The LINUX Users' Guide

All you need to know to start using LINUX, a free Unix clone. This manual covers the basic Unix commands, as well as the more specific LINUX ones. This manual is intended for the beginning Unix user, although it may be useful for more experienced users for reference purposes.

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These are some of the typographical conventions used in this book.

Bold — Used to mark **new concepts**, **WARNINGS**, and **keywords** in a language.

italics — Used for *emphasis* in text.

slanted — Used to mark **meta-variables** in the text, especially in representations of the command line. For example, "`ls -l` *foo*" where *foo* would "stand for" a filename, such as `/bin/cp`.

`Typewriter` — Used to represent screen interaction.

Also used for code examples, whether it is "C" code, a shell script, or something else, and to display general files, such as configuration files. When necessary for clarity's sake, these examples or figures will be enclosed in thin boxes.

Key — Represents a key to press. You will often see it in this form: "Press return to continue."

◇ — A diamond in the margin, like a black diamond on a ski hill, marks "danger" or "caution." Read paragraphs marked this way carefully.

This X in the margin indicates special instructions for users of the X Window System.

This indicates a paragraph that contains special information that should be read carefully.

Acknowledgments

The author would like to thank the following people for their invaluable help either with LINUX itself, or in writing *The* LINUX *Users' Guide*:

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David Channon wrote the appendix on `vi`. (Appendix A)

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The `fortune` program for supplying me with many of the wonderful quotes that start each chapter. They cheer me up, if no one else.

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Chapter 1

Introduction

How much does it cost to entice a dope-smoking Unix system guru to Dayton?
Brian Boyle, *Unix World*'s First Annual Salary Survey

1.1 Who Should Read This Book

Are you someone who should read this book? Let's answer by asking some other questions: Have you just gotten Linux from somewhere, installed it, and want to know what to do next? Or are you a non-Unix computer user who is considering Linux but wants to find out what it can do for you?

If you have this book, the answer to these questions is probably "yes." Anyone who has Linux, the free Unix clone written by Linus Torvalds, on their PC but doesn't know what to do next should read this book. In this book, we'll cover most of the basic Unix commands, as well as some of the more advanced ones. We'll also talk about GNU Emacs, a powerful editor, and several other large Unix applications.

1.1.1 What You Should Have Done Before Reading This Book

This book assumes that you have access to a Unix system. (It's a bit hard to learn without getting wet!) This Unix system is assumed to be an Intel PC running Linux. This requirement isn't necessary, but when versions of Unix differ, I'll be talking about how Linux acts—nothing else.

Linux is available in many forms, called distributions. It is hoped that you've found a complete distribution such as the Slackware, Redhat, or the MCC-Interim versions and have installed it. There are differences between the various distributions of Linux, but for the most part they're small and unimportant. You may find differneces in the examples in this book. For the most part, these should be fairly minor differences and are nothing to worry about. If there is a severe difference between this book and your actual experience, please inform me, the author.

If you're the superuser (the maintainer, the installer) of the system, you also should have created a normal user account for yourself. Please consult the installation manual(s) for this information.

If you aren't the superuser, you should have obtained an account from the superuser.

You should have time and patience. Learning LINUX isn't easy—most people find learning the Macintosh Operating System is easier. Once you learn LINUX things get a lot easier. Unix is a very powerful system and it is very easy to do some complex tasks.

In addition, this book assumes that you are moderately familiar with some computer terms. Although this requirement isn't necessary, it makes reading the book easier. You should know about computer terms such as 'program' and 'execution'. If you don't, you might want to get someone's help with learning Unix.

1.2 How to Avoid Reading This Book

The best way to learn about almost any computer program is at your computer. Most people find that reading a book without using the program isn't beneficial. The best way to learn Unix and LINUX is by using them. Use LINUX for everything you can. Experiment. Don't be afraid—it's *possible* to mess things up, but you can always reinstall. Keep backups and have fun!

Unix isn't as intuitively obvious as some other operating systems. Thus, you will probably end up reading at least Chapters 4, 5, and 6.

The number one way to avoid using this book is to use the on-line documentation that's available. Learn how to use the `man` command—it's described in Section 4.2.

1.3 How to Read This Book

The suggested way of learning Unix is to read a little, then to play a little. Keep playing until you're comfortable with the concepts, and then start skipping around in the book. You'll find a variety of topics are covered, some of which you might find interesting and some of which you'll find boring. After a while, you should feel confident enough to start using commands without knowing exactly what they should do. This is a good thing.

What most people regard as Unix is the Unix shell, a special program that interprets commands. It is the program that controls the obvious "look and feel" of Unix. In practice, this is a fine way of looking at things, but you should be aware that Unix really consists of many more things, or much less. This book tells you about how to use the shell as well as some programs that Unix usually comes with and some programs Unix doesn't always come with (but LINUX usually does).

The current chapter is a meta-chapter—it discusses this book and how to apply this book to getting work done. The other chapters contain:

Chapter 2 discusses where Unix and LINUX came from, and where they might be going. It also talks about the Free Software Foundation and the GNU Project.

Chapter 3 talks about how to start and stop using your computer, and what happens at these times. Much of it deals with topics not needed for using LINUX, but still quite useful and interesting.

Chapter 4 introduces the Unix shell. This is where people actually do work, and run programs. It talks about the basic programs and commands you must know to use Unix.

Chapter 5 covers the X Window System. X is the primary graphical front-end to Unix, and some distributions set it up by default.

Chapter 6 covers some of the more advanced parts of the Unix shell. Learning techniques described in this chapter will help make you more efficent.

Chapter 7 has short descriptions of many different Unix commands. The more tools a user knows how to use, the quicker he will get his work done.

Chapter 8 describes the Emacs text editor. Emacs is a very large program that integrates many of Unix's tools into one interface.

Chapter 9 talks about ways of customizing the Unix system to your personal tastes.

Chapter 10 investigates the ways a Unix user can talk to other machines around the world, including electronic mail and the World Wide Web.

Chapter 11 describes some of the larger, harder to use commands.

Chapter 12 talks about easy ways to avoid errors in Unix and LINUX.

1.4 LINUX Documentation

This book, *The* LINUX *Users' Guide*, is intended for the Unix beginner. Luckily, the Linux Documentation Project is also writing books for the more experienced users.

1.4.1 Other LINUX Books

The other books include *Installation and Getting Started*, a guide on how to aquire and install LINUX, *The* LINUX *System Adminstrator's Guide*, how to organize and maintain a LINUX system, and *The* LINUX *Kernel Hackers' Guide*, a book about how to modify LINUX. *The* LINUX *Network Administration Guide* talks about how to install, configure, and use a network connection.

1.4.2 HOWTOs

In additon to the books, the Linux Documentation Project has made a series of short documents describing how to setup a particular aspect of LINUX. For instance, the `SCSI-HOWTO` describes some of the complications of using `SCSI`—a standard way of talking to devices—with LINUX.

These `HOWTO`s are available in several forms: in a bound book such as *The Linux Bible* or *Dr. Linux*; in the newsgroup `comp.os.linux.answers`; or on various sites on the World Wide Web. A central site for LINUX information is `http://www.linux.org`.

1.4.3 What's the Linux Documentation Project?

Like almost everything associated with LINUX, the Linux Documentation Project is a collection of people working across the globe. Originally organized by Lars Wirzenius, the Project is now coordinated by Matt Welsh with help from Michael K. Johnson.

It is hoped that the Linux Documentation Project will supply books that will meet all the needs of documenting LINUX at some point in time. Please tell us if we've suceeded or what we should improve on. You can contact the author at `leg+@andrew.cmu.edu` and/or Matt Welsh at `mdw@cs.cornell.edu`.

1.5 Operating Systems

An operating system's primary purpose is to support programs that actually do the work you're interested in. For instance, you may be using an editor so you can create a document. This editor could not do its work without help from the operating system—it needs this help for interacting with your terminal, your files, and the rest of the computer.

If all the operating system does is support your applications, why do you need a whole book just to talk about the operating system? There are lots of routine maintenance activities (apart from your major programs) that you also need to do. In the case of LINUX, the operating system also contains a lot of "mini-applications" to help you do your work more efficently. Knowing the operating system can be helpful when you're not working in one huge application.

Operating systems (frequently abbreviated as "OS") can be simple and minimalist, like DOS, or big and complex, like OS/2 or VMS. Unix tries to be a middle ground. While it supplies more resources and does more than early operating systems, it doesn't try to do *everything*. Unix was originally designed as a simplification of an operating system named Multics.

The original design philosophy for Unix was to distribute functionality into small parts, the programs.[1] That way, you can easily achieve new functionality and new features by combining the small parts (programs) in new ways. And if new utilities appear (and they do), you can integrate them into your old toolbox. When I write this document, for example, I'm using these programs actively; `fvwm` to manage my "windows", `emacs` to edit the text, LaTeX to format it, `xdvi` to preview it, `dvips` to prepare it for printing and then `lpr` to print it. If there was a different dvi previewer available, I could use that instead of `xdvi` without changing my other programs. At the current time, my system is running thirty eight programs simultaneously. (Most of these are system programs that "sleep" until they have some specific work to do.)

When you're using an operating system, you want to minimize the amount of work you put into getting your job done. Unix supplies many tools that can help you, but only if you know what these tools do. Spending an hour trying to get something to work and then finally giving up isn't very productive. This book will teach you what tools to use in what situations, and how to tie these

[1] This was actually determined by the hardware Unix original ran on. For some strange reason, the resulting operating system was very useful on other hardware. The basic design is good enough to still be used twenty five years later.

various tools together.

The key part of an operating system is called the **kernel**. In many operating systems, like Unix, OS/2, or VMS, the kernel supplies functions for running programs to use, and schedules them to be run. It basically says program A can get so much time, program B can get this much time, and so on. A kernel is always running: it is the first program to start when the system is turned on, and the last program to do anything when the system is halted.

Chapter 2

What's Unix, anyway?

> Ken Thompson has an automobile which he helped design. Unlike most automobiles, it has neither speedometer, nor gas gage, nor any of the numerous idiot lights which plague the modern driver. Rather, if the driver makes any mistake, a giant "?" lights up in the center of the dashboard. "The experienced driver," he says, "will usually know what's wrong."

2.1 Unix History

In 1965, Bell Telephone Laboratories (Bell Labs, a division of AT&T) was working with General Electric and Project MAC of MIT to write an operating system called Multics. To make a long story slightly shorter, Bell Labs decided the project wasn't going anywhere and broke out of the group. This left Bell Labs without a good operating system.

Ken Thompson and Dennis Ritchie decided to sketch out an operating system that would meet Bell Labs' needs. When Thompson needed a development environment (1970) to run on a PDP-7, he implemented their ideas. As a pun on Multics, Brian Kernighan, another Bell Labs researcher, gave the system the name Unix.

Later, Dennis Ritchie invented the "C" programming language. In 1973, Unix was rewritten in C instead of the original assembly language.[1] In 1977, Unix was moved to a new machine through a process called **porting** away from the PDP machines it had run on previously. This was aided by the fact Unix was written in C since much of the code could simply be recompiled and didn't have to be rewritten.

In the late 1970's, AT&T was forbidden from competing in the computing industry, so it licensed Unix to various colleges and universities very cheaply. It was slow to catch on outside of academic institutions but was eventually popular with businesses as well. The Unix of today is different from the Unix of 1970. It has two major variations: System V, from Unix System Laboratories

[1] "Assembly language" is a very basic computer language that is tied to a particular type of computer. It is usually considered a challenge to program in.

(USL), a subsiderary of Novell[2], and the Berkeley Software Distribution (BSD). The USL version is now up to its forth release, or SVR4[3], while BSD's latest version is 4.4. However, there are many different versions of Unix besides these two. Most commercial versions of Unix derive from one of the two groupings. The versions of Unix that are actually used usually incorporate features from both variations.

Current commercial versions of Unix for Intel PCs cost between $500 and $2000.

2.2 LINUX History

The primary author of LINUX is Linus Torvalds. Since his original versions, it has been improved by countless numbers of people around the world. It is a clone, written entirely from scratch, of the Unix operating system. Neither USL, nor the University of California, Berkeley, were involved in writing LINUX. One of the more interesting facts about LINUX is that development occurs simulataneously around the world. People from Austrialia to Finland contributed to LINUXand will hopefully continue to do so.

LINUX began with a project to explore the 386 chip. One of Linus's earlier projects was a program that would switch between printing `AAAA` and `BBBB`. This later evolved to LINUX.

LINUX has been copyrighted under the terms of the GNU General Public License (GPL). This is a license written by the Free Software Foundation (FSF) that is designed to prevent people from restricting the distribution of software. In brief, it says that although you can charge as much as you'd like for a copy, you can't prevent the person you sold it to from giving it away for free. It also means that the source code[4] must also be available. This is useful for programmers. Anybody can modify LINUX and even distributed his/her modifications, provided that they keep the code under the same copyright.

LINUX supports most of popular Unix software, including the X Window System. The X Window System was created at the Massachusetts Institute of Technology. It was written to allow Unix systems to create graphical windows and easily interact with each other. Today, the X Window System is used on every version of Unix available.

In addition to the two variations of Unix, System V and BSD, there is also a set of standardization documents published by the IEEE entitled **POSIX**. LINUX is first and foremost compliant with the POSIX-1 and POSIX-2 documents. Its look and feel is much like BSD in some places, and somewhat like System V in others. It is a blend (and to most people, a good one) of all three standards.

Many of the utilities included with LINUX distributions are from the Free Software Foundation and are part of GNU Project. The GNU Project is an effort to write a portable, advanced operating system that will look a lot like Unix. "Portable" means that it will run on a variety of machines, not just Intel PCs, Macintoshes, or whatever. The GNU Project's operating system is called the Hurd. The main difference between LINUX and GNU Hurd is not in the user interface but in the

[2] It was recently sold to Novell. Previously, USL was owned by AT&T.

[3] A cryptic way of saying "system five, release four".

[4] The **source code** of a program is what the programmer reads and writes. It is later translated into unreadable machine code that the computer interprets.

programmer's interface—the Hurd is a modern operating system while Linux borrows more from the original Unix design.

The above history of Linux is deficient in mentioning anybody *besides* Linux Torvalds. For instance, H. J. Lu has maintained `gcc` and the Linux C Library (two items needed for all the programs on Linux) since very early in Linux's life. You can find a list of people who deserve to be recognized on every Linux system in the file `/usr/src/linux/CREDITS`.

2.2.1 Linux Now

The first number in Linux's version number indicates truly huge revisions. These change very slowly and as of this writing (February, 1996) only version "1" is available. The second number indicates less major revisions. Even second numbers signify more stable, dependable versions of Linuxwhile odd numbers are developing versions that are more prone to bugs. The final version number is the minor release number—every time a new version is released that may just fix small problems or add minor features, that number is increased by one. As of February, 1996, the latest stable version is 1.2.11 and the latest development version is 1.3.61.

Linux is a large system and unfortunately contains bugs which are found and then fixed. Although some people still experience bugs regularly, it is normally because of non-standard or faulty hardware; bugs that effect everyone are now few and far between.

Of course, those are just the kernel bugs. Bugs can be present in almost every facet of the system, and inexperienced users have trouble seperating different programs from each other. For instance, a problem might arise that all the characters are some type of gibberish—is it a bug or a "feature"? Surprisingly, this is a feature—the gibberish is caused by certain control sequences that somehow appeared. Hopefully, this book will help you to tell the different situations apart.

2.2.2 A Few Questions and Answers

Before we embark on our long voyage, let's get the ultra-important out of the way.

Question: Just how do you pronounce Linux?

Answer: According to Linus, it should be pronounced with a short *ih* sound, like prInt, mInImal, etc. Linux should rhyme with Minix, another Unix clone. It should *not* be pronounced like (American pronounciation of) the "Peanuts" character, Linus, but rather *LIH-nucks*. And the *u* is sharp as in rule, not soft as in ducks. Linux should almost rhyme with "cynics".

Question: Why work on Linux?

Answer: Why not? Linux is generally cheaper (or at least no more expensive) than other operating systems and is frequently less problematic than many commercial systems. It might not be the best system for your particular applications, but for someone who is interested in using Unix applications available on Linux, it is a high-performance system.

2.2.3 Commercial Software in Linux

There is a lot of commercial software available for Linux. Starting with Motif, a user interface for the X Window System that vaguely resembles Microsoft Windows, Linux has been gaining more and more commercial software. These days you can buy anything from Word Perfect (a popular word processor) to Maple, a complex symbolic manipulation package, for Linux.

For any readers interested in the legalities of Linux, this is allowed by the Linux license. While the GNU General Public License (reproduced in Appendix B) covers the Linux kernel and would seemingly bar commercial software, the GNU Library General Public License (reproduced in Appendix C) covers most of the computer code applications depend on. This allows commercial software providers to sell their applications and withhold the source code.

Please note that those two documents are copyright notices, and not licenses to use. They do *not* regulate how you may use the software, merely under what circumstances you can copy it and any derivative works. To the Free Software Foundation, this is an important distinction: Linux doesn't involve any "shrink-wrap" licenses but is merely protected by the same law that keeps you from photocopying a book.

Chapter 3

Getting Started

This login session: $13.99, but for you $11.88.

You may have previous experience with MS-DOS or other single user operating systems, such as OS/2 or the Macintosh. In these operating systems, you didn't have to identify yourself to the computer before using it; it was assumed that you were the only user of the system and could access everything. Well, Unix is a multi-user operating system—not only can more than one person use it at a time, different people are treated differently.

To tell people apart, Unix needs a user to identify him or herself[1] by a process called **logging in**. When you first turn on the computer a complex process takes place before the computer is ready for someone to use it. Since this guide is geared towards LINUX, I'll tell you what happens during the LINUX boot-up sequence.

If you're using LINUX on some type of computer besides an Intel PC, some things in this chapter won't apply to you. Mostly, they'll be in Section 3.1.

If you're just interested in using your computer, you can skip all the information in the chapter except for Section 3.3.

3.1 Power to the Computer

The first thing that happens when you turn an Intel PC on is that the BIOS executes. BIOS stands for **B**asic **I**nput/**O**utput **S**ystem. It's a program permenantly stored in the computer on read-only chips. It performs some minimal tests, and then looks for a floppy disk in the first disk drive. If it finds one, it looks for a "boot sector" on that disk, and starts executing code from it, if any. If there is a disk, but no boot sector, the BIOS will print a message like:

```
Non-system disk or disk error
```

[1]From here on in this book, I shall be using the masculine pronouns to identify all people. This is the standard English convention, and people shouldn't take it as a statement that only men can use computers.

Figure 3.1 The path an Intel PC takes to get to a shell prompt. `init` may or may not start the X Window System. If it does, `xdm` runs. Otherwise, `getty` runs.

Removing the disk and pressing a key will cause the boot process to continue.

If there isn't a floppy disk in the drive, the BIOS looks for a master boot record (MBR) on the hard disk. It will start executing the code found there, which loads the operating system. On Linux systems, LILO, the **LI**nux **LO**ader, can occupy the MBR position, and will load Linux. For now, we'll assume that happens and that Linux starts to load. (Your particular distribution may handle booting from the hard disk differently. Check with the documentation included with the distribution. Another good reference is the LILO documentation, [1].)

3.2 Linux Takes Over

After the BIOS passes control to LILO, LILO passes control to the Linux **kernel**. A kernel is the central program of the operating system, in control of all other programs. The first thing that Linux does once it starts executing is to change to protected mode. The 80386[2] CPU that controls your computer has two modes called "real mode" and "protected mode". DOS runs in real mode, as does the BIOS. However, for more advanced operating systems, it is necessary to run in protected mode. Therefore, when Linux boots, it discardes the BIOS.

Other CPUs will get to this stage differently. No other CPU needs to switch into protected mode and few have to have such a heavy framework around the loading procedure as LILO and the BIOS. Once the kernel starts up, Linux works much the same.

Linux then looks at the type of hardware it's running on. It wants to know what type of hard disks you have, whether or not you have a bus mouse, whether or not you're on a network, and other bits of trivia like that. Linux can't remember things between boots, so it has to ask these questions each time it starts up. Luckily, it isn't asking *you* these questions—it is asking the hardware!

[2] When I refer to the 80386, I am also talking about the 80486, Pentium, and Pentium Pro computers unless I specifically say so. Also, I'll be abbreviating 80386 as 386.

During boot-up, the Linux kernel will print variations on several messages. You can read about the messages in Section 3.4. This query process can some cause problems with your system but if it was going to, it probably would have when you first installed Linux. If you're having problems, consult your distribution's documentation.

The kernel merely manages other programs, so once it is satisfied everything is okay, it must start another program to do anything useful. The program the kernel starts is called `init` . (Notice the difference in font. Things in `this font` are usually the names of programs, files, directories, or other computer related items.) After the kernel starts `init`, it never starts another program. The kernel becomes a manager and a provider, not an active program.

So to see what the computer is doing after the kernel boots up, we'll have to examine `init`. `init` goes through a complicated startup sequence that isn't the same for all computers. Linux has many different versions of `init`, and each does things its own way. It also matters whether your computer is on a network and what distribution you used to install Linux. Some things that might happen once `init` is started:

- The file systems might be checked. What is a file system? A file system is the layout of files on the hard disk. It let's Linux know which parts of the disk are already used, and which aren't. (It's like an index to a rather large filing system or a card catalog to a library.) Unfortunately, due to various factors such as power losses, what the file system information thinks is going on in the rest of the disk and the actually layout of the rest of the disk are occasionally in conflict. A special program, called `fsck`, can find these situations and hopefully correct them.

- Special routing programs for networks are run. These programs tell your computer how it's suppose to contact other computers.

- Temporary files left by some programs may be deleted.

- The system clock can be correctly updated. This is trickier then one might think, since Unix, by default, wants the time in UCT (Universal Coordinated Time, also known as Greenwich Mean Time) and your CMOS clock, a battery powered clock in your computer, is probably set on local time. This means that some program must read the time from your hardware clock and correct it to UCT.

After `init` is finished with its duties at boot-up, it goes on to its regularly scheduled activities. `init` can be called the parent of all processes on a Unix system. A process is simply a running program. Since one program can be running two or more times, there can be two or more processes for any particular program.

In Unix, a process, an instance of a program, is created by a system call—a service provided by the kernel—called fork. (It's called "fork" since one process splits off into two seperate ones.) `init` forks a couple of processes, which in turn fork some of their own. On your Linux system, what `init` runs are several instances of a program called `getty`. `getty` is the program that will allow a user to login and eventually calls a program called `login`.

3.3 The User Acts

3.3.1 Logging In

The first thing you have to do to use a Unix machine is to identify yourself. The **login** is Unix's way of knowing that users are authorized to use the system. It asks for an account name and password. An account name is normally similar to your regular name; you should have already received one from your system administrator, or created your own if you are the system administrator. (Information on doing this should be available in *Installation and Getting Started* or *The* Linux *System Adminstrator's Guide*.)

You should see, after all the boot-up procedures are done, something like the following (the first line is merely a greeting message—it might be a disclaimer or anything else):

```
Welcome to the mousehouse. Please, have some cheese.

mousehouse login:
```

However, it's possible that what the system presents you with does *not* look like this. Instead of a boring text mode screen, it is graphical. However, it will still ask you to login, and will function mostly the same way. If this is the case on your system, you are going to be using The X Window System. This means that you will be presented with a windowing system. Chapter 5 will discuss some of the differences that you'll be facing. Logging in will be similar as will the basics to much of Unix. If you are using X, look for a giant X is the margin.

This is, of course, your invitation to login. Throughout this manual, we'll be using the fictional (or not so fictional, depending on your machine) user `larry`. Whenever you see `larry`, you should be substituting your own account name. Account names are usually based on real names; bigger, more serious Unix systems will have accounts using the user's last name, or some combination of first and last name, or even some numbers. Possible accounts for Larry Greenfield might be: `larry`, `greenfie`, `lgreenfi`, `lg19`.

`mousehouse` is, by the way, the "name" of the machine I'm working on. It is possible that when you installed Linux, you were prompted for some very witty name. It isn't very important, but whenever it comes up, I'll be using `mousehouse` or, rarely, `lionsden` when I need to use a second system for clarity or contrast.

After entering `larry` and pressing $\boxed{\text{return}}$, I'm faced with the following:

```
mousehouse login: larry
Password:
```

What Linux is asking for is your **password**. When you type in your password, you won't be able to see what you type. Type carefully: it is possible to delete, but you won't be able to see what you are editing. Don't type too slowly if people are watching—they'll be able to learn your password. If you mistype, you'll be presented with another chance to login.

If you've typed your login name and password correctly, a short message will appear, called the message of the day. This could say anything—the system adminstrator decides what it should be. After that, a **prompt** appears. A prompt is just that, something prompting you for the next command to give the system. It should look something like this:

```
/home/larry#
```

If you've already determined you're using X, you'll probably see a prompt like the one above in a "window" somewhere on the screen. (A "window" is a rectangular box.) To type into the prompt, move the mouse cursor (it probably looks like a big "x" or an arrow) using the mouse into the window.

3.3.2 Leaving the Computer

Do not just turn off the computer! You risk losing valuable data!

Unlike most versions of DOS, it's a bad thing to just hit the power switch when you're done using the computer. It is also bad to reboot the machine (with the reset button) without first taking proper precautions. LINUX, in order to improve performance, has a **disk cache**. This means it temporarily stores part of the computer's permanent storage in RAM.[3] The idea of what LINUX thinks the disk should be and what the disk actually contains is syncronized every 30 seconds. In order to turn off or reboot the computer, you'll have to go through a procedure telling it to stop caching disk information.

If you're done with the computer, but are logged in (you've entered a username and password), first you must logout. To do so, enter the command `logout`. All commands are sent by pressing return. Until you hit return nothing will happen and you can delete what you've done and start over.

```
/home/larry# logout

Welcome to the mousehouse. Please, have some cheese.

mousehouse login:
```

Now another user can login.

3.3.3 Turning the Computer Off

If this is a single user system, you might want to turn the computer off when you're done with it.[4] To do so, you'll have to log into a special account called `root`. The `root` account is the system adminstrator's account and can access any file on the system. If you're going to turn the computer

[3]The difference between "RAM" and a hard disk is like the difference between short term memory and long term memory. Shutting off the power is like giving the computer a knock on the head—it'll forget everything in short term memory. But things saved in long term memory, the hard disk, will be okay. The disk is thousands of times slower than RAM.

[4]To avoid possibly weakening some hardware components, only turn off the computer when you're done for the day. Turning the computer on and off once a day is probably the best compromise between energy and wear & tear on the system.

off, get the password from the system adminstrator. (In a single user system, that's *you*! Make sure you know the `root` password.) Login as `root`:

```
mousehouse login: root
Password:
Linux version 1.3.55 (root@mousehouse) #1 Sun Jan 7 14:56:26 EST 1996
/# shutdown now
Why? end of the day

URGENT: message from the sysadmin:
System going down NOW

          ... end of the day ...

Now you can turn off the power...
```

The command `shutdown now` prepares the system to be reset or turned off. Wait for a message saying it is safe to and then reset or turn off the system. (When the system asks you "Why?", it is merely asking for a reason to tell other users. Since no one is using the system when you shut it down, you can tell it anything you want or nothing at all.)

A quick message to the lazy: an alternative to the logout/login approach is to use the command `su`. As a normal user, from your prompt, type `su` and press return. It should prompt you for the root password, and then give you root privileges. Now you can shutdown the system with the `shutdown now` command.

3.4 Kernel Messages

When you first start your computer, a series of messages flash across the screen describing the hardware that is attached to your computer. These messages are printed by the LINUX kernel. In this section, I'll attempt to describe and explain those messages.

Naturally, these messages differ from machine to machine. I'll describe the messages I get for my machine. The following example contains all of the standard messages and some specific ones. (In general, the machine I'm taking this from is a minimally configured one: you won't see a lot of device specific configuration.) This was made with Linux version 1.3.55—one of the most recent as of this writing.

1. The first thing LINUX does is decides what type of video card and screen you have, so it can pick a good font size. (The smaller the font, the more that can fit on the screen on any one time.) LINUX may ask you if you want a special font, or it might have had a choice compiled in.[5]

   ```
   Console: 16 point font, 400 scans
   Console: colour VGA+ 80x25, 1 virtual console (max 63)
   ```

[5] "Compiled" is the process by which a computer program that a human writes gets translated into something the computer understands. A feature that has been "compiled in" has been included in the program.

In this example, the machine owner decided he wanted the standard, large font at compile time. Also, note the misspelling of the word "color." Linus evidently learned the wrong version of English.

2. The next thing the kernel will report is how fast your system is, as measured by "BogoMIPS". A "MIP" stands for a million instructions per second, and a "BogoMIP" is a "bogus MIP": how many times the computer can do absolutely nothing in one second. (Since this loop doesn't actually do anything, the number is not actually a measure of how fast the system is.) LINUX uses this number when it needs to wait for a hardware device.

```
Calibrating delay loop.. ok - 33.28 BogoMIPS
```

3. The LINUX kernel also tells you a little about memory usage:

```
Memory: 23180k/24576k available (544k kernel code, 384k reserved, 468k data)
```

This said that the machine had 24 megabytes of memory. Some of this memory was reserved for the kernel. The rest of it can be used by programs. This is the temporary **RAM** that is used only for short term storage. Your computer also has a permanent memory called a **hard disk**. The hard disk's contents stay around even when power is turned off.

4. Throughout the bootup procedure, LINUX tests different parts of the hardware and prints messages about these tests.

```
This processor honours the WP bit even when in supervisor mode. Good.
```

5. Now LINUX moves onto the network configuration. The following should be described in *The* LINUX *Networking Guide*, and is beyond the scope of this document.

```
Swansea University Computer Society NET3.033 for Linux 1.3.50
IP Protocols: ICMP, UDP, TCP
```

6. LINUX supports a FPU, a floating point unit. This is a special chip (or part of a chip, in the case of a 80486DX CPU) that performs arithmetic dealing with non-whole numbers. Some of these chips are bad, and when LINUX tries to identify these chips, the machine "crashes". The machine stops functioning. If this happens, you'll see:

```
Checking 386/387 coupling...
```

Otherwise, you'll see:

```
Checking 386/387 coupling... Ok, fpu using exception 16 error reporting.
```

if you're using a 486DX. If you are using a 386 with a 387, you'll see:

```
Checking 386/387 coupling... Ok, fpu using irq13 error reporting.
```

7. It now runs another test on the "halt" instruction.

```
Checking 'hlt' instruction... Ok.
```

8. After that initial configuration, LINUX prints a line identifying itself. It says what version it is, what version of the GNU C Compiler compiled it, and when it was compiled.

```
Linux version 1.3.55 (root@mousehouse) (gcc version 2.7.0) #1 Sun Jan 7 14:56:26 EST 1996
```

9. The serial driver has started to ask questions about the hardware. A **driver** is a part of the kernel that controls a device, usually a peripheral. It is responsible for the details of how the CPU communicates with the device. This allows people who write user applications to concentrate on the application: they don't have to worry about exactly how the computer works.

