<Location />
  Order allow,deny
  Allow @LOCAL
  Allow 10.0.0.5
</Location>

<Location /admin>
```

```
    Encryption Required
    Order allow,deny
    Allow localhost
    Allow 10.0.0.5
</Location>

<Location /admin/conf>
    AuthType Basic
    Require user @SYSTEM
    Order allow,deny
    Allow localhost
    Allow 10.0.0.5
</Location>
```

From the computer at address 10.0.0.5, I typed the same address line shown in Figure 16-3 in my Web browser (substituting the CUPS server's name or IP address for the local host). When prompted, I entered the `root` username and password.

Now, with the Admin screen displayed, you can set up a printer as follows:

1. Click on the “Add Printer” button. The Add New Printer screen appears.
2. Type a Name, Location, and Description for the printer and click Continue.
3. Select the device to which the printer is connected. The printer can be connected locally to a Parallel, SCSI, Serial, or USB port directly on the computer. Alternatively, you can select a network connection type for Apple printers (AppSocket/HP JetDirect), Internet Printing Protocol (HTTP or IPP), or Window printer (using SAMBA or SMB).
4. If prompted for further information, you may need to further describe the connection to the printer. For example, you may need to enter the baud rate and parity for a serial port, or you might be asked for the network address (Device URI) for an IPP or Samba printer.
5. Select the make of the print driver. (If you don't see the manufacturer of your printer listed, choose PostScript for a PostScript printer or HP for a PCL printer.) For the make you choose, you will be able to select a specific model. If options are available for that printer, the Set Printer Options screen appears.
6. Depending on the printer driver, there may be a few or a lot of options available for your printer. For example, you may be able to choose page size, manual feed, print quality, and other features. After you have chosen the settings you want, select “Set Printer Options.”
7. If the printer was added successfully, the next page you see should show a link to the description of that printer. Click that link. From the new printer page, you can print a test page or modify the printer configuration.

After you are able to print from CUPS, you can return to the CUPS Web-based administration page and do further work with your printers. Here are a few examples:

- **List Print Jobs** — Click “Manage Jobs” to see what print jobs are currently active from any of the printers configured for this server. Click “Show Completed Jobs” to see information about jobs that are already printed.

- **Create a Printer Class** — Click “Add Class”; then identify a name, location, and description for a printer class. Then, from the list of printers configured on your server, select which ones will go into this class and click “Add Class.”
- **View Printers** — You can click “Manage Printers” and view the printers you have configured. For each printer that appears, you can click “Stop Printer” (to stop the printer from printing, but still accept print jobs for the queue), “Reject Jobs” (to not accept any further print jobs for the moment), or “Print Test Page” (to print a page). Those and other actions you can do from the Printers page appear in Figure 16-4.

**FIGURE 16-4**

Temporarily stop printing or print test pages from the Printers page.



## Configuring the CUPS Server (cupsd.conf)

The `cupsd` daemon process listens for requests to your CUPS print server and responds to those requests based on settings in the `/etc/cups/cupsd.conf` file. The configuration variables in the `cupsd.conf` file are in the same form as those of the Apache configuration file (`httpd.conf`). After changing `cupsd.conf`, restart the server for changes to take effect.

The Printer Configuration window adds access information to the `cupsd.conf` file. You can step through the `cupsd.conf` file to further tune your CUPS server. Here are a few suggestions:

```
Classification topsecret
```

No classification is set by default. With the classification set to `topsecret`, you can have *Top Secret* displayed on all pages that go through the print server. Other classifications you can substitute for `topsecret` include `classified`, `confidential`, `secret`, and `unclassified`.

```
ServerCertificate /etc/cups/ssl/server.crt
ServerKey /etc/cups/ssl/server.key
```

The `ServerCertificate` and `ServerKey` lines (not set by default) can be set up to indicate where the certificate and key are stored, respectively. Activate these two lines if you want to do encrypted connections. Then add your certificate and key to the files noted. Keep in mind that these keys are for the CUPS Web interface and are not used for sending print jobs.

```
Browsing On
BrowseProtocols cups
BrowseOrder Deny,Allow
BrowseAllow from @LOCAL
BrowseAddress 255.255.255.255
Listen *:631
```

Browsing is the feature whereby you broadcast information about your printer on your local network and listen for other print servers' information. Browsing is on by default, but only for the local host (`@LOCAL`). You can allow incoming CUPS browser information for additional selected addresses. Browsing information is broadcast, by default, on address `255.255.255.255`.

To enable Web-based CUPS administration, the `cupsd` daemon listens on port 631 for all network interfaces to your computer based on this entry: `Listen *:631`.

```
BrowseRelay source-address destination-address
```

By turning on `BrowseRelay` (it's off by default), you can allow CUPS browse information to be passed among two or more networks. The *source-address* and *destination-address* can be individual IP addresses or can represent network numbers. This is a good way to allow users on several connected LANs to discover and use printers on other nearby LANs.

You can allow or deny access to different features of the CUPS server. An access definition for a CUPS printer (created from the Printer Configuration window) might appear as follows:

```
<Location /printers/ns1-hp1>
Order Deny,Allow
Deny From All
Allow From 127.0.0.1
AuthType None
</Location>
```

Here, printing to the `ns1-hp1` printer is allowed only for users on the local host (`127.0.0.1`). No password is needed (`AuthType None`). To share this printer with any remote machine that has access to it, you could add `Allow From All` just before the `</Location>` line.



If you change any of the settings in the `cupsd.conf` file, you must reload the CUPS service to have the changes take effect. As root user, type **service cups reload**. (The `reload` option reads the new configuration without restarting the daemon.)

## Configuring CUPS Printer Options

When a new printer is created from the Printer Configuration window, that printer is defined in the `/etc/cups/printers.conf` file. Here's an example of a printer definition in `printers.conf`:

```
<DefaultPrinter hp2100>
Info HP LaserJet 2100M
Location HP LaserJet 2100M in hall closet
DeviceURI hp:/par/HP_LaserJet_2100_Series?device=/dev/parport0
State Idle
Accepting Yes
Shared Yes
JobSheets none none
QuotaPeriod 0
PageLimit 0
KLimit 0
OpPolicy default
ErrorPolicy stop-printer
</Printer>
```

This is an example of a local printer that serves as the default printer for the local system. The most interesting information relates to the `DeviceURI`, which shows us that the printer is connected to parallel port `/dev/parport0`. The `State` is `Idle` (ready to accept printer jobs) and the `Accepting` value is `Yes` (the printer is accepting print jobs by default).

The `DeviceURI` has several ways to identify the device name of a printer, reflecting where the printer is connected. Here are some examples listed in the `printers.conf` file:

```
DeviceURI parallel:/dev/lp
DeviceURI serial:/dev/ttyd1?baud=38400+size=8+parity=none+flow=soft
DeviceURI scsi:/dev/scsi/scld610
DeviceURI socket://hostname:port
DeviceURI tftp://hostname/path
DeviceURI ftp://hostname/path
DeviceURI http://hostname[:port]/path
DeviceURI ipp://hostname/path
DeviceURI smb://hostname/printer
```

The first three examples show the form for local printers (`parallel`, `serial`, and `scsi`). The other examples are for remote hosts. In each case, `hostname` can be the host's name or IP address. Port numbers or paths identify the locations of each printer on the host.

### TIP

If you find that you are not able to print because a particular printer driver is not supported in CUPS, you can set up your printer to accept jobs in raw mode.

This can work well if you are printing from Windows clients that have the correct print drivers installed on those clients. To allow raw printing in CUPS, uncomment the following line from the `/etc/cups/mime.types` file in Linux:

```
application/octet-stream
```

And uncomment the following line from the `/etc/cups/mime.convs` file:

```
application/octet-stream
```

After that, you can print files as raw data to your printers without using the `-oraw` option to print commands. As an alternative, you can just select the Raw Print Queue driver when you first configure printing through the Printer Configuration window.

## Using Printing Commands

---

To remain backward-compatible with older UNIX and Linux printing facilities, CUPS supports many of the old commands for working with printing. Most command-line printing with CUPS can be performed with the `lpr` command. Word processing applications for Linux, such as StarOffice, OpenOffice.org, and AbiWord, are set up to use this facility for printing.

With the Printer Configuration window, you can define the filters needed for each printer so that the text can be formatted properly. Options to the `lpr` command can add filters to process the text properly. Other commands for managing printed documents include `lpq` (for viewing the contents of print queues), `lprm` (for removing print jobs from the queue), and `lpc` (for controlling printers).

**CROSS-REF** Chapter 6 provides examples of how to format and print documents in several different formats, including `troff` and `TeX`.

### Using `lpr` to Print

With the `lpr` command, you can print documents to both local and remote printers. Document files can be either added to the end of the `lpr` command line or directed to the `lpr` command using a pipe (`|`). Here is an example of a simple `lpr` command:

```
$ lpr doc1.ps
```

When you just specify a document file with `lpr`, output is directed to the default printer. As an individual user, you can change the default printer by setting the value of the `PRINTER` variable. Typically, you would add the `PRINTER` variable to one of your startup files, such as `$HOME/.bashrc`. Here is a line to add to your `.bashrc` file to set your default printer to `lp3`:

```
export PRINTER=lp3
```

For the new `PRINTER` value to take effect immediately, source the `.bashrc` file (type `source $HOME/.bashrc`). To override the default printer, specify a particular printer on the `lpr` command line. The following example uses the `-P` option to select a different printer:

```
$ lpr -P canyonps doc1.ps
```

The `lpr` command has a variety of options that enable `lpr` to interpret and format several different types of documents. These include `-# num`, where `num` is replaced by the number of copies to print (from 1 to 100) and `-l` (which causes a document to be sent in raw mode, presuming that the document has already been formatted).

## Listing Status with `lpc`

The `lpc` command in CUPS has limited features. You can use `lpc` to list the status of your printers. Here is an example:

```
$ lpc status
hp:
    printer is on device 'parallel' speed -1
    queuing is enabled
    printing is disabled
    no entries
    daemon present
deskjet_5550:
    printer is on device 'usb' speed -1
    queuing is enabled
    printing is disabled
    no entries
    daemon present
```

This output shows two active printers. The first (`hp`) is connected to the parallel port. The second (`deskjet_5550`) is a USB printer (shown as `usb`). The HP printer is currently disabled (offline), although the queue is enabled so people can continue to send jobs to the printer.

## Removing Print Jobs with `lprm`

Users can remove their own print jobs from the queue with the `lprm` command. Used alone on the command line, `lprm` removes all of the user's print jobs from the default printer. To remove jobs from a specific printer, use the `-P` option, as follows:

```
$ lprm -P lp0
```

To remove all print jobs for the current user, type the following:

```
$ lprm -
```

To remove an individual print job from the queue, indicate the job number of that print job on the `lprm` command line. To find the job number, type the `lpq` command. Here's what the output of that command may look like:

```
$ lpq
printer is ready and printing
Rank  Owner                Job Files          Total Size Time
active root                  133 /home/jake/pr1    467
2     root                  197 /home/jake/mydoc  23948
```

The output shows two printable jobs waiting in the queue. Under the Job column, you can see the job number associated with each document. To remove the first print job, type the following:

```
# lprm 133
```

## Configuring Print Servers

---

You've configured a printer so that you and the other users on your computer can print to it. Now you want to share that printer with other people in your home, school, or office. Basically, that means configuring your computer as a print server.

The printers that are configured on your Linux system can be shared in different ways with other computers on your network. Not only can your computer act as a Linux print server, but it can also look to client computers like an SMB print server. In other words, a Windows client would just see your printer as a printer from another Windows machine.

After a local printer is attached to your Linux system and your computer is connected to your local network, you can use the procedures in this section to share it with client computers using a Linux (UNIX) or SMB interface.

### Configuring a Shared CUPS Printer

After a local printer is added to your Linux computer, making it available to other computers on your network is fairly easy. If a TCP/IP network connection exists among the computers sharing the printer, you can simply grant permission to individual hosts or users from remote hosts to access your computer's printing service. The procedures for setting up local printers are discussed earlier in this chapter.

To share a local printer as a print server with other computers on your network, do the following:

1. From the desktop panel, select System > Administration > Printing. The Printer Configuration window appears.
2. Right-click on the icon of the printer you want to share. (If the printer is not yet configured, refer to the "Setting Up Printers" section earlier in this chapter.)
3. Select the Shared box on the menu so that a checkmark appears in the box.

4. If you want only selected users to access your printer, select Properties from the menu and then click on the “Access Control” item. Select “Deny printing for everyone except these users,” type each user you want to allow to use the printer, and click Add to add each user. Likewise, you could select “Allow printing for everyone except these users” and add selected users to be excluded from those allowed to print.
5. Select Settings from the Server menu at the top of the Printer Configuration window. From the Basic Server Settings screen that appears, select the “Publish shared printers connected to this system” checkbox.
6. Click OK to make the changes permanent.

At this point, you can configure other computers to use your printer. If you try to print from another computer and it doesn't work, here are a few things to try:

- **Open Your Firewall** — If you have a restrictive firewall, it may not permit remote users to access your printers. You must allow access to port 513 (UDP and TCP) and possibly port 631 to allow access to printing on your computer. See Chapter 13 for information on configuring your firewall.
- **Enable LPD-Style Printing** — Certain applications may require an older LPD-style printing service in order to print on your shared printer. To enable LPD-style printing on your CUPS server, you must turn on the `cups-lpd` service. As `root` user, type **chkconfig cups-lpd on**. Then restart the `xinetd` daemon (**service xinetd restart**). To use this service, you may need to install the `cups-lpd` package (**yum install cups-lpd**).
- **Check Names and Addresses** — Make sure that you entered your computer's name and print queue properly when you configured it on the other computer. Try using the IP address instead of the hostname (if that worked, it would indicate a DNS name resolution problem). Running a tool such as Wireshark can let you watch where the transaction fails.

Access changes to your shared printer are made in the `/etc/cups/cupsd.conf` file.

## Configuring a Shared Samba Printer

Your Linux printers can be configured as shared SMB printers. To share your printer as a Samba (SMB) printer, all you need to do is configure basic Samba server settings as described in Chapter 17. All your printers should be shared on your local network by default. The next section shows what the resulting settings look like and how you might want to change them.

### Understanding `smb.conf` for Printing

When you configure Samba, as described in Chapter 17, the `/etc/samba/smb.conf` file is configured to allow all your configured printers to be shared. Here are a few lines you might find in the `[global]` and `[printers]` sections of the `smb.conf` file that relate to printer sharing:

```
[global]
    workgroup = MYGROUP
```

```
serverstring = Samba Server
security = share
printcap name = /etc/printcap
load printers = yes
printing = cups
encrypt passwords = yes
smb passwd file = /etc/samba/smbpasswd
unix password sync = Yes

[printers]
comment = All Printers
path = /var/spool/samba
guest ok = yes
browseable = no
writeable = no
printable = yes
```

The settings shown resulted from configuring Samba from the Samba Server Configuration (System > Administration > Samba) window. You need to install the `system-config-samba` package to use the Samba Server Configuration window. In this case, I selected to use encrypted passwords. The lines show that printers from `/etc/printcap` were loaded and that the CUPS service is being used. The `/etc/samba/smbpasswd` file stores the encrypted passwords. Because password sync is on, each user's Samba password is synchronized with the local UNIX password for the user.

The last few lines shown here make up the `[printers]` section, which determines the defaults for how printers are shared in Samba. The final line (`printable = yes`) defines that users can print to all printers.

## Summary

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Sharing printers is an economical and efficient way to use your organization's printing resources. A centrally located printer can make it easier to maintain a printer, while still allowing everyone to get his or her printing jobs done.

You configure your printer with the Printer Configuration window. A variety of filters make it possible to print to different kinds of printers, as well as to printers that are connected to computers on the network.

The default printing service in CentOS is the Common UNIX Printing Service (CUPS). Besides being able to set up your computer as a Linux print server, you can also have your computer emulate an SMB (Windows) print server. After your network is configured properly and a local printer is installed, sharing that printer over the network as a UNIX or SMB print server is not very complicated.



# Chapter 17

## Setting Up a File Server

**W**hen groups of people need to work together on projects, they usually need to share documents. Likewise, it can be efficient for groups of people on a computer network to share common applications and directories of information needed to do their jobs. A common way to store files centrally and share them on a network is by setting up a file server.

CentOS systems include support for each of the most common file server protocols in use today. The Network File System (NFS) has always been the file-sharing protocol of choice for Linux and other UNIX systems. Networks with many Windows computers tend to use Samba, or SMB/CIFS (Server Message Block/Common Internet File System) protocol. This chapter describes how to set up file servers and clients associated with NFS and Samba, and file servers set up in Linux.

**CROSS-REF** Two other types of file servers are also described in this book: FTP (using vsFTP) and HTTP (using Apache). To set up public FTP file servers, refer to Chapter 19. Chapter 20 discusses how to set up a Web Server.

### Goals of Setting Up a File Server

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By centralizing data and applications on a file server, you can accomplish several goals:

- **Centralized Distribution** — You can add documents or applications to one location and make them accessible to any authorized computer or user. In this way, you don't have to be responsible for placing necessary files on every computer.

#### IN THIS CHAPTER

Setting up an NFS file server in Linux

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Setting up a Samba file server in Linux

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- **Transparency** — Using protocols like NFS, clients of your file server (Windows, Linux, or UNIX systems) can connect your file systems to their local file systems as if your file systems existed locally. (In other words, no drive letters on the Linux or UNIX systems. Just change to the remote system's mount point and you are there.)

## Setting Up an NFS File Server

---

Instead of representing storage devices as drive letters (A, B, C, etc.), as they are in Microsoft operating systems, Linux systems connect file systems from multiple hard disks, floppy disks, CD-ROMs, and other local devices invisibly to form a single Linux file system. The Network File System facility lets you extend your Linux file system in the same way, to connect file systems on other computers to your local directory structure as well.

**CROSS-REF** See Chapter 9 for a description of how to mount local devices on your Linux file system. The same command (`mount`) is used to mount both local devices and NFS file systems.

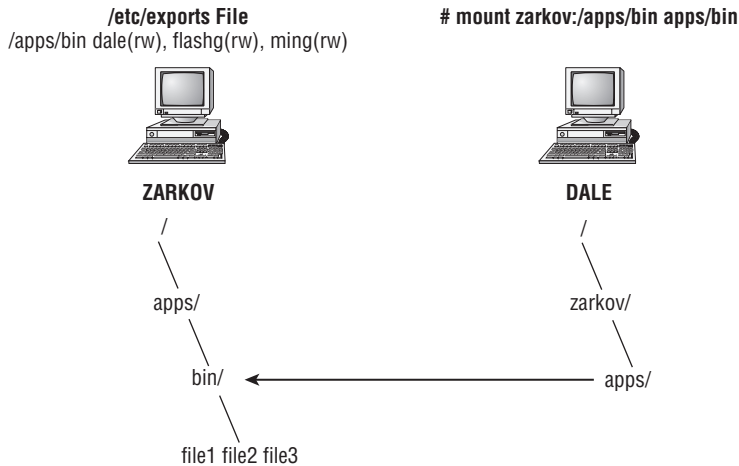
Creating an NFS file server is an easy way to share large amounts of data among the users and computers in an organization. An administrator of a Linux system that is configured to share its file systems using NFS has to perform the following tasks to set up NFS:

1. **Set Up the Network** — If a LAN or other network connection is already connecting the computers on which you want to use NFS (using TCP/IP as the network transport), you already have the network you need.
2. **On the Server, Choose What to Share** — Decide which file systems on your Linux NFS server to make available to other computers. You can choose any point in the file system and make all files and directories below that point accessible to other computers. However, it is most secure to share directories from the root of a file system partition.
3. **On the Server, Set Up Security** — You can use several different security features to suit the level of security with which you are comfortable. *Mount-level security* lets you restrict the computers that can mount a resource and, for those allowed to mount it, lets you specify whether it can be mounted Read/Write or Read Only. With *user-level security*, you map users from the client systems to users on the NFS server. In this way, users can rely on standard Linux Read/Write/Execute permissions, file ownership, and group permissions to access and protect files.
4. **On the Client, Mount the File System** — Each client computer that is allowed access to the server's NFS shared file system can mount it anywhere the client chooses. For example, you may mount a file system from a computer called `zarkov` on the `/media/zarkov` directory in your local file system. After it is mounted, you can view the contents of that directory by typing `ls /media/zarkov`. Then you can use the `cd` command below the `/media/zarkov` mount point to see the files and directories it contains.

Figure 17-1 illustrates a Linux file server using NFS to share (export) a file system and a client computer mounting the file system to make it available to its local users.

**FIGURE 17-1**

NFS can make selected file systems available to other computers.



In this example, a computer named `zarkov` makes its `/apps/bin` directory available to clients on the network (`dale`, `flashg`, and `ming`) by adding an entry to the `/etc/exports` file. The client computer (`dale`) sees that the resource is available, then mounts the resource on its local file system at the mount point `/zarkov/apps`. At this point, any files, directories, or subdirectories from `/apps/bin` on `zarkov` are available to users on `dale` (given proper permissions).

Although it is often used as a file server (or other type of server), Linux is a general-purpose operating system. So, any CentOS system can share file systems (*export*) as a server or use another computer's file systems (*mount*) as a client. Contrast this with dedicated file servers, such as NetWare, which was created to share files with client computers (such as Windows workstations) and was not intended to act as a client.

Many people use the term *file system* rather loosely. A *file system* is usually a structure of files and directories that exists on a single device (such as a hard-disk partition or CD-ROM). When I talk about the *Linux file system*, however, I am referring to the entire directory structure (which may include file systems from several disks or NFS resources), beginning from `root (/)` on a single computer. A shared directory in NFS may represent all or part of a computer's file system, which can be attached (from the shared directory down the directory tree) to another computer's file system.

## Sharing NFS File Systems

To share an NFS file system from your Linux system, you need to export it from the server system. Exporting is done in CentOS by adding entries into the `/etc/exports` file. Each entry identifies the directory in your local file system that you want to share with other computers. The entry identifies the other computers that can share the resource (or opens it to all computers) and includes other options that reflect permissions associated with the directory.

Remember that when you share a directory, you are sharing all files and subdirectories below that directory as well (by default). So, you need to be sure that you want to share everything in that directory structure. (There are still ways to restrict access within that directory structure. Those methods are described later.)

CentOS provides a graphical tool for configuring NFS called the *NFS Server Configuration window* (`system-config-nfs` command). The following sections explain how to use the NFS Server Configuration window to share directories with other computers, and then describe the underlying configuration files that are changed to make that happen.

### Using the NFS Server Configuration Window

The NFS Server Configuration window (`system-config-nfs` command from the package of the same name) allows you to share your NFS directories using a graphical interface. Start this window from the Desktop menu by clicking System > Administration > Server Settings > NFS. (If it's not there, type **yum install system-config-nfs** to install it.)

To share a directory with the NFS Server Configuration window, do the following:

1. From the NFS Server Configuration window, click File > Add Share. The Add NFS Share window appears, as shown in Figure 17-2.
2. In the Add NFS Share window Basic tab, enter the following information:
  - **Directory** — Type the name of the directory you want to share. (The directory must exist before you can add it.)
  - **Host(s)** — Enter one or more hostnames to indicate which hosts can access the shared directory. Hostnames, domain names, and IP addresses are allowed here. Separate each name with a space. (See the “Hostnames in `/etc/exports`” section later in this chapter for valid hostnames.) Add an asterisk (\*) to place no restrictions on which hosts can access this directory.
  - **Basic Permissions** — Click Read-only or Read/Write to let remote computers mount the shared directory with Read access only or Read/Write access, respectively.
3. Click on the General Options tab. This tab lets you add options that define how the shared directory behaves when a remote host connects to it (mounts it):
  - **Allow Connections from Ports 1024 and Higher** — Normally, an NFS client will request the NFS service from a port number under 1024. Select this option if you need to allow a client to connect to you from a higher port number. (This sets the `insecure`

option.) To allow a Mac OS X computer to mount a shared NFS directory, you must have the `insecure` option set for the shared directory.

**FIGURE 17-2**

Identify a directory to share and access permissions with the NFS Server Configuration window.



- **Allow Insecure File Locking** — If checked, NFS will not authenticate any locking requests from remote users of this shared directory. Older NFS clients may not deliver their credentials when they ask for a file lock. (This sets the `insecure_locks` option.)
- **Disable Subtree Checking** — By selecting this option, NFS won't verify that the requested file is actually in the shared directory (only that it's in the correct file system). You can disable subtree checking if an entire file system is being shared. (This sets the `no_subtree_check` option.)
- **Sync Write Operations on Request** — This is On by default, which forces a Write operation from a remote client to be synced on your local disk when the client requests it. (This sets the `sync` option.)
- **Force Sync of Write Operations Immediately** — If keeping the shared data immediately up-to-date is critical, select this option to force the immediate synchronization of Writes to your hard disk. (This sets the `no_wdelay` option.)

- **Hide Filesystems Beneath** — By default (`hide` option), if a shared NFS file system has another local file system mounted on it, the second file system will not appear when the client mounts the original file system. If this box is unchecked, the `nohide` option is set instead, causing the second mounted file system to be accessible from clients.
  - **Export Only if Mounted** — If a file system that is set to be shared is a mount point that is currently not mounted, the file system will not be exported if this option is On (represented by the `mp` option). This can prevent sharing empty directories and having contents stored to the empty directory disappear the next time the resource is mounted.
  - **Optional Mount Point** — You can also identify the mount point directly by checking this box and setting the file system mount point. For example, if you are sharing the `/mnt/files/isos` directory and you identify `/mnt/files` as the mount point (`mp=/mnt/files`), the `/mnt/files/isos` directory will not be shared if the `/mnt/files` directory isn't mounted.
  - **Set Explicit Filesystem ID** — Because not all file systems have UUIDs to identify them, you can identify a further file system you want to share using its file system ID. The result is that the `fsid` option is set to that value (`fsid=???`). If you prefer, you can identify a file system as the root of your shared file systems (`fsid=0`).
4. Click on the User Access tab, then select any of the following options:
    - **Treat the Remote Root User as Local Root** — If this option is on, it enables the remote `root` user host accessing your shared directory to save and modify files as though he or she were the local `root` user. Having this on is a security risk, since the remote user can potentially modify critical files. (This sets the `no_root_squash` option.)
    - **Treat All Client Users as Anonymous Users** — When this option is on, you can indicate that particular user and group IDs be assigned to every user accessing the shared directory from a remote computer. Enter the user ID and group ID you want assigned to all remote users. (This sets the `anonuid` and `anongid` options to the numbers you choose.)
  5. Click OK. The new shared directory appears in the NFS Server Configuration window.

At this point, the configuration file (`/etc/exports`) should have the shared directory entry created in it. To turn on the NFS service and make the shared directory available, type the following from a Terminal window as `root` user.

1. To immediately turn on NFS, type:
 

```
# service nfs start
```
2. To permanently turn on the NFS service, type:
 

```
# chkconfig nfs on
```
3. If you have a firewall configured, you must ensure that UDP ports 111 and 2049 are accepting requests. (See Chapter 13 for information on configuring your firewall.)

The next few sections describe the `/etc/exports` file you just created. At this point, a client can only use your shared directory if he or she mounts it on his local file system. Refer to the “Using NFS File Systems” section later in this chapter.

## Configuring the `/etc/exports` File

The shared directory information you entered into the NFS Server Configuration window is added to the `/etc/exports` file. As `root` user, you can use any text editor to configure the `/etc/exports` file to modify shared directory entries or add new ones. Here’s an example of an `/etc/exports` file, including some entries that it could include:

```
/cal    *.example.com(rw,sync)          # Company events
/pub    (ro,insecure,all_squash)      # Public dir
/home   flashg(rw,squash uids=0-99) ming(rw,squash uids=0-99)
```

The following text describes those entries:

- `/cal` — Represents a directory that contains information about events related to the company. It is made accessible to everyone with accounts to any computers in the company’s domain (`*.example.com`). Users can write files to the directory as well as read them (indicated by the `rw` option).

The `sync` option, which is the default behavior, is explicitly entered here to indicate that NFS will only reply to new requests after changes have been committed to storage. (The alternative is to enter **async**, which allows new requests before changes are committed to improve performance, but can result in data corruption.) The comment (`# Company events`) simply serves to remind you of what the directory contains.

- `/pub` — Represents a public directory. It allows any computer and user to read files from the directory (indicated by the `ro` option), but not to write files. The `insecure` option enables any computer, even one that doesn’t use a secure NFS port, to access the directory. The `all_squash` option causes all users (UIDs) and groups (GIDs) to be mapped to the `nfsnobody` user, giving them minimal permission to files and directories.
- `/home` — This entry enables a set of users to have the same `/home` directory on different computers. Say, for example, that you are sharing `/home` from a computer named `zarkov`. The computers named `flashg` and `ming` could each mount that directory on their own `/home` directory. If you gave all users the same user name/UID on all machines, you could have the same `/home/user` directory available for each user, regardless of which computer they logged into. The `uids=0-99` is used to exclude any administrative login from another computer from changing any files in the shared directory.

Of course, you can share any directories that you choose (these were just examples), including the entire file system (`/`). There are security implications of sharing the whole file system or sensitive parts of it (such as `/etc`). Security options that you can add to your `/etc/exports` file are described throughout the sections that follow.

The format of the `/etc/exports` file is:

```
Directory Host(Options) # Comments
```

*Directory* is the name of the directory that you want to share. *Host* indicates the host computer that the sharing of this directory is restricted to. *Options* can include a variety of options to define the security measures attached to the shared directory for the host. (You can repeat Host/Option pairs.) *Comments* are any optional comments you want to add (following the # sign).

### Hostnames in */etc/exports*

You can indicate in the */etc/exports* file which host computers can have access to your shared directory. Be sure to have a space between each hostname. Here are ways to identify hosts:

- **Individual Host** — You can enter one or more TCP/IP hostnames or IP addresses. If the host is in your local domain, you can simply indicate the hostname. Otherwise, you can use the full host.domain format. These are valid ways of indicating individual host computers:

```
flashg  
flashg.example.com  
10.0.0.11
```

- **IP Network** — To allow access to all hosts from a particular network address, indicate a network number and its netmask, separated by a slash (/). These are valid ways of indicating network numbers:

```
10.0.0.0/255.0.0.0  
172.16.0.0/255.255.0.0  
192.168.18.0/24  
192.168.18.0/255.255.255.0
```

- **TCP/IP Domain** — Using wildcards, you can include all or some host computers from a particular domain level. Here are some valid uses of the asterisk and question mark wildcards:

```
*.example.com  
*crafts.example.com  
???.example.com
```

The first example matches all hosts in the *example.com* domain. The second example matches *spacecrafts*, *artsn Crafts*, or any other hostnames ending in *crafts* in the *example.com* domain. The final example matches any three-letter hostnames in the domain.

#### NOTE

You can also separate multiple hostnames with spaces, but if you add options after each hostname, leave no spaces between the hostname and the parentheses. For example:

```
*.example.com(rw) *.example2.com(ro).
```

- **NIS Groups** — You can allow access to hosts contained in an NIS group. To indicate an NIS group, precede the group name with an at (@) sign: e.g., *@group*).

### Access Options in `/etc/exports`

You don't have to just give away your files and directories when you export a directory with NFS. In the options part of each entry in `/etc/exports`, you can add options that allow or limit access by setting Read/Write permission. These options, which are passed to NFS, are as follows:

- `ro` — Only allow the client to mount this exported file system as Read Only. The default is to mount the file system as Read/Write.
- `rw` — Explicitly ask that a shared directory be shared with Read/Write permissions. (If the client chooses, it can still mount the directory as Read Only.)

### User Mapping Options in `/etc/exports`

Besides options that define how permissions are handled generally, you can also use options to set the permissions that specific users have to NFS shared file systems.

One method that simplifies this process is to have each user with multiple user accounts have the same username and UID on each machine. This makes it easier to map users so that they have the same permission on a mounted file system as they do on files stored on their local hard disk. If that method is not convenient, user IDs can be mapped in many other ways. Here are some methods of setting user permissions and the `/etc/exports` option that you use for each method:

- **root User** — Normally, the client's `root` user is mapped into the `nfsnobody` username (UID 65534). This prevents the `root` user from a client computer from being able to change all files and directories in the shared file system. If you want the client's `root` user to have root permission on the server, use the `no_root_squash` option.

#### TIP

There may be other administrative users, in addition to `root`, that you want to squash. I recommend squashing UIDs 0–99 as follows: `squash_uids=0-99`.

- **nfsnobody User/Group** — By using the `nfsnobody` username and group name, you essentially create a user/group whose permissions will not allow access to files that belong to any real users on the server (unless those users open permission to everyone). However, files created by the `nfsnobody` user or group will be available to anyone assigned as the `nfsnobody` user or group. To set all remote users to the `nfsnobody` user/group, use the `all_squash` option.

The `nfsnobody` user is assigned to UIDs and GIDs of 65534. This prevents the ID from running into a valid user or group ID. Using `anonuid` or `anongid` options, you can change the `nfsnobody` user or group, respectively. For example, `anonuid=175` sets all anonymous users to UID 175, and `anongid=300` sets the GID to 300. (Only the number is displayed when you list file permission, however, unless you add entries with names to `/etc/passwd` and `/etc/group` for the new UIDs and GIDs.)

- **User Mapping** — If the same users have login accounts for a set of computers (and they have the same IDs), NFS, by default, will map those IDs. This means that if the user named



mike (UID 110) on flashg has an account on dale (mike, UID 110), he could use his own remotely mounted files from either computer.

If a client user who is not set up on the server creates a file on the mounted NFS directory, the file is assigned to the remote client's UID and GID. (An `ls -l` on the server would show the UID of the owner.) You can identify a file that contains user mappings using the `map_static` option.

**TIP**

The `exports` man page describes the `map_static` option, which should let you create a file that contains new ID mappings. These mappings should let you remap client IDs into different IDs on the server.

## Exporting the Shared File Systems

After you have added entries to your `/etc/exports` file, you can actually export the directories listed using the `exportfs` command. If you reboot your computer or restart the NFS service, the `exportfs` command is run automatically to export your directories. However, if you want to export them immediately, you can do so by running `exportfs` from the command line (as root).

**TIP**

It's a good idea to run the `exportfs` command after you change the `exports` file. If any errors are in the file, `exportfs` will identify those errors for you. If you are not able to immediately access changed NFS shares from clients, you might need to restart the NFS and portmap services.

Here's an example of the `exportfs` command:

```
# /usr/sbin/exportfs -a -v
exporting flashg:/pub
exporting ming:/pub
exporting flashg:/home
exporting ming:/home
exporting */media/win
```

The `-a` option indicates that all directories listed in `/etc/exports` should be exported. The `-v` option says to print verbose output. In this example, the `/pub` and `/home` directories from the local server are immediately available for mounting by those client computers that are named (`flashg` and `ming`). The `/media/win` directory is available to all client computers.

Running the `exportfs` command makes your exported NFS directories immediately available. Any changes to your `/etc/export` file will be used again the next time you reboot or otherwise restart the NFS service.

## Starting the `nfsd` Daemons

For security purposes, the NFS service is turned off by default on your CentOS system. You can use the `chkconfig` command to turn on the NFS service so that your files are exported and the `nfsd` daemons are running when your system boots.

There are two start-up scripts that you should turn on for the NFS service to work properly. The NFS service exports file systems (from `/etc/exports`) and starts the `nfsd` daemon that listens for service requests. The NFSLOCK service starts the `lockd` daemon, which helps allow file locking to prevent multiple simultaneous use of critical files over the network.

**NOTE**

If you see the message “Cannot register service: RPC: Unable to receive; errno=connection refused,” you probably need to start the portmap service on the client machine.

You can use the `chkconfig` command to turn on the NFS service by typing the following commands (as `root` user):

```
# chkconfig nfs on
```

The next time you start your computer, the NFS service will start automatically, and your exported directories will be available. If you want to start the service immediately, without waiting for a reboot, you can type the following:

```
# /etc/init.d/nfs start
```

The NFS service should now be running and ready to share directories with other computers on your network.

## Using NFS File Systems

After a server exports a directory over the network using NFS, a client computer connects that directory to its own file system using the `mount` command. The `mount` command is the same one used to mount file systems from local hard disks, CDs, and USB flash drives. Only the options to give to `mount` are slightly different.

The `mount` command can automatically mount NFS directories that are added to the `/etc/fstab` file, just as it does with local disks. NFS directories can also be added to the `/etc/fstab` file in such a way that they are not automatically mounted. With a `noauto` option, an NFS directory listed in `/etc/fstab` is inactive until the `mount` command is used, after the system is up and running, to mount the file system. The `_netdev` option will automatically mount the directory but will delay doing so until after the networking is up.

### Manually Mounting an NFS File System

If you know that the directory from a computer on your network has been exported (i.e., made available for mounting), you can mount that directory manually using the `mount` command. This is a good way to make sure that it is available and working before you set it up to mount permanently. Here’s an example of mounting the `/home/timothy/files` directory from a computer named `flashg` on your local computer:

```
# mkdir /media/flashg
# mount flashg:/home/timothy/files /media/flashg
```

The first command (`mkdir`) creates the mount point directory (`/media` is a common place to put temporarily mounted disks and NFS file systems). The `mount` command then identifies the remote computer and shared file system separated by a colon (`flashg:/home/timothy/files`). Then, the local mount point directory follows (`/media/flashg`).

**NOTE**

If the `mount` failed, make sure the NFS service is running on the server and that the server's firewall rules don't deny access to the service. From the server, type `ps ax | grep nfsd`. You should see a list of NFSD server processes. If you don't, try to start your NFS daemons as described in the previous section. To view your firewall rules, type `iptables -L` (see Chapter 13 for a description of firewalls). By default, the `nfsd` daemon listens for NFS requests on port number 2049. Your firewall must accept `udp` requests on ports 2049 (`nfs`) and 111 (`rpc`).

To ensure that the mount occurred, type `mount`. This command lists all mounted disks and NFS file systems. Here is an example of the `mount` command and its output:

```
# mount
/dev/sda3 on / type ext3 (rw)
none on /proc type proc (rw)
none on /sys type sysfs (rw)
none on /dev/pts type devpts (rw,gid=5,mode=620)usbdevfs on /proc/
bus/usb type usbdevfs (rw)
/dev/sda1 on /boot type ext3 (rw)
none on /dev/shm type tmpfs (rw)
flashg:/home/timothy/files on /media/flashg type nfs
(rw,addr=10.0.0.11)
```

The output from the `mount` command shows your mounted disk partitions, special file systems, and NFS file systems. The first output line shows your hard disk (`/dev/sda3`), mounted on the root file system (`/`), with Read/Write permission (`rw`), and with a file system type of `ext3` (the standard Linux file system type). The small `/boot` file system is also of type `ext3`. The `/proc`, `/sys`, `/dev/shm`, `/dev/pts`, and `usbdevfs` mount points represent special file system types. The just-mounted NFS file system is the `/home/timothy/files` directory from `flashg` (`flashg:/home/timothy/files`). It is mounted on `/media/flashg`, and its mount type is `nfs`. The file system was mounted Read/Write (`rw`), and the IP address of `flashg` is `10.0.0.11` (`addr=10.0.0.11`).

I just showed a simple case of using `mount` with NFS. The mount is temporary and is not remounted when you reboot your computer. You can also add options to the `mount` command line for NFS mounts:

- `-a` — Mount all file systems in `/etc/fstab` (except those indicated as `noauto`).
- `-f` — This goes through the motions of (*fakes*) mounting the file systems on the command line (or in `/etc/fstab`). Used with the `-v` option, `-f` is useful for seeing what `mount` would do before it actually does it.
- `-F` — When used with `-a`, you tell `mount` to fork off a new incarnation of `mount` for each file system listed to be mounted in the `/etc/fstab` file. An advantage of using this option,

as it relates to NFS shared directories, is that other file systems can be mounted if an NFS file system isn't immediately available. This option should not be used, however, if the order of mounting is important (e.g., if you needed to mount `/mnt/pcs` and then `/mnt/pcs/arctic`).

- `-r` — Mounts the file system as Read Only.
- `-w` — Mounts the file system as Read/Write. (For this to work, the shared file system must have been exported with Read/Write permission.)

The next section describes how to make the mount more permanent (using the `/etc/fstab` file) and how to select various options for NFS mounts.

### Automatically Mounting an NFS File System

To set up an NFS file system to mount automatically each time you start your CentOS system, you need to add an entry for that NFS file system to the `/etc/fstab` file. The `/etc/fstab` file contains information about all different kinds of mounted (and available to be mounted) file systems for your CentOS system.

The format for adding an NFS file system to your local system is the following:

```
host:directory    mountpoint    nfs    options    0    0
```

The first item (*host:directory*) identifies the NFS server computer and shared directory. *mountpoint* is the local mount point on which the NFS directory is mounted, followed by the file system type (*nfs*). Any options related to the mount appear next in a comma-separated list. (The last two zeros just tell CentOS not to dump the contents of the file system and not to run `fsck` on the file system.)

The following are two examples of NFS entries in `/etc/fstab`:

```
flashg:/home/timothy/files /media/flashg nfs    rsize=8192,
    wsize=8192,_netdev 0 0
zarkov:/apps    /zarkov/apps    nfs    noauto,ro,_netdev    0 0
```

In the first example, the remote directory `/home/timothy/files` from the computer named `flashg` (`flashg:/home/timothy/files`) is mounted on the local directory `/media/flashg` (the local directory must already exist). The file system type is `nfs`, and Read (`rsize`) and Write (`wsize`) buffer sizes are set at 8192 to speed data transfer associated with this connection. In the second example, the remote directory is `/apps` on the computer named `zarkov`. It is set up as an NFS file system (`nfs`) that can be mounted on the `/zarkov/apps` directory locally. This file system is not mounted automatically (`noauto`), however, and can be mounted only as Read Only (`ro`) using the `mount` command after the system is already running. The `_netdev` option means that the entry will not be mounted during the system's boot until the network service has been enabled and is working.

#### TIP

The default is to mount an NFS file system as Read/Write. However, the default for exporting a file system is as Read Only. If you are unable to write to an NFS file system, check that it was exported as Read/Write from the server.

### Mounting *noauto* File Systems

In your `/etc/fstab` file there can also be devices for other file systems that are not mounted automatically. For example, you might have multiple disk partitions on your hard disk or an NFS shared file system that you might want to mount only occasionally. A `noauto` file system can be mounted manually. The advantage is that when you type the `mount` command, you can type less information and have the rest filled in by the contents of the `/etc/fstab` file. So, for example, you could type:

```
# mount /zarkov/apps
```

With this command, `mount` knows to check the `/etc/fstab` file to get the file system to mount (`zarkov:/apps`), the file system type (`nfs`), and the options to use with the mount (in this case, `ro` for Read Only). Instead of typing the local mount point (`/zarkov/apps`), you could have typed the remote file system name (`zarkov:/apps`) instead and had other information filled in.

**TIP**

When naming mount points, including the name of the remote NFS server in that name can help you remember where the files are actually being stored. This may not be possible if you are sharing home directories (`/home`) or mail directories (`/var/spool/mail`).

### Using *mount* Options

You can add several `mount` options to the `/etc/fstab` file (or to a `mount` command line itself) to affect how the file system is mounted. When you add options to `/etc/fstab`, they must be separated by commas. The following are some options that are valuable for mounting NFS file systems:

- `hard` — With this option on, if the NFS server disconnects or goes down while a process is waiting to access it, the process will hang until the server comes back up. This option is helpful if it is critical that the data you are working with not get out of sync with the programs that are accessing it. (This is the default behavior.)
- `soft` — If the NFS server disconnects or goes down, a process trying to access data from the server will time out after a set period of time when this is on.
- `rsi ze` — The number of bytes of data read at a time from an NFS server. The default is 1,024. Using a larger number (such as 8,192) will get you better performance on a network that is fast (such as a LAN) and is relatively error-free (i.e., one that doesn't have a lot of noise or collisions).
- `ws i ze` — The number of bytes of data written at a time to an NFS server. The default is 1,024. Performance issues are the same as with the `rsi ze` option.
- `timeo=#` — Sets the time after an RPC time-out occurs that a second transmission is made, where `#` represents a number in tenths of a second. The default value is seven-tenths (0.7) of a second. Each successive time-out causes the time-out value to be doubled (up to 60 seconds maximum). You should increase this value if you believe that time-outs are occurring because of slow response from the server or a slow network.

- `retrans=#` — Sets the number of minor retransmission time-outs that occur before a major time-out. When a major time-out occurs, the process is either aborted (soft mount) or a “Server Not Responding” message appears on your console.
- `retry=#` — Sets how many minutes to continue to retry failed mount requests, where `#` is replaced by the number of minutes to retry. The default is 10,000 minutes (which is about 1 week).
- `bg` — If the first mount attempt times out, try all subsequent mounts in the background. This option is very valuable if you are mounting a slow or sporadically available NFS file system. By placing mount requests in the background, CentOS can continue to mount other file systems instead of waiting for the current one to complete.

**NOTE**

If a nested mount point is missing, a time-out to allow for the needed mount point to be added occurs. For example, if you mount `/usr/trip` and `/usr/trip/extra` as NFS file systems, if `/usr/trip` is not yet mounted when `/usr/trip/extra` tries to mount, `/usr/trip/extra` will time out. Hopefully, `/usr/trip` will come up and `/usr/trip/extra` will mount on the next retry.

- `fg` — If the first mount attempt times out, try subsequent mounts in the foreground. This is the default behavior. Use this option if it is imperative that the mount be successful before continuing (e.g., if you were mounting `/usr`).

Any of the options that don't require a value can have `no` prepended to have the opposite effect. For example, `nobg` indicates that the mount should not be done in the background.

## Using `autofs` to Mount NFS File Systems on Demand

Recent improvements to autodetecting and mounting removable devices have meant that you can simply insert or plug in those devices to have them detected, mounted, and displayed. However, to make the process of detecting and mounting remote NFS file systems more automatic, you still need to use a facility such as `autofs`. If it is not installed, you can install the `autofs` package with the `yum install autofs` command.

With the `autofs` facility configured and turned on, you can cause any NFS shared directories to mount on demand. If you know the hostname and directory being shared by another host computer, you can simply change (`cd`) to the `autofs` mount directory (`/net` by default) and have the shared resource automatically mount and be accessible to you.

The following steps explain how to turn on the `autofs` facility:

1. As `root` user from a Terminal window, open the `/etc/auto.master` file and look for a line that appears as follows:

```
/net -hosts
```

This causes the `/net` directory to act as the mount point for the NFS shared directories you want to access on the network. (If there is a comment character at the beginning of that line, remove it.)

2. Start the autofs service by typing the following as root user:

```
# service autofs start
```

3. Set up the autofs service to restart every time you boot your system:

```
# chkconfig autofs on
```

Believe it or not, that's all you have to do. Provided that you have a network connection to the NFS servers from which you want to share directories, you can try to access a shared NFS directory. For example, if you know that the `/usr/local/share` directory is being shared from the computer on your network named `shuttle`, do the following:

1. Type the following:

```
$ cd /net/shuttle
```

If the computer named `shuttle` has any shared directories that are available to you, you will be able to successfully change to that directory. Another thing to note is that you could use an IP address instead of a hostname (e.g., `cd /net/10.0.0.1`).

2. Type the following:

```
$ ls  
usr
```

You should be able to see that the `usr` directory is part of the path to a shared directory. If there are shared directories from other top-level directories, you should see those as well (such as `/var` or `/home`). Of course, seeing any of those directories is dependent on how security is set up on the server.

3. Next, you could try going straight to the shared directory. For example:

```
$ cd /net/shuttle/usr/local/share  
$ ls  
info man music television
```

At this point, the `ls` should reveal the contents of the `/usr/local/share` directory on the computer named `shuttle`. What you can do with that content depends on how that content was configured for sharing by the server.

## Unmounting NFS File Systems

After an NFS file system is mounted, unmounting it is simple. You use the `umount` command with either the local mount point or the remote file system name. For example, here are two ways you could unmount `flashg:/home/timothy/files` from the local directory `/media/flashg`:

```
# umount flashg:/home/timothy/files  
# umount /media/flashg
```

Either form will work. If `flashg:/home/timothy/files` is mounted automatically (from a listing in `/etc/fstab`), the directory will be remounted the next time you boot CentOS. If it was a temporary mount (or listed as `noauto` in `/etc/fstab`), it will not be remounted at boot time.

**TIP**

The command is not `unmount`, it is `umount`. This is easy to get wrong.

If you get the message “device is busy” when you try to unmount a file system, it means that the unmount fails because the file system is being accessed. Most likely, one of the directories in the NFS file system is the current directory for your shell (or the shell of someone else on your system). The other possibility is that a command is holding a file open in the NFS file system (such as a text editor). Check your Terminal windows and other shells, and `cd` out of the directory if you are in it, or just close the Terminal windows.

If an NFS file system won't unmount, you can force unmount it (`umount -f /media/flashg`) or unmount and clean up later (`umount -l /media/flashg`). The `-l` option is usually the better choice because a forced unmount can disrupt a file modification that is in progress.

## Other Cool Things to Do with NFS

You can share some directories to make it consistent for a user to work from any of several different Linux computers on your network. Some examples of useful directories to share are:

- **/var/spool/mail** — By sharing this directory from your mail server and mounting it on the same directory on other computers on your network, users can access their mail from any of those other computers. This saves users from having to download messages to their current computers or from having to log in to the server just to get mail. There is only one mailbox for each user, no matter from where it is accessed.
- **/home** — This is a similar concept to sharing mail, except that all users have access to their home directories from any of the NFS clients. Again, you would mount `/home` on the same mount point on each client computer. When the user logs in, that user has access to all the user's start-up files and data files contained in the `/home/user` directory.

**TIP**

If your users rely on a shared `/home` directory, you should make sure that the NFS server that exports the directory is fairly reliable. If `/home` isn't available, the user may not have the start-up files to log in correctly or any of the data files needed to get work done. One work-around is to have a minimal set of start-up files (`.bashrc`, `.Xdefaults`, etc.) available in the user's home directory when the NFS directory is not mounted. Doing so allows the user to log in properly at those times.

- **/project** — Although you don't have to use this name, a common practice among users on a project is to share a directory structure containing files that people on the project need to share. This way everyone can work on original files and keep copies of the latest versions in one place. (Of course, a better way to manage a project is with CVS or some other version control-type software, but this is a simple work-around.)



- **/var/log** — An administrator can keep track of log files from several different computers by mounting the `/var/log` file on the administrator's computer. (Each server may need to export the directory to allow `root` to be mapped between the computers for this to work.) If there are problems with a computer, the administrator can then easily view the shared log files live.

If you are working exclusively with CentOS and other Linux and UNIX systems, NFS is probably your best choice for sharing file systems. If your network consists primarily of Microsoft Windows computers or a combination of systems, you may want to look into using Samba for file sharing.

## Setting Up a Samba File Server

---

Samba is a software package that comes with CentOS and most other Linux systems. Samba enables you to share file systems and printers on a network with computers that use the Server Message Block (SMB) or Common Internet File System (CIFS) protocols. SMB is the Microsoft protocol that is delivered with Windows operating systems for sharing files and printers. CIFS is an open, cross-platform protocol that is based on SMB. Samba contains free implementations of SMB and CIFS.

Although you can't always count on NFS being installed on Windows clients (unless you install it yourself), SMB is always available (with a bit of setup). If Samba is not currently installed on Linux, refer to the "Getting and Installing Samba" section later in this chapter.

On CentOS, the Samba software package contains a variety of daemon processes, administrative tools, user tools, and configuration files. To do basic Samba configuration, you can start with the Samba Server Configuration window. This window provides a graphical interface for configuring the server and setting directories to share.

Most of the Samba configuration you do ends up in the `/etc/samba/smb.conf` file. If you need to access features that are not available through the Samba Server Configuration window, you can edit `/etc/samba/smb.conf` by hand or use SWAT (Samba Web Administration Tool), a Web-based interface to configure Samba.

Daemon processes consist of `smbd` (the SMB daemon) and `nmbd` (the NetBIOS name server). The `smbd` daemon makes the file sharing and printing services you add to your Linux system available to Windows client computers. The client computers this package supports include:

- Windows 9x
- Windows 2000
- Windows Server 2003
- Windows NT
- Windows ME

- Windows XP
- Windows Vista
- Windows for Workgroups
- MS Client 3.0 for DOS
- OS/2
- Dave for Macintosh Computers
- Mac OS X
- Samba for Linux

As for administrative tools for Samba, you have several shell commands at your disposal. You can check your configuration file using the `testparm` and `testprns` commands. The `smbstatus` command tells you which computers are currently connected to your shared resources. Using the `nmblookup` command, you can query for NetBIOS names (the names used to identify host computers in Samba).

Because SMB is considered a Windows system technology, some of the terms used to describe Samba sound more Windows than Linux. For example, a shared directory or file system is often referred to as a *share*.

Although Samba uses the NetBIOS service to share resources with SMB clients, the underlying network must be configured for TCP/IP. Although other SMB hosts can use TCP/IP, NetBEUI, and IPX/SPX to transport data, Samba for Linux supports only TCP/IP. Messages are carried between host computers with TCP/IP and are then handled by NetBIOS.

## Getting and Installing Samba

To see if Samba is installed on your CentOS system, type the following:

```
# rpm -qa | grep samba
samba-*
system-config-samba
samba-swat-*
samba-common-*
samba-client-*
```

You should see the name of each of these packages, followed by the version number (I represented version numbers with an asterisk). Although not installed with all installation groups in CentOS, the packages that make up Samba are all included on the DVD that comes with this book.

Before you start trying to configure Samba, read the README file (located in `/usr/share/doc/samba*`). It provides a good overview of the SMB protocol and Samba.

### NOTE

Other useful tools for working with Samba are now available. The `smb4k` package lets you search for available shared SMB/CIFS resources and mount them on

your computer. The `fuse-smb` package lets you find and browse available SMB shares on your network.

## Configuring a Simple Samba Server

The Samba Server Configuration window enables you to do a basic Samba configuration and then identify which directories you want to share. To make this procedure useful, I'm setting up a particular type of shared environment (which you can modify later if you prefer). Here are the characteristics:

- **A Single Local Area Network** — Contains multiple Windows and Linux machines.
- **User-Level Security** — Any user who wants to get to the shared Samba files must have a valid login and password on the Linux Samba server.
- **A Guest User Account** — The guest user account will be useful later, so you can set up Samba to let users without special accounts use the server's printers via Samba.

The following procedure describes how to configure Samba and create a shared directory in Samba:

1. To open the Samba Server Configuration window, click **System** > **Administration** > **Samba**. The Samba Server Configuration window opens. (You will likely need to enter the root password.)
2. Click **Preferences** > **Server Settings**. The Server Settings window appears, as shown in Figure 17-3.

**FIGURE 17-3**

Define the workgroup and description for your Samba server.



3. Type the workgroup name (to match that of other computers with which you want to share files) and a short description.
4. Click on the Security tab. A window appears, like the one shown in Figure 17-4.

**FIGURE 17-4**

Fill in Security information for your Samba server.



5. Provide the following information for the fields on the Security tab and click OK:
  - **Authentication Mode** — Select “User,” “Share,” “Server,” “ADS (Active Directory Server),” or “Domain.” For this example, I selected “User.” (See the “Security Options” section later in this chapter for details on each of the authentication modes.)
  - **Authentication Server** — This field is only valid if your Samba server is configured to use Server or Domain security. It identifies the server (NetBIOS name) that will be used to authenticate the username and password that the Samba client enters to gain access to this Samba server. With user authentication, passwords are checked on the Samba server (in this example, therefore, this field is blank).
  - **Kerberos Realm** — If your network uses Kerberos for user authentication, enter the name of your Kerberos realm here.
  - **Encrypt Passwords** — Select Yes (to expect clients to send encrypted passwords) or No (to expect clear-text password).
  - **Guest Account** — Set this field to a username that you want assigned to requests from anonymous users. Even with User mode security set globally, you can assign guest access to particular Samba shares (such as printers).

With User mode security (which is being used in this example), any user who wants to access a Samba share must have a regular user account on the Linux system. (Refer to Chapter 10 for information on adding user accounts.)

6. To add a user as a Samba user (i.e., one who can access your Samba server), select Preferences ➤ Samba Users. The Samba Users window appears.
7. Click “Add User.” The Create New Samba User window appears.
8. Provide information for the following fields in the Create New Samba User window and click OK:
  - **UNIX Username** — Click on this checkbox, and then select the Linux username to which you want to give access to the Samba server.
  - **Windows Username** — This is the username provided by the user when he or she requests the shared directory. (Often, it is the same as the UNIX Username.)
  - **Samba Password** — Type the Samba password, then retype it in the “Confirm Samba Password” field.

**NOTE**

There is a bug in `system-config-samba` that doesn't show added users in the configuration window. As a result, you can add users but you can't edit or remove them through the `system-config-samba` utility ([https://bugzilla.redhat.com/show\\_bug.cgi?id=467736](https://bugzilla.redhat.com/show_bug.cgi?id=467736)).

9. Repeat the previous step for each user you want to access the Samba shared directory.
10. Now that you have configured the default values for your Samba server, add a directory to share by clicking File ➤ Add Share. The Create Samba Share window appears.
11. Fill in the following fields shown in the Create Samba Share window:
  - **Directory** — Type the name of the directory you want to share. For example, you might want to share a user's home directory, such as `/home/timothy`.
  - **Description** — Type any description you like of the Shared directory.
  - **Basic Permissions** — Select either Read Only or Read/Write. For Read Only, files can be viewed, but not changed, on the shared directory. For Read/Write, the user is free to add, change, or delete files, provided he or she has Linux file access to the particular file.
12. While at this point you should be able to click on the Access tab to allow access to specific users or everyone, there is a bug that prevents you from doing so. For now, you can use the Access tab to make the share accessible to everyone, but you will need to edit the `/etc/samba/smb.conf` file either with a text editor or using SWAT (see the section titled, “Configuring Shared Directories with SWAT”) to restrict access to specific users.
  - **Only Allow Access to Specific Users** — This option should allow you to choose which users will be allowed to access the shared directory. For example, if you are sharing a user's directory (such as `/home/timothy`), you probably want to restrict access to that directory to the directory's owner (e.g., `timothy`). Read and Write access to particular files and directories are determined by the Linux ownership and group

assigned to them. Since this option doesn't work from `system-config-samba`, you'll need to specify the users with the `valid users` option either manually in `/etc/samba/smb.conf` or with SWAT.

- **Allow Access to Everyone** — This option allows you to grant anyone access this directory. (All users will have privileges assigned to the guest user when accessing the directory.)

After you click OK, Samba is started and the new directory is immediately available. You can close the Samba Server Configuration window.

13. Although Samba should be running at this point, you probably need to set Samba to start automatically every time you reboot Linux. To do that, type the following as `root` user in a Terminal window:

