Computers:
Tools for an Information Age

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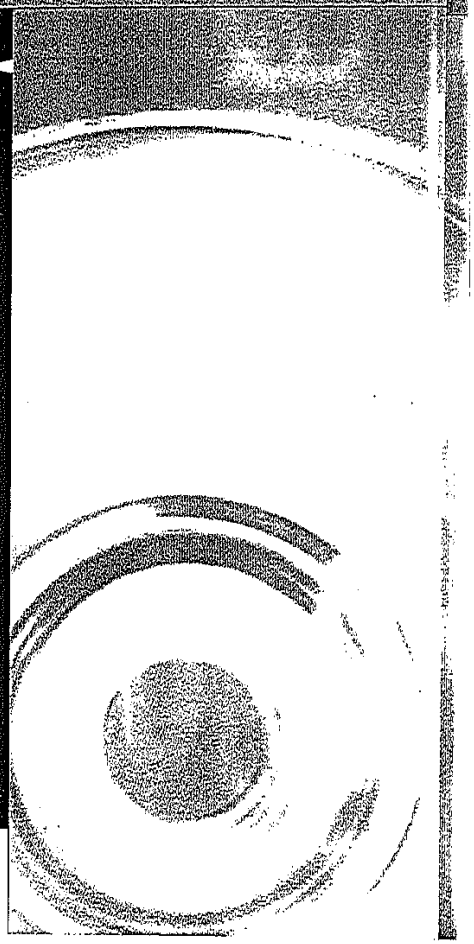


CHAPTER 1

Learning Objectives

- Describe the three fundamental characteristics of computers
- Describe at least four areas of society in which computers are used
- Identify the basic components of a computer system: input, processing, output, and storage
- List some common input, output, and storage media
- Distinguish data from information
- Describe the significance of networking
- Explain the significance of the Internet
- Explain the various classifications of computers

For years Mike McDowell refused to buy a personal computer. The 36-year-old McDowell, owner of a 1200-acre farm in Wisconsin, told his disappointed children that they would just have to use the computers at school. The family simply could not justify the expense of a computer in the home. "If I buy a new tractor," he noted, "I can make the farm more profitable. But a computer? I just can't see it."

He can now. Mr. McDowell took a look at the new price tags. As personal computer prices ducked below $1000, they attracted a whole new audience of home users. In fact, more than half of new computers are purchased by first-time buyers. In addition, computers are continuing their winning ways. Almost 80 percent of computer buyers are "satisfied" or "very satisfied" with their computers.

Mr. McDowell ticks off the uses his family has found for the computer. He took a class at his local community college and learned to use spreadsheets, a kind of rows and columns report to plan his crop planting and rotations. He uses the computer to send for weather and crop reports from agencies of the federal government. His wife favors e-mail, which lets her use the computer to send messages back and forth to her sisters in Duluth and Omaha. His teenage daughter, who wrote her high school reports using word processing, saved her summer job earnings to buy a laptop computer to take with her to college. Mr. McDowell now counts himself in the "very satisfied" category.

STEPPING OUT

Your first steps toward joining the Information Age include understanding how we got to where we are today. Perhaps you recall from history books how the Industrial Age took its place in our world. In just a few decades, society accepted the dizzying introduction of electricity, telephones, radio, automobiles, and airplanes. However, the Information Age is evolving even more rapidly. It is likely to continue to evolve well into the twenty-first century.

Forging a Computer-Based Society

Traditional economics courses define the cornerstones of an economy as land, labor, and capital. Today we can add a fourth key economic element: information. As we evolve from an industrial to an information society, our jobs are changing from physical to mental labor. Just as people moved physically from farms to factories in the Industrial Age, so today people are shifting from muscle power to brain power in a new, computer-based society.

You are making your move, too, taking your first steps by signing up for this computer class and reading this book. But should you go further and get your own computer? We look next at some of the reasons why you might.

A Computer in Your Future

Computers have moved into every nook and cranny of our daily lives. Whether or not you personally know anything about it, you invoke computers when you make a bank withdrawal, when you buy groceries at the supermarket, and even when you drive your car. But should you have a computer at your personal disposal? The answer today is "probably." Although only a little more than half of Americans have personal computers in their homes, a much higher percentage use computers on the job. Almost any career in your future will involve a computer in some way.

In their homes people use various forms of computer technology for writing papers and memos, for keeping track of bank accounts, for communicating with friends and

Computers have moved into every nook and cranny of our daily lives.

People use their home computers to compose letters and memos, play games, and keep track of their finances.

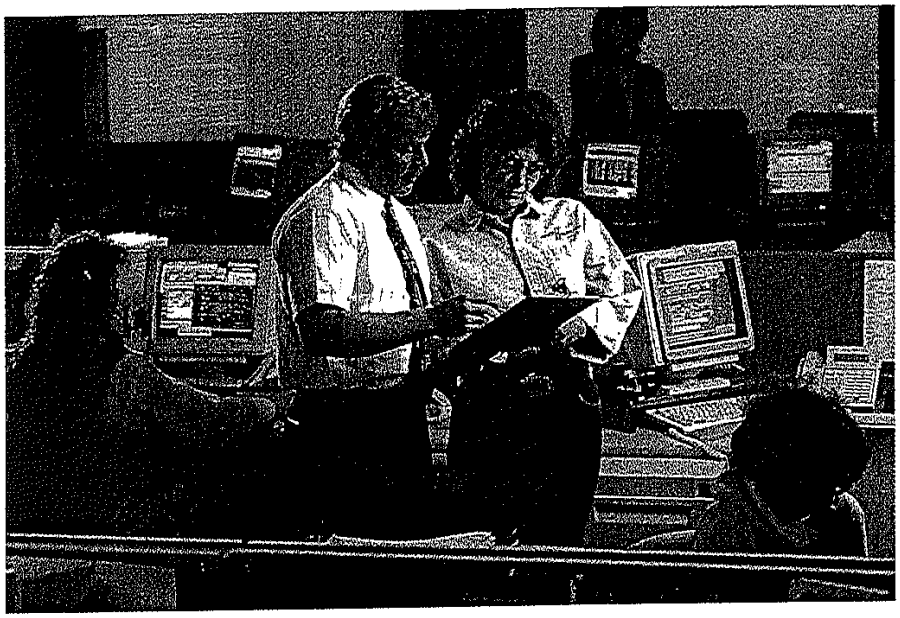
associates, for accessing knowledge, for purchasing goods, for entertainment, and for so much more.

Computer Literacy for All

Why are you studying about computers? In addition to curiosity (and perhaps a course requirement), you probably recognize that it will not be easy to get through the rest of your life without knowing about computers. We offer a three-pronged definition of **computer literacy:**

- **Awareness.** As you study about computers, you will become aware of their importance, their versatility, and their pervasiveness in our society.
- **Knowledge.** You will learn what computers are and how they work. This requires learning some technical jargon, but do not worry—no one expects you to become a computer expert.
- **Interaction.** There is no better way to understand computers than through interacting with one. So being computer literate also means being able to use a computer for some simple applications.

Note that no part of this definition suggests that you must be able to create the instructions that tell a computer what to do. That would be akin to saying that anyone who plans to drive a car must first become an automotive engineer. Someone else can write the instructions for the computer; you simply use the instructions to get your work done. For example, an accountant might use a computer to prepare a report, a teenager to play a video game, or a construction worker to record data from the field.



Computers are characterized by speed, reliability, and storage capability.

THE NATURE OF COMPUTERS

Every computer has three fundamental characteristics. Each characteristic has by-products that are just as important. The three fundamental characteristics are:

- **Speed.** Computers provide the processing speed essential to our fast-paced society. The quick service that we have come to expect—for bank withdrawals, stock quotes, telephone calls, and travel reservations, to name just a few—is made possible by computers. Businesses depend on the speedy processing that computers provide for everything from balancing ledgers to designing products.
- **Reliability.** Computers are extremely reliable. Of course, you might not think this from some of the stories you may have seen in the press about "computer errors." However, most errors supposedly made by computers are really human errors.
- **Storage Capability.** Computer systems can store tremendous amounts of data, which can be located and retrieved efficiently. The capability to store volumes of data is especially important in an information age.

These three characteristics—speed, reliability, and storage capability—have the following by-products:

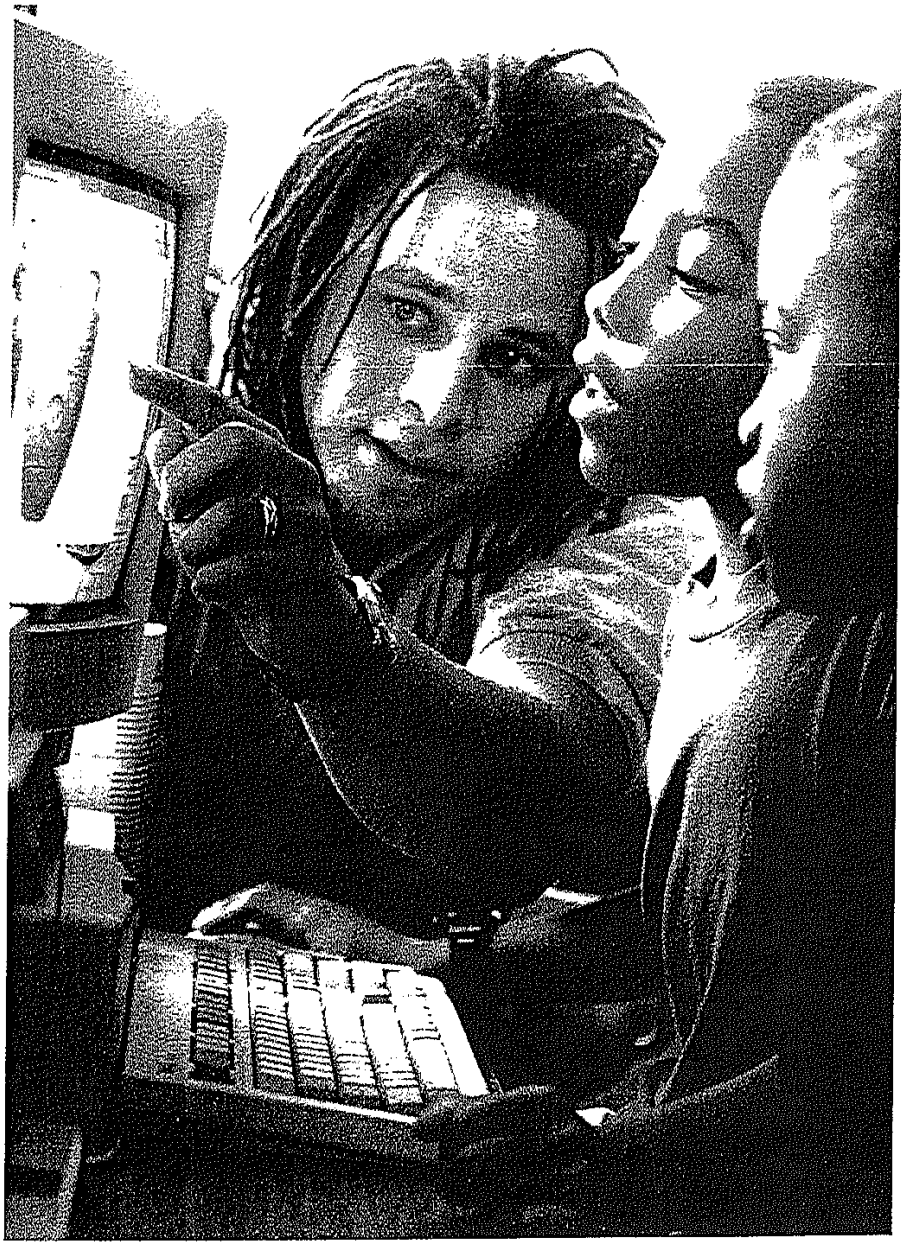
- **Productivity.** When computers move into business offices, managers expect increased productivity as workers learn to use computers to do their jobs better and faster. Furthermore, jobs such as punching holes in metal or monitoring water levels can be more efficiently controlled by computers.
- **Decision making.** To make decisions, managers need to take into account financial, geographical, and logistical factors. The computer helps decision makers sort things out and make better choices.
- **Cost reduction.** Finally, because it improves productivity and aids decision making, the computer helps us hold down the costs of labor, energy, and paperwork. As a result, computers help to reduce the costs of goods and services in our economy.

Next we look at some of the ways in which we use computers to make the workday more productive and our personal lives more rewarding.

WHERE COMPUTERS ARE USED

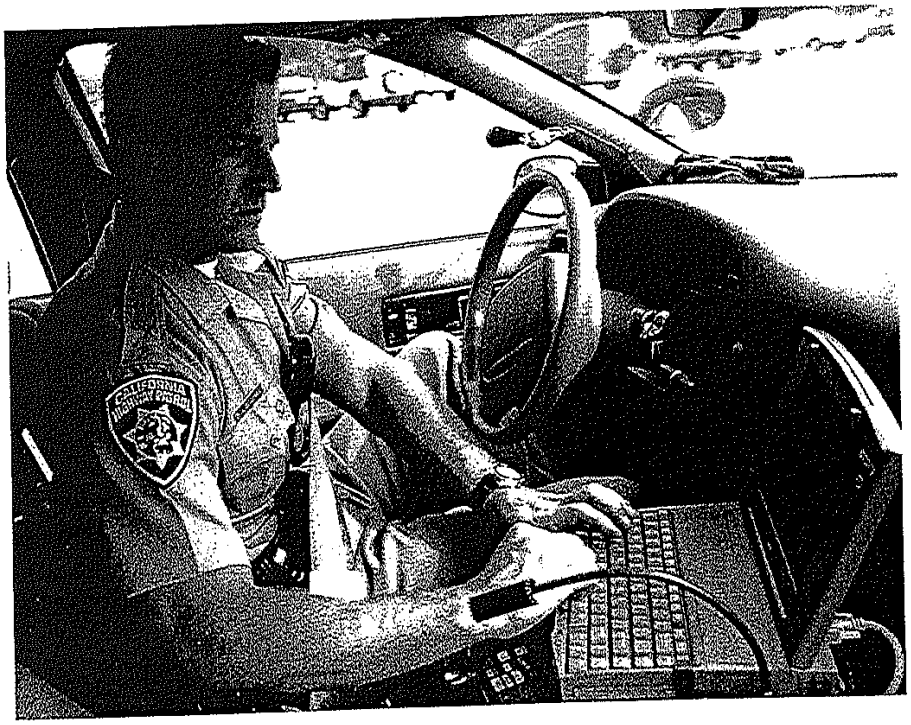
Computers can do just about anything imaginable, but they really excel in certain areas. This section lists some of the principal areas of computer use.