   ```
   Serial driver version 4.11 with no serial options enabled
   tty00 at 0x03f8 (irq = 4) is a 16450
   tty01 at 0x02f8 (irq = 3) is a 16450
   tty02 at 0x03e8 (irq = 4) is a 16450
   ```

   Here, it found 3 serial ports. A serial port is the equivalent of a DOS `COM` port, and is a device normally used to communicate with modems and mice.

   What it is trying to say is that serial port 0 (`COM1`) has an address of `0x03f8`. When it interrupts the kernel, usually to say that it has data, it uses IRQ 4. An IRQ is another means of a peripheral talking to the software. Each serial port also has a controller chip. The usual one for a port to have is a 16450; other values possible are 8250 and 16550.

10. Next comes the parallel port driver. A parallel port is normally connected to a printer, and the names for the parallel ports (in Linux) start with `lp`. `lp` stands for **L**ine **P**rinter, although in modern times it makes more sense for it to stand for **L**aser **P**rinter. (However, Linux will happily communicate with any sort of parallel printer: dot matrix, ink jet, or laser.)

    ```
    lp0 at 0x03bc, (polling)
    ```

    That message says it has found one parallel port, and is using the standard driver for it.

11. Linux next identifies your hard disk drives. In the example system I'm showing you, `mousehouse`, I've installed two IDE hard disk drives.

    ```
    hda: WDC AC2340, 325MB w/127KB Cache, CHS=1010/12/55
    hdb: WDC AC2850F, 814MB w/64KB Cache, LBA, CHS=827/32/63
    ```

12. The kernel now moves onto looking at your floppy drives. In this example, the machine has two drives: drive "A" is a 5 1/4 inch drive, and drive "B" is a 3 1/2 inch drive. Linux calls drive "A" `fd0` and drive "B" `fd1`.

    ```
    Floppy drive(s): fd0 is 1.44M, fd1 is 1.2M
    floppy: FDC 0 is a National Semiconductor PC87306
    ```

13. The next driver to start on my example system is the SLIP driver. It prints out a message about its configuration.

    ```
    SLIP: version 0.8.3-NET3.019-NEWTTY (dynamic channels, max=256) (6 bit encapsulation enabled)
    CSLIP: code copyright 1989 Regents of the University of California
    ```

14. The kernel also scans the hard disks it found. It will look for the different partitions on each of them. A partition is a logical separation on a drive that is used to keep operating systems from interfering with each other. In this example, the computer had two hard disks (`hda`, `hdb`) with four partitions and one partition, respectively.

```
Partition check:
  hda: hda1 hda2 hda3 hda4
  hdb: hdb1
```

15. Finally, Linux **mounts** the root partition. The root partition is the disk partition where the Linux operating system resides. When Linux "mounts" this partition, it is making the partition available for use by the user.

```
VFS: Mounted root (ext2 filesystem) readonly.
```

Chapter 4

The Unix Shell

> Making files is easy under the UNIX operating system. Therefore, users tend to create numerous files using large amounts of file space. It has been said that the only standard thing about all UNIX systems is the message-of-the-day telling users to clean up their files.
>
> System V.2 administrator's guide

4.1 Unix Commands

When you first log into a Unix system, you are presented with something that looks like the following:

```
/home/larry#
```

That "something" is called a **prompt**. As its name would suggest, it is prompting you to enter a command. Every Unix command is a sequence of letters, numbers, and characters. There are no spaces, however. Some valid Unix commands are `mail`, `cat`, and `CMU_is_Number-5`. Some characters aren't allowed—we'll go into that later. Unix is also **case-sensitive**. This means that `cat` and `Cat` are different commands.[1]

The prompt is displayed by a special program called the **shell**. Shells accept commands, and run those commands. They can also be programmed in their own language, and programs written in that language are called "shell scripts".

There are two major types of shells in Unix: Bourne shells and C shells. Bourne shells are named after their inventor, Steven Bourne. Steven Bourne wrote the original Unix shell `sh`, and most shells since then end in the letters `sh` to indicate they are extentions on the original idea. There are many implementations of his shell, and all those specific shell programs are called Bourne shells. Another class of shells, C shells (originally implemented by Bill Joy), are also common. Traditionally, Bourne shells have been used for shell scripts and compatibility with the original `sh` while C shells have been

[1] Case sensitivity is a very personal thing. Some operating systems, such as OS/2 or Windows NT are case preserving, but not case sensitive. In practice, Unix rarely uses the different cases. It is unusual to have a situation where `cat` and `Cat` are different commands.

used for interactive use. (C shells have had the advantages of having better interactive features but somewhat harder programming features.)

Linux comes with a Bourne shell called `bash`, written by the Free Software Foundation. `bash` stands for **B**ourne **A**gain **Sh**ell, one of the many bad puns in Unix. It is an "advanced" Bourne shell: it contains the standard programming features found in all Bourne shells with many interactive features commonly found in C shells. `bash` is the default shell to use running Linux.

When you first login, the prompt is displayed by `bash`, and you are running your first Unix program, the `bash` shell. As long as you are logged in, the `bash` shell will constantly be running.

4.1.1 A Typical Unix Command

The first command to know is `cat`. To use it, type `cat`, and then return:

```
/home/larry# cat
```

If you now have a cursor on a line by itself, you've done the correct thing. There are several variances you could have typed—some would work, some wouldn't.

- If you misspelled `cat`, you would have seen

  ```
  /home/larry# ct
  ct: command not found
  /home/larry#
  ```

  Thus, the shell informs you that it couldn't find a program named "`ct`" and gives you another prompt to work with. Remember, Unix is case sensitive: `CAT` is a misspelling.

- You could have also placed whitespace before the command, like this:[2]

  ```
  /home/larry#␣␣␣␣␣cat
  ```

  This produces the correct result and runs the `cat` program.

- You might also press return on a line by itself. Go right ahead—it does absolutely nothing.

I assume you are now in `cat`. Hopefully, you're wondering what it is doing. No, it is not a game. `cat` is a useful utility that won't seem useful at first. Type anything and hit return. What you should have seen is:

```
/home/larry# cat
Help! I'm stuck in a Linux program!
Help!  I'm stuck in a Linux program!
```

[2]The '␣' indicates that the user typed a space.

(The *slanted* text indicates what I typed to `cat`.) What `cat` seems to do is echo the text right back at yourself. This is useful at times, but isn't right now. So let's get out of this program and move onto commands that have more obvious benefits.

To end many Unix commands, type Ctrl-d[3]. Ctrl-d is the end-of-file character, or EOF for short. Alternatively, it stands for end-of-text, depending on what book you read. I'll refer to it as an end-of-file. It is a control character that tells Unix programs that you (or another program) is done entering data. When `cat` sees you aren't typing anything else, it terminates.

For a similar idea, try the program `sort`. As its name indicates, it is a sorting program. If you type a couple of lines, then press Ctrl-d, it will output those lines in a sorted order. These types of programs are called **filters**, because they take in text, filter it, and output the text slightly differently. Both `cat` and `sort` are unusual filters. `cat` is unusual because it reads in text and performs *no* changes on it. `sort` is unusual because it reads in lines and doesn't output anything until after it's seen the EOF character. Many filters run on a line-by-line basis: they will read in a line, perform some computations, and output a different line.

4.2 Helping Yourself

The `man` command displays reference pages for the command[4] you specify. For example:

```
/home/larry# man cat

cat(1)                                                     cat(1)

NAME
  cat - Concatenates or displays files

SYNOPSIS
  cat [-benstuvAET] [--number] [--number-nonblank] [--squeeze-blank]
  [--show-nonprinting] [--show-ends] [--show-tabs] [--show-all]
  [--help] [--version] [file...]

DESCRIPTION
  This manual page documents the GNU version of cat ...
```

There's about one full page of information about `cat`. Try running `man` now. Don't expect to understand the manpage given. Manpages usually assume quite a bit of Unix knowledge—knowledge that you might not have yet. When you've read the page, there's probably a little black block at the bottom of your screen similar to "`--more--`" or "`Line 1`". This is the **more-prompt**, and you'll learn to love it.

[3] Hold down the key labeled "Ctrl" and press "d", then let go of both.

[4] `man` will also display information on a system call, a subroutine, a file format, and more. In the original version of Unix it showed the exact same information the printed documentation would. For now, you're probably only interested in getting help on commands.

Instead of just letting the text scroll away, `man` stops at the end of each page, waiting for you to decide what to do now. If you just want to go on, press Space and you'll advance a page. If you want to exit (quit) the manual page you are reading, just press q. You'll be back at the shell prompt, and it'll be waiting for you to enter a new command.

There's also a keyword function in `man`. For example, say you're interested in any commands that deal with Postscript, the printer control language from Adobe. Type `man -k ps` or `man -k Postscript`, you'll get a listing of all commands, system calls, and other documented parts of Unix that have the word "ps" (or "Postscript") in their name or short description. This can be very useful when you're looking for a tool to do something, but you don't know it's name—or if it even exists!

4.3 Storing Information

Filters are very useful once you are an experienced user, but they have one small problem. How do you store the information? Surely you aren't expected to type everything in each time you are going to use the program! Of course not. Unix provides **files** and **directories**.

A directory is like a folder: it contains pieces of paper, or files. A large folder can even hold other folders—directories can be inside directories. In Unix, the collection of directories and files is called the file system. Initially, the file system consists of one directory, called the "root" directory. Inside this directory, there are more directories, and inside those directories are files and yet more directories.[5]

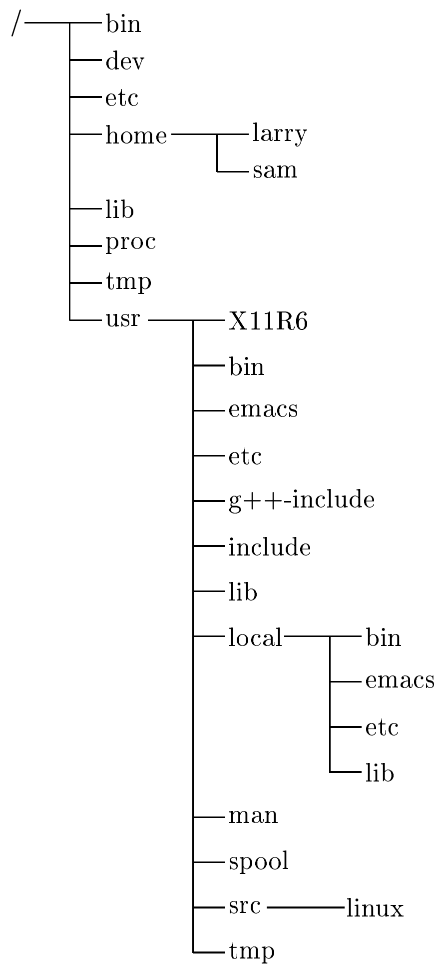
Each file and each directory has a name. It has both a short name, which can be the same as another file or directory somewhere else on the system, and a long name which is unique. A short name for a file could be `joe`, while it's "full name" would be `/home/larry/joe`. The full name is usually called the **path**. The path can be decode into a sequence of directories. For example, here is how `/home/larry/joe` is read:

`/home/larry/joe`
The initial slash indicates the root directory.
This signifies the directory called `home`. It is inside the root directory.
This is the directory `larry`, which is inside `home`.
`joe` is inside `larry`. A path could refer to either a directory or a filename,
so `joe` could be either. All the items *before* the short name must be directories.

An easy way of visualizing this is a tree diagram. To see a diagram of a typical Linux system, look at Figure 4.1. Please note that this diagram isn't complete—a full Linux system has over 8000 files!—and shows only some of the standard directories. Thus, there may be some directories in that diagram that aren't on your system, and your system almost certainly has directories not listed there.

[5] There may or may not be a limit to how "deep" the file system can go. (I've never reached it—one can easily have directories 10 levels deep.)

Figure 4.1 A typical (abridged) Unix directory tree.



4.3.1 Looking at Directories with `ls`

Now that you know that files and directories exist, there must be some way of manipulating them. Indeed there is. The command `ls` is one of the more important ones. It **lis**ts files. If you try `ls` as a command, you'll see:

```
/home/larry# ls
/home/larry#
```

That's right, you'll see nothing. Unix is intensionally terse: it gives you nothing, not even "no files" if there aren't any files. Thus, the lack of output was `ls`'s way of saying it didn't find any files.

But I just said there could be 8000 or more files lying around: where are they? You've run into the concept of a "current" directory. You can see in your prompt that your current directory is `/home/larry`, where you don't have any files. If you want a list of files of a more active directory, try the root directory:

```
/home/larry# ls /
bin      etc      install  mnt      root     user     var
dev      home     lib      proc     tmp      usr      vmlinux
/home/larry#
```

In the above command, "`ls /`", the directory ("/") is a **parameter**. The first word of the command is the command name, and anything after it is a parameter. Parameters generally modify what the program is acting on—for `ls`, the parameters say what directory you want a list for. Some commands have special parameters called options or switches. To see this try:

```
/home/larry# ls -F /
bin/     etc/     install/  mnt/     root/    user/    var@
dev/     home/    lib/      proc/    tmp/     usr/     vmlinux
/home/larry#
```

The `-F` is an **option**. An option is a special kind of parameter that starts with a dash and modifies how the program runs, but not what the program runs on. For `ls`, `-F` is an option that lets you see which ones are directories, which ones are special files, which are programs, and which are normal files. Anything with a slash is a directory. We'll talk more about `ls`'s features later. It's a surprisingly complex program!

Now, there are two lessons to be learned here. First, you should learn what `ls` does. Try a few other directories that are shown in Figure 4.1, and see what they contain. Naturally, some will be empty, and some will have many, many files in them. I suggest you try `ls` both with and without the `-F` option. For example, `ls /usr/local` looks like:

```
/home/larry# ls /usr/local
archives bin      emacs    etc      ka9q     lib      tcl
/home/larry#
```

The second lesson is more general. Many Unix commands are like `ls`. They have options, which are generally one character after a dash, and they have parameters. Unlike `ls`, some commands *require* certain parameters and/or options. To show what commands generally look like, we'll use the following form:

`ls` [-aRF] [*directory*]

I'll generally use command templates like that before I introduce any command from now on. The first word is the command (in this case `ls`). Following the command are all the parameters. Optional parameters are contained in brackets ("[" and "]"). Meta-variables are *slanted*—they're words that take the place of actual parameters. (For example, above you see *directory*, which should be replaced by the name of a real directory.)

Options are a special case. They're enclosed by brackets, but you can take any one of them without using all of them. For instance, with just the three options given for `ls` you have eight different ways of running the command: with or without each of the options. (Contrast `ls -R` with `ls -F`.)

4.3.2 The Current Directory and `cd`

`pwd`

Using directories would be cumbersome if you had to type the full path each time you wanted to access a directory. Instead, Unix shells have a feature called the "current" or "present" or "working" directory. Your setup most likely displays your directory in your prompt: `/home/larry`. If it doesn't, try the command `pwd`, for **p**resent **w**orking **d**irectory. (Sometimes the prompt will display the machine name. This is only really useful in a networked environment with lots of different machines.)

```
mousehouse>pwd
/home/larry
mousehouse>
```

`cd` [*directory*]

As you can see, `pwd` tells you your current directory[6]—a very simple command. Most commands act, by default, on the current directory. For instance, `ls` without any parameters displays the contents of the current directory. We can change our current directory using `cd`. For instance, try:

```
/home/larry# cd /home
/home# ls -F
larry/     sam/       shutdown/  steve/     user1/
/home#
```

If you omit the optional parameter *directory*, you're returned to your home, or original, directory. Otherwise, `cd` will change you to the specified directory. For instance:

```
/home# cd
/home/larry# cd /
/# cd home
/home# cd /usr
/usr# cd local/bin
/usr/local/bin#
```

As you can see, `cd` allows you to give either absolute or relative pathnames. An **absolute path** starts with `/` and specifies all the directories before the one you wanted. A **relative path** is in relation to your current directory. In the above example, when I was in `/usr`, I made a relative move to `local/bin`—`local` is a directory under `usr`, and `bin` is a directory under `local`! (`cd home` was also a relative directory change.)

[6]You'll see all the terms in this book: present working directory, current directory, or working directory. I prefer "current directory", although at times the other forms will be used for stylistic purposes.

There are two directories used *only* for relative pathnames: "`.`" and "`..`". . The directory "`.`" refers to the current directory and "`..`" is the parent directory. These are "shortcut" directories. They exist in *every* directory, but don't really fit the "folder in a folder" concept. Even the root directory has a parent directory—it's its own parent!

The file `./chapter-1` would be the file called `chapter-1` in the current directory. Occasionally, you need to put the "`./`" for some commands to work, although this is rare. In most cases, `./chapter-1` and `chapter-1` will be identical.

The directory "`..`" is most useful in "backing up":

```
/usr/local/bin# cd ..
/usr/local# ls -F
archives/  bin/       emacs@     etc/       ka9q/      lib/       tcl@
/usr/local# ls -F ../src
cweb/      linux/     xmris/
/usr/local#
```

In this example, I changed to the parent directory using `cd ..`, and I listed the directory `/usr/src` from `/usr/local` using `../src`. Note that if I was in `/home/larry`, typing `ls -F ../src` wouldn't do me any good!

The directory `~/` is an alias for your home directory:

```
/usr/local# ls -F ~/
/usr/local#
```

You can see at a glance that there isn't anything in your home directory! `~/` will become more useful as we learn more about how to manipulate files.

4.3.3 Creating and Removing Directories

`mkdir` *directory1* [*directory2* ... *directoryN*]

Creating your own directories is extremely simple under Unix, and can be a useful organizational tool. To create a new directory, use the command `mkdir`. Of course, `mkdir` stands for **mak**e **dir**ectory.

Let's do a small example to see how this works:

```
/home/larry# ls -F
/home/larry# mkdir report-1993
/home/larry# ls -F
report-1993/
/home/larry# cd report-1993
/home/larry/report-1993#
```

`mkdir` can take more than one parameter, interpreting each parameter as another directory to create. You can specify either the full pathname or a relative pathname; `report-1993` in the above example is a relative pathname.

```
/home/larry/report-1993# mkdir /home/larry/report-1993/chap1 ~/report-1993/chap2
/home/larry/report-1993# ls -F
chap1/  chap2/
/home/larry/report-1993#
```

`rmdir` *directory1* [*directory2* ... *directoryN*]

The opposite of `mkdir` is `rmdir` (**re**move **dir**ectory). `rmdir` works exactly like `mkdir`.

An example of `rmdir` is:

```
/home/larry/report-1993# rmdir chap1 chap3
rmdir: chap3: No such file or directory
/home/larry/report-1993# ls -F
chap2/
/home/larry/report-1993# cd ..
/home/larry# rmdir report-1993
rmdir: report-1993: Directory not empty
/home/larry#
```

As you can see, `rmdir` will refuse to remove a non-existant directory, as well as a directory that has anything in it. (Remember, `report-1993` has a subdirectory, `chap2`, in it!) There is one more interesting thing to think about `rmdir`: what happens if you try to remove your current directory? Let's find out:

```
/home/larry# cd report-1993
/home/larry/report-1993# ls -F
chap2/
/home/larry/report-1993# rmdir chap2
/home/larry/report-1993# rmdir .
rmdir: .: Operation not permitted
/home/larry/report-1993#
```

Another situation you might want to consider is what happens if you try to remove the parent of your current directory. This turns out not to be a problem since the parent of your current directory isn't empty, so it can't be removed!

4.4 Moving Information

All of these fancy directories are very nice, but they really don't help unless you have some place to store you data. The Unix Gods saw this problem, and they fixed it by giving the users **files**.

We will learn more about creating and editing files in the next few chapters.

The primary commands for manipulating files under Unix are `cp`, `mv`, and `rm`. They stand for **c**o**p**y, **m**o**v**e, and **rem**ove, respectively.

4.4.1 `cp` Like a Monk

`cp` [-i] *source destination*
`cp` [-i] *file1 file2 . . . fileN destination-directory*[7]

`cp` is a very useful utility under Unix, and extremely powerful. It enables one person to copy more information in a second than a fourteenth century monk could do in a year.

Be careful with `cp` if you don't have a lot of disk space. No one wants to see a "Disk full" message when working on important files. `cp` can also overwrite existing files without warning—I'll talk more about that danger later.

We'll first talk about the first line in the command template. The first parameter to `cp` is the file to copy—the second is where to copy it. You can copy to either a different filename, or a different directory. Let's try some examples:

```
/home/larry# ls -F /etc/passwd
/etc/passwd
/home/larry# cp /etc/passwd .
/home/larry# ls -F
passwd
/home/larry# cp passwd frog
/home/larry# ls -F
frog  passwd
/home/larry#
```

The first `cp` command I ran took the file `/etc/passwd`, which contains the names of all the users on the Unix system and their (encrypted) passwords, and copied it to my home directory. `cp` doesn't delete the source file, so I didn't do anything that could harm the system. So two copies of `/etc/passwd` exist on my system now, both named `passwd`, but one is in the directory `/etc` and one is in `/home/larry`.

Then I created a *third* copy of `/etc/passwd` when I typed `cp passwd frog`—the three copies are now: `/etc/passwd`, `/home/larry/passwd` and `/home/larry/frog`. The contents of these three files are the same, even if the names aren't.

`cp` can copy files between directories if the first parameter is a file and the second parameter is a directory. In this case, the short name of the file stays the same.

[7] `cp` has two lines in its template because the meaning of the second parameter can be different depending on the number of parameters.

It can copy a file and change it's name if both parameters are file names. Here is one danger of `cp`. If I typed `cp /etc/passwd /etc/group`, `cp` would normally create a new file with the contents identical to `passwd` and name it `group`. However, if `/etc/group` already existed, `cp` would destroy the old file without giving you a chance to save it! (It won't even print out a message reminding you that you're destroying a file by copying over it.)

Let's look at another example of `cp`:

```
/home/larry# ls -F
frog  passwd
/home/larry# mkdir passwd_version
/home/larry# cp frog passwd passwd_version
/home/larry# ls -F
frog         passwd        passwd_version/
/home/larry# ls -F passwd_version
frog  passwd
/home/larry#
```

How did I just use `cp`? Evidentally, `cp` can take *more* than two parameters. (This is the second line in the command template.) What the above command did is copied all the files listed (`frog` and `passwd`) and placed them in the `passwd_version` directory. In fact, `cp` can take any number of parameters, and interprets the first $n-1$ parameters to be files to copy, and the n^{th} parameter as what directory to copy them too.

You cannot rename files when you copy more than one at a time—they always keep their short name. This leads to an interesting question. What if I type `cp frog passwd toad`, where `frog` and `passwd` exist and `toad` isn't a directory? Try it and see.

4.4.2 Pruning Back with rm

`rm` [-i] *file1 file2 . . . fileN*

Now that we've learned how to create millions of files with `cp` (and believe me, you'll find new ways to create more files soon), it may be useful to learn how to delete them. Actually, it's very simple: the command you're looking for is `rm`, and it works just like you'd expect: any file that's a parameter to `rm` gets deleted.

For example:

```
/home/larry# ls -F
frog         passwd        passwd_version/
/home/larry# rm frog toad passwd
rm: toad: No such file or directory
/home/larry# ls -F
passwd_version/
/home/larry#
```

As you can see, `rm` is extremely unfriendly. Not only does it not ask you for confirmation, but it will also delete things even if the whole command line wasn't correct. This could actually be dangerous. Consider the difference between these two commands:

```
/home/larry# ls -F
toad  frog/
/home/larry# ls -F frog
toad
/home/larry# rm frog/toad
/home/larry#
```

and this

```
/home/larry# rm frog toad
rm: frog is a directory
/home/larry# ls -F
frog/
/home/larry#
```

As you can see, the difference of *one* character made a world of difference in the outcome of the command. It is vital that you check your command lines before hitting return!

4.4.3 A Forklift Can Be Very Handy

`mv` [-i] *old-name new-name*
`mv` [-i] *file1 file2 ... fileN new-directory*

Finally, the other file command you should be aware of is `mv`. `mv` looks a lot like `cp`, except that it deletes the original file after copying it. It's a lot like using `cp` and `rm` together. Let's take a look at what we can do:

```
/home/larry# cp /etc/passwd .
/home/larry# ls -F
passwd
/home/larry# mv passwd frog
/home/larry# ls -F
frog
/home/larry# mkdir report
/home/larry# mv frog report
/home/larry# ls -F
report/
/home/larry# ls -F report
frog
/home/larry#
```

As you can see, `mv` will rename a file if the second parameter is a file. If the second parameter is a directory, `mv` will move the file to the new directory, keeping it's shortname the same.

You should be very careful with `mv`—it doesn't check to see if the file already exists, and will remove any old file in its way. For instance, if I had a file named `frog` already in my directory `report`, the command `mv frog report` would delete the file `~/report/frog` and replace it with `~/frog`.

In fact, there is one way to make `rm`, `cp` and `mv` ask you before deleting files. All three of these commands accept the `-i` option, which makes them query the user before removing any file. If you use an **alias**, you can make the shell do `rm -i` automatically when you type `rm`. You'll learn more about this later in Section 9.1.3 on page 90.

Chapter 5

The X Window System

The nice thing about standards is that there are so many of them to choose from.
Andrew S. Tanenbaum

This chapter only applies to those using the X Window System. If you encounter a screen with multiply windows, colors, or a cursor that is only movable with your mouse, you are using X. (If your screen consists of white characters on a black background, you are not currently using X. If you want to start it up, take a look at Section 5.1.)

5.1 Starting and Stopping the X Window System

5.1.1 Starting X

Even if X doesn't start automatically when you login, it is possible to start it from the regular text-mode shell prompt. There are two possible commands that will start X, either `startx` or `xinit`. Try `startx` first. If the shell complains that no such command is found, try using `xinit` and see if X starts. If neither command works, you may not have X installed on your system—consult local documentation for your distribution.

If the command runs but you are eventually returned to the black screen with the shell prompt, X is installed but not configured. Consult the documentation that came with your distribution on how to setup X.

5.1.2 Exiting X

Depending on how X is configured, there are two possible ways you might have to exit X. The first is if your window manager controls whether or not X is running. If it does, you'll have to exit X using a menu (see Section 5.4.8 on page 43). To display a menu, click a button on the background.

The important menu entry should be "Exit Window Manager" or "Exit X" or some entry containing the word "Exit". Try to find that entry (there could be more than one menu—try different mouse buttons!) and choose it.

The other method would be for a special `xterm` to control X. If this is the case, there is probably a window labeled "login" or "system xterm". To exit from X, move the mouse cursor into that window and type "exit".

If X was automatically started when you logged in, one of these methods should log you out. Simply login again to return. If you started X manually, these methods should return you to the text mode prompt. (If you wish to logout, type `logout` at this prompt.)

5.2 What is The X Window System?

The X Window System is a distributed, graphical method of working developed primarily at the Massachusetts Institute of Technology. It has since been passed to a consortium of vendors (aptly named "The X Consortium") and is being maintained by them.

The X Window System (hereafter abbreviated as "X"[1]) has new versions every few years, called releases. As of this writing, the latest revision is X11R6, or release six. The eleven in X11 is officially the version number but there hasn't been a new version in many years, and one is not currently planned.

There are two terms when dealing with X that you should be familiar. The **client** is a X program. For instance, `xterm` is the client that displays your shell when you log on. The **server** is a program that provides services to the client program. For instance, the server draws the window for `xterm` and communicates with the user.

Since the client and the server are two separate programs, it is possible to run the client and the server *on two physically separate machines*. In addition to supplying a standard method of doing graphics, you can run a program on a remote machine (across the country, if you like!) and have it display on the workstation right in front of you.

A third term you should be familiar with is the **window manager**. The window manager is a special client that tells the server where to position various windows and provides a way for the user to move these windows around. The server, by itself, does nothing for the user. It is merely there to provide a buffer between the user and the client.

5.3 What's This on my Screen?

When you first start X, several programs are started. First, the server is started. Then, several clients are usually started. Unfortunately, this is not standardized across various distributions. It is likely that among these clients are a window manager, either `fvwm` or `twm`, a prompt, `xterm`, and a clock, `xclock`.

[1]There are several acceptable ways to refer to The X Window System. A common though incorrect way of referring to X is "X Windows".

Figure 5.1 An annotated example of a standard X screen. In this example, the user is running `twm`. The standard clock has been replaced by a transparent clock called `oclock`.

5.3.1 XClock

`xclock` [-digital] [-analog] [-update *seconds*] [-hands *color*]

I'll explain the simpliest one first: `xclock` functions exactly as you'd expect it would. It ticks off the seconds, minutes and hours in a small window.

No amounts of clicking or typing in `xclock`'s window will affect it—that's *all* it does. Or is it? In fact, there are various different options you can give to the program to have it act in different ways. For instance, `xclock -digital` will create a digital clock. `xclock -update 1` will create a second hand that moves every second, while `-update 5` will create a second hand that moves every 5 seconds.

For more information on `xclock`'s options, consult its manpage—`man xclock`. If you're going to try running a few of your own `xclock`s, you should probably read Section 6.4 (Multitasking) to learn how to run them in addition to your current programs. (If you run an `xclock` in the foreground—the usual way of running a program—and want to get out of it, type ctrl-c.)

5.3.2 XTerm

The window with a prompt in it (something that probably looks like `/home/larry#`) is being controlled by a program called `xterm`. `xterm` is a deceptively complicated program. At first glance, it doesn't seem to do much, but it actually has to do a lot of work. `xterm` emulates a terminal so that regular text-mode Unix applications work correctly. It also maintains a buffer of information so that you can refer back to old commands. (To see how to use this, look at Section 5.6.3.)

For much of this book, we're going to be learning about the Unix command-line, and you'll find that inside your `xterm` window. In order to type into `xterm`, you *usually* have to move your mouse cursor (possibly shaped like an "X" or an arrow) into the `xterm` window. However, this behavior is dependent on the window manager.

One way of starting more programs under X is through an `xterm`. Since X programs are standard Unix programs, they can be run from normal command prompts such as `xterm`s. Since running a long term program from a `xterm` would tie up the `xterm` as long as the program was running, people normally start X programs in the background. For more information about this, see Section 6.4.

5.4 Window Managers

On LINUX, there are two different window managers that are commonly used. One of them, called `twm` is short for "Tab Window Manager". It is larger than the other window manager usually used, `fvwm`. (`fvwm` stands for "F(?) Virtual Window Manager"—the author neglected to tie down exactly what the f stood for.) Both `twm` and `fvwm` are highly configurable, which means I can't tell you exactly what keys do what in your particular setup.

To learn about `twm`'s configuration, look at Section 9.2.1. `fvwm`'s configuration is covered in Section 9.2.2.