```
# chkconfig smb on
```

If Samba isn't running yet, type **service smb start** to start it right now. You can repeat the steps for adding a Samba shared directory for every directory you want to make available on your network. At this point, you can do one of the following:

- Go through your Samba server settings in more detail (as described in the “Configuring Samba with SWAT” section) to understand how you might want to further tune your Samba server.
- Try accessing the shared directories you just created from a client computer on your network. To do that, refer to the “Mounting Samba Directories in Linux” section later in this chapter.

If you cannot open the shared directory you just configured from a Windows computer or other Linux computer on your LAN, you are probably experiencing one of the following problems:

- The client isn't supplying a valid username and password.
- The client isn't supplying an encrypted password.

The quick way around these problems is to use only share-level security (which, of course, throws your security right out the window). The other solution is to get passwords up-to-date and make sure that clients are using encryption.

## Configuring Samba with SWAT

The *Samba Web Administration Tool* (SWAT) is a Web-based interface for configuring Samba. While it's not quite as easy to use as the Samba Server Configuration window, it does offer more options for tuning Samba and Help descriptions for each option. Also, because SWAT is Web-based, you can configure your system remotely from any Web browser.

### CAUTION

Both SWAT and the Samba Server Configuration window configure Samba by modifying the `/etc/samba/smb.conf` file. Different GUI tools can overwrite each other's settings, sometimes in a way that causes the other tool not to work.

In general, it's best to make a backup copy of your files before switching GUI tools. Eventually, you should choose one tool and stick with it.

## Turning on SWAT

Before you can use SWAT, you must have the `samba-swat` package installed (type **yum install samba-swat**) and start the SWAT service. To set up SWAT to run from your browser, follow these steps:

1. To turn on the SWAT service, type the following, as `root` user, from a Terminal window:

```
# chkconfig swat on
```

2. To pick up the change to the SWAT service, reload data for the running `xinetd` start-up script as follows:

```
# service xinetd reload
```

If `xinetd` is not already running, use `start` instead of `reload`. When you have finished this procedure, use the SWAT program, described in the next section, to configure Samba.

## Starting with SWAT

You can run the SWAT program by typing the following URL in your local browser:

```
http://localhost:901/
```

At this point, the browser will prompt you for a username and password. Enter the `root` username and password. The SWAT window should appear, as shown in Figure 17-5.

### TIP

Instead of running SWAT from your local browser, you can run it from another computer on the network by substituting the server computer's name for `localhost`. (To allow computers besides the local computer to access the `swat` service, you must change or remove the `only_from = 127.0.0.1` line from the `/etc/xinetd.d/swat` file and reload the `xinetd` service.) Keep in mind that you are entering clear-text passwords when you connect to the SWAT service, so using this feature outside of the local computer is not particularly secure.

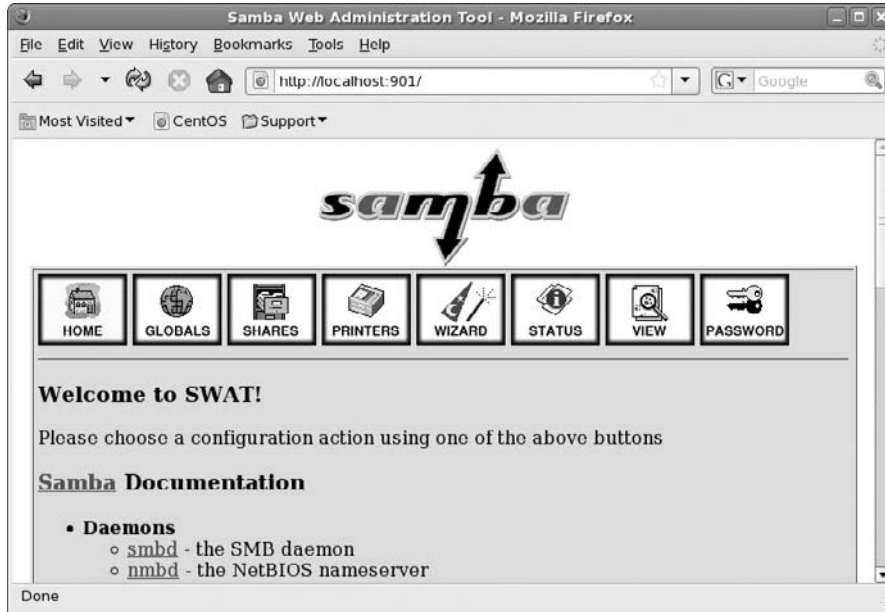
The rest of this section describes how to use SWAT to create your configuration entries (in `/etc/samba/smb.conf`) and to work with that configuration.

### CAUTION

Any time you use a GUI to change a plaintext configuration file (as you do with SWAT), you may lose some of the information that you put in by hand. In this case, SWAT deletes comment lines and rearranges other entries. To protect changes you have made manually, make a backup copy of your `/etc/samba/smb.conf` file before you edit it with SWAT.

**FIGURE 17-5**

Use SWAT from your browser to manage your Samba configuration.



## Creating Global Samba Settings in SWAT

A group of global settings affects how file and print sharing are generally accomplished on a Samba server. They appear under the [global] heading in the `/etc/samba/smb.conf` file. To edit global variables, click on the GLOBALS option on the SWAT window.

Nine option types are available: base options, security options, logging options, protocol, printing options, browse options, WINs, eventlog, and winbind options. To view and modify your global Samba server settings, click on the GLOBALS option. Then add the following options:

### NOTE

Each option shown relates to the exact parameters used in the `/etc/samba/smb.conf` file. You can refer to the `smb.conf` man page (type `man smb.conf`) to get more information on these parameters.

### Base Options

The following options relate to basic information associated with your Samba server:

- `workgroup` — The name of the workgroup associated with the group of SMB hosts. By default in CentOS, the value for this field is MYGROUP.



- `realm` — If you are using kerberos authentication, this value indicates the kerberos realm to use. Typically, that is reflected by the hostname of the server providing the service.
- `netbios name` — The name assigned to this Samba server. You can use the same name as your DNS hostname or leave it blank, in which case the DNS hostname is used automatically.
- `netbios alias` — This enables you to set a way of referring to a host computer (an alias) that is different from the host's TCP/IP DNS name.
- `server string` — A string of text identifying the server. This name appears in places such as the printer comment box. By default, it says Samba and the version number.
- `interfaces` — Lets you set up more than one network interface. This enables Samba to browse several different subnetworks. The form of this field can be *IP Address/Subnetwork Mask*. Or, you could identify a network interface (such as `eth0` for the first Ethernet card on your computer).

### Security Options

Of the security options settings, the first option (`security`) is the most important one to get right. It defines the type of security used to give access to the shared file systems and printers to the client computers. (To see some of the fields described here, you need to click on the Advanced view.)

- `security` — Sets how password and user information is transferred to the Samba server from the client computer. As noted earlier, it's important to get this value right. The default value for `security` (`security=user`) is different from the default value for `security` (`security=share`) in pre-2.0 versions of Samba. If you are coming from an earlier version of Samba and clients are failing to access your server, this setting is a good place to start. Here are your options:
  - `user` — The most common type of security used to share files and printers to Windows 95/98/2000 and Windows NT clients. It is the default set with Samba in the current release. This setting is appropriate if users are doing a lot of file sharing (as opposed to a Samba server used mostly as a print server). It requires that a user provide a username/password before using the server.

The easiest way to get this method working is to give a Linux user account to every client user who will use the CentOS Samba server. This provides basically the same file permissions to a user account through Samba as the same user would get if he or she were logged in directly to Linux.
  - `share` — The `share` value for `security` works best for just print sharing or for providing file access that is more public (guest sharing). A client doesn't need to provide a valid username and password to access the server. However, the user will typically have a "Guest" level of permission to access and change files. See the sidebar describing guest accounts for further information.

- `server` — The security option that, from the client's point of view, is the same as `user` security, in that the client still has to provide a valid username/password combination to use the Samba server at all. The difference is on the server side. With `server` security, the username/password is sent to another SMB server for validation. If this fails, Samba will try to validate the client using `user` security.
- `domain` — This security option also, from the client's point of view, looks the same as `user` security. This setting is used only if the Samba server has been added to a Windows NT domain (using the `net join` command). When a client tries to connect to the Samba server in this mode, its username and password are sent to a Windows NT Primary or Backup Domain controller. This is accomplished the same way that a Windows NT server would perform validation. Valid Linux user accounts must still be set up.
- `ads` — This security option causes Samba to act as a domain member in an ADS realm. Kerberos must be installed on the Samba machine to use this option. Samba must also join the ADS realm (see the `net` utility).
- `auth methods` — Sets the authentication method used by the Samba server (`smbd`). Leave the default in most cases. Authentication methods you can choose include anonymous access (`guest`), relay authentication through winbind (`winbind`), pre-winbind NT authentication (`ntdomain`), local lookups based on netbios or domain name (`sam`), or remote DC authentication of trusted users (`trustdomain`).
- `encrypt passwords` — Controls whether encrypted passwords can be negotiated with the client. This is on (Yes) by default. For `domain` security, this value must be Yes. Later versions of Windows NT (4.0 SP3 or later) and Windows 98 and Windows 2000 expect encrypted passwords to be on.
- `client schannel` — Chooses if the client is to require the use of netlogon schannel (`yes`), offer schannel but not enforce it (`auto`), or not even offer schannel (`no`).
- `server schannel` — Chooses if the server requires clients to use netlogon schannel (`yes`), offer schannel but not enforce it (`auto`), or not even offer schannel (`no`). If you set this to `no`, you must apply the Windows XP WinXP\_SignOrSeal.reg patch available from the Samba project.
- `passwd backend` — Chooses the method of storing the backend database used to store passwords. By default, a TDB-based method is used (`tdbsam`) with a file named `passwd.tdb`. Other options include `smbpasswd` (Samba password storage style) and `ldapsam` (LDAP-based storage style).

**NOTE**

Using `smbpasswd` back-end is deprecated, but it is currently still included for backward compatibility.

- `guest account` — Specifies the username for the guest account. When a service is specified as “Guest OK,” the username entered here will be used to access that service. The account is usually the `nobody` username.

**TIP**

Make sure that the guest account is a valid user. (The default of nobody should already be set up to work.) With an invalid user as the guest account, the IPC\$ connection that lists the shared resources fails.

## Assigning Guest Accounts

**S**amba always assigns the permissions level of a valid user on the Linux system to clients who use the server. In the case of share security, the user is assigned a guest account (the nobody user account by default).

If the guest account value isn't set, Samba goes through a fairly complex set of rules to determine which user account to use. The result is that it can be hard to assure which user permissions will be assigned in each case. This is why it is recommended to use user security if you want to provide more specific user access to your Samba server.

- `invalid users` — Can contain a list of users that should not be allowed to log in for Samba service. Add an at sign (@) before a name to have it interpreted as an NIS or UNIX (Linux) group name.
- `valid users` — Add a list of usernames that should be allowed to log in to the Samba service. If nothing is in this or the invalid users field, any user is allowed to log in.
- `admin users` — Can contain a list of users who have administrative privileges associated with a Samba share.
- `read list` — Can contain a list of users who have only Read Only access to a service.
- `write list` — Can contain a list of users who have Read/Write access to a service.
- `printer admin` — Add users to this list that you want to allow remote administrative privilege to control Samba printers using the MS-RPC service, typically from a NT workstation.
- `hosts allow` — Contains a list of one or more hosts that are allowed to use your computer's Samba services. By default, users from any computer can connect to the Samba server (of course, they still have to provide valid usernames and passwords). Usually, you use this option to allow connections from specific computers (such as 10.0.0.1) or computer networks (such as 10.0.0.) that are excluded by the `hosts deny` option.
- `hosts deny` — Contains a list of one or more hosts from which users are not allowed to use your computer's Samba services. You can make this option fairly restrictive and then add the specific hosts and networks you want to use the Samba server. By default, no hosts are denied.
- `preload modules` — Contains a list of modules you want to be loaded into the `smbd` daemon before any clients can connect to the service.

### Logging Options

The following options help define how logging is done on your Samba server:

- `log file` — Defines the location of the Samba smb log file. By default, Samba log files are contained in `/var/log/samba` (with filenames `nmbd.log`, `smbd.log`, and `smb.log`). In this option, the `%m` is replaced by the name of each host that tries to connect to the local Samba server. So, for example, for a client computer named `flashg`, the smb log file would be `/var/log/samba/flashg.log`.
- `max log size` — Sets the maximum amount of space, in kilobytes, that the log files can consume. By default, the value is set to 0 (no limit).

### Printing Options

The CUPS options field is used to define options that are passed to the CUPS service. By default, only the `raw` option is set, which causes printing data to be passed directly to the Samba printer.

### Browse Options

A *browse list* is a list of computers that are available on the network to SMB services. Clients use this list to find computers that are not only on their own LAN, but also computers in their workgroups that may be on other reachable networks.

In Samba, browsing is configured by options described below and implemented by the `nmbd` daemon. If you are using Samba for a workgroup within a single LAN, you probably don't need to concern yourself with the browsing options. If, however, you are using Samba to provide services across several physical subnetworks, you might want to consider configuring Samba as a domain master browser. Here are some points to think about:

- Samba can be configured as a master browser. This allows it to gather lists of computers from local browse masters to form a wide-area server list.
- If Samba is acting as a domain master browser, Samba should use a WINS server to help browse clients resolve the names from this list.
- Samba can be used as a WINS server, although it can also rely on other types of operating systems to provide that service.
- There should be only one domain master browser for each workgroup. Don't use Samba as a domain master for a workgroup with the same name as an NT domain.

If you are working in an environment that has a mix of Samba and Windows NT servers, you should use an NT server as your WINS server. If Samba is your only file server, you should choose a single Samba server (`nmbd` daemon) to supply the WINS services.

#### NOTE

A WINS server is basically a name server for NetBIOS names. It provides the same service that a DNS server does with TCP/IP domain names: It can translate names into addresses. A WINS server is particularly useful for allowing computers to communicate with SMB across multiple subnetworks where information is not being broadcast across the subnetworks' boundaries.

To configure the browsing feature in Samba, you must have the workgroup named properly (described earlier in this section). Here are the global options related to SMB browsing:

**NOTE**

If browsing isn't working, check the `nmbd` log file (`/var/log/samba/log.nmbd`). To get more detail, increase the debug information level to 2 or 3 (described earlier in the "Logging Options" section) and restart Samba. The log can tell you if your Samba server is the master browser and, if so, which computers are on its list.

- `os level` — Set a value to control whether your Samba server (`nmbd` daemon) may become the local master browser for your workgroup. Raising this setting increases the Samba server's chance to control the browser list for the workgroup in the local broadcast area.  
If the value is 0, a Windows machine will probably be selected. A value of 65 will probably ensure that the Samba server is chosen over an NT server. The default is 20.
- `preferred master` — Set this to Yes if you want to force selection of a master browser. By setting this to Yes, the Samba server also has a better chance of being selected. (Setting Domain Master to Yes along with this option should ensure that the Samba server will be selected.) This is set to Auto by default, which causes Samba to try to detect the current master browser before taking that responsibility.
- `local master` — Set this to Yes if you want the Samba server to become the local browser master. (This is not a guarantee but gives it a chance.) Set the value to No if you do not want your Samba server selected as the local master. Local Master is Auto by default.
- `domain master` — Set this to Yes if you want the Samba server (`nmbd` daemon) to identify itself as the domain master browser for its workgroup. This list will then allow client computers assigned to the workgroup to use SMB-shared files and printers from subnetworks that are outside their own subnetwork. This is set to No by default.

### **WINS Options**

Use the WINS options if you want to have a particular WINS server provide the name-to-address translation of NetBIOS names used by SMB clients. As noted earlier, you probably don't need to use a WINS server if all of the clients and servers in your SMB workgroup are on the same subnetwork. That's because NetBIOS names can be obtained through addresses that are broadcast. It is possible to have your Samba server provide WINS services.

- `wins server` — If there is a WINS server on your network that you want to use to resolve the NetBIOS names for your workgroup, you can enter the IP address of that server here. Again, you will probably want to use a WINS server if your workgroup extends outside the local subnetwork.
- `wins support` — Set this value to Yes if you want your Samba server to act as a WINS server. (It's No by default.) Again, this is not needed if all the computers in your workgroup are on the same subnetwork. Only one computer on your network should be assigned as the WINS server.

Besides the values described here, you can access dozens more options by clicking on the “Advanced View” button. When you have filled in all the fields you need, click “Commit Changes” on the screen to have the changes written to the `/etc/samba/smb.conf` file.

## Configuring Shared Directories with SWAT

To make your Samba share (shared directory) available to others, you can add an entry to the SWAT window. To use SWAT to set up Samba to share directories, do the following:

### NOTE

You may see one or more security warnings during the course of this procedure. These messages warn you that someone potentially can view the data you are sending to SWAT. If you are working on your local host or on a private LAN, the risk is minimal.

1. From the main SWAT window, click on the SHARES button.
2. Type the name of the directory that you want to share in the “Create Share” box, and then click “Create Share.”
3. Click Advanced if you would like to change to the Advanced view.
4. There are a few dozen options to choose from. Here are a few that might particularly interest you:
  - **Comment** — A few words to describe the shared directory (optional).
  - **Path** — The pathname of the directory you are sharing.
  - **Invalid Users** — Enables you to add a list of users who are not allowed to log in to the Samba service. Besides identifying usernames directly (from your `/etc/passwd` file), invalid users can be identified by Linux group or NIS netgroup, by adding a `+` or `&` in front of the name, respectively. Precede the name with `@` to have Samba first check your NIS netgroup, and then the Linux group for the name.
  - **Valid Users** — Add names here to identify which Linux user accounts can access the Samba service. As with invalid users, names can be preceded with `+`, `&`, or `@` characters.
  - **Admin Users** — Lets you identify users who have administrative privilege on a particular share. This is available with the `security = share` type of security only.
  - **Read List** — Add users to this list if you want to only grant Read access to shares (even if a share is available with Read/Write access). This is available with the `security = share` type of security only.
  - **Write List** — Add users to this list to grant Write access by those users to shares, even if the share is available with Read Only access to all others. This is available with the `security = share` type of security only.
  - **Read Only** — If Yes, then files can only be read from this file system, but no remote user can save or modify files on the file system. Select No if you want users to be allowed to save files to this directory over the network.

- **Guest OK** — Select Yes to enable anyone access to this directory without requiring a password.
  - **Hosts Allow** — Add the names of the computers that will be allowed to access this file system. You can separate hostnames by commas, spaces, or tabs. Here are some valid ways of entering hostnames:
    - `localhost` — Allows access to the local host.
    - `192.168.74.18` — IP address. Enter an individual IP address.
    - `192.168.74.` — Enter a network address to include all hosts on a network. (Be sure to put a dot at the end of the network number or it won't work!)
    - `flash, dale` — Enable access to individual hosts by name.
  - **EXCEPT host** — If you are allowing access to a group of hosts (such as by entering a network address), use EXCEPT to specifically deny access from one host from that group.
  - **Hosts Deny** — Deny access to specific computers by placing their names here. By default, no particular computers are excluded. Enter hostnames in the same forms you used for hosts allow.
  - **Browseable** — Indicates whether you can view this directory on the list of shared directories. This is on (Yes) by default.
  - **Available** — Enables you to leave this entry intact, but turns off the service. This is useful if you want to close access to a directory temporarily. This is on (Yes) by default. Select No to turn it off.
5. Select Commit Changes.

At this point, the shared file systems should be available to the Samba client computers (Windows 9x, Windows NT, Windows 2000, Windows Vista, Mac OS X, OS/2, Linux, etc.) that have access to your Linux Samba server. Before you try that, however, you can check a few things about your Samba configuration.

### Checking Your Samba Setup with SWAT

From the SWAT window, select the STATUS button.

From this window, you can restart your `smbd` and `nmbd` processes. Likewise, you can see lists of active connections, active shares, and open files.

#### NOTE

The preferred way to start the `smbd` and `nmbd` daemons is to set up the SMB service to start automatically. Type `chkconfig smb on` in a Terminal window to set the service to start at boot time.

## Working with Samba Files and Commands

Although you can set up Samba through the Samba Server Configuration window or SWAT, many administrators prefer to edit the `/etc/samba/smb.conf` directly. As `root` user, you can

view the contents of this file and make needed changes. If you selected user security (as recommended), you will also be interested in the `smbusers` and `smbpasswd` files (also in the `/etc/samba` directory). These files, as well as commands such as `testparm` and `smbstatus`, are described in the following sections.

## Editing the `smb.conf` File

Changes you make using the Samba Server Configuration window or SWAT web interface are reflected in your `/etc/samba/smb.conf` file. Here's an example of an `smb.conf` file (with comments removed):

```
[global]
workgroup = MONGO
server string = Samba Server on FlashG
hosts allow = 192.168.0.
printcap name = /etc/printcap
load printers = yes
printing = cups
log file = /var/log/samba/%m.log
max log size = 0
smb passwd file = /etc/samba/smbpasswd
security = user
encrypt passwords = Yes
unix password sync = Yes
passwd program = /usr/bin/passwd %u
passwd chat = *New*password* %n\n *Retype*new*password* %n\n *passwd:
             *all*authentication*tokens*updated*successfully*
pam password change = yes
obey pam restrictions = yes
socket options = TCP_NODELAY SO_RCVBUF=8192 SO_SNDBUF=8192
username map = /etc/samba/smbusers
dns proxy = no

[homes]
comment = Home Directories
browseable = no
writable = yes
valid users = %S
create mode = 0664
directory mode = 0775

[printers]
comment = All Printers
path = /var/spool/samba
browseable = no
guest ok = no
writable = no
printable = yes
```



In the `[global]` section, the workgroup is set to `MONGO`, the server is identified as the Samba Server on FlashG, and only computers that are on the local network (192.168.0.) are allowed access to the Samba service. You must change the `'hosts allow ='` parameter to match your network.

Definitions for the local printers that will be shared are taken from the `/etc/printcap` file, the printers are loaded (`yes`), and the CUPS printing service (which is the default print service used by CentOS) is used.

Separate log files for each host trying to use the service are created in `/var/log/samba/%m.log` (with `%m` automatically replaced with each hostname). There is no limit to log file size (`0`).

In this case, we are using user-level security (`security = user`). This allows a user to log in once and then easily access the printers and the user's home directory on the Linux system. Password encryption is on (`encrypt passwords = yes`) because most Windows systems have password encryption on by default. Passwords are stored in the `/etc/samba/smbpasswd` file on your Linux system.

The `dns proxy = no` option prevents Linux from looking up system names on the DNS server (used for TCP/IP lookups) when they can't be found among registered NetBIOS names.

The `[homes]` section allows each user to be able to access his or her Linux home directory from a Windows system on the LAN. The user will be able to write to the home directory. However, other users will not be able see or share this directory. The `[printers]` section allows all users to print to any printer that is configured on the local Linux system.

## Adding Samba Users

Doing user-style Samba security means assigning a Linux user account to each person using the Linux file systems and printers from his or her Windows workstation. You could assign users to a guest account instead, but in this example, all users will have their own accounts. Then you need to add SMB passwords for each user.

1. Type the following as `root` user from a Terminal window to add a Linux user account:

```
# useradd -m alexr
```

2. Add a Linux password for the new user as follows:

```
# passwd alexr
Changing password for user alexr
New UNIX password: *****
Retype new UNIX password: *****
```

3. Repeat the previous steps to add user accounts for all users from Windows workstations on your LAN that you want to give access to your Linux system to.
4. Type the following command to create the Samba password file (`smbpasswd`):

```
# cat /etc/passwd | /usr/bin/mksmbpasswd.sh > /etc/samba/smbpasswd
```

5. Add an SMB password for the user as follows:

```
# smbpasswd alexr
New SMB password: ****
Retype new SMB password: ****
```

(The `smbpasswd -a user` command can be used to create the `smbpasswd` file at the same time you set a user password.) Repeat this step for each user. Later, each user can log in to Linux and rerun the `passwd` and `smbpasswd` commands to set private passwords.

## NOTE

In the most recent version of Samba, options are available in the `smb.conf` file that cause SMB and Linux passwords to be synchronized automatically. See descriptions of the `passwd` program, `passwd chat`, and UNIX password sync options in the SWAT section of this chapter.

## Starting the Samba Service

To start the Samba SMB and NMB daemons, you can run the `/etc/init.d/smb` start-up script by typing the following as the `root` user:

```
# service smb start
```

This runs the Samba service during the current session. To set up Samba to start automatically when your Linux system starts, type the following:

```
# chkconfig smb on
```

This turns on the Samba service to start automatically in run levels 3, 4, or 5. You can now check SMB clients on the network to see if they can access your Samba server.

## Testing Your Samba Permissions

You can run several commands from a shell to work with Samba. One is the `testparm` command, which you can use to check the access permissions you have set up. It lists global parameters that are set, along with any shared directories or printers.

## Checking the Status of Shared Directories

The `smbstatus` command can view who is currently using Samba shared resources offered from your Linux system. The following is an example of the output from `smbstatus`:

```
# smbstatus

Samba version 3.0.28-1.el5_2.1
PID      Username      Group          Machine
-----
25770    timothy       timothy       tarnak        (10.0.0.50)
25833    timothy       timothy       10.0.0.50    (10.0.0.50)
```

```

Service      pid      machine      Connected at
-----
IPC$         25729    tarnak       Tue Jan 20 12:06:29 2009
mytmp       25770    tarnak       Tue Jan 20 12:16:03 2009
mytmp       25833    10.0.0.50    Tue Jan 20 12:25:52 2009
IPC$         25730    tarnak       Tue Jan 20 12:06:29 2009

```

Locked files:

```

Pid  Uid  DenyMode  Access  R/W  Oplock  SharePath  Name  Time
-----
25833 501  DENY_NONE 0x12019f RDWR NONE /home/timothy/files/
      .b.txt.swp Tue Jan 20 12:26:18 2009

```

This output shows that, from your Linux Samba server, the myhome service (which is a share of the /home/timothy/files directory) is currently open by the computer named `tarnak`. PID 25833 is the process number of the `smbd` daemon on the Linux server that is handling the service. The file that is open is the /home/timothy/files/.b.swap file, which happens to be opened by a `vi` command. It has Read/Write access.

## Setting Up Samba Clients

Once you have configured your Samba server, you can try using the shared directories from a client computer on your network. The following sections describe how to use your Samba server from another Linux system or from various Windows systems.

### Using Samba Shared Directories from Linux

There are several methods of connecting to shared directories from your Samba client. The following sections address these methods.

#### Using Samba from Nautilus

To connect to a Samba share from Nautilus, use the “Open Location” box by clicking File ➤ Open Location. Then type **smb:** in your Nautilus File Manager “Open Location” box.

A list of SMB workgroups on your network appears in the window. You can select a workgroup, choose a server, and then select a resource to use. This should work for shares requiring no password.

The Nautilus interface requires you to either send clear-text passwords or type the user and password into your location box. For example, to get to my home directory (/home/timothy) through Nautilus, I can type my username, password, server name, and share name as follows:

```
smb://timothy:my72mgb@roka/timothy
```

Instead of just typing this information into the Location box, you can use the “Connect to Server” feature of Nautilus. Select File ➤ Connect to Server. From the Connect to Server window

that appears, select the Service Type as Windows Share and type the server name to see all available shares from that window. Optionally, you can request a specific share, folder, or username. Then you can also choose a particular name to use for the connection. You can also drop the password portion (such as `smb://timothy@roka/timothy`) and be prompted for the password.

### **Mounting Samba Directories in Linux**

Linux can view your Samba shared directories as it does any other medium (hard disk, NFS shares, CD-ROM, etc.). Using the `mount` command, you can mount a Samba shared file system so that it is permanently connected to your Linux file system.

The following example of the `mount` command shows how I would mount my home directory (`/home/timothy`) from a computer named `roka` on a local directory (`/mnt/roka`). As `root` user, from a Terminal window, type:

```
# mkdir /mnt/roka
# mount -t cifs -o username=timothy,password=a72mg //roka/timothy
/mnt/roka
```

The file system type for a Samba share is `cifs` (`-t cifs`). I pass the username (`timothy`) and password (`a72mg`) as options (`-o`). The remote share of my home directory on `roka` is `//roka/timothy`. The local mount point is `/mnt/roka`. At this point, you can access the contents of `/home/timothy` on `roka` as you would any file or directory locally. You will have the same permission to access and change the contents of that directory (and its subdirectories) as you would if you were the user `timothy` using those contents directly from `roka`.

To mount the Samba shared directory permanently, you can add an entry to your `/etc/fstab` file. For the example just described, you could add the following line (as `root` user):

```
//roka/timothy /mnt/roka cifs username=timothy,password=a72mg
```

You can add a credentials file and use that to contain your username and password, instead of exposing that information to the command line. That way, someone running the `ps` command on your system won't be able to see that information. For example, you could create a file named `/etc/samba/creds.smbpub` containing the following two lines:

```
username=timothy
password=a72mg
```

You could then change the `mount` command shown earlier to appear as follows:

```
# mount -t cifs -o credentials=/etc/samba/creds.smbpub //roka/timothy
```

## **Troubleshooting Your Samba Server**

A lot can go wrong with a Samba server. If your Samba server isn't working properly, the descriptions in this section should help you pinpoint the problem.

## Basic Networking in Place?

Before computers can share directories and printers from Samba, they must be able to communicate on your LAN. Refer to Chapter 14 for information on setting up a LAN.

In Samba, your Samba server can use the TCP/IP name as the NetBIOS name (used by Window networks for file and printer sharing), or a separate NetBIOS name can be set in the `smb.conf` file. It is critical, however, that the broadcast address be the same as those for all clients communicating with your Samba server. To see your broadcast address, type the following:

```
$ ifconfig -a
eth0      Link encap:Ethernet  HWadd 00:D1:B3:75:A5:1B
          inet addr:10.0.0.1  Bcast:10.0.0.255  Mask:255.255.255.0
```

The important information is the broadcast address (Bcast: 10.0.0.255). This is determined by the netmask (Mask: 255.255.255.0). If the broadcast address isn't the same for the Samba server and the clients on the LAN, the clients cannot see that the Samba server has directories or printers to share.

## Samba Service Running?

First, try the `smbclient` command from your Linux system to check that everything is running and being shared as you expect it to be. The `smbclient` command is a great tool for getting information about a Samba server and even accessing shared directories from both Linux and Windows computers. While logged in as `root` or any user who has access to your Samba server, type the following:

```
$ smbclient -L localhost
Password: *****
Domain=[MONGO] OS=[Unix] Server=[Samba 3.2.4-0]

  Sharename      Type      Comment
  -----
  homes          Disk     Home Directories
  IPC$           IPC      IPC Service (Samba Server)
  ADMIN$        Disk     IPC Service (Samba Server)
  hp-ns1        Printer
Domain=[MONGO] OS=[Unix] Server=[Samba 3.2.4-0]

  Server          Comment
  -----
  DALE            Samba Server
  FLASHG         Windows XP
  NS1            Samba Server

  Workgroup       Master
  -----
  MONGO          DALE
```

This shows that the Samba server is running on the local computer. Shared directories and printers, as well as servers in the workgroup, appear here. If the Samba server is not running, you will see “Connection refused” messages. You need to start the Samba service as described in the “Starting the Samba Service” section earlier in this chapter.

## Firewall Open?

If the Samba server is running, it should begin broadcasting its availability on your LAN. If you try to access the server from a Windows or Linux client on your LAN but get a “Connection refused” error, the problem may be that the firewall on your Linux Samba server is denying access to the NetBIOS service. If you have a secure LAN, you can type the following (as `root` user) to flush your firewall rules temporarily:

```
# iptables -F
```

Then, try to connect to the Samba Server from a Windows or Linux client. If you find that you can connect to the server, turn the firewall back on:

```
# service iptables restart
```

You then need to open access to ports 137, 138, 139, and 445 in your firewall so that the Samba server will be able to accept connections for services. (See Chapter 13 for information on modifying your firewalls.)

## User Passwords Working?

Try accessing a shared Samba directory as a particular user (from the local host or other Linux system on your LAN). You can use the `smbclient` command to do this. Here’s an example:

```
# smbclient //localhost/home/timothy/files -U timothy
added interface ip=10.0.0.1 bcast=10.0.0.255 nmask=255.255.255.0
Password: *****
Domain=[MONGO] OS=[Unix] Server=[Samba 3.2.4]
smb: \>
```

In this example, `smbclient` connects to the directory share named `tmp` as the Samba user named `timothy`. If the password is accepted, you should see information about the server and a `smb:\>` prompt. If you cannot access the same shared directory from a Windows client, it’s quite possible that the client is passing an improper username and password.

### TIP

The `smbclient` command, used here to list server information and test passwords, can also be used to browse the shared directory and copy files after you are connected. After you see the `smb:\>` prompt, type **help** to see the available commands. The interface is similar to any FTP client, such as `SFTP`.

## Summary

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By providing centralized file servers, an organization can efficiently share information and applications with people within the organization, with customers, or with anyone around the world. Several different technologies are available in CentOS to enable you to make your Linux computer a file server.

The Network File System (NFS) protocol was one of the first file server technologies available. It is particularly well suited for sharing file systems among CentOS and other UNIX systems. NFS uses standard `mount` and `umount` commands to connect file systems to the directory structures of client computers.

The Samba software package that comes with CentOS contains protocols and utilities for sharing files and printers among Windows and OS/2 operating systems. It uses SMB protocols that are included with all Microsoft Windows systems and therefore provides a convenient method of sharing resources on LANs containing many Windows systems.

# Chapter 18

## Setting Up a Mail Server

**T**oday, electronic messaging is part of the communication backbone, the core of information dissemination within companies of all sizes. Everyone uses e-mail, from the mailroom to the laboratories to the CEO's office. And if you're in charge of an organization's mail server, you'll be notified (incessantly) when it stops working.

This chapter explains how to set up a mail server in CentOS to send and receive messages. In particular, it focuses on configuring a Sendmail mail server, but also tells how to configure a Postfix mail server (which is also in the CentOS distribution). Once the mail server is configured, CentOS provides your mail server's users with different ways of getting their e-mail from your server, such as downloading it to their mail clients (with IMAPv4 or POP3) or reading it from a Web browser (using SquirrelMail).

Mailing list configuration and administration (using the `mailman` software package) are also discussed in this chapter, detailing how mailing list management software integrates and interfaces with the mail server.

### NOTE

Although the primary aspects of mail server configuration are discussed in this chapter, many configuration aspects are beyond its scope and thus are not addressed. Because security is an important concern when you're connected to the Internet, it is given considerable focus here.

### IN THIS CHAPTER

**Introducing SMTP and Sendmail**

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**Installing and running Sendmail**

---

**Configuring Sendmail**

---

**Introducing Postfix**

---

**Stopping spam with SpamAssassin**

---

**Getting mail from the server (IMAPv4 and POP3)**

---

**Configuring SquirrelMail**

---

**Administering a Mailman mailing list**

---

## Introducing SMTP and Sendmail

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Even with the multimedia attachments and HTML encoding prevalent in e-mail messages today, the technology behind message transfer hasn't changed significantly since the early 1980s. The framework for the Simple



Mail Transfer Protocol (SMTP) was initially described in RFC 821 in 1982. The protocol itself was extended in 1993 (RFC 1425), yielding the Extended Simple Mail Transfer Protocol (ESMTP), which provides more commands and new delivery modes.

The three parts to message transfer are the Mail Transfer Agent (MTA), the Mail Delivery Agent (MDA), and the Mail User Agent (MUA). The MTA, commonly referred to as the *mail server* (of which Sendmail and Postfix are examples), actually handles distributing outgoing mail and listening for incoming mail from the Internet. The MDA accepts messages from the MTA and copies the message into a user's mailbox. CentOS uses `procmail` as the default MDA, as specified in the Sendmail configuration file (`sendmail.cf`). Other MDAs (also referred to as *Local Delivery Agents*, or LDAs) include `maildrop` and `postdrop`.

End-users, for whom the mail is ultimately intended, use MUAs to get mail from the server and read it from their desktops. Most MUAs support Post Office Protocol (POP3) and Internet Message Access Protocol (IMAPv4) features for getting mail from the server so it can be read and managed from the user's desktop computer. When possible, you should use the more secure Secure POP and IMAP protocols (POPS and IMAPS, respectively).

**CROSS-REF** See Chapter 8 for details on Mail User Agents available with CentOS.

This chapter focuses on the Sendmail MTA, the most common mail server on the Internet. Nearly 70 percent of all e-mail messages on the Internet are delivered by Sendmail. With the growing Internet population, billions of e-mail messages are sent and received each day. As an alternative to Sendmail, this chapter also includes a short description of Postfix.

For getting mail from the server, this chapter describes the `dovecot` software package, which includes POP3 and IMAPv4 server software. As an alternative, for allowing users to read and manage e-mail from a Web browser, this chapter describes how to configure SquirrelMail.

There have been three major releases of Sendmail. The original Sendmail (Sendmail version 5) was written in 1983 by Eric Allman, a student at the University of California at Berkeley. He maintained the code until 1987, when Lennart Lövstrand enhanced the program and developed IDA Sendmail. Eric Allman returned to Berkeley in 1991 and embarked on a major code revision, releasing Sendmail V8 in 1993, which incorporated the extensions from IDA Sendmail. The current version is based on this “version 8” code.

## Installing and Running Sendmail

---

In CentOS, the Sendmail distribution consists of three RPM packages: `sendmail`, `sendmail-cf`, and `sendmail-doc`. Only the first package is truly necessary to send and receive mail on your machine. The second package includes configuration macros and other files that can help you reconfigure your site's Sendmail installation if the defaults are insufficient. The third package contains documentation files that help to explain some of the details of the current version.

The Sendmail binary packages are included in the CentOS distribution. The `sendmail`, `sendmail-cf`, and `sendmail-doc` packages are on the CentOS distribution that comes with this book. From the CentOS RPMS directory on the DVD, the following command installs the packages:

```
# rpm -Uhv sendmail*
```

Because Sendmail is a common target of intruders, it's a good idea to immediately apply any updates that are available for Sendmail before proceeding. You can do that using the `yum` command or the `rpm` utility. To update Sendmail using `yum`, type:

```
# yum update sendmail*
```

## Other Mail Servers for CentOS

The Open Source version of Sendmail is not the only mail server available for CentOS, but it is definitely the most common. The following list describes other servers and provides URLs for further information:

- **Postfix** — As with Sendmail, the Postfix MTA is also included with CentOS. Written by Wietse Venema (of `tcp_wrappers` fame), this free mail server was designed with security in mind and executes most functions as an unprivileged user in a restricted chroot environment. The server encompasses more than a dozen small programs (each performing a simple, distinct task) and several single-purpose queues. You can find more information and source code at [www.postfix.org](http://www.postfix.org).
- **Exim** — The Exim MTA is a free mail server (under GPL) that runs on Linux and other UNIX systems. Exim is included in the CentOS distribution. This MTA includes flexible features for checking and routing mail. Find out more about Exim from the Exim home page ([www.exim.org](http://www.exim.org)).
- **Qmail** — Also conceived with security as a high priority, this mail server (written by Daniel J. Bernstein) offers secure and reliable message transfer, mailbox quotas, virtual domains, and antispam features. More information is available from [www.qmail.org/top.html](http://www.qmail.org/top.html).

## Starting Sendmail

Once installed, the Sendmail service is turned on by default. To start Sendmail immediately, you can either reboot the machine or just type **service sendmail start** to start the server. The procedure for starting and stopping Sendmail is similar to that of any other server process.

The default configuration for Sendmail only allows outgoing mail. (Sendmail initially only listens on `localhost`.) In order to receive any mail, the following line in `sendmail.mc` has to be commented out:

```
DAEMON_OPTIONS(`Port=smtp,Addr=127.0.0.1, Name=MTA')dn1
```

`sendmail.cf` has to be regenerated afterward. Then, incoming messages received by Sendmail are processed and stored in the `/var/spool/mail` directory.

Each file in this directory represents a valid username on the local machine. The file is created automatically the first time e-mail is sent to the user (or if it's otherwise missing). People with login accounts use this directory and their user account name as their incoming mailboxes (e.g., `/var/spool/mail/johnq`).

Outgoing messages go in the `/var/spool/mqueue` directory while waiting to be sent. Filenames in this directory follow a consistent naming scheme. The first two characters indicate what type of data is stored in the file (see Table 18-1). Subsequent characters form a unique random identifier based on the PID of the Sendmail process that is handling that message.

**TABLE 18-1**

### File Prefixes in `/var/spool/mqueue`

Filename Prefix	Type of Data Stored
df	The data that constitutes the body of an e-mail message
qf	The queue control file that contains the message headers and other administrative details
tf	A temporary copy of the qf file, created if delivery errors occur
xf	Any error messages generated while trying to send the message

## Other Programs

Several other executable programs are included in the distribution. These are described in Table 18-2.

## Logging Performed by Sendmail

The amount of logging performed by Sendmail is configurable in the `sendmail.mc` file, but the default level provides good coverage of informational notices and error messages. By default, the syslog facility configuration file (`/etc/syslog.conf`) tells syslog to store logging information from Sendmail in the `/var/log/maillog` file. A few examples from this file are shown in this section.

An informational message similar to the following is written in the `/var/log/maillog` file each time the daemon starts (which also causes the hashed alias database to be regenerated):

```
May 16 12:52:40 dale sendmail[1758]: alias database /etc/aliases
    rebuilt by root
May 16 12:52:40 dale sendmail[1758]: /etc/aliases: 63 aliases,
    longest
```

```

10 bytes, 625 bytes total
May 16 12:52:40 dale sendmail[1787]: starting daemon (8.12.8):
SMTP+queueing@01:00:00

```

TABLE 18-2

### Other Related Sendmail Programs

Program	Description
mailq	Displays a summary of the messages awaiting processing in the mail queue (the command is equivalent to <code>sendmail -bp</code> ).
mailstats	Displays message quantity and byte count statistics.
makemap	Translates text files ( <code>/etc/mail/virtusertable</code> ) to hashed Berkeley databases ( <code>/etc/mail/virtusertable.db</code> ). This command runs each time the <code>sendmail</code> script starts.
newaliases	Translates the plaintext <code>/etc/aliases</code> file into the hashed Berkeley database file <code>/etc/aliases.db</code> (the command is equivalent to <code>sendmail -bi</code> ).
praliases	Prints out all aliases defined in <code>/etc/aliases</code> .
procmail	Not included with the <code>sendmail</code> package, but is used as an MDA for Sendmail. (It is included in CentOS in the <code>procmail</code> package.)
purgestat	Clears the directory where host status information is stored. The command is equal to <code>sendmail -bH</code> , which is disabled by default.
rmail	Handles incoming mail via UUCP (UNIX to UNIX Copy).
smrsh	Implements a restricted shell for running programs from Sendmail.

Each time a message is sent or received, a log file entry is created:

```

May 16 12:54:34 dale sendmail[1120]: 0AA01120: from=root, size=161,
class=0, pri=3 0161, nrcpts=1,
msgid=<199907191254.0AA01120@dale.example.com>, relay=root
@localhost
May 16 12:54:35 dale sendmail[1127]: 0AA01120: to=jkpat,
ctladdr=root
(0/0), delay=00:00:01, xdelay=00:00:00, mailer=local, stat=Sent

```

Besides showing normal mail server activities, the logs also show when people attempt to break into your mail server. The `wiz` and `debug` commands were implemented in earlier versions of Sendmail and were found to be a huge security problem. You may see log file entries, such as those shown in the following code examples, as people with malicious intent check to make sure

that you're not running a vulnerable `sendmail` daemon. Also, the `expn` and `vrify` commands (which can be disabled via a configuration option) could give out more information than you'd care to distribute.

```
May 16 13:03:27 dale sendmail[699]: NOQUEUE: "wiz" command from
localhost [127.0.0.1] (127.0.0.1)
May 16 13:03:29 dale sendmail[699]: NOQUEUE: "debug" command from
localhost [127.0.0.1] (127.0.0.1)
May 16 13:03:37 dale sendmail[701]: NOQUEUE: localhost [127.0.0.1]:
expn oracle
May 16 13:03:43 dale sendmail[702]: NOQUEUE: localhost [127.0.0.1]:
vrify oracle
```

## Configuring Sendmail

---

To configure the Sendmail facility, you edit configuration files in `/etc/mail` and `/etc` that are then used to by the Sendmail startup script to generate database files. Those database files are, in turn, used by the `sendmail` daemon to control the behavior of your Sendmail server. Once Sendmail is configured, you can begin adding user accounts to have mailboxes on your server. The general steps I describe in this section for configuring Sendmail are:

1. **Getting a Domain Name** — You need a unique Internet domain name to assign to your mail server. You can purchase an Internet domain name from one of many different places, and then have DNS Mail eXchange (MX) records for your domain point to the mail server you are creating.
2. **Configuring Basic Sendmail Settings** — In this step, you edit the `/etc/mail/sendmail.mc` file. That file defines such things as the locations of other configuration and log files, as well as lets you configure some behavior of the `sendmail` daemon.
3. **Defining Outgoing Mail Access** — The most critical security issue associated with your mail server is which mail messages it will accept to relay to other mail servers. By editing the `/etc/mail/access` file, you can indicate the hosts and users from which your server will accept mail for local delivery or relay.
4. **Configuring Virtual Servers** — By default, Sendmail assumes that you are setting up the mail server for the domain of which the server is a member. To have Sendmail on a single computer be the mail server for multiple domains (referred to as *virtual servers*), you need to define each domain name in the `/etc/mail/local-host-names` file. (You must create `local-host-names` manually, since it is not in the `sendmail` package.)
5. **Configuring Virtual Users** — Using the `/etc/mail/virtusertable` configuration file, you can instruct the `sendmail` daemon what to do with the mail it receives for the users and domains that it's configured to handle. This file gives you a lot of flexibility to take mail addressed to a particular user and direct it to a particular mailbox, forward it to a different mail address, or reject that mail in various ways. To use `virtusertable`, you must create the file manually, since it is not in the `sendmail` package.

6. **Adding User Accounts** — You need to add a user account for every user that has a mailbox on your mail server.
7. **Starting Sendmail and Generating Database Files** — Starting the Sendmail service causes two major actions to happen: It runs the `sendmail` server daemon, and it compiles your configuration files into database files that can be used by Sendmail. If the server is already running, you can simply compile the configuration files and have any new settings take effect without restarting the server.

The following subsections provide details on each of these steps.

## Getting a Domain Name

For people to be able to send mail to the users on your mail server, you must have your own domain name. Chapter 24 describes how to get your own domain names and set up a DNS server. The critical issue for your mail server is to make sure that the MX record for your domain on the DNS server points to the address of your mail server.

### NOTE

It is possible that your ISP will not allow you to have a private mail server on your residential Internet account. To enforce this, the ISP may block packets from being addressed to port 25. You may need to contact them to open that port before you can set up a mail server on that connection. Because many spamming and otherwise evil (or at least poorly controlled) e-mail servers try to hide behind dynamic IP addresses, many ISPs will neither allow e-mail addresses from dynamic IP addresses nor accept e-mail sent from those servers.

## Configuring Basic Sendmail Settings (`sendmail.mc`)

Much of the configuration of your Sendmail server comes from information in your `/etc/mail/sendmail.mc` file. Because this file sets Sendmail default values that can be used in most cases, you may not have to do much with `sendmail.mc`. However, I recommend that you step through this section so you understand how your mail server is configured.

Changes you make to the `sendmail.mc` file do not immediately take effect. First, you must compile the `sendmail.mc` settings to generate the `/etc/mail/sendmail.cf` file. I describe how to do that in the “Starting Sendmail and Generating Database Files” section.

The resulting `/etc/mail/sendmail.cf` file contains more than 1,800 lines of settings and comments that are used to direct the behavior of your `sendmail` daemon. The m4 macros you use in the `sendmail.mc` file are different from the resulting settings in the `sendmail.cf` file.

### NOTE

The m4 utility can be used to process text files containing macros in IEEE Standard 1003.1-2001 format (Section 12-2, “Utility Syntax Guidelines”). This compiler is particular about how you use single quotes versus backticks, so be careful editing `sendmail.mc`. For details on the m4 utility, type **info m4**.

To find out which macros to use for a setting you find in the `sendmail.cf` file, refer to the `/usr/share/doc/sendmail*/README.cf` file.

**CAUTION**

Because of the way Sendmail is configured in CentOS, you should not directly modify the `sendmail.cf` file. The `sendmail.cf` file is regenerated automatically when Sendmail restarts if `sendmail.mc` changes. As a result, any modifications made directly to `sendmail.cf` will be lost.

The following code samples are from the `/etc/mail/sendmail.mc` file that accompanies the CentOS version of Sendmail.

**NOTE**

Lines that begin with `dn1` (“delete to new line”) in the `sendmail.mc` file are comment lines. In most cases, I have left them out in the examples shown. Also, notice that Sendmail uses backticks as opening quotes and straight quotes as ending quotes.

```
divert(-1)dn1
include(`/usr/share/sendmail-cf/m4/cf.m4')dn1
VERSIONID(`setup for linux')dn1
OSTYPE(`linux')dn1
```

The first few lines of the `sendmail.mc` file do some housekeeping. The `divert` line removes extra output when the configuration file is generated. The `include` line causes rule sets needed by Sendmail to be included. The `VERSIONID` line identifies the configuration file as being for Linux systems, such as CentOS (although this setting is not checked, so it could be anything you like). The `OSTYPE`, however, must be set to `linux` to get the proper location of files needed by Sendmail.

```
dn1 define(`confSMTP_LOGIN_MSG', `$_j Sendmail; $b')dn1
dn1 define(`SMART_HOST', `smtp.your.provider')dn1
```

Here are two lines you can consider uncommenting (removing the `dn1` string). The `confSMTP_LOGIN_MSG` definition can be used to disguise the mail server you are using (change *Sendmail* to whatever). As for the second line, by default, the `sendmail` daemon tries to send your outgoing e-mails directly to the mail server to which they are addressed. If you want all e-mail to be relayed through a particular mail server instead, you can remove the comment (`dn1`, which stands for “delete to new line”) from the beginning of the `SMART_HOST` line above (leave the one at the end). Then, change `smtp.your.provider` to the fully qualified domain name of the mail server you want to use. Of course, you need to be sure that the `SMART_HOST` you define will accept relays from your mail server.

```
define(`confDEF_USER_ID', ``8:12'')dn1
```

Instead of running as the `root` user, the daemon runs as the `mail` user (UID 8) and `mail` group (GID 12), based on the `confDEF_USER_ID` line set previously. This is a good policy, because it prevents someone who might compromise your mail server from gaining root access to your machine.

```
dn1 define(`confAUTO_REBUILD')dn1
define(`confTO_CONNECT', `1m')dn1
```

If you remove the initial `dn1`, the `confAUTO_REBUILD` line will tell Sendmail to rebuild the aliases database automatically, if necessary. The `confTO_CONNECT` line sets the time that Sendmail will wait for an initial connection to complete to 1 minute (1m).

```
define(`confTRY_NULL_MX_LIST', `True')dn1
define(`confDONT_PROBE_INTERFACES', `True')dn1
```

With `confTRY_NULL_MX_LIST` true, if a receiving server is the best mail exchange (MX) for a host, Sendmail will try connecting to that host directly. If `confDONT_PROBE_INTERFACES` is true, the `sendmail` daemon will not insert local network interfaces into the list of known equivalent addresses.

```
define(`PROCMAIL_MAILER_PATH', `/usr/bin/procmail')dn1
define(`ALIAS_FILE', `/etc/aliases')dn1
dn1 define(`STATUS_FILE', `/var/log/mail/statistics')dn1
```

The next three lines (`PROCMAIL_MAILER_PATH`, `ALIAS_FILE`, and `STATUS_FILE`) set locations for the program that distributes incoming mail (`procmail`, by default), the mail aliases file, and the mail statistics file, respectively.

```
define(`UUCP_MAILER_MAX', `2000000')dn1
define(`confUSERDB_SPEC', `/etc/mail/userdb.db')dn1
define(`confPRIVACY_FLAGS', `authwarnings,novrfy,noexpn,
    restrictqrun')dn1
define(`confAUTH_OPTIONS', `A')dn1
```

The `UUCP_MAILER_MAX` line sets the maximum size (in bytes) for messages received by the UUCP mailer. The `confUSERDB_SPEC` line sets the location of the user database (where you can override the default mail server for specific users). The `confPRIVACY_FLAGS` line causes Sendmail to insist on certain mail protocols. For example, `authwarnings` causes X-Authentication-Warning headers to be used and noted in log files. The `novrfy` and `noexpn` settings prevent those services from being requested. The `restrictqrun` option prevents the `-q` option to Sendmail.

```
dn1 define(`confAUTH_OPTIONS', `A p')dn1
dn1 TRUST_AUTH_MECH(`EXTERNAL DIGEST-MD5 CRAM-MD5 LOGIN PLAIN')dn1
dn1 define(`confAUTH_MECHANISMS', `EXTERNAL GSSAPI DIGEST-MD5
    CRAM-MD5 LOGIN PLAIN')dn1

dn1 define(`confCACERT_PATH', `/etc/pki/tls/certs')dn1
dn1 define(`confCACERT', `/etc/pki/tls/certs/ca-bundle.crt')dn1
dn1 define(`confSERVER_CERT', `/etc/pki/tls/certs/sendmail.pem')dn1
dn1 define(`confSERVER_KEY', `/etc/pki/tls/certs/sendmail.pem')dn1
dn1 define(`confDONT_BLAME_SENDMAIL', `groupreadablekeyfile')dn1
```

Some of the groups of lines just shown that begin with `dn1` (so they are commented out) can be uncommented (remove the initial `dn1`) to provide certain features. Others are set explicitly.



The `confAUTH_OPTIONS` line can be used to set options used with SMTP authentication. This example (with `A` and `p` options) would allow authenticated users with plaintext logins to send mail. The `TRUST_AUTH_MECH` line would cause Sendmail to allow authentication mechanisms other than plain passwords (if `dn1` were removed). The `confAUTH_MECHANISMS` line can configure the types of authentication mechanisms that can be used (if `dn1` were removed). The next few lines above set the location of the Certificates directory for Sendmail to `/etc/pki/tls/certs`, then identify different files in that directory that hold the certificates and keys needed for authentication. The `confDONT_BLAZE_SENDMAIL` line should be uncommented if the key file needs to be readable by applications other than Sendmail. (Typically, you would not want the file to be readable by everyone.)

```
dn1 define(`confTO_QUEUEWARN', `4h')dn1
dn1 define(`confTO_QUEUERETURN', `5d')dn1
dn1 define(`confQUEUE_LA', `12')dn1
dn1 define(`confREFUSE_LA', `18')dn1
define(`confTO_IDENT', `0')dn1
```

The commented lines above actually show the default values set for certain time-out conditions. You can remove comments and change these values if you like. The `confTO_QUEUEWARN` option sets how long after delivery of a message has been deferred to send a warning message to the sender. Four hours (4h) is the default. The `confTO_QUEUERETURN` option sets how long before an undeliverable message is returned. The `confQUEUE_LA` and `confREFUSE_LA` options set the system load average levels at which mail received is queued or refused, respectively. The `confTO_IDENT` option sets the time-out when waiting for a response to an `IDENT` query to be received (by default it is 0, which means no time-out).