- **Education.** Most schools in the United States have computers available for use in the classroom, and some colleges require entering freshmen to bring their own. Many educators prefer learning by doing—an approach uniquely suited to the computer.



Most schools in the United States have computers in the classroom because many educators prefer the learning-by-doing method.

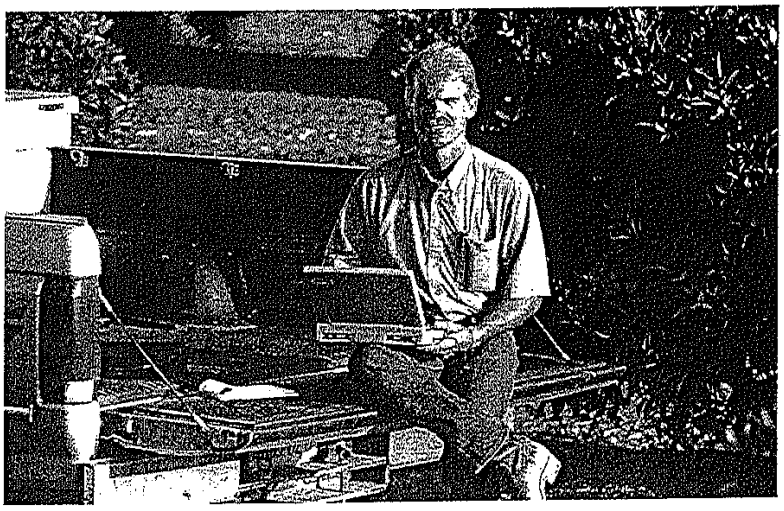
- **Graphics.** Business people make bar graphs and pie charts from tedious figures to convey information with far more impact than numbers alone convey. Architects use computer-generated graphics to experiment with possible exteriors and to give clients a visual walk-through of proposed buildings. Finally, a new kind of artist has emerged, one who uses computers to express his or her creativity.
- **Retailing.** Products from meats to magazines are packaged with zebra-striped bar codes that can be read by computer scanners at supermarket checkout stands to determine prices and help to manage inventory. Computers operate behind the scenes too; for example, this book was tracked from printer to warehouse to bookstore with the help of computers and the bar code on the back cover.
- **Energy.** Energy companies use computers to locate oil, coal, natural gas, and uranium. Electric companies use computers to monitor vast power networks. In addition, meter readers use handheld computers to record how much energy is used each month in homes and businesses.
- **Law enforcement.** Recent innovations in computerized law enforcement include national fingerprint files, a national file on the mode of operation of serial killers, and the computer modeling of DNA, which can be used to match traces from an alleged criminal's body, such as blood at a crime scene.
- **Transportation.** Computers are used in cars to monitor fluid levels, temperatures, and electrical systems. Computers also are used to help run rapid transit systems, load container ships, and track railroad cars across the country. The workers in an airport tower rely on computers to help monitor air traffic.
- **Money.** Computers speed up record keeping and allow banks to offer same-day services and even do-it-yourself banking over the phone. Computers have helped to fuel the cashless economy, enabling the widespread use of credit cards and instantaneous credit checks by banks and retailers.



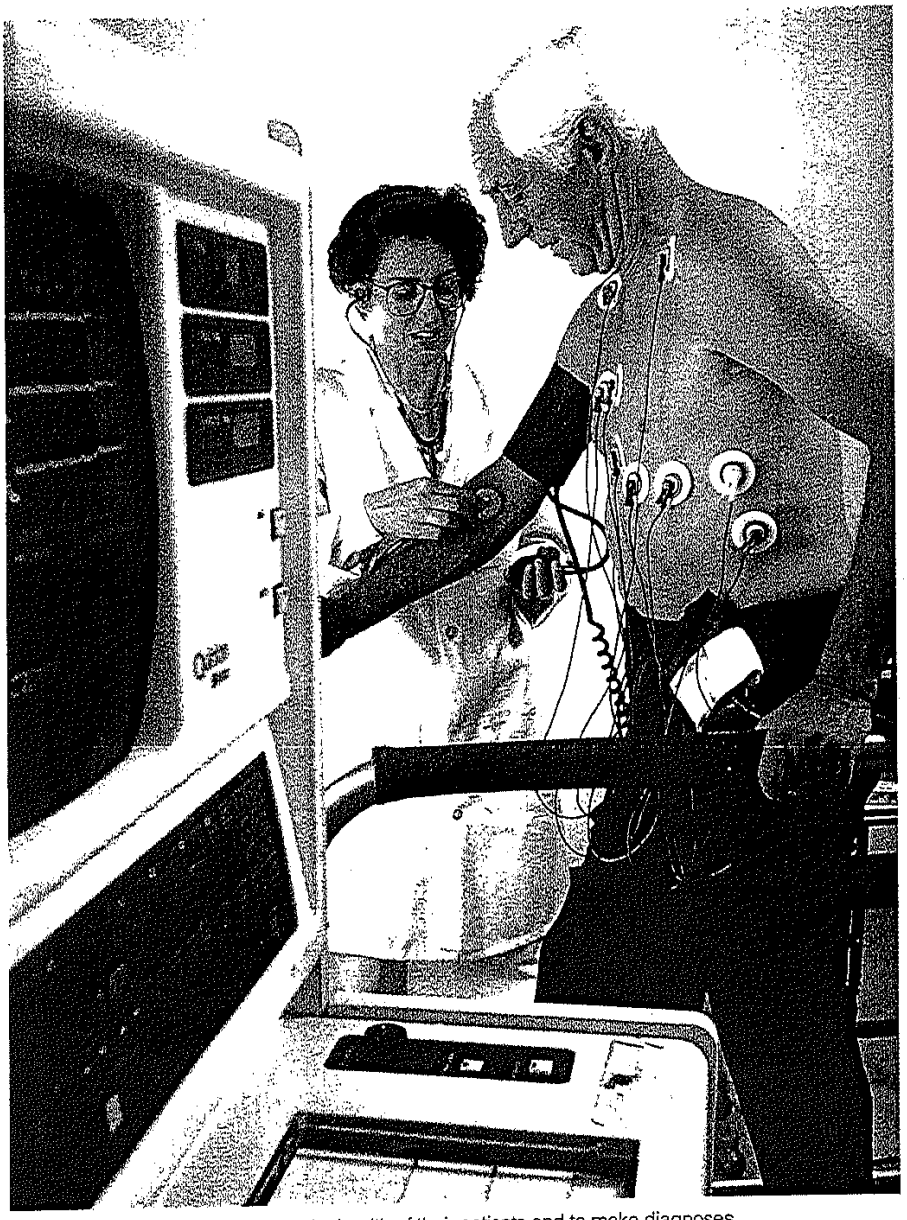
Recent innovations in computerized law enforcement include national fingerprint files and computer modeling of DNA.

Air traffic controllers use computers to monitor and direct air traffic.

- **Agriculture.** Farmers use small computers to help with billing, crop information, cost per acre, feed combinations, and market price checks. Cattle ranchers can also use computers for information about livestock breeding and performance.
- **Government.** Among other tasks, the federal government uses computers to forecast weather, to manage parks, to process immigrants, to produce Social Security benefit checks, and—of course—to collect taxes. State and local governments also use computers routinely.



Cattle ranchers use computers for information about livestock breeding and performance.



Doctors use computers to monitor the health of their patients and to make diagnoses.

- **The home.** People have computers in their homes, often justifying them as educational tools for their children. But that is only the beginning. Personal computers are being used at home to keep records, write letters, prepare budgets, draw pictures, publish newsletters, and connect with others.
- **Health and medicine.** Computers help to monitor the seriously ill in intensive care units and provide cross-sectional views of the body. Physicians can also use computers to assist in diagnoses; in fact, computers have been shown to correctly diagnose heart attacks more frequently than physicians do. If you are

This factory robot welds a new car under direction of the computer.

one of the thousands who suffer one miserable cold after another, you will be happy to know that computers have been able to map, in exquisite atomic detail, the structure of the human cold virus—the first step toward a cure for the common cold.

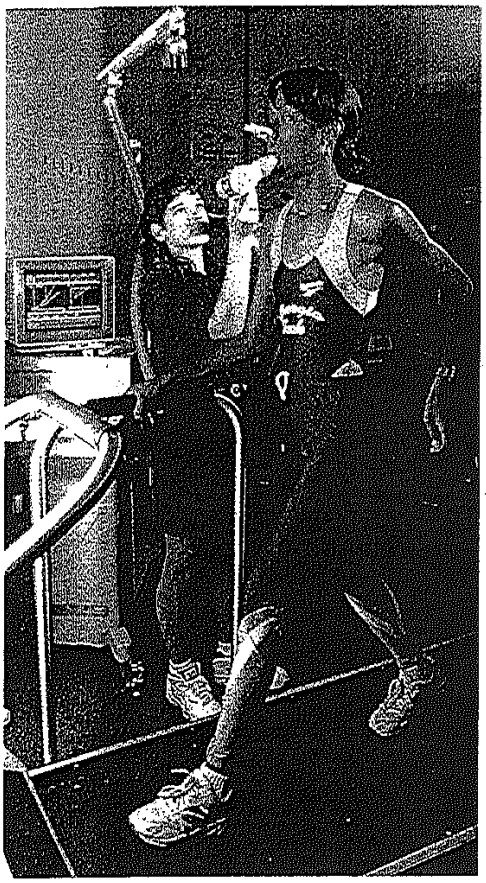
- **Robotics.** Computers have paved the way for robots to take over many of the jobs that are too unpleasant or too dangerous for humans, such as opening packages that are believed to contain bombs. Robots are best known for their work in factories, but they can do many other things, not the least of which is finding their way through the bloodstream.

- **The human connection.** Are computers cold and impersonal? The disabled do not think so; children, in particular, consider the computer their main education tool. Can the disabled walk again? Some can, with the help of computers. Can dancers and athletes improve their performance? Maybe they can, by using computers to monitor their movements. Can we learn more about our ethnic backgrounds and our cultural history with the aid of computers? Indeed we can.

- **The sciences.** Scientific researchers have long benefited from the high-speed capabilities of computers. Computers can simulate environments, emulate physical characteristics, and allow scientists to provide proofs in a cost-effective manner. Also, many mice—and other animals—have been spared since computer models have taken over their roles in research.

- **Connectivity.** One of the most popular uses of computers today is communicating with other people who have computers, whether for business or personal reasons. In addition, computers can give people the option of working at their homes instead of commuting to offices.

Athletes can use computers to assess and improve their physical performance.



- **Training.** It is much cheaper to teach aspiring pilots to fly in computerized training simulators than in real airplanes. Novice railroad engineers can also be given the experience of running a train with the help of a computerized device. Training simulations are relatively inexpensive and are always available on a one-to-one basis, making for very personal learning.
- **Paperwork.** In some ways the computer contributes to paper use by adding to the amount of junk mail you find in your mailbox. However, in many ways it cuts down on paper handling. Using a computer, for example, you might type several drafts of a term paper before printing anything. Computerized record keeping and ordering have also made paperwork more efficient.

Computers are all around us. You have been exposed to computer hype, computer advertisements, and computer headlines. You have interacted with computers in your everyday life—at the grocery store, your school, the library, and more. You know more about computers than you think you do. The beginnings of computer literacy are already apparent.

Have It Your Way
Have it your way exactly. The name of the new movement is *mass customization,* and the computer makes it possible.

Companies with millions of customers are starting to build products designed just for you. The woman in the photo is being measured for a pair of Levi jeans, which will be cut to fit her body. But clothes are just the beginning. You can buy a Dell computer made to your exact specifications. You can also buy eyeglasses molded to fit your face, CDs with music tracks you select, cosmetics mixed to match your skin tone, or a specially designed Barbie doll. Although these are mass-marketed goods, they can be uniquely tailored to the customers who buy them.

THE BIG PICTURE

A computer system has three main components: hardware, software, and people. The equipment associated with a computer system is called **hardware.** A set of instructions called **software** tells the hardware what to do. People, however, are the most important component of a computer system—people use the power of the computer for some purpose.

Software is also referred to as programs. To be more specific, a **program** is a set of step-by-step instructions that directs the computer to do the required tasks and produce the desired results. A **computer programmer** is a person who writes programs. **Users** are people who purchase and use computer software. In business, users are often called **end-users** because they are at the end of the "computer line," actually making use of the computer's capabilities.

This chapter examines hardware. The chapter looks at the big picture; therefore many of the terms introduced in this chapter are discussed only briefly here. Subsequent chapters will define the various parts of a computer system in greater detail.

HARDWARE: THE BASIC COMPONENTS OF A COMPUTER

What is a computer? A 6-year-old called a computer "radio, movies, and television combined!" A 10-year-old described a computer as "a television set you can talk to." The 10-year-old's definition is closer but still does not recognize the computer as a machine that has the power to make changes. A **computer** is a machine that can be programmed to accept **data** (*input*), process it into useful **information** (*output*), and store it away (in a *secondary storage* device) for safekeeping or later reuse. The processing of input to output is directed by the software but performed by the hardware, the subject of this chapter.

To function, a computer system requires four main aspects of data handling: input, processing, output, and storage (Figure 1-1). The hardware responsible for these four areas is as follows:

- *Input devices* accept data or commands in a form that the computer can use; they send the data or commands to the processing unit.