5.4.1 When New Windows are Created

There are three possible things a window manager will do when a new window is created. It is possible to configure a window manager so that an outline of the new window is shown, and you are allowed to position it on your screen. That is called **manual placement**. If you are presented with the outline of a window, simply use the mouse to place it where you wish it to appear and click the left mouse button.

It is also possible that the window manager will place the new window somewhere on the screen by itself. This is known as **random placement**.

Finally, sometimes an application will ask for a specific spot on the screen, or the window manager will be configured to display certain applications on the same place of the screen all the time. (For instance, I specify that I want `xclock` to always appear in the upper right hand corner of the screen.)

5.4.2 Focus

The window manager controls some important things. The first thing you'll be interested in is **focus**. The focus of the server is which window will get what you type into the keyboard. Usually in X the focus is determined by the position of the mouse cursor. If the mouse cursor is in one `xterm`'s window[2], that `xterm` will get your keypresses. This is different from many other windowing systems, such as Microsoft Windows, OS/2, or the Macintosh, where you must click the mouse in a window before that window gets focus. Usually under X, if your mouse cursor wanders from a window, focus will be lost and you'll no longer be able to type there.

Note, however, that it is possible to configure both `twm` and `fvwm` so that you must click on or in a window to gain focus, and click somewhere else to lose it, identical to the behavior of Microsoft Windows. Either discover how your window manager is configured by trial and error, or consult local documentation.

5.4.3 Moving Windows

Another very configurable thing in X is how to move windows around. In my personal configuration of `twm`, there are three different ways of moving windows around. The most obvious method is to move the mouse cursor onto the **title bar** and drag the window around the screen. Unfortunately, this may be done with any of the left, right, or middle buttons[3]. (To drag, move the cursor above the title bar, and hold down on the button while moving the mouse.) Most likely, your configuration is set to move windows using the *left* mouse buttons.

Another way of moving windows may be holding down a key while dragging the mouse. For instance, in *my* configuration, if I hold down the Alt key, move the cursor above a window, I can drag the window around using the left mouse button.

Again, you may be able to understand how the window manager is configured by trial and error, or by seeing local documentation. Alternatively, if you want to try to interpret the window manager's configuration file, see Section 9.2.1 for `twm` or Section 9.2.2 for `fvwm`.

5.4.4 Depth

Since windows are allowed to overlap in X, there is a concept of **depth**. Even though the windows and the screen are both two dimensional, one window can be in front of another, partially or completely obscuring the rear window.

There are several operations that deal with depth:

[2] You can have more then one copy of `xterm` running at the same time!

[3] Many PCs have only two button mice. If this is the case for you, you should be able to emulate a middle button by using the left and right buttons simultaneously.

- **Raising** the window, or bringing a window to the front. This is usually accomplished by clicking on a window's title bar with one of the buttons. Depending on how the window manager is configured, it could be any one of the buttons. (It is also possible that more then one button will do the job.)

- **Lowering** the window, or pushing the window to the back. This can generally be accomplished by a different click in the title bar. It is also possible to configure some window managers so that one click will bring the window foward if there is anything over it, while that same click will lower it when it is in the front.

- **Cycling** through windows is another operation many window managers allow. This brings each window to the front in an orderly cycle.

5.4.5 Iconization

There are several other operations that can obscure windows or hide them completely. First is the idea of "iconization". Depending on the window manager, this can be done in many different ways. In `twm`, many people configure an **icon manager**. This is a special window that contains a list of all the other windows on the screen. If you click on a name (depending on the setup, it could be with any of the buttons!) the window disappears—it is iconified. The window is still active, but you can't see it. Another click in the icon manager restores the window to the screen.

This is quite useful. For instance, you could have remote `xterm`s to many different computers that you occasionally use. However, since you rarely use all of them at a given time, you can keep most of the `xterm` windows iconified while you work with a small subset. The only problem with this is it becomes easy to "lose" windows. This causes you to create new windows that duplicate the functionality of iconified windows.

Other window managers might create actual icons across the bottom of the screen, or might just leave icons on the root window.

5.4.6 Resizing

There are several different methods to resize windows under X. Again, it is dependent on your window manager and exactly how your window manager is configured. The method many Microsoft Windows users are familiar with is to click on and drag the border of a window. If your window manager creates large borders that change how the mouse cursor looks when it is moved over them, that is probably the method used to resize windows.

Another method used is to create a "resizing" button on the titlebar. In Figure 5.3, a small button is visible on the right of each titlebar. To resize windows, the mouse is moved onto the resize button and the left mouse button is held down. You can then move the mouse outside the borders of the window to resize it. The button is released when the desired size has been reached.

5.4.7 Maximization

Most window managers support maximization. In `twm`, for instance, you can maximize the height, the width, or both dimensions of a window. This is called "zooming" in `twm`'s language although I prefer the term maximization. Different applications respond differently to changes in their window size. (For instance, `xterm` won't make the font bigger but will give you a larger workspace.)

Unfortunately, it is extremely non-standard on how to maximize windows.

5.4.8 Menus

Another purpose for window managers is for them to provide menus for the user to quickly accomplish tasks that are done over and over. For instance, I might make a menu choice that automatically launches Emacs or an additional `xterm` for me. That way I don't need to type in an `xterm`—an especially good thing if there aren't any running `xterms` that I need to type in to start a new program!

In general, different menus can be accessed by clicking on the root window, which is an immovable window behind all the other ones. By default, it is colored gray, but could look like anything.[4] To try to see a menu, click and hold down a button on the desktop. A menu should pop up. To make a selection, move (without releasing the mouse button) the cursor over one of the items any then release the mouse button.

5.5 X Attributes

There are many programs that take advantage of X. Some programs, like `emacs`, can be run either as a text-mode program *or* as a program that creates its own X window. However, most X programs can only be run under X.

5.5.1 Geometry

There are a few things common to all programs running under X. In X, the concept of **geometry** is where and how large a window is. A window's geometry has four components:

- The horizontal size, usually measured in pixels. (A pixel is the smallest unit that can be colored. Many X setups on Intel PCs have 1024 pixels horizontally and 768 pixels vertically.) Some applications, like `xterm` and `emacs`, measure their size in terms of number of characters they can fit in the window. (For instance, eighty characters across.)

- The vertical size, also usually measured in pixels. It's possible for it to be measured in characters.

[4] One fun program to try is called `xfishtank`. It places a small aquarium in the background for you.

- The horizontal distance from one of the sides of the screen. For instance, +35 would mean make the left edge of the window thirty-five pixels from the left edge of the screen. On the other hand, -50 would mean make the right edge of the window fifty pixels from the right edge of the screen. It's generally impossible to start the window off the screen, although a window can be moved off the screen. (The main exception is when the window is very large.)
- The vertical distance from either the top or the bottom. A positive vertical distance is measured from the top of the screen; a negative vertical distance is measured from the bottom of the screen.

All four components get put together into a geometry string that looks like: `503x73-78+0`. (That translates into a window 503 pixels long, 73 pixels high, put near the top right hand corner of the screen.) Another way of stating it is *hsize*x*vsize*±*hplace*±*vplace*.

5.5.2 Display

Every X application has a display that it is associated with. The display is the name of the screen that the X server controls. A display consists of three components:

- The machine name that the server is running on. At stand-alone LINUX installations the server is always running on the same system as the clients. In such cases, the machine name can be omitted.
- The number of the server running on that machine. Since any one machine could have multiple X servers running on it (unlikely for most LINUX machines, but possible) each must have a unique number.
- The screen number. X supports a particular server controlling more than one screen at a time. You can imagine that someone wants a lot of screen space, so they have two monitors sitting next to each other. Since they don't want two X servers running on one machine for performance reasons, they let one X server control both screens.

These three things are put together like so: *machine*:*server-number*.*screen-number*.

For instance, on `mousehouse`, all my applications have the display set to `:0.0`, which means the first screen of the first server on the local display. However, if I am using a remote computer, the display might be set to `mousehouse:0.0`.

By default, the display is taken from the environment variable (see Section 9.1.4) named `DISPLAY`, and can be overridden with a command-line option (see Figure 5.2). To see how `DISPLAY` is set, try the command `echo $DISPLAY`.

5.6 Common Features

While X is a graphical user interface, it is a very uneven graphical user interface. It's impossible to say how any component of the system is going to work, because every component can easily be

Figure 5.2 Standard options for X programs.

Name	Followed by	Example
`-geometry`	geometry of the window	`xterm -geometry 80x24+0+90`
`-display`	display you want the program to appear	`xterm -display lionsden:0.0`
`-fg`	the primary foreground color	`xterm -fg yellow`
`-bg`	the primary background color	`xterm -bg blue`

reconfigured, changed, and even replaced. This means it's hard to say exactly how to use various parts of the interface. We've already encountered one cause of this: the different window managers and how configurable each window manager is.

Another cause of this uneven interface is the fact that X applications are built using things called "widget sets". Included with the standard X distribution are "Athena widgets" developed at MIT. These are commonly used in free applications. They have the disadvantage that they are not particularly good-looking and are somewhat harder to use than other widgets.

The other popular widget set is called "Motif". Motif is a commercial widget set similar to the user interface used in Microsoft Windows. Many commercial applications use Motif widgets, as well as some free applications. The popular World Wide Web Browser `netscape` uses Motif.

Let's try to go through some of the more usually things you'll encounter.

5.6.1 Buttons

Buttons are generally the easiest thing to use. A button is invoked by positioning the mouse cursor over it and clicking (pressing and immediately releasing the mouse button) the left button. Athena and Motif buttons are functionally the same although they have cosmetic differences.

5.6.2 Menu Bars

A menu bar is a collection of commands accessible using the mouse. For instance, `emacs`'s menu bar is shown in Figure 5.3. Each word is a category heading of commands. File deals with commands that bring up new files and save files. By convention, this is also the category that contains the command to exit the program.

To access a command, move the mouse cursor over a particular category (such as File) and press and hold down the left mouse button. This will display a variety of commands. To select one of the commands, move the mouse cursor over that command and release the left mouse button. Some menu bars let you click on a category—if this is the case, clicking on the category will display the menu until you click on either a command, another menu, or outside the menu bar (indicating that you are not interested in running a particular command).

Figure 5.3 `emacs` will change its menu bar depending on the type of file you're working on. Here is one possible menu bar.

Figure 5.4 An Athena-type scroll bar is visible on the left of this `xterm` window. Next to it, a Motif-type scroll bar is visible on the `netscape` window.

5.6.3 Scroll Bars

A **scroll bar** is a method to allow people to display only part of a document, while the rest is off the screen. For instance, the `xterm` window is currently displaying the bottom third of the text available in Figure 5.4. It's easy to see what part of the available text is current being displayed: the darkened part of the scroll bar is relative to both the position and the amount of displayed text. If the text displayed is all there is, the entire scroll bar is dark. If the middle half of the text is displayed, the middle half of the scroll bar is darkened.

A vertical scroll bar may be to the left or right of the text and a horizontal one may be above or below, depending the application.

Athena scroll bars

Athena scroll bars operate differently from scroll bars in other windowing systems. Each of the three buttons of the mouse operate differently. To scroll upwards (that is, display material above what is currently visible) you can click the rightmost mouse button anywhere in the scroll bar. To scroll downwards, click the left mouse button anywhere in the scroll bar.

You can also jump to a particular location in the displayed material by clicking the middle mouse button anywhere in the scroll bar. This causes the window to display material starting at that point in the document.

Motif scroll bars

A Motif scroll bar acts much more like a Microsoft Windows or Macintosh scroll bar. An example of one is on the right in Figure 5.4. Notice that in addition to the bar, it has arrows above and below it. These are used for fine-tuning: clicking either the left or middle buttons on them will scroll a small amount such as one line; the right button does nothing.

The behavior of clicking inside the scroll bar is widely different for Motif scroll bars than Athena scroll bars. The right button has no effect. Clicking the left button above the current position scrolls upward. Similarly, clicking below the current position scrolls downward. Clicking and holding the left button *on* the current position allows one to move the bar at will. Releasing the left button positions the window.

Clicking the middle button anywhere on the bar will immediately jump to that location, similar to the behavior of the Athena middle button. However, instead of starting to display the data at the position clicked, that position is taken to be the *midpoint* of the data to be displayed.

Chapter 6

Working with Unix

A UNIX saleslady, Lenore,
Enjoys work, but she likes the beach more.
    She found a good way
    To combine work and play:
She sells C shells by the seashore.

Unix is a powerful system for those who know how to harness its power. In this chapter, I'll try to describe various ways to use Unix's shell, `bash`, more efficently.

6.1 Wildcards

In the previous chapter, you learned about the file maintence commands `cp`, `mv`, and `rm`. Occasionally, you want to deal with more than one file at once—in fact, you might want to deal with many files at once. For instance, you might want to copy all the files beginning with `data` into a directory called `~/backup`. You could do this by either running many `cp` commands, or you could list every file on one command line. Both of these methods would take a long time, however, and you have a large chance of making an error.

A better way of doing that task is to type:

```
/home/larry/report# ls -F
1993-1          1994-1          data1           data5
1993-2          data-new        data2
/home/larry/report# mkdir ~/backup
/home/larry/report# cp data* ~/backup
/home/larry/report# ls -F ~/backup
data-new        data1           data2           data5
/home/larry/report#
```

As you can see, the asterix told `cp` to take all of the files beginning with `data` and copy them to `~/backup`. Can you guess what `cp d*w ~/backup` would have done?

6.1.1 What *Really* Happens?

Good question. Actually, there are a couple of special characters intercepted by the shell, `bash`. The character "`*`", an asterix, says "replace this word with all the files that will fit this specification". So, the command `cp data* ~/backup`, like the one above, gets changed to `cp data-new data1 data2 data5 ~/backup` before it gets run.

To illustrate this, let me introduce a new command, `echo`. `echo` is an extremely simple command; it echoes back, or prints out, any parameters. Thus:

```
/home/larry# echo Hello!
Hello!
/home/larry# echo How are you?
How are you?
/home/larry# cd report
/home/larry/report# ls -F
1993-1          1994-1          data1           data5
1993-2          data-new        data2
/home/larry/report# echo 199*
1993-1 1993-2 1994-1
/home/larry/report# echo *4*
1994-1
/home/larry/report# echo *2*
1993-2 data2
/home/larry/report#
```

As you can see, the shell expands the wildcard and passes all of the files to the program you tell it to run. This raises an interesting question: what happens if there are *no* files that meet the wildcard specification? Try `echo /rc/fr*og` and `bash` passes the wildcard specification verbatim to the program.

Other shells, like `tcsh`, will, instead of just passing the wildcard verbatim, will reply `No match.` Here's the same command run under `tcsh`:

```
mousehouse>echo /rc/fr*og
echo: No match.
mousehouse>
```

The last question you might want to know is what if I wanted to have `data*` echoed back at me, instead of the list of file names? Well, under both `bash` and `tcsh`, just include the string in quotes:

```
/home/larry/report# echo "data*"            mousehouse>echo "data*"
data*                               OR      data*
/home/larry/report#                         mousehouse>
```

6.1.2 The Question Mark

In addition to the asterix, the shell also interprets a question mark as a special character. A question mark will match one, and only one character. For instance, `ls /etc/??` will display all two letter files in the the `/etc` directory.

6.2 Time Saving with `bash`

6.2.1 Command-Line Editing

Occasionally, you've typed a long command to `bash` and, before you hit return, notice that there was a spelling mistake early in the line. You could just delete all the way back and retype everything you need to, but that takes much too much effort! Instead, you can use the arrow keys to move back there, delete the bad character or two, and type the correct information.

There are many special keys to help you edit your command line, most of them similar to the commands used in GNU Emacs. For instance, C-t flips two adjacent characters.[1] You'll be able to find most of the commands in the chapter on Emacs, Chapter 8.

6.2.2 Command and File Completion

Another feature of `bash` is automatic completion of your command lines. For instance, let's look at the following example of a typical `cp` command:

```
/home/larry# ls -F
this-is-a-long-file
/home/larry# cp this-is-a-long-file shorter
/home/larry# ls -F
shorter              this-is-a-long-file
/home/larry#
```

It's a big pain to have to type every letter of `this-is-a-long-file` whenever you try to access it. So, create `this-is-a-long-file` by copying `/etc/passwd` to it[2]. Now, we're going to do the above `cp` command very quickly and with a smaller chance of mistyping.

Instead of typing the whole filename, type `cp th` and press and release the Tab. Like magic, the rest of the filename shows up on the command line, and you can type in `shorter`. Unfortunately, `bash` cannot read your thoughts, and you'll have to type all of `shorter`.

When you type Tab, `bash` looks at what you've typed and looks for a file that starts like that. For instance, if I type `/usr/bin/ema` and then hit Tab, `bash` will find `/usr/bin/emacs` since that's the only file that begins `/usr/bin/ema` on my system. However, if I type `/usr/bin/ld` and hit Tab, `bash` beeps at me. That's because three files, `/usr/bin/ld`, `/usr/bin/ldd`, and `/usr/bin/ld86` all start with `/usr/bin/ld` on my system.

If you try a completion and `bash` beeps, you can immediately hit Tab again to get a list of all the files your start matches so far. That way, if you aren't sure of the exact spelling of your file, you can start it and scan a much smaller list of files.

---

[1] C-t means hold down the key labeled "Ctrl", then press the "t" key. Then release the "Ctrl" key.
[2] `cp /etc/passwd this-is-a-long-file`

6.3 The Standard Input and The Standard Output

Let's try to tackle a simple problem: getting a listing of the `/usr/bin` directory. If all we do is `ls /usr/bin`, some of the files scroll off the top of the screen. How can we see all of the files?

6.3.1 Unix Concepts

The Unix operating system makes it very easy for programs to use the terminal. When a program writes something to your screen, it is using something called **standard output**. Standard output, abbreviated as stdout, is how the program writes things to a user. The name for what you tell a program is **standard input** (stdin). It's possible for a program to communicate with the user without using standard input or output, but most of the commands I cover in this book use stdin and stdout.

For example, the `ls` command prints the list of the directories to standard output, which is normally "connected" to your terminal. An interactive command, such as your shell, `bash`, reads your commands from standard input.

It is also possible for a program to write to **standard error**, since it is very easy to make standard output point somewhere besides your terminal. Standard error (stderr) is almost always connected to a terminal so an actual human will read the message.

In this section, we're going to examine three ways of fiddling with the standard input and output: input redirection, output redirection, and pipes.

6.3.2 Output Redirection

A very important feature of Unix is the ability to **redirect** output. This allows you, instead of viewing the results of a command, to save it in a file or send it directly to a printer. For instance, to redirect the output of the command `ls /usr/bin`, we place a `>` sign at the end of the line, and say what file we want the output to be put in:

```
/home/larry# ls
/home/larry# ls -F /usr/bin > listing
/home/larry# ls
listing
/home/larry#
```

As you can see, instead of writing the names of all the files, the command created a totally new file in your home directory. Let's try to take a look at this file using the command `cat`. If you think back, you'll remember `cat` was a fairly useless command that copied what you typed (the standard input) to the terminal (the standard output). `cat` can also print a file to the standard output if you list the file as a parameter to `cat`:

```
/home/larry# cat listing
...
/home/larry#
```

The exact output of the command `ls /usr/bin` appeared in the contents of `listing`. All well and good, although it didn't solve the original problem.[3]

However, `cat` does do some interesting things when it's output is redirected. What does the command `cat listing > newfile` do? Normally, the `> newfile` says "take all the output of the command and put it in `newfile`." The output of the command `cat listing` is the file `listing`. So we've invented a new (and not so efficient) method of copying files.

How about the command `cat > fox`? `cat` by itself reads in each line typed at the terminal (standard input) and prints it right back out (standard output) until it reads Ctrl-d. In this case, standard output has been redirected into the file `fox`. Now `cat` is serving as a rudimentary editor:

```
/home/larry# cat > fox
The quick brown fox jumps over the lazy dog.
press Ctrl-d
```

We've now created the file `fox` that contains the sentence "The quick brown fox jumps over the lazy dog." One last use of the versitile `cat` command is to con**cat**enate files together. `cat` will print out every file it was given as a parameter, one after another. So the command `cat listing fox` will print out the directory listing of `/usr/bin`, and then it will print out our silly sentence. Thus, the command `cat listing fox > listandfox` will create a new file containing the contents of both `listing` and `fox`.

6.3.3 Input Redirection

Like redirecting standard output, it is also possible to redirect standard input. Instead of a program reading from your keyboard, it will read from a file. Since input redirection is related to output redirection, it seems natural to make the special character for input redirection be `<`. It too, is used after the command you wish to run.

This is generally useful if you have a data file and a command that expects input from standard input. Most commands also let you specify a file to operate on, so `<` isn't used as much in day-to-day operations as other techniques.

6.3.4 The Pipe

Many Unix commands produce a large amount of information. For instance, it is not uncommon for a command like `ls /usr/bin` to produce more output than you can see on your screen. In order for you to be able to see all of the information that a command like `ls /usr/bin`, it's necessary to use another Unix command, called `more`.[4] `more` will pause once every screenful of information. For instance, `more < /etc/rc` will display the file `/etc/rc` just like `cat /etc/rc` would, except that

[3] For impatient readers, the command you might want to try is `more`. However, there's still a bit more to talk about before we get there.

[4] `more` is named because that's the prompt it originally displayed: `--more--`. In many versions of Linux the `more` command is identical to a more advanced command that does all that `more` can do and more. Proving that computer programmers make bad comedians, they named this new program `less`.

more will let you read it. more also allows the command more /etc/rc, and that's the normal way of invoking it.

However, that doesn't help the problem that ls /usr/bin displays more information than you can see. more < ls /usr/bin won't work—input redirection only works with files, not commands! You *could* do this:

```
/home/larry# ls /usr/bin > temp-ls
/home/larry# more temp-ls
...
/home/larry# rm temp-ls
```

However, Unix supplies a much cleaner way of doing that. You can just use the command ls /usr/bin | more. The character "|" indicates a **pipe**. Like a water pipe, a Unix pipe controls flow. Instead of water, we're controlling the flow of information!

A useful tool with pipes are programs called **filters**. A filter is a program that reads the standard input, changes it in some way, and outputs to standard output. more is a filter—it reads the data that it gets from standard input and displays it to standard output one screen at a time, letting you read the file. more isn't a great filter because its output isn't suitable for sending to another program.

Other filters include the programs cat, sort, head, and tail. For instance, if you wanted to read only the first ten lines of the output from ls, you could use ls /usr/bin | head.

6.4 Multitasking

6.4.1 Using Job Control

Job control refers to the ability to put processes (another word for programs, essentially) in the **background** and bring them to the **foreground** again. That is to say, you want to be able to make something run while you go and do other things, but have it be there again when you want to tell it something or stop it. In Unix, the main tool for job control is the shell—it will keep track of jobs for you, if you learn how to speak its language.

The two most important words in that language are fg, for foreground, and bg, for background. To find out how they work, use the command yes at a prompt.

```
/home/larry# yes
```

This will have the startling effect of running a long column of y's down the left hand side of your screen, faster than you can follow.[5] To get them to stop, you'd normally type ctrl-c to kill it, but instead you should type ctrl-z this time. It appears to have stopped, but there will be a message before your prompt, looking more or less like this:

[5]There are good reasons for this strange command to exist. Occasional commands ask for confirmation—a "yes" answer to a question. The yes command allows a programmer to automate the response to these questions.

```
[1]+   Stopped                  yes
```

It means that the process `yes` has been **suspended** in the background. You can get it running again by typing `fg` at the prompt, which will put it into the foreground again. If you wish, you can do other things first, while it's suspended. Try a few `ls`'s or something before you put it back in the foreground.

Once it's returned to the foreground, the `y`'s will start coming again, as fast as before. You do not need to worry that while you had it suspended it was "storing up" more `y`'s to send to the screen: when a program is suspended the whole program doesn't run until you bring it back to life. (Now type ctrl-c to kill it for good, once you've seen enough).

Let's pick apart that message we got from the shell:

```
[1]+   Stopped                yes
```

The number in brackets is the **job number** of this job, and will be used when we need to refer to it specifically. (Naturally, since job control is all about running multiple processes, we need some way to tell one from another). The `+` following it tells us that this is the "current job" — that is, the one most recently moved from the foreground to the background. If you were to type `fg`, you would put the job with the `+` in the foreground again. (More on that later, when we discuss running multiple jobs at once). The word `Stopped` means that the job is "stopped". The job isn't dead, but it isn't running right now. LINUX has saved it in a special suspended state, ready to jump back into the action should anyone request it. Finally, the `yes` is the name of the process that has been stopped.

Before we go on, let's kill this job and start it again in a different way. The command is named `kill` and can be used in the following way:

```
/home/larry# kill %1
[1]+  Stopped                 yes
/home/larry#
```

That message about it being "stopped" again is misleading. To find out whether it's still alive (that is, either running or frozen in a suspended state), type `jobs`:

```
/home/larry# jobs
[1]+  Terminated                yes
/home/larry#
```

There you have it—the job has been terminated! (It's possible that the `jobs` command showed nothing at all, which just means that there are no jobs running in the background. If you just killed a job, and typing `jobs` shows nothing, then you know the kill was successful. Usually it will tell you the job was "terminated".)

Now, start `yes` running again, like this:

```
/home/larry# yes > /dev/null
```

If you read the section about input and output redirection, you know that this is sending the output of `yes` into the special file `/dev/null`. `/dev/null` is a black hole that eats any output sent to it (you can imagine that stream of `y`'s coming out the back of your computer and drilling a hole in the wall, if that makes you happy).

After typing this, you will not get your prompt back, but you will not see that column of `y`'s either. Although output is being sent into `/dev/null`, the job is still running in the foreground. As usual, you can suspend it by hitting ctrl-z. Do that now to get the prompt back.

```
/home/larry# yes > /dev/null
["yes" is running, and we just typed ctrl-z]
[1]+  Stopped                 yes >/dev/null

/home/larry#
```

Hmm. . . is there any way to get it to actually *run* in the background, while still leaving us the prompt for interactive work? The command to do that is `bg`:

```
/home/larry# bg
[1]+ yes >/dev/null  &
/home/larry#
```

Now, you'll have to trust me on this one: after you typed `bg`, `yes > /dev/null` began to run again, but this time in the background. In fact, if you do things at the prompt, like `ls` and stuff, you might notice that your machine has been slowed down a little bit (endlessly generating and discarding a steady stream of y's does take some work, after all!) Other than that, however, there are no effects. You can do anything you want at the prompt, and `yes` will happily continue to sending its output into the black hole.

There are now two different ways you can kill it: with the `kill` command you just learned, or by putting the job in the foreground again and hitting it with an interrupt, ctrl-c. Let's try the second way, just to understand the relationship between `fg` and `bg` a little better;

```
/home/larry# fg
yes >/dev/null

[now it's in the foreground again.  Imagine that I hit ctrl-c to terminate it]

/home/larry#
```

There, it's gone. Now, start up a few jobs running in simultaneously, like this:

```
/home/larry# yes  > /dev/null &
[1] 1024
/home/larry# yes | sort > /dev/null &
[2] 1026
/home/larry# yes | uniq > /dev/null
[and here, type ctrl-z to suspend it, please]
```

```
[3]+  Stopped                 yes | uniq >/dev/null
/home/larry#
```

The first thing you might notice about those commands is the trailing `&` at the end of the first two. Putting an `&` after a command tells the shell to start in running in the background right from the very beginning. (It's just a way to avoid having to start the program, type ctrl-z, and then type `bg`.) So, we started those two commands running in the background. The third is suspended and inactive at the moment. You may notice that the machine has become slower now, as the two running ones require some amount of CPU time.

Each one told you it's job number. The first two also showed you their **process identification numbers**, or PID's, immediately following the job number. The PID's are normally not something you need to know, but occasionally come in handy.

Let's kill the second one, since I think it's making your machine slow. You could just type `kill %2`, but that would be too easy. Instead, do this:

```
/home/larry# fg %2
yes | sort >/dev/null
[type ctrl-c to kill it]

/home/larry#
```

As this demonstrates, `fg` takes parameters beginning with `%` as well. In fact, you could just have typed this:

```
/home/larry# %2
yes | sort >/dev/null
[type ctrl-c to kill it]

/home/larry#
```

This works because the shell automatically interprets a job number as a request to put that job in the foreground. It can tell job numbers from other numbers by the preceding `%`. Now type `jobs` to see which jobs are left running:

```
/home/larry# jobs
[1]-  Running                 yes >/dev/null  &
[3]+  Stopped                 yes | uniq >/dev/null
/home/larry#
```

The "`-`" means that job number 1 is second in line to be put in the foreground, if you just type `fg` without giving it any parameters. The "`+`" means the specified job is first in line—a `fg` without parameters will bring job number 3 to the foreground. However, you can get to it by naming it, if you wish:

```
/home/larry# fg %1
yes >/dev/null
[now type ctrl-z to suspend it]
```

```
[1]+  Stopped                 yes >/dev/null
/home/larry#
```

Having changed to job number 1 and then suspending it has also changed the priorities of all your jobs. You can see this with the `jobs` command:

```
/home/larry# jobs
[1]+  Stopped                 yes >/dev/null
[3]-  Stopped                 yes | uniq >/dev/null
/home/larry#
```

Now they are both stopped (because both were suspended with ctrl-z), and number 1 is next in line to come to the foreground by default. This is because you put it in the foreground manually, and then suspended it. The "+" always refers to the most recent job that was suspended from the foreground. You can start it running again:

```
/home/larry# bg
[1]+ yes >/dev/null  &
/home/larry# jobs
[1]-  Running                 yes >/dev/null
[3]+  Stopped                 yes | uniq >/dev/null
/home/larry#
```

Notice that now it is running, and the other job has moved back up in line and has the `+`. Now let's kill them all so your system isn't permanently slowed by processes doing nothing.

```
/home/larry# kill %1 %3
[3]   Terminated              yes | uniq >/dev/null
/home/larry# jobs
[1]+  Terminated              yes >/dev/null
/home/larry#
```

You should see various messages about termination of jobs—nothing dies quietly, it seems. Figure 6.1 on the facing page shows a quick summary of what you should know for job control.

6.4.2 The Theory of Job Control

It is important to understand that job control is done by the shell. There is no program on the system called `fg`; rather, `fg`, `bg`, `&`, `jobs`, and `kill` are all shell-builtins (actually, sometimes `kill` is an independent program, but the `bash` shell used by Linux has it built in). This is a logical way to do it: since each user wants their own job control space, and each user already has their own shell, it is easiest to just have the shell keep track of the user's jobs. Therefore, each user's job numbers are meaningful only to that user: my job number [1] and your job number [1] are probably two totally different processes. In fact, if you are logged in more than once, each of your shells will have unique job control data, so you as a user might have two different jobs with the same number running in two different shells.

Figure 6.1 A summary of commands and keys used in job control.