```
FEATURE(`no_default_msa', `dn1')dn1
FEATURE(`smrsh', `/usr/sbin/smrsh')dn1
FEATURE(`mailertable', `hash -o /etc/mail/mailertable.db')dn1
FEATURE(`virtusertable', `hash -o /etc/mail/virtusertable.db')dn1
FEATURE(redirect)dn1
FEATURE(always_add_domain)dn1
FEATURE(use_cw_file)dn1
FEATURE(use_ct_file)dn1
FEATURE(local_procmail, `', `procmail -t -Y -a $h -d $u')dn1
FEATURE(`access_db', `hash -T<TMPF> -o /etc/mail/access.db')dn1
FEATURE(`blacklist_recipients')dn1
```

The `FEATURE` macro is used to set some special Sendmail features. The `no_default_msa` feature tells Sendmail not to generate a default MSA daemon (which normally is set to listen on port 587). The `smrsh` feature defines `/usr/sbin/smrsh` as the simple shell used by Sendmail to receive commands. The `mailertable` and `virtusertable` options set the locations of the `mailertable` and `virtusertable` databases. The `redirect` option allows you to reject mail for users who have moved and provide new addresses. The `always_add_domain` option causes the local domain name to be added to the hostname on all delivered mail. The `use_cw_file` and `use_ct_file` options tell Sendmail to use the file `/etc/mail/local-host-names` for alternative

hostnames for this mail server and `/etc/mail/trusted-users` for trusted usernames, respectively. (A trusted user can send mail as another user without resulting in a warning message.)

The `local_procmail` option sets the command used to deliver local mail (procmail), as well as options to that command (including the `$h` hostname and `$u` username). The `access_db` option sets the location of the access database, which identifies which hosts and users are allowed to relay mail through the server. The `blacklist_recipients` option turns on the ability of the server to block incoming mail for selected users, hosts, or addresses. (The `access_db` and `blacklist_recipients` features are useful for blocking spam.)

```
EXPOSED_USER(`root')dn1
DAEMON_OPTIONS(`Port=smtp,Addr=127.0.0.1, Name=MTA')dn1
```

The `EXPOSED_USER` line allows the `root` username to be displayed instead of a masquerade name. As it stands, the `DAEMON_OPTIONS` line allows only incoming mail created by the local host to be accepted. Be sure to comment this line out if you want to allow incoming mail from the Internet or other network interface (such as the local LAN).

```
FEATURE(`accept_unresolvable_domains')dn1
```

The `accept_unresolvable_domains` option is on, causing you to accept mail from host computers that don't have resolvable domain names. If you have client computers (such as dial-up computers) that need to use your mail server, leave this option on. Turning it off, however, can help eliminate spam.

```
LOCAL_DOMAIN(`localhost.localdomain')dn1
MAILER(smtp)dn1
MAILER(procmail)dn1
```

The `LOCAL_DOMAIN` option here causes the name `localhost.localdomain` to be accepted as a name for your local computer. The last lines in your `sendmail.mc` file define the mailers to use on your server. The `/usr/share/sendmail-cf/mailler` directory contains definitions for SMTP, procmail, and other mailers. After you have made the changes you want to the `sendmail.mc` file, you can regenerate the `sendmail.cf` file as described in the “Starting Sendmail and Generating Database Files” section.

## Defining Outgoing Mail Access

Every time an e-mail message intended for outgoing mail is received by your Sendmail server, the server needs to decide if it will accept or reject relaying of that message. Policies that are too restrictive might prevent legitimate mail from getting out. Policies that are too loose can leave your server open to spammers.

With e-mail abuse the way it is these days, you should not run an open relay (where your server simply relays all messages it receives to the requested mail servers). Spammers can use software referred to as *spiders* to look for open relays. If you leave your mail server open, they will find

you quickly and use your machine to relay their spam. The results of a spammer using your machine can include the following:

- **You Can End Up on Blacklists** — Some e-mail blacklist maintainers look for open relays themselves and block them before abuse is even reported. Servers that use those blacklists will block all mail from you, even legitimate e-mail.
- **People Will Hate You** — Your mail server will be identified as the one sending the spam. As a result, people may retaliate against your server, or at the very least really wish you would stop sending them ads to help them get out of debt or enhance themselves in some way.
- **You Face Possible Fines and Jail** — More and more laws are being written to try to stop the spread of spam. You could be found guilty of negligence or have your machines shut down or confiscated, even if you didn't initiate the spam yourself.

This section describes how to set up the Sendmail access file (`/etc/mail/access`) to include a sensible set of rules defining for whom your server will relay mail. Using the access file, Sendmail can make decisions about whether or not to relay a message based on the sender's host/domain name, IP address, or e-mail address. You can further refine the match by checking for those addresses in *Connect*, *From*, or *To* data associated with the message.

There are then four basic actions you can have the server take on a match:

- RELAY — Your mail server could simply send the message on to the mail server requested in the mail message.
- REJECT — The message is rejected (not relayed), and the sender is told it was rejected.
- DISCARD — The message is silently discarded, and the sender is not told.
- ERROR: *text you choose* — You can add some informative text here, to give the sender some reason why the relay did not occur.

The `/etc/mail/access` file, by default, relays messages only from users who are directly logged into the mail server (`localhost`). Without being explicitly allowed, users from all other machines are not allowed to relay messages. Here's how the access file is set up by default:

```
Connect:localhost.localdomain    RELAY
Connect:localhost                RELAY
Connect:127.0.0.1                RELAY
```

With these defaults set, only mail sent from the local machine is relayed. So, if the only outgoing mail you send is sent while you are logged in directly to the server, you don't need to change this file. The following examples illustrate how you can selectively choose to relay or reject mail received by your Sendmail server:

```
Connect:192.168                  RELAY
Connect:example.com              RELAY
Connect:spammer-domain.com       REJECT
```

```
From:timothy@example.com      RELAY
To:spidermaker.com           RELAY
To:former-user@example.com    ERROR: User no longer works here
```

On the `Connect:192.168` line, the network address (presumably the first part of the IP addresses used on your LAN) is allowed to relay mail. This is a good way to allow everyone sending mail from a machine on the local LAN to have their mail relayed. On the next line (`Connect:example.com`), mail coming from any machine in the named domain is allowed to be relayed. The third line represents a domain that you know to be a spam relay, so you reject messages originating from that domain.

The next three lines indicate how to treat mail received for relaying, based on the *From* and *To* names associated with the message. As you can see, the first example allows relay of any messages from `timothy@example.com`. In the last example, mail being forwarded to a particular person (`former-user@example.com`) is rejected, and a custom error message (in this case, “User no longer works here”) is sent back to the sender.

**NOTE**

Use some caution when you are creating relay rules based on user e-mail address. Because those values are reported by the users themselves, they are vulnerable to being spoofed.

Once you have adjusted this file to suit you, you must rebuild the access database (`access.db` file) for the changes to take effect. See “Starting Sendmail and Generating Database Files” for information on this topic.

## Configuring Virtual Servers

If you have set up a Sendmail mail server for one domain, it’s quite possible that you will someday want to have multiple domains served from that same computer. To create virtual servers on the same computer, you must add the name of every domain being served to the `/etc/mail/local-host-names` file.

For example, if your Sendmail server were handling e-mail accounts for `example.com`, `example2.com`, and `example3.net` domains, the `local-host-names` file would appear as follows:

```
# local-host-names - include all aliases for your machine here.
example.com
example2.com
example3.net
```

Even if you are serving only one domain with your mail server, it is a good idea to identify that domain in this file. When messages come to the server for the domains listed here, Sendmail knows to try to deliver the messages locally. Sendmail interprets messages for domains not listed here as needing to be relayed.

**NOTE**

If you want to off-load the processing of mail for a particular domain that is currently being directed to your Sendmail server, you can use the `/etc/mail/mailertable` file. After setting up a DNS MX record to point to your Sendmail server for this domain and listing that domain name in the mailertable file, you can identify another computer that Sendmail will forward all the traffic to for that domain. For example:

```
example2.com      smtp:mx1.example.com
```

This example shows that all messages destined for `example2.com` that are received by your Sendmail server are forwarded to the server named `mx1.example.com`. The `smtp` indicates that the server supports Simple Mail Transfer Protocol.

## Configuring Virtual Users

Incoming mail to your Sendmail server will be directed to your machine with a request to deliver the message to a particular person at a particular domain name. For each domain that the Sendmail server supports, you can identify how e-mail to the mail recipients of that domain is treated.

With Sendmail, you set up virtual user definitions in the `/etc/mail/virtusertable` file. Essentially, you are telling Sendmail to re-direct messages addressed to particular usernames or domain names based on definitions you set up.

Configuring the `virtusertable` file is particularly important if your server is handling mail for multiple domains. That's because, by default, mail for the same username (regardless of the domain name) will be stored in the same mailbox. For example, if your server handles mail for `example2.com` and `example.com` domains, mail for `timothy@example2.com` and `timothy@example.com`, would all be directed to the `/var/spool/mail/timothy` mailbox. With the `virtusertable` file, you can change that behavior in a lot of ways.

The `virtusertable` file is empty by default. The following are some examples that illustrate how incoming messages can be directed in different ways based on `virtusertable` definitions.

```
timothy@example.com      timothy
tboronczyk@example.com  timothy
fgordon@example.com     fgordon@spidermaker.com
info@example.com         info-list
bogus@example.com       error:nouser No such user here
@example3.net            example-catchall
@example2.com            %1@example.com
```

In the first two lines, incoming mail destined for `timothy` or `tboronczyk` at `example.com` is directed to the mailbox for the local mail server user named `chris`. In the next line, any e-mail directed to `fgordon` in the same domain goes to `fgordon@spidermaker.com`. After that, e-mail sent to the `info` username is saved to the local `info-list` mail account.

The line beginning with `bogus@example.com` illustrates an error condition. Here, e-mail destined for the user named `bogus` will be rejected with the error message `No such user here`

being directed back to the sender. Besides creating custom error messages, you can also use any Enhanced Mail System Status codes that are compliant with RFC 1893.

The last two lines (beginning with `@example3.net` and `@example2.com`) illustrate how e-mail for all recipients for a given domain can all be directed to the same place. In the first case, all `example3.net` messages go into the mailbox for the user named `example-catchall`. The last line shows how the users from a particular domain can all be mapped into their same username (`%1`) on a selected domain name.

Once you have made changes to this file to suit you, you must rebuild the `virtusertable` database (`virtusertable.db` file) for the changes to take effect. See “Starting Sendmail and Generating Database Files” for information on this topic.

## Adding User Accounts

Ultimately, the e-mail received by your mail server is placed in a user’s mailbox, where the user can pick it up and read it at his or her leisure. Each of those usernames must be added as a real user on your CentOS system. For example, to add the user `timothy` to your CentOS Sendmail server, you could type (as `root` user):

```
# useradd -s /sbin/nologin timothy
```

This action creates a user account named `timothy` in the `/etc/passwd` file, sets the shell to `/sbin/nologin`, and creates a mailbox for that user in `/var/spool/mail/timothy`. The `/sbin/nologin` shell prevents the user from logging in to a shell (which is a good security practice when, e.g., you only want a user to have mail or FTP access). Now, Sendmail can direct e-mail to that user’s mailbox.

For that user to be able to access his e-mail later from his POP3 client, he will need a password for his user account. Set the password for that user with the `passwd` command as follows:

```
# passwd timothy
Changing password for user timothy
New UNIX password: ****
Retype new UNIX password: ****
passwd: all authentication tokens updated successfully
```

Make sure that the user has this user account name and password so it can be configured into the user’s e-mail client.

## Starting Sendmail and Generating Database Files

None of the configuration that you just did to your `sendmail.mc`, `virtusertable`, `access`, `domaintable`, and `mailtable` configuration files take effect until they are regenerated into database (`.db`) files. There are a few different ways you can go about loading your configuration files into database files:

- **Restarting Sendmail** — Each time you reboot your computer or restart the `sendmail` daemon (by typing `service sendmail restart`), all Sendmail configuration files (including

sendmail.mc) are compiled into database files that are ready to be used by the Sendmail server. You can also just rebuild the databases without stopping the `sendmail` daemon (including the `/etc/aliases.db` file) using the `sendmail` startup script. To simply rebuild the database, type:

```
# /etc/init.d/sendmail reload
```

- This command rebuilds all the database files, including the `/etc/aliases` file. (If the reload doesn't update your `sendmail.cf` file, be sure that the `sendmail-cf` package is installed: **yum install sendmail-cf**.)
- **Making the Configuration Files** — Using the `make` command, you can have some or all of the configuration files made into database files, so they become immediately usable by the `sendmail` daemon. To do that, change to the `/etc/mail` directory, and then type either **make all** or **make** with the target database file you are creating. For example:

```
# cd /etc/mail
# make virtusertable.db
```

- You can replace `virtusertable.db` with `access.db`, `domaintable.db`, `mailertable.db`, or `sendmail.db`. (Note that you use the `.db` target name and not the name of the original configuration file.) As mentioned, you can also use the `make all` command to rebuild all database files.

At this point, your Sendmail server should be up and running. You can test your server by sending mail to it and checking log files to see how the server reacted. Make sure that your firewall allows requests on TCP port 25. Then check that your mail server is responding to requests by typing the following:

```
# telnet 127.0.0.1 25
Trying 127.0.0.1...
Connected to localhost.localdomain (127.0.0.1).
Escape character is '^]'.
220 dale.example.com ESMTP Sendmail 8.14.3/8.14.3;
    Sun, 16 Nov 2008 03:34:02 -0500
```

You can see that the `sendmail` daemon is running and responding to port number 25. Try typing **HELO**. (That's literally *HELO* and not *HELLO*.) When you are done, type **QUIT** to exit.

**CROSS-REF** For more information on troubleshooting your mail server, refer to *Linux Troubleshooting Bible* by Christopher Negus and Thomas Weeks (Wiley, 2004).

## Re-Directing Mail

At times, your e-mail users may want to re-direct mail to some place other than their own mailboxes on the local server. Each user can re-direct his or her mail using the `.forward` file. System-wide, you as the administrator can set aliases to re-direct mail in the `/etc/aliases` file.

## The .forward File

One way for users to re-direct their own mail is through the use of the `.forward` file, which users can place in their own home directories (e.g., `/home/jkpat/.forward`). The format of a plaintext `.forward` file is a comma-separated list of mail recipients. Common uses of the `.forward` file include:

- Piping mail to a program to filter the mailbox contents:

```
"| /usr/bin/procmail"
```

- Sending mail destined for one user (e.g., `jkpat`) to another (e.g., `cht09`, on a different machine in this case):

```
cht09@other.mybox.com
```

- Delivering mail to the local user (`jkpat` again) *and* sending it to two others (`cht09` and `brannigan`):

```
\jkpat, cht09@other.mybox.com, \brannigan
```

### TIP

You are not allowed to have a `.forward` file in a directory that can be read by all users. If you leave permissions open on a `.forward` file, Sendmail will ignore that file and not forward mail as you want. To allow `.forward` files with open permissions to be used by Sendmail, you can remove the `dn1` from the `confDONT_BLAZE_SENDMAIL` line in the `sendmail.mc` file.

## The Aliases File

A more flexible method of handling mail delivery (system-wide rather than being specific to one particular user) involves the `/etc/aliases` file, which is also a plaintext file. The aliases file contains a name followed by a colon, and then a username, another alias, a list of addresses, a file, or a program to which mail will be delivered. The name to the left of the colon (which can be a valid username or just an alias) can then be used as an e-mail recipient on the local machine or on a remote machine.

Some aliases are already set by default in `/etc/aliases`. For example, because there are a lot of administrative users defined in CentOS (`bin`, `adm`, `lp`, etc.), instead of having separate mailboxes for each one, messages for all of them are directed to the `root` user's mailbox as follows:

```
bin:          root
daemon:      root
adm:         root
lp:          root
```



Using the aliases file for mail-aliasing allows for several extensions to normal mail-handling behavior:

- You can use the aliases file yourself to create mini-mailing lists. Here's an example:

```
info-list: timothy, tweeks, fgordon@spidermaker.com
```

- In this example, any messages sent to `info-list` are distributed to `timothy`, `tweeks`, and `fgordon@spidermaker.com`. Notice that the user list can be a combination of local users and outside mail addresses.
- One account can receive mail under several different names:

```
patterson: jkpat
```

- This indicates that any mail addressed to `patterson@mybox.com` (just an alias) will arrive in the mailbox of `jkpat` (an actual user account).
- Mail can be received under a name that isn't a valid (or reasonable) username:

```
dr.hans-zarkov@objectpartners.com: hzarkov
```

- He may not want to type **dr.hans-zarkov** as a username, but that doesn't mean he can't receive mail as such.
- Messages intended for one user can be re-directed to another account (or to several accounts):

```
oldemployee: bradford
consultant: bradford, jackson, patterson
users: :include:/root/mail/lists/users
```

- Here, any message for `oldemployee@mybox.com` would be delivered to the mailbox of user `bradford`. Also, the users `bradford`, `jackson`, and `patterson` would receive any mail addressed to `consultant`. The third line indicates that the recipients of the users alias are specified in the file `/root/mail/lists/users`.
- Mail can be sent directly to a file on the local machine:

```
acsp-bugs: /dev/null
trouble-ticket: /var/spool/trouble/incoming
```

- In the first line, because the fictional ACSP program is no longer used on the machine, there's no need to track its errors, so the mail is effectively ignored. The second line stores incoming trouble tickets in the `/var/spool/trouble/incoming` file. Remember that if you enable this, anyone anywhere can send you a sufficiently large message to fill up the partition on which that directory resides. This is a security risk and should be carefully evaluated before being implemented.

When you are done adding new aliases, type the following to have those changes take effect:

```
# newaliases
```

**TIP**

When resolving addresses, Sendmail doesn't actually use the `/etc/aliases` text file. For faster access, the text file is turned into a Berkeley database file, `/etc/aliases.db`, which resolves aliased addresses. For this reason, the `newaliases` command (equivalent to `sendmail -bi`) must be run to rebuild the database file each time the `/etc/aliases` text file is modified. This happens automatically each time Sendmail is restarted.

## Introducing Postfix

---

*Postfix* is a Mail Transfer Agent that you can use in place of Sendmail to handle mail service on your CentOS system. There are several reasons that Postfix proponents give for using Postfix instead of Sendmail for their mail service:

- Postfix is designed to be easier to administer. Instead of using m4 syntax in the `sendmail.mc` file, Postfix uses clear text directives.
- Postfix has multiple layers of security built in, including the ability to run in a chroot jail. It also filters *any* sender-provided information before exporting that information into the Postfix environment.

Although some of the configuration files and other components are different from those in Sendmail, many are meant to replace Sendmail components (such as aliases, access, and `.forward` files, as well as the `/var/mail` directory structure). To help you make the transition to Postfix from Sendmail, CentOS and RHEL have configured the two packages to use the alternative system. Chapter 9 describes how to use the Mail Transport Agent Switcher to change from one transport to the other.

When you switch to Postfix and start the `postfix` daemon, as described in Chapter 9, Postfix takes over as the MTA, replaces Sendmail components with Postfix components, and uses some of the same locations for mailboxes and log files. Postfix takes over mail transport based on configuration files set in the `/etc/postfix` directory. The following is an overview of the default locations used by the Postfix service:

- **Mail Configuration (`/etc/postfix/main.cf`)** — The primary configuration file for Postfix. Identifies the locations of Postfix queues, commands, and aliases, as well as defining the host and domain names that Postfix is serving. If you do not add a fully qualified domain name to this file, Postfix will use your local hostname as the name of the mail service it represents.
- **Mailboxes (`/var/spool/mail`)** — Directory containing incoming mail files, with each user's mailbox represented by a file of the user's name. (This is the same default spool directory used by Sendmail.)
- **Mail Queue (`/var/spool/postfix`)** — Location of directories where mail messages are queued for delivery
- **Mail Log (`/var/log/maillog`)** — Location of mail log files

Although most options you need for Postfix are described in the `/etc/postfix/main.cf` file, you can see many more available options in the `main.cf.default` file in the same directory. Based on the default configuration in the `main.cf` file, here is how Postfix will handle outbound and incoming mail:

- **Outbound Mail** — The local hostname is added as the sending host for the mail posted from this computer. You might want to change it to the local domain name (set `myorigin = $mydomain`).
- **Incoming Mail** — Only mail destined for the local hostname is kept on the local server by default. Other mail is forwarded. To have all mail for your domain kept on the local server, add `$mydomain` to the `mydestination` line.

For complete information on configuring Postfix, refer to [www.postfix.org/docs.html](http://www.postfix.org/docs.html).

## Stopping Spam with SpamAssassin

---

Despite the fact that it is rude and antisocial, there are people who send out thousands of unsolicited e-mail messages (referred to as *spam*), hoping to get a few responses. Owing to the economics of the Internet, spammers can send out literally millions of messages. A very small number of respondents is enough to make a profit for the spammers. Furthermore, modern spam can be dangerous, including messages designed to fool users into entering usernames and passwords (called *phishing*) or messages that try to exploit vulnerable systems (particularly Windows systems).

Because Linux systems are often used as mail servers, tools for scanning mail messages for spam and viruses have become quite sophisticated over the years. In this chapter, I describe how to use a tool called *SpamAssassin* to deal with spam and viruses on your mail server. If this doesn't meet your needs, you might add the ClamAV virus scanner to test mail messages for actual malware attachments. Here are a couple of links where you can learn about ClamAV and how to use it with different mail software:

- **ClamAV** ([www.clamav.net](http://www.clamav.net)) — Command-line virus scanner with database update features. The `clamav` package is in the RPMforge Repository (type `yum install clamav`).
- **Third-Party ClamAV Apps** ([www.clamav.net/3rdparty.html](http://www.clamav.net/3rdparty.html)) — Find links to third-party software that works with ClamAV.

## Using SpamAssassin

With SpamAssassin, you can configure your incoming mail service to tag messages it believes to be spam so that you and your users can deal with those messages as you choose.

There are several methods that SpamAssassin uses to identify spam:

- **Checking Mail Headers** — Examining the headers of your incoming mail to look for well-known tricks used to make the e-mail look valid

- **Checking Mail Text** — Looking for text style, content, and disclaimers in message bodies that are commonly used in spam
- **Checking Blacklists** — Checking blacklists to find e-mail sent from sites known before to relay spam. (The `mail-abuse.com` site provides a search tool for checking if a server at a particular IP address has been blacklisted. To use that tool, go to `www.mail-abuse.com/cgi-bin/lookup`.)
- **Checking Spam Signatures** — Comparing e-mail signatures. Because spam often consists of the exact same message sent thousands of times, taking signatures of spam messages lets SpamAssassin compare your message to a database of known spam messages. SpamAssassin uses Vipul's Razor (see `http://razor.sourceforge.net`).

Although there are many different ways to deal with spam (or rather, e-mail that *might* be spam), most of the experts I have consulted like to configure SpamAssassin to simply tag incoming e-mail messages that appear to be spam. Then they encourage each user of the e-mail server to create his or her own rules for filtering the spam.

## NOTE

Although the procedure here describes how to use SpamAssassin from the RPM package that comes with the latest version of CentOS, many people get their version of SpamAssassin directly from the SpamAssassin web site. Because anti-spam software is evolving so quickly (to keep ahead of spammers), some people like to make sure they have the very latest software. Instructions for installing SpamAssassin from source code are available from the SpamAssassin download page: `http://spamassassin.apache.org/downloads.cgi`. Typically, you can simply run the `rpmbuild -tb` command on the Mail-Spamassassin tar file to create a new RPM.

## Setting Up SpamAssassin on Your Mail Server

Here's a quick procedure for enabling SpamAssassin and having your users choose what to do with spam messages that are encountered:

1. Configure your Mail Transport Agent (Sendmail or Postfix) to use the `procmail` command as its mailer. For Sendmail, it is already configured as the default mailer, based on the following line in the `/etc/mail/sendmail.mc` file:

```
FEATURE(local_procmail,`, `procmail -t -Y -a $h -d $u')dnl
```

2. Make sure that the SpamAssassin `spamd` daemon is running (it should already be on for run levels 2–5), and if it isn't, start it by typing the following (as `root` user):

```
# chkconfig --list spamassassin
spamassassin 0:off 1:off 2:on 3:on 4:on 5:on 6:off
# chkconfig spamassassin on
```

3. Create an `/etc/procmailrc` file (using any text editor, as `root` user). This `procmailrc` file example pipes all mail messages received by `procmail` through `spamd` (which is the client side of the `spamd` daemon turned on in the previous step):

```
:0fw
| /usr/bin/spamd
```

If you like, you can do a lot more in the `procmailrc` file to deal with spam on a system-wide basis. You could, for example, create `procmail` recipes that take reported spam e-mail messages and sort them into a system-wide spam folder or delete them completely. Likewise, each user can create an individual `$HOME/.procmailrc` file to create personal `procmail` recipes. (Type **man procmailx** for examples of rules in a `procmailrc` file.)

4. Check the `/etc/mail/spamassassin/local.cf` file. This file contains rules that are used system-wide by SpamAssassin, unless they are overridden by a user's individual `$HOME/.spamassassin/user_prefs.cf` file. Here are the contents of the `local.cf` file:

```
required_hits 5
report_safe 0
rewrite_header Subject [SPAM]
```

5. In SpamAssassin, a scoring system is used to guess at whether a particular message is spam or not. The `required_hits` line shows that a score of 5 is needed to flag the message as spam. You should set that higher for a public mail server (e.g., 8 or 10). Setting `rewrite_header` to `[SPAM]` has SpamAssassin add the text `[SPAM]` to the Subject line of spam it finds. (Type **man Mail::SpamAssassin::Conf** to see other settings you can use in the `local.cf` file.)

Because false positives sometimes occur, you risk preventing your users from seeing an e-mail they need if you do system-wide filtering. To avoid this problem, the approach shown here lets the user decide what to do with e-mail tagged as spam. Users can even adjust their own thresholds for when a message is believed to be spam.

Next, you should have the users of that mail server set up their own user preferences in their home directories. The preferences set in each user's `$HOME/.spamassassin/user_prefs.cf` file help tell SpamAssassin how to behave for that user's e-mail. Here are examples of lines a user might want to have in that file:

```
required_score          3
whitelist_from          jsmith@example2.com bjones@example3.net
blacklist_from          *.example4.org
```

The `required_score` line (which is set to 5 by default, but set to 3 here) sets the score needed to consider the message to be spam. Scores are based on matching or not matching criteria in the tests SpamAssassin performs. (See <http://spamassassin.apache.org/tests.html>.)

The `whitelist_from` and `blacklist_from` lines let you set addresses for people, individual hosts, or entire domains that should *not* be considered as spam (`whitelist_from`) or should *always* be considered as spam (`blacklist_from`). For other ways to modify SpamAssassin behavior, type the following command:

```
man Mail::SpamAssassin::Conf
```

At this point, SpamAssassin should be running and identifying spam based on input from you and the people using your e-mail server. Next, each user needs to decide what to do with the messages that are marked as spam, as described in the following section.

**TIP**

Techniques that you can use along with SpamAssassin include services like SpamCop. SpamCop ([www.spamcop.net](http://www.spamcop.net)) provides a service that allows you to enter spam messages you receive into a database that helps others block the same spam messages.

## Setting E-Mail Readers to Filter Spam

Each user can turn on filtering in his or her e-mail reader to decide what to do with each message tagged as spam by SpamAssassin. A common practice is to direct e-mail marked as spam to a separate folder. Because some real mail can occasionally be mistakenly marked as spam, you can check the spam folder every week or two, just to make sure you don't miss anything.

Here's an example of how to add a filter rule from Evolution Email:

1. Create a folder labeled *SPAM* under your incoming mailbox.
2. Click Edit ► Message Filters.
3. From the Filters window, click Add. An Add Rule window appears.
4. Identify a rule name (such as *Spam*) that adds a criterion that looks for a specific header (X-Spam-Flag) containing specific text (*YES*). Then under Add Action, select an action ("Move to Folder") and identify the folder to contain the spam messages (*SPAM*).

When you ask to receive mail from your mail server, all messages with the X-Spam-Flag set to yes are sorted into your SPAM folder. As an alternative, you can check for the text [*SPAM*] to appear in the subject line as the criterion for sorting the spam messages.

Other mail readers (Sea Monkey mail, Pine, Netscape mail, and others) also include features for filtering and sorting e-mail based on criteria you enter.

A fairly new feature in Evolution includes some SpamAssassin features within the Evolution framework. Evolution runs a daemonized version of SpamAssassin using the `spamd` daemon. The `spamd` daemons automatically filter your mail to find junk mail. When it finds junk mail, it automatically puts it into the Junk folder in the Evolution window. You can ignore those messages or simply scan through them quickly and delete them.

## Getting Mail from the Server (POP3 or IMAPv4)

---

After you have set up your mail server, you will want to let users access their e-mail from that server. That means either having each user log in to the mail server to read his or her e-mail or, more likely, configuring POP3 or IMAPv4 to let users access their mail from their workstations. Here are descriptions of POP3 and IMAPv4:

- **POP3** — With POP3, users download and manage their e-mail messages on their local workstations. POP3 is simpler and requires fewer server resources.

- **IMAPv4** — With IMAPv4, messages stay on the server, although you can manipulate those messages from the mail client. Because the messages stay on the server, an IMAPv4 server requires more disk space and uses more CPU. However, you do have the advantage of logging in to different workstations to read your mail and having the mail and folders you have set up appear the same. With all the e-mail on the server, an administrator needs to back up only one machine to keep permanent records of everyone's e-mail.

CentOS comes with software that is able to provide POP3 and IMAPv4 service. The `dovecot` package is primarily an IMAPv4 server that also contains a small POP3 server. It supports mail in both Maildir (where each mail account can contain multiple folders on the server) and mbox (where all messages are in a single file) formats.

This section describes how to use POP3 to allow the users of your mail server to download their mail messages from your server over the network. POP3 is the simpler of the two protocols for accessing mailboxes over networks.

## Accessing Mailboxes in Linux

When e-mail messages are received on your Sendmail or Postfix mail server, they are sorted to separate files, each of which represents a user's mailbox. The default location of mailbox files is the `/var/spool/mail` directory. So the login account `jsmith` would have a mailbox:

```
/var/spool/mail/jsmith
```

While logged into the mail server, `jsmith` could simply type **mail** from a Terminal window to read his e-mail (using the simple, text-based `mail` command). However, because most people prefer to get their e-mail from the comfort of their own desktop computers, you can set up either Post Office Protocol (POP3) or Internet Message Access Protocol (IMAPv4).

POP3 and IMAPv4 servers listen on the network for requests for a user's e-mail and then either download the entire contents of the mailbox to the user's mail reader (as with POP3) or let the user manage the messages while the messages stay on the server (as with IMAPv4).

Typically, your mail server will be configured to use either POP3 or IMAPv4 to provide e-mail messages to your users (although it is possible to have both running on the same machine).

The next section explains how to set up an IMAPv4 or POP3 service to allow access to e-mail accounts.

### TIP

At times, you may want to check your e-mail on a computer that is not your regular computer, but be able to save messages later. In that case, most mail readers let you choose a setting that copies the e-mail messages without deleting them from your POP3 server. That way, when you get back to your regular computer, you can copy the messages again. IMAPv4 avoids that problem by always keeping the mail messages on the server and letting the user create and work with additional folders on the server.

## Configuring IMAPv4 and POP3 with Dovecot

When a user is added to CentOS, a mailbox is configured under that username in the `/var/spool/mail` directory (such as `/var/spool/mail/timothy`). The format of that file, by default, is the traditional `mbox` format, with all messages and attachments stored in that one file. By configuring the POP3 service on your mail server, users will be able to download their e-mail messages from e-mail clients on other machines. By configuring IMAPv4, users can work with messages and folders directly on the server.

The following procedure describes how to configure the IMAPv4 or POP3 service in CentOS using Dovecot.

1. Review the values set in the `/etc/dovecot.conf` file. For this example, I assume the defaults, so you can try Dovecot without changing anything in this file. For the purpose of this example, the POP3 protocol is enabled, plaintext passwords are enabled from the standard `/etc/passwd` file, and PAM is used for authentication. Read through the comments in the file to see if there are any settings you want to change.
2. Turn on the `dovecot` service by typing the following (as `root` user):

```
# chkconfig dovecot on
```

(If Dovecot is not installed, install it by typing **yum install dovecot**.)

3. Start the POP3 service immediately by starting up the `dovecot` service as follows:

```
# /etc/init.d/dovecot start
```

4. Open port 110 on your firewall to allow other computers to request POP3 service on your mail server. If you were using POP3 with SSL support, you would open port 995 instead (or port 993 for IMAPv4 over SSL). An easy way to open a port is through the Security Level and Firewall window (select **System** > **Administration** > **Security Level and Firewall**). Select “Other ports” and click on the **Add** button to add 110 as the port and TCP and UDP as the protocols.

All users who have user accounts on your mail server are configured, by default, to accept e-mail. For example, if e-mail comes in to the `mail.handsonhistory.com` server for a user named `jsmith`, the message is copied to the `/var/spool/mail/jsmith` file on the server. Continuing the example, the user named `jsmith` could set up his mail reader as follows:

- **Mail Server** — `mail.handsonhistory.com`
- **Username** — `jsmith`
- **Password** — `theuserspassword`
- **Protocol** — POP3

After the mail reader is configured, when `jsmith` clicks “Send & Receive” from his mail reader, all e-mail messages in the `/var/spool/mail/jsmith` file are downloaded to his local mail reader. The messages are then erased from the server.



**NOTE**

Keep in mind that regular POP3 and IMAPv4 service uses plaintext protocols to carry usernames and passwords across the network. Depending on your network environment, this may pose a security threat.

## Getting Mail from Your Browser with SquirrelMail

---

Once your mail server is up and running, you can configure SquirrelMail to allow the users of your mail server to get their mail from their Web browsers. To use SquirrelMail, you must install the `squirrelmail` package from the CentOS installation DVD that comes with this book (or type **yum install squirrelmail**). Also, to use SquirrelMail, you need to have configured and started the following components:

- Mail server (Sendmail or Postfix)
- IMAPv4 server (Dovecot)
- Web Server (httpd)
- User accounts that will read mail through SquirrelMail

SquirrelMail has a very intuitive, menu-based administrative interface. That interface includes a variety of plug-ins you can add to SquirrelMail, to use features such as spell checking, calendar, password changing, and fetching mail from a POP3 server. You can get more plug-ins from <http://squirrelmail.org> as well.

To configure SquirrelMail, type the following as `root` user from a Terminal window:

```
# /usr/share/squirrelmail/config/conf.pl
```

Features you might want to consider tuning include Organization Preferences (such as the organization's name and logo to put into the SquirrelMail interface), Themes (more than two dozen are available), and Plugins (just check whether any of those that are available to install are interesting).

Also, by default, mail can be accessed only from a browser on the local host, so you will probably want to change Server Settings. For example, change the Domain name to the name of the domain from which you will allow users to access their mail.

For users to get to mail using SquirrelMail, they simply need to type the following address into the location box of their Web browser (replacing `server` with `localhost` or the name of the computer, if you are running this outside of the local host):

```
http://server/webmail
```

Figure 18-1 shows an example of the webmail browser interface.

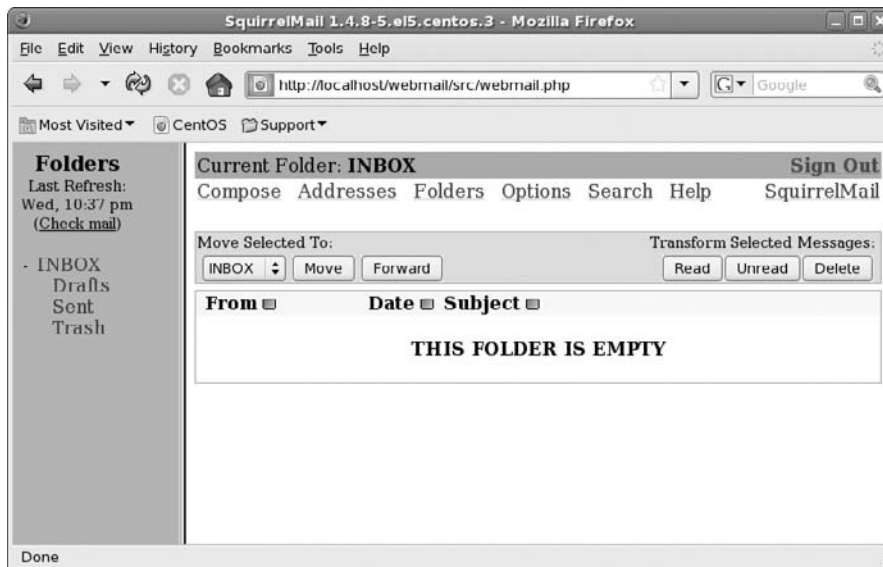
Type your username and password. Your mailbox should appear, as illustrated in Figure 18-2.

**FIGURE 18-1**

Let users log in from the Web to get mail.

**FIGURE 18-2**

Manage your mail from multiple folders in SquirrelMail.



## Administering a Mailing List with Mailman

Mailman is a popular Open Source package for managing e-mail discussion lists. Besides offering flexible administrative interfaces for setting up and managing lists, it also has Web-based interfaces that make it easy for people to join lists, access discussion list archives, and tune their own preferences.

If you need more information about configuring Mailman, there are plenty of places to go. Check the Mailman web site at [www.gnu.org/software/mailman/mailman.html](http://www.gnu.org/software/mailman/mailman.html). Also view README files in `/usr/share/doc/mailman-*`.

### NOTE

If you used Mailman previously in an earlier version of CentOS, note that the Mailman installation directory has moved from `/var/mailman` to `/usr/lib/mailman`. If you made any changes to files in the `/var/mailman` directory, you need to move those files to the `/usr/lib/mailman` directory after you upgrade the mailman software package.

The following is a brief procedure for configuring a discussion list using Mailman:

1. Install the mailman RPM from the CentOS DVD or type **yum install mailman**.
2. Start your Web Server (if it isn't already running) as follows:

```
# service httpd start
# chkconfig httpd on
```

3. Create a password for your site as follows:

```
# /usr/lib/mailman/bin/mmsitepass
New site password: *****
Again to confirm password: *****
```

4. Edit the `/usr/lib/mailman/Mailman/mm_cfg.py` file and change the `DEFAULT_URL_HOST` and `DEFAULT_EMAIL_HOST` values. For example, the hostname of the computer I'm configuring my mailing list on is `dale.example.com`. The default e-mail host is `example.com`. The values would appear as follows:

```
DEFAULT_EMAIL_HOST = 'dale.example.com'
DEFAULT_URL_HOST DEF = 'example.com'
```

You can leave these values as `fqdn` to simply use the local computer's fully qualified domain name.

5. Edit the `/etc/httpd/conf.d/mailman.conf` file. To cause queries to Mailman to go to the `listinfo` page, uncomment the `RedirectMatch` line at the bottom of the file, and change that line to include your fully qualified domain name. For example, when I did this for the `example.com` mailing list, the line appeared as follows:

```
RedirectMatch ^/mailman[/]*$ http://www.example.com/mailman/
listinfo
```

- To create a Mailman mailing list, you must first create an unpopulated mailing list called *mailman*. Along with that list, you must assign the e-mail and initial password for the person responsible for administering the list. To do that, type the following:

```
# /usr/lib/mailman/bin/newlist mailman
Enter the email of the person running the list: timothy@example.com
Initial mailman password: ****
Hit enter to notify mailman owner...
```

- Restart the Web (httpd) service and start the mailman service as follows:

```
# service httpd restart
# service mailman start
# chkconfig mailman on
```

- Create a new mailing list, using the `newlist` command as follows:

```
# /usr/lib/mailman/bin/newlist
Enter the name of the list: pro
Enter the email of the person running the list: timothy@example.com
Initial pro password: ****
To finish creating your mailing list, you must edit /etc/aliases
(or
equivalent) file by adding the following lines, and running the
`newaliases' program:
```

```
## pro mailing list
pro: "|/usr/lib/mailman/mail/mailman post pro"
pro-admin: "|/usr/lib/mailman/mail/mailman admin pro"
pro-bounces: "|/usr/lib/mailman/mail/mailman bounces pro"
pro-confirm: "|/usr/lib/mailman/mail/mailman confirm pro"
pro-join: "|/usr/lib/mailman/mail/mailman join pro"
pro-leave: "|/usr/lib/mailman/mail/mailman leave pro"
pro-owner: "|/usr/lib/mailman/mail/mailman owner pro"
pro-request: "|/usr/lib/mailman/mail/mailman request pro"
pro-subscribe: "|/usr/lib/mailman/mail/mailman subscribe pro"
pro-unsubscribe: "|/usr/lib/mailman/mail/mailman unsubscribe pro"
```

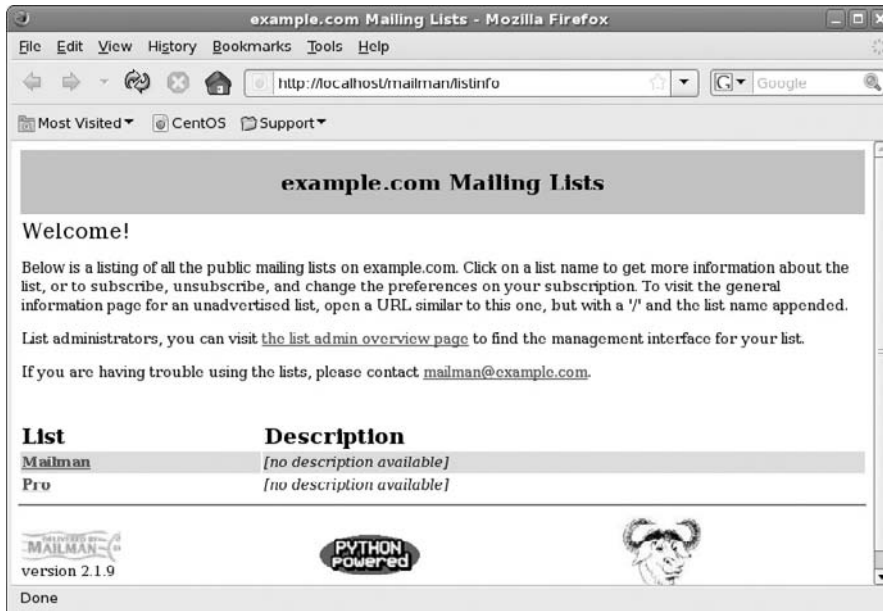
- Copy and paste the text just shown (starting from the line `## projectlist mailing list`) into the end of your `/etc/aliases` file.
- Run the `newaliases` command. At this point, you should be able to view the new mailing list from your Web browser. From a Web browser on the local system, type the following name in the address box:

```
http://localhost/mailman/listinfo
```

- If everything appears to be working, begin adding more mailing lists. In my example, I created a mailing list called *projectlist*. The name of that project appears on the list shown in Figure 18-3.
- Select that project name (click on it). The Info page should appear for the project.

**FIGURE 18-3**

Create multiple mailing lists in Mailman.



13. Scroll to the bottom of that page and click on the project administrative interface link.
14. When prompted, type in the List Administrator Password. Now you can configure the look, feel, and behavior of your mailing list. Important information you will want to consider includes:
  - **Privacy Options** — Do you want the list to be public or private (as in, just within your organization)? Who do you want to allow to see your member list?
  - **Send Filters** — Who can post messages to the list? Is the list moderated or unmoderated? Might the list just go in one direction, for example, as a way to contact customers?
  - **Membership Management** — Can your members see other member information? What are your policies for adding and removing members?
15. When you are finished configuring the options, be sure to submit your changes.

At this point, you can allow users to join the list. Encourage them to explore and set their own user preferences.

If you encounter problems configuring Mailman, refer to the `INSTALL.REDHAT` and `README` files in the `/usr/share/doc/mailman-*` directory.

## Summary

---

CentOS includes a full range of tools for configuring and managing mail servers. For Mail Transfer Agents, CentOS includes the Sendmail and Postfix software packages. Both are considered to be excellent, professional-quality mail servers.

To allow users to access their mailboxes from the server, CentOS includes the `dovecot` package. That package implements POP3 and IMAPv4 protocols to allow e-mail to be downloaded or manipulated on the server. You can also configure SquirrelMail to allow users to access their mail through a Web-based interface.

Information is included to help keep your mail service safe from intruders. In particular, filtering software such as SpamAssassin and virus scanner software such as ClamAV are critical to keeping your mail service clients safe from harm.

To set up mailing lists in CentOS, you can use the `mailman` package. In addition to including some very flexible configuration tools, Mailman also provides simple Web-based access to mailing list preferences and archives.



# Chapter 19

## Setting Up an FTP Server

**F**ile Transfer Protocol (FTP) has been the standard method for sharing files over the Internet for many years. Even with the popularity of the Web, which made document database services such as Gopher and WAIS obsolete, FTP servers are still the most common way to make directories of documents and software available to the public over the Internet.

File-sharing applications, such as NFS and Samba, are excellent tools for sharing files and directories over a private network. For organizations that need to share large numbers of files over public networks, however, FTP server software provides more robust tools for sharing files and protecting your computer systems. Also, FTP client software for accessing FTP servers is available for any type of computer that can access a network.

This chapter describes how to set up and maintain an FTP server using the Very Secure FTP Server package (vsFTPd).

Configuring your FTP server to allow users to upload files to your server involves more risk than just allowing downloads. Anyone could upload a malicious file, overwrite other files, or, depending on the configuration, place a file in an undesired location. To help mitigate this risk, you can set your server up in a chrooted environment to limit access to the file system.

Also, keep in mind that authentication information and file transfers are sent in plaintext across the network. If this traffic contains sensitive information, you might want to configure encryption. FTPS (also sometimes called *FTP/SSL*) is FTP over a Secure Sockets Layer connection. Space permits me only to cover a basic installation in this chapter. You can visit <http://chrootssh.sourceforge.net/docs/chrootedsftp.html> for more on setting up SFTP in a chrooted environment.

### IN THIS CHAPTER

**Understanding FTP servers**

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**Using the vsFTPd FTP server**

---

**Getting more information about FTP servers**

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**NOTE**

In discussing secure file transfer options, you may come across both SFTP and FTPS. FTPS is a newer protocol designed by the Internet Engineering Task Force (IETF) and offers more features than traditional FTP, including secure transfers. FTPS is FTP transacted over an encrypted SSL connection, while SFTP is SSH File Transfer Protocol.

**NOTE**

vsFTPD can easily be configured as an FTPS server. While I only discuss basic installation and configuration in this chapter, an overview of how to set up vsFTPD as an FTPS server can be found at <http://wingloon.com/2008/02/19/setup-vsftpd-205-with-tls-in-centos-51/>.

## Understanding FTP Servers

---

The first implementations of FTP date back to 1971, pre-dating the Web by almost two decades. FTP was created at a time when most computing was done on large mainframe computers and minicomputers. The predominant platforms using FTP were UNIX systems.

FTP set out to solve the need to publish documents and software so that people could get them easily from other computer systems. On the FTP server, files were organized in a directory structure. Users could connect to the server over the network (originally Darpanet and now the Internet), move up and down the directory structure to find the files that interested them, and download files from (and possibly upload files to) the server.

Originally, one drawback with FTP servers was that when people looked for a file or a document on the Internet, they had to know which FTP server held the file they were looking for. Tools such as Gopher and WAIS helped in searches. With the advent of the Web, however, users can now rely on a variety of search engines and links from web pages to help identify FTP servers that have the files they want. In fact, since most modern Web browsers have integrated multiple protocols to access content, when you download files by clicking a link from a web page, you may not even be aware that the file is being downloaded from an FTP server.

### Attributes of FTP Servers

That FTP was implemented on large, multiuser UNIX systems accounts for many of the design decisions that remain a part of FTP today. FTP servers in Linux draw on FTP features that have resulted from years of testing and experience gained from other UNIX versions of FTP. Some attributes of FTP servers follow:

- Because FTP was originally used on multiuser systems, only limited parts of the file system in CentOS are devoted to public FTP access. Those who access FTP from a public user account (by default, the `anonymous` username) are automatically given an FTP directory (often `/var/ftp`) as their root directory. From there, the `anonymous` user can access only files and directories below that point in the file system.

- Access to the FTP server relies on a login process that uses standard UNIX login names (i.e., those usernames found in `/etc/passwd`). Although strangers to the system could log in using `anonymous` as a username, users with their own accounts on the system could log in with their own usernames through FTP and most likely have access to a greater part of the file system (in particular, their own private files and directories).
- The `ftp` command and other FTP client programs let you log in and then operate from a command interpreter, similar to a very simple shell. Many of the commands that you use from that command interpreter are familiar UNIX commands. You change directories with `cd`, list files with `ls`, change permissions with `chmod`, and check your location with `pwd`, to name a few. When you find where you want to be, you use the `get` command to download a file or the `put` command to upload one.

As an administrator of an FTP server, it is your responsibility to make sure that you share your files in a way that gives people access to the information you want them to have without compromising the security of your system. This means implementing a strong security policy and relentlessly monitoring the system to prevent abuse.

## FTP User Types

Several different types of users can log in to and use an FTP server. *Real users* represent the category of users who have login accounts to the CentOS system that contains your FTP server (i.e., you know them and have given them permission for other uses besides FTP). With `vsftpd`, you can configure settings for each real user separately, if you choose.

A *guest user* is similar to a real user account, except that guest user access to the computer's file system is more restricted. The username `anonymous` is the most common for providing public (guest type) access.

The `vsftpd` server also supports the concept of *virtual users*. The recommended method for creating virtual users for `vsftpd` is to configure PAM (pluggable authentication modules) to point to per-user configuration files. Sample files for configuring virtual users are included with the `vsftpd` package. Refer to the `/usr/share/doc/vsftpd*/EXAMPLE` directory for directories containing virtual user example configuration files.

**CROSS-REF** See Chapter 10 for information on creating user accounts that have restricted access to your server.

## Using the Very Secure FTP Server

---

The Very Secure FTP Server (`vsftpd`) is the only general-purpose FTP server software included in CentOS distributions. `vsftpd` is becoming the FTP server of choice for sites that need to support thousands of concurrent downloads. It was also designed to secure your systems against most common attacks.

**NOTE**

The Trivial File Transfer Protocol server (`tftp-server` package), which is distributed with CentOS systems, can also be used to provide FTP service. The `tftpd` daemon is used primarily to provide support for diskless devices, which gather the files they need to boot and run from a TFTP server. TFTP is not intended for general, public FTP service. Because TFTP is considered a security risk to use publicly, it is generally used only on private LANs that are not accessible to public networks. Other FTP server packages now available from the RPMforge software repository include ProFTPD (<http://proftpd.org>) and Pure-FTPd (<http://pureftpd.org>).

Red Hat, Inc. uses vsFTPD on its own FTP servers (<ftp.redhat.com>). Other organizations in the Open Source software world have also made the switch to vsFTPD, including Debian Linux (<ftp.debian.org>), OpenBSD (<ftp.openbsd.org>) and the GNU Project (<ftp.gnu.org>).

Besides security and scalability, vsFTPD was designed for simplicity. Therefore, fewer options exist for configuring vsFTPD than you find in WU-FTPd, an older FTP server package that is still commonly used, so you are expected to rely on standard Linux file and directory permissions to provide refined access to your server. Getting started with vsFTPD, or using it to replace WU-FTPd, is fairly straightforward.

## Quick-Starting vsFTPD

By enabling the vsFTPD service, you can almost instantly have an FTP service running with the default values (set in the `/etc/vsftpd/vsftpd.conf` file). The following is a quick procedure for getting your vsFTPD server up and running. In case you didn't install vsFTPD when you originally installed CentOS, install it now by typing:

```
# yum install vsftpd
```

Here's how to start and try out the vsFTPD service.

1. To use the vsFTPD server, you must make sure that the vsFTPD software package is installed.