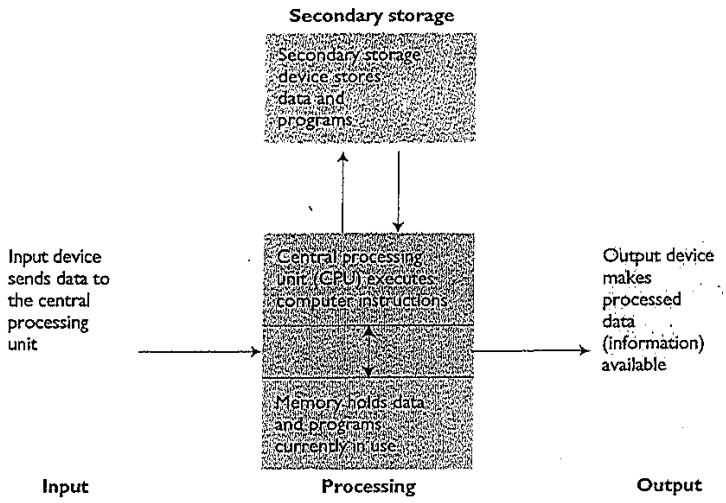


FIGURE 1-1

The four primary components of a computer system.

To function, a computer system requires input, processing, output, and storage.

- *The processor,* more formally known as the *central processing unit* (*CPU*), has electronic circuitry that manipulates input data into the information people want. The central processing unit actually executes computer instructions.
- *Output devices* show people the processed data—information—in understandable and usable form.
- *Storage* usually means *secondary storage,* which consists of secondary storage devices such as disk—hard disk or diskettes or some other kind of disk—that can store data and programs outside of the computer itself. These devices supplement *memory* or *primary storage,* which can hold data and programs only temporarily.

HARDWARE.

Prentice Hall EXPLORE Generation it

Before looking at each of these hardware aspects, consider them in terms of what you would find on a personal computer.

YOUR PERSONAL COMPUTER HARDWARE

Let us look at the hardware of a personal computer. Suppose you want to do word processing on a personal computer, using the hardware shown in Figure 1-2. Word processing software allows you to input data such as an essay, save it, revise and resave it, and print it whenever you wish. The *input* device, in this case, is a keyboard, which you use to key in—type—the original essay and any subsequent changes to it. You will also probably use the mouse as an input device. All computers, large and small, must have a *central processing unit,* so yours does too—it is within the personal computer housing. The central processing unit uses the word processing software to accept the data you input through the keyboard. Processed data from your personal computer is usually *output* in two forms: on a screen and by a printer. As you key in the essay on the keyboard, it appears on the screen in front of you. After you have examined the essay on the screen, made changes, and determined that you are satisfied with the result, you can print the essay on the printer. Your *secondary storage device,* as shown in Figure 1-2, which stores the essay until it is needed again, will probably be a hard disk or diskette. For reasons of convenience and speed, you are more likely to store your data—the essay—on a hard disk than on a diskette. (However, if you are using someone else's computer, such as a school computer, you will probably keep your own files on your own diskette.)

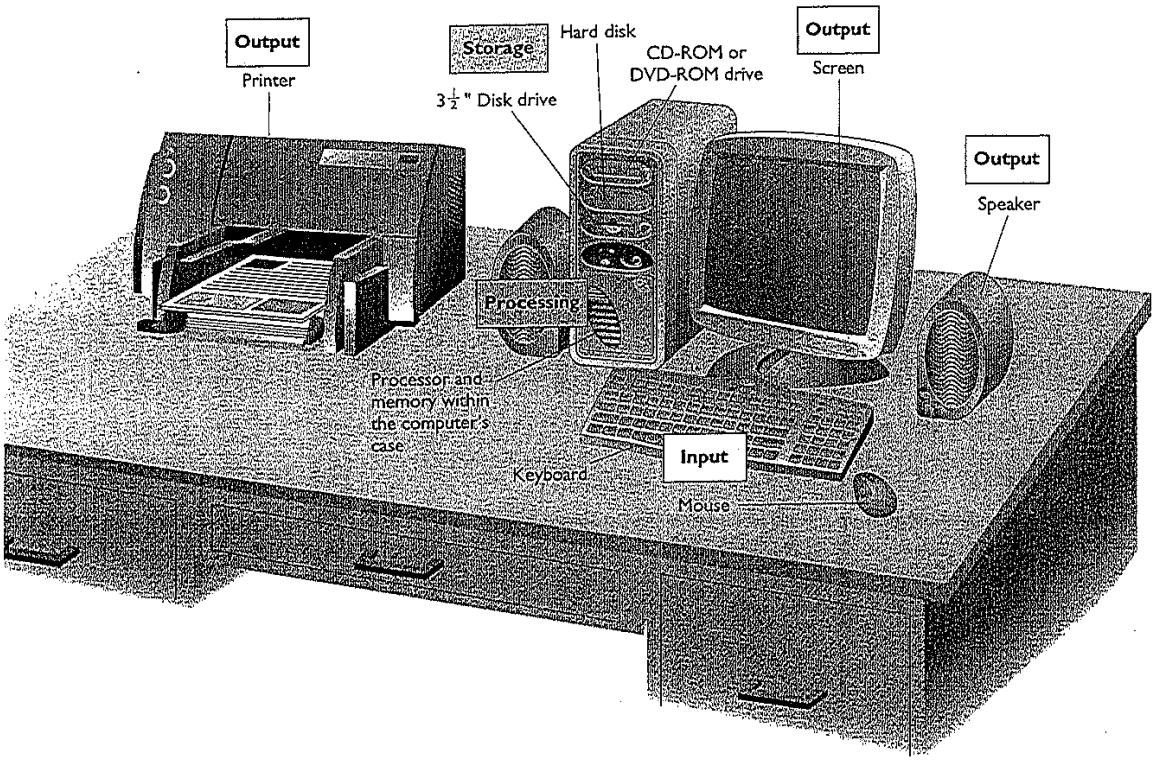


FIGURE 1-2

A personal computer system.

In this personal computer system, the input devices are a keyboard and a mouse. The input devices feed data to the central processing unit, which is inside the computer case, the vertical box to the left of the screen. The output devices in this example are the screen, the printer, and the speakers. The secondary storage devices are a hard drive, a 3½-inch disk drive, and a CD-ROM or DVD-ROM drive, all contained within the computer case. This popular configuration, with the case standing on end, is called a minitower.

Next is a general tour of the hardware needed for input, processing, output, and storage. These same components make up all computer systems, whether small, medium, or large.

Input: What Goes In

Input is the data that you put into the computer system for processing. Here are some common ways of feeding input data into the system:

- *Typing* on a **keyboard** (Figure 1-3a). The keys on a computer keyboard are arranged in much the same way as those on a typewriter. The computer responds to what you enter; that is, it "echoes" what you type by displaying it on the screen in front of you.
- *Pointing* with a **mouse** (Figure 1-3a). A mouse is a device that is moved by hand over a flat surface. As the ball on its underside rotates, the mouse movement causes corresponding movement of a pointer on the computer screen. Pressing buttons on the mouse lets you select commands.
- *Scanning* with a **wand reader, bar code reader, flatbed scanner,** or **sheet-fed scanner.** Wand and bar code readers, which you have seen used by clerks in retail

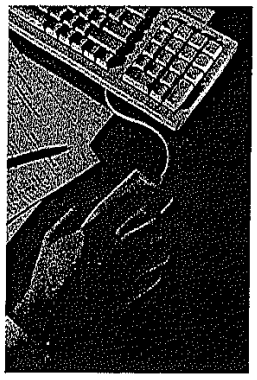
MAKING CONNECTIONS ◄ **The Wired Campus**

Campuses are "wired" in more ways than one. At most schools, each incoming student is automatically assigned an e-mail address and given access to Internet services. Some schools require incoming freshmen to possess a computer. Others include the cost of a new computer in their tuition. Students can often count on high-speed network connections for their computers right in their dorm rooms. Standard services offered by computer are registration for classes—no more lines!—and applications for financial aid. Coursework often can be submitted to a professor via computer. Wireless networks, which allow students access to the school's network through their laptops from anywhere on campus, are the latest trend among leading-edge colleges and universities.

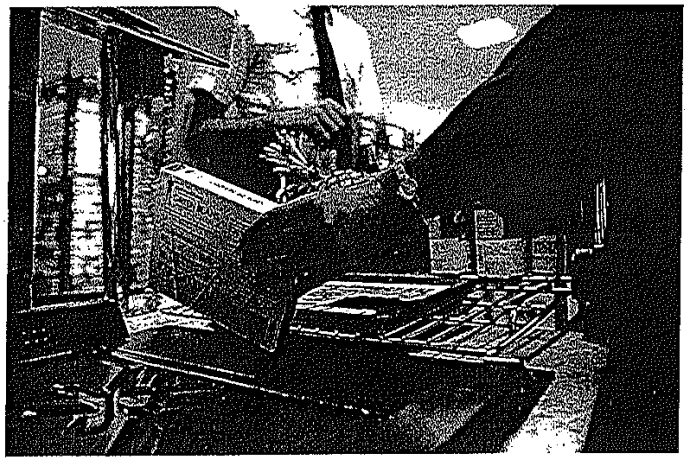
Quite a few students are making decisions about where to go to school on the basis of a school's computer services. As a point of interest, the ZDNet Ultimate College Guide 2000 lists the 10 most wired large universities as Carnegie Mellon University, the University of Delaware, New Jersey Institute of Technology, Indiana University–Bloomington, Dartmouth College, MIT, Rensselaer, the University of Virginia, Washington State University, and UCLA.

stores, use laser beams to read special letters, numbers, or symbols such as the black-and-white bar codes found on many products (Figure 1-3b). Flatbed or sheet-fed scanners are used to scan pictures or printed documents into your computer.

An input device may be part of a terminal. The simplest **terminal** includes a keyboard as the input device, a screen display for output, and some method of connection to a computer. For example, operators taking orders over the phone for a mail-order house would probably use terminals to input orders and send them to be processed by a large computer. You can input data into a computer in many other interesting ways, including by writing, speaking, pointing, or even just looking at the data.



(a)

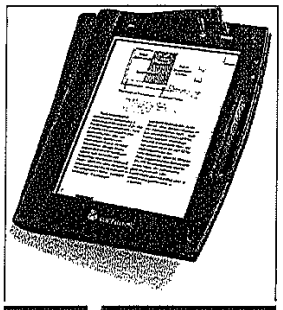


(b)

FIGURE 1-3

Input devices.

(a) The keyboard is the most widely used input device, though the mouse has become increasingly popular. Movement of the mouse on a flat surface causes corresponding movement of a pointer on the screen. (b) The information contained in the bar code on this package of green beans is scanned into the computer.



Curling Up with a Good Computer

It looks like a book, sort of, but it holds 50,000 pages. It weighs less than three pounds. It is, in fact, a computer book, and it has a beautiful screen. It can hold reference books and several of your favorite novels.

In addition to the familiar comforts, this book knows a few tricks. You can still dog-ear a page by pressing a corner of the touch-sensitive screen, and you can use a stylus-type pen to write notes or underline. You can also enlarge the typeface or touch a word to look it up in the dictionary.

Computer books are not cheap—yet. And, of course, you have to pay for the books you want to read on them too. New books can be purchased on the Internet and downloaded directly to the computer book.

The Processor and Memory: Data Manipulation

In a computer the processor is the center of activity. The **processor,** as has already been noted, is also called the **central processing unit (CPU).** The central processing unit consists of electronic circuits that interpret and execute program instructions as well as communicating with the input, output, and storage devices.

It is the central processing unit that actually transforms data into information. **Data** is the raw material to be processed by a computer, such as grades in a class, touchdowns scored, or light and dark areas in a photograph. Processed data becomes **information**—data that is organized, meaningful, and useful. In school, for instance, an instructor could enter various student scores (data), which could be processed to produce final grades and perhaps a class average (information). Note that the instructor's final grade information could, in turn, become the data for the school's student records system, which would produce grade reports and GPAs as its information. Data that is perhaps uninteresting on its own may become very interesting once it is converted to information. The raw facts (data) about your finances, such as a paycheck or a donation to charity or a medical bill, may not be captivating individually, but together these and other items can be processed to produce the refund or amount you owe on your income tax return (information).

Computer **memory,** also known as **primary storage,** is closely related to the central processing unit but separate and distinct from it. Memory holds the data after it is input into the system and before it is processed; also, memory holds the data after it has been processed but before it has been released to the output device. In addition, memory holds the programs (computer instructions) needed by the central processing unit. Memory can hold data only temporarily because memory requires a continuous flow of electric current; if the current is interrupted, the data is lost.

Output: What Comes Out

Output—the result produced by the central processing unit—is, of course, a computer's whole reason for being. Output is usable information—that is, raw input data that has been processed by the computer into information. Common forms of output are text, numbers, graphics, and even sounds. Text output, for example, might be the letters and memos prepared by office workers using word processing software. Other workers may be more interested in numbers, such as those found in formulas, schedules, and budgets. In many cases numbers can be understood more easily when output is in the form of graphics.

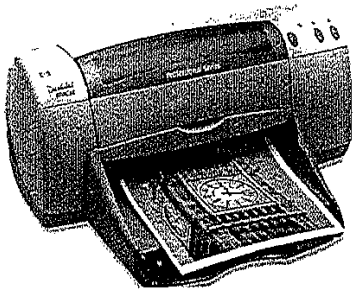
The most common output devices are computer screens and printers. A **screen,** or **monitor,** can vary in its form of display, producing text, numbers, symbols, art, photographs, and even video, in full color (Figure 1-4a). **Printers** produce printed reports as instructed by a computer program (Figure 1-4b). Many printers, particularly those associated with personal computers, can print in color.

You can produce output from a computer in other ways, including film, voice, and music.