`fg` *%job*	This is a shell command that returns a job to the foreground. To find out which one this is by default, type `jobs` and look for the one with the `+`. Parameters: Optional job number. The default is the process identified with `+`.
`&`	When an `&` is added to the end of the command line, it tells the command to run in the background automatically. This process is then subject to all the usual methods of job control detailed here.
`bg` *%job*	This is a shell command that causes a suspended job to run in the background. To find out which one this is by default, type `jobs` and look for the one with the `+`. Parameters: Optional job number. The default is the process identified with `+`.
`kill` *%job PID*	This is a shell command that causes a background job, either suspended or running, to terminate. You should always specify the job number or PID, and if you are using job numbers, remember to precede them with a `%`. Parameters: Either the job number (preceded by `%`) or PID (no `%` is necessary). More than one process or job can be specified on one line.
`jobs`	This shell command just lists information about the jobs currently running or suspending. Sometimes it also tells you about ones that have just exited or been terminated.
ctrl-c	This is the generic interrupt character. Usually, if you type it while a program is running in the foreground, it will kill the program (sometimes it takes a few tries). However, not all programs will respond to this method of termination.
ctrl-z	This key combination usually causes a program to suspend, although a few programs ignore it. Once suspended, the job can be run in the background or killed.

The way to tell for sure is to use the Process ID numbers (`PID`'s). These are system-wide — each process has its own unique `PID` number. Two different users can refer to a process by its `PID` and know that they are talking about the same process (assuming that they are logged into the same machine!)

Let's take a look at one more command to understand what `PID`s are. The `ps` command will list all running processes, including your shell. Try it out. It also has a few options, the most important of which (to many people) are `a`, `u`, and `x`. The `a` option will list processes belonging to any user, not just your own. The `x` switch will list processes that don't have a terminal associated with them.[6] Finally, the `u` switch will give additionally information about the process that is frequently useful.

To really get an idea of what your system is doing, put them all together: `ps -aux`. You can then see the process that uses the more memory by looking at the `%MEM` column, and the most CPU by looking at the `%CPU` column. (The `TIME` column lists the *total* amount of CPU time used.)

[6]This only makes sense for certain system programs that don't have to talk to users through a keyboard.

Another quick note about PIDs. `kill`, in addition to taking options of the form %*job#*, will take options of raw PIDs. So, put a `yes > /dev/null` in the background, run `ps`, and look for `yes`. Then type `kill PID`.[7]

If you start to program in C on your Linux system, you will soon learn that the shell's job control is just an interactive version of the function calls `fork` and `execl`. This is too complex to go into here, but may be helpful to remember later on when you are programming and want to run multiple processes from a single program.

6.5 Virtual Consoles: Being in Many Places at Once

Linux supports **virtual consoles**. These are a way of making your single machine seem like multiple terminals, all connected to one Linux kernel. Thankfully, using virtual consoles is one of the simplest things about Linux: there are "hot keys" for switching among the consoles quickly. To try it, log in to your Linux system, hold down the left Alt key, and press F2 (that is, the function key number 2).[8]

You should find yourself at another login prompt. Don't panic: you are now on virtual console (VC) number 2! Log in here and do some things — a few `ls`'s or whatever — to confirm that this is a real login shell. Now you can return to VC number 1, by holding down the left Alt and pressing F1. Or you can move on to a *third* VC, in the obvious way (Alt-F3).

Linux systems generally come with four VC's enabled by default. You can increase this all the way to eight; this should be covered in *The* LINUX *System Adminstrator's Guide*. It involves editing a file in `/etc` or two. However, four should be enough for most people.

Once you get used to them, VC's will probably become an indispensable tool for getting many things done at once. For example, I typically run Emacs on VC 1 (and do most of my work there), while having a communications program up on VC 3 (so I can be downloading or uploading files by modem while I work, or running jobs on remote machines), and keep a shell up on VC 2 just in case I want to run something else without tying up VC 1.

[7] In general, it's easier to just kill the job number instead of using PIDs.

[8] Make sure you are doing this from text consoles: if you are running X windows or some other graphical application, it probably won't work, although rumor has it that X Windows will soon allow virtual console switching under Linux.

Chapter 7

Powerful Little Programs

```
better !pout !cry
better watchout
lpr why
santa claus <north pole >town

cat /etc/passwd >list
ncheck list
ncheck list
cat list | grep naughty >nogiftlist
cat list | grep nice >giftlist
santa claus <north pole > town

who | grep sleeping
who | grep awake
who | egrep 'bad|good'
for (goodness sake) {
        be good
}
```

7.1 The Power of Unix

The power of Unix is hidden in small commands that don't seem too useful when used alone, but when combined with other commands (either directly or indirectly) produce a system that's much more powerful and flexible than most other operating systems. The commands I'm going to talk about in this chapter include `sort`, `grep`, `more`, `cat`, `wc`, `spell`, `diff`, `head`, and `tail`. Unfortunately, it isn't totally intuitive what these names mean right now.

Let's cover what each of these utilities do seperately and then I'll give some examples of how to use them together.[1]

[1]Please note that the short summaries on commands in this chapter are not comprehensive. Please consult the

7.2 Operating on Files

In addition to the commands like `cd`, `mv`, and `rm` you learned in Chapter 4, there are other commands that just operate on files but not the data in them. These include `touch`, `chmod`, `du`, and `df`. All of these files don't care what is *in* the file—the merely change some of the things Unix remembers about the file.

Some of the things these commands manipulate:

- The time stamp. Each file has three dates associated with it.[2] The three dates are the creation time (when the file was created), the last modification time (when the file was last changed), and the last access time (when the file was last read).
- The owner. Every file in Unix is owned by one user or the other.
- The group. Every file also has a group of users it is associated with. The most common group for user files is called `users`, which is usually shared by all the user account on the system.
- The permissions. Every file has permissions (sometimes called "privileges") associated with it which tell Unix who can access what file, or change it, or, in the case of programs, execute it. Each of these permissions can be toggled seperately for the owner, the group, and all other users.

`touch` *file1 file2 . . . fileN*

`touch` will update the time stamps of the files listed on the command line to the current time. If a file doesn't exist, `touch` will create it. It is also possible to specify the time that `touch` will set files to—consult the the manpage for `touch`.

`chmod` [-Rfv] *mode file1 file2 . . . fileN*

The command used to change the permissions on a file is called `chmod`, short for **ch**ange **mod**e. Before I go into how to use the command, let's discuss what permissions are in Unix. Each file has a group of permissions associated with it. These permissions tell Unix whether or not the file can be read from, written to, or executed as a program. (In the next few paragraphs, I'll talk about users doing these things. Any programs a user runs are allowed to do the same things a user is. This can be a security problem if you don't know what a particular program does.)

Unix recognizes three different types of people: first, the owner of the file (and the person allowed to use `chmod` on that file). Second, the "group". The group of most of your files might be "users", meaning the normal users of the system. (To find out the group of a particular file, use `ls -l` *file*.)

command's manpage if you want to know every option.

[2] Older filesystems in Linux only stored one date, since they were derived from Minix. If you have one of these filesystems, some of the information will merely be unavailable—operation will be mostly unchanged.

Then, there's everybody else who isn't the owner and isn't a member of the group, appropriately called "other".

So, a file could have read and write permissions for the owner, read permissions for the group, and no permissions for all others. Or, for some reason, a file could have read/write permissions for the group and others, but *no* permissions for the owner!

Let's try using `chmod` to change a few permissions. First, create a new file using `cat`, `emacs`, or any other program. By default, you'll be able to read and write this file. (The permissions given other people will vary depending on how the system and your account is setup.) Make sure you can read the file using `cat`. Now, let's take away your read privilege by using `chmod u-r` *filename*. (The parameter `u-r` decodes to "user minus read".) Now if you try to read the file, you get a `Permission denied` error! Add read privileges back by using `chmod u+r` *filename*.

Directory permissions use the same three ideas: read, write, and execute, but act slightly differently. The read privilege allows the user (or group or others) to read the directory—list the names of the files. The write permission allows the user (or group or others) to add or remove files. The execute permission allows the user to access files in the directory or any subdirectories. (If a user doesn't have execute permissions for a directory, they can't even `cd` to it!)

To use `chmod`, replace the *mode* with what to operate on, either **u**ser, **g**roup, **o**ther, or **a**ll, and what to do with them. (That is, use a plus sign to indicate adding a privilege or a minus sign to indicate taking one away. Or, an equals sign will specify the exact permissions.) The possible permissions to add are **r**ead, **w**rite, and e**x**ecute.

`chmod`'s `R` flag will change a directory's permissions, and all files in that directory, and all subdirecties, all the way down the line. (The 'R' stands for recursive.) The `f` flag forces `chmod` to attempt to change permissions, even if the user isn't the owner of the file. (If `chmod` is given the `f` flag, it won't print an error message when it fails to change a file's permissions.) The `v` flag makes `chmod` verbose—it will report on what it's done.

7.3 System Statistics

Commands in this section will display statistics about the operating system, or a part of the operating system.

`du` [-abs] [*path1 path2 . . . pathN*]

`du` stands for **d**isk **u**sage. It will count the amount of disk space a given directory *and all its subdirectories* take up on the disk. `du` by itself will return a list of how much space every subdirectory of the current directory consumes, and, at the very bottom, how much space the current directory (plus all the previously counted subdirectories) use. If you give it a parameter or two, it will count the amount of space used by those files or directories instead of the current one.

The `a` flag will display a count for files, as well as directories. An option of `b` will display, instead of kilobytes (1024 characters), the total in bytes. One byte is the equivalent of one letter in a text document. And the `s` flag will just display the directories mentioned on the command-line and *not* their subdirectories.

`df`

`df` is short for "disk filling": it summarizes the amount of disk space in use. For each filesystem (remember, different filesystems are either on different drives or partitions) it shows the total amount of disk space, the amount used, the amount available, and the total capacity of the filesystem that's used.

One odd thing you might encounter is that it's possible for the capacity to go over 100%, or the used plus the available not to equal the total. This is because Unix reserves some space on each filesystem for `root`. That way if a user accidentally fills the disk, the system will still have a little room to keep on operating.

For most people, `df` doesn't have any useful options.

`uptime`

The `uptime` program does exactly what one would suspect. It prints the amount of time the system has been "up"—the amount of time from the last Unix boot.

`uptime` also gives the current time and the load average. The load average is the average number of jobs waiting to run in a certain time period. `uptime` displays the load average for the last minute, five minutes, and ten minutes. A load average near zero indicates the system has been relatively idle. A load average near one indicates that the system has been almost fully utilized but nowhere near overtaxed. High load averages are the result of several programs being run simultaneously.

Amazingly, `uptime` is one of the few Unix programs that have *no* options!

`who`

`who` displays the current users of the system and when they logged in. If given the parameters `am i` (as in: `who am i`), it displays the current user.

`w` [-f] [*username*]

The `w` program displays the current users of the system and what they're doing. (It basically combines the functionality of `uptime` and `who`. The header of `w` is exactly the same as `uptime`, and each line shows a user, when the logged on (and how long they've been idle). `JCPU` is the total amount of CPU time used by that user, while `PCPU` the the total amount of CPU time used by their present task.

If `w` is given the option `f`, it shows the remote system they logged in from, if any. The optional parameter restricts `w` to showing only the named user.

7.4 What's in the File?

There are two major commands used in Unix for listing files, `cat` and `more`. I've talked about both of them in Chapter 6.

`cat` [-nA] [*file1 file2 ... fileN*]

`cat` is not a user friendly command—it doesn't wait for you to read the file, and is mostly used in conjuction with pipes. However, `cat` does have some useful command-line options. For instance, `n` will number all the lines in the file, and `A` will show control characters as normal characters instead of (possibly) doing strange things to your screen. (Remember, to see some of the stranger and perhaps "less useful" options, use the `man` command: `man cat`.) `cat` will accept input from stdin if no files are specified on the command-line.

`more` [-l] [+*linenumber*] [*file1 file2 ... fileN*]

`more` is much more useful, and is the command that you'll want to use when browsing ASCII text files. The only interesting option is `l`, which will tell `more` that you aren't interested in treating the character Ctrl-L as a "new page" character. `more` will start on a specified linenumber.

Since `more` is an interactive command, I've summarized the major interactive commands below:

Spacebar Moves to the next screen of text.

d This will scroll the screen by 11 lines, or about half a normal, 25-line, screen.

/ Searches for a regular expression. While a regular expression can be quite complicated, you can just type in a text string to search for. For example, `/toad` return would search for the next occurence of "toad" in your current file. A slash followed by a return will search for the next occurence of what you last searched for.

n This will also search for the next occurence of your regular expression.

: n If you specified more than one file on the command line, this will move to the next file.

: p This will move the the previous file.

q Exits from `more`.

`head` [-*lines*] [*file1 file2 . . . fileN*]

`head` will display the first ten lines in the listed files, or the first ten lines of stdin if no files are specified on the command line. Any numeric option will be taken as the number of lines to print, so `head -15 frog` will print the first fifteen lines of the file `frog`.

`tail` [-*lines*] [*file1 file2 . . . fileN*]

Like `head`, `tail` will display only a fraction of the file. Naturally, `tail` will display the end of the file, or the last ten lines that come through stdin. `tail` also accepts a option specifying the number of lines.

`file` [*file1 file2 . . . fileN*]

The `file` command attempts to identify what format a particular file is written in. Since not all files have extentions or other easy to identify marks, the `file` command performs some rudimentary checks to try and figure out exactly what it contains.

Be careful, though, because it is quite possible for `file` to make a wrong identification.

7.5 Information Commands

This section discusses the commands that will alter a file, perform a certain operation on the file, or display statistics on the file.

`grep` [-nvwx] [-*number*] *expression* [*file1 file2 . . . fileN*]

One of the most useful commands in Unix is `grep`, the **g**eneralized **r**egular **e**xpression **p**arser. This is a fancy name for a utility which can only search a text file. The easiest way to use `grep` is like this:

```
/home/larry# cat animals
Animals are very interesting creatures. One of my favorite animals is
the tiger, a fearsome beast with large teeth.
I also like the lion---it's really neat!
/home/larry# grep iger animals
the tiger, a fearsome beast with large teeth.
/home/larry#
```

One disadvantage of this is, although it shows you all the lines containing your word, it doesn't tell you where to look in the file—no line number. Depending on what you're doing, this might be fine. For instance, if you're looking for errors from a programs output, you might try `a.out | grep error`, where `a.out` is your program's name.

If you're interested in where the match(es) are, use the `n` switch to `grep` to tell it to print line numbers. Use the `v` switch if you want to see all the lines that *don't* match the specified expression.

Another feature of `grep` is that it matches only parts of a word, like my example above where `iger` matched `tiger`. To tell `grep` to only match whole words, use the `w`, and the `x` switch will tell grep to only match whole lines.

If you don't specify any files, `grep` will examine stdin.

`wc` [-clw] [*file1 file2 ... fileN*]

`wc` stands for **w**ord **c**ount. It simply counts the number of words, lines, and characters in the file(s). If there aren't any files specified on the command line, it operates on stdin.

The three parameters, `clw`, stand for **c**haracter, **l**ine, and **w**ord respectively, and tell `wc` which of the three to count. Thus, `wc -cw` will count the number of characters and words, but not the number of lines. `wc` defaults to counting everything—words, lines, and characters.

One nice use of `wc` is to find how many files are in the present directory: `ls | wc -w`. If you wanted to see how many files that ended with `.c` there are, try `ls *.c | wc -w`.

`spell` [*file1 file2 ... fileN*]

`spell` is a very simple Unix spelling program, usually for American English.[3] `spell` is a filter, like most of the other programs we've talked about, which sucks in an ASCII text file and outputs all the words it considers misspellings. `spell` operates on the files listed in the command line, or, if there weren't any there, stdin.

A more sophisticated spelling program, `ispell` is probably also available on your machine. `ispell` will offer possible correct spellings and a fancy menu interface if a filename is specified on the command line or will run as a filter-like program if no files are specified.

While operation of `ispell` should be fairly obvious, consult the man page if you need more help.

`cmp` *file1* [*file2*]

`cmp` **comp**ares two files. The first must be listed on the command line, while the second is either listed as the second parameter or is read in from standard input. `cmp` is very simple, and merely tells you where the two files first differ.

[3]While there are versions of this for several other European languages, the copy on your LINUX machine is most likely for American English.

`diff` *file1 file2*

One of the most complicated standard Unix commands is called `diff`. The GNU version of `diff` has over twenty command line options! It is a much more powerful version of `cmp` and shows you what the differences are instead of merely telling you where the first one is.

Since talking about even a good portion of `diff` is beyond the scope of this book, I'll just talk about the basic operation of `diff`. In short, `diff` takes two parameters and displays the differences between them on a line-by-line basis. For instance:

```
/home/larry# cat frog
Animals are very interesting creatures. One of my favorite animals is
the tiger, a fearsome beast with large teeth.
I also like the lion---it's really neat!
/home/larry# cp frog toad
/home/larry# diff frog toad
/home/larry# cat dog
Animals are very nteresting creatures. One of my favorite animals is

the tiger, a fearsome beast with large teeth.
I also   like the lion---it's really neat!
/home/larry# diff frog dog
1c1,2
< Animals are very interesting creatures. One of my favorite animals is
---
> Animals are very nteresting creatures. One of my favorite animals is
>
3c4
< I also like the lion---it's really neat!
---
> I also   like the lion---it's really neat!
/home/larry#
```

As you can see, `diff` outputs nothing when the two files are identical. Then, when I compared two different files, it had a section header, `1c1,2` saying it was comparing line 1 of the left file, `frog`, to lines 1–2 of `dog` and what differences it noticed. Then it compared line 3 of `frog` to line 4 of `dog`. While it may seem strange at first to compare different line numbers, it is much more efficent then listing out every single line if there is an extra return early in one file.

`gzip` [-v#] [*file1 file2 . . . fileN*]
`gunzip` [-v] [*file1 file2 . . . fileN*]
`zcat` [*file1 file2 . . . fileN*]

These three programs are used to compress and decompress data. `gzip`, or GNU Zip, is the program that reads in the original file(s) and outputs files that are smaller. `gzip` deletes the files specified on the command line and replaces them with files that have an identical name except that they have "`.gz`" appended to them.

`tr` *string1 string2*

The "translate characters" command operates on standard input—it doesn't accept a filename as a parameter. Instead, it's two parameters are arbitrary strings. It replaces all occurences of *string1* in the input with *string2*. In addition to relatively simple commands such as `tr frog toad`, `tr` can accept more complicated commands. For instance, here's a quick way of converting lowercase characters into uppercase ones:

```
/home/larry# tr [:lower:] [:upper:]
this is a WEIRD sentence.
THIS IS A WEIRD SENTENCE.
```

`tr` is fairly complex and usually used in small shell programs.

Chapter 8

Editing files with Emacs

FUNNY SOMETHING OR OTHER

8.1 What's Emacs?

In order to get anything done on a computer, you need a way to put text into files, and a way to change text that's already in files. An **editor** is a program for doing this. `Emacs` is one of the most popular editors around—partly because it's very easy for a complete beginner to get actual work done with it. (The classic Unix editor, `vi`, is covered in Appendix A.)

To learn `emacs`, you need to find a file of plain text (letters, numbers, and the like), copy it to your home directory[1] (we don't want to modify the actual file, if it contains important information), and invoke Emacs on the file:

```
/home/larry# emacs README
```

(Of course, if you decided to copy `/etc/rc`, `/etc/inittab`, or any other file, substitute that file name for `README`. For instance, if you `cp /etc/rc ~/rc`, then `emacs rc`.)

"Invoking" Emacs can have different effects depending on where where you do it. From a plain console displaying only text characters, Emacs will just take over the whole console. If you invoke it from X, Emacs will actually bring up its own window. I will assume that you are doing it from a text console, but everything carries over logically into the X Windows version—just substitute the word "window" in the places I've written "screen". Also, remeber that you have to move the mouse pointer into Emacs's window to type in it!

Your screen (or window, if you're using X) should now resemble Figure 8.1. Most of the screen contains your text document, but the last two lines are especially interesting if you're trying to learn Emacs. The second-to-last line (the one with the long string of dashes) is called the **mode line**.

[1]For instance, `cp /usr/src/linux/README ./README`

Figure 8.1 Emacs was just started with `emacs README`

In my mode line, you see "Top". It might be "All" instead, and there may be other minor differences. (Many people have the current time displayed in the mode line.) The line immediately below the mode line is called the **minibuffer**, or sometimes the **echo area**. Emacs uses the minibuffer to flash messages at you, and occasionally uses it to read input from you, when necessary. In fact, right now Emacs is telling you "`For information about the GNU Project and its goals, type C-h C-p.`" Ignore it for now; we won't be making much use of the minibuffer for a while.

Before you actually change any of the text in the file, you need to learn how to move around. The cursor should be at the beginning of the file, in the upper-left corner of the screen. To move forward, type `C-f` (that is, hold down the Control key while you press "f", for "forward"). It will move you forward a character at a time, and if you hold both keys down, your system's automatic key-repeat should take effect in a half-second or so. Notice how when you get to the end of the line, the cursor automatically moves to the next line. `C-b` (for "backward") has the opposite behavior. And, while we're at it, `C-n` and `C-p` take you to the next and previous lines, respectively.[2]

Using the control keys is usually the quickest way of moving around when you're editing. The goal of `Emacs` is to keep your hands over the alpha-numeric keys of the keyboard, where most of your work gets done. However, if you want to, the arrow keys should also work.

In fact, when you're using X, you should be able to position the mouse pointer and click with the left button to move the cursor where you want. However, this is very slow—you have to move your hand all the way to your mouse! Most people who use Emacs primarily use the keyboard for getting around.

Use `C-p` and `C-b` to get all the way back to the upper-left corner. Now keep `C-b` held a little longer. You should hear an annoying bell sound, and see the message "`Beginning of buffer`"

[2] In case you hadn't noticed yet, many of Emacs's movement commands consist of combining Control with a single mnemonic letter.

appear in the minibuffer. At this point you might wonder, "But what is a buffer?"

When Emacs works on a file, it doesn't actually work on the file itself. Instead, it copies the contents of the file into a special Emacs work area called a **buffer**, where you can modify it to your heart's content. When you are done working, you tell Emacs to save the buffer—in other words, to write the buffer's contents into the corresponding file. Until you do this, the file remains unchanged, and the buffer's contents exist only inside of Emacs.

With that in mind, prepare to insert your first character into the buffer. Until now, everything we have done has been "non-destructive", so this is a big moment. You can choose any character you like, but if you want to do this in style, I suggest using a nice, solid, capital "X". As you type it, take a look at the beginning of the mode line at the bottom of the screen. When you change the buffer so that its contents are no longer the same as those of the file on disk, Emacs displays two asterisks at the beginning of the mode line, to let you know that the buffer has been modified:

```
--**-Emacs: some_file.txt          (Fundamental)--Top------------------------
```

These two asterisks are displayed as soon as you modify the buffer, and remain visible until you save the buffer. You can save the buffer multiple times during an editing session—the command to do so is just `C-x C-s` (hold down Control and hit "x" and "s" while it's down...okay, so you probably already figured that out!). It's deliberately easy to type, because saving your buffers is something best done early and often.

I'm going to list a few more commands now, along with the ones you've learned already, and you can practice them however you like. I'd suggest becoming familiar with them before going any further:

`C-f`	Move forward one character.
`C-b`	Move backward one character.
`C-n`	Go to next line.
`C-p`	Go to previous line.
`C-a`	Go to beginning of line.
`C-e`	Go to end of line.
`C-v`	Go to next page/screenful of text.
`C-l`	Redraw the screen, with current line in center.
`C-d`	Delete this character (practice this one).
`C-k`	Delete text from here to end of line.
`C-x C-s`	Save the buffer in its corresponding file.
Backspace	Delete preceding character (the one you just typed).

8.2 Getting Started Quickly in X

If all you're interesting in is editing a few files quickly, an X user doesn't have to go much further beyond the menus at the top of the screen:

These menus are not available in text mode.

When you first start Emacs, there will be four menus at the top of the screen: Buffers, File, Edit, and Help. To use a menu, simply move the mouse pointer over the name (like File, click and hold down on the left button. Then, move the pointer to the action you want and release the mouse button. If you change your mind, move the mouse pointer away from the menu and release the button.

The Buffers menu lists the different files you've been editing in this incarnation of Emacs.The File menu shows a bunch of commands for loading and saving files—many of them will be described later. The Edit menu displays some commands for editing one buffer, and the Help menu should hopefully give on-line documentation.

You'll notice keyboard equivalents are listed next to the choices in the menu. Since, in the long run, they'll be quicker, you might want to learn them. Also, for better or for worse, most of Emacs's functionality is *only* available through the keyboard—you might want to read the rest of this chapter.

8.3 Editing Many Files at Once

Emacs can work on more than one file at a time. In fact, the only limit on how many buffers your Emacs can contain is the actual amount of memory available on the machine. The command to bring a new file into an Emacs buffer is `C-x C-f`. When you type it, you will be prompted for a filename in the minibuffer:

```
Find file: ~/
```

The syntax here is the same one used to specify files from the shell prompt; slashes represent subdirectories, ~means your home directory. You also get **filename completion**, meaning that if you've typed enough of a filename at the prompt to identify the file uniquely, you can just hit Tab to complete it (or to show possible completions, if there are more than one). Space also has a role in filename completion in the minibuffer, similar to Tab, but I'll let you experiment to find out how the two differ. Once you have the full filename in the minibuffer, hit Return, and Emacs will bring up a buffer displaying that file. In Emacs, this process is known as **finding** a file. Go ahead and find some other unimportant text file now, and bring it into Emacs (do this from our original buffer `some_file.txt`). Now you have a new buffer; I'll pretend it's called `another_file.txt`, since I can't see your mode line.

Your original buffer seems to have disappeared—you're probably wondering where it went. It's still inside Emacs, and you can switch back to it with `C-x b`. When you type this, you will see that the minibuffer prompts you for a buffer to switch to, and it names a default. The default is the buffer you'd get if you just hit Return at the prompt, without typing a buffer name. The default buffer to switch to is always the one most recently left, so that when you are doing a lot of work between two buffers, `C-x b` always defaults to the "other" buffer (which saves you from having to type the buffer name). Even if the default buffer is the one you want, however, you should try typing in its name anyway.

Notice that you get the same sort of completion you got when finding a file: hitting Tab completes as much of a buffer name as it can, and so on. Whenever you are being prompted for something in the minibuffer, it's a good idea to see if Emacs is doing completion. Taking advantage of completion whenever it's offered will save you a lot of typing. Emacs usually does completion when you are choosing one item out of some predefined list.

Everything you learned about moving around and editing text in the first buffer applies to the new one. Go ahead and change some text in the new buffer, but don't save it (i.e. don't type `C-x C-s`). Let's assume that you want to discard your changes without saving them in the file. The command for that is `C-x k`, which "kills" the buffer. Type it now. First you will be asked which buffer to kill, but the default is the current buffer, and that's almost always the one you want to kill, so just hit Return. Then you will be asked if you *really* want to kill the buffer—Emacs always checks before killing a buffer that has unsaved changes in it. Just type "yes" and hit Return, if you want to kill it.

Go ahead and practice loading in files, modifying them, saving them, and killing their buffers. Make sure you don't modify any important system files in a way that will cause trouble[3], of course, but do try to have at least five buffers open at once, so you can get the hang of switching between them.

8.4 Ending an Editing Session

When you are done with your work in Emacs, make sure that all buffers are saved that should be saved, and exit Emacs with `C-x C-c`. Sometimes `C-x C-c` will ask you a question or two in the minibuffer before it lets you leave—don't be alarmed, just answer them in the obvious ways. If you think that you might be returning to Emacs later, don't use `C-x C-c` at all; use `C-z`, which will suspend Emacs. You can return to it with the shell command "`fg`" later. This is more efficient than stopping and starting Emacs multiple times, especially if you have edit the same files again later.

Under X, hitting `C-z` will merely iconize the window. See the section on iconization in Chapter 5. This gives you two ways of iconizing Emacs—the normal way your window manager offers, and `C-z`. Remember, when you iconize, a simply `fg` won't bring the window back—you'll have to use your window manager.

8.5 The Meta Key

You've already learned about one "modifier key" in Emacs, the Control key. There is a second one, called the **Meta** key, which is used almost as frequently. However, not all keyboards have their Meta key in the same place, and some don't have one at all. The first thing you need to do is find where your Meta key is located. Chances are, your keyboard's Alt keys are also Meta keys, if you are using an IBM PC or other another keyboard that has an Alt key.

[3] If you are not the "root" user on the machine, you shouldn't be able to hurt the system anyway, but be careful just the same.

The way to test this is to hold down a key that you think might be a Meta key and type "x". If you see a little prompt appear in the minibuffer (like this: `M-x`) then you've found it. To get rid of the prompt and go back to your Emacs buffer, type `C-g`.

If you didn't get a prompt, then there is still one solution. You can use the Escape key as a Meta key. But instead of holding it down while you type the next letter, you have to tap it and release it quickly, and *then* type the letter. This method will work whether or not you have a real Meta key, so it's the safest way to go. Try tapping Escape and then typing "x" now. You should get that tiny prompt again. Just use `C-g` to make it go away. `C-g` is the general way in Emacs to quit out of something you don't mean to be in. It usually beeps annoyingly at you to let you know that you have interrupted something, but that's fine, since that's what you intended to do if you typed `C-g`![4]

The notation `M-x` is analogous to `C-x` (substitute any character for "x"). If you have found a real Meta key, use that, otherwise just use the Escape key. I will simply write `M-x` and you'll have to use your own Meta key.

8.6 Cutting, Pasting, Killing and Yanking

Emacs, like any good editor, allows you to cut and paste blocks of text. In order to do this, you need a way to define the start and end of the block. In Emacs, you do this by setting two locations in the buffer, known as **mark** and **point**. To set the mark, go to the place you want your block to begin and type `C-SPC` ("`SPC`" means Space, of course). You should see the message "Mark set" appear in the minibuffer.[5] The mark has now been set at that place. There will be no special highlighting indicating that fact, but you know where you put it, and that's all that matters.

What about **point**? Well, it turns out that you've been setting point every time you move the cursor, because "point" just refers to your current location in the buffer. In formal terms, point is the spot where text would be inserted if you were to type something. By setting the mark, and then moving to the end of the block of text, you have actually defined a block of text. This block is known as the **region**. The region always means the area between mark and point.

Merely defining the region does not make it available for pasting. You have to tell Emacs to copy it in order to be able to paste it. To copy the region, make sure that mark and point are set correctly, and type `M-w`. It has now been recorded by Emacs. In order to paste it somewhere else, just go there and type `C-y`. This is known as **yanking** the text into the buffer.

If you want to actually move the text of the region to somewhere else, type `C-w` instead of `M-w`. This will **kill** the region—all the text inside it will disappear. In fact, it has been saved in the same way as if you had used `M-w`. You can yank it back out with `C-y`, as always. The place Emacs saves all this text is known as the **kill-ring**. Some editors call it the "clipboard" or the "paste buffer".