```
# rpm -q vsftpd
```

2. Enable the vsFTPD server by typing the following line (as `root` user):

```
# chkconfig vsftpd on
```

3. Start the vsFTPD server as follows:

```
# service vsftpd start
```

4. Try to log in to the FTP server as anonymous (using any e-mail address as the password):

```
$ ftp localhost
Connected to yourhost (127.0.0.1)
```

```
220 (vsFTPd 2.0.7)
Name (localhost:timothy): anonymous
331 Please specify the password.
Password: *****
230 Login successful.
Remote system type is UNIX.
Using binary mode to transfer files.
ftp>
```

If you saw messages similar to the preceding, your vsFTPd server is now up and running. Next, try to access the server from another computer on the network to be sure that it is accessible.

**NOTE**

If your FTP server is not accessible to the outside world, you may need to ensure that your network is configured properly and that your firewall allows access to port 21 and possibly port 20. The quick way is to run `system-config-firewall` and add FTP as a trusted service. Also, if SELinux is enabled, it may prevent access to your FTP server that you might normally expect to work. To set SELinux to permissive mode, type `setenforce 0` as root. Or type `man ftpd_selinux` to learn how to use SELinux with vsftpd.

The next section explains the `/etc/vsftpd/vsftpd.conf` configuration file.

## Configuring vsFTPd

Most of the configuration of vsFTPd is done in the `/etc/vsftpd/vsftpd.conf` file. Although many values are not set explicitly in `vsftpd.conf`, you can override the defaults by setting `option=value` statements in this file. You can set such things as which users have access to your vsFTPd server, how logging is done, and how time-outs are set.

Read the following sections for more information about how vsFTPd is configured by default and how you can further configure your vsFTPd server.

### User Accounts

Users who can access your vsFTPd server are, by default, the `anonymous` user and any users with real user accounts on your system. A *guest user* is simply a real user account that is restricted to its own home directory. The following lines set these user access features:

```
anonymous_enable=YES
local_enable=YES
```

The `anonymous_enable` line lets users log in anonymously using either the `anonymous` or `ftp` username. If you want to disable access by anonymous users, don't just comment out `anonymous_enable`. Anonymous access is on by default, so you must set `anonymous_enable=NO` to disable it.

Any users with local accounts in `/etc/passwd` and valid passwords can log into the FTP server with `local_enable` set to YES. An exception to this rule is that, by default, all user accounts listed in the `/etc/vsftpd/user_list` file are denied access.

**NOTE**

Before you start logging into an FTP server with your personal username and password, keep in mind that FTP login service uses clear text passwords. Because of this fact, a network sniffer is capable of seeing this information. If you want to use an FTP interface to access files on an FTP server using your personal account, consider using the Openssh ([www.openssh.org/](http://www.openssh.org/)) `sftp` command instead of a normal FTP client. If the FTP server includes an SSH server, you can use `sftp` to connect to that server using encrypted passwords.

Check the `user_list` file to see which users are denied access to the vsFTPD server. Note that `root` and other administrative logins are excluded. You can add other users to this list or change the location of the list by setting the `userlist_file` parameter to the file you want. To add a user to the `user_list` or use the `userlist_file` parameter to create a new list, you must also have `userlist_enable` set to YES (as it is by default). For example:

```
userlist_file=/etc/vsftpd/user_list_local
userlist_enable=YES
```

If you like, you can change the meaning of the `/etc/vsftpd/user_list` file so that only the users in that list are allowed to use the vsFTPD service. Set `userlist_deny=NO` and change the `/etc/vsftpd/user_list` to include only names of users to whom you want to grant access to the server. All other users, including `anonymous` and `ftp`, will be denied access.

## Setting FTP Access

The vsFTPD server software provides a simple and seemingly secure approach to access permissions. Instead of using settings in the FTP service to selectively prevent downloads and uploads of particular directories (as FTP servers like WU-FTPD do), you can use standard Linux file and directory permissions to limit access. There are, however, the following general settings in the `/etc/vsftpd/vsftpd.conf` file to let users get files from and put files onto your vsFTPD server.

### Downloading Files

Any users with valid logins (anonymous or real users, excluding some administrative logins) can download files from the vsFTPD server by default. The ability to download a particular file or a file from a particular directory is governed by the following basic Linux features:

- **File and Directory Permissions** — Standard file and directory permissions apply as a means of limiting access to particular files, even in accessible file systems. So, if the `root` user puts a file with 600 permission (Read/Write to `root` only) in the `/var/ftp` directory, an anonymous user is not able to download that file.
- **Root Directory** — The root directory (`chroot`) for anonymous users is `/var/ftp`. The root directory for regular users is the entire computer's root directory (`/`), although their current directory after connecting to FTP is `/home/user`, where `user` is the username. So an anonymous user is restricted to downloads from the `/var/ftp` directory structure, while a regular user potentially has access to the whole file system. Another possibility is to create `guest` accounts by restricting some or all users to their home directories.

You can use the `chroot_local_user` option to change the root directory for regular users so that they are restricted to their home directory. To restrict all regular users to their home directory when using vsFTPd, add this line to the `vsftpd.conf` file:

```
chroot_local_user=YES
```

To enable the concept of *guest* users, you can choose to limit only selected users to their home directories. You do this by setting `chroot_list_enable` to `YES` and then adding a list of guest users to a file noted with the `chroot_list_file` option. The following example lets you add such a list (one username per line) to the `/etc/vsftpd/chroot_list` file:

```
chroot_list_enable=YES
chroot_list_file=/etc/vsftpd/chroot_list
```

**TIP**

To restrict a user to FTP access only, set the user's shell to `/sbin/nologin` in the `/etc/passwd` file. Do this by running the `system-config-users` command or `usermod` command and changing properties for the user, as described in Chapter 10.

You can add a setting to the `vsftpd.conf` file to affect how files are downloaded. To enable ASCII downloads, you can enable that feature as follows:

```
ascii_download_enable=YES
```

Without making that change, all downloads are done in binary mode. Although vsFTPd will seem to allow the user to change to `ascii` mode, `ascii` mode will not work if this setting is `NO`. Allowing ASCII file transfers is considered to be a security risk (vulnerable to denial-of-service attacks from an FTP client using the `size` command to check the size of large files on the server) and should be avoided. With ASCII downloads disabled, it is up to the client side to handle ASCII mangling when required.

### Uploading (Writing) Files from Local Users

Two values set in the `vsftpd.conf` file allow the uploading of files during a vsFTPd session. The following defaults allow any users with regular, local user accounts to upload files:

```
write_enable=YES
local_umask=022
```

The `write_enable` value must be `YES` if you intend to allow any users the capability to write to the FTP server. The `umask=022` value sets the default file permission used when a local user creates a file on the server. The `022` value causes files created to have 644 permission, allowing the user Read and Write permission and everyone else only Read permission.

As with downloading, uploading in `ascii` mode is prohibited by default. Although `ascii` downloads create a potential security hole for draining resources from your server, `ascii` uploads are apparently not as dangerous and can be useful for uploading text files. To allow `ascii` uploads, add the following line:

```
ascii_upload_enable=YES
```

### ***Uploading (Writing) Files from Anonymous Users***

The ability to upload files is turned off for anonymous FTP users. If you want to turn it on, add the following line to the `vsftpd.conf` file:

```
anon_upload_enable=YES
```

To use anonymous upload, the global write enable must be activated. You must also make sure that the `/var/ftp` directory contains one or more directories with Write permissions open to anonymous users. For example, you might want to create an incoming directory and open its permissions (`chmod 777 /var/ftp/incoming`).

Files uploaded by anonymous users will be created with 600 permission by default (Read/Write permission for the `ftp` user, not accessible to any other users so that even the user who uploaded the files can't remove them or even see them). To allow 644 permission, for example, you can add the following line:

```
anon_umask=022
```

When you allow the anonymous user to upload files, you can grant limited ability to change the files he or she uploads. By adding the following line, you can allow anonymous users to rename or delete any files owned by anonymous users provided that the files are in directories for which the users have Write permission:

```
anon_other_write_enable=YES
```

If you also want to allow anonymous users to create their own directories, add the following:

```
anon_mkdir_write_enable=YES
```

By default, the `ftp` user is given ownership of uploaded files from anonymous users. If you want to indicate that anonymous uploads be owned by a different user (of your choice), you can use the `chown_uploads` and `chown_username` options. For example, if you have a user account named `mynewuser`, you can set these options as follows:

```
chown_uploads=YES  
chown_username=mynewuser
```

Of course, you can create and use any username you want. However, for security reasons, you should not use the `root` login or any other administrative login for this purpose.

### **Adding Message Files**

Although `vsFTPd` doesn't support the arrangement of `README` and `welcome` files that FTP servers such as `WU-FTP` support, you can add `.message` files to any accessible directory on your `vsFTPd` server. Then, if you use the default `dirmessage_enable` option as follows, the text from the `.message` file will be displayed when the user enters the directory:

```
dirmessage_enable=YES
```

You will probably at least want to add a `.message` file to the root directory of the FTP server for anonymous users. By default, that location is `/var/ftp/.message`. If you want to use files other than `.message` files, you can set the `message_file` option. For example, to have text from the `.mymessage` file displayed when you enter a directory, you can add the following line:

```
message_file=.mymessage
```

A `.message` file provides an opportunity for you to add information about the contents of your server, copyright information, or instructions on how to use the software. By allowing different message files, you can tailor what you want to say to visitors, depending on where they are located on your file server.

You can also set a one-line message to appear before the login prompt. You can do this by entering the following line, replacing the text with anything you want to say:

```
ftpd_banner=Welcome to My FTP service.
```

As a security measure, you could consider adding a banner that indicates a different operating system from that you have running. Any information that can slow down a potential intruder from finding out what software you are running makes it easier for you to keep that intruder out.

## Logging vsFTPD Activities

Logging is enabled in vsFTPD by default, and the activities of your vsFTPD site are written to the `/var/log/xferlog` file. The following options enable logging and change the log file to `/var/log/vsftpd.log`:

```
xferlog_enable=YES  
xferlog_file=/var/log/vsftpd.log
```

You can turn off logging if you like by changing `YES` to `N0`. Note, however, that logging enables you to watch for potential break-ins, so turning it off is not recommended. Or you can change the location of the log file by changing the value of the `xferlog_file` option. Keep in mind that with a lot of usage, your FTP server can produce a lot of log messages. So, to be useful, you need to monitor the logs fairly often.

If you want to be able to use tools that generate transfer statistics, you can have vsFTPD log data written in the standard `xferlog` format that is used by WU-FTPD and other FTP servers. To store your transfer data in `xferlog` format, set the following option:

```
xferlog_std_format=YES
```



## Setting Time-Outs

The following time-outs are set by default in vsFTPD (these values are built in, so you don't have to make any changes to the `/etc/vsftpd/vsftpd.conf` file for them to take effect):

```
accept_timeout=60
connect_timeout=60
idle_session_timeout=600
data_connection_timeout=120
```

The `accept_timeout=60` and `connect_timeout=60` values determine how long the client has to establish a PASV or PORT style connection, respectively, before the connection times out. Both are set to 60 seconds. (Note that these two lines are not automatically included in the configuration file; you can add them by hand if you want to change their values.) The `idle_session_timeout=600` option causes the FTP session to be dropped if the user has been inactive for more than 10 minutes (600 seconds). The `data_connection_timeout` value sets the amount of time, during which no progress occurs, that the server will wait before dropping the connection (the default here is 120 seconds).

## Navigating a vsFTPD Site

Most shell wildcard characters that a user might expect to use, such as question marks and brackets, are supported by vsFTPD. There is one particularly useful wildcard character you can use with the `ls` command, and one option you can turn on. The asterisk (\*) wildcard can be used with the `ls` command. Multiple asterisks in the same line are supported.

By default, you cannot list directory contents recursively. This is because it is possible for an attacker to launch a DOS attack using this feature if the server has a large number of files on it. (The attacker could establish many slow connections to the server and run `ls -lR` at the same time on each connection.) To turn on support for the `-R` option of `ls` so that a user can recursively list the contents of the current directory and all subdirectories, you can add the following line to the `vsftpd.conf` file:

```
ls_recurse_enable=YES
```

## Setting Up vsFTPD behind a Firewall

If you are configuring an FTP server behind a firewall, you need to do some special configuration to allow communications to pass through that firewall to those you want to allow access to your server. To deal with the issue, you can use ephemeral port numbers (which provide random, temporary port numbers within a range of numbers as needed). For a description of the issue, refer to the “FTP and Your Firewall” page at [www.ncftpd.com/ncftpd/doc/misc/ftp\\_and\\_firewalls.html](http://www.ncftpd.com/ncftpd/doc/misc/ftp_and_firewalls.html).

## Getting More Information about FTP Servers

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There are plenty of resources for gaining more information about FTP servers. Here are some of your options:

- **FAQ** — To check out the vsFTPD FAQ, go to `/usr/share/doc/vsftpd*/FAQ`.
- **RFCs** — *Requests For Comments* are the documents that define standard protocols used with the Internet. The main RFC for FTP is RFC959. You can obtain RFCs from a variety of locations on the Internet, including the Internet RFC/FYI/STD/BCP Archives ([www.faqs.org/rfcs](http://www.faqs.org/rfcs)).
- **CERT** — This organization provides useful documents for setting up FTP servers. *Anonymous FTP Abuses* describes how to respond to and recover from FTP server abuse. It also tells how to deal with software piracy issues. *Anonymous FTP Configuration Guidelines* provides general guidance in setting up your FTP area, as well as specific challenges of setting up a writable FTP area. Both of those documents are available from the CERT Tech Tips page ([www.cert.org/tech\\_tips](http://www.cert.org/tech_tips)).

**TIP**

I strongly recommend reading the FTP documents from CERT. The tips in these documents will help keep your FTP server secure, while enabling you to offer the services that you want to share.

## Summary

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The FTP service is the primary method of offering archives of document and software files to users over the Internet. The only FTP server package delivered with CentOS is the Very Secure FTP (vsFTPD) server. The vsFTPD server relies on standard Linux file and user permissions to provide a simple, yet secure, FTP environment to run in CentOS.



# Chapter 20

## Setting Up a Web Server

Approximately 50 percent of all web sites today are powered by the Open Source Apache Web Server Project (compared to about 31% for Microsoft Web Servers). In April 2009, Netcraft ([www.netcraft.com](http://www.netcraft.com)) reported receiving responses from more than 231 million sites, more than 106 million of which were running Apache. As registration of Internet domain names continues to grow at an average rate of more than 1 million a month, Apache is getting the lion's share of new web sites being launched.

The Web has also been a boon to organizations seeking an inexpensive means to publish and distribute information. Using the CentOS distribution that comes with this book, you can launch your own web site using software available from the Apache project. Combine your own domain name, Internet connection, and CentOS to create your own presence on the World Wide Web.

This chapter shows you how to install and configure the Apache Web Server. Each of the server's configuration files is described and explained in detail. You learn about various options for starting and stopping the server, as well as how to monitor the activity of a Web Server. Related security concerns and practices are addressed throughout the chapter in the descriptions and examples, as well as in a special Web Server security section ("Protecting Web Servers with Certificates and Encryption") in Chapter 13.

### IN THIS CHAPTER

Introduction to Web Servers

Quick-starting the Apache Web Server

Configuring the Apache Web Server

Starting and stopping the server

Monitoring server activities

**NOTE**

The current version of CentOS comes with Apache version 2.2. Apache 2.2 includes support for a new Apache application programming interface, UNIX threading (for multiprocessing), Internet Protocol version 6 (IPv6), and multiple protocols. If you have been using a pre-2.0 version of Apache, you should note that the package names `apache` and `apache-manual` have changed to `httpd` and `httpd-manual`.

## Introduction to Web Servers

---

The World Wide Web, as it is known today, began as a project of Tim Berners-Lee at the European Center for Particle Physics (CERN). The original goal was to provide one consistent interface for geographically dispersed researchers and scientists who needed access to information in a variety of formats. From this idea came the concept of using one client (the Web browser) to access data (text, images, sounds, video, and binary files) from several types of servers (HTTP, FTP, SMTP, Gopher, NNTP, WAIS, Finger, and streaming-media servers).

The Web Server usually has a simpler job: to accept HyperText Transfer Protocol (HTTP) requests and send a response to the client. However, this job can get much more complex (as the server can also), executing functions such as:

- Performing access control based on file permissions, username/password pairs, and hostname/IP address restrictions
- Parsing a document (substituting appropriate values for any conditional fields within the document) before sending it to the client
- Spawning a Common Gateway Interface (CGI) script or custom Application Programming Interface (API) program to evaluate the contents of a submitted form, presenting a dynamically created document, or accessing a database
- Logging any successful accesses, failures, and errors

## The Apache Web Server

The Apache Web Server was originally based on HTTPd, a free server from the National Center for Supercomputing Applications (NCSA). At the time, HTTPd was the first and only Web Server on the Internet. Unfortunately, the development of the server wasn't keeping up with the needs of webmasters, and several security problems had been discovered. Many webmasters had been independently applying their own features and fixes to the NCSA source code.

In early 1995, a group of these developers pooled their efforts and created a new project from this code base called *Apache*. Since then, what is now the Apache Software Foundation ([www.apache.org](http://www.apache.org)) has largely re-written the code and created a stable, multiplatform Web Server daemon. More than two dozen related projects are also sponsored by the Apache Software Foundation. Those projects include `mod_perl` (to create dynamic web sites with the Perl language), `Jakarta` (to provide server-side Java content), `DB` (to create and maintain commercial-quality database solutions), and `SpamAssassin` (to identify and deal with junk e-mail).

The main features of the Apache Web Server include:

- The stability and rapid development cycle associated with a large group of cooperative volunteer programmers
- Full source code, downloadable at no charge. So restrictions by End User License Agreements (EULAs) and caps on the number of servers you can run don't apply.
- Ease of configuration using plaintext files
- Access control based on client hostname/IP address or username/password combinations.
- Support for server-side scripting as well as CGI scripts. This includes the ability to have different users controlling script execution (to limit the vulnerability of a whole Web Server if a single script is compromised).
- A custom API that enables external modules (e.g., for extended logging capabilities, improved authentication, caching, connection tracking, etc.) to be used by the server daemon

Apache is not the only Web Server for CentOS, but it is the one most often used with Linux and is still the most popular server used on the Internet according to Netcraft ([http://news.netcraft.com/archives/web\\_server\\_survey.html](http://news.netcraft.com/archives/web_server_survey.html)). In addition to Apache, you can find the `lighttpd` and `thttpd` lightweight Web Servers in the RPMforge Repository.

## Other Web Servers Available for CentOS

Some other Web Servers that can run on CentOS are described in the following list, with URLs that provide more detailed information.

- **lighttpd** — The `lighttpd` Web Server ([www.lighttpd.net](http://www.lighttpd.net)) is built for security, speed, compliance, and flexibility. It is particularly optimized for high-performance environments because it has a low memory footprint and balances CPU load. Sites such as YouTube, Wikipedia, and meebo have used `lighttpd` for some specialty web applications.
- **tclhttpd** — The `TclHttpd` Web Server (`tclhttpd` package) is created in the Tool Command Language (TCL). Besides acting as a Web Server, `TclHttpd` can also be used as a TCL application server.
- **thttpd** — The `thttpd` HTTP server (<http://acme.com/software/thttpd>) was designed to be simple, small, portable, fast, and secure. Its creators call it a “tiny, turbo, throttling HTTP server.” It implements little more than the minimum needed to be HTTP/1.1-compliant, so it can run much faster than many larger Web Servers under extreme loads.
- **XSP** — The `XSP` Web Server (`xsp` package) can run ASP.NET applications, as well as related services for working with ASP.NET applications.
- **Zope** — In addition to being able to serve Web content, `Zope` includes features for adding news, membership information, and search capabilities. Originally created by the

Zope Corporation ([www.zope.org](http://www.zope.org)), Zope is now available as an Open Source project covered under the GPL. Zope is not included with the current version of CentOS. You can get Zope from the Zope development site (<http://zope.sourceforge.net>). Zope is Python-based.

- **CERN (W3C) Jigsaw 2.2.6** — The latest HTTP/1.1 reference server, written completely in Java and freely available, can be found at [www.w3.org/Jigsaw](http://www.w3.org/Jigsaw). It features extensive caching, an improved mechanism for executing external programs (although CGI is also supported), and a graphical administration tool.

## Quick-Starting the Apache Web Server

---

If Apache wasn't installed during the CentOS installation, you can install it later from the DVD or CD that comes with this book. You will need the `httpd` package and optionally the `httpd-manual` package (named `apache` and `apache-manual` in earlier versions).

Here's a quick way to get your Apache Web Server going. From here, you'll want to customize it to match your needs and your environment (as described in the section that follows):

1. Make sure that Apache is installed by typing the following from a Terminal window:

```
$ rpm -qa | grep httpd
system-config-httpd-1.3.3.3-1.e15
httpd-2.2.3-11.e15_2.centos.4
httpd-devel-2.2.3-11.e15_2.centos.4
httpd-manual-2.2.3-11.e15_2.centos.4
```

The version number you see may be different. You need only the `httpd` package to get started. I recommend `httpd-manual` because it has excellent information on the whole Apache setup. The `httpd-devel` package includes the `apxs` tool for building and installing extension modules.

The `system-config-httpd` package contains a GUI-based Apache Configuration tool. Depending on the type of content you are serving, you might also add packages containing modules to run that code within the Apache server (such as `mod_perl`, `mod_python`, and `mod_mono`).

2. A valid hostname is recommended if it is a public Apache server. If you don't have a real, fully qualified domain name, you can edit the `/etc/httpd/conf/httpd.conf` file and define the `ServerName` as your computer's IP address. Open the `httpd.conf` file (as the root user) in any text editor, search for the line containing `ServerName www.example.com:80`, and uncomment it. It should appear as follows:

```
ServerName www.example.com:80
```

To make the Web Server available to your LAN, you can use your IP address instead of `www.example.com` (e.g., `ServerName 10.0.0.1`). The `:80` represents the port number (which is the default). For a public Web Server, get a real DNS hostname. (Refer to Chapter 24 for information on DNS and making a server public.) No changes are required to this file to make Apache available on the local host.

3. Add an administrative e-mail address where someone can contact you in case an error is encountered with your server. In the `/etc/httpd/conf/httpd.conf` file, the default administrative address appears as follows:
 

```
ServerAdmin root@localhost
```

Change `root@localhost` to the e-mail address of your Apache administrator.
4. Start the `httpd` server. As `root` user, type the following:
 

```
# service httpd start
```

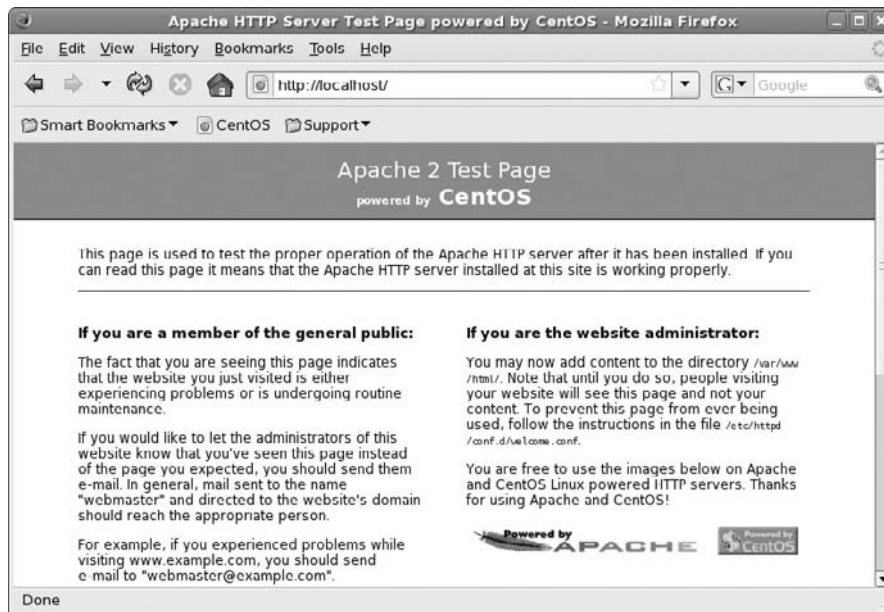
If all goes well, this message should appear: `Starting httpd: [OK]`. Now you're ready to go.
5. To have `httpd` start every time you boot your system, run the command as `root` user.
 

```
# chkconfig httpd on
```
6. To make sure that the Web Server is working, open Firefox (or another Web browser), type the following into the Location box, and press [Enter]:
 

```
http://localhost/
```
7. You should see the Test Page for the Apache Web Server, as shown in Figure 20-1. To access this page from another computer, you will need to enter your Apache server's hostname or IP address.

**FIGURE 20-1**

Appearance of the Test Page indicates that the Apache installation succeeded.





**TIP**

It is not necessary to be connected to a network (or even to have a network connection) just to test the server or to view the files on your local Apache machine. Rather than specify the server's real name in the URL, just use *localhost* (i.e., `http://localhost/`) from a browser on the same computer. In fact, it's best to test the configuration fully before making the server accessible on an unprotected network.

8. The Test Page is actually an error condition, indicating that you haven't added any content to your web site yet. To get started, you can add an `index.html` file that contains your own home page content in the `/var/www/html` directory. Then you can continue to add your own content to that directory structure.

Now that your Web Server is working (or, at least, I hope it is), you should step through the next section. It helps you understand how to set up more complex Web Server arrangements and protect your server from misuse. Stepping through that section will also help you troubleshoot your Web Server, in case it isn't working.

**TIP**

If your Web Server is accessible from your local host but not available to others from your LAN or the Internet, you may need to change your firewall rules to allow greater access. In particular, you need to open TCP port 80 and possibly TCP port 443 (if you offer HTTPS content). Also, if SELinux is enabled, it may prevent access to your Web Server that you might normally expect to work. To set SELinux to permissive mode, type `setenforce 0` as root. Or type `man httpd_selinux` to learn how to use SELinux with `httpd`.

## Configuring the Apache Server

---

The primary file for configuring your Apache Web Server is `httpd.conf` (located in the `/etc/httpd/conf` directory). A few years ago, the Apache project began recommending not using additional configuration files, such as `srm.conf` and `access.conf`, and simply putting everything in `httpd.conf`. In recent releases, however, there has been a trend toward having modules and other components that are used with Apache have their own configuration files (usually located in the `/etc/httpd/conf.d/` directory).

All Apache configuration files are plaintext files and can be edited with your favorite text editor. The `/etc/httpd/conf/httpd.conf` file is reproduced in its entirety in the following section, with explanations inserted after related blocks of options (intended to supplement the comments provided with each file).

Some individual modules, scripts, and other services related to Apache — such as Perl, PHP, SSL, Webalizer, and MySQL — have individual configuration files that may interest you. Those files are contained in the `/etc/httpd/conf.d/` directory. The “Configuring Modules and Related Services (`/etc/httpd/conf.d/*.conf`)” section later in this chapter discusses modules and related features.

**CROSS-REF**

More information on Apache can be obtained on your own Web Server, from `http://localhost/manual/` (if the `httpd-manual` package is installed).

## Configuring the Web Server (httpd.conf)

The `httpd.conf` file is the primary configuration file for the Apache Web Server. It contains options that pertain to the general operation of the server. The default filename (`/etc/httpd/conf/httpd.conf`) can be overridden by the `-f filename` command-line argument to the `httpd` daemon or the `ServerConfigFile` directive. The following sections list the contents of the `httpd.conf` file and describe how to use the file.

The first section contains comments about the `httpd.conf` file:

```
# This is the main Apache server configuration file. It contains the
# configuration directives that give the server its instructions.
# See <URL:http://httpd.apache.org/docs/2.2/> for detailed information.
# In particular, see
# <URL:http://httpd.apache.org/docs/2.2/mod/directives.html>
# for a discussion of each configuration directive.
#
# Do NOT simply read the instructions in here without understanding
# what they do. They're here only as hints or reminders. If you are
# unsure consult the online docs. You have been warned.
#
# The configuration directives are grouped into three basic sections:
# 1. Directives that control the operation of the Apache server
#    process as a whole (the 'global environment').
# 2. Directives that define parameters of the main or default server,
#    which responds to requests that aren't handled by a virtual host.
#    These directives also provide default values for the settings
#    of all virtual hosts.
# 3. Settings for virtual hosts, which allow Web requests to be sent
#    to different IP addresses or hostnames and have them handled by
#    the same Apache server process.
#
# Configuration and logfile names: If the filenames you specify for
# many of the server's control files begin with "/" (or "drive:/" for
# Win32), the server will use that explicit path. If the filenames do
# *not* begin with "/", the value of ServerRoot is prepended -- so
# "logs/foo.log" with ServerRoot set to "/usr/local/apache" will be
# interpreted by the server as "/usr/local/apache/logs/foo.log".
#
```

This section consists entirely of comments. It basically tells you how information is grouped together in this file and how the `httpd` daemon accesses this file. By default, log files are in the `/var/log/httpd` directory.

### Setting the Global Environment

In “Section 1: Global Environment” of the `httpd.conf` file, you set directives that affect the general workings of the Apache server. Here is what the different directives are for:

```
### Section 1: Global Environment
#
# The directives in this section affect overall operation of Apache,
# such as the number of concurrent requests it can handle or where it
# can find its configuration files.
#
```

### **Revealing Subcomponents**

The `ServerTokens` directive lets you prevent remote computers from finding out what sub-components you are running on your Apache server. Comment out this directive if you don't mind exposing this information. To prevent exposure, `ServerTokens` is set as follows:

```
#
# Don't give away too much information about all the subcomponents
# we are running. Comment out this line if you don't mind remote sites
# finding out what major optional modules you are running
ServerTokens OS
```

Setting `ServerTokens` to `ProductOnly` would minimize the connection information a potential cracker could see.

### **Setting the Server Root Directory**

The `ServerRoot` directive specifies the directory that contains the configuration files, a link to the log file directory, and a link to the module directory. An alternative `ServerRoot` pathname can be specified using the `-d` command-line argument to `httpd`.

```
# ServerRoot: The top of the directory tree under which the server's
# configuration, error, and log files are kept.
#
# NOTE! If you intend to place this on an NFS (or other network) mounted
# filesystem then please read the LockFile documentation (available
# at <URL:http://httpd.apache.org/docs/2.2/mod/core.html#lockfile>);
# you will save yourself a lot of trouble.
#
# Do NOT add a slash at the end of the directory path.
#
ServerRoot "/etc/httpd"
```

### **Storing the Server's PID File**

The Apache Web Server keeps track of the PID for the running server process. You can change the locations of this file using the entry described next:

```
#
# PidFile: The file in which the server should record its process
# identification number when it starts.
#
PidFile run/httpd.pid
```

Apache uses the `PidFile` to store the process ID of the first (root-owned) master daemon process. This information is used by the `/etc/init.d/httpd` script when shutting down the server and also by the server-status handler (as described later).

### **Configuring Time-Out Values**

You can set several values that relate to time-out. Some of these values are described in the text following the code:

```
#
# Timeout: The number of seconds before receives and sends time out.
#
Timeout 120

#
# KeepAlive: Whether or not to allow persistent connections (more than
# one request per connection). Set to "Off" to deactivate.
#
KeepAlive Off

#
# MaxKeepAliveRequests: The maximum number of requests to allow
# during a persistent connection. Set to 0 to allow unlimited amount.
# We recommend you leave this number high, for maximum performance.
#
MaxKeepAliveRequests 100

#
# KeepAliveTimeout: Number of seconds to wait for the next request from
# the same client on the same connection.
#
KeepAliveTimeout 15
```

The `Timeout` directive determines the number of seconds that Apache will hold a connection open between the receipt of packets, between the receipt of acknowledgments on sent responses, or while receiving an incoming request. The default of 2 minutes (120 seconds) can be lowered if you find an excessive number of open, idle connections on your machine.

The `KeepAlive` directive instructs Apache to hold a connection open for a period of time after a request has been handled. This enables subsequent requests from the same client to be processed faster, as a new connection doesn't need to be created for each request. This is preferred so you can keep the load and number of connections down.

The `MaxKeepAliveRequests` directive sets a limit on the number of requests that can be handled with one open connection. The default value is certainly reasonable because most connections will hit the `KeepAliveTimeout` before `MaxKeepAliveRequests`.

The `KeepAliveTimeout` directive specifies the number of seconds to hold the connection while awaiting another request. You might want to increase the default (15 seconds). Reasons for having a longer time-out could be to allow all the images on the page to be downloaded

on the same connection or to take into account how long it may take a client to peruse your average page and select a link from it. The web application you are using may also need a longer persistent connection. (Of course, a longer `KeepAliveTimeout` prevents each server from moving on to another client during this time period, so you may find that you need to add more request processes to account for that.)

## Setting the Number of Server Processes

To operate efficiently, a Web Server has to be able to handle lots of incoming requests for content simultaneously. To be ready for requests for Web content, Apache (as it is set up in CentOS) has multiple server processes (`httpd` daemons) running and listening to service requests. Those servers can, in turn, direct requests to multiple threads to service the content requests.

With the Multi-Processing Module (MPM) feature (introduced in Apache 2.0), support for threads was added to Apache. On an operating system that supports Native POSIX Thread Libraries (which CentOS does), threading allows Apache to improve performance by needing fewer process slots and less memory for the number of servers it needs. Adding threads consumes fewer resources than adding processes.

For a low-volume Web Server, you can probably leave the parameters alone that support the MPM feature. You will probably have enough processes to handle your incoming requests, but not so many that they will be a drain on your server. However, if your server needs to serve up lots of content consistently or needs to respond occasionally to large spikes of requests, you should consider tuning the MPM-related parameters in the `httpd.conf` file.

Here are a few issues to consider if you want to change any of the MPM-related parameters:

- **RAM Is Critical** — Every process and thread that is active consumes some amount of memory. If the number of active processes and threads goes beyond the amount of RAM you have, your computer will begin to use swap space, and performance will degrade quickly. Make sure that there is enough RAM on your system to handle the maximum number of server processes and threads you expect to run on your Apache Web Server.
- **Configure for Maximum Load** — Apache is able to create new server processes and threads as they are needed. You don't need to have the maximum number of processes and threads available at all times. Instead, you can configure the maximum number of servers and threads that Apache can dynamically add as demand on the server requires.
- **Configure for Performance** — Performance degrades when Apache has to start a new thread (small amount), start a server process (greater amount), or use swap space (greatest amount). In the perfect world, the exact number of servers you need should be the default number of servers running, with a few spares to handle reasonable spikes. If response is critical, you might opt to have more servers running than you need so that performance isn't hurt when spikes come.

When Apache starts up, it launches a set number of `httpd` server processes (one parent and multiple child `httpd` processes) to handle incoming requests for content for the Web Server. Parameters for defining how many `httpd` server processes are available include those that set:

- How many child server processes should be started by the parent httpd server (`StartServers`)
- The minimum number of idle server processes kept spare (`MinSpareServers`)
- The maximum number of idle server processes kept spare (`MaxSpareServers`)
- The maximum value `MaxClients` can be over the life of the server (`ServerLimit`)
- The maximum number of server processes allowed to start (`MaxClients`)
- The maximum number of requests a process can serve (`MaxRequestsPerChild`)

Parameters for defining how many threads are available for each httpd server process include those that set:

- The minimum number of spare threads that should always be available, after which more will be created (`MinSpareThreads`)
- The maximum number for spare threads, after which active threads will be deleted to get back to the number of threads per child (`MaxSpareThreads`)
- The number of threads always available to each child process (`ThreadsPerChild`)

The following code example shows how MPM-specific parameters in the `httpd.conf` file are set for the `prefork.c` module (non-threaded module for managing servers processes) and `worker.c` (multithread, multiprocess Web Server module).

```
###
### Server-Pool Size Regulation (MPM specific)
###
<IfModule prefork.c>
StartServers      8
MinSpareServers   5
MaxSpareServers   20
ServerLimit       256
MaxClients        256
MaxRequestsPerChild 4000
</IfModule>

<IfModule worker.c>
StartServers      2
MaxClients        150
MinSpareThreads   25
MaxSpareThreads   75
ThreadsPerChild   25
MaxRequestsPerChild 0
</IfModule>
```

Apache starts a master daemon process owned by `root` that binds to the appropriate port and then switches to a non-privileged user. More servers (equivalent to the value of the `StartServers` directive in `prefork.c`) will then be started as the same non-privileged user (the `apache` user in this case).

Apache attempts to intelligently start and kill servers based on the current load. If the amount of traffic decreases and there are too many idle servers, some will be killed (down to the number of servers noted in `MinSpareServers`). Similarly, if many requests arrive in close proximity and there are too few servers waiting for new connections, more servers will be started (up to the number of servers noted in `MaxClients`).

**NOTE**

Getting the value of `MaxClients` right is critical because it puts a lid on the total number of simultaneous client connections that can be active at a time. If the number of `MaxClients` servers are in use, no more will be created and subsequent requests to the server will fail until one is freed up.

Using the values specified above, when the daemon is started, the parent and eight child server processes will run, waiting for connections (as defined by `StartServers`). As more requests arrive, Apache will ensure that at least five server processes are ready to answer requests. When requests have been fulfilled and no new connections arrive, Apache will begin killing processes until the number of idle Web Server processes is below 20. The value of `StartServers` should always be somewhere between `MinSpareServers` and `MaxSpareServers`.

Apache limits the total number of simultaneous threads with the `MaxClients` directive. The default value is 150, which should be sufficiently high. However, if you find that you frequently have nearly that many threads running, remember that any connection beyond the 150th will be rejected. In such cases, if your hardware is sufficiently powerful (and if your network connection can handle the load), you should increase the value of `MaxClients`.

**NOTE**

You can see the state of your Apache server processes and get a feel for the server's activity by viewing the [Server Status page](#) for your server, as described later in this chapter. The `ps -fU apache` command will show you if the Apache server processes (`httpd` daemon) are currently running.

To minimize the effect of possible memory leaks (and to keep the server pool “fresh”), each server process is limited in the number of requests that it can handle (equal to the value of `MaxRequestsPerChild`). After servicing 4,000 requests (the value specified above), the process will be killed. It is even more accurate to say that each process can service 4,000 *connections* because all `KeepAlive` requests (occurring prior to encountering a `KeepAliveTimeout`) are calculated as just one request.

In a multiprocessor environment, setting thread values described previously can both limit the number of threads that servers can consume and supply as many threads as you will allow to handle server processing. `MinSpareThreads` and `MaxSpareThreads` control the number of threads available that are not being used. More are added if available threads fall below `MinSpareThreads`. If spare threads go above `MaxSpareThreads`, some are dropped.

## Binding to Specific Addresses

You can bind to specific IP addresses using the `Listen` directive. `Listen` directives can be used to add to the default bindings you already have:

```
# Listen: Allows you to bind Apache to specific IP addresses and/or
# ports, in addition to the default. See also the <VirtualHost>
# directive.
#
# Change this to Listen on specific IP addresses as shown below to
# prevent Apache from glomming onto all bound IP addresses (0.0.0.0)
#Listen 12.34.56.78:80
Listen 80
```

The `Listen` directive is more flexible than the `BindAddress` directive. Multiple `Listen` commands can be specified, enabling you to specify several IP address/port number combinations. It can also be used to specify just IP addresses or just port numbers.

By default, Apache listens to port 80 (for standard http services) and port 443 (for secure https services) on all interfaces on the local computer (which is where Web browsers expect to find Web content). Listening on only `localhost:80` restricts access only to users on the local machines. A Web Server run by a non-privileged user often will bind to port 8080 (only root can bind to ports lower than 1024). If you have multiple network interface cards, you can limit which interfaces Apache will listen on (e.g., you can have a Web Server only intended for the company LAN that is not exposed to your Internet interface).

## Selecting Modules in `httpd.conf`

During the compilation process, individual Apache modules can be selected for dynamic linking. Dynamically linked modules are not loaded into memory with the httpd server process unless `LoadModule` directives explicitly identify those modules to be loaded. The blocks of code that follow select several modules to be loaded into memory by using the `LoadModule` directive with the module name and the path to the module (relative to `ServerRoot`). The following text shows a partial listing of these modules:

```
#
# Dynamic Shared Object (DSO) Support
# Example:
# LoadModule foo_module modules/mod_foo.so
#
LoadModule auth_basic_module modules/mod_auth_basic.so
LoadModule auth_digest_module modules/mod_auth_digest.so
LoadModule authn_file_module modules/mod_authn_file.so
.
.
.
LoadModule file_cache_module modules/mod_file_cache.so
LoadModule mem_cache_module modules/mod_mem_cache.so
LoadModule cgi_module modules/mod_cgi.so
```

Apache modules are included in the list of active modules via the `LoadModule` directive. The `ClearModuleList` directive removes all entries from the current list of active modules. Each of the standard modules that come with Apache is described in Table 20-1.



TABLE 20-1

### Dynamic Shared Object (DSO) Modules

Module	Description
<code>mod_actions</code>	Conditionally executes CGI scripts based on the file's MIME type or the request method.
<code>mod_alias</code>	Allows for re-direction and mapping parts of the physical file system into logical entities accessible through the Web Server.
<code>mod_asis</code>	Enables files to be transferred without adding any HTTP headers (e.g., the <code>Status</code> , <code>Location</code> , and <code>Content-Type</code> header fields).
<code>mod_auth_basic</code>	Provides HTTP Basic Authentication. It is used in combination with authentication modules (such as <code>mod_authn_file</code> ) and authorization modules (such as <code>mod_authz_user</code> ).
<code>mod_auth_digest</code>	Provides MD5 Digest user authentication.
<code>mod_authn_alias</code>	Lets you create extended authentication providers that are assigned to aliases. Later you can reference the aliases through <code>AuthBasicProvider</code> or <code>AuthDigestProvider</code> directives.
<code>mod_authn_anon</code>	Similar to anonymous FTP, this module enables predefined usernames access to authenticated areas by using a valid e-mail address as a password.
<code>mod_authn_dbd</code>	Provides access to SQL tables to authenticate users. It lets you use <code>mod_auth_basic</code> and <code>mod_auth_digest</code> front-ends.
<code>mod_authn_dbm</code>	Provides access control based on username/password pairs. The authentication information is stored in a DBM binary database file, with encrypted passwords.
<code>mod_authn_default</code>	Offers a fallback authentication module, if no other is in use. Any credentials presented by the user are rejected.
<code>mod_authn_file</code>	Provides access control by user lookup in plaintext password files (similar to <code>mod_authn_dbm</code> , but without encryption).
<code>mod_authnz_ldap</code>	Lets you use an LDAP directory to store the HTTP Basic Authentication database.
<code>mod_authz_dbm</code>	Provides access control to authenticated users based on group name. The authentication information is stored in a DBM binary database file.
<code>mod_authz_default</code>	If modules such as <code>mod_authz_user</code> or <code>mod_authz_groupfile</code> are not configured, the module provides a fallback (simply rejecting authorization requests).

*continued*

**TABLE 20-1** (continued)

Module	Description
<code>mod_authz_groupfile</code>	Provides access control based on group membership.
<code>mod_authz_host</code>	Provides access control based on client hostname, IP address, or other environment variable characteristics.
<code>mod_authz_owner</code>	With a verified username and password, this module allows access to files based on ownership.
<code>mod_authz_user</code>	Allows access to files based on whether an authenticated user is listed in a <code>Required User</code> directive.
<code>mod_autoindex</code>	Implements automatically generated directory indexes.
<code>mod_cache</code>	Allows local or proxied Web content to be cached. Used with the <code>mod_disk_cache</code> or <code>mod_mem_cache</code> modules.
<code>mod_cern_meta</code>	Offers a method of emulating CERN HTTPD meta file semantics.
<code>mod_cgi</code>	Controls the execution of files that are parsed by the “ <code>cgi-script</code> ” handler or that have a MIME type of <code>x-httpd-cgi</code> . <code>ScriptAlias</code> sets the default directory.
<code>mod_cgid</code>	Similar to <code>mod_cgi</code> with the exception that this module offers a <code>ScriptSock</code> directive to name the socket used with the <code>cgi</code> daemon.
<code>mod_dav</code>	Provides Web-based Distributed Authoring and Versioning (WebDAV) to upload Web content using copy, create, move, and delete resources.
<code>mod_dav_fs</code>	Used to provide file system features to the <code>mod_dav</code> module, used with Web-based Distributed Authoring and Versioning (WebDAV)
<code>mod_dbd</code>	Uses <code>apr_dbd</code> to manage SQL database connections. (The <code>apr_dbd</code> framework offers a common API for different SQL databases.)
<code>mod_deflate</code>	Includes the DEFLATE output filter, to compress data before it is sent to the client.
<code>mod_dir</code>	Sets the list of filenames that may be used if no explicit filename is selected in a URL that references a directory.
<code>mod_disk_cache</code>	Enables a disk-based storage manager to use with <code>mod_proxy</code> .
<code>mod_dumpio</code>	Lets you log all input received by or sent from Apache. Because this can involve a lot of data, it is used mostly for debugging purposes.
<code>mod_env</code>	Controls environment variables passed to CGI scripts.

*continued*

**TABLE 20-1** (continued)

Module	Description
mod_expires	Implements time limits on cached documents by using the Expires HTTP header.
mod_ext_filter	Before delivering a response to the client, passes it through an external filter.
mod_file_cache	Allows caching of frequently requested static files.
mod_filter	Allows you to configure context-sensitive output filtering.
mod_headers	Enables the creation and generation of custom HTTP headers.
mod_ident	Lets you query an RFC 1413-compatible daemon on a remote host to request information on the owner of a connection.
mod_imagemap	Replaces the functions of the imagemap CGI program to process.map files.
mod_include	Implements Server-Side Includes (SSI), which are HTML documents that include conditional statements parsed by the server prior to being sent to a client. This module also has the ability to include files one into another.
mod_info	Provides a detailed summary of the server's configuration, including a list of actively loaded modules and the current settings of every directive defined within each module.
mod_ldap	Used to speed performance of web sites using LDAP servers
mod_logio	Can be used to log bytes of data that are sent and received
mod_log_config	Enables a customized format for information contained within the log files.
mod_log_forensic	Provides the ability to do forensic logging of client requests.
mod_mem_cache	Used with mod_cache to provide memory-based storage
mod_mime	Alters the handling of documents based on predefined values or the MIME type of the file.
mod_mime_magic	Similar to the UNIX file command, this module attempts to determine the MIME type of a file based on a few bytes of the file's contents.
mod_negotiation	Provides for the conditional display of documents based on the Content-Encoding, Content-Language, Content-Length, and Content-Type HTTP header fields.
mod_proxy	Implements an HTTP 1.1 proxy/gateway server.

*continued*

**TABLE 20-1** (continued)

Module	Description
mod_proxy_ajp	Uses mod_proxy to provide support for Apache JServ Protocol (version 1.3).
mod_proxy_balancer	Extension to mod_proxy to handle load balancing
mod_proxy_connect	Extension to mod_proxy to handle CONNECT requests
mod_proxy_ftp	Extension to mod_proxy to handle FTP requests
mod_proxy_http	Extension to mod_proxy to handle HTTP requests
mod_rewrite	Provides a flexible and extensible method for re-directing client requests and mapping incoming URLs to other locations in the file system.
mod_setenvif	Conditionally sets environment variables based on the contents of various HTTP header fields.
mod_speling	Attempts to correct misspellings automatically in requested URLs.
mod_ssl	Implements cryptography using SSL and TLS protocols.
mod_status	Provides a summary of the activities of each individual httpd server process, including CPU and bandwidth usage levels.
mod_suexec	Lets CGI scripts run with permission of a particular user or group.
mod_unique_id	Assigns the UNIQUE_ID environment variable to provide a unique identifier for each request.
mod_userdir	Specifies locations that can contain individual users' HTML documents.
mod_usertrack	Uses cookies to track the progress of users through a web site.
mod_version	Allows you to use <IFVersion> containers to allow version-dependent configuration.
mod_vhost_alias	Contains support for dynamically configured mass virtual hosting.

If a particular module contains features that are not necessary, it can easily be commented out of the preceding list. In fact, it is a good security practice to comment-out unused modules. Similarly, you might want to add the features or functionality of a third-party module (e.g., mod\_perl, which integrates the Perl runtime library for faster Perl script execution, or mod\_php, which provides a scripting language embedded within HTML documents) by including those modules in the list.

**NOTE**

Some modules, including core, prefork, http\_core, and mod\_so, are compiled into the httpd daemon in CentOS. To see the list of modules compiled into the daemon, type **httpd -l**.

More information about each module (and the directives that can be defined within it) can be found on your server at `http://localhost/manual/mod/` (provided that you have installed the `httpd-manual` package).

## Including Module-Specific Configuration Files

The following lines cause Apache to load configuration files from the `/etc/httpd/conf.d/` directory. This directory contains configuration files associated with specific modules.

```
#
# Load config files from the config directory "/etc/httpd/conf.d".
#
Include conf.d/*.conf
```

**CROSS-REF** The “Configuring Modules and Related Services (`/etc/httpd/conf.d/*.conf`)” section, later in this chapter, describes some of the configuration files in the `conf.d` directory that may interest you.

## Choosing the Server’s User and Group

The `httpd` daemon doesn’t have to run as the `root` user; the fact that it doesn’t run as `root` by default makes your system more secure. By setting `User` and `Group` entries, you can have the `httpd` daemon run using the permissions associated with a different user and group:

```
# If you wish httpd to run as a different user or group, you must run
# httpd as root initially and it will switch.
#
# User/Group: The name (or #number) of the user/group to run httpd as.
# . On SCO (ODT 3) use "User nouser" and "Group nogroup".
# . On HPUX you may not be able to use shared memory as nobody, and
# the suggested workaround is to create a user www and use that user.
# NOTE that some kernels refuse to setgid(Group) or semctl(IPC_SET)
# when the value of (unsigned)Group is above 60000;
# don't use Group #-1 on these systems!
#
User apache
Group apache
```

By default, `apache` is defined as both the user and group for the server. If you change the `User` and `Group` directives, you should specify a non-privileged entity. This minimizes the risk of damage if your site is compromised. The first daemon process that is started runs as `root`. This is necessary to bind the server to a low-numbered port and to switch to the user and group specified by the `User` and `Group` directives. All other processes run under the user ID (UID) and group ID (GID) defined by those directives.

## Setting the Main Server's Configuration

The second section of the `http.conf` file relates to directives handled by your main server (the one defined by the `ServerName` directive). In other words, these values are used by the default server and for all virtual hosts, unless they are explicitly changed for a virtual host. To change the same directives for particular virtual hosts, add them within virtual host containers.

### Setting an E-Mail Address

You can identify an address where users can send e-mail if there is a problem with your server. This is done with the `ServerAdmin` directive:

```
#
# ServerAdmin: Your address, where problems with the server should be
# e-mailed. This address appears on some server-generated pages, such
# as error documents. e.g. admin@your-domain.com
#
ServerAdmin you@your.address
```

The `ServerAdmin` directive can be set to any valid e-mail address. The default is `root@localhost`.

### Setting the Server Name

If your server name is anything but your exact registered hostname or domain name, you should identify your server name here. As the comments point out, the `ServerName` directive can be set to a value other than the actual hostname of your machine. However, this other name should still point to your machine in DNS if the server is to be a public Internet server. Frequently, `www` is just an alias for the real name of the machine (e.g., a machine may respond to `www.linuxtoys.net`, but its real name may be `al.linuxtoys.net`).

```
ServerName jukebox.linuxtoys.net
```

Apache tries to use your hostname as the `ServerName`, if you don't enter a valid server name. It is recommended that you explicitly enter a `ServerName` here.

### Setting Canonical Names

Use the `UseCanonicalName` directive to create a self-referencing URL, as follows:

```
## UseCanonicalName: Determines how Apache constructs self-referencing
# URLs and the SERVER_NAME and SERVER_PORT variables.
# When set "Off", Apache will use the Hostname and Port supplied
# by the client. When set "On", Apache will use the value of the
# ServerName directive.
#
UseCanonicalName Off
```

The `UseCanonicalName` directive provides a form of naming consistency. When it is set to `On`, Apache uses the `ServerName` and `Port` directives to create a URL that references a file on the same machine (e.g., `www.linuxtoys.net/docs/`). When `UseCanonicalName` is `Off`, the URL consists of whatever the client specified (e.g., the URL could be `http://al.linuxtoys.net/docs/` or `http://al/docs/` if the client is within the same domain).

This can be problematic, particularly when access-control rules require username and password authentication: if the client is authenticated for the host `al.linuxtoys.net` but a link sends him or her to `www.linuxtoys.net` (physically the same machine), the client will be prompted to enter a username and password again. It is recommended that `UseCanonicalName` be set to `On`. In the preceding situation, the authentication would not need to be repeated because any reference to the same server would always be interpreted as `www.linuxtoys.net`.

### Identifying HTTP Content Directories

There are several directives for determining the location of your server's Web content. The main location for your Web content is set to `/var/www/html` by the `DocumentRoot` directive. Notice that the trailing slash is not used on the pathname.

#### NOTE

This location has changed from early versions; the location was formerly in `/home/http`.

```
# DocumentRoot: The directory out of which you will serve your
# documents. By default, all requests are taken from the directory, but
# symbolic links and aliases may be used to point to other locations.
DocumentRoot "/var/www/html"
```

### Setting Access Options and Overrides

You can set individual access permissions for each directory in the Web Server's directory structure. The default is fairly restrictive. Here is the default:

```
<Directory />
    Options FollowSymLinks
    AllowOverride None
</Directory>
```

This segment sets up a default block of permissions for the `Options` and `AllowOverride` directives. The `<Directory /> . . . </Directory>` tags enclose the directives that are to be applied to the `/` directory (which is `/var/www/html` by default, as defined by `DocumentRoot`).

The `Options FollowSymLinks` directive instructs the server that symbolic links within the directory can be followed to allow content that resides in other locations on the computer. None of the other special server features will be active in the `/` directory, or in any directory below that, without being explicitly specified later. Next, the following access options are

specifically set for the root of your Web Server (`/var/www/html`). (I removed the comments here for clarity.)

```
<Directory "/var/www/html">
    Options Indexes FollowSymLinks
    AllowOverride None
    Order allow,deny
    Allow from all
</Directory>
```

If you have changed the value of `DocumentRoot` earlier in this file, you need to change the `/var/www/html` to match that value. The `Options` set for the directory are `Indexes` and `FollowSymLinks`. Those and other special server features are described in Table 20-2. The `AllowOverride None` directive instructs the server that an `.htaccess` file (or the value of `AccessFileName`) cannot override any of the special access features. You can replace `None` with any of the special access features described in Table 20-3.

**TABLE 20-2**

### Special Server Features for the Options Directive

Feature	Description
<code>ExecCGI</code>	The execution of CGI scripts is permitted.
<code>FollowSymLinks</code>	The server will traverse symbolic links.
<code>Includes</code>	Server-Side Includes are permitted.
<code>IncludesNOEXEC</code>	Server-Side Includes are permitted, except the <code>#exec</code> element.
<code>Indexes</code>	If none of the files specified in the <code>DirectoryIndex</code> directive exists, a directory index will be generated by <code>mod_autoindex</code> .
<code>MultiViews</code>	The server allows content negotiation based on preferences from the user's browser, such as preferred language, character set, and media type.
<code>SymLinksIfOwnerMatch</code>	The server will traverse symbolic links only if the owner of the target is the same as the owner of the link.
<code>None</code>	None of the features above are enabled.
<code>All</code>	All the features above are enabled, with the exception of <code>MultiViews</code> . This must be explicitly enabled.

**NOTE**

Remember that unless you specifically enable a feature described in Tables 20-2 and 20-3, that feature is not enabled for your server (with the exceptions of `Indexes` and `FollowSymLinks`).



TABLE 20-3

### Special Access Features for the AllowOverride Directive

Feature	Description
AuthConfig	Enables authentication-related directives (AuthName, AuthType, AuthUserFile, AuthGroupFile, Require, etc.).
FileInfo	Enables MIME-related directives (AddType, AddEncoding, AddLanguage, LanguagePriority, etc.).
Indexes	Enables directives related to directory indexing (FancyIndexing, DirectoryIndex, IndexOptions, IndexIgnore, HeaderName, ReadmeName, AddIcon, AddDescription, etc.).
Limit	Enables directives controlling host access (Allow, Deny, and Order).
Options	Enables the Options directive (as described in Table 20-2).

### Identifying User Directories

If you have multiple users on your server and you want each to be able to publish its own Web content, it is common practice to identify a directory name that users can create in their own home directories to store that content. When you identify the name that is appended to a user's home directory, that directory is used to respond to requests to the server for the user's name (`~user`). This directory name used to be set to `public_html` by default; however, it is now turned off by default.

To allow access to your users' personal web pages, add a comment character (`#`) to the `UserDir` disable line. Then remove the `#` from the `UserDir public_html` line to make users' personal `public_html` directories accessible through the Web Server. After removing extra comment lines, the following text shows what the enabled section looks like:

```
# UserDir: The name of the directory which is appended onto a user's
# home directory if a ~user request is received.

<ifModule mod_userdir.c>
# UserDir disable
UserDir public_html
</IfModule>
```

Besides uncommenting the `UserDir public_html` line shown in the previous example, you must make both the user's home directory and `public_html` directory executable by everyone in order for the `UserDir` directive to allow access to a particular user's `public_html` directory. For example, the user `cjb` could type the following to make those directories accessible.

```
$ chmod 711 /home/cjb
$ mkdir /home/cjb/public_html
$ chmod 755 /home/cjb/public_html
```

For UserDir to work, the `mod_userdir` module must also be loaded (which it is by default).

There are two ways in which the UserDir directive can handle an incoming request that includes a username (e.g., `~cjb`). One possible format identifies the physical pathname of the individual users' publicly accessible directories. The other can specify a URL to which the request is re-directed. A few examples are presented in Table 20-4, using the URL `www.mybox.com/~cjb/proj/c004.html` as a sample request.

**TABLE 20-4**

### UserDir Pathname and URL Examples

UserDir Directive	Referenced Path or URL
<code>UserDir public_html</code>	<code>~cjb/public_html/proj/c004.html</code>
<code>UserDir /public/*/WWW</code>	<code>/public/cjb/WWW/proj/c004.html</code>
<code>UserDir /usr/local/web</code>	<code>/usr/local/web/cjb/proj/c004.html</code>
<code>UserDir http://www.mybox.com/users</code>	<code>http://www.mybox.com/users/cjb/proj/ c004.html</code>
<code>UserDir http://www.mybox.com/~*</code>	<code>http://www.mybox.com/~cjb/proj/c004.html</code>
<code>UserDir http://www.mybox.com/*/html</code>	<code>http://www.mybox.com/cjb/html/proj/ c004.html</code>

The UserDir directive can also be used to explicitly allow or deny URL-to-pathname translation for particular users. For example, it is a good idea to include the following line to avoid publishing data that shouldn't be made public:

```
UserDir disable root
```

Alternatively, use the following lines to disable the translations for all but a few users:

```
UserDir disable  
UserDir enable wilhelm cjb jsmith
```

#### NOTE

You should always be careful about content you publish about yourself on the Internet (names, addresses, personal information, etc.) and also keep in mind that you can be held accountable for the content you publish on your Web Server. When you allow others to publish on your Web Server, your liability can extend to what those users publish as well. Be sure to have a clear policy about what is acceptable (and legal) to publish on your Web Server, and give that information to those you allow to use the server.

### Setting Default Index Files for Directories

The `DirectoryIndex` directive establishes a list of files that is used when an incoming request specifies a directory rather than a file. For example, a client requests the URL

`www.mybox.com/~jsmith`. Because it's a directory, it is automatically translated to `www.mybox.com/~jsmith/`. Now that directory is searched for in any of the files listed in the `DirectoryIndex` directive. The first match (from the default list of `index.html` and `index.html.var`) is used as the default document in that directory. If none of the files exist and the `Indexes` option (as in the `httpd.conf` file) is selected, the server will automatically generate an index of the files in the directory.

```
# DirectoryIndex: sets the file that Apache will serve if a directory
# is requested.
#
# The index.html.var file (a type-map) is used to deliver content-
# negotiated documents. The MultiViews Option can be used for the
# same purpose, but it is much slower.
#
DirectoryIndex index.html index.html.var
```

Sometimes dynamic content (such as `index.php` or `index.cgi`) will be added to the `DirectoryIndex` to make sure that dynamic content is accessed before static content when a user simply requests a domain name or directory.

### Setting Directory-Access Control

You and your users can add an access file to each directory to control access to that directory. By default, the `AccessFileName` directive sets `.htaccess` as the file containing this information. The following lines set this filename and prevent the contents of that file from being viewed by visitors to the web site. If you change the file to a name other than `.htaccess`, be sure to change the line below ("`^\.ht`") that denies access to that file.