Secondary Storage

Secondary storage provides additional storage separate from memory. Recall that memory holds data and programs only temporarily; therefore there is a need for secondary storage. The most common secondary storage media for personal computers are magnetic disks. A **magnetic disk** can be a diskette or a hard disk. A **diskette** usually consists of a flexible magnetic disk 3½ inches in diameter, enclosed in a plastic case (Figure 1-5a). **Hard disks** have more storage capacity than diskettes and also offer much faster access to the data they hold. On large computer systems, hard disks are often contained in disk packs. Disk data is read by **disk drives.** Most personal computers have a built-in hard disk and a drive that reads diskettes. **Optical**

(a)



(b)

FIGURE 1-4

Output devices.

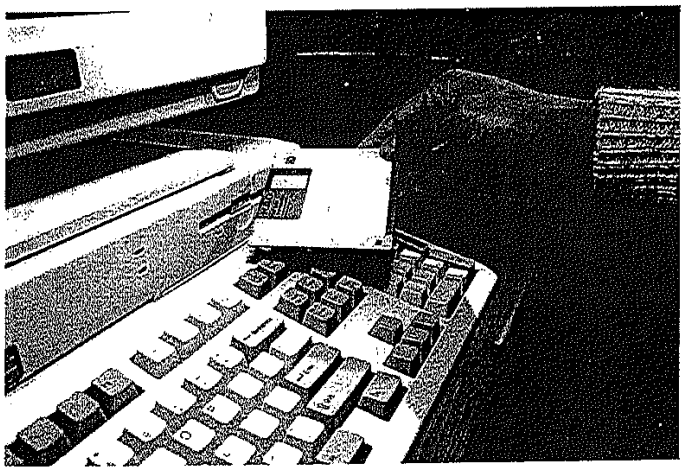
Monitors and printers are two types of output devices. (a) This monitor can display text or the colorful graphics shown here. (b) This ink-jet printer is used to produce high-quality text and graphics output.

disk drives, such as **CD-ROM**s and **DVD-ROM**s, use a laser beam to read large volumes of data relatively inexpensively (Figure 1-5b).

Magnetic tape is a storage medium that is used primarily with large computer systems, though some personal computers also use this form of secondary storage. This tape usually comes on a cartridge and is similar to tape that is played on a tape recorder. Magnetic tape cartridges are inserted in a **tape drive** when the data on them need to be read by the computer system or when new data is to be written on the tape. Magnetic tape is usually used for backup purposes—for "data insurance"—because tape is inexpensive. The chapter on storage presents more detailed information about storage media, notably alternative types of disk storage.

The Complete Hardware System

The hardware devices that are attached to the computer are called peripheral equipment. **Peripheral equipment** includes all input, output, and secondary storage



(a)

(b)

FIGURE 1-5

Secondary storage devices.

(a) A 3½-inch diskette is being inserted into a disk drive. (b) Optical disks can hold enormous amounts of data: text, music, graphics—even video and movies.

GETTING PRACTICAL **Those Necessary Extras**

Like people who have boats or cameras, computer owners are tempted to buy the latest gadget. There are many from which to choose, some new, neat, and nifty—and some more useful than others.

For greater flexibility, check out a wireless keyboard or mouse, which works well as long as it is within direct line of sight of the computer. For everyday computer comfort, consider gel-based wrist rests for your keyboard and mouse pad. To reduce neck strain, get a document holder that attaches to the side of your monitor. While you are at it, you can reduce eyestrain by attaching a magnifier to the screen itself.

If you prefer to say what you think instead of writing it, you can purchase a microphone and accompanying software to accept your voice input. Road warriors can buy practical laptop cases, with lots of padding and pockets for accessories. Webcams enable you to send video images across the Internet. If music and gaming are a big part of your computer life, you could invest in the very best: surround-sound speakers with a separate subwoofer.

devices. In most personal computers, the CPU and disk drives are all contained in the same housing, a metal case; the keyboard, mouse, and monitor are separate.

In larger computer systems, however, the input, processing, output, and storage functions may be in separate rooms, separate buildings, or even separate countries. For example, data may be input on terminals at a branch bank and then transmitted to the central processing unit at the bank's headquarters. The information produced by the central processing unit may then be transmitted to the international offices, where it is printed out. Meanwhile, disks with stored data may be kept at the bank headquarters, and duplicate data may be kept on disk or tape in a warehouse across town for safekeeping.

Although the equipment may vary widely from the simplest computer to the most powerful, by and large the four elements of a computer system remain the same: input, processing, output, and storage. These basic components are supplemented by hardware that can make computers much more useful, giving them the ability to connect to one another.

BUILDING A NETWORK.

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NETWORKING

Many organizations find that their needs are best served by a **network,** a system that uses communications equipment to connect computers and their resources. Resources include printers and hard disks and even software and data. In one type of network, a **local area network (LAN),** personal computers in an office are connected together so that users can communicate with one another. Users can operate their personal computers independently or in cooperation with other computers to exchange data and share resources. The networking process can be much more complex; we will describe how large computers can be involved in networks in the chapter on networking.

Individual users in homes or offices have joined the trend to connectivity by hooking up their personal computers, usually via telephone lines, to other computers. Users who connect their computers to other computers via the phone lines must use a hardware device called a **modem** as a go-between to reconcile the inherent differences between computers and the phone system. From their own homes, users can connect to all sorts of computer-based services, performing such tasks as getting stock quotes, making airline reservations, and shopping for videotapes. An important

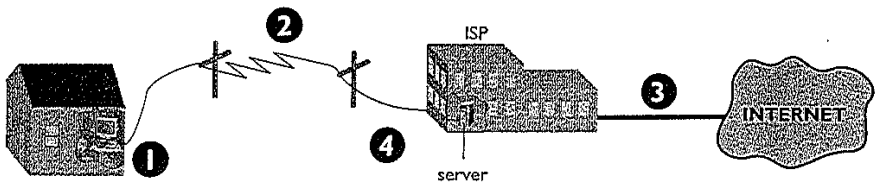

FIGURE 1-6

The Internet.

(1) At his or her own computer, a user accesses the ISP's server computer, (2) probably over the phone line. (3) The server computer communicates with the Internet, perhaps passing on e-mail messages or requests for certain Web sites and picking up responses. (4) Incoming messages, e-mail, or requested Internet information is returned to the original requesting computer. This back-and-forth communication goes on as long as the user wishes to remain connected to the Internet.

service for individuals is **electronic mail,** or **e-mail,** which lets people send and receive messages via computer.

Whether the user is operating in a business capacity or simply exploring the options, a popular conduit for connectivity is the Internet.

THE INTERNET

INTERNET AND THE WWW.

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The **Internet,** sometimes called simply "the Net," is the largest and most far-flung network system of them all, connecting users worldwide. Surprisingly, the Internet is not really a single network but a loosely organized collection of thousands of networks. Many people are astonished to discover that no one owns the Internet. It has no central headquarters, no centrally offered services, and no comprehensive index to tell you what information is available.

Originally developed by the U.S. government, the Internet connects libraries, college campuses, research labs, government organizations, businesses, and any other organization or individual who has the capacity to hook up.

Getting Connected

How are all kinds of different computers able to communicate with one another? To access the Internet, a user's computer must connect to a type of computer called a **server.** Each server uses the same special software called **TCP/IP** (for **Transmission Control Protocol/Internet Protocol);** it is this standard that allows different types of computers to communicate with each other (Figure 1-6). The supplier of the server computer, often called an **Internet service provider (ISP),** charges a fee, usually monthly, that either covers unlimited access or is based on the amount of service provided. Once a user has chosen a service provider, he or she will be furnished with the information needed to connect to the server and, from there, to the Internet.

Getting Around

Since the Internet did not begin as a commercial customer-pleasing package, it did not initially offer attractive options for finding information. Most of the information was text-only, and the arcane commands needed to find it were invoked only by a hardy and determined few. Furthermore, the vast sea of information, including news and trivia, can seem an overwhelming challenge to navigate. As both the Internet user population and the types and amount of available information grew, new ways were developed to tour the Internet.

The most attractive method used to move around the Internet is called *browsing.* Using a program called a **browser,** you can use a mouse to point and click on screen text or pictures to explore the Internet, particularly the **World Wide Web (WWW or the Web),** an Internet subset of text, images, and sounds linked together to allow users to peruse related topics. Each different location on the Web is called a **Web site** or, more commonly, just a **site.** You may have heard the term **home page;** this is just the main page of a Web site.

FOCUS ON ETHICS **Can the Government Really Do That?**

Carnivore is an FBI system that can read e-mail, Web page views, and other Internet data from selected individuals, store them, and forward them to government agencies. Currently, the FBI must obtain a secret court order before monitoring Internet traffic.

The FBI says that it needs Carnivore's electronic surveillance capabilities to combat terrorism and drug dealers. Privacy advocates and some members of Congress are concerned that Carnivore captures data from more than just the authorized individuals and that the standard of proof required to obtain permission to employ Carnivore is too weak.

Find some recent development related to Carnivore and electronic eavesdropping. Where would you draw the line between national security and personal privacy?

Move Over, Kid
Computers in business? Of course. Computers for youngsters? Certainly. But senior citizens are the fastest-growing group of computer users. Furthermore, the average senior spends about twice as much time per month at a personal computer as the average teenage user spends. This is partly because many seniors have more discretionary income and more time on their hands than teenagers do.

The majority of seniors say that they were drawn to computers because they did not want to be left behind. They flock to classes, both private and public. Many senior students use their new word processing skills to write memoirs for their grandchildren. Others monitor their investments, research their family genealogy, create greeting cards, or even begin postretirement businesses.

The Internet is an important and complex topic. Although it is easy to use once you know how, there is much to learn about its use and its place in the world of computers. This opening chapter merely scratches the surface. More detailed information can be found in specific chapters devoted to the Internet. In addition, this book has a two-page spread, called "Planet Internet," at the end of each chapter, giving examples of some aspect of the Internet. The more generic topic of connectivity is discussed in the feature "Making Connections," offered in each chapter of the book.

CLASSIFICATION OF COMPUTERS

Computers come in sizes from tiny to monstrous, in both appearance and power. The size of a computer that a person or an organization needs depends on the computing requirements. Clearly, the National Weather Service, keeping watch on the weather fronts of many continents, has requirements that are different from those of a car dealer's service department that is trying to keep track of its parts inventory. And the requirements of both of them are different from the needs of a salesperson using a small notebook computer to record client orders or those of a student writing a paper. Although we will describe categories of computers here, keep in mind that computers do not fall too readily into groups of distinct islands; the reality is blurry and overlapping—and changing all the time.

Personal Computers

Most often called **personal computers,** or just **PCs,** desktop computers are occasionally known as **microcomputers** or sometimes **home computers.** Personal computers now fall into categories; most are low-end functional computers (sometimes ungallantly referred to as "cheap PCs") or else fully powered personal computers. A third category of upper-end PCs, called **workstations,** is used by specialized workers such as engineers, financial traders, and graphic designers. Workstations are small enough to fit on a desktop but approach the power of a mainframe.

Most users choose between personal computers in the first two categories: less expensive or more expensive. For many years PCs were offered only in the fully powered state-of-the-art category and cost upwards of $2000, enough to make some home buyers hesitate. But now, for a few hundred dollars, anyone can own a personal computer. At the low end, a cheap PC has less of everything: a slower and less powerful microprocessor, less memory, a smaller and less crisp screen, less hard drive space, and fewer software choices. Nevertheless, cheap PCs perform primary functions more than adequately. Customers who want a computer mainly for basic applications such as word processing, personal finance, record keeping, simple games, and access to the Internet are usually happy with computers at the low end.

There are, of course, people who should buy the more expensive, cutting-edge computers. You will want all the computer you can get if you plan to spend a lot of

time on graphic images, heavy-duty calculations, programming, and—above all—action-oriented arcade games.

A variation on the personal computer is the **net computer,** or **net box,** a limited piece of hardware with a central processing unit and minimal memory, offered with Internet access in mind. The net computer hooks up to the Internet via a telephone line. In the office, keyboards and monitors are provided. In the home, people can use a net computer with the television set as the computer screen and a keyboard as an optional add-on. (The best-known consumer net computer is the WebTV®.) Most net computers have no disk storage at all. The original idea behind this un-PC was simplicity and low price. However, net computers have faltered in the marketplace, mainly because cheap PCs have cut into their territory.

Notebook Computers

Notebook computers are lightweight (often under six pounds) and portable. Travelers use them to get work done while on the move in trains and airplanes, consultants load their analytical software on them to take to client locations, and salespeople use them as presentation tools (Figure 1-7). Somewhat larger and heavier versions of these computers are known as laptops and can be used as desktop replacements for those with only occasional portability requirements.

The memory and storage capacity of notebook computers today can compete with those of desktop computers. Notebooks have a hard disk drive and most accept diskettes, so it is easy to move data from one computer to another. Many offer a CD-ROM or DVD-ROM drive. Furthermore, notebooks can run most available software. Notebooks are not as inexpensive as their size might suggest; they carry a price tag

◄ FIGURE 1-7

Notebook computer.

This woman can get some work done in a convenient place away from the office.

Your Notebook Is a Sissy
Your Notebook has probably never had to defend itself from life's knocks. Compare your notebook to notebooks that have been ruggedized to withstand shock, falls, vibration, dust, and water. Who needs all this hardiness? The military, construction engineers, oil rig managers, and anyone else whose center of operations is based on sand, water, or ice.

greater than that of a full-size personal computer with the same features. However, like other technology, notebook computers are getting faster, lighter, and more feature-rich.

Smaller Still: Handheld Computers

A handheld computer called a **personal digital assistant (PDA)** can be used to keep track of appointments and other business information, such as customer names and orders. PDAs are also called pen-based computers because, with the use of a penlike stylus, they can accept handwritten input directly on a touch-sensitive screen. Many PDAs offer multiple functions, including wireless e-mail and fax capabilities (Figure 1-8). The **Pocket PC** is a handheld computer with slightly more power than a PDA. In addition to the functions performed by a PDA, the Pocket PC can also run stripped-down versions of PC productivity software such as word processing and spreadsheets.