There's another way to do cutting and pasting: whenever you use `C-k` to kill to the end of a line, the killed text is saved in the kill-ring. If you kill more than one line in a row, they are all saved

[4] Occasionally, even one `C-g` isn't enough to persuade Emacs that you really wanted to interrupt what you're doing. Just keep at it, and Emacs will usually return to a saner mode.

[5] On some terminals, `C-SPC` doesn't work. For these machines, you must use `C-@`.

in the kill-ring together, so that the next yank will paste in all the lines at once. Because of this feature, it is often faster to use repeated `C-k`'s to kill some text than it is to explicitly set mark and point and use `C-w`. However, either way will work. It's really a matter of personal preference how you do it.

8.7 Searching and Replacing

There are several ways to search for text in Emacs. Many of them are rather complex, and not worth going into here. The easiest and most entertaining way is to use **isearch**. "Isearch" stands for "incremental search". Suppose you want to search for the string "gadfly" in the following buffer:

```
I was growing afraid that we would run out of gasoline, when my passenger exclaimed
``Gadzooks!  There's a gadfly in here!''.
```

You would move to the beginning of the buffer, or at least to some point that you know is before the first occurence of the goal word, "gadfly", and type `C-s`. That puts you in isearch mode. Now start typing the word you are searching for, "gadfly". But as soon as you type the "g", you see that Emacs has jumped you to the first occurence of "g" in the buffer. If the above quote is the entire contents of the buffer, then that would be the first "g" of the word "growing". Now type the "a" of "gadfly", and Emacs leaps over to "gasoline", which contains the first occurence of a "ga". The "d" gets you to gadzooks, and finally, "f" gets you to "gadfly", without your having had to type the entire word.

What you are doing in an isearch is defining a string to search for. Each time you add a character to the end of the string, the number of matches is reduced, until eventually you have entered enough to define the string uniquely. Once you have found the match you are looking for, you can exit the search with [Return] or any of the normal movement commands. If you think the string you're looking for is behind you in the buffer, then you should use `C-r`, which does an isearch backwards.

If you encounter a match, but it's not the one you were looking for, then hit `C-s` again while still in the search. This will move you forward to the next complete match, each time you hit it. If there is no next match, it will say that the search failed, but if you press `C-s` again at that point, the search will wrap around from the beginning of the buffer. The reverse holds true for `C-r` — it wraps around the end of the buffer.

Try bringing up a buffer of plain English text and doing and isearch for the string "`the`". First you'd type in as much as you wanted, then use repeated `C-s`'s to go to all instances of it. Notice that it will match words like "`them`" as well, since that also contains the substring "`the`". To search only for "`the`", you'd have to do add a space to the end of your search string. You can add new characters to the string at any point in the search, even after you've hit `C-s` repeatedly to find the next matches. You can also use [Backspace] or [Delete] to remove characters from the search string at any point in the search, and hitting [Return] exits the search, leaving you at the last match.

Emacs also allows you to replace all instances of a string with some new string—this is known as **query-replace**. To invoke it, type `query-replace` and hit [Return]. Completion is done on the command name, so once you have typed "query-re", you can just hit Tab to finish it. Say you wish to replace all instances of "gadfly" with "housefly". At the "`Query replace: `" prompt, type "gadfly", and hit Return. Then you will be prompted again, and you should enter "housefly". Emacs will then step through the buffer, stopping at every instance of the word "gadfly", and asking if you want to replace it. Just hit "y" or "n" at each instance, for "Yes" or "No", until it finishes. If this doesn't make sense as you read it, then try it out.

8.8 What's Really Going On Here?

Actually, all these **keybindings** you have been learning are shortcuts to Emacs functions. For example, `C-p` is a short way of telling Emacs to execute the internal function `previous-line`. However, all these internal functions can be called by name, using `M-x`. If you forgot that `previous-line` is bound to `C-p`, you could just type `M-x previous-line` Return, and it would move you up one line. Try this now, to understand how `M-x previous-line` and `C-p` are really the same thing.

The designer of Emacs started from the ground up, first defining a whole lot of internal functions, and then giving keybindings to the most commonly-used ones. Sometimes it's easier just to call a function explicitly with `M-x` than to remember what key it's bound to. The function `query-replace`, for example, is bound to `M-%` in some versions of Emacs. But who can remember such an odd keybinding? Unless you use query-replace extremely often, it's easier just to call it with `M-x`.

Most of the keys you type are letters, meant to be inserted into the text of the buffer. So each of those keys is **bound** to the function `self-insert-command`, which does nothing but insert that letter into the buffer. Combinations that use the Control key with a letter are generally bound to functions that do other things, like moving you around. For example, `C-v` is bound to a function called `scroll-up`, which scrolls the buffer up by one screenful (meaning that your position in the buffer moves *down*, of course).

If you ever actually wanted to insert a Control character into the buffer, then, how would you do it? After all, the Control characters are `ASCII` characters, although rarely used, and you might want them in a file. There is a way to prevent Control characters from being interpreted as commands by Emacs. The key `C-q`[6] is bound to a special function named `quoted-insert`. All `quoted-insert` does is read the next key and insert it literally into the buffer, without trying to interpret it as a command. This is how you can put Control characters into your files using Emacs. Naturally, the way to insert a C-q is to press `C-q` twice!

Emacs also has many functions that are not bound to any key. For example, if you're typing a long message, you don't want to have to hit return at the end of every line. You can have Emacs do it for you (you can have Emacs do anything for you)—the command to do so is called `auto-fill-mode`, but it's not bound to any keys by default. In order to invoke this command, you would type "`M-x auto-fill-mode`". "`M-x`" is the key used to call functions by name. You could even use it to call functions like `next-line` and `previous-line`, but that would be very inefficient, since they are already bound to `C-n` and `C-p`!

[6] We call `C-q` a "key", even though it is produced by holding down Control and pressing "q", because it is a single `ASCII` character.

By the way, if you look at your mode line after invoking `auto-fill-mode`, you will notice that the word "Fill" has been added to the right side. As long as it's there, Emacs will fill (wrap) text automatically. You can turn it off by typing "`M-x auto-fill-mode`" again—it's a toggle command.

The inconvenience of typing long function names in the minibuffer is lessened because Emacs does completion on function names the same way it does on file names. Therefore, you should rarely find yourself typing in the whole function name, letter by letter. If you're not sure whether or not you can use completion, just hit Tab. It can't hurt: the worst thing that will happen is that you'll just get a tab character, and if you're lucky, it'll turn out that you can use completion.

8.9 Asking Emacs for Help

Emacs has extensive help facilities—so extensive, in fact, that we can only touch on them here. The most basic help features are accessed by typing `C-h` and then a single letter. For example, `C-h k` gets help on a key (it prompts you to type a key, then tells you what that key does). `C-h t` brings up a short Emacs tutorial. Most importantly, `C-h C-h C-h` gets you help on help, to tell you what's available once you have typed `C-h` the first time. If you know the name of an Emacs function (`save-buffer`, for example), but can't remember what key sequence invokes it, then use `C-h w`, for "`where-is`", and type in the name of the function. Or, if you want to know what a function does in detail, use `C-h f`, which prompts for a function name.

Remember, since Emacs does completion on function names, you don't really have to be sure what a function is called to ask for help on it. If you think you can guess the word it might start with, type that and hit Tab to see if it completes to anything. If not, back up and try something else. The same goes for file names: even if you can't remember quite what you named some file that you haven't accessed for three months, you can guess and use completion to find out if you're right. Get used to using completion as means of asking questions, not just as a way of saving keystrokes.

There are other characters you can type after `C-h`, and each one gets you help in a different way. The ones you will use most often are `C-h k`, `C-h w`, and `C-h f`. Once you are more familiar with Emacs, another one to try is `C-h a`, which prompts you for a string and then tells you about all the functions who have that string as part of their name (the "a" means for "apropos", or "about").

Another source of information is the **Info** documentation reader. Info is too complex a subject to go into here, but if you are interested in exploring it on your own, type `C-h i` and read the paragraph at the top of the screen. It will tell you how get more help.

8.10 Specializing Buffers: Modes

Emacs buffers have **modes** associated with them[7]. The reason for this is that your needs when writing a mail message are very different from your needs when, say, writing a program. Rather than try to come up with an editor that would meet every single need all the time (which would be

[7]To make matters worse, there are "Major Modes" and "Minor Modes", but you don't need to know about that right now.

impossible), the designer of Emacs[8] chose to have Emacs behave differently depending on what you are doing in each individual buffer. Thus, buffers have modes, each one designed for some specific activity. The main features that distinguish one mode from another are the keybindings, but there can be other differences as well.

The most basic mode is `fundamental` mode, which doesn't really have any special commands at all. In fact, here's what Emacs has to say about Fundamental Mode:

```
Fundamental Mode:

Major mode not specialized for anything in particular.
Other major modes are defined by comparison with this one.
```

I got that information like this: I typed `C-x b`, which is `switch-to-buffer`, and entered "foo" when it prompted me for a buffer name to switch to. Since there was previously no buffer named "`foo`", Emacs created one and switched me to it. It was in `fundamental-mode` by default, but it it hadn't been, I could have typed "`M-x fundamental-mode`" to make it so. All mode names have a command called `<modename>-mode` which puts the current buffer into that mode. Then, to find out more information about that major mode, I typed `C-h m`, which gets you help on the current major mode of the buffer you're in.

There's a slightly more useful mode called `text-mode`, which has the special commands `M-S`, for `center-paragraph`, and `M-s`, which invokes `center-line`. `M-S`, by the way, means exactly what you think it does: hold down both the Meta and the Shift key, and press "S".

Don't just take my word for this—go make a new buffer, put it into `text-mode`, and type `C-h m`. You may not understand everything Emacs tells you when you do that, but you should be able to get some useful information out of it.

Here is an introduction to some of the more commonly used modes. If you use them, make sure that you type `C-h m` sometime in each one, to find out more about each mode.

8.11 Programming Modes

8.11.1 C Mode

If you use Emacs for programming in the C language, you can get it to do all the indentation for you automatically. Files whose names end in "`.c` " or "`.h`" are automatically brought up in `c-mode`. This means that certain special editing commands, useful for writing C-programs, are available. In C-mode, Tab is bound to `c-indent-command`. This means that hitting the Tab key does not actually insert a tab character. Instead, if you hit Tab anywhere on a line, Emacs automatically indents that line correctly for its location in the program. This implies that Emacs knows something about C syntax, which it does (although nothing about semantics—it cannot insure that your program has no errors!)

[8] Richard Stallman, also sometimes referred to as "`rms`", because that's his login name.

In order to do this, it assumes that the previous lines are indented correctly. That means that if the preceding line is missing a parenthesis, semicolon, curly brace, or whatever, Emacs will indent the current line in a funny way. When you see it do that, you will know to look for a punctuation mistake on the line above.

You can use this feature to check that you have punctuated your programs correctly—instead of reading through the entire program looking for problems, just start indenting lines from the top down with Tab, and when something indents oddly, check the lines just before it. In other words, let Emacs do the work for you!

8.11.2 Scheme Mode

This is a major mode that won't do you any good unless you have a compiler or an interpreter for the Scheme programming language on your system. Having one is not as normal as having, say, a C compiler, but it's becoming more and more common, so I'll cover it too. Much of what is true for Scheme mode is true for Lisp mode as well, if you prefer to write in Lisp.

Well, to make matters painful, Emacs comes with two different Scheme modes, because people couldn't decide how they wanted it to work. The one I'm describing is called `cmuscheme`, and later on, in the section on customizing Emacs, I'll talk about how there can be two different Scheme modes and what to do about it. For now, don't worry about it if things in your Emacs don't quite match up to what I say here. A customizable editor means an unpredictable editor, and there's no way around that!

You can run an interactive Scheme process in Emacs, with the command `M-x run-scheme`. This creates a buffer named "`*scheme*`", which has the usual Scheme prompt in it. You can type in Scheme expressions at the prompt, hit Return, and Scheme will evaluate them and display the answer. Thus, in order to interact with the Scheme process, you could just type all your function definitions and applications in at the prompt. Chances are you have previously-written Scheme source code in a file somewhere, and it would be easier to do your work in that file and send the definitions over to the Scheme process buffer as necessary.

If that source file ends in "`.ss`" or "`.scm`", it will automatically be brought up in **Scheme mode** when you find it with `C-x C-f`. If for some reason, it doesn't come up in Scheme mode, you can do it by hand with `M-x scheme-mode`. This `scheme-mode` is not the same thing as the buffer running the Scheme process; rather, the source code buffer's being in `scheme-mode` means that it has special commands for communicating with the process buffer.

If you put yourself inside a function definition in the Scheme source code buffer and type `C-c C-e`, then that definition will be "sent" to the process buffer — exactly as if you had typed it in yourself. `C-c M-e` sends the definition and then brings you to the process buffer to do some interactive work. `C-c C-l` loads a file of Scheme code (this one works from either the process buffer or the source code buffer). And like other programming language modes, hitting Tab anywhere on a line of code correctly indents that line.

If you're at the prompt in the process buffer, you can use `M-p` and `M-n` to move through your previous commands (also known as the **input history**). So if you are debugging the function 'rotate', and have already applied it to arguments in the process buffer, like so:

```
> (rotate '(a b c d e))
```

then you can get that command back by typing M-p at the prompt later on. There should be no need to retype long expressions at the Scheme prompt — get in the habit of using the input history and you'll save a lot of time.

Emacs knows about quite a few programming languages: C, C++, Lisp, and Scheme are just some. Generally, it knows how to indent them in intuitive ways.

8.11.3 Mail Mode

You can also edit and send mail in Emacs. To enter a mail buffer, type C-x m. You need to fill in the To: and Subject: fields, and then use C-n to get down below the separator line into the body of the message (which is empty when you first start out). Don't change or delete the separator line, or else Emacs will not be able to send your mail—it uses that line to distinguish the mail's headers, which tell it where to send the mail, from the actual contents of the message.

You can type whatever you want below the separator line. When you are ready to send the message, just type C-c C-c, and Emacs will send it and then make the mail buffer go away.

8.12 Being Even More Efficient

Experienced Emacs users are fanatical about efficiency. In fact, they will often end up wasting a lot of time searching for ways to be more efficient! While I don't want that to happen to you, there are some easy things you can do to become a better Emacs user. Sometimes experienced users make novices feel silly for not knowing all these tricks—for some reason, people become religious about using Emacs "correctly". I'd condemn that sort of elitism more if I weren't about to be guilty of it myself. Here we go:

When you're moving around, use the fastest means available. You know that C-f is forward-char—can you guess that M-f is forward-word? C-b is backward-char. Guess what M-b does? That's not all, though: you can move forward a sentence at a time with M-e, as long as you write your sentences so that there are always two spaces following the final period (otherwise Emacs can't tell where one sentence ends and the next one begins). M-a is backward-sentence.

If you find yourself using repeated C-f's to get to the end of the line, be ashamed, and make sure that you use C-e instead, and C-a to go to the beginning of the line. If you use many C-n's to move down screenfuls of text, be very ashamed, and use C-v forever after. If you are using repeated C-p's to move up screenfuls, be embarrassed to show your face, and use M-v instead.

If you are nearing the end of a line and you realize that there's a mispelling or a word left out somewhere earlier in the line, *don't* use Backspace or Delete to get back to that spot. That would require retyping whole portions of perfectly good text. Instead, use combinations of M-b, C-b, and C-f to move to the precise location of the error, fix it, and then use C-e to move to the end of the line again.

When you have to type in a filename, don't ever type in the whole name. Just type in enough of it to identify it uniquely, and let Emacs's completion finish the job by hitting Tab or Space. Why waste keystrokes when you can waste CPU cycles instead?

If you are typing some kind of plain text, and somehow your auto-filling (or auto-wrapping) has gotten screwed up, use `M-q`, which is `fill-paragraph` in common text modes. This will "adjust" the paragraph you're in as if it had been wrapped line by line, but without your having to go mess around with it by hand. `M-q` will work from inside the paragraph, or from its very beginning or end.

Sometimes it's helpful to use `C-x u`, (**undo**), which will try to "undo" the last change(s) you made. Emacs will guess at how much to undo; usually it guesses very intelligently. Calling it repeatedly will undo more and more, until Emacs can no longer remember what changes were made.

8.13 Customizing Emacs

Emacs is *so* big, and *so* complex, that it actually has its own programming language! I'm not kidding: to really customize Emacs to suit your needs, you have to write programs in this language. It's called Emacs Lisp, and it's a dialect of Lisp, so if you have previous experience in Lisp, it will seem quite friendly. If not, don't worry: I'm not going to go into a great deal of depth, because it's definitely best learned by doing. To really learn about programming Emacs, you should consult the Info pages on Emacs Lisp, and read a lot of Emacs Lisp source code.

Most of Emacs's functionality is defined in files of Emacs Lisp[9] code. Most of these files are distributed with Emacs and collectively are known as the "Emacs Lisp library". This library's location depends on how Emacs was installed on your system — common locations are `/usr/lib/emacs/lisp`, `/usr/lib/emacs/19.19/lisp/`, etc. The "`19.19`" is the version number of Emacs, and might be different on your system.

You don't need to poke around your filesystem looking for the lisp library, because Emacs has the information stored internally, in a variable called **load-path**. To find out the value of this variable, it is necessary to **evaluate** it; that is, to have Emacs's lisp interpreter get its value. There is a special mode for evaluating Lisp expressions in Emacs, called **lisp-interaction-mode**. Usually, there is a buffer called "`*scratch*`" that is already in this mode. If you can't find one, create a new buffer of any name, and type `M-x lisp-interaction-mode` inside it.

Now you have a workspace for interacting with the Emacs Lisp interpreter. Type this:

```
load-path
```

and then press `C-j` at the end of it. In lisp-interaction-mode, `C-j` is bound to `eval-print-last-sexp`. An "`sexp`" is an "**s-expression**", which means a balanced group of parentheses, including none. Well, that's simplifying it a little, but you'll get a feel for what they are as you work with Emacs Lisp. Anyway, evaluating `load-path` should get you something like this:

```
load-path C-j
("/usr/lib/emacs/site-lisp/vm-5.35" "/home/kfogel/elithp"
```

[9] Sometimes unofficially called "Elisp".

```
"/usr/lib/emacs/site-lisp" "/usr/lib/emacs/19.19/lisp")
```

It won't look the same on every system, of course, since it is dependant on how Emacs was installed. The above example comes from my 386 PC running Linux. As the above indicates, `load-path` is a list of strings. Each string names a directory that might contain Emacs Lisp files. When Emacs needs to load a file of Lisp code, it goes looking for it in each of these directories, in order. If a directory is named but does not actually exist on the filesystem, Emacs just ignores it.

When Emacs starts up, it automatically tries to load the file `.emacs` in your home directory. Therefore, if you want to make personal customizations to Emacs, you should put them in `.emacs`. The most common customizations are keybindings, so here's how to do them:

```
(global-set-key "\C-cl" 'goto-line)
```

`global-set-key` is a function of two arguments: the key to be bound, and the function to bind it to. The word "`global`" means that this keybinding will be in effect in all major modes (there is another function, `local-set-key`, that binds a key in a single buffer). Above, I have bound `C-c l` to the function `goto-line`. The key is described using a string. The special syntax "`\C-<char>`" means the Control key held down while the key `<char>` is pressed. Likewise, "`\M-<char>`" indicates the Meta key.

All very well, but how did I know that the function's name was "`goto-line`"? I may know that I want to bind `C-c l` to some function that prompts for a line number and then moves the cursor to that line, but how did I find out that function's name?

This is where Emacs's online help facilities come in. Once you have decided what kind of function you are looking for, you can use Emacs to track down its exact name. Here's one quick and dirty way to do it: since Emacs gives completion on function names, just type `C-h f` (which is `describe-function`, remember), and then hit Tab without typing anything. This asks Emacs to do completion on the empty string — in other words, the completion will match every single function! It may take a moment to build the completion list, since Emacs has so many internal functions, but it will display as much of it as fits on the screen when it's ready.

At that point, hit `C-g` to quit out of `describe-function`. There will be a buffer called "`*Completions*`", which contains the completion list you just generated. Switch to that buffer. Now you can use `C-s`, `isearch`, to search for likely functions. For example, it's a safe assumption that a function which prompts for a line number and then goes to that line will contain the string "`line`" in its name. Therefore, just start searching for the string "`line`", and you'll find what you're looking for eventually.

If you want another method, you can use `C-h a`, `command-apropos`, to show all functions whose names match the given string. The output of `command-apropos` is a little harder to sort through than just searching a completion list, in my opinion, but you may find that you feel differently. Try both methods and see what you think.

There is always the possibility that Emacs does not have any predefined function to do what you're looking for. In this situation, you have to write the function yourself. I'm not going to talk about how to do that — you should look at the Emacs Lisp library for examples of function definitions, and read the Info pages on Emacs Lisp. If you happen to know a local Emacs guru, ask her how to do it. Defining your own Emacs functions is not a big deal — to give you an idea, I have written 131 of them in the last year or so. It takes a little practice, but the learning curve is not steep at all.

Another thing people often do in their `.emacs` is set certain variables to preferred values. For example, put this in your `.emacs` and then start up a new Emacs:

```
(setq inhibit-startup-message t)
```

Emacs checks the value of the variable `inhibit-startup-message` to decide whether or not to display certain information about version and lack of warranty when it starts up. The Lisp expression above uses the command `setq` to set that variable to the value '`t`', which is a special Lisp value that means **true**. The opposite of '`t`' is '`nil`', which is the designated **false** value in Emacs Lisp. Here are two things that are in my `.emacs` that you might find useful:

```
(setq case-fold-search nil) ; gives case-insensitivity in searching
;; make C programs indent the way I like them to:
(setq c-indent-level 2)
```

The first expression causes searches (including `isearch`) to be case-insensitive; that is, the search will match upper- or lower-case versions of a character even though the search string contains only the lower-case version. The second expression sets the default indentation for C language statements to be a little smaller than it is normally — this is just a personal preference; I find that it makes C code more readable.

The comment character in Lisp is "`;`". Emacs ignores anything following one, unless it appears inside a literal string, like so:

```
;; these two lines are ignored by the Lisp interpreter, but the
;; s-expression following them will be evaluated in full:
(setq some-literal-string "An awkward pause; for no purpose.")
```

It's a good idea to comment your changes to Lisp files, because six months later you will have no memory of what you were thinking when you modified them. If the comment appears on a line by itself, precede it with two semicolons. This aids Emacs in indenting Lisp files correctly.

You can find out about internal Emacs variables the same ways you find out about functions. Use `C-h v`, `describe-variable` to make a completion list, or use `C-h C-a`, `apropos`. `Apropos` differs from `C-h a`, `command-apropos`, in that it shows functions and variables instead of just functions.

The default extension for Emacs Lisp files is "`.el`", as in "`c-mode.el`". However, to make Lisp code run faster, Emacs allows it to be **byte-compiled**, and these files of compiled Lisp code end in "`.elc`" instead of "`.el`". The exception to this is your `.emacs` file, which does not need the `.el` extension because Emacs knows to search for it on startup.

To load a file of Lisp code interactively, use the command `M-x load-file`. It will prompt you for the name of the file. To load Lisp files from inside other Lisp files, do this:

```
(load "c-mode") ; force Emacs to load the stuff in c-mode.el or .elc
```

Emacs will first add the .elc extension to the filename and try to find it somewhere in the load-path. If it fails, it tries it with the .el extension; failing that, it uses the literal string as passed to load. You can byte-compile a file with the command M-x byte-compile-file, but if you modify the file often, it's probably not worth it. You should never byte-compile your .emacs, though, nor even give it a .el extension.

After your .emacs has been loaded, Emacs searches for a file named default.el to load. Usually it's located in a directory in load-path called site-lisp or local-elisp or something (see the example load-path I gave a while ago). People who maintain Emacs on multi-user systems use default.el to make changes that will affect everyone's Emacs, since everybody's Emacs loads it after their personal .emacs. Default.el should not be byte-compiled either, since it tends to be modified fairly often.

If a person's .emacs contains any errors, Emacs will not attempt to load default.el, but instead will just stop, flashing a message saying "Error in init file." or something. If you see this message, there's probably something wrong with your .emacs.

There is one more kind of expression that often goes in a .emacs. The Emacs Lisp library sometimes offers multiple packages for doing the same thing in different ways. This means that you have to specify which one you want to use (or you'll get the default package, which is not always the best one for all purposes). One area in which this happens is Emacs's Scheme interaction features. There are two different Scheme interfaces distributed with Emacs (in version 19 at least): xscheme and cmuscheme.

```
prompt> ls /usr/lib/emacs/19.19/lisp/*scheme*
/usr/lib/emacs/19.19/lisp/cmuscheme.el
/usr/lib/emacs/19.19/lisp/cmuscheme.elc
/usr/lib/emacs/19.19/lisp/scheme.el
/usr/lib/emacs/19.19/lisp/scheme.elc
/usr/lib/emacs/19.19/lisp/xscheme.el
/usr/lib/emacs/19.19/lisp/xscheme.elc
```

I happen to like the interface offered by cmuscheme much better than that offered by xscheme, but the one Emacs will use by default is xscheme. How can I cause Emacs to act in accordance with my preference? I put this in my .emacs:

```
;; notice how the expression can be broken across two lines.  Lisp
;; ignores whitespace, generally:
(autoload 'run-scheme "cmuscheme"
"Run an inferior Scheme, the way I like it." t)
```

The function autoload takes the name of a function (quoted with "'", for reasons having to do with how Lisp works) and tells Emacs that this function is defined in a certain file. The file is the second argument, a string (without the ".el" or ".elc" extension) indicating the name of the file to search for in the load-path.

The remaining arguments are optional, but necessary in this case: the third argument is a documentation string for the function, so that if you call describe-function on it, you get some useful information. The fourth argument tells Emacs that this autoloadable function can be called interactively (that is, by using `M-x`). This is very important in this case, because one should be able to type `M-x run-scheme` to start a scheme process running under Emacs.

Now that `run-scheme` has been defined as an autoloadable function, what happens when I type `M-x run-scheme`? Emacs looks at the function `run-scheme`, sees that it's set to be autoloaded, and loads the file named by the autoload (in this case, "`cmuscheme`"). The byte-compiled file `cmuscheme.elc` exists, so Emacs will load that. That file *must* define the function `run-scheme`, or there will be an autoload error. Luckily, it does define `run-scheme`, so everything goes smoothly, and I get my preferred Scheme interface[10].

An `autoload` is a like a promise to Emacs that, when the time comes, it can find the specified function in the file you tell it to look in. In return, you get some control over what gets loaded. Also, autoloads help cut down on Emacs's size in memory, by not loading certain features until they are asked for. Many commands are not really defined as functions when Emacs starts up. Rather, they are simply set to autoload from a certain file. If you never invoke the command, it never gets loaded. This space saving is actually vital to the functioning of Emacs: if it loaded every available file in the Lisp library, Emacs would take twenty minutes just to start up, and once it was done, it might occupy most of the available memory on your machine. Don't worry, you don't have to set all these autoloads in your `.emacs`; they were taken care of when Emacs was built.

8.14 Finding Out More

I have not told you everything there is to know about Emacs. In fact, I don't think I have even told you 1% of what there is to know about Emacs. While you know enough to get by, there are still lots of time-saving tricks and conveniences that you ought to find out about. The best way to do this is to wait until you find yourself needing something, and then look for a function that does it.

The importance of being comfortable with Emacs's online help facilities cannot be emphasized enough. For example, suppose you want to be able to insert the contents of some file into a buffer that is already working on a different file, so that the buffer contains both of them. Well, if you were to guess that there is a command called `insert-file`, you'd be right. To check your educated guess, type `C-h f`. At the prompt in the minibuffer, enter the name of a function that you want help on. Since you know that there is completion on function names, and you can guess that the command you are looking for begins with "insert", you type insert and hit Tab. This shows you all the function names that begin with "insert", and "insert-file" is one of them.

So you complete the function name and read about how it works, and then use `M-x insert-file`. If you're wondering whether it's also bound to a key, you type `C-h w insert-file` Return, and find out. The more you know about Emacs's help facilities, the more easily you can ask Emacs questions about itself. The ability to do so, combined with a spirit of exploration and a willingness to learn new ways of doing things, can end up saving you a lot of keystrokes.

To order a copy of the Emacs user's manual and/or the Emacs Lisp Programming manual, write

[10] By the way, `cmuscheme` was the interface I was talking about earlier, in the section on working with Scheme, so if you want to use any of the stuff from that tutorial, you need to make sure that you run `cmuscheme`.

to:

Free Software Foundation
675 Mass Ave
Cambridge, MA 02139
USA

Both of these manuals are distributed electronically with Emacs, in a form readable by using the Info documentation reader (`C-h i`), but you may find it easier to deal with treeware than with the online versions. Also, their prices are quite reasonable, and the money goes to a good cause — quality free software! At some point, you should type `C-h C-c` to read the copyright conditions for Emacs. It's more interesting than you might think, and will help clarify the concept of free software. If you think the term "free software" just means that the program doesn't cost anything, please do read that copyright as soon as you have time!

Chapter 9

I Gotta Be Me!

If God had known we'd need foresight, she would have given it to us.

9.1 `bash` Customization

One of the distinguishing things about the Unix philosophy is that the system's designers did not attempt to predict every need that users might have; instead, they tried to make it easy for each individual user to tailor the environment to their own particular needs. This is mainly done through **configuration files**. These are also known as "init files", "rc files" (for "run control"), or even "dot files", because the filenames often begin with "`.`". If you'll recall, filenames that start with "`.`" aren't normally displayed by `ls`.

The most important configuration files are the ones used by the shell. Linux's default shell is `bash`, and that's the shell this chapter covers. Before we go into how to customize `bash`, we should know what files `bash` looks at.

9.1.1 Shell Startup

There are several different ways `bash` can run. It can run as a **login shell**, which is how it runs when you first login. The login shell should be the first shell you see.

Another way `bash` can run is as an **interactive shell**. This is any shell which presents a prompt to a human and waits for input. A login shell is also an interactive shell. A way you can get a non-login interactive shell is, say, a shell inside `xterm`. Any shell that was created by some other way besides logging in is a non-login shell.

Finally, there are **non-interactive shells**. These shells are used for executing a file of commands, much like MS-DOS's batch files—the files that end in `.BAT`. These **shell scripts** function like mini-programs. While they are usually much slower than a regular compiled program, it is often true that they're easier to write.

Depending on the type of shell, different files will be used at shell startup:

Type of Shell	Action
Interactive login	The file `.bash_profile` is read and executed
Interactive	The file `.bashrc` is read and executed
Non-interactive	The shell script is read and executed

9.1.2 Startup Files

Since most users want to have largely the same environment no matter what type of interactive shell they wind up with, whether or not it's a login shell, we'll start our configuration by putting a very simple command into our `.bash_profile`: "`source ~/.bashrc`". The `source` command tells the shell to interprete the argument as a shell script. What it means for us is that everytime `.bash_profile` is run, `.bashrc` is *also* run.