```
#
# AccessFileName: The name of the file to look for in each directory
# for access control information.
#
AccessFileName .htaccess

<Files ~ "^\.ht">
    Order allow,deny
    Deny from all
</Files>
```

You can add the same access directives to an `.htaccess` file as you do to the `httpd.conf` file. In general, it is more efficient to use a `<Directory>` directive in the `httpd.conf` file than it is to create an `.htaccess` file. With a `<Directory>` directive, you can specifically identify the access associated with that directory alone. Because directives you put in `.htaccess` apply to all directories below the current directory, any time you add an `.htaccess` file to a directory, Apache must search all directories above that point (e.g., `/`, `/var`, `/var/www`, etc.) to include settings from possible `.htaccess` files in those directories as well.

### Setting MIME-Type Defaults

The location of the MIME-type definitions file is defined by the `TypesConfig` directive. The `DefaultType` directive sets the MIME type:

```
# TypesConfig describes where the mime.types file (or equivalent) is
# to be found.
#
TypesConfig /etc/mime.types

#
# DefaultType is the default MIME type the server will use for a
# document if it cannot otherwise determine one, such as from filename
# extensions. If your server contains mostly text or HTML documents,
# "text/plain" is a good value. If most of the content is binary, such
# as applications or images, you may want to use "application/octet-
# stream" instead to keep browsers from trying to display binary files
# as though they are text.
#
DefaultType text/plain
```

With the `mod_mime_magic` module, a server can look for hints to help figure out what type of file is being requested. You must make sure this module is loaded to Apache for it to be used (it is loaded by default). The module can use hints from the `/usr/share/magic.mime` (off by default) and `/etc/httpd/conf/magic` (on by default) files to determine the contents of a requested file. Here are the directives that cause that module to be used:

```
<IfModule mod_mime_magic.c>
#  MIMEMagicFile /usr/share/magic.mime
#  MIMEMagicFile conf/magic
</IfModule>
```

### Setting Hostname Lookups

With the Apache Web Server, you can have the server look up addresses for incoming client requests. Turning on the `HostnameLookups` entry can do this:

```
# HostnameLookups: Log the names of clients or just their IP addresses
HostnameLookups Off
```

If the `HostnameLookups` directive is turned on, every incoming connection will generate a DNS lookup to translate the client's IP address into a hostname. If your site receives many requests, the server's response time could be adversely affected. The `HostnameLookups` should be turned off unless you use a log file analysis program or statistics package that requires fully qualified domain names and cannot perform the lookups on its own. The `logresolve` program that is installed with the Apache distribution can be scheduled to edit log files by performing hostname lookups during off-peak hours.

### Configuring HTTP Logging

You can set several values related to logging of Apache information. When a relative path-name is shown, the directory set by `ServerRoot` (`/etc/httpd/` by default) is appended (e.g., `/etc/httpd/logs/error_log`). As shown in the following example, you can set the location of error logs, the level of log warnings, and some log nicknames:

```
#
# ErrorLog: The location of the error log file.
# If you do not specify an ErrorLog directive within a <VirtualHost>
# container, error messages relating to that virtual host will be
# logged here. If you *do* define an error logfile for a <VirtualHost>
# container, that host's errors will be logged there and not here.
#
ErrorLog logs/error_log

#
# LogLevel: Control the number of messages logged to the error_log.
# Possible values include: debug, info, notice, warn, error, crit,
# alert, emerg.
#
LogLevel warn

#
# The following directives define some format nicknames for use with
# a CustomLog directive (see below).
#
LogFormat "%h %l %u %t \"%r\" %>s %b \"%{Referer}i\" \"%{User-
Agent}i\"" combined
LogFormat "%h %l %u %t \"%r\" %>s %b" common
LogFormat "%{Referer}i -> %U" referer
LogFormat "%{User-agent}i" agent

#
# Location and format of the access logfile (Common Logfile Format).
# If you do not define any access logfiles within a <VirtualHost>
# container, they will be logged here. Contrariwise, if you *do*
# define per-<VirtualHost> access logfiles, transactions will be
# logged therein and *not* in this file.
#
# CustomLog logs/access_log common

# If you would like to have separate agent and referer logfiles,
# uncomment the following directives.

#
#CustomLog logs/referer_log referer
#CustomLog logs/agent_log agent
```

```
#  
# For a single logfile with access, agent, and referer information  
# (Combined Logfile Format), use the following directive:  
#  
CustomLog logs/access_log combined
```

These lines deal with how server errors, client tracking information, and incoming requests are logged. The `ErrorLog` directive, which can specify an absolute pathname or a pathname relative to the `ServerRoot` (which is `/etc/httpd` by default), indicates where the server should store error messages. In this case, the specified file is `logs/error_log`, which expands to `/etc/httpd/logs/error_log` (which, in reality, is a symlink to the `error_log` file in the `/var/log/httpd` directory).

The `LogLevel` directive controls the severity and quantity of messages that appear in the error log. Messages can range from the particularly verbose `debug` log level to the particularly silent `emerg` log level. With `debug`, a message is logged any time the configuration files are read, when an access-control mechanism is used, or if the number of active servers has changed. With `emerg`, only critical system-level failures that create panic conditions for the server are logged.

The level specified by the `LogLevel` directive indicates the least-severe message that will be logged — all messages at that severity and above are recorded. For example, if `LogLevel` is set to `warn`, the error log will contain messages at the `warn`, `error`, `crit`, `alert`, and `emerg` levels. The default value of `warn` is a good choice for normal use (it will log only significant events that may eventually require operator intervention), but `info` and `debug` are perfect for testing a server's configuration or tracking down the exact location of errors.

The four `LogFormat` lines define (for later use) four types of log file formats: `combined`, `common`, `referer`, and `agent`. You can also add a fifth format called *combinedio*. The tokens available within the `LogFormat` directive are described in Table 20-5. The `LogFormat` definitions can be modified to your own personal preference, and other custom formats can be created as needed.

The *common* format includes the client's hostname or IP address, the username as reported by the `ident` daemon and the server's authentication method (if applicable), the local time at which the request was made, the actual HTTP request, the server response code, and the number of bytes transferred. This format is a de facto standard among Web Servers (and lately even among FTP servers).

For the purpose of connection tracking, the *referer* format stores the URL (from the same site or an external server) that linked to the document just delivered (relative to the `ServerRoot`). For example, if the page `www.example.com/corp/about_us.html` contained a link to your home page at `www.mybox.com/linuxguy/bio.html`, when a client accessed that link, the `referer` log on `www.mybox.com` would look like:

```
http://www.example.com/corp/about_us.html -> /linuxguy/bio.html
```

This information can be used to determine which path each client took to reach your site.

TABLE 20-5

## Available Tokens within LogFormat

Token	Description
%a	The IP address of the client machine
%b	The number of bytes sent to the client (excluding header information)
%{VAR}e	The contents of the environment variable VAR
%f	The filename referenced by the requested URL
%h	The hostname of the client machine
%{Header}i	The contents of the specified header line in the HTTP request
%l	As reported by the <code>identd</code> daemon (if available), the user on the client machine who initiated the request
%{Note}n	The contents of the message <code>Note</code> from a different module
%{Header}o	The contents of the specified header line in the HTTP response
%p	The port number on which the request was received
%P	The PID of the server process that handled the request
%r	The actual HTTP request from the client
%s	The server response code generated by the request
%t	The current local time and date. The time format can be altered using <code>%{Format}t</code> , where <code>Format</code> is described in the <code>strftime(3)</code> man page.
%T	The number of seconds required to fulfill the client request
%u	If access-control rules require username and password authentication, this represents the username supplied by the client.
%U	The URL requested by the client
%v	The hostname and domain name of the server according to the Domain Name System (DNS)
%V	The hostname and domain name of the server handling the request according to the <code>ServerName</code> directive

The *agent* format stores the contents of the `User-Agent` HTTP header for each incoming connection. This field typically indicates the browser name and version, the language, and the operating system or architecture on which the browser was run. On a Pentium II running CentOS, Mozilla will produce the following entry:

```
Mozilla/5.0 (X11; U; Linux i686; en-US; rv:1.6)
```

The *combined* format includes all the information from the other three log file formats into one line. This format is useful for storing all connection-related log entries in one centralized file. The *combinedio* format, which is commented out by default, can be enabled (by removing the # character) to log the actual number of bytes received (%I) and sent (%O), provided the `mod_logio` module is loaded.

The `CustomLog` directive assigns one of the defined `LogFormat` formats to a filename (again, specified as an absolute pathname or a pathname relative to the `ServerRoot`). The only uncommented definition assigns a combined format to the `/etc/httpd/logs/access_log` file. To retain the agent or referer information separately, uncomment the definitions. Also, you could choose to comment-out the `CustomLog logs/access_log combined` line and use the definition for the common format instead.

### ***Adding a Signature***

Any page that is generated by the Apache server can have a signature line added to the bottom of the page. Examples of server-generated pages include a directory listing, error page, a status page, or an info page. The `ServerSignature` directive can be set to `On`, `Off`, or `EEmail`. Here is how `ServerSignature` appears by default:

```
# Optionally add a line containing the server version and virtual
# host name to server-generated pages (error documents, FTP directory
# listings, mod_status and mod_info output etc., but not CGI generated
# documents).
# Set to "EEmail" to also include a mailto: link to the ServerAdmin.
# Set to one of: On | Off | EEmail
#
ServerSignature On
```

With `ServerSignature On`, a line similar to the following appears at the bottom of server-generated pages:

```
Apache/2.2.8 (CentOS) Server at zarkov.example.com Port 80
```

With `ServerSignature` set to `EEmail`, a link to the web page's administrative e-mail account is added to the signature line (the server name becomes the link). If the directive is set to `Off`, the line doesn't appear at all. With SSL or WebDAV enabled, this information will appear in the server signature as well. In general, it's best to reveal as little information as possible on Internet-facing servers (so it may be best to leave these directives off).

### ***Aliasing Relocated Content***

There are various ways to define alias content. These include the `Alias` and the `ScriptAlias` directives. Here are alias-related settings in `httpd.conf` (with comments removed):

```
#
# Aliases: Add here as many aliases as you need (with no limit). The format is
# Alias fakename realname
```



```

#
Alias /icons/ "/var/www/icons/"

<Directory "/var/www/icons">
    Options Indexes MultiViews FollowSymLinks
    AllowOverride None
    Order allow,deny
    Allow from all
</Directory>

# ScriptAlias: This controls which directories contain server scripts.
ScriptAlias /cgi-bin/ "/var/www/cgi-bin/"

# "/var/www/cgi-bin" should be changed to whatever your ScriptAliased
# CGI directory exists, if you have that configured.
#
<Directory "/var/www/cgi-bin">
    AllowOverride None
    Options None
    Order allow,deny
    Allow from all
</Directory>

```

The `Alias` directive points to a file system location (not necessarily within the `DocumentRoot`). For example, with the following line in place, requests for documents in `/bigjob` (`www.mybox.com/bigjob/index.html`) would result in the retrieval of `/home/newguy/proj/index.html`.

```
Alias /bigjob /home/newguy/proj
```

The `icons` alias allows access to the Apache icons used by the Web Server for your web site. The `icons` directory is accessible from the `/var/www` directory.

The `ScriptAlias` directive performs a related function, but directories that it aliases contain executable code (most likely CGI scripts). The syntax is the same as for the `Alias` directive. Pay special attention whenever you use `ScriptAlias`. Because `ScriptAlias` defines where scripts that can be run from Web content on the server are located, you should make sure that you assign only those directories that contain scripts that are secured and won't open security holes in your system.

### ***Redirecting Requests for Old Content***

As content changes on your Web Server, some content will become obsolete, while other content may move to a different place in the file system or to a different server. Using the `Redirect` directive, you can re-direct requests for old content to new locations.

By default, there are no `Redirect` directives set for your Apache server. However, you can uncomment the following example and tailor it to your needs:

```
# Redirect permanent /foo http://www.example.com/bar
```

`Redirect` can be used to instruct clients that the document they seek has moved elsewhere (to the same server or to an external location) by simply indicating the old and new locations. If the previous `Redirect` option were in place, a client's attempt to access `www.mybox.com/foo` would re-direct to `www.example.com/bar`.

Besides using `permanent` as the service for `Redirect` (which results in a re-redirect status 301), you could instead use `temp` (a re-redirect status of 302), `seeother` (a replaced status of 303), or `gone` (a permanently removed status of 401). You could also give any status code between 300 and 399 as the service, which represent different error responses. (These numbers are HTTP status codes.)

**CROSS-REF** The HTTP status codes are defined as part of the HTTP protocol in RFC 2616. Refer to that document at [www.w3.org/Protocols/rfc2616/rfc2616.txt](http://www.w3.org/Protocols/rfc2616/rfc2616.txt).

## Defining Indexing

It's possible to have your Apache server show different icons for different types of files. To use this feature, `IndexOptions` should be set to `FancyIndexing`; and `AddIconByEncoding`, `AddIconByType`, and `AddIcon` directives should be used:

```
# Directives controlling display of server-generated directory listings.

# FancyIndexing is if you want fancy directory indexing or standard.
# VersionSort is whether files containing version numbers should be
# compared in the natural way, so that 'apache-1.3.9.tar' is placed
# before 'apache-1.3.12.tar'.
#
IndexOptions FancyIndexing VersionSort NameWidth=* HTMLTable
#
# AddIcon* directives tell the server which icon to show for different
# files or filename extensions. These are only displayed for
# FancyIndexed directories.
#
AddIconByEncoding (CMP,/icons/compressed.gif) x-compress x-gzip

AddIconByType (TXT,/icons/text.gif) text/*
AddIconByType (IMG,/icons/image2.gif) image/*
AddIconByType (SND,/icons/sound2.gif) audio/*
AddIconByType (VID,/icons/movie.gif) video/*

AddIcon /icons/binary.gif .bin .exe
AddIcon /icons/binhex.gif .hqx
AddIcon /icons/tar.gif .tar
AddIcon /icons/world2.gif .wrl .wrl.gz .vrm .vrm .iv
AddIcon /icons/compressed.gif .Z .z .tgz .gz .zip
AddIcon /icons/a.gif .ps .ai .eps
AddIcon /icons/layout.gif .html .shtml .htm .pdf
```

```
AddIcon /icons/text.gif .txt
AddIcon /icons/c.gif .c
AddIcon /icons/p.gif .pl .py
AddIcon /icons/f.gif .for
AddIcon /icons/dvi.gif .dvi
AddIcon /icons/uuencoded.gif .uu
AddIcon /icons/script.gif .conf .sh .shar .csh .ksh .tcl
AddIcon /icons/tex.gif .tex
AddIcon /icons/bomb.gif core

AddIcon /icons/back.gif ..
AddIcon /icons/hand.right.gif README
AddIcon /icons/folder.gif ^^DIRECTORY^^
AddIcon /icons/blank.gif ^^BLANKICON^^

#
# DefaultIcon: which icon to show for files which do not have an icon
# explicitly set.
#
DefaultIcon /icons/unknown.gif

#
# AddDescription: allows you to place short description after a file in
# server-generated indexes. These are only displayed for FancyIndexed
# directories.
# Format: AddDescription "description" filename
#
#AddDescription "GZIP compressed document" .gz
#AddDescription "tar archive" .tar
#AddDescription "GZIP compressed tar archive" .tgz

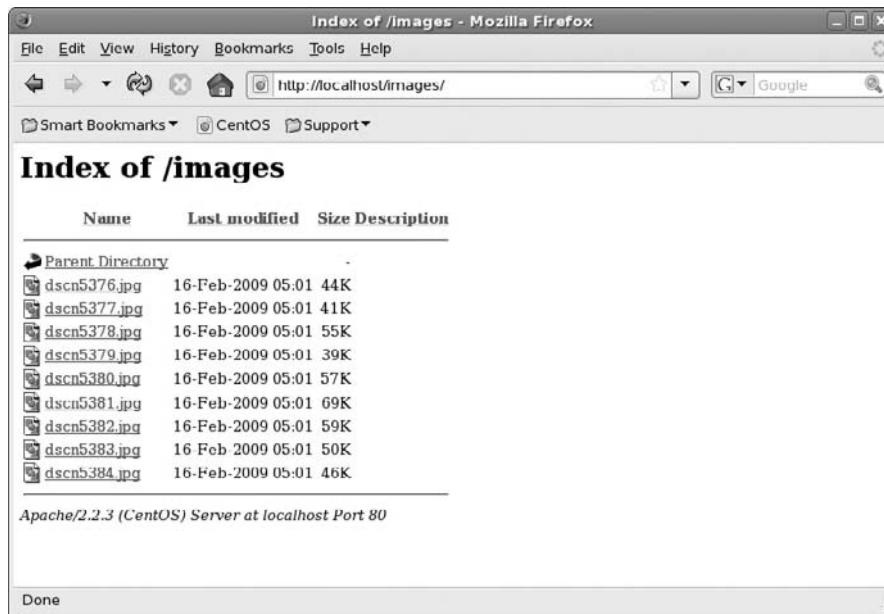
#
# ReadmeName: the name of the README file the server will look for by
# default, and append to directory listings.
#
# HeaderName is the name of a file which should be prepended to
# directory indexes.
#
ReadmeName README.html
HeaderName HEADER.html

#
# IndexIgnore is a set of filenames which directory indexing should
# ignore and not include in the listing. Shell-style wildcarding is
# permitted.
#
IndexIgnore .??.* *~ *# HEADER* README* RCS CVS *,v *,t
```

The previous block of options deals with how server-generated directory indexes are handled. The `IndexOptions FancyIndexing VersionSort NameWidth=*` directive enables an auto-generated directory index to include several bits of information about each file or directory, including an icon representing the file type, the filename, the last modification time for the file, the file's size, and a description of the file. Figure 20-2 shows an example of a directory using default `FancyIndexing` settings.

**FIGURE 20-2**

Change how directories are displayed from Apache using `IndexOptions`.



The `VersionSort` option allows files that include version numbers to be sorted as would be most natural (so, e.g., `version-2` would come before `version-10` with this option on). The `NameWidth=*` option allows filenames of any length to be displayed. You change the asterisk to a number representing the maximum number of characters that can be displayed in the `Name` column. If `IndexOptions` is not set to `FancyIndexing`, the index lists only the filename.

The `AddIconByEncoding` directive is used to configure the output of `FancyIndexing`. It causes a particular icon to be displayed for files matching a particular MIME encoding. In the `AddIconByEncoding` line in the previous example, `compressed.gif` (with an alternative image tag of `CMP` for browsers that don't load images) will be displayed for files with a MIME encoding of `x-compress` and `x-gzip`. The `AddIconByType` directive has the same syntax but matches files based on their MIME type.

The `AddIcon` directive performs a similar function, but the icons are displayed based on a pattern in the filename. In the lines above, for example, `bomb.gif` will be displayed for files ending with `core`, and `binary.gif` will be displayed for files ending in `.bin` and `.exe`. The `folder.gif` icon represents a subdirectory.

If there is a conflict between the `AddIcon`, `AddIconByEncoding`, or `AddIconByType` directives, the `AddIcon` directive has precedence. The `DefaultIcon` directive specifies the image to be displayed (`unknown.gif`, according to the line above) if no previous directive has associated an icon with a particular file.

The `HeaderName` and `ReadmeName` directives specify files that will be inserted at the top and bottom of the auto-generated directory index, if they exist. Using the default values, the server first looks for `HEADER.html`, then `HEADER`, to include at the top of the “fancy index.” At the end of the index, `README.html` or `README` (whichever is located first) is inserted.

The `IndexIgnore` directive specifies files that should not appear in an auto-generated directory index. The line above excludes:

- Any filename starting with a dot and containing at least two additional characters
- Any filename ending with a tilde (~) or what is commonly called a hash mark (#) (typically used by text editors as temporary files or backup files)
- Filenames beginning with `HEADER` or `README` (the files displayed at the top and bottom of the directory listing, according to the `HeaderName` and `ReadmeName` directives)
- The RCS (Revision Control System) or CVS (Concurrent Versions System) directories

## Defining Encoding and Language

The `AddEncoding` directive lets you set compression definitions that can be used by browsers to encode data as it arrives. The `AddLanguage` directive lets you indicate the language of a document, based on its file suffix.

```
#
# AddEncoding: allows you to have certain browsers (Mosaic/X 2.1+)
# uncompress information on fly. Note: Not all browsers support this.
# Despite name similarity, the following Add* directives have nothing
# to do with the FancyIndexing customization directives above.
#
AddEncoding x-compress Z
AddEncoding x-gzip gz tgz

#
# DefaultLanguage and AddLanguage allows you to specify the language of
# a document. You can then use content negotiation to give a browser a
# file in a language it can understand.
#
#
```

```

# Spanish (es) - Swedish (sv) - Catalan (ca) - Czech(cz)
# Polish (pl) - Brazilian Portuguese (pt-br) - Japanese (ja)
# Russian (ru)
#
AddLanguage da .dk
AddLanguage nl .nl
AddLanguage en .en
AddLanguage et .ee
AddLanguage fr .fr
.
.
# LanguagePriority: allows you to give precedence to some languages
# in case of a tie during content negotiation.
#
# Just list the languages in decreasing order of preference. We have
# more or less alphabetized them. You probably want to change this.
#
LanguagePriority en da nl et fr de el it ja ko no pl pt pt-br ru ltz ca
          es sv tw

```

The `AddEncoding` directive supplements or overrides mappings provided by the `TypesConfig` file (`/etc/mime.types` by default). Knowledge of the MIME type/encoding may allow certain browsers to manipulate files automatically as they are being downloaded or retrieved.

The `AddLanguage` directive performs similar mappings, associating a MIME language definition with a filename extension. The `LanguagePriority` directive determines the precedence if a particular file exists in several languages (and if the client does not specify a preference). Using the preceding definition, if the file `index.html` were requested from a directory that contained the files `index.html.de`, `index.html.en`, `index.html.fr`, and `index.html.it`, the `index.html.en` file would be sent to the client.

Using `LanguagePriority`, you can set which language is used in case a decision on what language to use can't be made during content negotiation. If you are expecting multilanguage use of your Web content, you should check (and probably change) the priority here.

## Adding MIME Types and Handlers

With the `AddType` directive, you can enhance the MIME types assigned for your Apache Web Server without editing the `/etc/mime.types` file. With the `AddHandler` directive, you can map selected file extensions to handlers (that result in certain actions being taken):

```

# AddType allows you to add to or override the MIME configuration
# file mime.types for specific file types.

AddType application/x-tar .tgz

#

```

```
# For server-parsed imagemap files:
#
AddHandler imap-file map

#
# For type maps (negotiated resources):
# (This is enabled by default to allow the Apache "It Worked" page
# to be distributed in multiple languages.)
#
AddHandler type-map var
```

## Defining Actions and Headers

Some types of media can be set to execute a script when they are opened. Likewise, certain handler names, when opened, can be set to perform specified scripts. The `Action` directive can be used to configure these scripts:

```
# Action lets you define media types that execute a script whenever
# a matching file is called. This eliminates the need for repeated URL
# pathnames for oft-used CGI file processors.
# Format: Action media/type /cgi-script/location
# Format: Action handler-name /cgi-script/location
```

The `Action` directive maps a CGI script to a handler or a MIME type, whereas the `Script` directive maps a CGI script to a particular HTTP request method (GET, POST, PUT, or DELETE). These options allow scripts to be executed whenever a file of the appropriate MIME type is requested, a handler is called, or a request method is invoked.

## Customizing Error Responses

For different error conditions that occur, you can define specific responses. The responses can be in plaintext, re-directs to pages on the local server, or re-directs to external pages:

```
#
# Customizable error responses come in three flavors:
# 1) plain text 2) local redirects 3) external redirects
#
# Some examples:
#ErrorDocument 500 "The server made a boo boo."
#ErrorDocument 404 /missing.html
#ErrorDocument 404 "/cgi-bin/missing_handler.pl"
#ErrorDocument 402 http://www.example.com/subscription_info.html
#
```

As the comments suggest, the `ErrorDocument` directive can customize any server response code, re-directing it to an external page, a local file or CGI script, or to a simple text sentence. Table 20-6 lists the most common server response codes and their meanings.

TABLE 20-6

### HTTP Response Codes

Response Code	Meaning
200 OK	The request was successfully processed.
201 Created	Using the POST request method, a new file was successfully stored on the server.
202 Accepted	The request has been received and is currently being processed.
204 No Content	The request was successful, but there is no change in the current page displayed to the client.
301 Moved Permanently	The requested page has been permanently moved, and future references to that page should use the new URL that is displayed.
302 Moved Temporarily	The requested page has been temporarily relocated. Future references should continue to use the same URL, but the current connection is being re-directed.
304 Not Modified	A cached version of the page is identical to the requested page.
400 Bad Request	The client's request contains invalid syntax.
401 Unauthorized	The client specified an invalid username/password combination.
402 Payment Required	The client must provide a means to complete a monetary transaction.
403 Forbidden	Access-control mechanisms deny the client's request.
404 Not Found	The requested page does not exist on the server.
500 Internal Server Error	Usually encountered when running a CGI program, this response code indicates that the program or script contains invalid code or was given input that it cannot handle.
501 Not Implemented	The request method (e.g., GET, POST, PUT, DELETE, HEAD) is not understood by the server.
502 Bad Gateway	With the Web Server acting as a proxy server, an error was encountered when trying to fulfill the request to an external host.
503 Service Unavailable	The server is currently processing too many requests.
505 HTTP Version Not Supported	The request version (e.g., HTTP/1.0, HTTP/1.1) is not understood by the server.



To make it easier to internationalize error messages and standardize how these messages are presented, the latest version of Apache includes what are referred to as *variant pages* (ending in a .var suffix). These variant pages, which offer variable output based on language, are stored in the /var/www/error directory.

```
Alias /error/ "/var/www/error/"

<IfModule mod_negotiation.c>
<IfModule mod_include.c>
  <Directory "/var/www/error">
    AllowOverride None
    Options IncludesNoExec
    AddOutputFilter Includes html
    AddHandler type-map var
    Order allow,deny
    Allow from all
    LanguagePriority en es de fr
    ForceLanguagePriority Prefer Fallback
  </Directory>

  ErrorDocument 400 /error/HTTP_BAD_REQUEST.html.var
  ErrorDocument 401 /error/HTTP_UNAUTHORIZED.html.var
  ErrorDocument 403 /error/HTTP_FORBIDDEN.html.var
  ErrorDocument 404 /error/HTTP_NOT_FOUND.html.var
  ErrorDocument 405 /error/HTTP_METHOD_NOT_ALLOWED.html.var
  .
  .
  .
```

The ErrorDocument directive associates a particular error code number with a particular .var file that contains multiple possible responses based on language.

## Setting Responses to Browsers

If file extensions are not enough to determine a file's MIME type, you can define hints with the MimeMagicFile directive. With the BrowserMatch directive, you can set responses to conditions based on particular browser types:

```
#
# The following directives modify normal HTTP response behavior to
# handle known problems with browser implementations.
#
BrowserMatch "Mozilla/2" nokeepalive
BrowserMatch "MSIE 4\.0b2;" nokeepalive downgrade-1.0 force-response-1.0
BrowserMatch "RealPlayer 4\.0" force-response-1.0
BrowserMatch "Java/1\.0" force-response-1.0
BrowserMatch "JDK/1\.0" force-response-1.0

#
```

```
# The following directive disables redirects on non-GET requests for
# a directory that does not include the trailing slash. This fixes a
# problem with Microsoft WebFolders which does not appropriately handle
# redirects for folders with DAV methods.
# Same deal with Apple's DAV filesystem and Gnome VFS support for DAV.
#
BrowserMatch "Microsoft Data Access Internet Publishing Provider"
    redirect-carefully
BrowserMatch "MS FrontPage" redirect-carefully
BrowserMatch "^WebDrive" redirect-carefully
BrowserMatch "^WebDAVFS/1.[0123]" redirect-carefully
BrowserMatch "^gnome-vfs/1.0" redirect-carefully
BrowserMatch "^XML Spy" redirect-carefully
BrowserMatch "Dreamweaver-WebDAV-SCM1" redirect-carefully
```

The `BrowserMatch` directive enables you to set environment variables based on the contents of the `User-Agent` header field. The `force-response-1.0` variable causes a HTTP/1.0 response, indicating that Apache will respond to the browser in basic HTTP 1.0 operations.

## NOTE

If you are following the `httpd.conf` file, you notice that we are skipping descriptions of the `server-status` lines and `server-info` lines. They are described in the section “Monitoring Server Activities” later in this chapter.

## Enabling Proxy and Caching Services

Proxy and caching services are turned off by default. You can turn them on by uncommenting the following directives:

```
#
# Proxy Server directives. Uncomment the following lines to
# enable the proxy server:
#
#<IfModule mod_proxy.c>
#   ProxyRequests On
#
#<Proxy:*>
#   Order deny,allow
#   Deny from all
#   Allow from .example.com
#</Proxy>

#
# Enable/disable the handling of HTTP/1.1 "Via:" headers.
# ("Full" adds server version; "Block" removes outgoing Via: headers)
# Set to one of: Off | On | Full | Block
#
#ProxyVia On

# To enable a cache of proxied content, uncomment the following lines.
```

```
# See http://httpd.apache.org/docs/2.2/mod/mod_cache.html for more details.
#
#<IfModule mod_disk_cache.c>
# CacheEnable disk /
# CacheRoot "/var/cache/mod_proxy"
#</IfModule>

#</IfModule>
# End of proxy directives.
```

Apache can function as a proxy server, a caching server, or a combination of the two. If `ProxyRequests` is set to `Off`, the server will simply cache files without acting as a proxy. If `CacheRoot` (which specifies the directory used to contain the cache files) is undefined, no caching will be performed. Both proxy and caching services are `Off` (commented out) by default.

If you turn on caching, the `CacheRoot` should exist on a file system with enough free space to accommodate the cache, which is limited by the `CacheSize` directive. However, you should have 20 to 40 percent more space available in the file system because cache cleanup (to maintain the `CacheSize`, in kilobytes) occurs only periodically (which you can set using the `CacheGcInterval` directive).

You can add other directives to this example to enable other caching features. The `CacheMaxExpire` directive can indicate the maximum number of hours that a document will exist in the cache without checking the original document for modifications. The `CacheLastModifiedFactor` applies to documents that do not have an expiration time, even though the protocol would support one. To formulate an expiration date, the factor (a floating-point number) is multiplied by the number of hours since the document's last modification. For example, if the document were modified 3 days ago and the `CacheLastModifiedFactor` were 0.25, the document would expire from the cache in 18 hours (as long as this value is still below the value of `CacheMaxExpire`).

The `CacheDefaultExpire` directive (specifying the number of hours before a document expires) applies to documents received via protocols that do not support expiration times. The `NoCache` directive contains a space-separated list of IP addresses, hostnames, or keywords in hostnames that should not have documents cached.

Here's how the caching server behaves if you uncomment the previous `Cache` lines:

- The cached files would exist in `/var/cache/mod_proxy`.
- Cache size is limited to 500 KB.

You might want to allow a much larger `CacheSize`, and possibly set a short `CacheGcInterval`, but otherwise the supplied values are reasonable. The `CacheGcInterval` value can be a floating-point number (e.g., 1.25 indicates 75 minutes).

## Configuring Virtual Hosting

If you have one Web Server computer but more than one domain that you want to serve with that computer, you can set up Apache to do virtual hosting. With name-based virtual hosting, a single IP address can be the access point for multiple domain names on the same computer. With IP-based virtual hosting, you have a different IP address for each virtual host, which you achieve by having multiple network interfaces to a machine.

With virtual hosting, when a request comes into your Apache server from a Web browser through a particular IP address on your computer, Apache checks the domain name being requested and displays the content associated with that domain name. As an administrator of a Web Server that supports virtual hosting, you must make sure that everything that needs to be configured for that virtual server is set up properly (you must define such things as locations for the Web content, log files, administrative contact, etc.).

Virtual hosting is defined with the `VirtualHost` tags. Information related to virtual hosts in the `/etc/httpd/conf/httpd.conf` file is shown in the following code:

```
### Section 3: Virtual Hosts
#
# VirtualHost: If you want to maintain multiple domains/hostnames on
# your machine you can setup VirtualHost containers for them. Most
# configurations use only name-based virtual hosts so the server
# doesn't need to worry about IP addresses. This is indicated by the
# asterisks in the directives below.
#
# Please see the documentation at
# <URL:http://httpd.apache.org/docs/2.2/vhosts/>
# for further details before you try to setup virtual hosts.
#
# You may use the command line option '-S' to verify your virtual host
# configuration.
#
# Use name-based virtual hosting.
#
#NameVirtualHost *:80
#
# NOTE: NameVirtualHost cannot be used without a port specifier
# (e.g. :80) if mod_ssl is being used, due to the nature of the
# SSL protocol.

#
# VirtualHost example:
# Almost any Apache directive may go into a VirtualHost container.
# The first VirtualHost section is used for requests without a known
# server name.
#
#<VirtualHost *:80>
```

```
# ServerAdmin webmaster@dummy-host.example.com
# DocumentRoot /www/docs/dummy-host.example.com
# ServerName dummy-host.example.com
# ErrorLog logs/dummy-host.example.com-error_log
# CustomLog logs/dummy-host.example.com-access_log common
#</VirtualHost>
```

The following example lists virtual host directives that would allow you to host the domains `handsonhistory.com` and `linuxtoys.net` on the same computer:

```
NameVirtualHost *:80

<VirtualHost *:80>
    DocumentRoot /var/www/handsonhistory
    ServerName www.handsonhistory.com
    ServerAlias handsonhistory.com
    ServerAdmin webmaster@handsonhistory.com
    ErrorLog logs/handsonhistory.com-error_log
    CustomLog logs/handsonhistory.com-access_log common
</VirtualHost>

<VirtualHost *:80>
    DocumentRoot /var/www/linuxtoys
    ServerName www.linuxtoys.net
    ServerAlias linuxtoys.net
    ServerAdmin webmaster@linuxtoys.net
    ErrorLog logs/linuxtoys.net-error_log
    CustomLog logs/linuxtoys.net-access_log common
</VirtualHost>
```

To experiment with virtual hosts, you can add the new host name to your local `/etc/hosts` file and point at your localhost IP address. For example:

```
127.0.0.1    www.linuxtoys.net
```

If you see the content you set up for your virtual host, and not the CentOS error page or default content you set up, then you probably set up your virtual host properly.

## Configuring Modules and Related Services (`/etc/httpd/conf.d/*.conf`)

Any module that requires special configuration will typically have a configuration file (`.conf` file) in the `/etc/httpd/conf.d/` directory. Here are modular configuration files that might be contained in that directory, along with some ways of using those files and the packages associated with them (type **`yum install package`** to install each package you want):

- **`htdig.conf`** — Identifies the location of the `htdig` search content that can be used on your web site (`/usr/share/htdig` is the default location). To see the `htdig` search screen from a

Web browser, type `http://localhost/htdig`. The htdig system lets you set up tools for indexing and searching your web site or company intranet. It is optional for your Web Server. (Install the `htdig-web` package.)

- **mailman.conf** — Sets up Mailman list server software to allow features such as making mailing-list archives available from Apache. (Install the `mailman` package.)
- **manual.conf** — Defines the location of Apache manuals (`/var/www/manual`) on the server for different languages. Type `http://localhost/manual` in a browser window. (Install the `httpd-manual` package.)
- **mrtg.conf** — Defines the location of daily MRTG output (`/var/www/mrtg`), which tracks network traffic. Type `http://localhost/mrtg` in a browser window. (Install the `mrtg` package.)
- **perl.conf** — Identifies and loads the `mod_perl` module so that your web pages can include Perl code. (Install the `mod_perl` package.)
- **php.conf** — Identifies and loads the `libphp5` module so that your web pages can include PHP scripting language. There is also a `DirectoryIndex` setting that allows an `index.php` file you add to a directory to be served as a directory index. (Install the `php` package.)
- **python.conf** — Identifies and loads the `mod_python` module so web pages can include Apache handlers written in Python. (Install the `mod_python` package.)
- **squirrelmail.conf** — Identifies the location of the SquirrelMail Web-based mail interface so that it can be incorporated into your Apache Web Server. To see the SquirrelMail login screen, type `http://localhost/webmail` into a browser window. (Install the `squirrelmail` package.)
- **ssl.conf** — Configure SSL support so that Apache knows how to serve pages requested over a secure connection (https). (Install the `mod_ssl` package.)
- **subversion.conf** — Loads the `mod_dav_svn` and `mod_authz_svn` modules to let you access a Subversion repository from Apache. By uncommenting lines in this file, you can set `/home/svnroot` as the location where you hold authorization files. (Install the `mod_dav_svn` package.)
- **webalizer.conf** — Lets you identify who can access the Webalizer data (statistics about your web site). (Install the `webalizer` package.)
- **wordtrans.conf** — Identifies the location of the WORDtrans language translation window so that it can be incorporated into your Apache Web Server. To see the WORDtrans login screen, type `http://localhost/wordtrans` into a browser window. (Install the `mod_auth_pgsq1` package.)

These configuration files are read when the `httpd` server starts. The information in these files could have been added to `httpd.conf`. However, files are put here so that different packages can add their own configuration settings without having the RPM software package incorporate some automated method of adding their configuration information to the `httpd.conf` file.

## Starting and Stopping the Server

The procedure for starting and stopping the Apache Web Server is no different from that of many other daemons. You can use the `chkconfig` command to set the `httpd` service to start at boot time.

**CROSS-REF** See Chapter 11 for detailed information on the inner workings of the shell scripts that control starting and stopping daemons and server processes.

The `/etc/init.d/httpd` shell script accepts any of a handful of command-line arguments. If it is called with the argument `start`, the `httpd` script will run one master daemon process (owned by `root`), which will spawn other daemon processes (equal to the number specified by the `StartServers` directive) owned by the user `apache` (from the `User` and `Group` directives). These processes are responsible for responding to incoming HTTP requests. If called with `stop`, the server will be shut down as all `httpd` processes are terminated.

If given a command-line argument of `restart`, the script will simply execute `stop` and `start` procedures in sequence. Using `reload` as the argument will send the hang-up signal (`-HUP`) to the master `httpd` daemon, which causes it to re-read its configuration files and restart all the other `httpd` daemon processes. The shell script also supports an argument of `status`, which will report if the daemon is running and, if it is, the PIDs of the running processes. All other command-line arguments result in an error and cause a usage message to be printed.

The actual binary for Apache, `/usr/sbin/httpd`, supports several command-line arguments, although the default values are typically used. The possible command-line arguments are listed in Table 20-7.

**TABLE 20-7**

### Command-Line Arguments to `httpd`

Argument	Description
<code>-c directive</code>	Reads the configuration files and then processes the <i>directive</i> . This may supersede a definition for the directive within the configuration files.
<code>-C directive</code>	Processes the <i>directive</i> and then reads the configuration files. The <i>directive</i> may alter the evaluation of the configuration file, but it may also be superseded by another definition within the configuration file.
<code>-d directory</code>	Uses <i>directory</i> as the <code>ServerRoot</code> directive, specifying where the module, configuration, and log file directories are located.
<code>-D parameter</code>	Defines <i>parameter</i> to be used for conditional evaluation within the <code>IfDefine</code> directive.

*continued*

**TABLE 20-7** (continued)

Argument	Description
-f <i>file</i>	Uses <i>file</i> as the <code>ServerConfigFile</code> directive, rather than the default of <code>/etc/httpd/conf/httpd.conf</code> .
-h	Displays a list of possible command-line arguments.
-l	Lists the modules linked into the executable at compile time.
-L	Prints a verbose list of directives that can be used in the configuration files, along with a short description and the module that contains each directive.
-S	Lists the configured settings for virtual hosts.
-t	Performs a syntax check on the configuration files. The results will either be Syntax OK or an error notification, for example, Syntax error on line 118 of <code>/etc/httpd/conf/httpd.conf</code> .
-T	Same as <code>-t</code> , except that there is no check of the <code>DocumentRoot</code> value
-v	Prints the version information: Server version: Apache/2.2.8 (Unix) Server built: Feb 25 2008 07:05:32
-V	Lists the version information and any values defined during compilation: Server version: Apache/2.2.8 (Unix) Server built: Feb 25 2008 07:05:32 Server's Module Magic Number: 20051115:11 Architecture: 32-bit ..... Server compiled with.... -D APACHE_MPM_DIR="server/mpm/prefork" -D APR_HAS_MMAP -D APR_HAVE_IPV6 (IPV4-mapped addresses enabled) : : : -D SERVER_CONFIG_FILE="conf/httpd.conf"
-k <i>option</i>	Uses <code>-k</code> with the <code>start</code> , <code>stop</code> , <code>restart</code> , <code>graceful</code> or <code>graceful-stop</code> options to change the current state of the Web Server.

## Monitoring Server Activities

An Apache Web Server is a tempting target for someone with a desire to hijack a computer for bad purposes. There are many techniques you can use to secure your server (covered in Chapter 13), which range from SELinux to using certificates to controlling how scripts are run. Described here, however, are techniques for keeping an eye on the performance and security of



your Apache Web Server. Watching your server carefully can often stop an attack before it gets anywhere.

Apache provides two unique built-in methods to check the performance and status of your Web Server. The server-status handler can be configured to show information about server processes. The server-info handler can be configured to display a detailed summary of the Web Server's configuration. You can activate these services by adding the following lines to the `/etc/httpd/conf/httpd.conf` file:

```
<Location /server-status>
    SetHandler server-status
    Order deny,allow
    Deny from all
    Allow from 127.0.0.1
</Location>
<Location /server-info>
    SetHandler server-info
    Order deny,allow
    Deny from all
    Allow from 127.0.0.1
</Location>
```

In this example, all users from the local computer can display the server-info and server-status pages. You can change `127.0.0.1` to the name of any domain or host that your Apache server is hosting.

## Displaying Server Information

The Server Information (server-info) page contains the server version information and various general configuration parameters and breaks up the rest of the data by module. Each loaded module is listed, with information about all directives supported by that module, and the current value of any defined directives from that module.

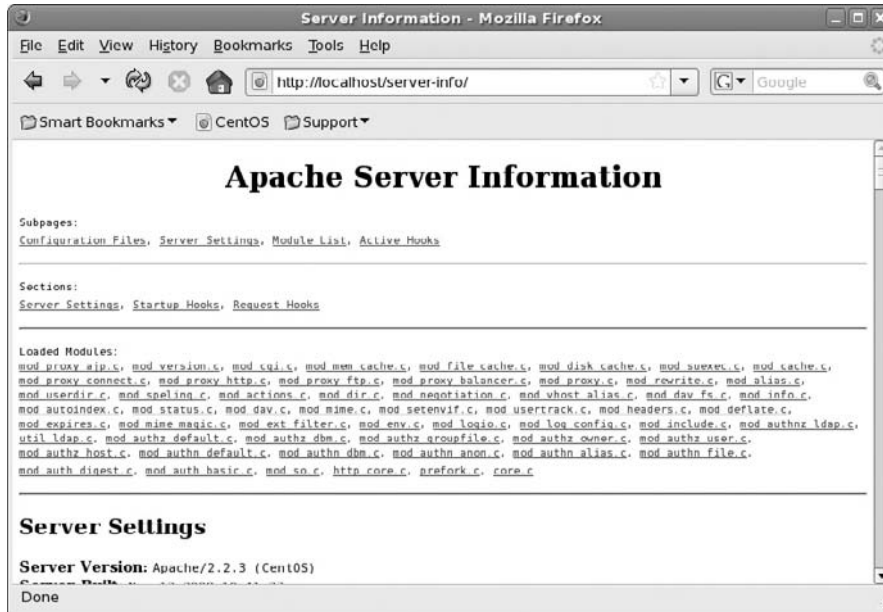
The Server Information is usually quite verbose and contains much more information than can be displayed in Figure 20-3, which shows only the links to each module's section and the general Server Settings section.

## Displaying Server Status

The contents of the server-status page include version information for the server, the current time, a time stamp of when the server was last started, and the server's uptime. The page also details the status of each server process, choosing from several possible states (waiting for a connection, just starting up, reading a request, sending a reply, waiting to read a request before reaching the number of seconds defined in the `KeepAliveTimeout`, performing a DNS lookup, logging a transaction, or gracefully exiting).

**FIGURE 20-3**

The server-info page displays server and module information.



The bottom of the server-status page lists each server by process ID (PID) and indicates its state, using the same possible values. Figure 20-4 shows an example of this page.

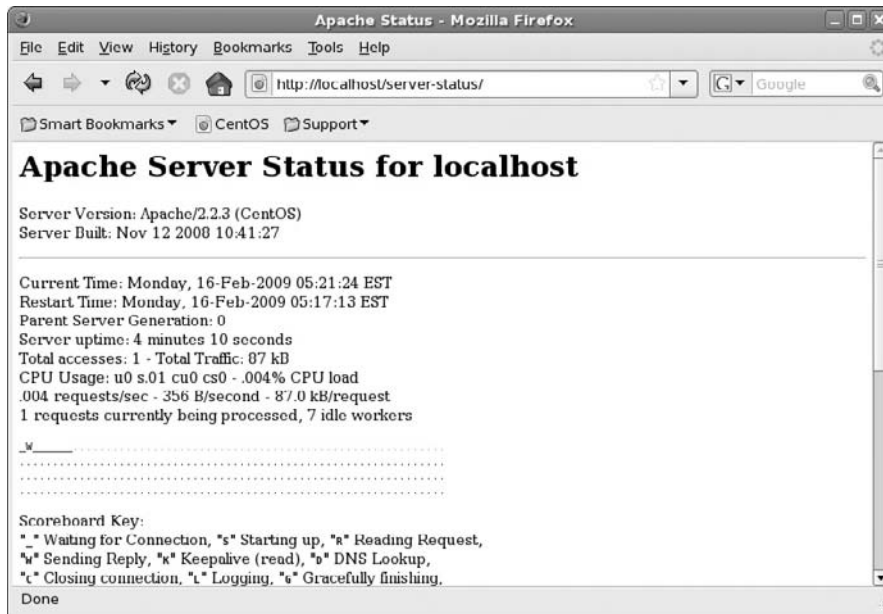
The server-status page can also perform automatic updates to provide even closer monitoring of the server. If the URL `http://localhost/server-status?refresh=40` is specified, the server-status page displayed in your browser will be updated every 40 seconds. This enables a browser window to be entirely devoted to continually monitoring the activities of the Web Server.

By default, only basic status information is generated. If you would like to generate full status information, you need to turn on the `ExtendedStatus` directive by uncommenting the last line in the following code:

```
#
# ExtendedStatus: controls whether Apache will generate "full" status
# information (ExtendedStatus On) or basic information (ExtendedStatus
# Off) when the "server-status" handler is called. The default is Off.
#
#ExtendedStatus On
```

**FIGURE 20-4**

The Apache server-status page displays general Apache information and reports on individual server process activities.



## Further Security of Server-Info and Server-Status

Because both the server-info and server-status pages contain private information that should not be accessible to just anyone on the network, there are a few extra ways you can secure that information. You can restrict that information only to the local host; however, in some environments that may not be practical.

If you must allow other machines or networks access to such detailed configuration information, allow only as many machines as is necessary, and preferably only those machines on your local network. Also, be aware that, in the wrong hands, the information displayed by the server-info and server-status pages can make it much easier for the security of your entire machine to be compromised.

It may also be beneficial to change the URL used to reference both of the aforementioned pages. This is an example of “security through obscurity,” which should not be relied on but which can make it just a little more difficult for unauthorized individuals to obtain information about your Web Server’s configuration (particularly if you cannot restrict such connections to the local

network). To accomplish this, simply change the filename in the `Location` directive, as in the following lines:

```
<Location /server.information.page>
```

and:

```
<Location /server.status.page>
```

## Logging Errors

The error log contains messages generated by the server that describe various error conditions. The `ErrorLog` and `LogLevel` directives in the `httpd.conf` file (as described in the section on configuring the server) can modify the filename and the amount of information that is logged. The default file is `/etc/httpd/logs/error_log` (which is a link to `/var/log/httpd/error_log`). Here are a few sample lines from the error log:

```
[Mon Feb 16 05:13:41 2009] [notice] Apache/2.2.3 (CentOS)
    configured -- resuming normal operations
[Mon Feb 16 05:13:46 2009] [error] [client 127.0.0.1] client denied by server
    configuration: /var/www/html/server-info
[Mon Feb 16 05:13:53 2009] [error] [client 127.0.0.1] File does not exist:
    /var/www/html/favicon.ico
[Mon Feb 16 05:15:44 2009] [notice] caught SIGTERM, shutting down
```

The first line indicates that the server has just been started and will be logged regardless of the `LogLevel` directive. The second line indicates an error that was logged to demonstrate a denied request. The third line shows an error, which represents a request for a file that does not exist. The fourth line, also logged regardless of the `LogLevel` directive, indicates that the server is shutting down. The error log should also be monitored periodically because it will contain the error messages from CGI scripts that might need repair.

## Logging Hits

Every incoming HTTP request generates an entry in the transfer log (by default, `/etc/httpd/logs/access_log`, which is a link to `/var/log/httpd/access_log`). Statistics packages and log file analysis programs typically use this file because manually reading through it can be a rather tedious exercise. (See the information on the `logwatch` facility in Chapter 13.)

The format of the transfer log can be altered by the `LogFormat` and `CustomLog` directives in the `httpd.conf` file, as described in the “Configuring the Web Server (`httpd.conf`)” section. If you attempted to access `http://localhost/` following the installation procedure (from Figure 20-1), the following lines (in the “common” format) would be written to the `access_log`:

```
127.0.0.1 - - [16/Feb/2009:05:21:16 -0500] "GET / HTTP/1.1" 403 5043 "-"
    "Mozilla/5.0 (X11; U; Linux i686; en-US; rv:1.9b5) Gecko/2008052519
```

```
CentOS/3.0b5-0.beta5.6.el5.centos Firefox/3.0b5"
127.0.0.1 - - [16/Feb/2009:05:21:16 -0500] "GET /icons/apache_pb.gif HTTP/1.1"
200 2326 "http://localhost/" "Mozilla/5.0 (X11; U; Linux i686; en-US;
rv:1.9b5) Gecko/2008052519 CentOS/3.0b5-0.beta5.6.el5.centos Firefox/3.0b5"
127.0.0.1 - - [16/Feb/2009:05:21:16 -0500] "GET /icons/powered_by_rh.png
HTTP/1.1" 200 1213 "http://localhost/" "Mozilla/5.0 (X11; U; Linux i686;
en-US; rv:1.9b5) Gecko/2008052519 CentOS/3.0b5-0.beta5.6.el5.centos
Firefox/3.0b5"
```

The Apache Test Page actually is an error condition (403), which indicates that the Apache server is running, but that the administrator of the server hasn't added a home page yet. The next two lines show the Apache (`apache_pb.gif`) and CentOS (`powered_by_rh.png`) icons that appear on the test page, respectively, for CentOS.

## Analyzing Web-Server Traffic

The `webalizer` package can take Apache log files and produce usage reports for your server. Those reports are created in HTML format so you can display the information graphically. Information is produced in both table and graph form.

To use the `webalizer` command, the `webalizer` package must be installed (type **yum install webalizer**). You can run `Webalizer` with no options and have it take the values in the `/etc/webalizer.conf` files to get the information it needs. As an alternative, you can use command-line options to override settings in the `webalizer.conf` file. To use the defaults, simply run the following:

```
# webalizer
```

If all goes well, the command should run for a few moments and exit silently. Based on the information in the `/etc/webalizer.conf` file, the `/var/log/httpd/access_log` log file is read and an `index.html` file is copied to the `/var/www/html/usage/` directory. You can view the output by opening the file in any browser window. For example, you could type the following in the Location box:

```
http://localhost/usage
```

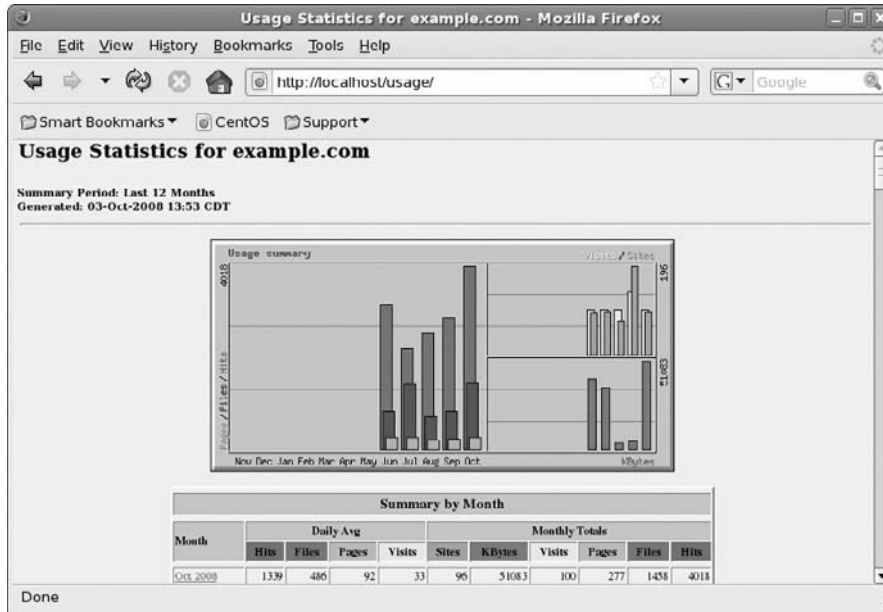
The output report shows a 12-month summary of Web Server activity. On the bar chart, for each month a green bar represents the number of hits on the web site, a dark blue bar shows the number of different files hit, and a light blue bar shows the number of pages opened. It also shows data for the number of visits and the number of sites that visited in the right column. The amount of data transferred, in kilobytes, is displayed as well.

Figure 20-5 shows an example of a `Webalizer` output file for a Web Server that has been running for several months.

Below the chart, a table shows daily and monthly summaries for activity during each month. Users can click on the name of a month to see detailed activity.

**FIGURE 20-5**

Webalizer displays Web data in chart and column formats.

**TIP**

Because Webalizer supports both common log format (CLF) and combined log format, it can be used to display information for log files other than those produced for Apache. For example, you could display statistics for your FTP server or Squid server.

Several other software tools are available for analyzing transfer statistics. The accompanying sidebar on statistics packages available for CentOS systems describes some of these tools.

## Statistics Packages Available for CentOS

Analyzing the transfer log by hand isn't much fun. Several packages have been written to automate this task, including the following two:

- **Analog** — This free log-file analyzer is very fast and easily configurable, and it produces very detailed output (including bar graphs and hypertext links). More information can be found at [www.analog.cx](http://www.analog.cx).

*continued*

*continued*

- **AWStats** — The Advanced Web Statistics tool (`aws_tats` package) produces graphical statistics representing Web Server access. AWStats can work with log files in the Apache common log format, as well as log files from Sendmail, FTP, and other network servers. It can report statistics, such as the number of people who have visited, visits made per person, the domain and country of each visitor, and the number of visits made by robots.

## Summary

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Web Servers are responsible for storing and delivering the vast amount of content available on the World Wide Web to clients all over the world. Although several Web Server software packages are available for CentOS systems, the most popular is by far the Apache Web Server.

This chapter described how to install, configure, and run an Apache server in CentOS. The `httpd` daemon process handles requests for Web content (HTTP). Configuration files define what content is made available and how it can be accessed. In particular, the `/etc/httpd/conf/httpd.conf` file is used to configure the server.

The Apache `httpd` package also includes facilities for logging error and transfer messages. You can look for the `access_log` and `error_log` files in the `/etc/httpd/logs` directory. The `access_log` file contains information on content requests that have been serviced by the server. The `error_log` file lists error conditions that have occurred and times when service has been denied. You can use tools such as Webalizer to simplify the viewing of Apache log data.

# Chapter 21

## Setting Up an LDAP Address Book Server

Sometimes an organization needs a convenient way to gather, store, and distribute information for access by the applications that need it. The Lightweight Directory Access Protocol (LDAP) simplifies the process of creating and using directories of information by network-ready applications.

The intention of LDAP is to simplify the overhead needed to provide directory services described in the X.500 specification. LDAP is a subset of X.500 features. By standardizing the structure of database information, LDAP can get around proprietary storage formats to allow many different applications to share the same data.

### NOTE

X.500 is a CCITT specification that has become part of the Open Systems Interconnection (OSI) standards that define a layered framework for interconnecting networks and related services. With the dominance of TCP/IP networks (such as the Internet) in the world, OSI never became the predominant network framework that some expected it to be. Despite that, the seven-layer OSI reference model is often used in classrooms to teach networking theory. Likewise, some of these specifications, such as X.500, have been adopted (and sometimes adapted) where standard, cross-platform features are required.

CentOS systems include OpenLDAP software packages to implement LDAP server and client services. To illustrate how to configure and use an LDAP server with OpenLDAP and make it accessible to user applications, this chapter goes through the process of setting up a shared address book to run on a CentOS system. It also describes how to use e-mail clients that can access the LDAP address book.

### IN THIS CHAPTER

Understanding LDAP

Using OpenLDAP

Configuring an LDAP server

Creating an LDAP address book

Using Thunderbird to access the address book



## Understanding LDAP

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LDAP lets people create directories of information that can be shared among client applications over a network. It is particularly geared toward applications that are used to look up information that is fairly stable over and over again (in other words, information that's being looked at more than it's being changed). That's why LDAP is popular for uses such as storing information about people, addresses, and other kinds of data that may require high access with relatively few changes.

Because of LDAP's extraordinarily flexible design, as an LDAP developer or administrator you have a lot of control over:

- How the information in the directories is organized.
- How and by whom information can be accessed.
- The scale, local to global, by which information is distributed. (Information can be replicated to other servers at any scale you choose and synced up automatically.)

As an example, an LDAP address book might resemble the following:

```
dc=example,dc=com
  ou=members
    cn=Andrew Smith
      homeAddress
      homeTelephoneNumber
      workAddress
      workTelephoneNumber
    cn=John Wilson
      homeAddress
      homeTelephoneNumber
      workAddress
      workTelephoneNumber
  ...
```

Despite its flexibility, however, you don't have to begin designing each directory you create from scratch. LDAP has many predefined structures of information you can rely on to build your LDAP directories.

**TIP**

Microsoft's Active Directory (AD) is often touted as an "LDAP-based" entity, giving some users high hopes of integrating OpenLDAP and AD. While it is possible to exchange information between AD and OpenLDAP, setting this up requires a lot of patience and skill. Unless you must interoperate with AD, a better path for supporting Windows clients is through the use of OpenLDAP and Samba.

## Defining Information in Schemas

The elements that make up LDAP directories are organized into what are called *schemas*. When you create or use an LDAP directory, the types of information in the schemas you will be working with include the following types of items:

- **Object Classes** — An object provides a name under which you would group together a bunch of attributes. So, with an address book, you might include the `inetOrgPerson` object class, under which you could store attributes associated with a person.
- **Attributes** — As its name implies, an attribute holds a piece of information associated with an object class. For example, the `inetOrgPerson` object class could have attributes such as telephone number, e-mail address, and so on.

### NOTE

If you are familiar with databases, the LDAP directory terminology might seem a bit different to you. LDAP is more of a directory structure provider than a real database. You can think of attributes as fields and object classes as tables.

Examples of object classes include `country`, `locality`, `organization`, and many others. For each object class, there may be required attributes and a list of optional attributes. You can see the definitions for many standard object classes and attributes in the schema files that come with any LDAP server.

In OpenLDAP, several default schemas are included in the `/etc/openldap/schema` directory. The example e-mail address book I show you how to create in this chapter relies entirely on schemas provided with OpenLDAP. You don't have to create any schema files yourself to do the examples in this chapter. If you need more objects and attributes than are provided by default, you can get schemas from other places or create your own.

### NOTE

LDAP schemas are defined in several different standards documents referred to as *RFCs* (Request for Comments) that you can list from the IETF site ([www.ietf.org/rfc.html](http://www.ietf.org/rfc.html)). There are RFCs for almost every aspect of the Internet protocols and related application services. Important RFCs for LDAP definitions include:

- **RFC 2252** — Defines the framework for LDAP.
- **RFC 2256** — Defines the X.500 user schema for LDAPv3.
- **RFCs 1274, 2079, 2247, 2307, 2587, 2589** — Define specifications for including user attributes, Uniform Resource Identifiers, domain names, NIS data, public key infrastructure (PKI), and dynamic directory services in LDAP directories.

The documents on which these RFCs are based include the CCITT X.500 standard and the related ISO IS9594 directory services standards. In particular, X.521 and X.520 define some of the most basic object classes and attribute types.

For information on schemas included with OpenLDAP, refer to the OpenLDAP Schema Specification page ([www.openldap.org/doc/admin22/schema.html](http://www.openldap.org/doc/admin22/schema.html)). That page also describes how

you can go about extending those schemas. Keep in mind, however, that these standards provide guidelines. When you put together your own LDAP directory, your OpenLDAP server will have to deal directly with the schemas that implement those standards on the OpenLDAP server. Check those schemas, as well as the schema definitions in RFCs described earlier, before you create your own object classes or attributes.

As you begin dealing with your LDAP directory, you will access the object classes and attributes as names. To the LDAP server, however, each of those items is represented by a unique string of numbers and dots. Each string is referred to as an *Object Identifier* (OID). If you are not creating your own object classes or attributes, you don't need to deal with OIDs. To understand what OIDs are and when you might want to get your own OID assignment, refer to the sidebar, "Understanding OIDs."

## Understanding OIDs

If you look into a schema file (`/etc/openldap/schema/*`), you will see that every LDAP object class and attribute is mapped into a dot-separated number. That number is a hierarchical string that is referred to as an Object Identifier (OID).

Because LDAP is intended to be a global directory (where all entries can be unique), if you want to create a directory that can be accessed globally, you should try to use items that have existing OIDs assigned whenever possible. However, if you find that you need to create object classes or attributes that are not already defined, you can consider getting an OID for your organization. The alternative is to make up your own attribute name and OID, in which case you should either never expect that data to be globally accessible or try not to conflict with existing OIDs.

Like a domain name, an OID assignment enables you to create branches under that OID as you need them. If your organization has its own OID assigned, you are guaranteed of having every item you create under that number be globally unique (as long as you maintain those assignments properly yourself).

Private enterprise numbers are examples of useful information that is stored as OIDs. Private enterprise numbers used primarily for companies using SNMP are stored under the OID number 1.3.6.1.4.1. Companies represented under that OID include IBM (1.3.6.1.4.1.2), Cisco Systems (1.3.6.1.4.1.9), and Hewlett Packard (1.3.6.1.4.1.11). For Red Hat Software, the OID is 1.3.6.1.4.1.2312.

If you break down each number into its component parts, you see that they start with the top-level OID 1 (for ISO-assigned OIDs), then 3 (ISO-identified organizations), then 6 (U.S. Department of Defense), then 1 (Internet), then 4 (private), then 1 (enterprise). After that is the number representing each company.

You can see the complete list of enterprise numbers on the Private Enterprise Numbers list at [www.iana.org/assignments/enterprise-numbers](http://www.iana.org/assignments/enterprise-numbers). Search for OID assignments (from the top node) at [www.alvestrand.no/objectid/top.html](http://www.alvestrand.no/objectid/top.html). You can request your OID from the Internet Assigned Numbers Authority ([www.iana.org/cgi-bin/mediatypes.pl](http://www.iana.org/cgi-bin/mediatypes.pl)).

## Structuring Your LDAP Directories

While standards documents are used to keep the object classes, attributes, and other elements of LDAP directories unique, you are free to put together those elements into your own LDAP directories however you want. The structure you use to create your LDAP databases is the LDAP Data Interchange Format (LDIF).

Every piece of information you store in your LDAP directory must fall under a base distinguished name (or *base dn*). Because many organizations these days can be represented by a unique Internet domain name, the domain name is a popular way to identify your LDAP base dn. In fact, for the examples in this chapter, the base distinguished name I use is *example.com*. If you are creating an LDAP directory for an organization that can be represented by a domain name, you can replace *example.com* with your domain name.

If you are creating an LDAP directory structure for a larger organization (in other words, more than just a single address book as I am doing here), you need to think hard about how you want the directory structured. You may want to add country codes (us, de, it, etc.) under your base distinguished name for a multinational company.

## Setting Up the OpenLDAP Server

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All the software packages you need to set up an OpenLDAP server are included on the DVD that comes with CentOS distributions. As an alternative, you can easily install the packages over the Internet using yum. With those packages installed, you can start configuring your OpenLDAP server.

### Installing OpenLDAP Packages

To configure your OpenLDAP server, you should start by installing all the `openldap` packages from your CentOS distribution. First, check which OpenLDAP packages are installed:

```
# rpm -qa "openldap*"
```

You need the `openldap-devel` package only if you are developing LDAP applications. Otherwise, you can install the `openldap`, `openldap-clients`, and `openldap-servers` packages from the DVD that comes with this book.

### Configuring the OpenLDAP Server (`slapd.conf`)

You configure the access and use of your OpenLDAP databases in the configuration file, `/etc/openldap/slapd.conf`.

**NOTE**

For a more complete description of features that you can use in your `slapd.conf` file, refer to the `slapd.conf` man page.

1. **Edit `slapd.conf`** — Make a backup copy of the `/etc/openldap/slapd.conf`, and then open the file as `root` user, using any text editor. The following steps tell you some of the information you might want to change.
2. **Review the Schemas** — In the `slapd.conf` file, schemas that are generally useful for creating LDAP directories are included from the `/etc/openldap/schema` directory. Other schemas you might use will often rely on these schemas being included. So, unless you know you don't need them, don't delete any of these schemas:

```
include /etc/openldap/schema/corba.schema
include /etc/openldap/schema/core.schema
include /etc/openldap/schema/cosine.schema
include /etc/openldap/schema/duaconf.schema
include /etc/openldap/schema/dyngroup.schema
include /etc/openldap/schema/inetorgperson.schema
include /etc/openldap/schema/java.schema
include /etc/openldap/schema/misc.schema
include /etc/openldap/schema/nis.schema
include /etc/openldap/schema/openldap.schema
include /etc/openldap/schema/ppolicy.schema
include /etc/openldap/schema/collective.schema
```

Because schemas are plain text files, you can open them with any text editor to read what they do. Several of the schemas are of interest to us. The `core.schema` file is required for all LDAP directories. The `cosine.schema` and `inetorgperson.schema` files are particularly useful (and needed for this procedure). The `nis.schema` file is used to provide Network Information System data in an LDAP directory. The `misc.schema` file contains some miscellaneous mail-related schema definitions.

**NOTE**

The LDAP Schema Viewer (<http://ldap.akbhome.com>) enables you to view object classes, attributes, syntaxes, and matching rules for common schemas for LDAP. Definitions also point to RFCs that more fully define each object class.

3. **Add Backend Database Definitions** — In the `slapd.conf` file, you need to define some backend database definitions. Each set of backend definitions applies to a group of databases of the same type.

Here's an example of how the backend database definitions would appear for a computer in the domain named `example.com` (of course, you would replace `example` and `com` with those of your own domain):

```
#####
# ldbm and/or bdb database definitions
#####

database          bdb
suffix            "dc=example,dc=com"
directory         /var/lib/ldap
rootdn            "cn=Manager,dc=example,dc=com"
```

```

cachesize 10000
searchstack 8
dbnosync
dirtyread

```

This database is of the type `bdb` (Berkeley DB transactional backend), which defines how data for this directory is stored. The `ldb` (Lightweight Directory Access Protocol Proxy backend) database is another type you could use. The suffix specifies that queries to this `slapd` server for `example.com` are directed to this database. The directory line identifies the `/var/lib/ldap` directory as the location for this LDAP directory.

The `rootdn` line indicates that root access can be granted to change data in databases associated with the `example.com` distinguished name (provided the password is supplied with `rootpw`, as described in the next step). I added the last four options to improve performance of the `bdb` database (type **man `slapd-bdb`** for details).

- 4. Add a Password** — In the `slapd.conf` file, you need to enter the password that is required to modify your OpenLDAP backend database. By default, the `rootpw` line defines a clear-text string that is your password. The password will give you full control of the backend database. It will look something like the following:

```
rootpw      mysecret
```

## NOTE

If you are going to use a clear-text password, you should make sure that your `slapd.conf` file has Read permissions closed to the world (`chmod 640 /etc/openldap/slapd.conf`). See the sidebar, “Creating an Encrypted Password,” for information on creating an encrypted password to access your OpenLDAP backend database.

## Creating an Encrypted Password

To create an encrypted password for the administrator of the OpenLDAP database, you can use the `slappasswd` command. You can create the password using Crypt, SSHA, SMD5, MD5, or SSH encryption. Here’s an example of creating a password for OpenLDAP using MD5 encryption:

```

# slappasswd -h {md5} > /tmp/myldap
New password: *****
Re-enter new password: *****
# cat /tmp/myldap
{MD5}uBoM+L0Qg5GHHJ2Z4NLu9A==

```

Enter a password (twice) to create an encrypted MD5 password. This example directs the encrypted password into the `/tmp/myldap` file; you can read into the `slapd.conf` file later. In this example, I had you `cat` the file so you could see what the encrypted password looks like. Your password will be different. Here’s what the `rootpw` line will look like with an encrypted, rather than a clear-text password:

```
rootpw      {MD5}uBoM+L0Qg5GHHJ2Z4NLu9A==
```

5. **Save `slapd.conf`** — Save your changes to the `slapd.conf` file and close it.
6. **Check `slapd.conf`** — You can check for syntax errors in your `slapd.conf` file by running the `slaptest` command, as follows:

```
# slaptest -u
config file testing succeeded
```

If something was wrong with the syntax of the file (e.g., if you left off a quote or misplaced a comma), the message would say `slaptest: bad configuration file!` instead. Try to correct the problem and check the file again. Later, when the databases are created, you can run `slaptest` again (without the `-u` option) to make sure that `slapd.conf` points to existing, properly configured data bases.

At this point, you can try starting the OpenLDAP service.

## Starting the OpenLDAP Service

You start the OpenLDAP as you do most services in CentOS systems, using the `service` and `chkconfig` commands. The service name for OpenLDAP is `ldap`. To start the service immediately, type the following:

```
# service ldap start
Starting slapd:          [ OK ]
```

To set the LDAP service to start each time the system is rebooted, type the following:

```
# chkconfig ldap on
```

By default, the LDAP service will have Read permissions open to everyone.

## Setting Up the Address Book

---

When I set up the structure of the address book database, I base the distinguished name (dn) for the database on the organization's name.

With the suffix set to `example.com` (`suffix "dc=example,dc=com"`) in the `slapd.conf` file (yours will be different), the backend database is set up to handle queries to the distinguished name (dn) `example.com`. Next, you can create the structure for the address book for that organization under that distinguished name.

### NOTE

The `dc=` stands for *domain component*. When you include a domain name as your distinguished name, the order in which you put the parts of that domain name places the part closest to the DNS root last. In this example, the `dc=example` comes before `dc=com`. See RFC 2247 if you are interested in the specification for including domain names in LDAP directories.

You want to create the address book file in a format that can be loaded into the OpenLDAP database. The format you need is referred to as the *LDAP Data Interchange Format* (LDIF). Information you enter in this format can be used to build the database and load a lot of data into the directory at once from a file.

The following steps explain how to create an LDIF file containing the definitions of your address book for the example.com LDAP directory (distinguished name) and then load that file into your LDAP server:

1. **Create an LDIF File** — As root user, using any text editor, create a file to hold your LDAP directory entry. In my example, I used the file `/etc/openldap/people.ldif`.

### NOTE

When you create your LDIF file, be sure to leave a blank line before each new distinguished name (dn:) line. The blank line tells `ldapadd` to start a new entry. Without the blank line, LDAP will not think that you are starting a new distinguished name. Also, remove any blank spaces before each line, making sure that all new lines begin on column 1. (A space at the beginning of a line indicates that the new line is actually part of the preceding line.)

2. **Define the Organization** — You need to define the directory that you will be loading into the LDAP server. For my example, I added information defining the organization as Example Organization under the distinguished name `example.com` (`dc=example,dc=com`), by adding the following information to my `people.ldif` file.

```
dn:                dc=example,dc=com
objectClass:       dcObject
objectClass:       organization
dc:                example
o:                 Example Organization
```

3. **Add an Organizational Role** — I identified the role of administrator of the address book by adding the following lines to the `people.ldif` file.

```
dn:                cn=Manager,dc=example,dc=com
objectClass:       organizationalRole
cn:                Manager
description:       Example Address Book Administrator
```

4. **Add an Organizational Unit** — Because in this example the address book basically consists of names and addresses of members of the organization, I call the organizational unit (ou) members.

```
dn:                ou=members,dc=example,dc=com
objectClass:       top
objectClass:       organizationalUnit
ou:                members
```

### NOTE

Although in my example I am creating an address book that is at the top of my directory structure, if you are in a large company, chances are that you will want a more complex directory structure. For example, instead of having one address book at the top of your directory structure, you may create additional organizational units for countries, locations, or departments.



Then, every single unit might have its own address book. You also might want to support multiple directories under each unit. For example, there may be a separate directory for keeping track of computer equipment or company vehicles.

- 5. Add People** — With the directory structure in place, and with a `members` unit under the `example.com` distinguished name, I can begin adding people to the directory. I define each person as `organizationalPerson` and `inetOrgPerson` object classes. There are a lot of different attributes I could add to each person's information. However, most of the attributes I've chosen are attributes that will be read by the Thunderbird mail client (which I will show later in this chapter). Here are the two entries:

```
dn: cn=John Wilson,ou=members,dc=example,dc=com
objectClass: organizationalPerson
objectClass: inetOrgPerson
cn: John Wilson
mail: jwilson@example.com
givenname: John
sn: Wilson
uid: jbwilson
o: Example Organization
telephoneNumber: 800-555-1212
homePhone: 800-555-1313
mobile: 800-555-1414
pager: 800-555-1515
facsimileTelephoneNumber: 800-555-1414
title: Account Executive
homePostalAddress: 1234 Broadway$New York NY 99999
```

```
dn: cn=Andrew Smith,ou=members,dc=example,dc=com
objectClass: organizationalPerson
objectClass: inetOrgPerson
cn: Andrew Smith
mail: awsmith@example.com
givenname: Andrew
sn: Smith
uid: awsmith
o: Example Organization
telephoneNumber: 800-555-2893
homePhone: 800-555-4329
mobile: 800-555-8458
pager: 800-555-4955
facsimileTelephoneNumber: 800-555-3838
title: Interior Decorator
homePostalAddress: 167 E Street$Salt Lake UT 99999
```

As you can see here, the two people listed in the address book directory (called `members`) are each associated with a common name (`cn`), John Wilson and Andrew Smith, in the `members` organizational unit, which falls under the `example.com` domain components.

You can add as many people as you want to this file by repeating this structure. (Notice that a \$ is used to separate lines in an address.)

**NOTE**

You may find that you don't need all of the attributes shown here or may want to add others. Refer to the schema files to see a list of attributes that are available with `organizationalPerson`, `inetOrgPerson`, and other object classes you might want to use with your address book.

6. **Save the LDIF File** — Save the changes to your LDIF file (in my case, the file is called `/etc/openldap/people.ldif`).
7. **Add the Information to the LDAP Server** — You can use the `ldapadd` command to add the entire contents of the LDIF file you created to your LDAP directory. Here is the command I used to add the contents of my LDIF file (called `people.ldif`) to my LDAP directory:

```
# ldapadd -xv -D "cn=Manager,dc=example,dc=com" -W -f people.ldif
Enter LDAP Password: mysecret
add objectClass:
      dcObject
      organization
add dc:
      example
add o:
      Example Organization
adding new entry "dc=example,dc=com"
modify complete

add objectClass:
      organizationalRole
add cn:
      Manager
add description:
      Example Address Book Administrator
adding new entry "cn=Manager,dc=example,dc=com"
modify complete
.
.
.
add cn:
      John Wilson
add mail:
      jbwilson@example.com
add givenname:
      John
add sn:
      Wilson
.
.
.
```

```

add cn:
    Andrew Smith
add mail:
    awsmith@example.com
add givenname:
    Andrew
add sn:
    Smith
.
.
.

```

The password shown here (which will not display as you type it) is the one you added to your `slapd.conf` file. In the example, I used `mysecret` as the password. The `-x` says to use simple authentication (no SASL). The `-D` says to use the distinguished name defined earlier in the `slapd.conf` file (`cn=Manager,dc=example,dc=com`). The `-W` says to prompt for the password, instead of entering it on the command line. The `-f` indicates the file to load (in the example presented here, `people.ldif`).

As the `ldapadd` command successfully adds each entry, it lists the objects associated with each one.

8. **Restart the Server** — You can restart the server at this point by typing the following:

```
# /etc/init.d/ldap restart
```

9. **Search the Directory** — To make sure that everything was properly inserted into the directory, you can run the following search command:

```

# ldapsearch -x -W -D 'cn=manager,dc=example,dc=com' \
  -b 'dc=example,dc=com' '(objectClass=*)'
# extended LDIF
#
# LDAPv3
# base <dc=example,dc=com> with scope subtree
# filter: (objectClass=*)
# requesting: ALL
#
# example.com
dn: dc=example,dc=com
objectClass: top
objectClass: dcObject
objectClass: organization
dc: example
o: Example Organization

# Manager, example.com
dn: cn=Manager,dc=example,dc=com
objectClass: organizationalRole
cn: Manager

```

```

description: Example Address Book Administrator

# members, example.com
dn: ou=members,dc=example,dc=com
objectClass: top
objectClass: organizationalUnit
ou: members

# John Wilson, example.com
dn: cn=John Wilson,ou=members,dc=example,dc=com
objectClass: organizationalPerson
objectClass: inetOrgPerson
cn: John Wilson
mail: jbwilson@example.com
givenName: John
sn: Wilson
uid: jbwilson
o: Example Organization
.
.
.

```

In this example, I asked to use simple authentication (clear-text passwords with the `-x` option), start at the base (`-b`) of the `example.com` directory to begin the search, and list all object classes (`objectClass=*`). If you like, you can pipe the output to `less` so you can page through it.

- 10. Debug Your Directory** — Don't expect your LDIF file to load the first time without any errors. While you debug your address book directory, I recommend that you use a non-production machine and just clear out the database files after each failed attempt to load your directory. Assuming that you kept your LDAP directory files in `/var/lib/ldap` and that it's OK to erase the whole database while you debug your entries, you can do the following:

### WARNING

You're about to erase the LDAP directory files you created. Don't do this step if you have information in your LDAP directory files that is not in your LDIF file. Don't erase your LDIF file, because you need it to re-create your directory files.

```

# /etc/init.d/ldap stop
# rm /var/lib/ldap/*
# /etc/init.d/ldap restart
# ldapadd -x -D "cn=Manager,dc=example,dc=com" -W -f people.ldif

```

Repeat this process until you feel that your LDIF file and all the information that it contains have been properly loaded into your LDAP directory files.

At this point, you can decide if you need to further tune your LDAP directory (as described in the section, "More Ways to Configure LDAP"). After that, I recommend that you check that your LDAP address book directory is working properly by trying to access it from Thunderbird, using its Contacts feature (as described later in this chapter).

## More Ways to Configure LDAP

---

If you plan to scale up your LDAP directory to be used by more than just a small office or home e-mail server, there are some additional configuration options you might want to consider. Here are a few suggestions:

- **Replicate the LDAP Directory** — You can make your LDAP directory accessible from multiple LDAP servers and have updates to your directory be disseminated to those servers. See the man page for the `slurpd` daemon (which handles update replication) and the *OpenLDAP Administrator's Guide* for information on setting up LDAP directory replication (`/usr/share/doc/openldap-servers*/guide.html`).
- **Add Certificates** — Transport Layer Security is built into the OpenLDAP server. For information on defining certificates and ciphers that will be accepted by the `slapd` daemon, refer to the `slapd.conf` man page.
- **Change Log Levels** — You can specify the level of debugging that is done by the `slapd` daemon. By adding the `loglevel <integer>` option to the `slapd.conf` file, you can have `slapd` do the following types of logging:

1	Trace function calls
2	Debug packet handling
4	Heavy trace debugging
8	Connection management
16	Print out packets sent and received
32	Search filter processing
64	Configuration file processing
128	Access control list processing
256	Stats log connections/operations/results
512	Stats log entries sent
1024	Print communication with shell backends
2048	Entry parsing

By default, the `loglevel` is 256. To log everything, set the `loglevel` to 4095. To get combinations of `loglevel` features, simply add the numbers you want together. For example, for trace function calls, heavy trace debugging and connection management, use the number 13 (as in `1 + 4 + 8`).

- **Limit Searches** — You can limit the number of entries that can be returned by a search (`sizelimit 500`, by default) and the amount of time `slapd` will take to answer a search request in seconds (`timelimit 3600`). Add new values that you want for your LDAP directory to your `slapd.conf` file.
- **Add Access Control Policy** — In the `slapd.conf` file, the default database access is set to allow Read access by anyone who can access the database. If you want to change that behavior, you can add access lines to selectively decide who can read and write to your database. For this example, I want to allow everyone to be able to read from the database but only allow people to change their own information. Refer to the `slapd.conf` man page for further information.

## Accessing an LDAP Address Book from Thunderbird

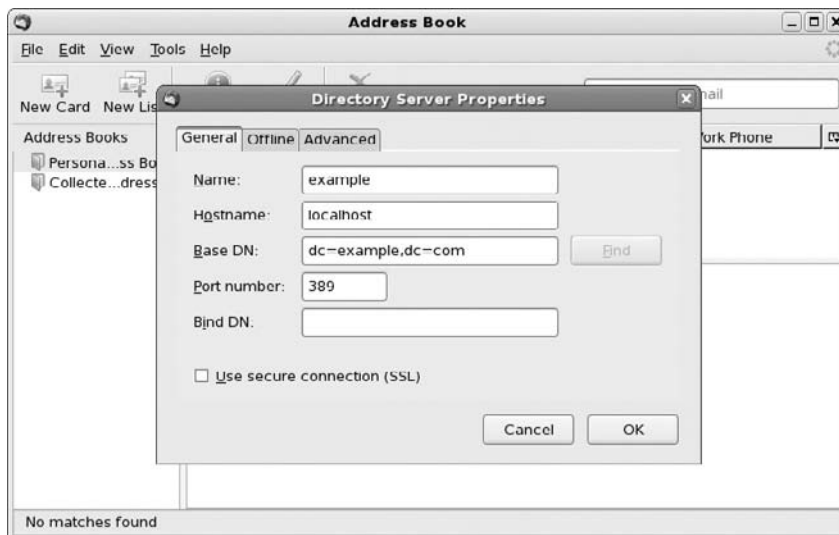
With your LDAP address book configured and running, you should be able to use it to get e-mail addresses from any e-mail client that supports LDAP directories. Assuming that your LDAP directory is up and running, the following example shows how to use Thunderbird (which is available with CentOS distributions) to search your LDAP directory for e-mail addresses.

1. From Thunderbird, click on the “Address Book” button.
2. From the Address Book window, select File > New > LDAP Directory. From the Thunderbird Directory Server Properties window that appears, enter at least the following information on the General tab:
  - **Name** — The name that identifies the server on your LDAP Servers List
  - **Hostname** — The name or IP address of the computer hosting the LDAP content
  - **Base DN** — Indicates the point in the LDAP directory to begin searching. You can select Find to have Thunderbird check your LDAP server for the Search base. In the example, `dc=example,dc=com` is the search base.
  - **Port** — Enter an IP address for the LDAP server. The port number is 389 by default.

Figure 21-1 shows the Directory Server Properties window that was just filled out.

**FIGURE 21-1**

Enter information about your LDAP directory server to search for addresses from Thunderbird.

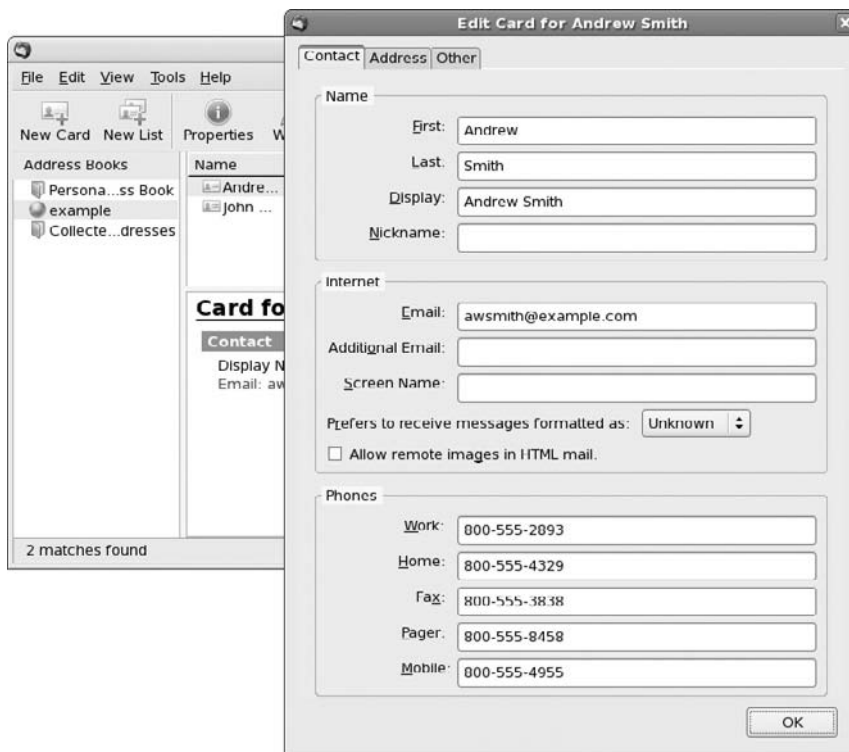


Click OK to save the configuration.

3. If you want to search the directory for an e-mail address, with the name of the LDAP address book selected in the left column, type a search term into the search box on the Thunderbird Address Book window and press [Enter]. Figure 21-2 shows one of the entries that were added during the example of setting up the LDAP directory.

**FIGURE 21-2**

Search an LDAP address book directory by name, e-mail address, or other information.



4. After an entry is found, you can do the following:
  - Double-click on the entry to see an address book card with as much information as is available for the person displayed.
  - Click on the highlighted e-mail address for an entry to open a Compose window, ready to send an e-mail to the person selected.

If your LDAP directory is not accessible from the Thunderbird client, run the Thunderbird or other LDAP-enabled e-mail application on the LDAP server. If you are able to access the

LDAP directory from the local server, it means that for some reason requests are being rejected from the server to outside hosts. Verify that the firewall on the server has port 389 open (which is used by default to access LDAP services). Next, check how access permissions are being set in the `slapd.conf` file.

## Summary

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Lightweight Directory Access Protocol (LDAP) is a popular tool for creating directories of information that need to be accessed by a variety of different network-ready applications. LDAP is based on the CCITT X.500 standard but provides a more workable subset of those features for creating directories of information that needs to be highly accessible.

In CentOS systems, OpenLDAP is included for you to use if you want to offer LDAP services from your computer. To configure an LDAP server, you need to set up the `slapd.conf` file (to configure the `slapd` daemon) and create entries that are then loaded into your LDAP directory files. Those entries are typically added to a file in LDIF format and loaded into files in the `/var/lib/ldap` directory by the `ldapadd` command.

To check the address book created by the example in this chapter, you can use the Thunderbird e-mail client. Using Thunderbird or other LDAP-enabled e-mail application, you can search the LDAP directory for names, e-mail addresses, and other information contained in that directory.





# Chapter 22

## Setting Up a DHCP Boot Server

If you are tasked with maintaining a network, you are probably interested in automating as much of the routine maintenance as possible. As your network grows, this becomes particularly important. When a new computer is added to your network or when a new employee joins your organization, you need to make configuration changes. You'd probably like a painless means of getting the changes pushed out quickly and preferably without having to touch each and every computer on your network. This is where the Dynamic Host Configuration Protocol (DHCP) comes in.

The Internet Protocol (IP) has enabled network functionality that could scarcely be imagined when IP was first developed. In order for your network client and servers to take advantage of the numerous IP network services, software, and devices, each of your clients needs an IP address.

For all but the smallest networks, manually assigning and then tracking IP addresses can be a risky proposition. On top of the hassle of tracking who has which address, you could find yourself having to reconfigure every network client you have if you need to make a change in your IP addressing structure to accommodate new users or ISP services. Because DHCP can be used to dynamically assign IP addresses to DHCP clients, all of these pitfalls become irrelevant when DHCP is in use.

This chapter describes how to set up CentOS as a DHCP server. It then explains how to verify that the services are working and how to set up client computers to use those services.

### IN THIS CHAPTER

Using Dynamic Host Configuration Protocol (DHCP)

Setting up a DHCP server

Setting up a DHCP client

## Using the Dynamic Host Configuration Protocol

---

Did you ever wonder why you can just plug your computer's Ethernet cable into a LAN jack at work, a hotel, or a DSL router in your home and immediately be up on the Internet? In most cases, it's because that LAN is set up to do DHCP. Linux and Windows systems are set up by default to look for a DHCP server on all Ethernet cards when the systems boot up. If your ISP or support staff has configured DHCP, you can be on the Internet faster than you can open your browser.

Setting up a DHCP server enables you to centrally manage the addresses and other network information for client computers on your private network. With DHCP configured on your network, a client computer can simply indicate that it wants to use DHCP and the DHCP server can provide its IP address, network mask, DNS server, NetBIOS server, router (gateway), and other information needed to get up and running on the network.

With DHCP, you can greatly simplify the initial network configuration that each client computer on your network needs to do. Later, as your network evolves, you can easily update that information, having changes automatically picked up by clients when they restart their network interfaces.

### NOTE

Although this chapter focuses on the configuration of DHCP client and server services on your CentOS systems, your CentOS DHCP client can use the services of other network devices. For example, you might have a Cisco routing switch, a DSL/Cable device with DHCP services, or even a Windows-based DHCP server. DHCP clients for CentOS will not have trouble working with any standards-compliant DHCP server.

To configure the DHCP server described in this chapter, you need to have the `dhcp` package installed (type `yum install dhcp`).

## Setting Up a DHCP Server

---

To configure a DHCP server, you need to install the `dhcp` package. Assuming that you have already set up the physical connections between your DHCP server and the client computers on your network (presumably an Ethernet LAN), the minimum tools you need to get the DHCP server working are:

- A firewall that allows requests for DHCP service
- A configured `/etc/dhcpd.conf` file
- A running `dhcpd` server daemon (which can be started at boot time)

After the DHCP server is running, it listens to UDP port 67 for requests from DHCP clients on the LAN. A client simply boots up (with an Ethernet network interface turned on and DHCP identified as its method of getting network addresses). This causes the client to send out a DHCP discovery request to 255.255.255.255 (the global broadcast address). The DHCP server picks up that request and feeds the client the information it needs to get up and running on the network.

**NOTE**

The `dhcpd.conf` file can serve a wide range of configuration information to DHCP clients. To see the full set of options and parameters you can set in that file, refer to the `dhcp-options` and `dhcpd.conf` man pages (type **man dhcp-options**).

## Opening Your Firewall and SELinux for DHCP

The firewall on your DHCP server must be configured to allow access to UDP ports 67 and 68. The easiest way to do this is to select System > Administration > Firewall from the GNOME desktop. From the Firewall Configuration window that appears, select “Other Ports” and add UDP ports 67 and 68.

If you prefer to use `iptables` directly to change your firewall, you can add a new rule to `iptables` and then save the changes permanently. Type the following as root user:

```
# iptables -I INPUT -i eth0 -p udp --sport  
67:68 --dport 67:68 -j ACCEPT
```

In this example, requests are allowed to and from source and destination ports 67 and 68 (`--sport 67:68` and `--dport 67:68`) on the `eth0` interface (which is your first Ethernet card). DHCP uses the UDP protocol (`-p udp`). If your DHCP server is also a routing firewall for your network, you want to make sure that you are only offering DHCP services to your LAN and not to the Internet. (You need to figure out if `eth0`, `eth1`, or some other card is connected to your LAN.)

If the rule was accepted (type **iptables -L -n** to make sure), you can save your entire firewall configuration so that the new rule is included permanently. To change your firewall, type the following (as root user):

```
# service iptables save
```

This updates your `/etc/sysconfig/iptables` file so that all the current rules (including the one you just added) are included the next time `iptables` is restarted. To restore those firewall settings without rebooting, use the `iptables-restore` command:

```
# iptables-restore < /etc/sysconfig/iptables
```

SELinux should not block normal operations of the `dhcpd` daemon. If it does, however, you can consider setting SELinux to permissive by typing **setenforce 0** on the command line as root user.

## Configuring the `/etc/dhcpd.conf` File

Suppose you have a single pool of IP addresses that you want to distribute to a set of computers that are all on the same subnetwork. In other words, all the computers are connected to one switch or cluster of switches with no routing between the devices. Here is an example of a simple `dhcpd.conf` file:

```
ddns-update-style interim;
ignore client-updates;

subnet 10.0.0.0 netmask 255.255.255.0 {

    option routers          10.0.0.1;
    option domain-name-servers 10.0.0.1;
    option subnet-mask      255.255.255.0;
    option domain-name      "example.com";

    range 10.0.0.150 10.0.0.225;
    default-lease-time 21600;
    max-lease-time 43200;

    # Set name server to appear at a fixed address
    host ns {
        next-server ns1.example.com;
        hardware ethernet 00:D0:B3:79:B5:35;
        fixed-address 10.0.0.1;
    }
}
```

In this example, this DHCP server provides IP addresses for client computers on a small LAN. The first two lines tell the DHCP server to update DNS records for the local domain if the server also gives out hostnames to the clients.

The DHCP server is serving a single LAN, represented by a `10.0.0.0` network address with a `255.255.255.0` netmask. Other data in this file defines what information the DHCP server will hand out to clients on this LAN.

A single server at address `10.0.0.1` is used as the router (or gateway) and DNS server for the LAN. To ensure that this server always gets the fixed address of `10.0.0.1`, a host entry is set to the hardware address (`00:D0:B3:79:B5:35`) for the Ethernet card on the host named `ns`. Using the MAC address as shown above along with the option `deny unknown-clients;`, you can allow only specified MAC addresses to obtain DHCP leases.

The pool of addresses handed out by this DHCP server is `10.0.0.150` to `10.0.0.225`, as set by the `range` line. Along with the IP address that each client is assigned, the client is also given the associated subnetmask and domain name.

The IP addresses that the DHCP server hands out are leased to each client for a particular time. The `default-lease-time` (set to 21,600 seconds here, or 6 hours) is the time assigned if the

client doesn't request a particular lease period. The `max-lease-time` (43,200 seconds here, or 12 hours) is the highest amount of time the server will assign, if the client requests it. Clients can renew leases, so they don't have to lose the IP address while they are still using it.

## Expanding the `dhcpd.conf` File

As I noted earlier, this is a very simple example that works well for a single network of client computers. The following are some examples of ways that you can expand your `dhcpd.conf` file:

- If you have multiple ranges of addresses on the same subnetwork, you can add multiple range options to a subnet declaration. Here is an example:

```
subnet 10.0.0.0 netmask 255.255.255.0 {
    range 10.0.0.10 10.0.0.100;
    range 10.0.0.200 10.0.0.250;
}
```

- This example causes the DHCP server to assign IP addresses between the ranges of 10 and 100 and between 200 and 250 on network 10.0.0.
- You can set fixed addresses for particular host computers, also called *address reservations*. In particular, you would want to do this for your server computers so that their addresses don't change. While you could simply omit the fixed IP addresses from your pool of DHCP assigned addresses, you would lose centralized management of IP configurations. The DHCP reservations allow you to centrally configure all IP address information. One way to do this is based on the Ethernet hardware address of the server's Ethernet card. All information for that computer can be contained in a host definition, such as the following:

```
host zarkov {
    hardware ethernet 00:04:5A:4F:8E:47;
    fixed-address 10.0.0.254;
}
```

- Here, when the DHCP server encounters the Ethernet address, the `fixed-address 10.0.0.254` is assigned to it. It's a good idea to statically assign server IP addresses. Type **ifconfig -a** on the server computer to see the address of its Ethernet hardware (while the interface is up). Within this host definition, you can add other options as well. For example, you could set the location of different routes (`routers` option).
- Many of the options enable you to define the locations of various server types. These options can be set globally or within particular host or subnet definitions. For example:

```
option netbios-name-servers 10.0.0.252;
option time-servers 10.0.0.253;
```

- In these examples, the `netbios-name-servers` option defines the location of the WINS server (if you are doing Windows file and print server sharing using Samba). The `time-servers` option sets the location of a time server on your network.

- The DHCP server can be used to provide the information an X Terminal or diskless workstation could use to boot up on the network. The following is an example of a definition you could use to start such a computer on your network:

```
host flashg {
    filename "/dwboot/flashg.nb";
    hardware ethernet 00:04:5A:4F:8E:47;
    fixed-address 10.0.0.150;
}
```

In the previous example, the boot file used by the diskless workstation from the DHCP server is located at `/dwboot/flashg.nb`. The `hardware ethernet` value identifies the address of the Ethernet card on the client. The client's IP address is set to `10.0.0.150`. All of those lines are contained within a host definition, where the hostname is defined as `flashg`. (See Table 22-1 for descriptions of data types and the "Thin Clients" heading in Table 22-2 for other options that may be useful for configuring thin clients.)

## Adding Options

There are dozens of options you can use in the `/etc/dhcpd.conf` file to pass information from the DHCP server to DHCP clients. Table 22-1 describes data types you can use for different options. Table 22-2 describes options that are available.

**TABLE 22-1**

### Data Types

Data Types	Description
IP address	Enter IP addresses as either an IP address number (11.111.111.11) or a fully qualified domain name (comp1.example.com). To use a domain name, the name must be resolvable to an IP address number.
int32, int16, int8, uint32, uint16, uint8	Used to represent signed and unsigned 32-, 16-, and 8-bit integers
string	Enter a string of characters, surrounded by double quotes (").
Boolean	Enter <code>true</code> or <code>false</code> when a Boolean value is required.
data-string	Enter a string of characters in quotes (" <code>client1</code> ") or a hexadecimal series of octets (00:04:5A:4F:8E:47).

Options contain values that are passed from the DHCP server to clients. Although Table 22-2 lists valid options, the client computer will not be able to use every value you could potentially pass to it. In other words, not all options are appropriate in all cases.

TABLE 22-2

## DHCP Options

Options	Descriptions
<b>Names, Addresses, and Time</b>	
<code>option host-name string;</code>	Indicates the name that the client computer can use to identify itself. It can either be a simple hostname (e.g., <code>zarkov</code> ) or a fully qualified domain name (e.g., <code>zarkov.example.com</code> ). You may use this in a <code>host</code> declaration, where a host computer is identified by an Ethernet address.
<code>option domain-name string;</code>	Identifies the default domain name the client should use to resolve DNS hostnames.
<code>option subnet-mask ip-address;</code>	Associates a subnetwork mask with an IP address, for example:  <code>option 255.255.255.0 10.0.0.1;</code>
<code>option time-offset int32;</code>	Indicates the offset (in seconds) from Coordinated Universal Time (UTC). For example, a UTC offset for U.S. Eastern Standard Time is set as follows:  <code>option time-offset -18000;</code>
<b>Servers and Routers</b>	
<code>option routers ip-address [, ip-address... ];</code>	Lists, in order of preference, one or more routers connected to the local subnetwork. The client may refer to this value as the <i>gateway</i> .
<code>option domain-name-servers ip-address [, ip-address... ];</code>	Lists one or more Domain Name System (DNS) servers that the client can use to resolve names into IP addresses. Lists servers in the order in which they should be tried.
<code>option time-servers ip-address [, ip-address... ];</code>	Lists, in order of preference, one or more time servers that can be used by the DHCP client.
<code>option ien116-name-servers ip-address [, ip-address... ];</code>	Lists, in order of preference, one or more IEN 116 name servers that can be used by the client. (IEN 116 name servers predate modern DNS servers and are considered obsolete.)
<code>option log-servers ip-address [, ip-address... ];</code>	Lists one or more MIT-LCS UDP log servers. Lists servers in the order in which they should be tried.

*continued*



**TABLE 22-2** (continued)

Options	Descriptions
<code>option cookie-servers ip-address [, ip-address... ];</code>	Lists one or more Quote of the Day (cookie) servers (see RFC 865). List servers in the order in which they should be tried.
<code>option lpr-servers ip-address [, ip-address... ];</code>	Lists one or more line printer servers that are available. List servers in the order in which they should be tried.
<code>option impress-servers ip-address [, ip-address... ];</code>	Lists one or more Imagen Impress image servers. List servers in the order in which they should be tried.
<code>option resource-location-servers ip-address [, ip-address... ];</code>	Lists one or more Resource Location servers (RFC 887). List servers in the order in which they should be tried.
<code>option nis-domain string;</code>	Indicates the name of the NIS domain, if an NIS server is available to the client.
<code>option nis-servers ip-address [, ip-address... ];</code>	Lists addresses of NIS servers available to the client, in order of preference.
<code>option ntp-servers ip-address [, ip-address... ];</code>	Lists addresses of network time protocol servers, in order of preference.
<code>option netbios-name-servers ip-address [, ip-address... ];</code>	Lists the addresses of WINS servers, used for NetBIOS name resolution (for Windows file and print sharing).
<code>option netbios-dd-server ip-address [, ip-address... ];</code>	Lists the addresses of NetBIOS datagram distribution (NBDD) servers, in preference order.
<code>option netbios-node-type uint8;</code>	Contains a number (a single octet) that indicates how NetBIOS names are determined (used with NetBIOS over TCP/IP). Acceptable values include: 1 (broadcast: no WINS), 2 (peer: WINS only), 4 (mixed: broadcast, then WINS), 8 (hybrid: WINS, then broadcast).
<code>option font-servers ip-address [, ip-address... ];</code>	Indicates the location of one or more X Window font servers that can be used by the client, listed in preference order.
<code>option nisplus-domain string;</code>	Indicates the NIS domain name for the NIS+ domain.
<code>option nisplus-servers ip-address [, ip-address... ];</code>	Lists addresses of NIS+ servers available to the client, in order of preference.

continued

**TABLE 22-2** (continued)

Options	Descriptions
<code>option smtp-server ip-address [ , ip-address... ];</code>	Lists addresses of SMTP servers available to the client, in order of preference.
<code>option pop-server ip-address [ , ip-address... ];</code>	Lists addresses of POP3 servers available to the client, in order of preference.
<code>option nntp-server ip-address [ , ip-address... ];</code>	Lists addresses of NNTP servers available to the client, in order of preference.
<code>option www-server ip-address [ , ip-address... ];</code>	Lists addresses of WWW servers available to the client, in order of preference.
<code>option finger-server ip-address [ , ip-address... ];</code>	Lists addresses of Finger servers available to the client, in order of preference.
<code>option irc-server ip-address [ , ip-address... ];</code>	Lists addresses of IRC servers available to the client, in order of preference.
<b>Routing</b>	
<code>option ip-forwarding flag;</code>	Indicates whether the client should allow (1) or not allow (0) IP forwarding. This would be allowed if the client were acting as a router.
<code>option non-local-source-routing flag;</code>	Indicates whether or not the client should allow (1) or disallow (0) datagrams with nonlocal source routes to be forwarded.
<code>option static-routes ip-address ip-address [ , ip-address ip-address... ];</code>	Specifies static routes that the client should use to reach specific hosts. (List multiple routes to the same location in descending priority order.)
<code>option router-discovery flag;</code>	Indicates whether the client should try to discover routers (1) or not (0) using the router discovery mechanism.
<code>option router-solicitation-address ip-address;</code>	Indicates an address the client should use to transmit router solicitation requests.
<b>Thin Clients</b>	
<code>option boot-size uint16;</code>	Indicates the size of the default boot image (in 512-octet blocks) that the client computer uses to boot.
<code>option merit-dump string;</code>	Indicates where the core image should be dumped if the client crashes.
<code>option swap-server ip-address;</code>	Indicates where the client computer's swap server is located.

*continued*

**TABLE 22-2** (continued)

Options	Descriptions
<code>option root-path string;</code>	Indicates the location (pathname) of the root disk used by the client.
<code>option tftp-server-name string;</code>	Indicates the name of the TFTP server that the client should use to transfer the boot image; used more often with DHCP clients than with BOOTP clients.
<code>option bootfile-name string;</code>	Indicates the location of the bootstrap file that is used to boot the client; used more often with DHCP clients than with BOOTP clients.
<code>option x-display-manager ip-address [, ip-address... ];</code>	Indicates the locations of X Window System Display Manager servers that the client can use, in order of preference.

Table 22-2 is divided into the following categories:

- **Names, Addresses, and Time** — These options set values that are used by clients to have their hostnames, domain names, network numbers, and time zones (offset from GMT) defined.
- **Servers and Routers** — These options are used to tell DHCP clients where on the network to find routers and servers. Although more than a dozen server types are listed, most often you will just indicate the address of the router and the DNS servers the client will use.
- **Routing** — These options indicate whether or not the client routes packets.
- **Thin Clients** — These options are useful if DHCP is being used as a boot server for thin clients. A thin client may be an X Terminal or diskless workstation that has processing power but no disk (or a very small disk), so it can't store a boot image and a file system itself.

## Starting the DHCP Server

After the `/etc/dhcpd.conf` file is configured, you can start the DHCP server immediately. As `root` user from a Terminal window, type the following:

```
# service dhcpd start
```

Your DHCP server should now be available to distribute information to the computers on your LAN. If there are client computers on your LAN waiting on your DHCP server, their network interfaces should now be active.

If everything is working properly, you can have your DHCP server start automatically each time your computer boots by turning on the `dhcpd` service as follows:

```
# chkconfig dhcpd on
```

There are a few ways you can verify that your DHCP server is working:

- Check the `/var/log/messages` file. If the DHCP service has trouble starting, you will see messages in this file indicating what the problem is.
- Check the `/var/lib/dhcpd/dhcpd.leases` file. If a client has been assigned addresses successfully from the DHCP server, a lease line should appear in that file. There should be one set of information that looks like the following for each client that has leased an IP address:

```
lease 10.0.0.225 {
    starts 2 2009/05/04 03:48:12;
    ends 2 2009/05/04 15:48:12;
    hardware ethernet 00:50:ba:d8:03:9e;
    client-hostname "zarkov";
}
```

- Launch Wireshark (type **yum install wireshark** to install and **wireshark** to run) and start capturing data (in promiscuous mode). Restart the DHCP server and restart the network interface on the client. You should see a series of DHCP packets that show a sequence like the following: DHCP Discover, DHCP Offer, DHCP Request, and DHCP ACK.
- From the client computer, you should be able to start communicating on the network. If the client is a Linux system, type the **ifconfig -a** command. Your Ethernet interface (probably `eth0`) should appear, with the IP address set to the address assigned by the DHCP server. If your client is a Windows system, open a command prompt and type **ipconfig /all**. You will see the configuration information for all of your network interfaces.

When the server is running properly, you can continue to add DHCP clients to your network to draw on the pool of addresses you assign.

## Setting Up a DHCP Client

---

Most client computers are configured by default to boot up using DHCP to connect to the network. However, when that is not the case, you may need to indicate manually that DHCP be used. Configuring a network client to get addresses from your DHCP server is fairly easy.

1. While you are initially installing Linux, click Configure using DHCP on the Network Configuration screen. Your network client should automatically pick up its IP address from your DHCP server when it starts up.

2. To set up DHCP after installation, open the Network Configuration window (select System > Administration > Network or run the `system-config-network` command).
3. From the Network Configuration window:
  - a. Click on the Devices tab (on by default).
  - b. Click on your Ethernet device (probably `eth0`).
  - c. Click Edit.
  - d. Click on the General tab.
  - e. Click “Automatically obtain IP address settings with” and select `dhcp`.
  - f. Click OK.
  - g. Click Activate.
4. Then, from a Terminal window, type:

```
# service network restart
```

By default, a CentOS client will not accept all information passed to it from the DHCP server. The way that client handles DHCP server input is based on settings in the `/etc/sysconfig/network-scripts/ifup` script. If the client has DHCP turned on, when the system starts up networking, the `ifup` script runs the `dhclient` command. You can adjust the behavior of `dhclient` by creating the `/etc/dhclient.conf` file. (Type **man dhclient.conf** to find out how you can set your `dhclient.conf` file.)

## Summary

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DHCP provides a mechanism for centrally administering computers on your network and can provide information that helps client computers get up and running quickly on the network.

DHCP is used to provide information about your network to other clients on your network. IP addresses can be assigned dynamically, meaning they are distributed from a pool of IP addresses. Or specific addresses can be assigned to clients, based on specific Ethernet hardware addresses.

# Chapter 23

## Setting Up a MySQL Database Server

**M**ySQL is a popular Structured Query Language (SQL) database server. Like other SQL servers, MySQL provides the means of accessing and managing SQL databases. However, MySQL also provides tools for creating database structures, as well as for adding, modifying, and removing data from those structures. Because MySQL is a relational database, data can be stored and controlled in small, manageable tables. Those tables can be used in combination to create flexible yet complex data structures.

A Swedish company called MySQL AB was responsible for developing MySQL ([www.mysql.com](http://www.mysql.com)). MySQL AB released MySQL as an Open Source product several years ago, gaining revenue by offering a variety of MySQL support packages, commercial licenses, and MySQL brand franchise products. In February 2008, Sun Microsystems Inc. acquired MySQL AB for about \$1 billion. (Who says you can't make money with Open Source software?)

MySQL has been ported to several different operating systems (primarily UNIX and Linux systems, although there are Windows versions and now even a Mac OS X version as well). As you may have guessed, these include binary versions of MySQL that run on CentOS. This chapter contains descriptions of and procedures for the version of MySQL that is contained in the CentOS distributions.

### IN THIS CHAPTER

**Finding MySQL packages**

---

**Configuring the MySQL server**

---

**Working with MySQL databases**

---

**Displaying MySQL databases**

---

**Making changes to tables and records**

---

**Adding and removing user access**

---

**Checking and fixing databases**

---

## Finding MySQL Packages

---

You need at least the `mysql` and `mysql-server` packages installed to set up MySQL using the procedures described in this chapter. The following MySQL packages that come with the CentOS distribution are what you need to get started:

- `mysql` — This software package contains a lot of MySQL client programs (in `/usr/bin`), several client shared libraries, the default MySQL configuration file (`/etc/my.cnf`), a few sample configuration files, files to support different languages, and documentation.
- `mysql-server` — This software package contains the MySQL server daemon (`mysqld`) and the `mysqld` startup script (`/etc/init.d/mysqld`). The package also creates various administrative files and directories needed to set up the MySQL databases.
- `mysql-devel` — This software package contains libraries and header files required for developing MySQL applications.

Other packages available to add functionality to your MySQL databases include `php-mysql` (contains a shared library to allow PHP applications access to MySQL databases), `mod_auth_mysql` (tools to authorize Apache Web Server access from data in a MySQL database), and `perl-DBD-MySQL` (provides a Perl interface to MySQL databases). Packages including tools for using MySQL databases include `mysql-bench` (contains scripts for benchmarking MySQL databases), `MySQL-python` (contains a Python interface to MySQL), and `qt4-MySQL` (MySQL drivers for QT SQL classes).

If MySQL isn't installed yet, type the following:

```
# yum install mysql-server
```

If MySQL was installed during initial CentOS installation, you should update your MySQL packages (run `yum` with `update` instead of `install`).

While most of this chapter focuses on using and administering a MySQL database from the command line, some graphical tools are available for working with MySQL databases. Unfortunately, the packages for these tools aren't in the base CentOS Repository. Instead, you will find them in the KBS-Extras Repository (<http://centos.karan.org/>). See Chapter 5 for how to configure `yum` to check for packages in additional repositories.

In particular, the `mysql-administrator` package contains GUI software for connecting to a MySQL server. To install the `mysql-administrator` package, type the following as `root` user:

```
# yum install mysql-administrator
```

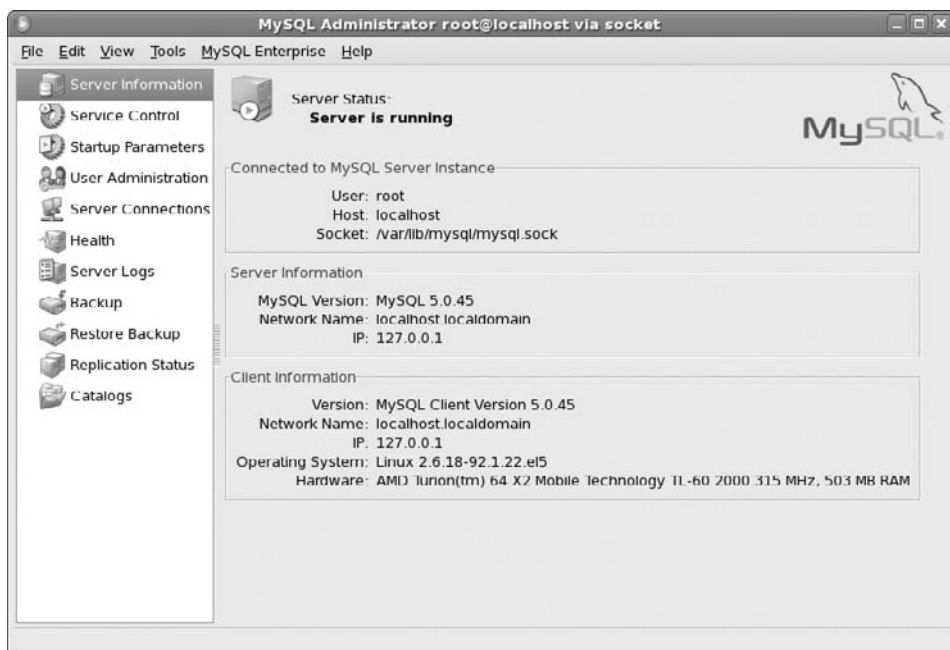
If you are familiar with MySQL, you can go ahead and use MySQL Administrator to connect to your MySQL database (assuming it is already running). If MySQL is new to you, I recommend

that you run through the procedures in this chapter to become familiar with how MySQL works and how to use it from the command line.

To launch the MySQL Administrator window, type **mysql-administrator**. If your MySQL database server is running, as described later in this chapter, enter the server hostname (such as localhost), username (such as root), and password. The MySQL Administrator window will appear, as shown in Figure 23-1.

**FIGURE 23-1**

Connect to your MySQL database using the MySQL Administrator window.



At this point, you can use the MySQL Administrator window to find information about your MySQL server, back up and restore data, or select Catalogs to display information about each database. You can even select the Health option to view all kinds of information about the activity and usage of your server machine.

**NOTE**

If you want to try another MySQL graphical utility, check out the `mysql-query-browser` package. That tool is made for designing MySQL tables and running queries.



## Configuring the MySQL Server

---

Like most server software in CentOS, the MySQL server relies on a start-up script and a configuration file to provide the service. Server activities are logged to the `mysqld.log` file in the `/var/log` directory. There are also `mysql` user and group accounts for managing MySQL activities. The following sections describe how these components all work together.

**TIP**

For many of the steps described in this section, the MySQL server daemon must be running. Starting the server is described in detail later in this chapter. For the moment, you can start the server temporarily (as `root`, type **service mysqld start**). Then add a password, as shown in the next section.

### Using MySQL User/Group Accounts

When the MySQL software is installed, it automatically creates a `mysql` user account and a `mysql` group account. These user and group accounts are assigned to MySQL files and activities. In this way, someone can manage the MySQL server without needing to have root permission.

The `mysql` user entry appears in the `/etc/passwd` file as follows:

```
mysql:x:27:27:MySQL Server:/var/lib/mysql:/bin/bash
```

The `mysql` entry just shown indicates that both the UID and GID for the `mysql` user are 27. The text string identifying this user account is `MySQL Server`. The home directory is `/var/lib/mysql`, and the default shell is `/bin/bash`. The home directory identified will contain directories that hold each table of data you define for the MySQL server.

The group entry for `mysql` is even simpler. The following entry in the `/etc/group` file indicates that the `mysql` group has a group ID (GID) of 27.