Users of handhelds are often clipboard-carrying workers, such as parcel delivery drivers and meter readers. Other potential users are workers who cannot easily use a notebook computer because they are on their feet all day: nurses, sales representatives, real estate agents, and insurance adjusters. But the biggest group of users is found right in the office; these users like the fact that this convenient device can keep their lives organized.

Mainframes

In the jargon of the computer trade, large computers are called **mainframes.** Mainframes are capable of processing data at very high speeds—billions of instructions per second—and have access to billions of characters of data. The price of these large systems can vary from several hundred thousand to many millions of dollars. With that kind of price tag, you will not buy a mainframe for just any purpose. Their principal use is for processing vast amounts of data quickly, so some of the obvious customers are banks, insurance companies, and manufacturers. But this list is not all-inclusive; other types of customers are large mail-order houses, airlines with sophisticated reservation systems, government accounting services, aerospace companies doing complex aircraft design, and the like. As you can tell from these examples of mainframe applications, a key characteristic of large computers is that they are designed for multiple users. For example, many reservations clerks could be accessing the same computer at the same time to make reservations for waiting customers.

FIGURE 1-8
PDAs
Personal digital assistants can be used to keep track of appointments and other business information, such as customer names and orders.

As computer users have marched inexorably toward personal computers and networking, pundits have erroneously predicted the demise of mainframes. But "big iron," the affectionate nickname for these computers, is proving to be hardy and versatile. More recent uses include helping large businesses carry out critical applications such as running automated teller machines and delivering e-mail. Thus the mainframe has taken on the coloration of a server and is often referred to as a server. On the Internet, where computers of all stripes can coexist and even work in concert, vast data stores are being kept on large servers. The large server—the mainframe—is still the most reliable way to manage vast amounts of data. As an example, national retailer L.L. Bean is using an IBM mainframe system to offer its entire catalog of merchandise on the Internet.

Typically, the machine's innards are housed in a titanium alloy case, about 20 times as strong as the plastic that is generally used in conventional notebooks. The keyboard is sealed to prevent liquid from seeping into the internal circuitry, and all external connections are dust-resistant. The disk drives are mounted in a shock-absorbing gel compound.

So who needs all this hardiness? The military, for openers. Also, construction engineers, oil rig managers, and anyone else whose center of operations is based on sand, water, or ice.

Supercomputers

The mightiest computers—and, of course, the most expensive—are known as **supercomputers.** Supercomputers are also the fastest: They can process trillions of instructions per second. Supercomputers can be found in mainstream activities as varied as stock analysis, automobile design, special effects for movies, and even sophisticated artwork. However, for many years supercomputer customers were an exclusive group: agencies of the federal government. The federal government uses supercomputers for tasks that require mammoth data manipulation, such as worldwide weather forecasting and weapons research (Figure 1-9).

▲

This chapter has taken a rather expansive look at computer hardware. However, hardware by itself is just an empty shell. Software is the ingredient that gives value to the computer.

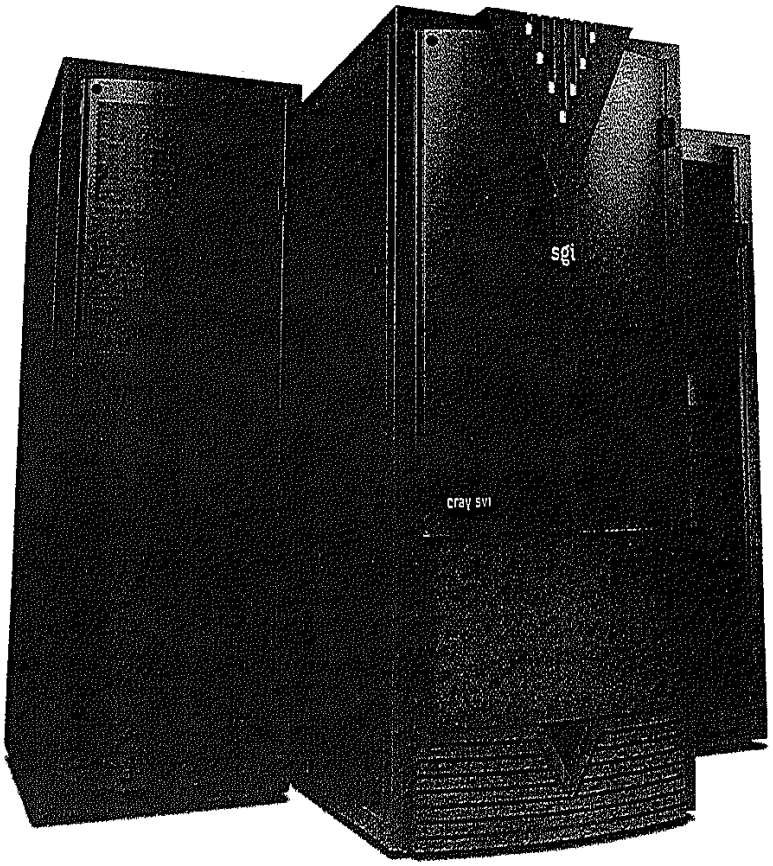

FIGURE 1-9

A Cray Supercomputer.

Supercomputers are the most expensive and fastest computers, processing trillions of instructions per second.

Operating Systems:
Software in the Background

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CHAPTER 2

LEARNING OBJECTIVES

- Describe the functions of an operating system
- Explain the basics of a personal computer operating system
- Describe the advantages of a graphical operating system
- Differentiate among different versions of Microsoft Windows
- Explain the need for network operating systems
- Describe the methods of resource allocation on large computers
- Describe the differences among multiprocessing, multiprogramming, and time sharing
- Explain the principles of memory management
- List several functions that are typically performed by utility programs

When Linda Ronquillo was taking a beginning class in applications software at a community college four years ago, she did not have to worry much about the operating system, the necessary software in the background. The college personal computers were on a network that managed all the computers. As Linda sat down to begin work, the computer screen showed a menu of numbered choices referring to the software packages available: WordPerfect, Microsoft Word, Microsoft Excel, and so forth. At the bottom of the screen, Linda was instructed to type the number of the chosen selection. If she typed 1 (for example), the system put her into WordPerfect. Linda had to learn operating system commands to prepare her own diskette and save data on them so that she could take her work with her, but she had little other contact with the operating system.

On the job as a supervisor for a small freight company, Linda needed to use word processing, spreadsheet, and database software packages on her personal computer. Eventually, she had set up a home office there, with a little advice from colleagues. She learned what she needed to know about the operating system, MS-DOS. She learned, among other things, to execute the software she needed to use and to take care of her data files, copying files from one disk to another and sometimes renaming or deleting them. She eventually became quite comfortable with her operating system knowledge.

Two months later, Linda was informed by the company personal computer manager that the company's three personal computers were going to be switched to Microsoft Windows Me, an operating system that included a user-friendly interface. Despite assurances that the new system would be colorful and easy to use, Linda was less than thrilled to be making another change. But she didn't say so. She knew that being a computer user meant being willing to adjust to change. So Linda learned to use a mouse and mastered icons, overlapping windows, pull-down menus, and other mysteries.

Approximately six months later, Linda took a job at another, larger airline freight company. Part of the reason she was hired was her response to the revelation that the new company used Windows 2000, which she knew was yet another operating system. Linda said, "Oh, I have learned several systems. It shouldn't be any problem learning another." She was right, of course. In fact, she had little trouble switching to the new operating system.

OPERATING SYSTEMS: HIDDEN SOFTWARE

When a brand-new computer comes off the factory assembly line, it can do nothing. The hardware needs software to make it work. Part of the story is the applications software, such as word processing or spreadsheet software, that allows users to perform useful work. This type of software will be discussed in the next chapter. But applications software cannot communicate directly with the hardware, so the operating system software serves as an intermediary between the applications software and the hardware. An **operating system** is a set of programs that lies between applications software and the hardware; it is the fundamental software that controls access to all other hardware and software resources. Figure 2-1 illustrates this concept. Incidentally, the term **systems software** is often used interchangeably with *operating system*, but systems software means all programs related to coordinating computer operations. Systems software includes the operating system but also includes programming language translators and a variety of utility programs.

OPERATING SYSTEMS

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Note that we said that an operating system is a set of programs. The most important program in the operating system, the program that manages the operating system, is the **kernel,** most of which remains in memory and is therefore referred to as *resident*. The kernel controls the entire operating system and loads into memory other operating system programs (called *nonresident*) from disk storage only as needed (Figure 2-2).

No matter what operating system is being used, when the computer is turned on, the kernel will be loaded from the hard drive into the computer's memory, thus making it available for use. This process of loading the operating system into memory is

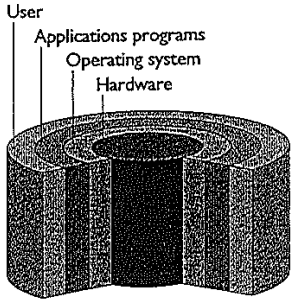


FIGURE 2-1

A conceptual diagram of an operating system.

Closest to the user are applications programs, software that helps a user to compute a payroll or play a game or write a report. The operating system is the set of programs between the applications programs and the hardware.

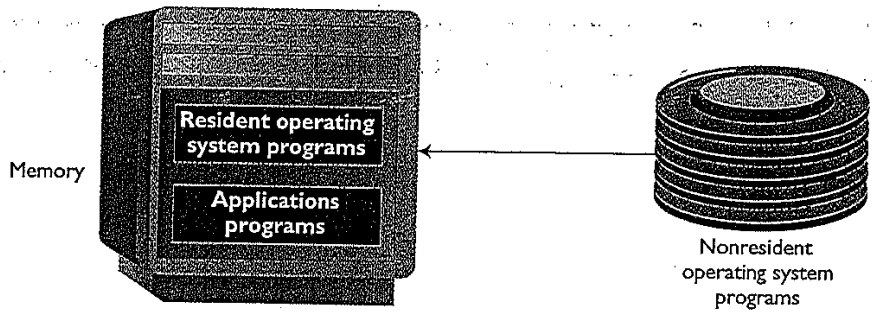


FIGURE 2-2

Retrieving operating system programs from disk.

The kernel of the operating system is resident in memory and calls in nonresident operating system programs from the disk as needed.

called *bootstrapping*, or **booting,** the system. The word "booting" is used because, figuratively speaking, the operating system pulls itself up by its own bootstraps. When the computer is turned on, a small program stored in a ROM chip performs some internal hardware component tests, then loads the kernel from the hard disk.

An operating system has three main functions: (1) managing the computer's resources, such as the central processing unit, memory, disk drives, and printers; (2) establishing a user interface; and (3) executing and providing services for applications software. Keep in mind, however, that much of the work of an operating system is hidden from the user; many necessary tasks are performed behind the scenes. In particular, the first listed function—managing the computer's resources—is taken care of without the user being aware of the details. Furthermore, all input and output operations, although invoked by an applications program, are actually carried out by the operating system.

Although many of its functions are hidden from view, you will have to communicate directly with the operating system to begin using an applications software package and to perform various housekeeping tasks. This communication occurs through the operating system's **user interface,** which determines how the user interacts with the operating system. The two basic forms of user interfaces are the command-line interface and the graphical user interface (GUI). The command-line interface is text-based and requires you to type in complete operating system commands. MS-DOS, Unix, Linux, and many large-computer operating systems use a command-line interface, as you will see in the following pages. GUIs use visual images and menus to allow users to enter commands. Windows and Mac OS use GUIs. Some installations of Linux and Unix are set up to offer a GUI.

Operating systems for large computers must keep track of several programs from several users, all running in the same time frame. We will examine the inherent complexities of such systems later in the chapter. For now, we focus on the interaction between a single user and a personal computer operating system.

OPERATING SYSTEMS FOR PERSONAL COMPUTERS

If you browse the software offerings at a retail store, you will generally find the software grouped according to the platform on which the software can run. The term **platform** refers to a combination of computer hardware and operating system software. The most common microcomputer platform today consists of some version of Microsoft Windows running on an Intel-based PC, often referred to as *Wintel* for short. Generally, applications software—word processing, spreadsheets, games, whatever—can run on just one platform. Just as you cannot place a Nissan engine in a Ford truck and expect it to run, you cannot take a version of WordPerfect that was designed to run on a computer using the Wintel platform and run it on an Apple

FOCUS ON ETHICS **Bugs and Back Doors: Who Is Responsible?**

Operating systems, like all software, are far from perfect. In fact, because of their complexity and demanding performance requirements, they probably have more defects than common application programs do. Suppose you are a programmer and you discover a serious software bug in a widely used operating system. Imagine further that this bug could allow an attacker to read or alter sensitive files on many computers. Weigh the following possible actions and decide which one you think is most practical and ethically sound.

1. Keep quiet about the bug. Maybe it will get fixed in a new release, and at least you aren't helping potential hackers by publicizing it.
2. Contact the manufacturer and describe the bug. Ask them to fix the bug in the next release but realize that they may give it a low priority.
3. Contact a popular computer magazine and describe the nature of the bug, hoping that publication of the problem will pressure the manufacturer to fix it immediately, but knowing that publicity about it might help potential exploiters of the bug.

Macintosh using the Mac OS operating system. Software makers must decide for which platform to write an applications software package, although some make versions of their software for more than one platform.

Most users do not set out to buy an operating system; they want computers and the applications software to make them useful. However, since the operating system determines what software is available for a given computer, users must at least be aware of their own computer's operating system.

Although operating systems differ, many of their basic functions are similar. Let us examine some of the basic functions of operating systems by examining MS-DOS.

A BRIEF LOOK AT MS-DOS

The MS-DOS operating system employs a command-line user interface. When a computer using MS-DOS (often called just DOS, rhyming with "boss") is booted, the screen is blank except for the characters C:\> appearing in the upper left corner. The C:\ refers to the disk drive; the > is a **prompt,** a signal that the system is prompting you to do something. At this point, you must give some instruction, or command, to the operating system. Although the prompt is the only visible result of booting the system, DOS also provides the basic software that coordinates the computer's hardware components and a set of programs that lets you perform the many computer tasks you need to do. To execute a given DOS program, you must type a **command,** a name that invokes a specific DOS program. Some typical tasks that you can perform with DOS commands are listing the files on a disk, copying files from one disk to another, and erasing files from a disk. Figure 2-3 gives some examples of MS-DOS commands. As you can see, these are not the easiest commands to remember.