Now, we'll just add commands to our `.bashrc`. If you ever want a command to only be run when you login, add it to your `.bash_profile`.

9.1.3 Aliasing

What are some of the things you might want to customize? Here's something that I think about 90% of Bash users have put in their `.bashrc`:

```
alias ll="ls -l"
```

That command defined a shell **alias** called `ll` that "expands" to the normal shell command "`ls -l`" when invoked by the user. So, assuming that Bash has read that command in from your `.bashrc`, you can just type `ll` to get the effect of "`ls -l`" in only half the keystrokes. What happens is that when you type `ll` and hit Return, Bash intercepts it, because it's watching for aliases, replaces it with "ls -l", and runs that instead. There is no actual program called `ll` on the system, but the shell automatically translated the alias into a valid program.

Some sample aliases are in Figure 9.1.3. You could put them in your own `.bashrc`. One especially interesting alias is the first one. With that alias, whenever someone types `ls`, they automatically have a `-F` flag tacked on. (The alias doesn't try to expand itself again.) This is a common way of adding options that you use every time you call a program.

Notice the comments with the `#` character in Figure 9.1.3. Whenever a `#` appears, the shell ignores the rest of the line.

You might have noticed a few odd things about them. First of all, I leave off the quotes in a few of the aliases—like `pu`. Strictly speaking, quotes aren't necessary when you only have one word on the right of the equal sign.

It never hurts to have quotes either, so don't let me get you into any bad habits. You should certainly use them if you're going to be aliasing a command with options and/or arguments:

```
alias rf="refrobnicate -verbose -prolix -wordy -o foo.out"
```

Figure 9.1 Some sample aliases for bash.

```
alias ls="ls -F"          # give characters at the end of listing
alias ll="ls -l"          # special ls
alias la="ls -a"
alias ro="rm *~; rm .*~"  # this removes backup files created by Emacs
alias rd="rmdir"          # saves typing!
alias md="mkdir"
alias pu=pushd            # pushd, popd, and dirs weren't covered in this
alias po=popd             # manual---you might want to look them up
alias ds=dirs             # in the bash manpage
# these all are just keyboard shortcuts
alias to="telnet cs.oberlin.edu"
alias ta="telnet altair.mcs.anl.gov"
alias tg="telnet wombat.gnu.ai.mit.edu"
alias tko="tpalk kold@cs.oberlin.edu"
alias tjo="talk jimb@cs.oberlin.edu"
alias mroe="more"         # spelling correction!
alias moer="more"
alias email="emacs -f rmail" # my mail reader
alias ed2="emacs -d floss:0 -fg \"grey95\" -bg \"grey50\""
                          # one way of invoking emacs
```

Also, the final alias has some funky quoting going on:

```
alias ed2="emacs -d floss:0 -fg \"grey95\" -bg \"grey50\""
```

As you might have guessed, I wanted to pass double-quotes in the options themselves, so I had to quote those with a backslash to prevent bash from thinking that they signaled the end of the alias.

Finally, I have actually aliased two common typing mistakes, "mroe" and "moer", to the command I meant to type, more. Aliases do not interfere with your passing arguments to a program. The following works just fine:

```
/home/larry# mroe hurd.txt
```

In fact, knowing how to make your own aliases is probably at least half of all the shell customization you'll ever do. Experiment a little, find out what long commands you find yourself typing frequently, and make aliases for them. You'll find that it makes working at a shell prompt a much more pleasant experience.

9.1.4 Environment Variables

Another major thing one does in a .bashrc is set **environment variables**. And what are environment variables? Let's go at it from the other direction: suppose you are reading the documentation for the program fruggle, and you run across these sentences:

> Fruggle normally looks for its configuration file, `.fugglerc`, in the user's home directory. However, if the environment variable `FRUGGLEPATH` is set to a different filename, it will look there instead.

Every program executes in an **environment**, and that environment is defined by the shell that called the program[1]. The environment could be said to exist "within" the shell. Programmers have a special routine for querying the environment, and the `fruggle` program makes use of this routine. It checks the value of the environment variable `FRUGGLEPATH`. If that variable turns out to be undefined, then it will just use the file `.frugglerc` in your home directory. If it is defined, however, `fruggle` will use the variable's value (which should be the name of a file that `fruggle` can use) instead of the default `.frugglerc`.

Here's how you can change your environment in `bash`:

```
/home/larry# export PGPPATH=/home/larry/secrets/pgp
```

You may think of the `export` command as meaning "Please export this variable out to the environment where I will be calling programs, so that its value is visible to them." There are actually reasons to call it `export`, as you'll see later.

This particular variable is used by Phil Zimmerman's infamous public-key encryption program, `pgp`. By default, `pgp` uses your home directory as a place to find certain files that it needs (containing encryption keys), and also as a place to store temporary files that it creates when it's running. By setting variable `PGPPATH` to this value, I have told it to use the directory `/home/larry/secrets/pgp` instead. I had to read the `pgp` manual to find out the exact name of the variable and what it does, but it is farily standard to use the name of the program in capital letters, prepended to the suffix "PATH".

It is also useful to be able to query the environment:

```
/home/larry# echo $PGPPATH
/home/larry/.pgp
/home/larry#
```

Notice the "$"; you prefix an environment variable with a dollar sign in order to extract the variable's value. Had you typed it without the dollar sign, `echo` would have simply echoed its argument(s):

```
/home/larry# echo PGPPATH
PGPPATH
/home/larry#
```

The "$" is used to *evaluate* environment variables, but it only does so in the context of the shell—that is, when the shell is interpreting. When is the shell interpreting? Well, when you are

[1] Now you see why shells are so important. Imagine if you had to pass a whole environment by hand every time you called a program!

Figure 9.2 Some important environment variables.

Variable name	Contains	Example
HOME	Your home directory	/home/larry
TERM	Your terminal type	xterm, vt100, or console
SHELL	The path to your shell	/bin/bash
USER	Your login name	larry
PATH	A list to search for programs	/bin:/usr/bin:/usr/local/bin:/usr/bin/X11

typing commands at the prompt, or when `bash` is reading commands from a file like `.bashrc`, it can be said to be "interpreting" the commands.

There's another command that's very useful for querying the environment: `env`. `env` will merely list all the environment variables. It's possible, especially if you're using X, that the list will scroll off the screen. If that happens, just pipe `env` through `more`: `env | more`.

A few of these variables can be fairly useful, so I'll cover them. Look at Figure 9.1.4. Those four variables are defined automatically when you login: you don't set them in your `.bashrc` or `.bash_login`.

Let's take a closer look at the `TERM` variable. To understand that one, let's look back into the history of Unix: The operating system needs to know certain facts about your console, in order to perform basic functions like writing a character to the screen, moving the cursor to the next line, etc. In the early days of computing, manufacturers were constantly adding new features to their terminals: first reverse-video, then maybe European character sets, eventually even primitive drawing functions (remember, these were the days before windowing systems and mice). However, all of these new functions represented a problem to programmers: how could they know what a terminal supported and didn't support? And how could they support new features without making old terminals worthless?

In Unix, the answer to these questions was `/etc/termcap`. `/etc/termcap` is a list of all of the terminals that your system knows about, and how they control the cursor. If a system administrator got a new terminal, all they'd have to do is add an entry for that terminal into `/etc/termcap` instead of rebuilding all of Unix. Sometimes, it's even simplier. Along the way, Digital Equipment Corporation's vt100 terminal became a pseudo-standard, and many new terminals were built so that they could emulate it, or behave as if they were a vt100.

Under LINUX, `TERM`'s value is sometimes `console`, which is a vt100-like terminal with some extra features.

Another variable, `PATH`, is also crucial to the proper functioning of the shell. Here's mine:

```
/home/larry# env | grep ^PATH
PATH=/home/larry/bin:/bin:/usr/bin:/usr/local/bin:/usr/bin/X11:/usr/TeX/bin
/home/larry#
```

Your `PATH` is a colon-separated list of the directories the shell should search for programs, when you type the name of a program to run. When I type `ls` and hit Return, for example, the Bash first looks in /home/larry/bin, a directory I made for storing programs that I wrote. However, I didn't write ls (in fact, I think it might have been written before I was born!). Failing to find it in /home/larry/bin, Bash looks next in /bin—and there it has a hit! /bin/ls does exist and is executable, so Bash stops searching for a program named ls and runs it. There might well have been another ls sitting in the directory /usr/bin, but bash would never run it unless I asked for it by specifying an explicit pathname:

```
/home/larry# /usr/bin/ls
```

The PATH variable exists so that we don't have to type in complete pathnames for every command. When you type a command, Bash looks for it in the directories named in PATH, in order, and runs it if it finds it. If it doesn't find it, you get a rude error:

```
/home/larry# clubly
clubly: command not found
```

Notice that my PATH does not have the current directory, ".", in it. If it did, it might look like this:

```
/home/larry# echo $PATH
.:/home/larry/bin:/bin:/usr/bin:/usr/local/bin:/usr/bin/X11:/usr/TeX/bin
/home/larry#
```

This is a matter of some debate in Unix-circles (which you are now a member of, whether you like it or not). The problem is that having the current directory in your path can be a security hole. Suppose that you cd into a directory where somebody has left a "Trojan Horse" program called ls, and you do an ls, as would be natural on entering a new directory. Since the current directory, ".", came first in your PATH, the shell would have found this version of ls and executed it. Whatever mischief they might have put into that program, you have just gone ahead and executed (and that could be quite a lot of mischief indeed). The person did not need root privileges to do this; they only needed write permission on the directory where the "false" ls was located. It might even have been their home directory, if they knew that you would be poking around in there at some point.

On your own system, it's highly unlikely that people are leaving traps for each other. All the users are probably friends or colleagues of yours. However, on a large multi-user system (like many university computers), there could be plenty of unfriendly programmers whom you've never met. Whether or not you want to take your chances by having "." in your path depends on your situation; I'm not going to be dogmatic about it either way, I just want you to be aware of the risks involved[2]. Multi-user systems really are communities, where people can do things to one another in all sorts of unforseen ways.

The actual way that I set my PATH involves most of what you've learned so far about environment variables. Here is what is actually in my .bashrc:

```
export PATH=${PATH}:.:${HOME}/bin:/bin:/usr/bin:/usr/local/bin:/usr/bin/X11:/usr/TeX/bin
```

[2]Remember that you can always execute programs in the current directory by being explicit about it, i.e.: "./foo".

Here, I am taking advantage of the fact that the `HOME` variable is set before Bash reads my `.bashrc`, by using its value in setting my `PATH`. The curly braces ("`{...}`") are a further level of quoting; they delimit the extent of what the "$" is to evaluate, so that the shell doesn't get confused by the text immediately following it ("`/bin`" in this case). Here is another example of the effect they have:

```
/home/larry# echo ${HOME}foo
/home/larryfoo
/home/larry#
```

Without the curly braces, I would get nothing, since there is no environment variables named `HOMEfoo`.

```
/home/larry# echo $HOMEfoo

/home/larry#
```

Let me clear one other thing up in that path: the meaning of "`$PATH`". What that does is includes the value of any `PATH` variable *previously* set in my new `PATH`. Where would the old variable be set? The file `/etc/profile` serves as a kind of global `.bash_profile` that is common to all users. Having one centralized file like that makes it easier for the system administrator to add a new directory to everyone's `PATH` or something, without them all having to do it individually. If you include the old path in your new path, you won't lose any directories that the system already setup for you.

You can also control what your prompt looks like. This is done by setting the value of the environment variable **PS1**. Personally, I want a prompt that shows me the path to the current working directory—here's how I do it in my `.bashrc`:

```
export PS1='$PWD# '
```

As you can see, there are actually *two* variables being used here. The one being set is `PS1`, and it is being set to the value of `PWD`, which can be thought of as either "Print Working Directory" or "Path to Working Directory". But the evaluation of `PWD` takes place inside single quotes. The single quotes serve to evaluate the expression inside them, which itself evaluates the variable `PWD`. If you just did `export PS1=$PWD`, your prompt would constantly display the path to the current directory *at the time that* `PS1` *was set*, instead of constantly updating it as you change directories. Well, that's sort of confusing, and not really all that important. Just keep in mind that you need the quotes if you want the current directory displayed in your prompt.

You might prefer `export PS1='$PWD>'`, or even the name of your system: `` export PS1=`hostname`'>' ``. Let me dissect that last example a little further.

That last example used a *new* type of quoting, the back quotes. These don't protect something—in fact, you'll notice that "hostname" doesn't appear anywhere in the prompt when you run that. What actually happens is that the command inside the backquotes gets evaluated, and the output is put in place of the backquotes and the command name.

Try `` echo `ls` `` or `` wc `ls` ``. As you get more experienced using the shell, this technique gets more and more powerful.

There's a lot more to configuring your .bashrc, and not enough room to explain it here. You can read the bash man page for more, or ask questions of experienced Bash users. Here is a complete .bashrc for you to study; it's fairly standard, although the search path is a little long.

```
# some random stuff:
ulimit -c unlimited
export history_control=ignoredups
export PS1='$PWD>'
umask 022

# application-specific paths:
export MANPATH=/usr/local/man:/usr/man
export INFOPATH=/usr/local/info
export PGPPATH=${HOME}/.pgp

# make the main PATH:
homepath=${HOME}:~/bin
stdpath=/bin:/usr/bin:/usr/local/bin:/usr/ucb/:/etc:/usr/etc:/usr/games
pubpath=/usr/public/bin:/usr/gnusoft/bin:/usr/local/contribs/bin
softpath=/usr/bin/X11:/usr/local/bin/X11:/usr/TeX/bin
export PATH=.:${homepath}:${stdpath}:${pubpath}:${softpath}
# Technically, the curly braces were not necessary, because the colons
# were valid delimiters; nevertheless, the curly braces are a good
# habit to get into, and they can't hurt.

# aliases
alias ls="ls -CF"
alias fg1="fg %1"
alias fg2="fg %2"
alias tba="talk sussman@tern.mcs.anl.gov"
alias tko="talk kold@cs.oberlin.edu"
alias tji="talk jimb@totoro.bio.indiana.edu"
alias mroe="more"
alias moer="more"
alias email="emacs -f vm"
alias pu=pushd
alias po=popd
alias b="~/.b"
alias ds=dirs
alias ro="rm *~; rm .*~"
alias rd="rmdir"
alias ll="ls -l"
alias la="ls -a"
alias rr="rm -r"
alias md="mkdir"
alias ed2="emacs -d floss:0 -fg \"grey95\" -bg \"grey50\""

function gco
```

```
{
  gcc -o $1 $1.c -g
}
```

9.2 The X Window System Init Files

Most people prefer to do their work inside a graphical environment, and for Unix machines, that usually means using X. If you're accustomed to the Macintosh or to Microsoft Windows, the X Window System may take a little getting used to, especially in how it is customized.

With the Macintosh or Microsoft Windows, you customize the environment from *within* the environment: if you want to change your background, for example, you do by clicking on the new color in some special graphical setup program. In X, system defaults are controlled by text files, which you edit directly—in other words, you'd type the actual color name into a file in order to set your background to that color.

There is no denying that this method just isn't as slick as some commercial windowing systems. I think this tendency to remain text-based, even in a graphical environment, has to do with the fact that X was created by a bunch of programmers who simply weren't trying to write software that their grandparents could use. This tendency may change in future versions of X (at least I hope it will), but for now, you just have to learn to deal with more text files. It does at least give you very flexible and precise control over your configuration.

Here are the most important files for configuring X:

`.xinitrc`	A script run by X when it starts up.
`.twmrc`	Read by an X window manager, `twm`.
`.fvwmrc`	Read by an X window manager, `fvwm`.

All of these files should be located in your home directory, if they exist at all.

The `.xinitrc` is a simple shell script that gets run when X is invoked. It can do anything any other shell script can do, but of course it makes the most sense to use it for starting up various X programs and setting window system parameters. The last command in the `.xinitrc` is usually the name of a window manager to run, for example `/usr/bin/X11/twm`.

What sort of thing might you want to put in a `.xinitrc` file? Perhaps some calls to the `xsetroot` program, to make your root (background) window and mouse cursor look the way you want them to look. Calls to `xmodmap`, which tells the server[3] how to interpret the signals from your keyboard. Any other programs you want started every time you run X (for example, `xclock`).

Here is some of my `.xinitrc`; yours will almost certainly look different, so this is meant only as an example:

```
#!/bin/sh
# The first line tells the operating system which shell to use in
```

[3]The "server" just means the main X process on your machine, the one with which all other X programs must communicate in order to use the display. These other programs are known as "clients", and the whole deal is called a "client-server" system.

```
# interpreting this script.  The script itself ought to be marked as
# executable; you can make it so with "chmod +x ~/.xinitrc".

# xmodmap is a program for telling the X server how to interpret your
# keyboard's signals.  It is *definitely* worth learning about. You
# can do "man xmodmap", "xmodmap -help", "xmodmap -grammar", and more.
# I don't guarantee that the expressions below will mean anything on
# your system (I don't even guarantee that they mean anything on
# mine):
xmodmap -e 'clear Lock'
xmodmap -e 'keycode 176 = Control_R'
xmodmap -e 'add control = Control_R'
xmodmap -e 'clear Mod2'
xmodmap -e 'add Mod1 = Alt_L Alt_R'

# xset is a program for setting some other parameters of the X server:
xset m 3 2 &       # mouse parameters
xset s 600 5 &     # screen saver prefs
xset s noblank &   # ditto
xset fp+ /home/larry/x/fonts # for cxterm
# To find out more, do "xset -help".

# Tell the X server to superimpose fish.cursor over fish.mask, and use
# the resulting pattern as my mouse cursor:
xsetroot -cursor /home/lab/larry/x/fish.cursor /home/lab/larry/x/fish.mask &

# a pleasing background pattern and color:
xsetroot -bitmap /home/lab/larry/x/pyramid.xbm -bg tan

# todo: xrdb here?  What about .Xdefaults file?

# You should do "man xsetroot", or "xsetroot -help" for more
# information on the program used above.

# A client program, the imposing circular color-clock by Jim Blandy:
/usr/local/bin/circles &

# Maybe you'd like to have a clock on your screen at all times?
/usr/bin/X11/xclock -digital &

# Allow client X programs running at occs.cs.oberlin.edu to display
# themselves here, do the same thing for juju.mcs.anl.gov:
xhost occs.cs.oberlin.edu
xhost juju.mcs.anl.gov

# You could simply tell the X server to allow clients running on any
# other host (a host being a remote machine) to display here, but this
# is a security hole -- those clients might be run by someone else,
```

```
# and watch your keystrokes as you type your password or something!
# However, if you wanted to do it anyway, you could use a "+" to stand
# for all possible hostnames, instead of a specific hostname, like
# this:
# xhost +

# And finally, run the window manager:
/usr/bin/X11/twm
# Some people prefer other window managers.  I use twm, but fvwm is
# often distributed with Linux too:
# /usr/bin/X11/fvwm
```

Notice that some commands are run in the background (i.e.: they are followed with a "&"), while others aren't. The distinction is that some programs will start when you start X and keep going until you exit—these get put in the background. Others execute once and then exit immediately. `xsetroot` is one such; it just sets the root window or cursor or whatever, and then exits.

Once the window manager has started, it will read its own init file, which controls things like how your menus are set up, which positions windows are brought up at, icon control, and other earth-shakingly important issues. If you use `twm`, then this file is `.twmrc` in your home directory. If you use `fvwm`, then it's `.fvwmrc`, etc. I'll deal with only those two, since they're the window managers you'll be most likely to encounter with Linux.

9.2.1 Twm Configuration

The `.twmrc` is not a shell script—it's actually written in a language specially made for `twm`, believe it or not![4] The main thing people like to play with in their `.twmrc` is window style (colors and such), and making cool menus, so here's an example `.twmrc` that does that:

```
# Set colors for the various parts of windows.  This has a great
# impact on the "feel" of your environment.
Color
{
    BorderColor "OrangeRed"
    BorderTileForeground "Black"
    BorderTileBackground "Black"
    TitleForeground "black"
    TitleBackground "gold"
    MenuForeground "black"
    MenuBackground "LightGrey"
    MenuTitleForeground "LightGrey"
    MenuTitleBackground "LightSlateGrey"
    MenuShadowColor "black"
```

[4]This is one of the harsh facts about init files: they generally each have their own idiosyncratic command language. This means that users get very good at learning command languages quickly. I suppose that it would have been nice if early Unix programmers had agreed on some standard init file format, so that we wouldn't have to learn new syntaxes all the time, but to be fair it's hard to predict what kinds of information programs will need.

```
    IconForeground "DimGray"
    IconBackground "Gold"
    IconBorderColor "OrangeRed"
    IconManagerForeground "black"
    IconManagerBackground "honeydew"
}

# I hope you don't have a monochrome system, but if you do...
Monochrome
{
    BorderColor "black"
    BorderTileForeground "black"
    BorderTileBackground "white"
    TitleForeground "black"
    TitleBackground "white"
}

# I created beifang.bmp with the program "bitmap".  Here I tell twm to
# use it as the default highlight pattern on windows' title bars:
Pixmaps
{
    TitleHighlight "/home/larry/x/beifang.bmp"
}

# Don't worry about this stuff, it's only for power users :-)
BorderWidth     2
TitleFont       "-adobe-new century schoolbook-bold-r-normal--14-140-75-75-p-87-iso8859-1"
MenuFont        "6x13"
IconFont        "lucidasans-italic-14"
ResizeFont      "fixed"
Zoom 50
RandomPlacement

# These programs will not get a window titlebar by default:
NoTitle
{
  "stamp"
  "xload"
  "xclock"
  "xlogo"
  "xbiff"
  "xeyes"
  "oclock"
  "xoid"
}

# "AutoRaise" means that a window is brought to the front whenever the
# mouse pointer enters it.  I find this annoying, so I have it turned
```

```
# off.  As you can see, I inherited my .twmrc from people who also did
# not like autoraise.
AutoRaise
{
  "nothing"     # I don't like auto-raise  # Me either  # nor I
}

# Here is where the mouse button functions are defined.  Notice the
# pattern: a mouse button pressed on the root window, with no modifier
# key being pressed, always brings up a menu.  Other locations usually
# result in window manipulation of some kind, and modifier keys are
# used in conjunction with the mouse buttons to get at the more
# sophisticated window manipulations.
#
# You don't have to follow this pattern in your own .twmrc -- it's
# entirely up to you how you arrange your environment.

# Button = KEYS : CONTEXT : FUNCTION
# ----------------------------------
Button1 =      : root    : f.menu "main"
Button1 =      : title   : f.raise
Button1 =      : frame   : f.raise
Button1 =      : icon    : f.iconify
Button1 = m    : window  : f.iconify

Button2 =      : root    : f.menu "stuff"
Button2 =      : icon    : f.move
Button2 = m    : window  : f.move
Button2 =      : title   : f.move
Button2 =      : frame   : f.move
Button2 = s    : frame   : f.zoom
Button2 = s    : window  : f.zoom

Button3 =      : root    : f.menu "x"
Button3 =      : title   : f.lower
Button3 =      : frame   : f.lower
Button3 =      : icon    : f.raiselower

# You can write your own functions; this one gets used in the menu
# "windowops" near the end of this file:
Function "raise-n-focus"
{
    f.raise
    f.focus
}

# Okay, below are the actual menus referred to in the mouse button
# section).  Note that many of these menu entries themselves call
```

```
# sub-menus.  You can have as many levels of menus as you want, but be
# aware that recursive menus don't work.  I've tried it.

menu "main"
{
"Vanilla"       f.title
"Emacs"         f.menu "emacs"
"Logins"        f.menu "logins"
"Xlock"         f.menu "xlock"
"Misc"          f.menu "misc"
}

# This allows me to invoke emacs on several different machines.  See
# the section on .rhosts files for more information about how this
# works:
menu "emacs"
{
"Emacs"      f.title
"here"       !"/usr/bin/emacs &"
""           f.nop
"phylo"      !"rsh phylo \"emacs -d floss:0\" &"
"geta"       !"rsh geta \"emacs -d floss:0\" &"
"darwin"     !"rsh darwin \"emacs -d floss:0\" &"
"ninja"      !"rsh ninja \"emacs -d floss:0\" &"
"indy"       !"rsh indy \"emacs -d floss:0\" &"
"oberlin"    !"rsh cs.oberlin.edu \"emacs -d floss.life.uiuc.edu:0\" &"
"gnu"        !"rsh gate-1.gnu.ai.mit.edu \"emacs -d floss.life.uiuc.edu:0\" &"
}

# This allows me to invoke xterms on several different machines.  See
# the section on .rhosts files for more information about how this
# works:
menu "logins"
{
"Logins"     f.title
"here"       !"/usr/bin/X11/xterm -ls -T `hostname` -n `hostname` &"
"phylo"      !"rsh phylo \"xterm -ls -display floss:0 -T phylo\" &"
"geta"       !"rsh geta \"xterm -ls -display floss:0 -T geta\" &"
"darwin"     !"rsh darwin \"xterm -ls -display floss:0 -T darwin\" &"
"ninja"      !"rsh ninja \"xterm -ls -display floss:0 -T ninja\" &"
"indy"       !"rsh indy \"xterm -ls -display floss:0 -T indy\" &"
}

# The xlock screensaver, called with various options (each of which
# gives a different pretty picture):
menu "xlock"
{
"Hop"   !"xlock -mode hop &"
```

```
"Qix"   !"xlock -mode qix &"
"Flame" !"xlock -mode flame &"
"Worm" !"xlock -mode worm &"
"Swarm" !"xlock -mode swarm &"
"Hop NL"   !"xlock -mode hop -nolock &"
"Qix NL"   !"xlock -mode qix -nolock &"
"Flame NL" !"xlock -mode flame -nolock &"
"Worm NL" !"xlock -mode worm -nolock &"
"Swarm NL" !"xlock -mode swarm -nolock &"
}

# Miscellaneous programs I run occasionally:
menu "misc"
{
"Xload"         !"/usr/bin/X11/xload &"
"XV"            !"/usr/bin/X11/xv &"
"Bitmap"        !"/usr/bin/X11/bitmap &"
"Tetris"        !"/usr/bin/X11/xtetris &"
"Hextris"       !"/usr/bin/X11/xhextris &"
"XRoach"        !"/usr/bin/X11/xroach &"
"Analog Clock"  !"/usr/bin/X11/xclock -analog &"
"Digital Clock" !"/usr/bin/X11/xclock -digital &"
}

# This is the one I bound to the middle mouse button:
menu "stuff"
{
"Chores"       f.title
"Sync"         !"/bin/sync"
"Who"          !"who | xmessage -file - -columns 80 -lines 24 &"
"Xhost +"      !"/usr/bin/X11/xhost + &"
"Rootclear"    !"/home/larry/bin/rootclear &"
}

# X functions that are sometimes convenient:
menu "x"
{
"X Stuff"                f.title
"Xhost +"                !"xhost + &"
"Refresh"                f.refresh
"Source .twmrc"          f.twmrc
"(De)Iconify"            f.iconify
"Move Window"            f.move
"Resize Window"          f.resize
"Destroy Window"         f.destroy
"Window Ops"             f.menu "windowops"
""                       f.nop
"Kill twm"               f.quit
```

```
}

# This is a submenu from above:
menu "windowops"
{
"Window Ops"            f.title
"Show Icon Mgr"         f.showiconmgr
"Hide Icon Mgr"         f.hideiconmgr
"Refresh"               f.refresh
"Refresh Window"        f.winrefresh
"twm version"           f.version
"Focus on Root"         f.unfocus
"Source .twmrc"         f.twmrc
"Cut File"              f.cutfile
"(De)Iconify"           f.iconify
"DeIconify"             f.deiconify
"Move Window"           f.move
"ForceMove Window"      f.forcemove
"Resize Window"         f.resize
"Raise Window"          f.raise
"Lower Window"          f.lower
"Raise or Lower"        f.raiselower
"Focus on Window"       f.focus
"Raise-n-Focus"         f.function "raise-n-focus"
"Destroy Window"        f.destroy
"Kill twm"              f.quit
}
```

Whew! Believe me, that's not even the most involved .twmrc I've ever seen. It's quite probable that some decent example `.twmrc` files came with your X. Take a look in the directory `/usr/lib/X11/twm/` or `/usr/X11/lib/X11/twm` and see what's there.

One bug to watch out for with `.twmrc` files is forgetting to put the & after a command on a menu. If you notice that X just freezes when you run certain commands, chances are that this is the cause. Break out of X with Control-Alt-Backspace, edit your `.twmrc`, and try again.

9.2.2 Fvwm Configuration

If you are using `fvwm`, the directory `/usr/lib/X11/fvwm/` (or `/usr/X11/lib/X11/fvwm/`) has some good example config files in it, as well.

[Folks: I don't know anything about fvwm, although I might be able to grok something from the example config files. Then again, so could the reader :-). Also, given the decent but small system.twmrc in the above-mentioned directory, I wonder if it's worth it for me to provide that lengthy example with my own .twmrc. It's in for now, but I don't know whether we want to leave it there or not. -Karl]

9.3 Other Init Files

Some other initialization files of note are:

`.emacs`	Read by the Emacs text editor when it starts up.
`.netrc`	Gives default login names and passwords for ftp.
`.rhosts`	Makes your account remotely accessible.
`.forward`	For automatic mail forwarding.

9.3.1 The Emacs Init File

If you use `emacs` as your primary editor, then the `.emacs` file is quite important. It is dealt with at length in Chapter 8.

9.3.2 FTP Defaults

Your .netrc file allows you to have certain `ftp` defaults set before you run `ftp`. Here is a small sample `.netrc`:

```
machine floss.life.uiuc.edu login larry password fishSticks
machine darwin.life.uiuc.edu login larry password fishSticks
machine geta.life.uiuc.edu login larry password fishSticks
machine phylo.life.uiuc.edu login larry password fishSticks
machine ninja.life.uiuc.edu login larry password fishSticks
machine indy.life.uiuc.edu login larry password fishSticks

machine clone.mcs.anl.gov login fogel password doorm@
machine osprey.mcs.anl.gov login fogel password doorm@
machine tern.mcs.anl.gov login fogel password doorm@
machine altair.mcs.anl.gov login fogel password doorm@
machine dalek.mcs.anl.gov login fogel password doorm@
machine juju.mcs.anl.gov login fogel password doorm@

machine sunsite.unc.edu login anonymous password larry@cs.oberlin.edu
```

Each line of your `.netrc` specifies a machine name, a login name to use by default for that machine, and a password. This is a great convenience if you do a lot of `ftp`-ing and are tired of constantly typing in your username and password at various sites. The `ftp` program will try to log you in automatically using the information found in your `.netrc` file, if you `ftp` to one of the machines listed in the file.