```
mysql:x:27:
```

If you care to check the ownership of files associated with MySQL, you will see that most of these files have `mysql` assigned as the user account and group account that own each file. This allows daemon processes that are run by the `mysql` user to access the database files.

### Adding Administrative Users

To administer MySQL, you need to have at least one administrative account. By default, the `root` user has full access to your MySQL server database and no password assigned. You can assign a password to the `root` user using the `mysqladmin` command, once the `mysqld` server is running. To add the `root` user as a MySQL administrator, log in as the `root` user and type the following from a Terminal window (substituting your own password in place of *myownpasswd*):

```
# mysqladmin -u root password myownpasswd
```

After this command is run, the MySQL root user can run any MySQL administrative commands using the password.

MySQL maintains a list of users and passwords that is separate from the list maintained by CentOS. If you don't provide a username on the command line (as in `-u root` shown above), MySQL assumes that you want to use your current CentOS username to log in to MySQL. However, you will still need to provide the MySQL password (not the CentOS password) for that user to use the MySQL service.

If you want to do MySQL administration, simply add the `-u root` argument to the command line of the MySQL command you are running. The Linux root user account has no connection to the MySQL root user account after the MySQL account is created. You would typically use different passwords for the two accounts.

**TIP**

To save yourself the trouble of typing in the password each time you run a MySQL client command, you can add a password option under the `[client]` group in one of the option files. The most secure way to do that is to create a `.my.cnf` file in the root user's home directory that can only be accessed by root (type `chmod 600 /root/.my.cnf`) and contains the following lines (substituting your password for the last argument shown):

```
[client]
password=myownpasswd
```

## Setting MySQL Options

You can set options that affect how the MySQL applications behave by using options files or command-line arguments. The MySQL server (as well as other administrative tools) reads the following options files when it starts up (if those files exist):

- **/etc/my.cnf** — Contains global options read by `mysqld` (server daemon) and `mysql.server` (script to start the server daemon).
- **-defaults-extra-file** — You can identify a file on the command line that contains options to be used by the server. For example, the following command would cause the file `/home/timothy/my.cnf` to be read for options after the global options and before the user-specific options:

```
# mysqld --defaults-extra-file=/home/timothy/my.cnf
```

- **\$HOME/.my.cnf** — Contains user-specific options. (The `$HOME` refers to the user's home directory, such as `/home/timothy`.)

Table 23-1 shows the MySQL commands that read the options files (in the order shown in the previous bullet list) and use those options in their processing. Options are contained within groups that are identified by single words within brackets. Group names that are read by each command are also shown in the table.

Although you can use any of the options files to set your MySQL options, begin by configuring the `/etc/my.cnf` file. Later, if you want to override any of the values set in that file, you can do so using the other options files or command-line arguments.

TABLE 23-1

## Option Groups Associated with MySQL Commands

Command	Description	Group Names
mysqld (in /usr/libexec)	The MySQL server daemon	[mysqld] [server]
mysqld_safe	Run by the mysqld start-up script to start the MySQL server	[mysql] [server] [mysql.server]
mysql	Offers a command-line interface for displaying and working with MySQL databases.	[mysql] [client]
mysqladmin	Used to create and maintain MySQL databases	[mysqladmin] [client]
myisamchk	Used to check, fix, and optimize MyISAM databases (.myi suffix)	[myisamchk]
myisampack	Used to compress MyISAM database tables	[myisampack]
mysqldump	Offers a text-based interface for backing up MySQL databases	[mysqldump] [client]
mysqlimport	Loads plaintext data files into MySQL databases	[mysqlimport] [client]
mysqlshow	Shows MySQL databases and tables you select	[mysqlshow] [client]

## Creating the my.cnf Configuration File

Global options that affect how the MySQL server and related client programs run are defined in the /etc/my.cnf file. The default my.cnf file contains only a few settings needed to get a small MySQL configuration going. The following is an example of the /etc/my.cnf file that comes with the mysql package from CentOS:

```
[mysqld]
datadir=/var/lib/mysql
socket=/var/lib/mysql/mysql.sock
user=mysql
# Default to using old password format for compatibility with mysql 3.x
# clients (those using the mysqlclient10 compatibility package).
old_passwords=1
[mysqld_safe]
log-error=/var/log/mysqld.log
pid-file=/var/run/mysqld/mysqld.pid
```

Most of the settings in the default `my.cnf` file define the locations of files and directories needed by the `mysqld` server. Each option is associated with a particular group, with each group identified by a name in square brackets. The previous options are associated with the `mysqld` daemon (`[mysqld]`) and the `safe_mysqld` script that starts the `mysqld` daemon (`[mysqld_safe]`). (Refer to Table 23-1 for a list of these groups.)

The default `datadir` value indicates that `/var/lib/mysql` is the directory that stores the MySQL databases you create. The `socket` option identifies `/var/lib/mysql/mysql.sock` as the socket that is used to create the MySQL communications endpoint associated with the `mysqld` server. The `user` option identifies `mysql` as the user account that has permission to do administration of the MySQL service. Based on the `old_passwords=1` value, your MySQL database will use the password format used in previous MySQL 3.x databases.

The `log-error` and `pid-file` options tell the `safe_mysqld` script the locations of the error log (`/var/log/mysqld.log`) and the file that stores the process ID of the `mysqld` daemon when it is running (`/var/run/mysqld/mysqld.pid`). The `safe_mysqld` script actually starts the `mysqld` daemon from the `mysqld` start-up script.

**NOTE**

Each option that follows a group name is assigned to that group. Group assignments end when a new group begins or when the end of a file is reached.

## Choosing Options

Many values are used by the MySQL server that are not explicitly defined in the `my.cnf` file. The easiest way to see which options are available for MySQL server and clients is to run each command with the `--help` option. For example, to view the available `mysqld` options (as well as other information), type the following from a Terminal window:

```
# /usr/libexec/mysqld --verbose --help | less
```

Then press the Spacebar to step through the information one screen at a time. (An example of this output is shown in the next section.)

You can also use the `man` command to find which options are available. For example, to see which options are available to set for the `mysqld` daemon, type the following:

```
man mysqld
```

It's quite likely that you can try out your MySQL database server without changing any options at all. However, after you set up your MySQL database server in a production environment, you will almost surely want to tune the server to match the way the server is used. For example, if it is a dedicated MySQL server, you will want to allow MySQL to consume more of the system resources than it would by default.

The following list shows a few examples of additional options that you might want to set for MySQL:

- `password=yourpwd` — Adding this option to a `[client]` group in a user's `$HOME/.my.cnf` file allows the user to run MySQL client commands without having to enter a password each time. (Replace *yourpwd* with the user's password.)
- `port=#` — Defines the port number to which the MySQL service listens for MySQL requests. (Replace *#* with the port number you want to use.) By default, MySQL listens to port number 3306 on TCP and UDP protocols.
- `safe-mode` — Tells the server to skip some optimization steps when the server starts.
- `tmpdir=path` — Identifies a directory, other than the default `/tmp`, for MySQL to use for writing temporary files. (Substitute a full pathname for *path*.)

In addition to the options you can set, MySQL clients also have many variables that you can set. Variables set such things as buffer sizes, time-out values, and acceptable packet lengths. These variables are also listed on the `--help` output. To change a variable value, you can use the `--set-variable` option, followed by the variable name and value. For example, to set the `sort_buffer` variable to 10 MB, you could add the following option under your `[mysqld]` group:

```
[mysqld]
set-variable=sort_buffer=10M
```

The following list identifies other variables you could set for your server. In general, raising the values of these variables improves performance, but also consumes more system resources. So you need to be careful raising these values on machines that are not dedicated to MySQL or that have limited memory resources.

**NOTE**

For variables that require you to enter a size, indicate megabytes using an *M* (e.g., 10M) or kilobytes using a *K* (e.g., 256K).

- `key_buffer_size=size` — Sets the buffer size that is used for holding index blocks that are used by all threads. This is a key value to raise to improve MySQL performance.
- `max_allowed_packet=size` — Limits the maximum size of a single packet. Raise this limit if you require processing of very large columns.
- `mysam_sort_buffer_size=size` — Sets the buffer size used for sorting while repairing an index, creating an index, or altering a table.
- `sort_buffer=size` — Defines how much buffer size is allocated for each thread that needs to do a sort. Raising this value makes sorting threads go faster.
- `table_cache=#` — Limits the total number of tables that can be open at the same time for all threads. The number of this variable represents the total number of file descriptors that MySQL can have open at the same time.

- `thread_cache_size=size` — Sets the number of threads that are kept in cache, awaiting use by MySQL. When a thread is done being used, it is placed back in the cache. If all the threads are used, new threads must be created to service requests.

## Checking Options

In addition to seeing how options and variables are set in the options files, you can also view how all variables are set on your current system. You can view both the defaults and the current values being used by the MySQL server.

The `--help` command-line argument lets you see the options and variables as they are set for the server and for each MySQL client. Here is an example of the output showing this information for the `mysqld` server daemon:

```
# /usr/libexec/mysqld --verbose --help | less
.
.
.
Variables (--variable-name=value)
and boolean options {FALSE|TRUE}  Value (after reading options)
-----
help                                TRUE
abort-slave-event-count             0
allow-suspicious-udfs               FALSE
auto-increment-increment            1
automatic-sp-privileges              TRUE
basedir:                             /usr/
.
.
.
tmp_table_size                       33554432
transaction_alloc_block_size         8192
transaction_prealloc_size            4096
updatable_views_with_limit           1
wait_timeout                          28800
```

To see what values a running MySQL server is using, type `'mysqladmin variables'` instead of `'mysqld --verbose --help'`

After the server is started, you can see the values that are actually in use by running the `mysqladmin` command with the `variables` option. (Pipe the output to the `less` command so you can page through the information.) Here is an example (if you haven't stored your password, you will be prompted to enter your password before you see any output):

```
# mysqladmin -u root -p variables | less
+-----+-----+
| Variable_name | Value |
+-----+-----+
```

```

| auto_increment_increment | 1 |
| auto_increment_offset   | 1 |
| automatic_sp_privileges | ON |
| back_log                 | 50 |
| basedir                  | /usr/ |
| bdb_cache_size           | 8388600 |
| bdb_log_buffer_size     | 32768 |
| bdb_home                 | /var/lib/mysql/ |
| bdb_max_lock             | 10000 |
| bdb_logdir               | |
| bdb_shared_data         | OFF |
| bdb_tmpdir               | /tmp/ |
|
|
|
|
| tmp_table_size          | 33554432 |
| tmpdir                  | /tmp/ |
| version                  | 5.0.45 |
| wait_timeout             | 28800 |
+-----+

```

If you decide that the option and variable settings that come with the default MySQL system don't exactly suit you, you don't have to start from scratch. Sample `my.cnf` files that come with the `mysql` package let you begin with a set of options and variables that are closer to the ones you need.

## Using Sample `my.cnf` Files

Sample `my.cnf` files are available in the `/usr/share/doc/mysql-server*` directory. To use one of these files, do the following:

1. Keep a copy of the old `my.cnf` file:
 

```
# mv /etc/my.cnf /etc/my.cnf.old
```
2. Copy the sample `my.cnf` file you want to the `/etc/my.cnf` file. For example, to use the `my-medium.cnf` file, type the following:
 

```
# cp /usr/share/doc/mysql-server*/my-medium.cnf /etc/my.cnf
```
3. Edit the new `/etc/my.cnf` file (as `root` user) using any text editor to further tune your MySQL variables and options.

The following bullets describe each of the sample `my.cnf` files:

- **my-small.cnf** — This options file is recommended for computer systems that have less than 64 MB of memory and are used only occasionally for MySQL. With this options file, MySQL won't be able to handle a lot of usage, but it won't be a drag on the performance of your computer.

For the `mysqld` server, buffer sizes are set low — only 64K for the `sort_buffer` and 16K for the `key_buffer`. The `thread_stack` is set to only 64K and `net_buffer_length` is only 2K. The `table_cache` is set to 4.

- **my-medium.cnf** — As with the small options file, the `my-medium.cnf` file is intended for systems where MySQL is not the only important application running. This system also has a small amount of total memory available — between 32 MB and 64 MB — but more consistent MySQL use is expected.

The `key_buffer` size is set to 16 MB in this file, while the `sort_buffer` value is raised to 512 KB for the `mysqld` server. The `table_cache` is set to 64 (allowing more simultaneous threads to be active). The `net_buffer_length` is raised to 8 KB.

- **my-large.cnf** — The `my-large.cnf` sample file is intended for computers that are dedicated primarily to MySQL service. It assumes about 512 MB of available memory.

Server buffers allow more active threads and better sorting performance. Half of the system's assumed 512 MB of memory is assigned to the `key_buffer` variable (256 MB). The `sort_buffer` size is raised to 1 MB. The `table_cache` allows more simultaneous users (up to 256 active threads).

- **my-huge.cnf** — As with the `my-large.cnf` file, the `my-huge.cnf` file expects the computer to be used primarily for MySQL. However, the system for which it is intended offers much more total memory (between 1 GB and 2 GB of memory).

Sort buffer size (`sort_buffer`) is raised to 2 MB, while the `key_buffer` is set to consume 384 MB of memory. The `table_cache` size is doubled to allow up to 512 active threads.

- **my-innodb-heavy-4G.cnf** — This sample configuration file is best suited for computers with 4 GB of RAM that are expected to service complex queries without too many connections (using the InnoDB transaction storage engine). Special `innodb` options in this file allow MySQL to take advantage of a large buffer pool size (2 GB).

## Starting the MySQL Server

---

For CentOS, the MySQL server is off by default. To turn it on, however, is fairly simple. The `/etc/init.d/mysqld` start-up script is delivered with the `mysql-server` package. To start the server, you can run the `mysqld` startup script to have it start immediately, and then set it to start each time your system boots.

To start the MySQL server immediately, type the following from a Terminal window as root user:

```
# service mysqld start
```

To set the MySQL server to start each time the computer reboots, type the following (as root):

```
# chkconfig mysqld on
```



This sets `mysqld` to start during most multiuser run states (levels 3, 4, and 5). To check that the service is turned on for those levels, type `chkconfig --list mysqld` from a Terminal window.

## Checking That MySQL Server Is Working

You can use the `mysqladmin` or `mysqlshow` commands to check that the MySQL server is up and running. Here's an example of how to check information about the MySQL server using the `mysqladmin` command:

```
# mysqladmin -u root -p version proc
Enter password: *****
mysqladmin Ver 8.41 Distrib 5.0.45, for redhat-linux-gnu on i386
Copyright (C) 2000-2006 MySQL AB
This software comes with ABSOLUTELY NO WARRANTY. This is free software,
and you are welcome to modify and redistribute it under the GPL license

Server version          5.0.45
Protocol version        10
Connection              Localhost via UNIX socket
UNIX socket             /var/lib/mysql/mysql.sock
Uptime:                 2 days 10 hours 47min 35 sec

Threads: 2 Questions: 184 Slow queries: 0 Opens: 11 Flush tables: 1 Open
tables: 0 Queries per second avg: 0.004
+-----+-----+-----+-----+-----+-----+-----+-----+
| Id | User | Host      | db | Command | Time | State | Info          |
+-----+-----+-----+-----+-----+-----+-----+
| 2  | root | localhost |    | Query   | 0    |      | show processlist |
+-----+-----+-----+-----+-----+-----+-----+-----+

```

Each of the two options to `mysqladmin` shown here provides useful information. The version information shows that the `mysqladmin` version is 8.41 and the number assigned to this distribution of the MySQL server is 5.0.45. The binary package was created for PC versions of Linux/GNU on the i386 processor. The connection to the server is through a UNIX socket (`mysql.sock`) on the local host. The server has been up for 2 days, 10 hours, 47 minutes, and 35 seconds. Statistics show that there is one thread (connection to the server) currently active. There have been 184 requests to the server.

The `proc` option shows that one client is currently connected to the server. That client is logged into MySQL as the `root` user on the `localhost`. The client that has an ID of 2 (which tells you who the user is, allowing you to use that information, as the server's administrator, if you wanted to disconnect the user) is currently querying the MySQL database.

If the server were not running at the moment, the `mysqladmin` command shown in the previous example would result in a failure message:

```
mysqladmin: connect to server at 'localhost' failed.
```

The recommended remedy is to try to restart the server (by typing **service mysqld restart**).

## Working with MySQL Databases

---

The first time you start the MySQL server (using the start-up script described previously), the system creates the initial grant tables for the MySQL database. It does this by running the `mysql_install_db` command.

The `mysql_install_db` command starts you off with two databases: `mysql` and `test`. As you create data for these databases, that information is stored in the `/var/lib/mysql/mysql` and `/var/lib/mysql/test` directories, respectively.

Because the MySQL root user doesn't have to be the system's root user (provided you have the MySQL root user's password), you can be logged into CentOS as any user you choose. In the following examples, be sure to provide the MySQL root user password when you run the commands shown.

### NOTE

If you are using the old ISAM tables instead of MyISAM, support for ISAM tables was removed for MySQL 5.0. You need to convert your tables to MyISAM using a statement such as the following:

```
ALTER TABLE table ENGINE=MYISAM
```

where *table* is your table name. Refer to the MySQL Reference Manual (<http://dev.mysql.com/doc/refman/5.0/en/upgrade.html>) for further information on upgrading to MySQL 5.0.

## Starting the mysql Command

To get started creating databases and tables, you can use the `mysql` command. From any Terminal window, open the `mysql` database on your computer by typing the following:

```
$ mysql -u root -p mysql
Enter password: *****
```

```
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 39
Server version: 5.0.45 Source distribution
Type 'help;' or '\h' for help. Type '\c' to clear the buffer
```

```
mysql>
```

Type in the root user's MySQL password as prompted. (If no password has been set, you can skip the `-p` option.) The `mysql>` prompt appears, ready to accept commands for working with the `mysql` default database on the local host. If you are connecting to the MySQL server from another host computer, add `-h hostname` to the command line (where *hostname* is the name or IP address of the computer on which the MySQL server is running). Remember that you can also log in as any valid MySQL login you created, regardless of which Linux login account you are currently logged in under.

As the MySQL monitor welcome text notes, be sure to end each command that you type with a semicolon (;) or \g. If you type a command and it appears to be waiting for more input, it's probably because you forgot to put a semicolon at the end.

Before you begin using the `mysql` interface to create databases, try checking the status of the MySQL server using the `status` command. The following is an example of output from the `status` command:

```
mysql> status
-----
mysql Ver 14.12 Distrib 5.0.45, for redhat-linux-gnu (i386) using
readline 5.0

Connection id:          26
Current database:      mysql
Current user:           root@localhost
Current pager:         stdout
Using outfile:         ''
Server version:        5.0.45
Protocol version:      10
Connection:            Localhost via UNIX socket
Server characterset:   latin1
Db characterset:       latin1
Client characterset:   latin1
Conn. characterset:    latin1
UNIX socket:           /var/lib/mysql/mysql.sock
Uptime:                1 day 2 hours 57min 19 sec

Threads: 1 Questions: 136 Slow queries: 0 Opens: 12
Flush tables: 1 Open tables: 6 Queries per second avg: 0.001
```

The status information tells you about the version of the MySQL server (14.12) and the distribution (5.0.45). The output also reminds you of the current database (`mysql`) and your username (`root@localhost`). You can see how long the server has been up (Uptime). You can also see how many threads are currently active and how many commands have been run to query this server (Questions).

## Creating a Database with MySQL

Within an interactive `mysql` session, you can create and modify databases and tables. If you are not already connected to a `mysql` session, type the following command (assuming the MySQL username of `root`):

```
$ mysql -u root -p
Enter password: *****
mysql>
```

The general steps for creating a MySQL database include creating the database name, identifying the new database as the current database, creating tables, and adding data to the tables. While you are connected to a `mysql` session, you can run the following procedure to create a sample database.

1. To create a new database name, use the `CREATE DATABASE` command at the `mysql>` prompt. For example, to create a database named `allusers`, type the following:

```
mysql> CREATE DATABASE allusers;
```

This action creates a database called `allusers` in the `/var/lib/mysql` directory. (While you don't have to use capitals for the commands just shown, it makes it easier to distinguish the commands from the database entries.)

## NOTE

Alternatively, you can create a database from the command line using the `mysqladmin` command. For example, to create the database named `allusers` with `mysqladmin`, you could type the following: **`mysqladmin -u root -p create allusers`**.

2. To see what databases are available for your MySQL server, type the following at the `mysql>` command prompt. The databases shown are named `information_schema`, `allusers`, `mysql`, and `test`. The `information_schema` database contains metadata about information in other databases on your server (such as the types of data, columns, or tables used in each). The `allusers` database is the one created in the previous step. The `mysql` database contains user access data. The `test` database is created automatically for creating test `mysql` databases.

```
mysql> SHOW DATABASES;
+-----+
| Database |
+-----+
| information_schema |
| allusers |
| mysql |
| test |
+-----+
4 rows in set (0.00 sec)
```

3. To work with the database you just created (`allusers`), you need to make `allusers` your current database. To do that, type the following at the `mysql>` command prompt:

```
mysql> USE allusers;
Database changed
```

4. Creating a table for your database requires some planning and understanding of table syntax. You can type in the following commands and column information to try out creating a table. For more detailed information on creating tables and using different data types, refer to the section “Understanding MySQL Tables” later in this chapter.

To create a table called `name`, use the following `CREATE TABLE` command at the `mysql>` prompt:

```
mysql> CREATE TABLE name (  
->  firstname      varchar(20)    not null,  
->  lastname       varchar(20)    not null,  
->  streetaddr    varchar(30)    not null,  
->  city          varchar(20)    not null,  
->  state         varchar(20)    not null,  
->  zipcode      varchar(10)    not null  
-> );  
Query OK, 0 rows affected (0.00 sec)
```

You have now created a table called `name` for a database named `allusers`. It contains columns called `firstname`, `lastname`, `streetaddr`, `city`, `state`, and `zipcode`. Each column allows record lengths of between 10 and 30 characters. Although MySQL supports several different database formats, because none is specified here, the default MyISAM database type is used.

With a database and one table created, you can now add data to the table.

## Adding Data to a MySQL Database Table

After the database is created and the structure of a database table is in place, you can begin working with the database. You can add data to your MySQL database by manually entering each record during a `mysql` session or by adding the data into a plaintext file and loading that file into the database.

### NOTE

While you are in a `mysql` session, keep in mind that you can use the up arrow key to retrieve and change previous commands. This is particularly useful if you are manually entering database records that contain similar information.

## Manually Entering Data

To do the procedure in this section, I assume you have an open interactive `mysql` session and that you have created a database and table as described in the previous section. If you are not already connected to a `mysql` session, type the following command (assuming the MySQL username of `root`):

```
$ mysql -u root -p  
Enter password: *****  
mysql>
```

To add data to an existing MySQL database, the following procedure describes how to view the available tables and load data into those tables manually. The next section describes how to create a plaintext file containing database data and how to load that file into your database.

1. To make the database you want to use your current database (in this case, `allusers`), type the following command from the `mysql>` prompt:

```
mysql> USE allusers;  
Database changed
```

- To see the tables that are associated with the current database, type the following command from the `mysql>` prompt:

```
mysql> SHOW tables;
+-----+
| Tables_in_allusers |
+-----+
| name                |
+-----+
1 row in set (0.00 sec)
```

You can see that the only table defined so far for the `allusers` database is the one called `name`.

- To display the format of the `name` table, type the following command at the `mysql>` prompt:

```
mysql> DESCRIBE name;
+-----+-----+-----+-----+-----+-----+
| Field      | Type          | Null | Key | Default | Extra |
+-----+-----+-----+-----+-----+-----+
| firstname  | varchar(20)   | NO   |     |         |       |
| lastname   | varchar(20)   | NO   |     |         |       |
| streetaddr | varchar(30)   | NO   |     |         |       |
| city       | varchar(20)   | NO   |     |         |       |
| state      | varchar(20)   | NO   |     |         |       |
| zipcode    | varchar(10)   | NO   |     |         |       |
+-----+-----+-----+-----+-----+-----+
```

- To add data to the new table, you can use the `INSERT INTO` command from the `mysql>` prompt. Here is an example of how to add a person's name and address to the new table:

```
mysql> INSERT INTO name
-> VALUES ('Jerry','Wingnut','167 E Street',
-> 'Roy','UT','84103');
```

In this example, the `INSERT INTO` command identifies the `name` table. Then it indicates that values for a record in that table include the name Jerry Wingnut at the address 167 E Street, Roy, UT 84103.

- To check that the data has been properly entered into the new table, type the following command from the `mysql>` prompt:

```
mysql> SELECT * FROM name;
+-----+-----+-----+-----+-----+-----+
| firstname | lastname | streetaddr | city | state | zipcode |
+-----+-----+-----+-----+-----+-----+
| Jerry     | Wingnut  | 167 E Street | Roy  | UT    | 84103   |
+-----+-----+-----+-----+-----+-----+
```

The resulting output shows the data you just entered, displayed in the columns you defined for the `name` table. If you like, you can continue adding data in this way.

Typing each data item individually can be tedious. As an alternative, you can add your data to a plaintext file and load it into your MySQL database, as described in the following section.

### Loading Data from a File

Using the `LOAD DATA` command during a `mysql` session, you can load a file containing database records into your MySQL database. Here are a few things you need to know about creating a data file to be loaded into MySQL:

- You can create the file using any Linux text editor.
- Each record, consisting of all the columns in the table, must be on its own line. (A line feed indicates the start of the next record.)
- Separate each column by a [Tab] character.
- You can leave a column blank for a particular record by placing an `\N` in that column.
- Any blank lines you leave in the file result in blank lines in the database table.

In this example, the following text is added into a plaintext file. The text is in a format that can be loaded into the `name` table created earlier in this chapter. To try it out, type the following text into a file. Make sure that you insert a [Tab] character between each value.

Chris	Smith	175 Harrison Street	Gig Harbor	WA	98999
John	Jones	18 Talbot Road NW	Coventry	NJ	54889
Howard	Manty	1515 Broadway	New York	NY	10028

When you are done entering the data, save the text to any filename that is accessible to the `mysql` server daemon (e.g., `/tmp/name.txt`). Remember the filename so that you can use it later. If you are not already connected to a `mysql` session, type the following command (assuming that `mysql` is the username `root`):

```
$ mysql -u root -p
Enter password: *****
mysql>
```

Next, identify the database (`allusers` in this example) as the current database by typing the following:

```
mysql> USE allusers;
Database changed
```

To actually load the file into the `name` table in the `allusers` database, type the following command to load the file (in this case, `/tmp/name.txt`) from the `mysql>` prompt:

#### NOTE

Either enter the full path to the file or have it in the directory where the `mysql` command starts. In the latter case, you can type the filename without indicating its full path.

```
mysql> LOAD DATA INFILE "/tmp/name.txt" INTO TABLE name;
Query OK, 3 rows affected (0.02 sec)
Records: 3 Deleted: 0 Skipped: 0 Warnings: 0
```

Type the following at the `mysql>` prompt to make sure that the records have been added correctly:

```
mysql> SELECT * FROM name;
+-----+-----+-----+-----+-----+-----+
| firstname| lastname| streetaddr      | city      | state | zipcode|
+-----+-----+-----+-----+-----+-----+
| Chris   | Smith  | 175 Harrison Street| Gig Harbor | WA   | 98999 |
| John    | Jones  | 18 Talbot Road NW  | Coventry  | NJ   | 54889 |
| Howard  | Manty  | 1515 Broadway     | New York  | NY   | 10028 |
+-----+-----+-----+-----+-----+-----+
```

At this point, you have a database that includes some data that you can begin working with. If something went wrong, refer to the “Updating and Deleting MySQL Records” section later in this chapter. If you find you need more information than is provided in this chapter, refer to the MySQL documentation at <http://dev.mysql.com/doc>.

Although MySQL doesn’t support all of SQL, it does contain enough features for most users. If you find that MySQL doesn’t meet your needs, you can try the PostgreSQL object-relational database management system (which also comes with CentOS systems). For further information on PostgreSQL, refer to [www.postgresql.org](http://www.postgresql.org). Firebird ([www.firebirdsql.org](http://www.firebirdsql.org)) is another Open Source relational database that might interest you.

## Understanding MySQL Tables

You have a lot of flexibility when it comes to setting up MySQL tables. To have your MySQL database operate as efficiently as possible, you want to have the columns be assigned to the most appropriate size and data type to hold the data you need to store.

Use the following tables as a reference to the different data types that can be assigned to your columns. Data types available for use in MySQL fall into these categories: numbers, time and date, and character strings. Here are a few things you need to know as you read these tables:

- The maximum display size for a column is 255 characters. An `M` data type option sets the number of characters that are displayed and, in most cases, stored for the column.
- There can be up to 30 digits following the decimal point for floating-point or fixed-point data types. A `D` option to a data type indicates the number of digits allowed for a number



following the decimal point. (The value should be no more than two digits less than the value of the display size being used.)

- The UNSIGNED option (shown in brackets) indicates that only positive numbers are allowed in the column. This allows the column to hold larger positive numbers.
- The ZEROFILL option (shown in brackets) indicates that the data in the column will be padded with zeros. For example, the number 25 in a column with a data type of INTEGER(7) ZEROFILL would appear as 0000025. (Any ZEROFILL column automatically becomes UNSIGNED.)
- All values shown in brackets are optional.
- The parentheses shown around the (M) and (D) values are necessary if you enter either of those values. In other words, don't type the brackets, but do type the parentheses.

Table 23-2 shows numeric data types that you can use with MySQL.

**TABLE 23-2**

### Numeric Data Types for Columns

Data Type	Description	Space Needed
BIGINT[(M)] [UNSIGNED] [ZEROFILL]	Can contain large integers with the following allowable values: -9223372036854775808 to 9223372036854775807 (signed) 0 to 18446744073709551615 (unsigned)	Uses 8 bytes.
DECIMAL[(M[,D])] [ZEROFILL]	Contains an unpacked fixed-point number (signed only). Each digit is stored as a single character. When you choose the display value (M), decimal points and minus signs are not counted in that value. The value of (M) is 10 by default. Setting D to zero (which is the default) causes only whole numbers to be used.	Uses $M+2$ bytes if $D$ is greater than 0. Uses $M+1$ bytes if $D$ is equal to 0.
DOUBLE[(M,D)] [ZEROFILL]	Contains a double-precision, floating-point number of an average size. Values that are allowed include: -1.7976931348623157E+308 to -2.2250738585072014E-308 0 2.2250738585072014E-308 to 1.7976931348623157E+308.	Uses 8 bytes.
DOUBLE PRECISION	Same as DOUBLE	Same as DOUBLE

*continued*

**TABLE 23-2** (continued)

Data Type	Description	Space Needed
FLOAT( <i>X</i> ) [ZEROFILL]	Contains a floating-point number. For a single-precision floating-point number, <i>X</i> can be less than or equal to 24. For a double-precision floating-point number, <i>X</i> can be between 25 and 53. The display size and number of decimals are undefined.	Uses 4 bytes if <i>X</i> is less than or equal to 24. Uses 8 bytes if <i>X</i> is greater than or equal to 25 and less than or equal to 53.
FLOAT[( <i>M</i> , <i>D</i> )] [ZEROFILL]	Contains a single-precision floating-point number. Values that are allowed include: -3.402823466E+38 to -1.175494351E-38 0 1.175494351E-38 to 3.402823466E+38. If the display value ( <i>M</i> ) is less than or equal to 24, the number is a single-precision floating-point number.	Uses 4 bytes.
INT[( <i>M</i> )] [UNSIGNED] [ZEROFILL]	Contains an integer of normal size. The range is -2147483648 to 2147483647 if it's signed, and 0 to 4294967295 if unsigned.	Uses 4 bytes.
INTEGER[( <i>M</i> )] [UNSIGNED] [ZEROFILL]	Same as INT	Same as INT
MEDIUMINT[( <i>M</i> )] [UNSIGNED] [ZEROFILL]	Contains an integer of medium size. The range is -8388608 to 8388607 if it's signed and 0 to 16777215 if unsigned.	Uses 3 bytes.
NUMERIC( <i>M</i> , <i>D</i> ) [ZEROFILL]	Same as DECIMAL	Same as DECIMAL
REAL	Same as DOUBLE	Same as DOUBLE
SMALLINT[( <i>M</i> )] [UNSIGNED] [ZEROFILL]	Contains an integer of small size. The range is -32768 to 32767 if it's signed and 0 to 65535 if it's unsigned.	Uses 2 bytes.
TINYINT[( <i>M</i> )] [UNSIGNED] [ZEROFILL]	A very small integer, with a signed range of -128 to 127 and a 0 to 255 unsigned range	Uses 1 byte.

The default format of dates in MySQL is YYYY-MM-DD, which stands for the year, month, and day. Any improperly formatted date or time values will be converted to zeros. Table 23-3 shows time and date data types that you can use with MySQL.

Table 23-4 shows string data types that you can use with MySQL.

TABLE 23-3

## Time/Date Data Types for Columns

Data Type	Description	Space Needed
DATE	Contains a date between January 1, 1000 (1000-01-01) and December 31, 9999 (9999-12-31).	Uses 3 bytes.
DATETIME	Contains a combination of date and time between the zero hour of January 1, 1000 (1000-01-01 00:00:00) and the last second of December 31, 9999 (9999-12-31 23:59:59).	Uses 8 bytes.
TIMESTAMP[(M)]	Contains a time stamp from between the zero hour of January 1, 1970 (1970-01-01 00:00:00) and a time in the year 2037. It is stored in the form YYYYMMDDHHMMSS. Using (M), you can reduce the size of the TIMESTAMP displayed to less than the full 14 characters (although the full 4-byte TIMESTAMP is still stored).	Uses 4 bytes.
TIME	Contains a time between -838:59:59 and 838:59:59. The format of the field is in hours, minutes, and seconds (HH:MM:SS).	Uses 3 bytes.
YEAR[(2 4)]	Contains a year, represented by either two or four digits. For a four-digit year, YEAR means 1901–2155 (0000 is also allowed). For a two-digit year, the digits 70–69 can represent 1970–2069.	Uses 1 byte.

TABLE 23-4

## String Data Types for Columns

Data Type	Description	Space Needed
BLOB	Contains a binary large object (BLOB) that varies in size, based on the actual value of the data, rather than on the maximum allowable size. Searches on a BLOB column are case-sensitive.	Uses up to $L + 2$ bytes, where $L$ is less than or equal to 65,535.
[NATIONAL] CHAR(M) [BINARY]	Contains a character string of fixed length, with spaces padded to the right to meet the length. To display the value, the spaces are deleted. The value of (M) determines the number of characters (from 1 to 255). If the BINARY keyword is used, sorting of values is case-sensitive (it is case-insensitive by default). The NATIONAL keyword indicates that the default character set should be used.	Uses between 1 and 255 bytes, based on the value of (M).

*continued*

**TABLE 23-4** (continued)

Data Type	Description	Space Needed
ENUM('val1', 'val2',...)	Contains enumerated strings that are typically chosen from a list of values indicated when you create the column. For example, you set a column definition to ENUM("dog", "cat", "mouse"). Then, if you set the value of that column to 1, the value displayed would be <i>dog</i> , 2 would be <i>cat</i> , and 3 would be <i>mouse</i> . It lets you take a number as input and have a string as output. Up to 65,535 values are allowed.	Uses either 1 byte (for up to about 255 values) or 2 bytes (for up to 65,535 values).
LONGBLOB	Contains a binary large object (BLOB) that varies in size, based on the actual value of the data, rather than on the maximum allowable size. LONGBLOB allows larger values than MEDIUMBLOB. Searches on a LONGBLOB column are case-sensitive.	Uses up to $L + 4$ bytes, where $L$ is less than or equal to 4,294,967,295.
LONGTEXT	Same as LONGBLOB, except that searching is done on these columns in case-insensitive style	Uses up to $L + 4$ bytes, where $L$ is less than or equal to 4,294,967,295.
MEDIUMBLOB	Contains a binary large object (BLOB) that varies in size, based on the actual value of the data, rather than on the maximum allowable size. MEDIUMBLOB allows larger values than BLOB. Searches on a MEDIUMBLOB column are case-sensitive.	Uses up to $L + 3$ bytes, where $L$ is less than or equal to 16,777,215.
MEDIUMTEXT	Same as MEDIUMBLOB, except that searching is done on these columns in case-insensitive style	Uses up to $L + 3$ bytes, where $L$ is less than or equal to 16,777,215.
SET('val1', 'val2',...)	Contains a set of values. A SET column can display zero or more values from the list of values contained in the SET column definition. Up to 64 members are allowed.	Uses 1, 2, 3, 4, or 8 bytes, varying based on how many of the up to 64 set members are used.
TEXT	Same as BLOB, except that searching is done on these columns in case-insensitive style	Uses up to $L + 2$ bytes, where $L$ is less than or equal to 65,535.

*continued*

**TABLE 23-4** (continued)

Data Type	Description	Space Needed
TINYBLOB	Contains a binary large object (BLOB) that varies in size, based on the actual value of the data, rather than on the maximum allowable size. TINYBLOB allows smaller values than BLOB. Searches on a TINYBLOB column are case-sensitive.	Uses up to $L + 1$ bytes, where $L$ is less than or equal to 255.
TINYTEXT	Same as TINYBLOB, except that searching is done on these columns in case-insensitive style	Uses up to $L + 1$ bytes, where $L$ is less than or equal to 255.
[NATIONAL] VARCHAR( $M$ ) [BINARY]	Contains a character string of variable length, with no padded spaces added. The value of ( $M$ ) determines the number of characters (from 1 to 255). If the BINARY keyword is used, sorting of values is case-sensitive (it is case-insensitive by default). The NATIONAL keyword indicates that the default character set should be used.	Uses $L + 1$ bytes, where $L$ is less than or equal to $M$ and $M$ is from 1 to 255 characters.

## Displaying MySQL Databases

There are many different ways of sorting and displaying database records during a `mysql` session. If you are not already connected to a `mysql` session, type the following command (assuming the MySQL username of `root`):

```
$ mysql -u root -p
Enter password: *****
mysql>
```

When you are in your `mysql` session (and have chosen a database), you can display all or selected table records, choose which columns are displayed, or choose how records are sorted.

### Displaying All or Selected Records

Assuming that the current database is `allusers` (as shown in the previous examples), type the following command to choose (SELECT) all records (\*) from the `name` table and display them in the order in which they were entered into the database:

```
mysql> SELECT * FROM name;
+-----+-----+-----+-----+-----+
| firstname | lastname | streetaddr      | city      | state | zipcode |
+-----+-----+-----+-----+-----+
| Chris    | Smith   | 175 Harrison Street | Gig Harbor | WA    | 98999  |
```

```
| John      | Jones  | 18 Talbot Road NW | Coventry | NJ   | 54889 |
| Howard   | Manty  | 1515 Broadway     | New York | NY   | 10028 |
+-----+-----+-----+-----+-----+-----+
```

The following command displays all records from the name table that have the `lastname` column set to `Jones`. Instead of using `lastname`, you could search for a value from any column name used in the table:

```
mysql> SELECT * FROM name WHERE lastname="Jones";
+-----+-----+-----+-----+-----+-----+
| firstname | lastname | streetaddr         | city      | state | zipcode |
+-----+-----+-----+-----+-----+-----+
| John      | Jones   | 18 Talbot Road NW | Coventry  | NJ   | 54889   |
+-----+-----+-----+-----+-----+-----+
```

Using the `OR` operator, you can select records that match several different values. In the following command, records that have either `Chris` or `Howard` as the `firstname` are matched and displayed.

```
mysql> SELECT * FROM name WHERE firstname="Chris" OR firstname="Howard";
+-----+-----+-----+-----+-----+-----+
| firstname | lastname | streetaddr         | city      | state | zipcode |
+-----+-----+-----+-----+-----+-----+
| Chris     | Smith   | 175 Harrison Street | Gig Harbor | WA   | 98999   |
| Howard    | Manty   | 1515 Broadway       | New York  | NY   | 10028   |
+-----+-----+-----+-----+-----+-----+
```

To match and display a record based on the value of two columns in a record, you can use the `AND` operator. In the following command, any record that has `Chris` as the `firstname` and `Smith` as the `lastname` is matched.

```
mysql> SELECT * FROM name WHERE firstname="Chris" AND lastname="Smith";
+-----+-----+-----+-----+-----+-----+
| firstname | lastname | streetaddr         | city      | state | zipcode |
+-----+-----+-----+-----+-----+-----+
| Chris     | Smith   | 175 Harrison Street | Gig Harbor | WA   | 98999   |
+-----+-----+-----+-----+-----+-----+
```

## Displaying Selected Columns

You don't need to display every column of data. Instead of using the asterisk (\*) shown in the previous examples to match all columns, you can enter a comma-separated list of column names. The following command displays the `firstname`, `lastname`, and `zipcode` records for all of the records in the name table:

```
mysql> SELECT firstname,lastname,zipcode FROM name;
+-----+-----+-----+
| firstname | lastname | zipcode |
+-----+-----+-----+
```

```

+-----+-----+-----+
| Chris  | Smith | 98999 |
| John   | Jones | 54889 |
| Howard | Manty | 10028 |
+-----+-----+-----+

```

Likewise, you can sort columns in any order you choose. Type the following command to show the same three columns with the `zipcode` column displayed first:

```

mysql> SELECT zipcode,firstname,lastname FROM name;
+-----+-----+-----+
| zipcode | firstname | lastname |
+-----+-----+-----+
| 98999   | Chris    | Smith    |
| 54889   | John     | Jones    |
| 10028   | Howard   | Manty    |
+-----+-----+-----+

```

You can also mix column selection with record selection as shown in the following example:

```

mysql> SELECT firstname,lastname,city FROM name WHERE firstname="Chris";
+-----+-----+-----+
| firstname | lastname | city      |
+-----+-----+-----+
| Chris     | Smith   | Gig Harbor |
+-----+-----+-----+

```

## Sorting Data

You can sort records based on the values in any column you choose. For example, using the `ORDER BY` operator, you can display the records based on the `lastname` column:

```

mysql> SELECT * FROM name ORDER BY lastname;
+-----+-----+-----+-----+-----+-----+
| firstname|lastname |streetaddr      | city      | state | zipcode|
+-----+-----+-----+-----+-----+-----+
| John     |Jones   |18 Talbot Road NW | Coventry  | NJ    | 54889 |
| Howard   |Manty   |1515 Broadway     | New York  | NY    | 10028 |
| Chris    |Smith   |167 Small Road    | Gig Harbor | WA    | 98999 |
+-----+-----+-----+-----+-----+-----+

```

To sort records based on city name, you can use the following command:

```

mysql> SELECT * FROM name ORDER BY city;
+-----+-----+-----+-----+-----+-----+
| firstname |lastname |streetaddr      | city      | state | zipcode|
+-----+-----+-----+-----+-----+-----+
| John      |Jones   |18 Talbot Road NW | Coventry  | NJ    | 54889 |

```

```
| Chris | Smith | 167 Small Road | Gig Harbor | WA | 98999 |
| Howard | Manty | 1515 Broadway | New York | NY | 10028 |
+-----+-----+-----+-----+-----+-----+
```

You can also add ASC or DESC to indicate the sorting order, because MySQL doesn't otherwise guarantee the order in which data is displayed. Now that you have entered and displayed the database records, you may find that you need to change some of them. The following section describes how to update database records during a `mysql` session.

## Making Changes to Tables and Records

As you begin to use your MySQL database, you will find that you need to make changes to both the structure and content of the database tables. The following section describes how you can alter the structure of your MySQL tables and change the content of MySQL records. If you are not already connected to a `mysql` session, type the following command (assuming the MySQL username of `root`):

```
$ mysql -u root -p
Enter password: *****
mysql>
```

To use the examples shown in the following sections, identify the database (`allusers` in this example) as the current database by typing the following:

```
mysql> USE allusers;
Database changed
```

### Altering the Structure of MySQL Tables

After you have created your database tables, there will inevitably be changes you want to make to them. This section describes how to use the `ALTER` command during a `mysql` session for the following tasks: adding a column, deleting a column, renaming a column, and changing the data type for a column.

To add a column to the end of your table that displays the current date, type the following:

```
mysql> ALTER TABLE name ADD curdate TIMESTAMP;
```

The previous line tells MySQL to change the table in the current database called `name` (`ALTER TABLE name`), add a column named `curdate` (`ADD curdate`), and assign the value of that column to display the last edit date (`TIMESTAMP data type`). If you decide later that you want to remove that column, you can remove it by typing the following:

```
mysql> ALTER TABLE name DROP COLUMN curdate;
```



If you want to change the name of an existing column, you can do so using the `CHANGE` option to `ALTER`. Here is an example:

```
mysql> ALTER TABLE name CHANGE city town varchar(20);
```

In the previous example, the name table is chosen (`ALTER TABLE name`) to change the name of the `city` column to `town` (`CHANGE city town`). The data type of the column must be entered as well [`varchar(20)`], even if you are not changing it. In fact, if you just want to change the data type of a column, you would use the same syntax as the previous example but simply repeat the column name twice (in this case, `zipcode`). Here's an example:

```
mysql> ALTER TABLE name CHANGE zipcode zipcode INTEGER;
```

The previous example changes the data type of the `zipcode` column from its previous type (`varchar`) to the `INTEGER` type.

**NOTE**

If you specify a column when you first create a table (`CREATE TABLE` command), it will change a column's default value. By running an `ALTER TABLE` statement, you can re-specify the column default value, if you want to return to that value.

## Updating and Deleting MySQL Records

You can select records based on any value you choose and update any values in those records. When you are in your `mysql` session, you can use `UPDATE` to change the values in a selected table. Here is an example:

```
mysql> UPDATE name SET streetaddr="933 3rd Avenue" WHERE firstname="Chris";
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0
```

This example attempts to update the name table (`UPDATE name`). In this example, each record that has the `firstname` column set to `Chris` will have the value of the `streetaddr` column for that record changed to `933 3rd Avenue` instead. Note that the query found one row that matched. That one row matched was also changed, with no error warnings necessary. You can use any combination of values to match records (using `WHERE`) and change column values (using `SET`) that you would like. After you have made a change, it is a good idea to display the results to make sure that the change was made as you expected.

To remove an entire row (i.e., one record), you can use the `DELETE` command. For example, if you wanted to delete any row where the value of the `firstname` column is `Chris`, you would type the following:

```
mysql> DELETE FROM name WHERE firstname="Chris";
Query OK, 1 row affected (0.00 sec)
```

The next time you show the table, there should be no records with the first name `Chris`.

## Adding and Removing User Access

---

There are several different methods you can use to control user access to your MySQL databases. To begin with, assign a username and password to every user who accesses your MySQL databases. Then you can use the `GRANT` and `REVOKE` commands of `mysql` to specifically indicate the databases and tables users and host computers can access, as well as the rights they have to those databases and tables.

**WARNING** Database servers are common targets of attacks from crackers. While this chapter gives some direction for granting access to your MySQL server, you need to provide much more stringent protection for the server if you are allowing Internet access. Refer to the *MySQL Reference Manual* (type `info mysql`) for further information on securing your MySQL server.

### Adding Users and Granting Access

Although you have a user account defined to create databases (the `root` user, in this example), to make a database useful, you might want to allow access to other users as well. The following procedure describes how to grant privileges for your MySQL database to other users.

**NOTE** If you are upgrading your MySQL from a version previous to 3.22, run the `mysql_fix_privilege_tables` script. This script adds new `GRANT` features to your databases. If you don't run the script, you will be denied access to the databases.

In this example, I am adding a user named `steve` who can log in to the MySQL server from the local host. The password for `steve` is `i8yer2shuz`. (Remember that there does not have to be a CentOS user account named `steve`. So any user on the local host with the password for `steve` can log in to that MySQL account.)

1. If you are not already connected to a `mysql` session, type the following command (assuming the MySQL username of `root`):

```
$ mysql -u root -p
Enter password: *****
mysql>
```

2. To create the user named `steve` and a password `i8yer2shuz`, use the `GRANT` command as follows:

```
mysql> GRANT USAGE ON *.*
-> TO steve@localhost IDENTIFIED BY "i8yer2shuz";
```

At this point, someone could log in from the local host using the name `steve` and `i8yer2shuz` password (type `mysql -u steve -p`). But the user would have no privilege to work with any of the databases. Next you need to grant privileges.

3. To grant `steve` privileges to work with the database called `allusers`, type the following:

```
mysql> GRANT DELETE,INSERT,SELECT,UPDATE ON allusers.*
-> TO steve@localhost;
```

In this example, the user named `steve` is allowed to log in to the MySQL server on the local host and access all tables from the `allusers` database (`USE allusers`). For that database, `steve` can use the `DELETE`, `INSERT`, `SELECT`, and `UPDATE` commands.

4. To see the privileges that you just granted, select `mysql` as your current database, and then select the `db` table as follows:

```
mysql> USE mysql;
Database changed
mysql> SELECT * FROM db WHERE db="allusers";
+-----+-----+-----+-----+-----+-----+-----+
|Host      |Db        |User   |Select_priv|Insert_priv |Update_priv|Delete_priv|
+-----+-----+-----+-----+-----+-----+-----+
|localhost|allusers |steve  |Y          |Y          |Y          |Y          |
+-----+-----+-----+-----+-----+-----+-----+
```

The output here shows all users who are specifically granted privileges to the `allusers` database. Only part of the output is shown here because it is very long. You can make a very wide Terminal window to view the output if you don't like reading wrapped text. Other privileges on the line will be set to `N` ("no access").

## Revoking Access

You can revoke privileges you grant using the `REVOKE` command. To revoke all privileges for a user to a particular database, use the following procedure:

1. If you are not already connected to a `mysql` session, type the following command (assuming the MySQL username of `root`):

```
$ mysql -u root -p
Enter password: *****
mysql>
```

2. To revoke all privileges of a user named `steve` to use a database named `allusers` on your MySQL server, type the following:

```
mysql> REVOKE ALL PRIVILEGES ON allusers.*
-> FROM steve@localhost;
```

At this point, `steve` has no privileges to use any of the tables in the `allusers` databases.

3. To see the privileges that you just granted, select `mysql` as your current database, then select the `db` table as follows:

```
mysql> USE mysql;
Database changed
mysql> SELECT * FROM db WHERE db="allusers";
```

The output should show that the user named `steve` is no longer listed as having access to the `allusers` database. (The results might just say “Empty set.”)

## Backing Up Databases

---

You can use the `mysqldump` command to back up your MySQL databases. The following command backs up all your MySQL databases:

```
# mysqldump -u root -p --opt --all-databases > /home/timothy/all-databases
```

In this case, all databases on the local system are copied to the file `all-databases` in the `/home/timothy` directory. You can also use `mysqldump` to back up a single database, several databases, or tables within a database. Refer to the `mysqldump` man page for further information.

## Checking and Fixing Databases

---

Over time, databases can become corrupted or store information inefficiently. MySQL comes with commands that you can use to check and repair your databases. The `myisamchk` command is available to check MyISAM database tables.

MyISAM tables are used by default with MySQL. (To use a different table type, you can assign it when you first create your MySQL table.) The tables are stored in the directory `/var/lib/mysql/dbname` by default, where `dbname` is replaced by the name of the database you are using. For each table, there are three files in this directory. Each file begins with the table name and ends with one of the following three suffixes:

- **.frm** — Contains the definition (or form) of the table.
- **.MYI** — Contains the table’s index.
- **.MYD** — Contains the table’s data.

The following procedure describes how to use the `myisamchk` command to check your MyISAM tables.

### WARNING

Do a backup of your database tables before running a repair with `myisamchk`. Although `myisamchk` is unlikely to damage your data, backups are still a good precaution.

1. Stop MySQL temporarily by typing the following from a Terminal window as `root` user:

```
# /etc/init.d/mysqld stop
```

2. You can check all or some of your database tables at once. The first example shows how to check a table called `name` in the `allusers` database.