FIGURE 2-3
MS-DOS commands.

C:\>FORMAT A: Prepares an unformatted diskette on drive A for use.

C:\>DIR A: Lists the files on the diskette in drive A (DIR stands for directory).

C:\>COPY MRKTDATA.SUM A: Copies file MRKTDATA.SUM on drive C to Drive A.

C:\>DEL A:SALESRPT.TXT Deletes file SALESRPT.TXT from drive A.

C:\>RENAME MRKTDATA.SUM SSDATA.CHT Renames the file MRKTDATA.SUM on drive C to SSDATA.CHT.

Command-line interfaces have the reputation of being very user-unfriendly and have been largely replaced by GUIs. However, if you wish, you can still execute DOS commands from within Windows, Microsoft's GUI operating system.

MICROSOFT WINDOWS

Today there is another—most say better—way to interact with the computer's operating system. **Microsoft Windows**—Windows for short—uses a colorful graphics interface that, among other things, eases access to the operating system. Microsoft Windows defines the operating environment standard for computers with Intel processors. Most new personal computers come with Windows already installed.

A Windows Overview

The feature that makes Windows so easy to use is a **graphical user interface (GUI,** pronounced "goo-ee"), in which users work with on-screen pictures called **icons** and with **menus** rather than keyed-in commands (see Figure 2-4). Clicking the icons or menu items activates a command or function. The menus in Figure 2-5 are called **pull-down menus** because they appear to pull down like a window shade from the original selection on the menu bar. Some menus, called **pop-up menus,** originate from a selection at the bottom of the screen or when the right mouse button is clicked. Icons and menus allow pointing and clicking with a mouse, an approach that can make computer use fast, easy, and intuitive.

Windows started out as an **operating environment** for MS-DOS, another layer added to separate the operating system from the user. This layer is often called the **shell** because it forms a "coating," with icons and menus, over the operating system.

Windows is now a family of operating systems, with three branches serving different users. The branch serving the home/consumer market is often referred to as

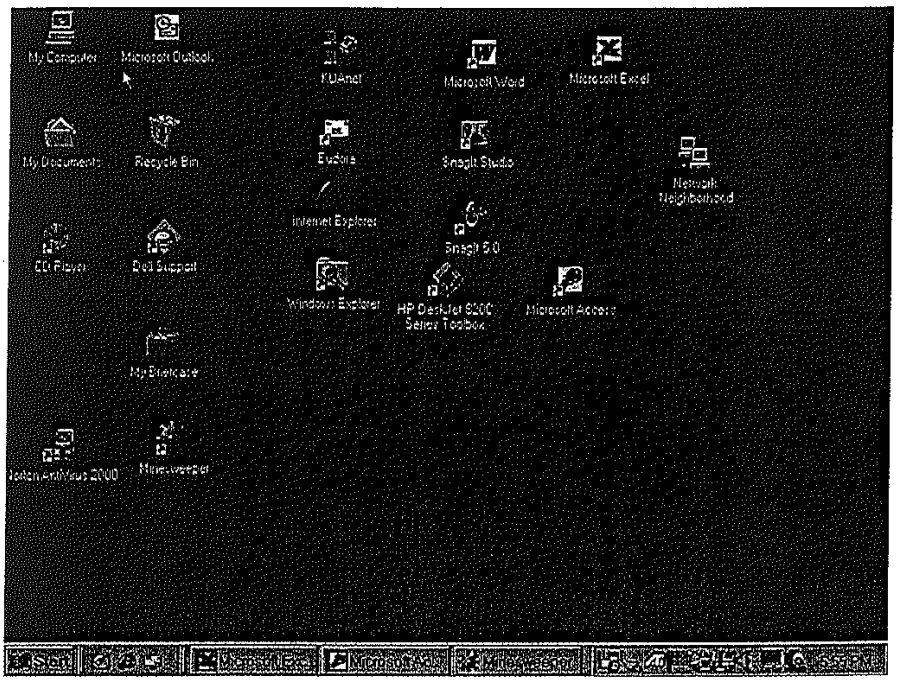


FIGURE 2-4

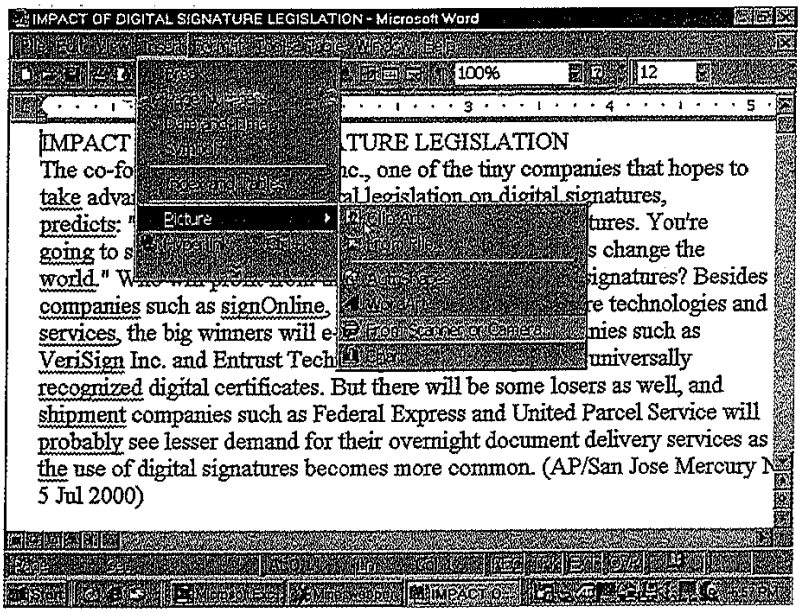
A typical Windows desktop display.

The icons represent programs, which can be run by double-clicking the corresponding icon. The taskbar across the bottom of the screen contains the Start button on the left, which can be clicked to show a pop-up menu with various options, including shutting down. Next are three clickable icons for (left to right) returning to the desktop, Internet Explorer, and Outlook Express. Next are the buttons representing active application programs; here Microsoft Excel, Microsoft Access, and Minesweeper (a game) are shown. The set of icons on the right represent various system functions. For example, the speaker icon is used to control your speaker volume. Finally, the rightmost entry is the system time; if you rest your mouse pointer on it, the day and date appear.

FIGURE 2-5

Windows menus.

This screen from Microsoft Word illustrates Windows menus. Here, the user has clicked the Insert choice on the menu bar to get a drop-down menu. Note the little triangular arrowhead to the right of the Picture option; this indicates that a submenu will be displayed if this option is highlighted. The submenu shown presents a series of locations from which a picture may be inserted into a Word document.



Introducing Mr. Gates

Anyone who has not figured out what the freebies on operating systems has missed the heavy press coverage of billionaire Bill Gates, the founder of Microsoft Corporation, the largest software company in the world. Mr. Gates has graced the covers of *Time*, *Fortune* and any other news magazine you could name. Each time he is interviewed, Mr. Gates makes a pitch for his vision of the future, which features, among other things, Microsoft Windows.

Windows 9x and consists of a series of versions called Windows 95, Windows 98, and Windows Millennium Edition (Me). For the corporate market the two most recent versions are Windows NT and Windows 2000. The newest member of the Windows family, Windows XP, is designed to replace both Windows Me and Windows 2000, serving both the consumer and corporate markets with a single product. Finally, Windows CE has been introduced for pocket computers and Internet appliances. All of these are discussed next.

Windows 95 and 98

Beginning with **Windows 95,** Windows is no longer a shell; it is a self-contained operating system and therefore requires no preinstalled DOS. However, DOS commands are still available. **Windows 98** is a variation on Windows 95 and has much the same screen look.

Windows features a Start button in the lower left-hand corner (refer to Figure 2-4). From this button you can conveniently find a program or a file. Programs can also be invoked—started—by double-clicking an icon on the desktop, the Windows opening screen. Figure 2-4 shows a number of program icons on the desktop area. Perhaps the greatest convenience, as you can see in Figure 2-4, is the taskbar along the bottom of the screen, which contains an array of buttons for the programs that are currently in use. You can click from program to program as easily as changing channels on your TV. Windows allows longer file names of up to 255 characters (MS-DOS and Windows 3.1, the shell version of Windows, permitted only eight).

Anyone who has added a new component, perhaps a modem or a sound card, to an existing computer knows that it must be configured into the system, a process that may involve some software and even hardware manipulations. Windows supports **Plug and Play,** a concept that lets the computer configure itself when a new component is added. For Plug and Play to work, hardware components must also feature the Plug and Play standard. Once a peripheral is built to the Plug and Play

standard, a user can install it simply by plugging it in and turning on the computer. Windows recognizes that the new device has been added and proceeds to configure it.

A Windows technology called **object linking and embedding (OLE**—wonderfully pronounced "oh-lay") lets you embed or link one document to another. For instance, you can embed a spreadsheet within a report created in a word processing program that supports OLE. When you click the spreadsheet to modify it, you will be taken to the program that you used to create the spreadsheet.

Features added by Windows 98 include the following:

- **Internet/intranet browsing capabilities.** Microsoft's browser, Internet Explorer, is included with Windows. In fact, Windows itself has been made to look more like a browser.
- **Support for state-of-the-art hardware.** This includes support for digital video disk (DVD) and the latest multimedia components. DVD and multimedia are described in the chapter on storage.
- **Support for huge disk drives.** Everyone wants more disk space, and multigigabyte drives provide an answer. Support for high-capacity drives is provided in Windows in the form of tables that can handle the sizes of today's hard drives.
- **TV viewer and broadcast ability.** A broadcast-enabled computer blends television with new forms of information and entertainment. It blurs the line between television, Web pages, and computer content. It also enables the reception of broadcast Web pages and other live data feeds, such as across-the-screen news headlines and stock quotes.
- **Wizards.** Windows lets users accomplish various tasks by using "wizards," step-by-step software tools that make tasks more user-friendly (Figure 2-6).

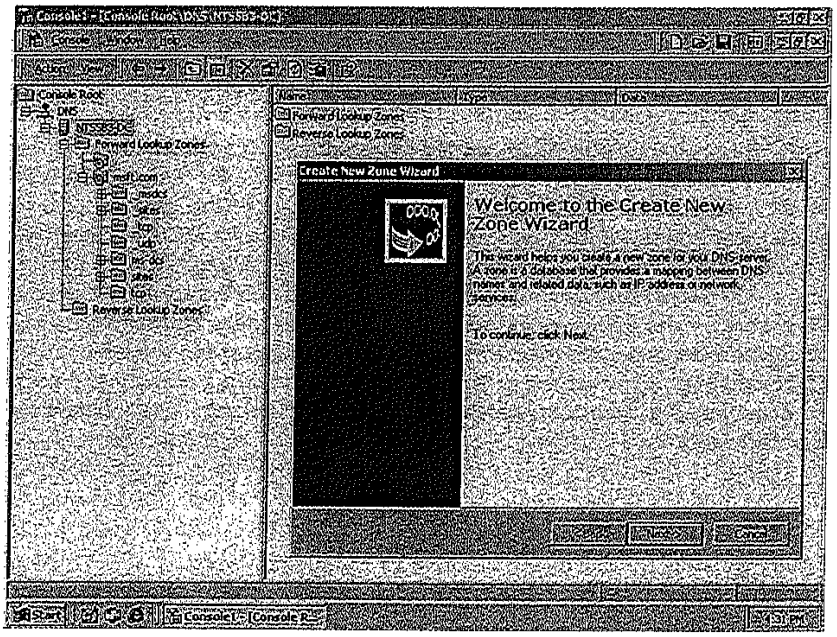


FIGURE 2-6

Wizards.

Wizards are easy-to-use, step-by-step software tools that make tasks more user-friendly.

Further, Windows 98 includes technologies to help reduce the cost of owning and maintaining a personal computer. Other features include improved backup, improved interfaces with other software, new and improved networking features, and increased security. Finally, Windows 98 includes an improved Dr. Watson, which provides technical information about the computer when it suffers a general protection fault, commonly called a crash.

Windows Me

The newest member of the Windows 9x family is **Windows Millennium Edition (Windows Me).** It is built on the same code base as both Windows 95 and Windows 98 and has a similar look and feel. The major features added in this version include the following:

- **Multimedia support.** Windows Media Player 7 now includes a jukebox and music database controls and allows you to record music CDs as digital files. Windows Movie Maker provides basic video editing capabilities on your PC. Windows Image Acquisition provides additional support for manipulating scanner and digital camera images.
- **Reliability features.** Anyone who has accidentally overwritten key system files while installing new software will appreciate the System File Protection feature. If any system files are accidentally deleted or overwritten with out-of-date versions, the System File Protection feature will automatically restore them the next time you boot the system. An AutoUpdate function automatically checks appropriate sites on the Internet for updates to installed system and application software. A system restore feature lets you return to an earlier system configuration if the addition of hardware or software disrupts your system's settings. Finally, a Help Center contains a variety of problem-solving tools to help users troubleshoot their systems.
- **Home network support.** As the number of homes with multiple PCs increases, the demand for home networking grows. Windows Me includes the Home Networking Wizard to guide the user through the often confusing process of interconnecting multiple computers and peripherals. On this network, multiple users can share a single Internet connection.

Windows NT

The operating system called **Windows NT** (NT stands for "new technology") is meant mostly for corporate, networked environments. Version 4.0, the last with the NT designation, looks exactly like Windows 98 and runs most of the same software that runs under Windows 98. But beneath the surface, Windows NT is far more robust and heavy-duty. It has been engineered for stability and, as befits a networked environment, has much stronger security features. Windows NT comes in two versions: NT Workstation, designed for individual users on a network, and NT Server, a network operating system. Because Windows NT lacks support for older Windows and MS-DOS software and hardware, is more complex to learn and use, and requires more memory and processor power than the Windows 9x family, it is seldom used on nonnetworked PCs.