You can tell `ftp` to ignore your .netrc and not attempt auto-login by invoking it with the `-n` option: "`ftp -n`".

You must make sure that your `.netrc` file is readable *only* by you. Use the `chmod` program to set the file's read permissions. If other people can read it, that means they can find out your password at various other sites. This is about as big a security hole as one can have; to encourage you to be careful, `ftp` and other programs that look for the `.netrc` file will actually refuse to work if the read permissions on the file are bad.

There's more to the `.netrc` file than what I've said; when you get a chance, do "`man .netrc`" or "`man ftp`".

9.3.3 Allowing Easy Remote Access to Your Account

If you have an `.rhosts` file in your home directory, it will allow you to run programs on this machine remotely. That is, you might be logged in on the machine `cs.oberlin.edu`, but with a correctly configured `.rhosts` file on floss.life.uiuc.edu, you could run a program on `floss.life.uiuc.edu` and have the output go to `cs.oberlin.edu`, without ever having to log in or type a password.

A `.rhosts` file looks like this:

```
frobnozz.cs.knowledge.edu jsmith
aphrodite.classics.hahvaahd.edu wphilps
frobbo.hoola.com trixie
```

The format is fairly straightforward: a machine name, followed by username. Suppose that that example is in fact my `.rhosts` file on `floss.life.uiuc.edu`. That would mean that I could run programs on floss, with output going to any of the machines listed, as long as I were also logged in as the corresponding user given for that machine when I tried to do it.

The exact mechanism by which one runs a remote program is usually the `rsh` program. It stands for "remote shell", and what it does is start up a shell on a remote machine and execute a specified command. For example:

```
frobbo$ whoami
trixie
frobbo$ rsh floss.life.uiuc.edu "ls ~"
foo.txt    mbox   url.ps    snax.txt
frobbo$ rsh floss.life.uiuc.edu "more ~/snax.txt"
[snax.txt comes paging by here]
```

User trixie at floss.life.uiuc.edu, who had the example `.rhosts` shown previously, explicitly allows trixie at frobbo.hoola.com to run programs as trixie from floss.

You don't have to have the same username on all machines to make a `.rhosts` work right. Use the "`-l`" option to `rsh`, to tell the remote machine what username you'd like to use for logging in. If that username exists on the remote machine, and has a `.rhosts` file with your current (i.e.: local) machine and username in it, then your `rsh` will succeed.

```
frobbo$ whoami
trixie
frobbo$ rsh -l larry floss.life.uiuc.edu "ls ~"
[Insert a listing of my directory on floss here]
```

This will work if user `larry` on `floss.life.uiuc.edu` has a `.rhosts` file which allows `trixie` from `frobbo.hoopla.com` to run programs in his account. Whether or not they are the same person is irrelevant: the only important things are the usernames, the machine names, and the entry in larry's `.rhosts` file on floss. Note that trixie's `.rhosts` file on frobbo doesn't enter into it, only the one on the remote machine matters.

There are other combinations that can go in a `.rhosts` file—for example, you can leave off the username following a remote machine name, to allow any user from that machine to run programs as you on the local machine! This is, of course, a security risk: someone could remotely run a program that removes your files, just by virtue of having an account on a certain machine. If you're going to do things like leave off the username, then you ought to make sure that your `.rhosts` file is readable by you and no one else.

9.3.4 Mail Forwarding

You can also have a `.forward` file, which is not strictly speaking an "init file". If it contains an email address, then all mail to you will be forwarded to that address instead. This is useful when you have accounts on many different systems, but only want to read mail at one location.

There is a host of other possible initialization files. The exact number will vary from system to system, and is dependent on the software installed on that system. One way to learn more is to look at files in your home directory whose names begin with "`.`". These files are not all guaranteed to be init files, but it's a good bet that most of them are.

9.4 Seeing Some Examples

The ultimate example I can give you is a running Linux system. So, if you have Internet access, feel free to telnet to `floss.life.uiuc.edu`. Log in as "guest", password "explorer", and poke around. Most of the example files given here can be found in `/home/kfogel`, but there are other user directories as well. You are free to copy anything that you can read. Please be careful: floss is not a terribly secure box, and you can almost certainly gain root access if you try hard enough. I prefer to rely on trust, rather than constant vigilance, to maintain security.

Chapter 10

Talking to Others

"One basic notion underlying Usenet is that it is a cooperative."

Having been on Usenet for going on ten years, I disagree with this. The basic notion underlying Usenet is the flame.

Chuq Von Rospach

Modern Unix operating systems are very good at talking to other computers, or networking. Two different Unix computers can exchange information in many, many different ways. This chapter is going to try to talk about how you can take advantage of that strong network ability.

We'll try to cover electronic mail, Usenet news, and several basic Unix utilities used for communication.

10.1 Electronic Mail

One of the most popular standard features of Unix is electronic mail. With it, you are spared the usual hassle of finding an envelope, a piece of paper, a pen, a stamp, and the postal service, and, instead, given the hassle of negotiating with the computer.

10.1.1 Sending Mail

All you need to do is type `mail` *username* and type your message.

For instance, suppose I wanted to send mail to a user named `sam`:

```
/home/larry# mail sam
Subject: The user documentation
Just testing out the mail system.
EOT
/home/larry#
```

The `mail` program is very simple. Like `cat`, it accepts input from standard input, one line at a time, until it gets the end-of-text character on a line by itself: Ctrl-d. So, to send my message off I had to hit return and then Ctrl-d.

`mail` is the quickest way to send mail, and is quite useful when used with pipes and redirection. For instance, if I wanted to mail the file `report1` to "Sam", I could `mail sam < report1`, or I could have even run "`sort report1 | mail sam`".

However, the downside of using `mail` to send mail means a very crude editor. You can't change a line once you've hit return! So, I recommend you send mail (when not using a pipe or redirection) is with Emacs's mail mode. It's covered in Section 8.10.

10.1.2 Reading Mail

`mail` [*user*]

The `mail` program offers a clumsy way of reading mail. If you type `mail` without any parameters, you'll see the following:

```
/home/larry# mail
No mail for larry
/home/larry#
```

I'm going to send myself some mail so I can play around with the mailreader:

```
/home/larry# mail larry
Subject: Frogs!
and toads!
EOT
/home/larry# echo "snakes" | mail larry
/home/larry# mail
Mail version 5.5 6/1/90.  Type ? for help.
"/usr/spool/mail/larry": 2 messages 2 new
>N  1 larry                 Tue Aug 30 18:11  10/211   "Frogs!"
 N  2 larry                 Tue Aug 30 18:12   9/191
&
```

The prompt inside the mail program is an ampersand ("&"). It allows a couple of simple commands, and will give a short help screen if you type `?` and then return.

The basic commands for `mail` are:

`t` *message-list* Show (or **t**ype) the messages on the screen.

`d` *message-list* Delete the messages.

`s` *message-list file*
: Save the messages into *file*.

`r` *message-list*
: Reply to the messages—that is, start composing a new message to whoever sent you the listed messages.

`q`
: Quit and save any messages you didn't delete into a file called `mbox` in your home directory.

What's a *message-list*? It consists of a list of integers seperated by spaces, or even a range, such as `2-4` (which is identical to "`2 3 4`"). You can also enter the username of the sender, so the command `t sam` would `t`ype all the mail from Sam. If a message list is omitted, it is assumed to be the last message displayed (or typed).

There are several problems with the `mail` program's reading facilities. First of all, if a message is longer than your screen, the mail program doesn't stop! You'll have to save it and use `more` on it later. Second of all, it doesn't have a very good interface for old mail—if you wanted to save mail and read it later.

Emacs also has a facility for reading mail, called `rmail`, but it is not covered in this book. Additionally, most Linux systems have several other mailreaders available, such as `elm` or `pine`.

10.2 More than Enough News

10.3 Searching for People

10.3.1 The `finger` command

The `finger` command allows you to get information on other users on your system and across the world. Undoubtably the `finger` command was named based on the AT&T advertisements exhorting people to "reach out and touch someone". Since Unix has its roots in AT&T, this was probably amusing to the author.

`finger` [-slpm] [*user*][@*machine*]

The optional parameters to `finger` may be a little confusing. Actually, it isn't that bad. You can ask for information on a local user ("sam"), information on another machine ("@lionsden"), information on a remote user ("sam@lionsden"), and just information on the local machine (nothing).

Another nice feature is, if you ask for information about a user and there isn't an account name that is exactly what you asked for, it will try and match the real name with what you specified. That would mean that if I ran `finger Greenfield`, I would be told that the account `sam` exists for Sam Greenfield.

```
/home/larry# finger sam
Login: sam                             Name: Sam Greenfield
Directory: /home/sam                   Shell: /bin/tcsh
Last login Sun Dec 25 14:47 (EST) on tty2
No Plan.
/home/larry# finger greenfie@gauss.rutgers.edu
[gauss.rutgers.edu]
Login name: greenfie                   In real life: Greenfie
Directory: /gauss/u1/greenfie          Shell: /bin/tcsh
On since Dec 25 15:19:41 on ttyp0 from tiptop-slip-6439
13 minutes Idle Time
No unread mail
Project: You must be joking!
No Plan.
/home/larry# finger
Login    Name                 Tty  Idle  Login Time   Office     Office Phone
larry    Larry Greenfield      1   3:51  Dec 25 12:50
larry    Larry Greenfield      p0        Dec 25 12:51
/home/larry#
```

The `-s` option tells `finger` to always display the short form (what you normally get when you finger a machine), and the `-l` option tells it to always use the long form, even when you finger a machine. The `-p` option tells `finger` that you don't want to see `.forward`, `.plan`, or `.project` files, and `-m` tells `finger` that, if you asked for information about a user, only give information about an account name—don't try to match the name with a real name.

10.3.2 Plans and Projects

Now, what's a `.plan` and a `.project`, anyway? They're files stored in a user's home directory that are displayed whenever they're fingered. You can create your own `.plan` and `.project` files—the only restriction is that only the first line of a `.project` file is displayed.

Also, everybody must have execute privileges in your home directory (`chmod a+x ~/`) and everybody has to be able to read the `.plan` and `.project` files (`chmod a+r ~/.plan ~/.project`).

10.4 Using Systems by Remote

`telnet` *remote-system*

The principal way of using a remote Unix system is through `telnet`. `telnet` is usually a fairly simple program to use:

```
/home/larry# telnet lionsden
Trying 128.2.36.41...
```

```
Connected to lionsden
Escape character is '^]'.

lionsden login:
```

As you can see, after I issue a `telnet` command, I'm presented with a login prompt for the remote system. I can enter any username (as long as I know the password!) and then use that remote system almost the same as if I was sitting there.

The normal way of exiting `telnet` is to `logout` on the remote system, but another way is to type the escape character, which (as in the example above) is usually Ctrl-]. This presents me with a new prompt titled `telnet>`. I can now type `quit` and return and the connection to the other system will be closed and `telnet` will exit. (If you change your mind, simply hit return and you'll be returned to the remote system.)

If you're using X, let's create a new `xterm` for the other system we're travelling to. Use the command "`xterm -title "lionsden" -e telnet lionsden &`". This will create a new `xterm` window that's automatically running `telnet`. (If you do something like that often, you might want to create an alias or shell script for it.)

10.5 Exchanging Files

`ftp` *remote-system*

The normal way of sending files between Unix systems is `ftp`, for the **file transfer protocol**. After running the `ftp` command, you'll be asked to login to the remote system, much like `telnet`. After doing so, you'll get a special prompt: an `ftp` prompt.

The `cd` command works as normal, but on the remote system: it changes your directory on the *other* system. Likewise, the `ls` command will list your files on the remote system.

The two most important commands are `get` and `put`. `get` will transfer a file from the remote system locally, and `put` will take a file on the local system and put in on the remote one. Both commands work on the directory in which you started `ftp` locally and your current directory (which you could have changed through `cd`) remotely.

One common problem with `ftp` is the distinction between text and binary files. `ftp` is a very old protocol, and there use to be advantages to assuming that files being transferred are text files. Some versions of `ftp` default to this behavior, which means any programs that get sent or received will get corrupted. For safety, use the `binary` command before using `get` or `put`.

To exit `ftp` use the `bye` command.

10.6 Travelling the Web

World Wide Web, or WWW, is a popular use of the Internet. It consists of **pages**, each associated with its own URL—**uniform resource locator**. URLs are the funny sequence of in the form `http://www.rutgers.edu/`. Pages are generally written in HTML (**hypertext markup language**).

HTML allows the writer of a document to link certain words or phrases (or pictures) to other documents anywhere else in the Web. When a user is reading one document, she can quickly move to another by clicking on a key word or a button and been presented with another document—possibly from thousands of miles away.

`netscape` [*url*]

The most popular web browser on Linux is `netscape`, which is a commercial browser sold (and given away) by Netscape Communications Corporation. `netscape` only runs under X.

`netscape` tries to be as easy to use as possible and uses the Motif widget set to display a very Microsoft Windows-like appearance. The basic strategy for using `netscape` is that underlined blue words are links, as are many pictures. (You can tell which pictures are links by clicking on them.) By clicking on these words with your left mouse button, you'll be presented with a new page.

Linux supports many other browsers, including the original web browser `lynx`. `lynx` is a text browser—it won't display any of the pictures that the Web is currently associated with—but it will work without X.

`lynx` [*url*]

It's somewhat harder to learn how to use `lynx`, but generally playing with the arrow keys will let you get the hand of it. The up and down arrow keys move between links on a given page, which the right arrow key follows the current (highlighted) link. The left arrow key will reload the previous page. To quit `lynx`, type $\boxed{\texttt{q}}$. `lynx` has many other key commands—consult the manpage for more.

Chapter 11

Funny Commands

Well, most people who had to do with the UNIX commands exposed in this chapter will not agree with this title. "What the heck! You have just shown me that the Linux interface is very standard, and now we have a bunch of commands, each one working in a completely different way. I will never remember all those options, and you are saying that they are *funny*?" Yes, you have just seen an example of hackers' humor. Besides, look at it from the bright side: there is no MS-DOS equivalent of these commands. If you need them, you have to purchase them, and you never know how their interface will be. Here they are a useful – and inexpensive – add-on, so enjoy!

The set of commands dwelled on in this chapter covers `find`, which lets the user search in the directory tree for specified groups of files; `tar`, useful to create some archive to be shipped or just saved; `dd`, the low-level copier; and `sort`, which ... yes, sorts files. A last proviso: these commands are by no means standardized, and while a core of common options could be found on all *IX systems, the (GNU) version which is explained below, and which you can find in your Linux system, has usually many more capabilities. So if you plan to use other UNIX-like operating systems, please don't forget to check their man page in the target system to learn the maybe not-so-little differences.

11.1 `find`, the file searcher

11.1.1 Generalities

Among the various commands seen so far, there were some which let the user recursively go down the directory tree in order to perform some action: the canonical examples are `ls -R` and `rm -R`. Good. `find` is *the* recursive command. Whenever you are thinking "Well, I have to do so-and-so on all those kind of files in my own partition", you have better think about using `find`. In a certain sense the fact that `find` finds files is just a side effect: its real occupation is to evaluate.

The basic structure of the command is as follows:

`find` *path* [...] *expression* [...]

This at least on the GNU version; other version do not allow to specify more than one path, and besides it is very uncommon the need to do such a thing. The rough explanation of the command syntax is rather simple: you say from where you want to start the search (the *path* part; with GNU find you can omit this and it will be taken as default the current directory `.`), and which kind of search you want to perform (the *expression* part).

The standard behavior of the command is a little tricky, so it's worth to note it. Let's suppose that in your home directory there is a directory called garbage, containing a file foobar. You happily type `find . -name foobar` (which as you can guess searches for files named foobar), and you obtain ...nothing else than the prompt again. The trouble lies in the fact that `find` is by default a silent command; it just returns 0 if the search was completed (with or without finding anything) or a non-zero value if there had been some problem. This does not happen with the version you can find on Linux, but it is useful to remember it anyway.

11.1.2 Expressions

The *expression* part can be divided itself in four different groups of keywords: *options*, *tests*, *actions*, and *operators*. Each of them can return a true/false value, together with a side effect. The difference among the groups is shown below.

options affect the overall operation of find, rather than the processing of a single file. An example is -follow, which instructs `find` to follow symbolic links instead of just stating the inode. They always return true.

tests are real tests (for example, -empty checks whether the file is empty), and can return true or false.

actions have also a side effect the name of the considered file. They can return true or false too.

operators do not really return a value (they can conventionally be considered as true), and are used to build compress expression. An example is -or, which takes the logical OR of the two subexpressions on its side. Notice that when juxtaposing expression, a -and is implied.

Note that `find` relies upon the shell to have the command line parsed; it means that all keyword must be embedded in white space and especially that a lot of nice characters have to be escaped, otherwise they would be mangled by the shell itself. Each escaping way (backslash, single and double quotes) is OK; in the examples the single character keywords will be usually quoted with backslash, because it is the simplest way (at least in my opinion. But it's me who is writing these notes!)

11.1.3 Options

Here there is the list of all options known by GNU version of `find`. Remember that they always return true.

- -daystart measures elapsed time not from 24 hours ago but from last midnight. A true hacker probably won't understand the utility of such an option, but a worker who programs from eight to five does appreciate it.

- -depth processes each directory's contents before the directory itself. To say the truth, I don't know many uses of this, apart for an emulation of `rm -F` command (of course you cannot delete a directory before all files in it are deleted too ...

- -follow deferences (that is, follows) symbolic links. It implies option -noleaf; see below.

- -noleaf turns off an optimization which says "A directory contains two fewer subdirectories than their hard link count". If the world were perfect, all directories would be referenced by each of their subdirectories (because of the `..` option), as `.` inside itself, and by it's "real" name from its parent directory.

  That means that every directory must be referenced at least twice (once by itself, once by its parent) and any additional references are by subdirectories. In practice however, symbolic links and distributed filesystems[1] can disrupt this. This option makes `find` run slightly slower, but may give expected results.

- -maxdepth *levels*, -mindepth *levels*, where *levels* is a non-negative integer, respectively say that at most or at least *levels* levels of directories should be searched. A couple of examples is mandatory: `-maxdepth 0` indicates that it the command should be performed just on the arguments in the command line, i.e., without recursively going down the directory tree; `-mindepth 1` inhibits the processing of the command for the arguments in the command line, while all other files down are considered.

- -version just prints the current version of the program.

- -xdev, which is a misleading name, instructs `find` **not** to cross device, i.e. changing filesystem. It is very useful when you have to search for something in the root filesystem; in many machines it is a rather small partition, but a `find /` would otherwise search the whole structure!

11.1.4 Tests

The first two tests are very simple to understand: -false always return false, while -true always return true. Other tests which do not need the specification of a value are -empty, which returns true whether the file is empty, and the couple -nouser / -nogroup, which return true in the case that no entry in `/etc/passwd` or `/etc/group` match the user/group id of the file owner. This is a common thing which happens in a multiuser system; a user is deleted, but files owned by her remain in the strangest part of the filesystems, and due to Murphy's laws take a lot of space.

Of course, it is possible to search for a specific user or group. The tests are -uid *nn* and -gid *nn*. Unfortunately it is not possibile to give directly the user name, but it is necessary to use the numeric id, *nn*.

[1] Distributed filesystems allow files to appear like their local to a machine when they are actually located somewhere else.

allowed to use the forms $+nn$, which means "a value strictly greater than nn", and $-nn$, which means "a value strictly less than nn". This is rather silly in the case of UIDs, but it will turn handy with other tests.

Another useful option is -type *c*, which returns true if the file is of type *c*. The mnemonics for the possible choices are the same found in `ls`; so we have **b** when the file is a block special; **c** when the file is character special; **d** for directories; **p** for named pipes; **l** for symbolic links, and **s** for sockets. Regular files are indicated with **f**. A related test is -xtype, which is similar to -type except in the case of symbolic links. If -follow has not been given, the file pointed at is checked, instead of the link itself. Completely unrelated is the test -fstype *type*. In this case, the filesystem type is checked. I think that the information is got from file `/etc/mtab`, the one stating the mounting filesystems; I am certain that types nfs, tmp, msdos and ext2 are recognized.

Tests -inum *nn* and -links *nn* check whether the file has inode number *nn*, or *nn* links, while -size *nn* is true if the file has *nn* 512-bytes blocks allocated. (well, not precisely: for sparse files unallocated blocks are counted too). As nowadays the result of `ls -s` is not always measured in 512-bytes chunks (Linux for example uses 1k as the unit), it is possible to append to *nn* the character *b*, which means to count in butes, or *k*, to count in kilobytes.

Permission bits are checked through the test -perm *mode*. If *mode* has no leading sign, then the permission bits of the file must exactly match them. A leading − means that all permission bits must be set, but makes no assumption for the other; a leading + is satisfied just if any of the bits are set. Oops! I forgot saying that the mode is written in octal or symbolically, like you use them in `chmod`.

Next group of tests is related to the time in which a file has been last used. This comes handy when a user has filled his space, as usually there are many files he did not use since ages, and whose meaning he has forgot. The trouble is to locate them, and `find` is the only hope in sight. -atime *nn* is true if the file was last accessed *nn* days ago, -ctime *nn* if the file status was last changed *nn* days ago – for example, with a `chmod` – and -mtime *nn* if the file was last modified *nn* days ago. Sometimes you need a more precise timestamp; the test -newer *file* is satisfied if the file considered has been modified later than *file*. So, you just have to use `touch` with the desidered date, and you're done. GNU find add the tests -anewer and -cnewer which behave similarly; and the tests -amin, -cmin and -mmin which count time in minutes instead than 24-hours periods.

Last but not the least, the test I use more often. -name *pattern* is true if the file name exactly matches *pattern*, which is more or less the one you would use in a standard `ls`. Why 'more or less'? Because of course you have to remember that all the parameters are processed by the shell, and those lovely metacharacters are expanded. So, a test like `-name foo*` won't return what you want, and you should either write `-name foo` or `-name "foo*"`. This is probably one of the most common mistakes made by careless users, so write it in BIG letters on your screen. Another problem is that, like with `ls`, leading dots are not recognized. To cope with this, you can use test -path *pattern* which does not worry about dot and slashes when comparing the path of the considered file with *pattern*.

11.1.5 Actions

I have said that actions are those which actually do something. Well, -prune rather does not do something, i.e. descending the directory tree (unless -depth is given). It is usally find together with -fstype, to choose among the various filesystems which should be checked.

The other actions can be divided into two broad categories;

- Actions which *print* something. The most obvious of these – and indeed, the default action of `find` – is -print which just print the name of the file(s) matching the other conditions in the command line, and returns true. A simple variants of -print is -fprint *file*, which uses *file* instead of standard output, -ls lists the current file in the same format as `ls -dils`; -printf *format* behaves more or less like C function printf(), so that you can specify how the output should be formatted, and -fprintf *file format* does the same, but writing on *file*. These action too return true.

- Actions which *execute* something. Their syntax is a little odd and they are used widely, so please look at them.

  -exec *command* `\;` the command is executed, and the action returns true if its final status is 0, that is regular execution of it. The reason for the `\;` is rather logical: `find` does not know where the command ends, and the trick to put the exec action at the end of the command is not applicable. Well, the best way to signal the end of the command is to use the character used to do this by the shell itself, that is '`;`', but of course a semicolon all alone on the command line would be eaten by the shell and never sent to `find`, so it has to be escaped. The second thing to remember is how to specify the name of the current file within *command*, as probably you did all the trouble to build the expression to do something, and not just to print `date`. This is done by means of the string `{}`. Some old versions of `find` require that it must be embedded in white space – not very handy if you needed for example the whole path and not just the file name – but with GNU find could be anywhere in the string composing *command*. And shouldn't it be escaped or quoted, you surely are asking? Amazingly, I never had to do this neither under tcsh nor under bash (sh does not consider `{` and `}` as special characters, so it is not much of a problem). My idea is that the shells "know" that `{}` is not an option making sense, so they do not try to expand them, luckily for `find` which can obtain it untouched.

  -ok *command* `\;` behaves like -exec, with the difference that for each selected file the user is asked to confirm the command; if the answer starts with `y` or `Y`, it is executed, otherwise not, and the action returns false.

11.1.6 Operators

There are a number of operators; here there is a list, in order of decreasing precedence.

\(*expr* \)
: forces the precedence order. The parentheses must of course be quoted, as they are meaningful for the shell too.

! *expr*

-not *expr*

change the truth value of expression, that is if *expr* is true, it becomes false. The exclamation mark needn't be escaped, because it is followed by a white space.

expr1 expr2

expr1 -a *expr2*

expr1 -and *expr2*

all correspond to the logical AND operation, which in the first and most common case is implied. *expr2* is not evaluated, if *expr1* is false.

expr1 -o *expr2*

expr1 -or *expr2*

correspond to the logical OR operation. *expr2* is not evaluated, if *expr1* is true.

expr1 , *expr2*

is the list statement; both *expr1* and *expr2* are evaluated (together with all side effects, of course!), and the final value of the expression is that of *expr2*.

11.1.7 Examples

Yes, `find` has just too many options, I know. But there are a lot of cooked instances which are worth to remember, because they are usen very often. Let's see some of them.

```
% find . -name foo\* -print
```

finds all file names starting with `foo`. If the string is embedded in the name, probably it is more sensitive to write something like `"*foo*"`, rather than `foo`.

```
% find /usr/include -xtype f -exec grep foobar \
          /dev/null {} \;
```

is a grep executed recursively starting from directory /usr/include. In this case, we are interested both in regular file and in symbolic links which point to regular files, hence the -xtype test. Many times it is simpler to avoid specyfing it, especially if we are rather sure no binary file contains the wanted string. And why the /dev/null in the command? It's a trick to force grep to write the file name where a match has been found. The command grep is applied to each file in a different invocation, and so it doesn't think it is necessary to output the file name. But now there are *two* files, i.e. the current one and `/dev/null`! Another possibility should be to pipe the command to `xargs` and let it perform the grep. I just tried it, and completely smashed my filesystem (together with these notes which I am tring to recover by hand `:-(`).

```
% find /  -atime +1 -fstype ext2 -name core \
             -exec rm {} \;
```

is a classical job for crontab. It deletes all file named `core` in filesystems of type ext2 which have not been accessed in the last 24 hours. It is possible that someone wants to use the core file to perform a post mortem dump, but nobody could remember what he was doing after 24 hours...

```
% find /home -xdev -size +500k -ls > piggies
```

is useful to see who has those files who clog the filesystem. Note the use of -xdev; as we are interested in just one filesystem, it is not necessary to descend other filesystems mounted under `/home`.

11.1.8 A last word

Keep in mind that `find` is a very time consuming command, as it has to access each and every inode of the system in order to perform its operation. It is therefore wise to combine how many operations you need in a unique invocation of `find`, especially in the 'housekeeping' jobs usually ran via a crontab job. A enlightening example is the following: let's suppose that we want to delete files ending in `.BAK` and change the protection of all directories to 771 and that of all files ending in `.sh` to 755. And maybe we are mounting NFS filesystems on a dial-up link, and we'd like not to check for files there. Why writing three different commands? The most effective way to accomplish the task is this:

```
% find . \( -fstype nfs -prune \) -o \
         \( -type d       -a -exec chmod 771 {} \; \) -o \
         \( -name "*.BAK" -a -exec /bin/rm {}   \; \) -o \
         \( -name "*.sh"  -a -exec chmod 755 {} \; \)
```

It seems ugly (and with much abuse of backslashes!), but looking closely at it reveals that the underlying logic is rather straightforward. Remember that what is really performed is a true/false evaluation; the embedded command is just a side effect. But this means that it is performed only if `find` must evaluate the exec part of the expression, that is only if the left side of the subexpression evaluates to true. So, if for example the file considered at the moment is a directory then the first exec is evaluated and the permission of the inode is changed to 771; otherwise it forgets all and steps to the next subexpression. Probably it's easier to see it in practice than to writing it down; but after a while, it will become a natural thing.

11.2 `tar`, the tape archiver

11.2.1 Introduction

11.2.2 Main options

11.2.3 Modifiers

11.2.4 Examples

11.3 `dd`, the data duplicator

Legend says that back in the mists of time, when the first UNIX was created, its developers needed a low level command to copy data between devices. As they were in a hurry, they decided to borrow the syntax used by IBM-360 machines, and to develop later an interface consistent with that of the other commands. Time passed, and all were so used with the odd way of using `dd` that it stuck. I don't know whether it is true, but it is a nice story to tell.

11.3.1 Options

To say the truth, `dd` it's not completely unlike the other Unix command: it is indeed a **filter**, that is it reads by default from the standard input and writes to the standard output. So if you just type dd at the terminal it remains quiet, waiting for input, and a ctrl-C is the only sensitive thing to type.

The syntax of the command is as follows:

`dd` [if=*file*] [of=*file*] [ibs=*bytes*] [obs=*bytes*] [bs=*bytes*] [cbs=*bytes*] [skip=*blocks*] [seek=*blocks*] [count=*blocks*] [conv={ascii, ebcdic, ibm, block, unblock, lcase, ucase, swab, noerror, notrunc, sync}]

All options are of the form *option=value*. No space is allowed either before or after the equal sign; this used to be annoying, because the shell did not expand a filename in this situation, but the version of `bash` present in Linux is rather smart, so you don't have to worry about that. It is important also to remember that all numbered values (`bytes` and `blocks` above) can be followed by a multiplier. The possible choices are **b** for block, which multiplies by 512, **k** for kilobytes (1024), **w** for word (2), and **xm** multiplies by **m**.

The meaning of options if explained below.

- if=*filein* and of=*fileout* instruct `dd` to respectively read from *filein* and write to *fileout*. In the latter case, the output file is truncated to the value given to `seek`, or if the keyword is not present, to 0 (that is deleted), before performing the operation. But look below at option `notrunc`.

- ibs=*nn* and obs=*nn* specify how much bytes should be read or write at a time. I think that the default is 1 block, i.e. 512 bytes, but I am not very sure about it: certainly it works that way with plain files. These parameters are very important when using special devices as input or output; for example, reading from the net should set `ibs` at 10k, while a high density 3.5" floppy has as its natural block size 18k. Failing to set these values could result not only in longer time to perform the command, but even in timeout errors, so be careful.

- bs=*nn* both reads and writes *nn* bytes at a time. It overrides `ibs` and `obs` keywords.

- cbs=*nn* sets the conversion buffers to *nn* bytes. This buffer is used when translating from ASCII to EBCDIC, or from an unblocked device to a blocked one. For example, files created under VMS have often a block size of 512, so you have to set `cbs` to 1b when reading a foreign VMS tape. Hope that you don't have to mess with these things!

- skip=*nbl* and seek=*nbl* tell the program to skip *nbl* blocks respectively at the beginning of input and at the beginning of output. Of course the latter case makes sense if conversion `notrunc` is given, see below. Each block's size is the value of `ibs` (`obs`). Beware: if you did not set `ibs` and write `skip=1b` you are actually skipping 512×512 bytes, that is 256KB. It was not precisely what you wanted, wasn't it?