```
# myisamchk /var/lib/mysql/allusers/name.MYI
Checking MyISAM file: /var/lib/mysql/allusers/name.MYI
Data records:      5   Deleted blocks:      0
- check file-size
- check key delete-chain
- check record delete-chain
- check index reference
- check record links
```

You could also check tables for all your databases at once as follows:

```
# myisamchk /var/lib/mysql/*/*.MYI
```

The preceding example shows a simple, five-record database where no errors were encountered. If instead of the output shown in the previous example, you see output like the following, you may need to repair the database:

```
Checking MyISAM file: name.MYI
Data records:      5   Deleted blocks:      0
- check file-size
myisamchk: warning: Size of datafile is: 89 Should be: 204
- check key delete-chain
- check record delete-chain
- check index reference
- check record links
myisamchk: error: Found wrong record at 0
MyISAM-table 'name.MYI' is corrupted
Fix it using switch "-r" or "-o"
```

3. To fix a corrupted database, you could run the following command:

```
# myisamchk -r /var/lib/mysql/allusers/name.MYI
- recovering (with keycache) MyISAM-table 'name.MYI'
Data records: 5
Found wrong stored record at 0
Data records: 4
```

4. If for some reason the `-r` option doesn't work, you can try running the `myisamchk` command with the `-o` option. This is a slower, older method of repair, but it can handle a few problems that the `-r` option cannot. Here is an example:

```
# myisamchk -o /var/lib/mysql/allusers/name.MYI
```

If your computer has a lot of memory, you can raise the key buffer size value on the `myisamchk` command line, which will lessen the time it takes to check the databases. For example, you could use the following command line:

```
myisamchk -r -0 --key_buffer_size=64M *.MYI
```

This would set the key buffer size to 64 MB.

## Summary

---

MySQL is a structured query language (SQL) database server that runs on CentOS, as well as other operating systems. Using a start-up script (`/etc/init.d/mysql`) and a configuration file (`/etc/my.cnf`), you can quickly get a MySQL server up and running.

With tools such as the `mysqladmin` and `mysql` commands, you can administer the MySQL server and create databases and tables that are as simple or complex as you need. During `mysql` sessions, you can modify the structure of your database tables or add, update, and delete database records. You have a variety of options for querying data and sorting the output. You also have a lot of control over who can access your database tables and what privileges users have to modify, add to, or delete from the databases you control.



# Chapter 24

## Making Servers Public with DNS

In previous chapters, you built Web, mail, and FTP servers in Linux. Now you want to expose those servers to the outside world. Options range from handing them to a hosting company and saying, “Take care of it,” to managing the servers yourself out of your own home or office.

The following are some cases in which you may want to consider some level of self-hosting:

- You’re willing to provide the level of support that your organization needs in its servers.
- You just want an inexpensive way to publish some documents on the Web or maintain a public mail server for a few people, and 24/7 support isn’t critical.
- You think self-hosting is cool, and you want to try it.

The first goal of this chapter is to help you decide how much server support you want to maintain or provide to someone else. The second goal is to suggest how to set up your own public servers, including possibly configuring your own Domain Name System (DNS) server.

The descriptions of setting up your LAN (see Chapter 14) and connecting it to the Internet (see Chapter 15) focus on how to share information locally and let local users share an outgoing Internet connection, respectively. Building on that information, this chapter explains how to set up a DNS server, as well as other issues that relate to securing and maintaining public servers.

### IN THIS CHAPTER

Determining goals for your server

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Connecting a public server

---

Configuring a public server

---

Setting up a DNS server

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**CAUTION**

After you open your server to Internet traffic, break-in attempts will occur. Most will come from automated scripts, sent from infected computers on the Internet. Because CentOS comes with good built-in security features, many attacks bounce off harmlessly. Allowing incoming connections, however, creates vulnerabilities that aren't there with an outgoing-only Internet connection. I strongly recommend that you use security tools, described in Chapter 13, to protect your servers.

## Determining Goals for Your Server

---

Before you open up that server sitting in your back office to the Internet, stop for a moment and think about your goals. Here are a few questions that you may want to ask yourself:

- How critical is this server for supporting your business?
- How much traffic do you expect on your server?
- Do you need to support the server 24 hours per day, 365 days per year?
- Do you know enough to maintain and secure your server?
- Can you get the connection speed that you require at a reasonable cost for your location?
- Do you need special equipment, such as an uninterruptible power supply, RAID storage devices, or clustered servers, to ensure continuous service?

Maintaining a public server requires some resources. If the server is critical to your business and in high demand, you may not have the time or expertise to support this server yourself. Also, if no high-speed Internet access is available to your location, even a well-configured server may not have the bandwidth to support your clients.

## Using a Hosting Service

Tons of places are ready and willing to host your Web content. The number gets a bit smaller, however, if you need to find a place that can help you maintain your CentOS server. In that case, you want to find a company that offers dedicated hosting (i.e., gives you control of an entire server) or permits you to co-locate your server on its premises. In either case, you want to make sure that your server:

- Is physically secure.
- Can access enough Internet bandwidth.
- Has someone there if the server goes down.

You can use such a hosting provider in these ways and still use CentOS as your server:

- **Co-locate Your Server at a Hosting Provider or ISP** — In this arrangement, you can get lots of bandwidth and retain your root privileges so that you can still maintain the server yourself. The downside is that the provider probably isn't expected to fix your server if a hardware failure occurs.

- **Rent a Server** — (at a place such as `Rackspace.com`), where you get the bandwidth and someone to fix the hardware (which that organization often puts together and maintains) if something goes wrong. A place such as `Rackspace.com` can also assure you that the hardware has been tested to run Linux.

Although this setup probably costs more money, the added support and security may prove well worth it. In either of the preceding cases, where the server resides at the hosting provider, you can also expect that service to include such extras as the use of its DNS service. (In other words, after you register a domain name and sign up with the hosting service, you can probably skip the rest of this chapter.)

## Connecting a Public Server

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If your organization's Internet service is currently used for outgoing connections, you must consider different security issues if you intend to allow incoming connections. The following are some differences:

- **Outgoing Connection** — By providing outgoing Internet access, you need only enable your users to connect to the Internet and gain access to other computers' services. You don't need a domain name, and you don't need your own static IP address. (Chapter 15 describes how to set up a LAN to share an Internet service used primarily for outgoing service.) The focus of your network is on outgoing requests for services.
- **Incoming Connection** — If you're setting up a public server, you want people from the Internet to find you and access services that you offer. The focus is on incoming requests for your computer's services, which means that you probably want a public host/domain name for the server and one or more static, public IP addresses for the server.

You have many different ways to connect your CentOS server to the Internet and offer its services to the public. In the following sections, I describe what you need to get your server up and running on the Internet.

## Choosing an ISP

Although every ISP expects to see outgoing traffic on your Internet connection, not all of them expect incoming traffic (i.e., traffic that someone initiates from outside your network). Although your ISP — which may be your local phone company, your cable TV company, or an independent ISP — may expect you to download files from remote servers, it may not expect people to download large files from you.

Assuming that you're going to house the server in your place of work or residence, you need to obtain the following information from a potential ISP:

- Does its Terms of Service agreement enable you to offer services over its connection?
- Does it have static IP addresses that it's willing to assign to you?
- Does it provide connections robust enough to handle the traffic demands on your server?

## Checking Terms of Service

Any ISP that handles more than a few users has a document that describes what you can do with the Internet connection that it provides you. That document probably carries a name such as “Terms of Service” or “User Agreement.” If you can’t find it on the ISP’s web site, you will almost certainly see it after you click a link to sign up for an account.

Typically, an ISP requires you to sign up for a business account if you want to do any kind of business on your Internet service. Here are some excerpts from agreements for several ISPs:

*... you are not permitted to use your Internet connection to sell or advertise goods or services.*

*This is permitted only to those who have purchased a business account or a virtual server.*

*Dialup clients are not to use their dialup connection for active or constantly connected Web/FTP/mail or other server services.*

*Anyone wanting to promote a business or sell a product must use a business account.*

Internet access is the volume business for most ISPs, and they consider business accounts for those who want to manage their own Web presence as premium services. Although you can technically use a personal account to set up a server (TCP/IP doesn’t care what goes across the wire), the ISP’s “Terms of Service” or “Acceptable Use Policy” may not permit you to do so. Although your DSL connection may easily handle a handful of hits a day on your Web Server, offering that service can result in the termination of your account by the ISP. Check into what the ISP considers acceptable use before you use any Internet account to set up a public server.

## Getting Static IP Addresses

Most dial-up and DSL Internet-access accounts use dynamic IP addresses, so whenever you connect to your Internet service, the provider assigns the IP address to that connection. After you disconnect, the ISP can reclaim that IP address to assign to someone else. The next time you connect, it is possible that you will get a different IP address.

For a server to have a constant, reliable presence on the Internet, it will typically have one or more static IP addresses. Most ISPs charge an additional fee for static IP addresses. Each static IP address typically costs between \$3 and \$20 per month at the time of writing.

### NOTE

**You can assign a public DNS hostname to a server without a static IP address using Dynamic DNS. Dynamic DNS involves running software on your server that monitors your IP address and notifies the Dynamic DNS provider when that IP address changes.**

The number of static IP addresses that you need varies, depending on how you configure your servers. Most likely, you want at least two static IP addresses, one for each of two DNS servers (if you’re configuring DNS). In a small organization, those same servers may also offer your Web Server, mail server, and other services as well. In general, you want one static IP address for each computer that you make publicly accessible to the Internet.

**TIP**

You can do some tricks with services such as port forwarding (iptables in Chapter 13) and virtual hosting (Apache Web Server in Chapter 20) that enable multiple physical computers to offer services or give the appearance of having multiple computers on a single static IP address. These tricks can reduce the number of IP addresses you need to buy. (To simplify the discussion here, however, I'm describing a case in which each public server has its own static, public IP address.)

## Choosing a Connection Speed

Another difficulty with keeping your servers in your own home or business is choosing how fast an Internet connection you need. Although most data centers at ISPs offer more than enough bandwidth for your needs, high-speed Internet connections may not be available to your location — or may prove prohibitively expensive.

Although it's technically possible, using a dial-up connection (up to 56 Kbps) to support an Internet server is generally considered unacceptable. Always-on connection services that you may want to consider include the following:

- **Digital Subscriber Line (DSL)** — DSL service is widely available these days. Using only the standard telephone wiring in your home, you can maintain an always-on Internet connection and telephone service on the same wires. Speeds of between 256 Kbps and 7 Mbps are available with DSL service (although the actual speeds that you attain are typically slower than those in the advertisements).
- **Integrated Services Digital Network (ISDN)** — ISDN has been around longer than DSL to offer high-speed network services, and it's comparable to DSL in the speeds that it can offer. However, ISDN is typically more expensive to implement than DSL at comparable speeds.
- **Cable Internet** — Often, cable television providers will offer Internet access as well. Some cable Internet services offer higher download speeds than you can get with DSL, but may limit upload speeds (which may restrict its value for use with a server). For example, a major cable television provider currently offers a basic 3-Mbps download speed, but only 256-Kbps upload speed for its standard service. To use your cable television provider to run your Internet server, find out about the business Internet services it offers.
- **Frame Relay** — This service is a packet-switching protocol that runs across wide-area networks. Although it can prove much more expensive than either DSL or ISDN, it can achieve much higher rates of speed. Speeds can range from 56 Kbps to 1.544 Mbps, or even as much as 45 Mbps. Frame relay can operate across a variety of network media. A primary advantage is that it uses virtual circuits that offer a fixed rate of speed because the circuit between you and the ISP isn't shared with other ISP customers.

If your business can afford it, you might want dedicated T-1 or T-3 lines for your business. A *T-1 connection* can operate at data rates of 1.544 Mbps. A *T-3 line* can support rates of 44.736 Mbps. Check with your local ISPs for available connection types and pricing.

## Getting a Domain Name

Domain names are available from dozens of different domain registrars these days. You can check the availability of domain names from any of these registrar's web sites, such as 1&1 (<http://1and1.com>), GoDaddy (<http://www.godaddy.com>), or Network Solutions (<http://www.networksolutions.com>). You can also use the `whois` command that comes with CentOS.

The *top-level domain* (TLD) in which you register your own domain should reflect the type of business or organization that you represent. Commercial businesses typically use the `.com` TLD. Newer TLDs, however, such as `.biz` and `.info`, are now available for domains that represent a business community or for information about businesses and individuals. Some people choose `.ws` to represent their web site, although the `.ws` TLD is actually owned by the government of Western Samoa, which agreed to license it as a general-purpose web site domain. (See [www.icann.org/en/tlds](http://www.icann.org/en/tlds) for more information on TLDs.)

Other common TLDs are `.net`, which was originally intended for network services companies, and `.org`, which was originally intended for organizations. Although those domains were intended for special purposes, there are really no restrictions on who can get and use those domain names.

Institutions of higher education in the United States use the `.edu` TLD. A TLD that has recently become available for public use is the `.us` TLD, for organizations within the United States (public K-12 schools in the United States typically use the `.us` TLD). Countries outside of the United States each already has its own TLD.

## Checking Domain Name Availability

With an active Internet connection, you can use the `whois` command to check if a domain name is available in the `.com`, `.net`, `.org`, or `.edu` domains. Following is an example of using `whois` to check the availability of the domain `google.com`:

```
$ whois google.com
[Querying whois.verisign-grs.com]
[whois.verisign-grs.com]
```

```
Whois Server Version 2.0
```

```
Domain names in the .com and .net domains can now be registered
with many different competing registrars. Go to
http://www.internic.net for detailed information.
```

```
Domain Name: GOOGLE.COM
Registrar: MARKMONITOR INC.
Whois Server: whois.markmonitor.com
Referral URL: http://www.markmonitor.com
Name Server: NS1.GOOGLE.COM
Name Server: NS2.GOOGLE.COM
```

```
Name Server: NS3.GOOGLE.COM
Name Server: NS4.GOOGLE.COM
Status: clientDeleteProhibited
Status: clientTransferProhibited
Status: clientUpdateProhibited
Status: serverDeleteProhibited
Status: serverTransferProhibited
Status: serverUpdateProhibited
Updated Date: 18-nov-2008
Creation Date: 15-sep-1997
Expiration Date: 14-sep-2011
```

```
>>> Last update of whois database: Sun, 04 Jan 2009 19:20:27 EST <<<
.
.
.
```

If the name were available, you'd see the message `No match for GOOGLE.COM`. Because the name is already taken, you can see information about the domain name registrar, name servers containing address records for the domain, and a variety of contact information.

## Reserving a Domain Name

At one point, Network Solutions was the only company from which you could get a domain name in the most popular U.S. domains (.com, .net, and .org). Now, there are new TLDs and dozens of domain registrars from which you can select a domain name.

You can have your ISP obtain your domain name for you, or you can go to one of the domain registrars yourself and register online to get your domain name.

### NOTE

Because prices and services can vary so widely, I recommend that you shop around for a domain registrar. The Internet Corporation for Assigned Names and Numbers (ICANN) maintains a list of accredited registrars at [www.icann.org/registrars/accredited-list.html](http://www.icann.org/registrars/accredited-list.html). The list contains links to registrar sites and a list of the TLDs that they support.

Although each registrar offers different domain and hosting-related services, the following list describes the information that you want to collect before you register your domain (and if you don't have all this information at the moment, don't worry — you can go back and fill in most of it later):

- **Domain Name** — If you haven't already chosen a domain name by using the `whois` command, each registrar offers a search tool at its web site that enables you to check the availability of any name that interests you.
- **Term of Registration** — You must decide how many years of use you want to pay for on the domain name. You can typically pay in 1-year increments, with the cost per year usually less the more years for which you reserve the name. Before the domain name expires, you can re-register it.

- **Contact Information** — Provide the name, e-mail address, street address, company name, and phone numbers for the person in charge of the domain-name registration (probably you). You fill in separate sets of information for the registrant, technical contact, administrative contact, and billing contact.

**NOTE**

If you don't fill in the other contact information, the registrar uses the registrant contact information for each of those categories. If someone else is managing your server, you are the registrant and the hosting company provides a technical contact.

- **Hosting Options** — If you're providing your own hosting in CentOS, you want to decline the Web-hosting service offer that you're given as you register the domain. Along with hosting, the registrar is likely to offer you other hosting options (such as support for PHP or ASP pages). It may also offer you e-mail service.
- **Domain Name System Servers** — The registrar asks you to supply the primary DNS server and one or more secondary DNS servers. If your ISP is providing your DNS service, you can add that information now. If you're getting set up on DNS later, you can usually "park" the domain at the domain registrar and then come back after you obtain DNS to identify the DNS servers with the registrar.

To pay for the domain name, the service expects you to provide a credit card number. Some registrars accept other forms of payment, although credit cards are the most popular means.

## Configuring Your Public Server

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With a domain name, a suitable Internet connection, and one or more static IP addresses, you need to prepare your server to share it on the Internet. In addition to choosing the types of services you want to offer, you must be more thoughtful about the security of your servers.

### Configuring Networking

Whether you're configuring your computer for browsing the Web or offering up a server, procedures for creating network interfaces are very similar. See Chapters 14 and 15 for information on configuring TCP/IP for your computer. Following is a quick review of what you need to do to get a live connection to the Internet that's suitable for your server:

- **Add Network Interfaces** — Depending on what type of network connection you have, you must configure TCP/IP to work across that connection. Most likely, that connection requires that you configure an Ethernet, PPP, or ISDN interface. If you didn't already configure the connection when you installed CentOS, you can do so at any time by using the Network Configuration window (via the `system-config-network` command).

**NOTE**

One major difference between configuring a server for connection to the Internet and a computer that you use primarily for Internet access is in how you set your IP address. You quite likely got the IP address for your Internet connection by using DHCP. Now you will probably enter the IP address that you got from your ISP as a static IP address.

- **Add DNS Server Information** — Although the server IP addresses that you enter for DNS servers are probably ones that your ISP configured, you may want to add your own DNS servers. If so, make sure that your server points to your master and slave DNS servers for IP address resolution. You can also have the other computers on your LAN point to your DNS servers to resolve domain names to IP addresses. (The `/etc/resolv.conf` file is where you identify your DNS servers.) After you add your own DNS server, all your clients should change their `/etc/resolv.conf` files to include the new domain name and DNS server information.
- **Add Hostname** — As soon as you have a real domain name, you can name your computer within the structure of that domain name. If you haven't installed CentOS, you can enter this hostname during installation.

**NOTE**

Changing your hostname after you install can sometimes cause problems. Services such as printing and the X server (for your graphical desktop) sometimes fail after you change your hostname. Check to make sure that printing and other network services are still working after you change your hostname. Sometimes restarting the network interface can solve the problem.

After you set up your network interfaces and related information for your server, test the Internet connection by using commands such as `host`, `nslookup`, and `dig`. Next, if DNS is already configured for your domain, try to query your server by name to see whether those in the outside world can reach you by name. Make sure that the static IP addresses that appear in response match the static IP addresses that you were assigned.

## Configuring Servers

Some services are more appropriate for public exposure than others. You probably don't want to offer your print server, for example, to anyone on the Internet. Similarly, file sharing with Samba or NFS isn't appropriate to share those services natively across the public Internet. (To access those services over an Internet connection, however, you could run them over a virtual private network.)

If you're creating your first public server, you may want to consider setting up at least the following basic types of servers:

- **Web Server** — This type of server, of course, provides the most common way to publish text, images, and a variety of other content to the Internet. Refer to Chapter 20 for information on configuring an Apache Web Server.
- **FTP Server** — This type of server provides the most common way of sharing directories of documents, images, application programs, and other content that users can download from your site. See Chapter 19 for information on setting up an FTP server.
- **Mail Server** — Presumably, if you have a domain name that you like and a Linux server up and running, you may very well want to get a mail server running too. That way, you can create one or more e-mail addresses that are specific to your domain. Because mail servers are high-risk targets for spammers, if you are inexperienced at system



administration, you might decide not to maintain your own public mail server. See Chapter 18 for information on configuring a mail server.

Of course, you can share any type of server that you choose. Web, FTP, and mail servers, however, are designed for sharing publicly. The basic configuration for these types of servers isn't that difficult. Securing and monitoring these — or any — public servers, however, requires special effort, as the following sections describe.

## Managing Security

Before you set up your CentOS system as a server, you can use it simply to make outgoing connections to the Internet. You can use your firewall (iptables) to close off the ports on your interface to the Internet (making your computer quite secure). Now, however, you need to open some of the ports on that interface to accept incoming requests. With more ports open, you must also become more consistent in monitoring those ports. You can use SELinux to set boundaries around your Internet services.

### Opening Your Firewall

Making your server public doesn't mean leaving your computer wide open. By using firewall rules, you can set your computer to allow outsiders to open connections to certain ports and block requests on other ports. Assuming that you set up your firewall to block incoming connections, here's a list of services (and the associated port numbers) that you may want to consider accepting through your firewall from your external interface to the Internet:

- **Web Server** — Port 80
- **Mail Server** — Port 25 (and possibly port 587)
- **FTP Server** — Ports 20 and 21
- **DNS Server** — Port 53 (if you're supporting your own DNS)
- **SSH Server** — Port 22 (allows secure login service to administer the computer remotely or remote users to add Web content or other server content to the server)

To see which ports are assigned to which services by default, refer to the `/etc/services` file. See [www.iana.org/assignments/port-numbers](http://www.iana.org/assignments/port-numbers) for a full list of service ports. In most cases, a configuration file for a service indicates the default port number the service listens on. One way of making a service more private is to change the port number that a service listens on. Then the user must know to ask for the service at that particular port. To see which ports are currently exposed on your system, you can use the `nmap` command.

Chapter 13 describes how to change your firewall to accept requests for these services. I start with the iptables example in that chapter when I create the DNS example later in this chapter. You can use that description as a model for setting up a firewall to go with DNS. In the DNS example, you have separate computers for mail, FTP, and Web services. For a low-volume server, however, you can have them all on the same computer.

## Enabling SELinux

Security Enhanced Linux (SELinux) is now enabled by default in CentOS. As it is implemented with targeted policies, most popular server types (including Web, FTP, and DNS) have policies set that restrict what intruders can do if they manage to break into the service. You should look over how policies are set on the SELinux Administration window (`system-config-selinux` command) for services you are offering. Refer to Chapter 9 for more information on SELinux.

## Checking Logs and System Files

By making your servers public, you also make them more open to attacks. Although firewalls are a good first line of defense, you still need to watch the activity on those ports that you leave open. A consistent program of monitoring traffic and checking changes to your server, therefore, becomes more critical. The following are a few techniques that you can use to help secure your servers:

- **General Security** — Make sure that you protect all your user accounts by using good passwords and the correct file permissions settings.
- **Aide** — Use `aide` to take a snapshot of your critical system files so that you can check later whether anyone's altered those files. The `aide` package is available in the CentOS repository.
- **File System Saint** — As with `aide`, File System Saint maintains a database of every file on your system. You can find out more information from the project's SourceForge.net site (<http://sourceforge.net/projects/fss>).
- **Logwatch** — Use Logwatch, which is on by default in CentOS, to screen log files and suspicious e-mail messages to you. At the very least, you should change the `MailTo` value in the `/etc/logwatch/conf/logwatch.conf` file to an e-mail address you keep up with (this is where Logwatch will send its screened log messages).

I describe these and other security techniques in Chapter 13.

## Keeping Up with Updates

You can expect to find and correct security issues continuously. You must keep up with software updates that are published to plug security holes. Although some of these updates address theoretical security problems, others are created in response to real break-ins or denial-of-service attacks that are known to exploit weaknesses in the components that come with your operating system.

For CentOS, you can use `pirut` or `yum` to download and install updates from CentOS mirror sites that carry those updates (see Chapter 5 for information on using `yum`). You should also check CERT and other organizations (which I describe in Chapter 13) for security alerts.

After your server is secure and correctly configured, your last step is to start the server on the Internet with a domain name that points to it. Either ask your service provider to configure DNS for you or set up your own DNS server, as I describe in the following section.

## Setting Up a Domain Name System Server

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The *Domain Name System* (DNS) is essentially a distributed database that translates hostnames into IP addresses (and IP addresses back to hostnames). That database also contains information related to each domain, such as how the domain is organized into zones, where to route mail for that domain, and whom to contact with questions associated with the domain.

By setting up a DNS server, you become part of a hierarchy of DNS servers that make up the Internet. At the top of this hierarchy is the root server, represented by a dot (.). Below the root server are the top-level domains, or TLDs (such as .com, .org, etc.). Domains that individual organizations own and maintain lie below the TLDs, branching in a way that looks like an upside-down tree structure. That's where you come in.

As someone who's setting up a DNS server, you're responsible for managing the hostnames and IP addresses for the computers in the domain (or domains) for which you're responsible. Keeping your DNS information correct means that people can access the services that you want to share, and the Internet as a whole works that much better as a result.

Besides using your DNS server to help people from the Internet find the public servers in your domain, you can also use DNS to provide name and IP address mapping for computers on your private network. The example in the “DNS Name Server Example” section later in this chapter describes how to configure both private and public name and IP address records for a domain.

### WARNING

Setting up a DNS server can be a complex and (these days) potentially dangerous undertaking. A compromised DNS server can cause requests for host addresses to be directed to a cracker's server. The sample DNS server in this section is one created as an example of a DNS server for a home or small office environment. For information on the many different ways to set up a DNS server, go to the *BIND 9 Administrator Reference Manual* at [/usr/share/doc/bind-9\\*/arm/Bv9ARM.html](/usr/share/doc/bind-9*/arm/Bv9ARM.html).

## Understanding DNS

The basic function of a name server is to answer queries by providing the information that those queries request. A DNS name server primarily translates domain and hostnames into IP addresses. Each domain is typically represented by at least two DNS servers.

- **Primary (Master) Name Server** — This name server contains the master copy of authoritative information about the domains that it serves. In response to queries for information about its domains, this server provides that information marked as being authoritative. The primary is the ultimate source for data about the domain.
- **Secondary (Slave) Name Server** — This name server gets all information for the domain from the primary name server. As is the case for the primary server, DNS considers the secondary's information about the domain that it serves authoritative, although the domain records can be overwritten from the primary.

NS (which stands for “Name Server”) records in the parent zone for a domain list the primary and one or more secondary name servers. This *delegation* of servers defines the servers that have authority for the zone.

Because zone records change as you add, remove, or reconfigure the computers in the zone, you assign expiration times for information about your zone. You set the expiration time in the time to live (TTL) field, in the `named.conf` file (which I describe later).

Other specialized types of DNS servers are possible as well. Although these types of servers don't have authority for any zones, they can prove useful for special purposes:

- **Caching Name Server** — This type of server simply caches the information it receives about the locations of hosts and domains. It holds information that it obtains from other authoritative servers and reuses that information until the information expires (as set by the TTL fields).

**NOTE**

The `caching-nameserver` package in CentOS automatically sets up a caching instance of `bind` for instant use in an office or home environment where you don't want to rely on your ISP's name servers.

- **Forwarding Name Server** — Creating a server that's not authoritative for a zone but that can forward name server requests to other name servers may prove efficient. This server is essentially a caching name server but is useful in cases in which computers lie behind a firewall and in which only one computer can make DNS queries outside that firewall on behalf of all the internal computers.

## Understanding Authoritative Zones

As an administrator of a DNS server, you need to configure several zones. Each zone represents part of the DNS namespace as you view it from your DNS server. Besides the one or more zones representing your domain, you have a zone that identifies your local host and possibly your local, private LAN.

If you configure a server as authoritative for a zone, that server has the last word on resolving addresses for that zone. In the upcoming “DNS Name Server Example” section, your primary master name server is authoritative for the domain you control (as are the secondary name servers it passes its records to), but not for domains outside your domain.

Remember that the DNS server that you configure is the ultimate authority for your zone. Other zones don't know how you configure your hostnames and IP addresses unless you properly set up your DNS server to distribute that information across the Internet.

The definitive data that you set up for your domain exists in the form of resource records. *Resource records* consist of the data associated with all names below the authoritative point in the tree structure. When the DNS server uses these records to reply to queries, it sets the *authoritative answer* (AA) bit in the packet that includes the reply. The AA bit indicates that your name server has the best and most current information available about your domain.

## Understanding DNS Risks

When you set up a public DNS server, you are essentially responsible for providing reliable name-to-address conversion for the clients that use that server. Because of the potential security risks in maintaining a DNS server, you should not take this responsibility lightly.

Someone breaking in to control the information in a DNS server has the potential to re-direct queries to the server for addresses to sites that the intruder chooses. So, for example, if someone is trying to contact a Web Server in the domain your DNS server controls, they might be entering their credit card number or other personal information into a web site that the intruder set up for the purpose of stealing that information.

There are several different types of attacks directed at DNS servers. *DNS cache poisoning* is where fraudulent addresses are attached to hostnames that are placed in a DNS server's cache. *Pay-per-click frauds* will infect DNS servers in such a way that the Web browsers are directed to sites that set off a string of clicks to sites that pay each time you visit them. The person using the browser may never even see any indication that he has contacted those sites.

While BIND servers seem to have a better record of resisting attacks than Microsoft servers, there is still enough risk to warrant educating yourself against such attacks. Here are a few links where you can learn more about DNS attacks:

- **DNS Poisoning** (<http://isc.sans.org/presentations/dnspoisoning.html>) — Contains a good description of DNS poisoning and ways of dealing with it.
- **DNS Amplification** ([www.isotf.org/news/DNS-Amplification-Attacks.pdf](http://www.isotf.org/news/DNS-Amplification-Attacks.pdf)) — Contains a description of DNS amplification attacks, where DDoS attacks are used recursively along a chain of DNS servers.

Refer to the ISC BIND site for security alerts that relate to DNS service with BIND.

## Understanding BIND

In CentOS, and most other Linux and UNIX systems, you implement DNS services by using the Berkeley Internet Name Domain (BIND) software. The Internet Software Consortium maintains BIND (at [www.isc.org/sw/bind](http://www.isc.org/sw/bind)). The particular version of BIND that I describe in this chapter is BIND 9.3.4. To use BIND as described in this section, you need to install these packages: `bind`, `bind-utils`, `bind-chroot`, and `bind-libs`. There is also a `system-config-bind` package that contains a graphical means of working with your DNS files.

BIND can be configured to run in a changed root (chroot) environment (provided you install the `bind-chroot` package). This means that instead of having configuration files in `/etc` and `/var/named` as they always have been with BIND, they are located in `/var/named/chroot/etc` and `/var/named/chroot/var/named` instead. This is a security measure to limit the access that an intruder could gain by taking control of the `named` daemon. SELinux also is configured to limit access to the `named` and `nscd` daemons (see the Security Level Configuration window for details).

**NOTE**

Because `/etc/named.conf` file and files in the `/var/named/` directory are linked to their counterparts in `/var/named/chroot`, you can edit those files in either directory. However, as you add zone files to the `/var/named/chroot/var/named` directory, you will need to create new links to those files in `/var/named` directory to continue to edit them from that location.

The basic components of BIND include the following:

- **DNS Server Daemon** (`/usr/sbin/named`) — The named daemon listens on a port (port number 53 by default) for DNS service requests and then fulfills those requests based on information in the configuration files that you create. Mostly, named receives requests to resolve the hostnames in your domain to IP addresses.

**NOTE**

The named daemon actually launches from the `/etc/init.d/named` start-up script. You need to set that script to start automatically after your DNS server is ready to go. You can also use the named start-up script to check the status of the named daemon.

- **DNS Configuration Files (named.conf File and named Directory)** — The `/var/named/chroot/etc/named.conf` file is where you add most of the general configuration information that you need to define the DNS services for your domain. Separate files in the `/var/named/chroot/var/named` directory contain specific zone information. The location of the chrooted DNS configuration files in CentOS (`/var/named/chroot`) is set in the `/etc/sysconfig/named` file.

**NOTE**

If you run BIND in a non-chrooted environment, configuration files are located in `/etc/named.conf` file and the `/var/named` directory. You must uninstall the `bind-chroot` package to do this.

- **DNS Lookup Tools** — You can use several tools to check that your DNS server is resolving hostnames properly. These include commands such as `host`, `dig`, and `nslookup` (which are part of the `bind-utils` software package).

To maintain your DNS server correctly, you can also perform the following configuration tasks with your DNS server:

- **Logging** — You can indicate what you want to log and where log files reside.
- **Remote Server Options** — You can set options for specific DNS servers to perform such tasks as blocking information from a bad server, setting encryption keys to use with a server, or defining transfer methods.

You don't need to give out DNS information to everyone who requests it. You can restrict access to those who request it based on the following:

- **Access Control List (acl)** — This list can contain those hosts, domains, or IP addresses that you want to group together and apply the same level of access to your DNS server. You create acl records to group those addresses and then indicate what domain information the locations in that acl can or can't access.

- **Listen-On Ports** — By default, your name server accepts only name server requests that come to port 53 on your name server. You can add more port numbers if you want your name server to accept name service queries on different ports.
- **Authentication** — To verify the identities of hosts that are requesting services from your DNS server, you can use keys for authentication and authorization. (The key and trusted-keys statements are used for authentication.)

**CROSS-REF**

You should already know what domain names and IP addresses are. Refer to Chapter 14 for IP addresses and Chapter 15 for DNS information, if you need to refresh your memory.

## DNS Name Server Example

To get an idea of what you need to set up your DNS server, the following sections step you through an example of a DNS server for a domain called `example.com`. In the example, you're creating a DNS server for a small office network that includes the following:

- A private, local network that resides behind a firewall
- A server providing DNS service

In this office, other computers on the LAN are using the same Internet connection for outgoing communications, so the firewall on the server does Network Address Translation (NAT) to enable the client computers to use the firewall as a router to the Internet. Figure 24-1 shows the configuration of the example `example.com` domain.

Figure 24-1 illustrates a small office network that's sharing a single Internet connection. The DNS, Web, mail, and FTP servers all have public IP addresses. (These addresses are fictitious, so please don't try to use them.) Behind the DNS server (which is also operating as a firewall) are four client computers that have private IP addresses. (You can reuse these addresses and other private addresses that I describe in Chapter 14.)

**NOTE**

Because this is an example of how DNS works, it doesn't deal with all the complexities you might face in setting up the computing infrastructure at your company. For example, you might well want a dedicated firewall protecting your Internet connection, with the DNS server being placed with the other servers behind what is referred to as a *demilitarized zone* that is separated from the company LAN.

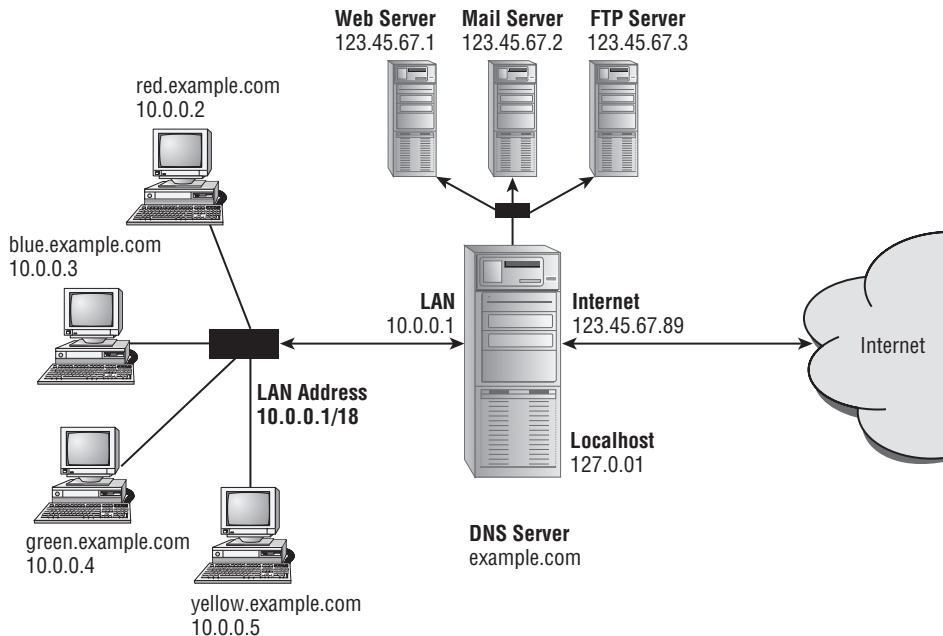
The job of the DNS server, in this configuration, is to map the names of the public servers (`www.example.com`, `mail.example.com`, `ftp.example.com`, and `ns1.example.com`) into the static IP addresses that the ISP assigns (123.45.67.1, 123.45.67.2, 123.45.67.3, and 123.45.67.89, for our example). The DNS server also provides DNS service from the private addresses on the LAN, so each computer can reach the others on the LAN without needing to store all computer names in its own `/etc/hosts` file.

A key feature to this example is that it divides the view of this domain between what the outside world can see and what the computers on the private network can see. Using the `view`

feature of BIND, I create an *outside* view that lets queries from the Internet find only public servers (Web, Mail, and FTP) in the domain. Then I create an *inside* view that lets queries from the local LAN find both the public servers and private computers (red, blue, green, and yellow) in the domain.

**FIGURE 24-1**

The sample example.com DNS server has a combination of public servers and private client computers.



The sections that follow describe how to set up a DNS server for the example in Figure 24-1.

## Quick-Starting a DNS Server

The DNS server software that comes with the current CentOS version is BIND version 9.3.4. To configure BIND 9.3.4, you work with the following components:

- **Configuration File** (`/var/named/chroot/etc/named.conf`) — The main DNS server configuration file
- **Zone Directory** (`/var/named/chroot/var/named`) — The directory containing files that keep information about Internet root DNS servers (`named.ca` file) and information about the zones that you create for your DNS server



- **Daemon Process (/usr/sbin/named)** — The daemon process that listens for DNS requests and responds with information that the `named.conf` file presents.
- **Debugging Tools** (`named-checkconf` and `named-checkzone`) — What you use to determine whether you created your DNS configuration correctly

**NOTE**

CentOS comes with a GUI tool for configuring BIND called `system-config-bind`. (Type `yum install system-config-bind` to install it.) If you decide to use that tool, you need to be careful editing the BIND configuration files by hand. It is recommended that if there are changes you want to make to the `named.conf` file that are not supported by the `system-config-bind` window, you should put those changes in the `/etc/named.custom` file instead.

BIND 9.3.4 also includes tools for creating DNSSEC secured zones. By using these tools, you can create and generate keys to provide authentication and secure address resolution. The example illustrated in these sections doesn't include DNSSEC configuration.

The basic steps in creating a DNS server for your example are as follows:

1. Identify your DNS servers.
2. Create DNS Configuration files (`named.conf` file and the `named` directory).
3. Start the `named` daemon.
4. Monitor `named` activities.

In the example configuration, you set up a primary master DNS server and a slave DNS server. The primary server holds the master copy of the authoritative records for the domain. The secondary server is there to share requests for information about the domain, particularly in case the primary goes down. The secondary typically gets its records from the primary server. The secondary is also considered to be authoritative in regard to the DNS records for the domains it controls.

## Identifying Your DNS Servers

If you didn't have your DNS servers set up at the time that you purchased your domain name with a registration authority, you might have just “parked” the domain name there until you configured your DNS servers. Whenever you're ready to set up your DNS servers, return to that registration authority and provide the following information about your DNS servers:

- DNS server IP addresses (the static IP addresses of your DNS servers, probably primary and slave)
- DNS server hostnames (often `ns1.example.com`, where you replace `example.com` with your domain name for the primary; the slave hostname is `ns2.example.com`)

You should register both the primary and slave DNS servers. After you update this record, that information typically takes a day or two to propagate throughout the Internet. When your DNS servers are registered, you also need to tell the registration authority to use those DNS servers as

the authority for addresses in your domain. The registration authority probably offers an online form you can fill out to identify your DNS servers.

## Creating DNS Configuration Files (`named.conf` and `var/named`)

In configuring a DNS server, you're actually creating definitions that apply to a particular *zone* in the public DNS tree, as well as several local zones that apply to your computer and local network. To create a useful DNS server for your example small-office environment, you have the following zones:

- **Public DNS Server Zone** — The DNS server is authoritative for the domain that you're serving. This zone serves the names and IP addresses for your public servers. In the example `named.conf` file shown in the next section, you need to replace the name `example.com` with the domain that you're creating. These records become accessible to everyone on the Internet.
- **Private DNS Server Zone** — So each computer on the private network doesn't need to know the IP addresses for other computers on your private network, a zone is added in the example `named.conf` file to let the DNS server resolve these addresses. The names and IP addresses (which are private) are available only to computers on your LAN.

Note that by creating different views of these zones, different information will be returned to queries, depending on where the queries come from. For example, when someone from the Internet requests the address of the DNS server (`ns1.example.com`), they will get the address `123.45.67.89`. However, when a query for `ns1.example.com` comes from inside the LAN, the address `10.0.0.1` is returned. Also, any queries from the Internet for addresses of private computers (`red.example.com`, `blue.example.com`, etc.) are rejected.

## Editing `named.conf`

To begin, you configure the `/var/named/chroot/etc/named.conf` file on the primary master DNS server representing your example `example.com` domain. This example starts from the `/etc/named.conf` file that comes with the `caching-nameserver` package in CentOS. (Make sure that you install the `caching-nameserver` and `bind` packages before you continue, and make a backup copy of any configuration files you edit.) Following are a few tips relating to editing the `named.conf` file:

- If a statement contains substatements, make sure that you end the last substatement with a semicolon.
- Comments can appear in the same formats that popular programming languages use. These languages include C (begin with `/*` and end with `*/`), C++ (begin with `//` and go to the end of the physical line), shell or Perl styles (begin from a `#` and go to the end of the physical line), and ini style (begin from a `;` and go to the end of the line).
- A leading exclamation mark (!) negates an element. Putting `!123.45.67.89` in a statement causes the IP address `123.45.67.89` not to match the element. (Just make sure that the negation occurs before a positive match or the positive match takes precedence.)

The edited version of the `/var/named/chroot/etc/named.conf` file is as follows:

```
options {
    directory "/var/named";
    dump-file "/var/named/data/cache_dump.db";
    statistics-file "/var/named/data/named_stats.txt";
};

acl "mylan" {
    127/8; 10.0.0.0/24;
};

controls {
    inet 127.0.0.1 allow { localhost; } keys { rndckey; };
};

view "inside" {
    match-clients { "mylan"; };
    recursion yes;

    zone "." IN {
        type hint;
        file "named.ca";
    };

    zone "0.0.10.in-addr.arpa" IN {
        type master;
        file "yourlan.db";
    };

    zone "example.com" {
        type master;
        file "db.example.com.inside";
        allow-transfer { 10.0.0.2; };
    };
};

view "outside" {
    match-clients { any; };
    recursion no;

    zone "." IN {
        type hint;
        file "named.ca";
    };

    zone "example.com" {
        type master;
        file "db.example.com.outside";
        allow-transfer { 123.45.67.2; };
    };
};
```

```

    };
};

include "/etc/rndc.key";

```

The `options` definition lies at the beginning of the `named.conf` file and identifies the `/var/named` directory as the location where the zone files reside. The `acl` lines define the `mylan` access-control list, which consists of host computers on the 10.0.0.0 local private network and the local host (127/8). (See Chapter 14 for information on the form of IP addresses, CIDR, and netmasks.) You use this definition in the `0.0.10.in-addr.arpa` zone to enable only users on the LAN to perform reverse lookups of names of computers on the LAN.

The DNS server is broken up into two views: `inside` and `outside`. The `inside` view defines how IP addresses are resolved for requests that come from the private LAN and localhost (as defined in `mylan`). By having recursion on (`recursion yes`), the `named` daemon will allow name server queries to any domain (even domains that the local DNS server doesn't control) from any computer on the LAN. The `outside` view defines how queries coming from all other places (presumably, the Internet) are handled. With recursion off (`recursion no`), only queries from other name servers for domains controlled by the local DNS server are honored. Requests for information about other domains will be rejected with a `not found` message. (Turning recursion off can help eliminate a common attack in which a cracker causes your server to seek information from a DNS server controlled by the cracker.)

Each zone entry in the `named.conf` file describes the type of server this computer is for the zone (master in all cases here, except the root zone), the database file (in the `named` directory) that contains records for the zone, and other options relating to the zone records. The `named.ca` file is set up for you by default. It identifies the locations of the Internet root servers.

I made the other zones (`yourlan.db`, `db.example.com.inside`, `db.example.com.outside`, and `0.0.10.in-addr.arpa`) for this example. For the “inside” view, the `yourlan.db` file lets the computers on your LAN do reverse address lookups (getting the names for IP address queries). The `db.example.com.inside` file contains names and addresses for all computers in your domain (including those on the local LAN). The DNS slave server for the inside view of this domain is at 10.0.0.2. (Clients in your LAN would use 10.0.0.1 and 10.0.0.2 as DNS servers in `/etc/resolv.conf`.)

For the “outside” view, the `db.example.com.outside` file contains names and IP addresses for any computers in your domain you want to make public (computers on your private LAN are excluded). The DNS slave server for the outside view of this domain is 123.45.67.2.

Notice that each zone points to a zone file in the `named` directory. Table 24-1 shows which file in the `named` directory each zone points to.

Be very careful editing the `named.conf` file. Forgetting a semicolon is all too easy and results in the entire file not loading. To ensure that the `named.conf` file doesn't contain any syntax errors, you can run the following command (as `root` user):

```
# named-checkconf
```

TABLE 24-1

## Zones and Related Zone Files in DNS Example

Zone	Zone File (Located in the /var/named/chroot/var/named Directory)
. (a single dot representing Internet root servers)	named.ca
0.0.10.in-addr.arpa	you1an.db
example.com (inside view)	db.example.com.inside
example.com (outside view)	db.example.com.outside

If a syntax error is present, a message identifies the problematic line and informs you what seems to be wrong with it. If the syntax is correct, continue to create the zone files in the /var/named directory.

**Setting Up the Zone Files (Inside)**

The /var/named/chroot/var/named directory contains the zone files that the /var/named/chroot/etc/named.conf file points to. For the example, you need to create only three zone files from scratch. You can (and should) leave the named.ca file alone.

Most of the real work of the domain name server occurs in the zone files. In the example, the db.example.com.inside file contains the basic records for the example.com domain, including all private names and addresses. The following is an example of that file:

```
$TTL      86400
@         IN      SOA      example.com. hostmaster.example.com. (
                                2009042701 ; Serial
                                28800     ; Refresh
                                14400     ; Retry
                                3600000   ; Expire
                                86400    ) ; Minimum

; Name servers
                IN      NS      ns1.example.com.
                IN      NS      ns2.example.com.

; Mail server for domain
                IN      MX      10   mail.example.com.

; Public servers
ns1             IN      A        10.0.0.1
ns2             IN      A        10.0.0.2
mail            IN      A        123.45.67.2
```

```

www             IN      A       123.45.67.3
ftp            IN      A       123.45.67.4

; Private clients on the LAN
red            IN      A       10.0.0.2
blue          IN      A       10.0.0.3
green         IN      A       10.0.0.4
yellow        IN      A       10.0.0.5

; EOF

```

The zone file for your “inside” `example.com` contains resource records that include information about the zone. Your DNS server uses the TTL (time-to-live) record to tell name servers that store the information that you provide for this domain how long they can keep the information before they need to throw it out and get fresh information. The first value is the default for the entire zone, and the time is in seconds. So a value of 86,400 seconds indicates that a client that is using the information should obtain fresh records about this domain every 24 hours.

The SOA line identifies the start of authority for the domain. The at (@) sign represents the `example.com.` name — the dot (.) must appear at the end of the domain name. The dot represents the root server of the Internet. If you leave the dot off, your DNS server appends the domain name, so the DNS server will use the name `example.com.example.com`. The `hostmaster.example.com` string indicates the e-mail address of the person who is to receive e-mail regarding the domain. (The first dot changes to an @ sign, resulting in `hostmaster@example.com`). Other information regarding the SOA record is as follows:

- **Serial** — Start with any number here. If the zone records change, increase the serial number to alert other servers that they need to get fresh data about your domain.

### WARNING

If you forget to increase the serial number after changing zone records, other servers that cache this data never pick up your changes. To help remember, use the date in the serial number. The number 2009042701 would be for April 27, 2009. The 01 represents the first change made on that day.

- **Refresh** — Defines how often the slave DNS server for the zone checks for changes. (Here, 28,800 seconds represents 8 hours.)
- **Retry** — If the slave can’t reach the master, it tries again after this retry interval. (Here, 14,400 seconds represents 4 hours.)
- **Expire** — If the slave can’t contact the master within the expire time (here, 3,600,000 seconds, or 1,000 hours), the slave discards the data.
- **Minimum** — Defines the cache time to live for negative answers. (Here, it’s 86,400 seconds, or 24 hours.)

The name server (NS) records define the name servers that represent this zone. In this case, NS records define hosts with the names `ns1` and `ns2` in `example.com`. The MX record indicates the location of the mail server for the domain, so that the DNS server can direct e-mail to users in

example.com. The rest of the file defines IP addresses for the private clients and public servers that are associated with the domain. Notice that the server at address 10.0.0.2 serves as a client on the LAN and a slave DNS server.

### Setting Up the Zone Files (Outside)

For the “outside” example.com zone, you made a db.example.com.outside file using the same information from the “inside” file, with the following exceptions:

- Removed all references to private clients on the LAN. That way, someone poking around from the Internet can’t get information about your private computers.
- Changed the addresses of the primary and slave DNS servers (ns1 and ns2) to 123.45.67.1 and 123.45.67.2, respectively. In that way, only public addresses for name servers are seen by the public. (Of course, you need to use your own public IP addresses instead of the examples 123.45.67.1 and 123.45.67.2.)

### Setting Up the Zone Files (Reverse Lookup)

The other new file in the example is the yourlan.db file, which contains the information necessary to perform reverse IP lookups for the computers on your LAN. Here’s an example:

```
$TTL      86400
@         IN      SOA     ns1.example.com hostmaster.example.com. (
                                2006042701 ; Serial
                                28800     ; Refresh
                                14400     ; Retry
                                3600000   ; Expire
                                86400    ) ; Minimum

        IN      NS      ns1.example.com
1       IN      PTR     example.com.
2       IN      PTR     red.example.com.
3       IN      PTR     blue.example.com.
4       IN      PTR     green.example.com.
5       IN      PTR     yellow.example.com.

; EOF
```

The SOA record identifies 0.0.10.in-addr.arpa. as the start of authority for the zone. The NS line defines 0.0.10.in-addr.arpa. as the name server for the zone. Other records are pointers to hostnames that reverse-map on the 10.0.0. network. The records represent the address for the DNS server (example.com) and each of the clients on the LAN (red, blue, green, and yellow).

After you finish creating your own zone files, you can use the named-checkzone command to make sure that each zone file is formed correctly. Here is how you’d run the named-checkzone command (as root user) to check the two example.com zone files (be sure to type each command on one line, even though each is shown here on two):

```
# named-checkzone example.com /var/named/chroot/var/named/db.  
example.com.inside  
zone example.com/IN: loaded serial 2009042701  
OK  
# named-checkzone example.com /var/named/chroot/var/named/db.  
example.com.outside  
zone example.com/IN: loaded serial 2009042701  
OK
```

The output indicates that both files are OK and that the `named-checkzone` command is able to load the new serial numbers. In this case, the serial number represents the first serial number (01) on April 27, 2009 (2009042701).

## Starting the named (DNS) Daemon

To start the `named` daemon and see whether it's working, type the following (as `root` user):

```
# /etc/init.d/named start
```

If the `named` daemon starts successfully, clients of your DNS server should start getting information about your domain. To set the `named` daemon to start each time that the system boots up, type the following:

```
# chkconfig named on
```

Remember that, whenever you make changes to the `named.conf` or any of the zone files, you must increase the serial number for anyone checking your domain records to pick up those changes. After that, you should restart the `named` service too (as `root` user) as follows:

```
# /etc/init.d/named restart
```

Then you should consider adding the server's own local address to its own `/etc/resolv.conf` file. For example, the `/etc/resolv.conf` file could include the following:

```
search example.com  
nameserver 127.0.0.1
```

If you see the `Starting named` message, your DNS server is probably up and running. If you want to make sure that your server is correctly resolving addresses, the next section, "Checking That DNS Is Working," describes some tools that you can use to check your DNS name server.

## Checking That DNS Is Working

The best way to verify whether your DNS server is working correctly is to watch it in action. Here are a few commands you can use to check out your DNS server. The first example uses the `host` command to get the IP address for the host computer named `blue` in the local domain:

```
# host blue  
blue.example.com has address 10.0.0.3
```



Instead of using the simple hostname to get the computer's IP address, you can enter an IP address (instead of the name) or a fully qualified hostname. In the following example, the `dig` command is used with a domain name to get information about the addresses for a domain:

```
# dig example.com
; <<>> DiG 9.3.4-P1 <<>> example.com
;; global options: printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 38166
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 2, ADDITIONAL: 1

;; QUESTION SECTION:
;example.com.    IN A

;; ANSWER SECTION:
example.com.    604800 IN A 208.77.188.166

;; AUTHORITY SECTION:
example.com.    604800 IN NS ns1.example.com.
example.com.    604800 IN NS ns2.example.com.

;; Query time: 24 msec
;; SERVER: 10.0.0.1#53(10.0.0.1)
;; WHEN: Tue Mar 17 02:12:32 2009
;; MSG SIZE rcvd: 129
```

Sections in the output from `dig` include a question section and an authority section. The results show name server assignments and addresses associated with the domain you're querying about. The `nslookup` command is another tool you can use to look up domain information. In the following example, `nslookup` looks up the server that is resolving `ftp.example.com`:

```
# nslookup ftp.example.com
Server:      123.45.67.1
Address:     123.45.67.1#53

Name:   ftp.example.com
Address: 123.45.67.4
```

The output from the `nslookup` command includes the name of the computer fulfilling the request and its IP address, along with the name and address of the computer you're asking for. Try `nslookup` with an IP address (such as `10.0.0.1`) to make sure that reverse lookup works. You can also consider using `dig` instead of `nslookup`.

To check the status of the named server that is running on your local system, use the same script that starts `named`. Type the following to check the status of your DNS server daemon:

```
# /etc/init.d/named status
number of zones: 5
debug level: 0
```

```
xfers running: 0
xfers deferred: 0
soa queries in progress: 0
query logging is OFF
recursive clients: 0/1000
tcp clients: 0/100
server is up and running
```

If you can't reach the computers that your DNS server is serving by name or IP address, you should make sure that each client's address records are correct. You can also try to ping each client and server computer using the full hostname or IP address.

## Getting More Information about BIND

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For details on many other BIND options that I don't describe in this chapter, you can refer to several places, as the following list relates:

- `/usr/share/doc/bind-9*/arm` — Contains HTML and XML versions of the *BIND 9 Administrator Reference Manual*.
- **Man Pages** — Type the **man** command, following it with **named** or **named.conf**. These man pages contain terse descriptions of options and variables that relate to the named daemon and named.conf file, respectively.
- **Internet Software Consortium** ([www.isc.org/sw/bind](http://www.isc.org/sw/bind)) — The ISC web site contains information and downloads related to BIND. On this site, find links to BIND mailing lists, security advisories relating to BIND, and BIND history.

## Summary

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The choice to connect your CentOS server to the Internet isn't one to make lightly. If the server is critical to your business and support for the server is too much for you to handle, you should consider handing your server over to a hosting provider.

If you do decide to expose your CentOS server to the Internet to offer Web, FTP, mail, or other types of services, you should carefully consider the security implications and prepare for them. By using Linux features that I describe in other parts of this book, you can create firewalls, monitor log files, and track changes to system files to protect your computers.

One way of controlling the public exposure of your servers is to obtain a domain name and configure your own Domain Name System (DNS) server. You can set up your DNS server to resolve hostnames to IP addresses for clients that request the information from the Internet, as well as to the users on your local, private LAN.



# Appendix A

## About the Media

If you have a DVD drive on a standard PC (32-bit i686 architecture), you can install CentOS 5 from the DVD that comes with this book, or try CentOS without installing it using the Live CD.

### System Requirements

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Make sure that your computer meets the minimum system requirements listed in this section. If your computer doesn't match up to most of these requirements, you may have a problem using the contents of the media that come with this book.

#### For Linux or Windows Systems

- PC with a Pentium-class processor running at 400 MHz or faster; for best performance, we recommend a Pentium 4 or AMD equivalent running at 700 MHz or better.
- At least 256 MB of total RAM installed on your computer; for best performance, we recommend at least 512 MB.
- Ethernet Network Interface Card (NIC) or modem with a speed of at least 28,800 bps
- A CD-ROM drive if you are testing CentOS with the Live CD or a DVD drive if you are installing from the DVD disk
- A VGA graphics card that is capable of at least 1024 × 768 resolution
- At least 3 GB of available disk space if installing CentOS

#### IN THIS APPENDIX

System requirements

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Using the installation DVD

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Using the CentOS live CD

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What's on the media

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Source code

---

Troubleshooting

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If your system does not satisfy these requirements, you may still be able to install CentOS on your system with one of the alternative installation methods discussed in Chapter 2.

**NOTE**

The media included with this book are for 32-bit PC architectures. They will not work on other computer architectures. However, you can download ISO images of CentOS installation media for X86 64-bit (x86\_64) architectures from the CentOS download page (<http://mirror.centos.org/centos/5/isos/>).

## Using the Installation DVD

---

To install CentOS from the DVD to your hard drive, follow these steps:

1. Insert the DVD into your computer's DVD drive.
2. Reboot your computer system, booting from the DVD drive. If your system is not already configured to boot from a DVD before booting from the hard drive, you may need to modify your computer's BIOS settings in order to give precedence to booting from the DVD drive.
3. Press the [Enter] key to install CentOS.
4. During installation, you are asked questions about your computer hardware and the network connections. After you have completed each answer, click Next.

**CROSS-REF**

For more information on installing CentOS 5 from the DVD, follow the instructions provided in Chapter 2 and in the README files on the DVD.

If for some reason you don't have your DVD handy, you can download different installation images from <http://mirror.centos.org/centos/5/isos/>. If you have a DVD drive on another computer on your LAN, see Chapter 2 for information on setting up a CentOS install server, so you can install CentOS on your chosen machine over your LAN.

Repositories can help you find extra, useful software packages that are not in CentOS. Some of these sites act as yum or apt repositories that allow you to download sets of dependent packages (see the descriptions of yum and useful third-party software repositories in Chapter 5).

## Using the CentOS Live CD

---

The CentOS Live CD that is included with this book can be used to help prepare your computer before installation with the DVD, or if you just want to try CentOS out without installing it to your system's hard drive. You can boot up to a working GNOME desktop that works like most desktop computer systems installed to hard disk. If you don't like the system, then reboot, remove the CD, and your computer will return to the way it was.

1. Insert the CentOS 5 Live CD into your CD drive and reboot.
2. From the boot screen, either let the CD time out and boot or press any key to see other selections. From the boot menu, highlight “Boot” and then press [Enter].
3. When you see the login screen, you can select a language or just let the login prompt time out. (No password is required.) The GNOME desktop starts up.

## What’s on the Media

---

The following sections provide a summary of the software and other materials you’ll find on the media that accompany this book.

### Operating System and Applications

The Live CD provides a version of CentOS 5 that you can test-drive on a 32-bit, x86-compatible computer system. The installation DVD provides the necessary installation and software packages to install CentOS on a new system or as an alternate operating system on an existing computer system. You can install it as an alternate operating system by either repartitioning your disk to provide a partition where CentOS Linux can be installed directly, or as an alternate operating system on an existing Microsoft Windows system that has at least 4 GB of free space without repartitioning.

### Source Code

---

From time to time, you may want to recompile the Linux kernel or other software package that comes with CentOS. Like the binary software packages, the source code packages are available (<http://isoredirect.centos.org/centos/5/os/SRPMS/>). To work with CentOS source code packages, here is what you need:

- `kernel-devel` — The `kernel-devel` package comes with the CentOS binary packages. Included in the package name is the version number of the kernel it contains. The source code for the current kernel is contained in the `/usr/src/kernels` directory, ready to be recompiled, if the `kernel-devel` package is installed.
- **SRPMS Directory** — Source code for each binary package outside of the kernel that is included in CentOS is available from any CentOS repository. Install the source code package for the software that interests you (the name ends in `.src.rpm`) and a copy of that software in subdirectories of the `/usr/src/redhat` directory.

To do the actual compilations, you will need to install at least the `gcc` package.

## Troubleshooting

---

The media that are included with this book contain a complete version of CentOS that you can either test-drive (Live CD) or install (DVD) on your computer system. If you have problems installing or running CentOS Linux on a particular computer system, consult the CentOS forums at [www.centos.org/modules/newbb/](http://www.centos.org/modules/newbb/).

### Customer Care

If you have trouble with the CD-ROM, please call the Wiley Product Technical Support phone number at (800) 762-2974. Outside the United States, call 1 (317) 572-3994. You can also contact Wiley Product Technical Support at <http://support.wiley.com>. John Wiley & Sons will provide technical support only for installation and other general quality-control items. For technical support on the applications themselves, consult the program's vendor or author.

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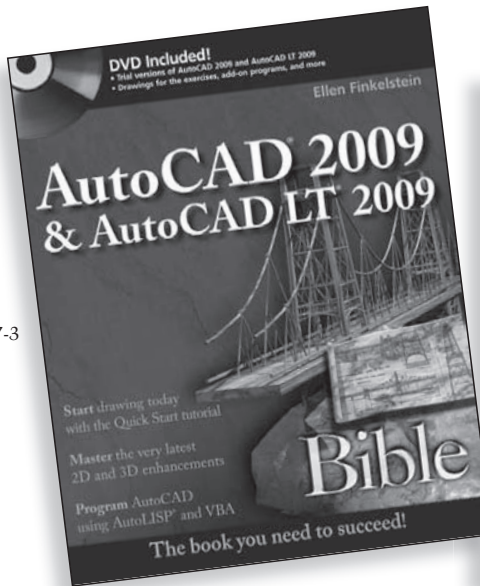
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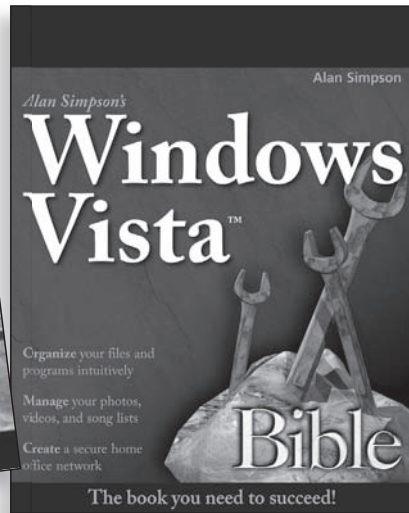
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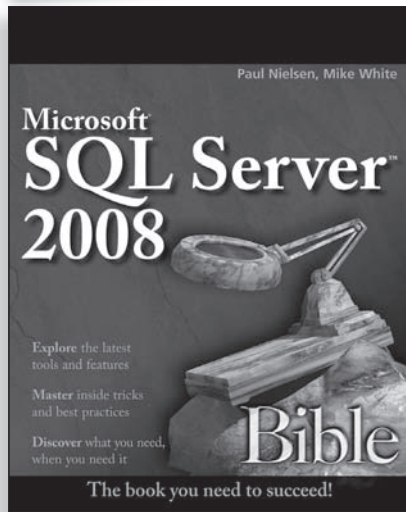
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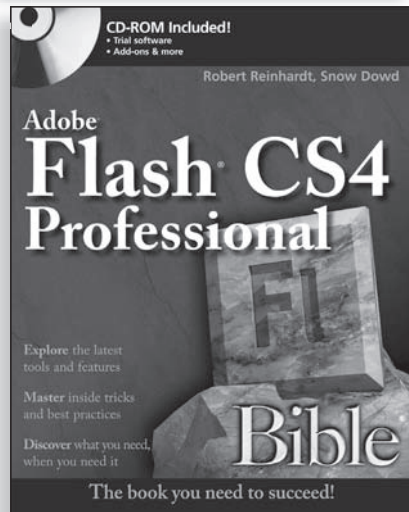
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