Windows 2000

Windows 2000 is the latest generation in the Windows NT series. As such, it maintains the stability and security features that are NT's hallmark and incorporates Windows 98's ease of setup and hardware awareness. As with Windows NT, there are

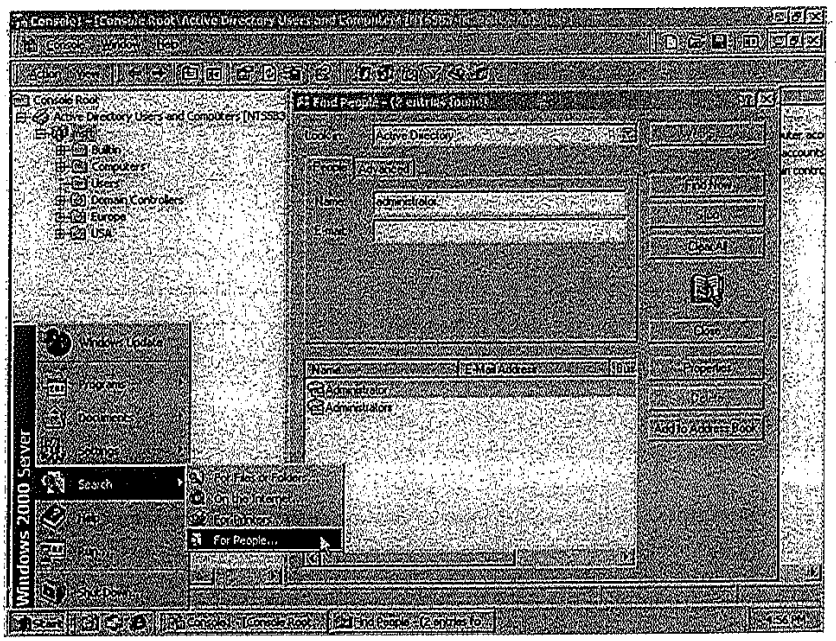


FIGURE 2-7

Windows 2000.
Windows 2000, the latest generation in the Windows NT series, maintains the stability and security features of Windows NT and includes support for Windows 98's file structure, Plug and Play features, and better support for laptops.

two versions: Windows 2000 for network servers and Windows 2000 Professional for individual users. Microsoft originally intended that Windows 2000 would be the convergence of the 9x and NT series, providing a single operating system for both home and corporate users (Figure 2-7). However, Window 2000's complexity and heavy demand for computer resources convinced Microsoft to update the Windows 9x home user series with a newer version (Windows Me, discussed above) and delay the convergence for another software generation.

The most noticeable new feature of Windows 2000 is that it knows who you are. One computer can serve many people. Once you identify yourself, it will immediately reconfigure to your preferences. It personalizes the Start menu so that the programs you use most frequently are visible and others are hidden. A particularly attractive feature is the self-healing applications software: If you accidentally delete a necessary component, Windows will automatically restore it. Other improvements over Windows NT include support for the Windows 98 file structure, Plug and Play features, and much better support for laptops.

Windows XP

Windows XP, the latest generation of Windows, brings Microsoft's consumer and corporate operating systems together into a single product. It incorporates and extends the consumer-oriented features of Windows Me into the stable, dependable Windows 2000 environment. Windows XP versions fall into two categories, network server and desktop computer. There are three versions for network servers, based on network complexity. Two additional versions are designed for desktop computers. The Professional Client version is aimed toward business users connected to corporate networks and includes features for file encryption, remote desktop access, and dual processor support. New features in the Personal Client consumer-oriented version include:

- **Improved user interface.** The desktop appears much cleaner and uncluttered. Most icons have been replaced with entries in a redesigned Start menu. Any desk-

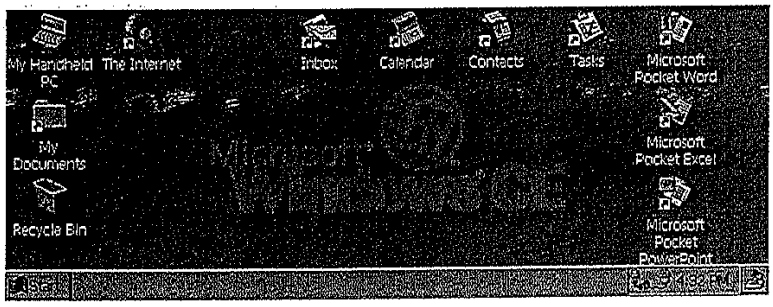


FIGURE 2-8

Windows CE on the Pocket PC.
Windows CE includes an interactive scheduling calendar, an address book for contacts, electronic mail, and Web browsing.

top shortcuts that haven't been used recently will be placed into a separate folder by the Desktop Cleanup Wizard.

- **Improved multimedia support.** Support for digital media, such as MP3 music and digital still and video cameras, has been integrated into the operating system. Much plug-in software is no longer required.
- **More extensive personalization.** A feature called Visual Styles allows the user to customize the appearance of many Windows components. What's more, applications written to the new standards will automatically take on the same appearance.
- **Multiple user support.** Since many home computers have more than one user, Windows XP allows multiple users to be logged on at the same time. One user can walk away leaving applications running, come back later and resume work with all applications still active. During that time, other users can log on, then leave their own applications running. A child can be assigned a limited use configuration that restricts what can be done on the computer.

Windows CE

Windows CE (CE stands for "consumer electronics") is a Windows-based modular operating system designed for the embedded system and Internet appliance market. Its most noticeable use is as the operating system for the Pocket PCs being produced by Hewlett-Packard, Compaq, and others (see Figure 2-8). Windows CE is a subset of Windows, scaled back to work with less memory on smaller screens and without much, if any, file storage. **Embedded systems** are computing devices that are integrated into other products. Embedded systems powered by Windows CE are currently being used in such diverse products as industrial controllers, robots, office equipment, cameras, telephones, home entertainment devices, and automobile navigation systems. In addition to giving all these devices a familiar Windows-like interface, Windows CE provides one other important feature: Internet connectivity. In the eyes of many, almost everything electronic will be connected to the Internet in the not-too-distant future.

MAC OS

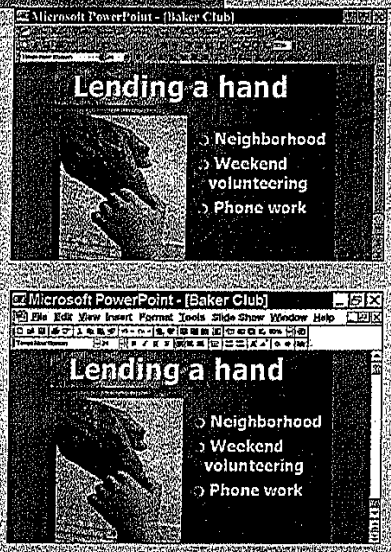
Apple's Macintosh operating system **(Mac OS)** was introduced along with the Macintosh microcomputer in 1984. It had the first commercially successful graphical user interface and quickly gained a reputation for user-friendliness. Based on concepts developed at Xerox's PARC research center in Palo Alto, California, the Mac OS GUI has served as a model for most of the graphical interfaces that have been developed since then. Still considered by many to be easier to use than Windows, Mac OS

GETTING PRACTICAL — Accessibility Options

Long hours staring at the computer screen can be hard on the eyes. As shown here, Windows offers the option of enlarged letters and high-contrast colors.

Improved visibility is only part of the story. The Accessibility Options icon, found in the control panel, offers aids for seeing, hearing, and touching. For example, a hearing-impaired individual can elect to have any computer sound show up as a visual indicator on the screen. Furthermore, spoken words can be seen as screen captions.

An option called StickyKeys permits keys that normally must be pressed at the same time to invoke a command, such as Ctrl-Alt-Del, to be pressed separately but still achieve the same effect. Another option, handy for anyone who has a habit of inadvertently pressing the Caps Lock key, is to sound a beep whenever the Caps Lock, Num Lock, or Scroll Lock key is pressed. Mouse movements can also be replaced by using the arrow keys on the numeric keypad.



X (X is the Roman numeral for 10) contains enhancements in multimedia support and multitasking—the ability to do several things at once. See Figure 2-9 for an illustration of the Mac OS X desktop.

UNIX

Unix, a multiuser time-sharing operating system, was developed in 1971 by Ken Thompson and Dennis Ritchie at AT&T's Bell Laboratories for use on its DEC minicomputers. In the late 1970s Bell gave Unix away to many colleges and universities, and students became accustomed to using it. Consequently, when many of

FIGURE 2-9

Mac OS X.

The Mac OS interface has served as a model for most of the graphical interfaces available today. Still considered by many to be easier to use than Windows, Mac OS X contains enhancements in multimedia support and multitasking.

these school's graduates entered the work force, they began agitating for the acceptance of Unix in industry, thus producing what is known as the "Unix graduate" phenomenon.

At its basic level, Unix is a character-based system with a command-line user interface. In contrast to the operating systems we have discussed up to this point, Unix is not tied to any specific family of processors. It will run on just about every type of computer available, from microcomputers to mainframes, from any manufacturer. No one company controls Unix, and several versions are available. These versions are similar enough that an experienced Unix user would be comfortable with any of them, but there are some software compatibility problems. The main reason that you need to be aware of Unix is that it is the primary operating system in use on Internet servers today.

LINUX

In 1991 Linus Torvalds, a student at the University of Helsinki in Finland, created the kernel of a Unix-like operating system named **Linux.** He made the source code available to the public free of charge, under a concept known as **open-source** software. Users can download Linux for free, make any changes they wish, and freely distribute copies. The only restriction is that any changes they make must be freely available to the public.

Currently, most PC systems come with Windows preinstalled; if you would like to use Linux, you must install it yourself. Although the Linux code may be downloaded for free from the Internet, installing it is a complex task suitable only for the most advanced users. Several companies have packaged the Linux code with an installation program, documentation, customer support, and a number of utilities and application packages. These packages, know as distributions, make it easier for a typical user to install and use Linux and are relatively inexpensive (less than $50). Since Linux itself uses a command-line inerface, most distributions also provide a GUI that the user can install. Many users install Linux in a **dual-boot** configuration with Windows; that is, when you boot the system, you choose which operating system will be loaded (Figure 2-10).

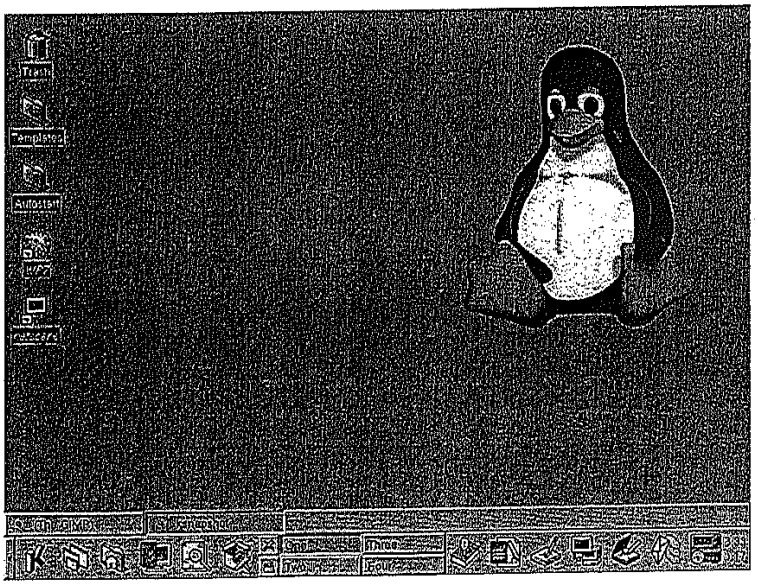


FIGURE 2-10

Linux.

Linux is the fastest-growing operating system for Intel-based computers. Linux includes all the respected features of UNIX and it's free.

Linux has several advantages over Windows. Windows users accustomed to the occasional system crash will be happy to learn that Linux is extremely stable—it rarely ever crashes. Also, Linux users form a close-knit community. If you have a problem or question, posting it on the Internet will almost always result in a quick, accurate answer from Linux experts who are happy to share their knowledge. Finally, if the operating system should somehow become corrupted, reinstallation of Linux is a much simpler task than reinstalling Windows.

The biggest disadvantage of Linux is the relative scarcity of applications. Although a number of applications have become available, many under the same open-source concept as Linux itself, the numbers are still far fewer than for Windows. As Linux gains acceptance, this disparity may disappear.

The Technology Spiral

Many people wonder whether the constant upgrading of both hardware and operating systems is really necessary. After all, what you've got works for you. Why should you have to buy new stuff? The short answer is, you don't. But there is an interesting dynamic at work here. Technological advances in hardware make it possible for manufacturers to offer more powerful systems at a lower price. At the same time, competition leads software developers to add more features to their products. This increased functionality requires the faster processors, larger memory capacity, and bigger hard drives of the newer systems. Frequently, this new software just will not function well on an older computer that has, relatively speaking, limited capacity. Consumers can resist new software for just so long. In particular, if they bring too long to an older operating system, they will find that no applications software is being written for it. There are several stopgap measures: adding memory, adding a hard drive, upgrading the microprocessor. But most people eventually buy the new computer, one with the capacity to handle all the new software. And then the cycle begins again.

OPERATING SYSTEMS FOR NETWORKS

An extension of operating systems for personal computers is a **network operating system (NOS),** which is designed to let computers on a network share resources such as hard disks and printers. A NOS is similar to a standard operating system but includes special features for handling network functions. Our earlier discussion of Windows 2000 described the workstation version; the server version of Windows 2000 is one example of a network operating system. Novell NetWare is another example. In addition to resource sharing, a NOS supports data security (does this user have the right to that data?), troubleshooting (oops, computer XYZ on the network failed to receive a message intended for it), and administrative control (track the online hours and track the number of messages to and from each computer).

In a client/server relationship, parts of the NOS (mostly file access and management programs) run on the server computer, while other NOS components, such as software that permits requests to the server and messages to other computers, run on the client (user) computers. In addition, each of the client computers has its own operating system, such as Windows Me.