- count=*nbl* means to copy only *nbl* blocks from input, each of the size given by `ibs`. This option, together with the previous, turns useful if for example you have a corrupted file and you want to recover how much it is possible from it. You just skip the unreadable part and get what remains.

- conv=*conversion*,[*conversion*...] convert the file as specified by its argument. Possible conversions are ascii, which converts from EBCDIC to ASCII; ebcdic and `ibm`, which both perform an inverse conversion (yes, there is not a unique conversion from EBCDIC to ASCII! The first is the standard one, but the second works better when printing files on a IBM printer); block, which pads newline-terminated records to the size of `cbs`, replacing newline with trailing spaces; unblock, which performs the opposite (eliminates trailing spaces, and replaces them with newline); lcase and ucase, to convert test to lowercase and uppercase; swab, which swaps every pair of input bytes (for example, to use a file containing short integers written on a 680x0 machine in an Intel-based machine you need such a conversion); noerror, to continue processing after read errors; sync, which pads input block to the size of `ibs` with trailing NULs.

11.3.2 Examples

The canonical example is the one you have probably bumped at when you tried to create the first Linux diskette: how to write to a floppy without a MS-DOS filesystem. The solution is simple:

```
% dd if=disk.img of=/dev/fd0 obs=18k count=80
```

I decided not to use `ibs` because I don't know which is the better block size for a hard disk, but in this case no harm would have been if instead of `obs` I use `bs` – it could even be a trifle quicker. Notice the explicitation of the number of sectors to write (18KB is the occupation of a sector, so `count` is set to 80) and the use of the low-level name of the floppy device.

Another useful application of `dd` is related to the network backup. Let's suppose that we are on machine *alpha* and that on machine *beta* there is the tape unit `/dev/rst0` with a tar file we are interested in getting. We have the same rights on both machines, but there is no space on *beta* to dump the tar file. In this case, we could write

```
% rsh beta 'dd if=/dev/rst0 ibs=8k obs=20k' | tar xvBf -
```

to do in a single pass the whole operation. In this case, we have used the facilities of `rsh` to perform the reading from the tape. Input and output sizes are set to the default for these operations, that is 8KB for reading from a tape and 20KB for writing to ethernet; from the point of view of the other side of the tar, there is the same flow of bytes which could be got from the tape, except the fact that it arrives in a rather erratic way, and the option B is necessary.

I forgot: I don't think at all that `dd` is an acronym for "data duplicator", but at least this is a nice way to remember its meaning ...

11.4 `sort`, the data sorter

11.4.1 Introduction

11.4.2 Options

11.4.3 Examples

Chapter 12

Errors, Mistakes, Bugs, and Other Unpleasantries

> Unix was never designed to keep people from doing stupid things, because that policy would also keep them from doing clever things.
>
> Doug Gwyn

12.1 Avoiding Errors

Many users report frustration with the Unix operating system at one time or another, frequently because of their own doing. A feature of the Unix operating system that many users' love when they're working well and hate after a late-night session is how very few commands ask for confirmation. When a user is awake and functioning, they rarely think about this, and it is an assest since it let's them work smoother.

However, there are some disadvantages. `rm` and `mv` never ask for confirmation and this frequently leads to problems. Thus, let's go through a small list that might help you avoid total disaster:

- Keep backups! This applies especially to the one user system—all system adminstrators should make regular backups of their system! Once a week is good enough to salvage many files. See the *The* LINUX *System Adminstrator's Guide* for more information.
- Individual user's should keep there own backups, if possible. If you use more than one system regularly, try to keep updated copies of all your files on each of the systems. If you have access to a floppy drive, you might want to make backups onto floppies of your critical material. At worst, keep additional copies of your most important material lying around your account *in a seperate directory*!
- Think about commands, especially "destructive" ones like `mv`, `rm`, and `cp` before you act. You also have to be careful with redirection (`>`)—it'll overwrite your files when you aren't paying attention. Even the most harmless of commands can become sinister:

```
/home/larry/report# cp report-1992 report-1993 backups
```

can easily become disaster:

```
/home/larry/report# cp report-1992 report-1993
```

- The author also recommends, from his personal experience, not to do file maintanence late at night. Does you directory structure look a little messy at 1:32am? Let it stay—a little mess never hurt a computer.
- Keep track of your present directory. Sometimes, the prompt you're using doesn't display what directory you are working in, and danger strikes. It is a sad thing to read a post on `comp.unix.admin`[1] about a `root` user who was in `/` instead of `/tmp`! For example:

```
mousehouse> pwd
/etc
mousehouse> ls /tmp
passwd
mousehouse> rm passwd
```

The above series of commands would make the user very unhappy, seeing how they have just removed the password file for their system. Without it, people can't login!

12.2 What to do When Something Goes Wrong

12.3 Not Your Fault

Unfortunately for the programmers of the world, not all problems are caused by user-error. Unix and LINUX are complicated systems, and all known versions have bugs. Sometimes these bugs are hard to find and only appear under certain circumstances.

First of all, what is a bug? An example of a bug is if you ask the computer to compute "5+3" and it tells you "7". Although that's a trivial example of what can go wrong, most bugs in computer programs involve arithmetic in some extremely strange way.

12.3.1 When Is There a Bug

If the computer gives a wrong answer (verify that the answer is wrong!) or crashes, it is a bug. If any one program crashes or gives an operating system error message, it is a bug.

If a command never finishes running can be a bug, but you must make sure that you didn't tell it to take a long time doing whatever you wanted it to do. Ask for assistance if you didn't know what the command did.

Some messages will alert you of bugs. Some messages are not bugs. Check Section 3.4 and any other documentation to make sure they aren't normal informational messages. For instance,

[1] A international discussion group on Usenet, which talks about administring Unix computers.

messages like "disk full" or "lp0 on fire" aren't software problems, but something wrong with your hardware—not enough disk space, or a bad printer.

If you can't find anything about a program, it is a bug in the documentation, and you should contact the author of that program and offer to write it yourself. If something is incorrect in existing documentation[2], it is a bug with that manual. If something appears incomplete or unclear in the manual, that is a bug.

If you can't beat `gnuchess` at chess, it is a flaw with your chess algorithm, but not necessarily a bug with your brain.

12.3.2 Reporting a Bug

After you are sure you found a bug, it is important to make sure that your information gets to the right place. Try to find what program is causing the bug—if you can't find it, perhaps you could ask for help in `comp.os.linux.help` or `comp.unix.misc`. Once you find the program, try to read the manual page to see who wrote it.

The preferred method of sending bug reports in the LINUX world is via electronic mail. If you don't have access to electronic mail, you might want to contact whoever you got LINUX from—eventually, you're bound to encounter someone who either has electronic mail, or sells LINUX commercially and therefore wants to remove as many bugs as possible. Remember, though, that no one is under any obligation to fix any bugs unless you have a contract!

When you send a bug report in, include all the information you can think of. This includes:

- A description of what you think is incorrect. For instance, "I get 5 when I compute 2+2" or "It says `segmentation violation -- core dumped`." It is important to say exactly what is happening so the maintainer can fix *your* bug!
- Include any relevant environment variables.
- The version of your kernel (see the file `/proc/version`) and your system libraries (see the directory `/lib`—if you can't decipher it, send a listing of `/lib`).
- How you ran the program in question, or, if it was a kernel bug, what you were doing at the time.
- **All** peripheral information. For instance, the command `w` may not be displaying the current process for certain users. Don't just say, "`w` doesn't work when for a certain user". The bug could occur because the user's name is eight characters long, or when he is logging in over the network. Instead say, "`w` doesn't display the current process for user `greenfie` when he logs in over the network."
- And remember, be polite. Most people work on free software for the fun of it, and because they have big hearts. Don't ruin it for them—the LINUX community has already disillusioned too many developers, and it's still early in LINUX's life!

[2]Especially this one!

Appendix A

Introduction to Vi

vi (pronounced “vee eye”) is really the only editor you can find at almost every Unix installation. It was originally written at the University of California at Berkeley and versions can be found it almost every vendor’s edition of Unix, including LINUX. It is initially somewhat hard to get used to, but it has many powerful features. In general, we suggest that a new user learn Emacs, which is generally easier to use. However, people who will use more than one platform or find they dislike Emacs may want to try to learn vi.

A brief historical view of vi is necessary to understand how the key k can mean move cursor up one line and why there are three different modes of use. If you are itchy to learn the editor, then the two tutorials will guide you from being a raw beginner, through to having enough knowledge of the command set you are ever likely to need. The chapter also incorporates a command guide, which makes a useful reference to keep by the terminal.

Even if vi does not become your regular text editor, the knowledge of its use is not wasted. It is almost certain that the Unix system you are using will have some variant of the vi editor. It may be necessary to use vi while installing another editor, such as Emacs. Many Unix tools, applications and games use a subset of the vi command set.

A.1 A Quick History of Vi

Early text editors were line oriented and typically were used from dumb printing terminals. A typical editor that operates in this mode is **Ed**. The editor is powerful and efficient, using a very small amount of computer resources, and worked well with the display equipment of the time. vi offers the user a visual alternative with a significantly expanded command set compared with ed.

vi as we know it today started as the line editor ex. In fact ex is seen as a special editing mode of vi, although actually the converse is true. The visual component of ex can be initiated from the command line by using the vi command, or from within ex.

The ex/vi editor was developed at the University of California at Berkeley by William Joy. It was originally supplied as an unsupported utility until its official inclusion in the release of AT&T

System 5 Unix. It has steadily become more popular, even with the challenges of more modern full screen editors.

Due to the popularity of `vi` there exists many clone variants and versions can be found for most operation systems. It is not the intention of this chapter to include all the commands available under `vi` or its variants. Many clones have expanded and changed the original behaviour of `vi`. Most clones do not support all the original commands of `vi`.

If you have a good working knowledge of `ed` then `vi` offers a smaller learning curve to master. Even if you have no intention of using `vi` as your regular editor, a basic knowledge of `vi` can only be an asset.

A.2 Quick Ed Tutorial

The aim of this tutorial is to get you started using `ed`. `ed` is designed to be easy to use, and requires little training to get started. The best way to learn is to practice, so follow the instructions and try the editor before discounting its practical advantages.

A.2.1 Creating a file

`ed` is only capable of editing one file at a time. Follow the next example to create your first text file using `ed`.

```
/home/larry# ed
a
This is my first text file using Ed.
This is really fun.
.
w firstone.txt
/home/larry# q
```

You can verify the file's contents using the Unix concatenate utility.

```
/home/larry# cat firstone.txt
```

The above example has illustrated a number of important points. When invoking `ed` as above you will have an empty file. The key $\boxed{\texttt{a}}$ is used to add text to the file. To end the text entering session, a period $\boxed{.}$ is used in the first column of the text. To save the text to a file, the key $\boxed{\texttt{q}}$ is used in combination with the file's name and finally, the key $\boxed{\texttt{q}}$ is used to exit the editor.

The most important observation is the two modes of operation. Initially the editor is in command mode. A command is defined by characters, so to ascertain what the user's intention is, `ed` uses a **text mode**, and a **command mode**.

A.2.2 editing a existing file

To add a line of text to an existing file follow the next example.

```
/home/larry# ed firstone.txt
a
This is a new line of text.
.
w
q
```

If you check the file with `cat` you'll see that a new line was inserted between the original first and second lines. How did `ed` know where to place the new line of text?

When `ed` reads in the file it keeps track of the current line. The command $\boxed{\texttt{a}}$ will add the text after the current line. `ed` can also place the text before the current line with the key command $\boxed{\texttt{i}}$. The effect will be the insertion of the text before the current line.

Now it is easy to see that `ed` operates on the text, line by line. All commands can be applied to a chosen line.

To add a line of text at the end of a file.

```
/home/larry# ed firstone.txt
        $a
        The last line of text.
        .
        w
        q
```

The command modifier $\boxed{\texttt{\$}}$ tells `ed` to add the line after the last line. To add the line after the first line the modifier would be $\boxed{\texttt{1}}$. The power is now available to select the line to either add a line of text after the line number, or insert a line before the line number.

How do we know what is on the current line? The command key $\boxed{\texttt{p}}$ will display the contents of the current line. If you want to change the current line to line 2 and see the contents of that line then do the following.

```
/home/larry# ed firstone.txt
        2p
        q
```

A.2.3 Line numbers in detail

You have seen how to display the contents of the current line, by the use of the $\boxed{\texttt{p}}$ command. We also know there are line number modifiers for the commands. To print the contents of the second line.

```
2p
```

There are some special modifiers that refer to positions that can change, in the lifetime of the edit session. The $\boxed{\$}$ is the last line of the text. To print the last line.

```
$p
```

The current line number uses the special modifier symbol $\boxed{.}$. To display the current line using a modifier.

```
.p
```

This may appear to be unnecessary, although it is very useful in the context of line number ranges.

To display the contents of the text from line 1 to line 2 the range needs to be supplied to `ed`.

```
1,2p
```

The first number refers to the starting line, and the second refers to the finishing line. The current line will subsequently be the second number of the command range.

If you want to display the contents of the file from the start to the current line.

```
1,.p
```

To display the contents from the current line to the end of the file.

```
.,$p
```

All that is left is to display the contents of the entire file which is left to you.

How can you delete the first 2 lines of the file.

```
1,2d
```

The command key $\boxed{d}$ deletes the text line by line. If you wanted to delete the entire contents you would issue.

```
1,$d
```

If you have made to many changes and do not want to save the contents of the file, then the best option is to quit the editor without writing the file beforehand.

Most users do not use `ed` as the main editor of choice. The more modern editors offer a full edit screen and more flexible command sets. Ed offers a good introduction to `vi` and helps explain where its command set originates.

A.3 Quick Vi Tutorial

The aim of this tutorial is to get you started using the `vi` editor. This tutorial assumes no `vi` experience, so you will be exposed to the ten most basic `vi` commands. These fundamental commands are enough to perform the bulk of your editing needs, and you can expand your `vi` vocabulary as needed. It is recommended you have a machine to practice with, as you proceed through the tutorial.

A.3.1 Invoking vi

To invoke vi, simply type the letters `vi` followed by the name of the file you wish to create. You will see a screen with a column of tildes (~) along the left side. `vi` is now in command mode. Anything you type will be understood as a command, not as text to be input. In order to input text, you must type a command. The two basic input commands are the following:

```
i     insert text to the left of the cursor
a     append text to the right of the cursor
```

Since you are at the beginning of an empty file, it doesn't matter which of these you type. Type one of them, and then type in the following text (a poem by Augustus DeMorgan found in *The Unix Programming Environment* by B.W. Kernighan and R. Pike):

```
Great fleas have little fleas<Enter>
  upon their backs to bite 'em,<Enter>
And little fleas have lesser fleas<Enter>
  and so ad infinitum.<Enter>
And the great fleas themselves, in turn,<Enter>
  have greater fleas to go on;<Enter>
While these again have greater still,<Enter>
  and greater still, and so on.<Enter>
<Esc>
```

Note that you press the Esc key to end insertion and return to command mode.

A.3.2 Cursor movement commands

```
h     move the cursor one space to the left
j     move the cursor one space down
k     move the cursor one space up
l     move the cursor one space to the right
```

These commands may be repeated by holding the key down. Try moving around in your text now. If you attempt an impossible movement, e.g., pressing the letter **k** when the cursor is on the top line, the screen will flash, or the terminal will beep. Don't worry, it won't bite, and your file will not be harmed.

A.3.3 Deleting text

```
x     delete the character at the cursor
dd    delete a line
```

Move the cursor to the second line and position it so that it is underneath the apostrophe in *'em*. Press the letter x, and the ' will disappear. Now press the letter i to move into insert mode and type the letters **th**. Press Esc when you are finished.

A.3.4 File saving

```
:w    save (write to disk)
:q    exit
```

Make sure you are in command mode by pressing the Esc key. Now type **:w**. This will save your work by writing it to a disk file.

The command for quitting vi is q. If you wish to combine saving and quitting, just type **:wq**. There is also a convenient abbreviation for **:wq** — **ZZ**. Since much of your programming work will consist of running a program, encountering a problem, calling up the program in the editor to make a small change, and then exiting from the editor to run the program again, **ZZ** will be a command you use often. (Actually, **ZZ** is not an exact synonym for **:wq** — if you have not made any changes to the file you are editing since the last save, **ZZ** will just exit ¿from the editor whereas **:wq** will (redundantly) save before exiting.)

If you have hopelessly messed things up and just want to start all over again, you can type **:q!** (remember to press the Esc key first). If you omit the **!**, vi will not allow you to quit without saving.

A.3.5 What's next

The ten commands you have just learned should be enough for your work. However, you have just scratched the surface of the vi editor. There are commands to copy material from one place in a file to another, to move material from one place in a file to another, to move material from one file to another, to fine tune the editor to your personal tastes, etc. In all, there about 150 commands.

A.4 Advanced Vi Tutorial

The advantage and power of `vi` is the ability to use it successfully with only knowing a small subset of the commands. Most users of `vi` feel a bit awkward at the start, however after a small amount of time they find the need for more command knowledge.

The following tutorial is assuming the user has completed the quick tutorial (above) and hence feels comfortable with `vi`. It will expose some of the more powerful features of `ex/vi` from copying text to macro definitions. There is a section on `ex` and its settings which helps customize the editor. This tutorial describes the commands, rather then taking you set by set through each of them. It is recommended you spend the time trying the commands out on some example text, which you can afford to destroy.

This tutorial does not expose all the commands of `vi` though all of the commonly used commands and more are covered. Even if you choose to use an alternative text editor, it is hoped you will appreciate `vi` and what it offers those who do choose to use it.

A.4.1 Moving around

The most basic functionality of an editor, is to move the cursor around in the text. Here are more movement commands.

```
h          move the cursor one space to the left
j          move one line down
k          move one line up
l          move one line right

Some implementations also allow the arrows keys to move the cursor.

w          move to the start of the next word
e          move to the end of the next word
E          move to the end of the next word before a space
b          move to the start of the previous word
0          move to the start of the line
^          move to the first word of the current line
$          move to the end of the line
<CR>       move to the start of the next line
-          move to the start of the previous line
G          move to the end of the file
1G         move to the start of the file
nG         move to line number n
<Cntl> G   display the current line number
%          to the matching bracket
H          top line of the screen
M          middle line of the screen
L          bottom of the screen
n|         more cursor to column n
```

The screen will automatically scroll when the cursor reaches either the top or the bottom of the screen. There are alternative commands which can control scrolling the text.

```
<Cntl> f   scroll forward a screen
<Cntl> b   scroll backward a screen
```

```
<Cntl> d   scroll down half a screen
<Cntl> u   scroll down half a screen
```

The above commands control cursor movement. Some of the commands use a command modifier in the form of a number preciding the command. This feature will usually repeat the command that number of times.

To move the cursor a number of positions left.

```
nl         move the cursor n positions left
```

If you wanted to enter a number or spaces in front of the some text you could use the command modifier to the insert command. Enter the repeat number then i followed by the space then press ESC.

```
ni         insert some text and repeat the text n times.
```

The commands that deal with lines use the modifier to refer to line numbers. The G is a good example.

```
1G         Move the cursor to the first line.
```

`vi` has a large set of commands which can be used to move the cursor around the file. Single character movement through to direct line placement of the cursor. `vi` can also place the cursor at a selected line from the command line.

```
vi +10 myfile.tex
```

This command opens the file called *myfile.tex* and places the cursor 10 lines down from the start of the file.

Try out some of the commands in this section. Very few people can remember all of them in one session. Most users use only a subset of the above commands.

You can move around, so how do you change the text?

A.4.2 Modifing Text

The aim is to change the contents of the file and `vi` offers a very large set of commands to help in this process.

This section will focus on adding text, changing the existing text and deleting the text. At the end of this section you will have the knowledge to create any text file desired. The remaining sections focus on more desireable and convenient commands.

When entering text, multiple lines can be entered by using the return key. If a typing mistake needs to be corrected and you are on the entering text on the line in question. You can use the

$\boxed{\text{backspace}}$ key to move the cursor over the text. The different implementations of `vi` behave differently. Some just move the cursor back and the text can still be viewed and accepted. Others will remove the text as you backspace. Some clones even allow the arrow keys to be used to move the cursor when in input mode. This is not normal `vi` behaviour. If the text is visable and you use the $\boxed{\text{ESC}}$ key when on the line you have backspaced on the text after the cursor will be cleared. Use your editor to become accustomed to its' behaviour.

```
a           Append some text from the current cursor postion
A           Append at the end of the line
i           Insert text to the Left of the cursor
I           Inserts text to the Left of the first non-white character
                on current line
o           Open a new line and adds text Below current line
O           Open a new line and adds text Above the current line
```

We give it and we take it away. `vi` has a small set of delete commands which can be enhanced with the use of command modifiers.

```
x           Delete one character from under the cursor
dw          Delete from the current position to the end of the word
dd          Delete the current line.
D           Delete from the current position to the end of the line
```

The modifiers can be used to add greater power to the commands. The following examples are a subset of the posibilities.

```
nx          Delete n characters from under the cursor
ndd         Delete n lines
dnw         Deletes n words. (Same as ndw)
dG          Delete from the current position to the end of the file
d1G         Delete from the current postion to the start of the file
d$          Delete from current postion to the end of the line
            (This is the same as D)
dn$         Delete from current line the end of the nth line
```

The above command list shows the delete operating can be very powerfull. This is evident when applied in combination with the cursor movement commands. One command to note is $\boxed{\text{D}}$ since it ignores the modifier directives.

On occasions you may need to undo the changes. The following commands restore the text after changes.

```
u           Undo the last command
U           Undo the current line from all changes on that line
:e!         Edit again. Restores to the state of the last save
```

`vi` not only allows you to undo changes, it can reverse the undo. Using the command `5dd` delete 5 lines then restore the lines with `u`. The changes can be restored by the `u` again.

`vi` offers commands which allow changes to the text to be made without first deleting then typing in the new version.

```
rc          Replace the character under the cursor with c
            (Moves cursor right if repeat modifier used eg 2rc)
R           Overwrites the text with the new text
cw          Changes the text of the current word
c$          Changes the text from current position to end of the line
cnw         Changes next n words.(same as ncw)
cn$         Changes to the end of the nth line
C           Changes to the end of the line (same as c$)
cc          Changes the current line
s           Substitutes text you type for the current character
ns          Substitutes text you type for the next n characters
```

The series of change commands which allow a string of characters to be entered are exited with the `ESC` key.

The `cw` command started from the current location in the word to the end of the word. When using a change command that specifies a distance the change will apply. `vi` will place a **$** at the last character position. The new text can overflow or underflow the original text length.

A.4.3 Copying and Moving sections of text

Moving text involves a number of commands all combined to achieve the end result. This section will introduce named and unnamed buffers along with the commands which cut and paste the text.

Coping text involves three main steps.

1. **Yanking** (copying) the text to a buffer.
2. **Moving** the cursor to the destination location.
3. **Pasting** (putting) the text to the edit buffer.

To **Yank** text to the unnamed use `y` command.

```
yy          Move a copy of the current line to the unnamed buffer.
Y           Move a copy of the current line to the unnamed buffer.
nyy         Move the next n lines to the unnamed buffer
nY          Move the next n lines to the unnamed buffer
yw          Move a word to the unnamed buffer.
ynw         Move n words to the unnamed buffer.
nyw         Move n words to the unnamed buffer.
y$          Move the current position to the end of the line.
```

The unnamed buffer is a tempory buffer that is easily currupted by other common commands. On occations the text my be needed for a long period of time. In this case the named buffers would be used. `vi` has 26 named buffers. The buffers use the letters of the alphabet as the identification name. To distinguish the difference between a command or a named buffer, `vi` uses the " character. When using a named buffer by the lowercase letter the contents are over written while the uppercase version appends to the current contents.

```
"ayy      Move current line to named buffer a.
"aY       Move current line to named buffer a.
"byw      Move current word to named buffer b.
"Byw      Append the word the contents of the named buffer b.
"by3w     Move the next 3 words to named buffer b.
```

Use the p command to paste the contents of the cut buffer to the edit buffer.

```
p         Paste from the unnamed buffer to the RIGHT of the cursor
P         Paste from the unnamed buffer to the LEFT of the cursor
nP        Paste n copies of the unnamed buffer to the LEFT of the cursor
"ap       Paste from the named buffer a RIGHT of the cursor.
"b3P      Paste 3 copies from the named buffer b LEFT of the cursor.
```

When using `vi` within an xterm you have one more option for copying text. Highlight the section of text you wish to copy by draging the mouse cursor over text. Holding down the left mouse button and draging the mouse from the start to the finish will invert the text. This automatically places the text into a buffer reserved by the X server. To paste the text press the middle button. Remmember the put `vi` into insert mode as the input could be interpreted as commands and the result will be unknown. Using the same techinque a single word can be copied by double clicking the left mouse button over the word. Just the single word will be copied. Pasting is the same as above. The buffer contents will only change when a new highlighted area is created.

Moving the text has three steps.

1. **Delete** text to a named or unnamed buffer.

2. **Moving** the cursor the to destination location.

3. **Pasting** the named or unnamed buffer.

The process is the same as copying with the change on step one to delete. When the command dd is performed the line is deleted and placed into the unnamed buffer. You can then paste the contents just as you had when copying the text into the desired position.

```
"add      Delete the line and place it into named buffer a.
"a4dd     Delete 4 lines and place into named buffer a.
dw        Delete a word and place into unnamed buffer
```

See the section on modifying text for more examples of deleting text.

On the event of a system crash the named and unnamed buffer contents are lost but the edit buffers content can be recovered (See Usefull commands).

A.4.4 Searching and replacing text

`vi` has a number of search command. You can search for individual charaters through to regular expressions.

The main two character based search commands are f and t.

```
fc        Find the next character c. Moves RIGHT to the next.
Fc        Find the next character c. Moves LEFT to the preceding.
tc        Move RIGHT to character before the next c.
Tc        Move LEFT to the character following the preceding c.
          (Some clones this is the same as Fc)
;         Repeats the last f,F,t,T command
,         Same as ; but reverses the direction to the orginal command.
```

If the character you were searching for was not found, `vi` will beep or give some other sort of signal.

`vi` allows you to search for a string in the edit buffer.

```
/str      Searches Right and Down for the next occurance of str.
?str      Searches Left and UP for the next occurance of str.
n         Repeat the last / or ? command
N         Repeats the last / or ? in the Reverse direction.
```

When using the / or ? commands a line will be cleared along the bottom of the screen. You enter the search string followed by RETURN.

The string in the command / or ? can be a regular expression. A regular expression is a description of a set of characters. The description is build using text intermixed with special characters. The special characters in regular expressions are **. *** [] **^$**.

```
.         Matches any single character except newline.
\         Escapes any special characters.
*         Matches 0 or More occurances of the preceding character.
[]        Matches exactly one of the enclosed characters.
^         Match of the next character must be at the begining of the line.
$         Matches characters preceding at the end of the line.
[^]       Matches anything not enclosed after the not character.
[-]       Matches a range of characters.
```

The only way to get use to the regular expression is to use them. Following is a series of examples.

```
        c.pe       Matches cope, cape, caper etc
        c\.pe      Matches c.pe, c.per etc
        sto*p      Matches stp, stop, stoop etc
        car.*n     Matches carton, cartoon, carmen etc
        xyz.*      Matches xyz to the end of the line.
        ^The       Matches any line starting with The.
        atime$     Matches any line ending with atime.
        ^Only$     Matches any line with Only as the only word in the line.
        b[aou]rn   Matches barn, born, burn.
        Ver[D-F]   Matches VerD, VerE, VerF.
        Ver[^1-9]  Matches Ver followed by any non digit.
       the[ir][re] Matches their,therr, there, theie.
  [A-Za-z][A-Za-z]* Matches any word.
```

vi uses ex command mode to perform search and replace operations. All commands which start with a colon are requests in ex mode.

The search and replace command allows regular expression to be used over a range of lines and replace the matching string. The user can ask for confirmation before the substitution is performed. It may be well worth a review of line number representation in the ed tutorial.

```
:<start>,<finish>s/<find>/<replace>/g   General command

:1,$s/the/The/g       Search the entire file and replace the with The.
:%s/the/The/g         % means the complete file. (Same as above).
:.,5s/^.*//g          Delete the contents from the current to 5th line.
:%s/the/The/gc        Replace the with The but ask before substituting.
:%s/^....//g          Delete the first four characters on each line.
```

The search command is very powerfull when combined with the regular expression search strings. If the g directive is not included then the change is performed only on the first occurance of a match on each line.

Sometimes you may want to use the original search string in the replacement result. You could retype the command on the line but vi allows the replacement string to contain some special characters.

```
:1,5s/help/&ing/g     Replaces help with helping on the first 5 lines.
:%s/ */&&/g           Double the number of spaces between the words.
```

Using the complete match string has its limits hence vi uses the escaped parentheses (and) to select the range of the substitution. Using an escaped digit 1 which identifies the range in the order of the definition the replacement can be build.

```
:s/^\(.*\):.*/\1/g    Delete everything after and including the colon.
:s/\(.*\):\(.*\)/\2:\1/g    Swap the words either side of the colon.
```

You will most likely read the last series of gems again. `vi` offers powerfull commands that many more modern editors do not or can not offer. The cost for this power is also the main argument against `vi`. The commands can be difficult to learn and read. Though most good things can be a little awkward at first. With a little practice and time, the `vi` command set will become second nature.

Appendix B

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Appendix C

The GNU Library General Public License

GNU LIBRARY GENERAL PUBLIC LICENSE
Version 2, June 1991

[This is the first released version of the library GPL. It is numbered 2 because it goes with version 2 of the ordinary GPL.]

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Because of this blurred distinction, using the ordinary General Public License for libraries did not effectively promote software sharing, because most developers did not use the libraries. We concluded that weaker conditions might promote sharing better.

However, unrestricted linking of non-free programs would deprive the users of those programs of all benefit from the free status of the libraries themselves. This Library General Public License is intended to permit developers of non-free programs to use free libraries, while preserving your freedom as a user of such programs to change the free libraries that are incorporated in them. (We have not seen how to achieve this as regards changes in header files, but we have achieved it as regards changes in the actual functions of the Library.) The hope is that this will lead to faster development of free libraries.

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Bibliography

[1] Almesberger, Werner. *LILO: Generic Boot Loader for Linux.* Available electronically: `tsx-11.mit.edu`. July 3, 1993.

[2] Bach, Maurice J. *The Design of the UNIX Operating System.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1986.

[3] Lamport, Leslie. *LaTeX: A Document Preparation System.* Reading, Massachusetts: Addison-Wesley Publishing Company. 1986.

[4] Stallman, Richard M. *GNU Emacs Manual*, eight edition. Cambridge, Massachusetts: Free Software Foundation. 1993.

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