One of the network operating system's main tasks is to make the resources appear as though they are running from the client's computer. Whether issuing commands, running applications software, or sending jobs to a printer, the role of a NOS is to make the desired services appear to be local to that client computer. The whole point of a client/server system is to provide expanded services to individual users at their own networked computers; the network operating system is the software that makes it possible.

OPERATING SYSTEMS FOR LARGE COMPUTERS

Large computers—mainframes—have been around about twice as long as personal computers. Those big computers are usually owned by businesses and universities, which make them available to many users. So, unlike the scenario with which you may be familiar—one person per personal computer at a time—a large computer is used by many people at once. This presents special problems, which must be addressed by the operating system.

Computer users often have questions when they first realize that their program is "in there" with all those other programs. At any given moment, which program gets the CPU? If several programs are in memory at the same time, what keeps the programs from getting mixed up with one another? How is storage handled when several programs may want to get data from disk or send processed data to disk at the same time? Why doesn't printer output from several programs get all jumbled up? The oper-

ating system anticipates these problems and takes care of them behind the scenes so that users can share the computer's resources without worrying about how it is done.

RESOURCE ALLOCATION

Notice that the questions above all address sharing problems, that is, multiple users sharing the CPU, memory, storage, and the printer. Shared resources are said to be allocated. **Resource allocation** is the process of assigning computer resources to certain programs for their use. Those same resources are deallocated—released—when the program using them is finished, and then they are reallocated elsewhere.

Sharing the Central Processing Unit

Since most computers have a single central processing unit, all programs running on the computer must share it. The sharing process is controlled by the operating system. Two approaches to sharing are multiprogramming and time-sharing. But first, let us distinguish multiprogramming from multiprocessing. **Multiprocessing** refers to the use of a powerful computer with multiple CPUs so that multiple programs can run simultaneously, each using its own processor.

MULTIPROGRAMMING If there is only one central processing unit (the usual case), it is not physically possible for more than one program to use it at the same time. **Multiprogramming** means that two or more programs are being executed in the same time frame, that is, **concurrently,** on a computer. What this really means is that the programs are taking turns; one program runs for a while, and then another one runs. The key word here is *concurrently* as opposed to *simultaneously.* One program could be using the CPU while another does something else, such as sending output to the printer. Concurrent processing means that two or more programs are using the central processing unit in the same time frame—during the same minute, for instance—but not exactly at the same instant. In other words, concurrent processing allows one program to use one resource while another program uses another resource; this gives the illusion of simultaneous processing. As a result, there is less idle time for the computer system's resources. Concurrent processing is effective because CPU speeds are many times faster than input/output speeds. During the time it takes a disk drive to perform a read instruction for one program, for example, the central processing unit can execute thousands or even tens of thousands of calculation instructions for another program.

Multiprogramming is **event-driven.** This means that programs share resources based on events that take place in the programs. Normally, a program is allowed to complete a certain activity (event), such as a calculation, before relinquishing the resource (the central processing unit, in this example) to another program that is waiting for it.

The operating system implements multiprogramming through a system of interrupts. An **interrupt** is a signal that causes normal program processing to be suspended temporarily. Suppose, for example, that several programs are running on a large computer, two of them being a payroll program and an inventory management program. When the payroll program needs to read the next employee record, that program is interrupted—or, in a sense, interrupts itself—while the operating system takes over to do the actual reading. Once the read operation has begun and the payroll program is waiting for the results, the operating system may allocate the CPU to the inventory program to do some calculations. When the read operation is completed, another interrupt is generated. The operating system suspends the inventory program, determines the reason for the interrupt—completion of the payroll program's read operation in this case—and then determines which program gets to resume using the CPU. That determination may be based on priorities—the program with the highest priority goes next—or on which has been waiting the longest.

The point of this discussion is not to clarify which program does what when. Rather, it is to show that shared resources are being managed by the operating system in the background. Although it may appear to the user that a program is being run continuously from start to finish, in fact it is constantly being interrupted. This process is not without cost—the operating system does use some of the CPU resources itself—but the overall effect is much more efficient use of the CPU.

In large computer systems, programs that run in an event-driven multiprogramming environment are usually batch programs that don't require user input. Typical examples are programs for payroll, accounts receivable, and sales and marketing analysis. If any interactive programs are running, they can be given the highest priority so that the users won't have to wait.

TIME-SHARING A special case of multiprogramming, **time-sharing** is usually **time-driven** rather than event-driven. A common approach is to give each user a **time slice**—a fraction of a second—during which the computer works on a single user's tasks. However, the operating system does not wait for completion of an event; at the end of the time slice—that is, when time is up—the resources are taken away from that user and given to someone else. This is hardly noticeable to the user: When you are sitting before a terminal in a time-sharing system, the computer's response time will be quite short—fractions of a second—and it may seem as if you have the computer to yourself.

Response time is the time between your typed computer request and the computer's reply. Even if you are working on a calculation and the operating system interrupts it, sending you to the end of the line until other users have had their turns, you may not notice that you have been deprived of service. Not all computer systems give ideal service all the time, however; if a computer system is trying to serve too many users at the same time, response time may slow down noticeably.

Typical time-sharing applications are those with many users, each of whom has a series of brief, randomly occurring actions; examples include credit checking, point-of-sale systems, and airline reservation systems. Each of these systems has many users, perhaps hundreds, who need to share the system resources.

Sharing Memory

What if you have a very large program for which it might be difficult to find space in memory? Or what if several programs are competing for space in memory? These questions are related to memory management. **Memory management** is the process of allocating memory to programs and of keeping the programs in memory separate from one another.

There are many methods of memory management. Some systems simply divide memory into separate areas, each of which can hold a program. The problem is how to know how big the areas, sometimes called **partitions** or **regions**, should be; at least one of them should be large enough to hold the largest anticipated program. Some systems use memory areas that are not of a fixed size; that is, the sizes can change to meet the needs of the current assortment of programs. In either case, whether the areas are of a fixed or variable size, there is a problem with unused memory between programs. When these memory spaces are too small to be used, space is wasted.

FOREGROUND AND BACKGROUND Large all-purpose computers often divide their memory into foreground and background areas. The **foreground** is generally for programs that have higher priority and therefore receive more CPU time. A typical foreground program is in a time-sharing environment, with the user at a terminal awaiting response. That is, a foreground program is interactive, with the CPU often unused while the user is entering the next request. Thus there is CPU time available for the waiting background programs. The **background**, as the name implies, is for programs with less pressing schedules and therefore lower priorities and less CPU

time. Typical background programs are batch programs in a multiprogramming environment. Foreground programs are given privileged status—more turns for the central processing unit and other resources—and background programs take whatever they need that is not currently in use by another program. Lists of programs waiting to run are kept in **queues** suitable to their job class.

VIRTUAL STORAGE Many computer systems manage memory by using a technique called **virtual storage** (also called **virtual memory**). The virtual storage concept means that the programs currently being executed are stored on disk and portions of these programs are brought into memory as needed. Since only one part of a program can be executing at any given time, the parts that are not currently needed are left on the disk. Since only part of the program is in memory at any given time, the amount of memory needed is minimized. Memory, in this case, is considered to be **real storage,** while the secondary storage (hard disk, most likely) holding the rest of the program is considered virtual storage.

Virtual storage can be implemented in a variety of ways. Consider the paging method, for example. Suppose you have a very large program, which means that there will be difficulty in finding space for it in the computer's shared memory. If your program is divided into small pieces, it will be easier to find places to put those pieces. This is essentially what paging does. **Paging** is the process of dividing a program into equal-size pieces called **pages** and storing them in equal-size memory spaces called **page frames.** All pages and page frames are the same fixed size, typically 2 kilobytes (KB) or 4 KB. The pages are stored in memory in *noncontiguous* locations—locations that are not necessarily next to each other (Figure 2-11).

Even though the pages are not right next to each other in memory, the operating system is able to keep track of them. It does this by using a **page table,** which, like an index, lists each page that is part of the program and the corresponding beginning memory address where it has been placed. The operating system does require CPU time to control paging. If too large a portion of available CPU time is spent performing this paging, very little is left over to actually execute user programs. This situation, called **thrashing,** can be eliminated by running fewer programs concurrently or by adding additional memory.

MEMORY PROTECTION In a multiprogramming environment it is theoretically possible for the computer, while executing one program, to destroy or modify another program by transferring to the wrong memory locations. That is, without protection, one program might accidentally hop into the middle of another, causing destruction of data and general chaos. This, of course, is not permitted. To avoid this problem, the operating system confines each program to certain defined limits in memory. If a program inadvertently attempts to enter some memory area outside its limits, the operating system terminates the execution of that program. This process of keeping one program from straying into another is called **memory protection.**

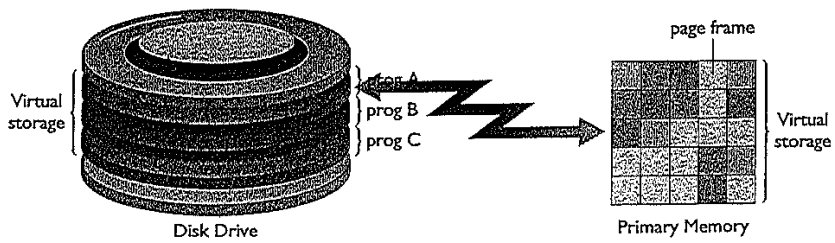


FIGURE 2-11

Virtual storage.

In this illustration, three programs (A, B, and C) are currently running. All three programs in virtual storage are divided in to standard-sized segments called pages. Primary memory, referred to as real storage, is divided into the same sized segments called page frames. As pages of each program are needed for execution, they are copied from virtual storage into available pages frames. If all the page frames are full, the system will copy the contents of the least recently used page frame back to virtual storage to make room for the new page.

Sharing Storage Resources

The operating system keeps track of which file is where and responds to commands to manipulate files. But the situation is complicated by the possibility that more than one user may want to read or write a record from the same disk pack at the same time. Again, it is the operating system that keeps track of the input and output requests and processes them, usually in the order in which they were received. Any program instruction to read or write a record is routed to the operating system, which processes the request and then returns control to the program.

Sharing Printing Resources

Suppose half a dozen programs are active but the computer has only one printer. If all programs took turns printing out their output a line or two at a time, interspersed with the output of other programs, the resulting printed report would be worthless. To get around this problem, a process called **spooling** is used: Each program writes onto a disk each line that is to be printed. Or, to be more accurate, the program "thinks" that it is writing the line to the printer, but the operating system intercepts the line and sends it instead to a disk file. When the program finishes printing, the disk file is placed into a queue to be printed when the printer becomes available.

Spooling also addresses the problem of relatively slow printer speeds. Writing a record to disk is much faster than writing that same record to a printer. A program therefore completes execution more quickly if records to be printed are written temporarily to disk. The actual printing can be done at some later time, after the program has completed execution. Some large installations use a separate (usually smaller) computer dedicated exclusively to the printing of spooled files; some print lengthy reports during off-hours or overnight so that smaller, more immediate jobs can use the printer during the day.

Utility Programs

Most of the resource allocation tasks just described are done by the operating system without user involvement. For example, activities such as paging and spooling go on without explicit commands from users. But the operating system can also perform explicit services at the request of the user.

Why reinvent the wheel? Duplication of effort is what **utility programs,** or just **utilities,** are supposed to avoid. Such programs perform many secondary chores, such as backing up and restoring files, compressing files and entire hard disks, locating files, and ferreting out computer viruses. As we have noted, strictly speaking, these utilities are considered part of the system software but not part of the operating system. Some utilities are packaged with operating systems; others can be purchased separately. A few typical utilities are described below.

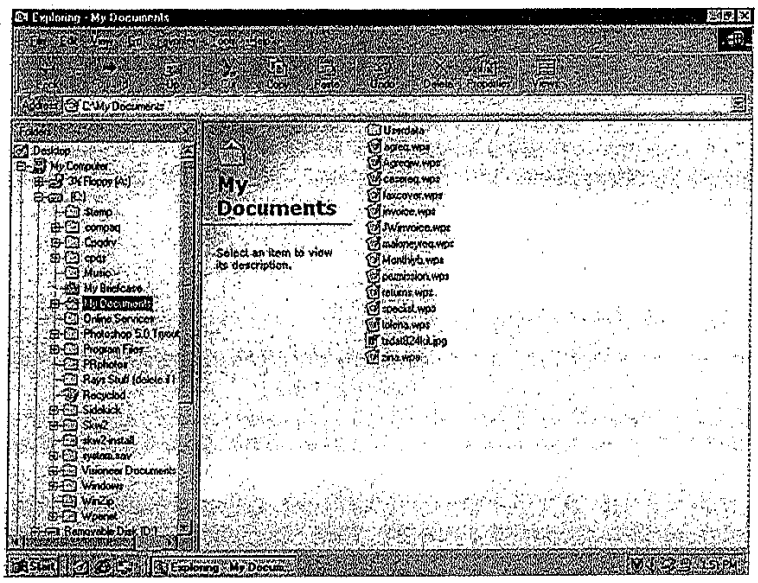
FILE MANAGER Most storage devices can store large numbers of files. Imagine how difficult it would be to locate a single file among thousands of files on your hard drive. The **file manager** utility allows you to store your files in a hierarchical directory structure that is organized in a way that makes sense to you. A **directory** is a named area in storage that can contain files and other directories. For example, you might have a directory called `Word Processing`, in which you plan to store the files that you create with your word processor. You could then create a subdirectory named `School` within the `Word Processing` directory for all your schoolwork. Within the `School` directory you might create individual subdirectories for each of your classes. Incidentally, the newer versions of Windows refer to directories as *folders.*

In addition to enabling you to create this directory structure, the file manager also provides the capability to display lists of files in directories; to copy, move, rename, and delete files; and to format and copy diskettes. Figure 2-12 shows a dis-

FIGURE 2-12

Windows Explorer.

Windows Explorer is the file manager utility that is part of the Windows operating system. The left screen panel shows the systems device and folder structure; the right panel shows the contents of the selected folder.



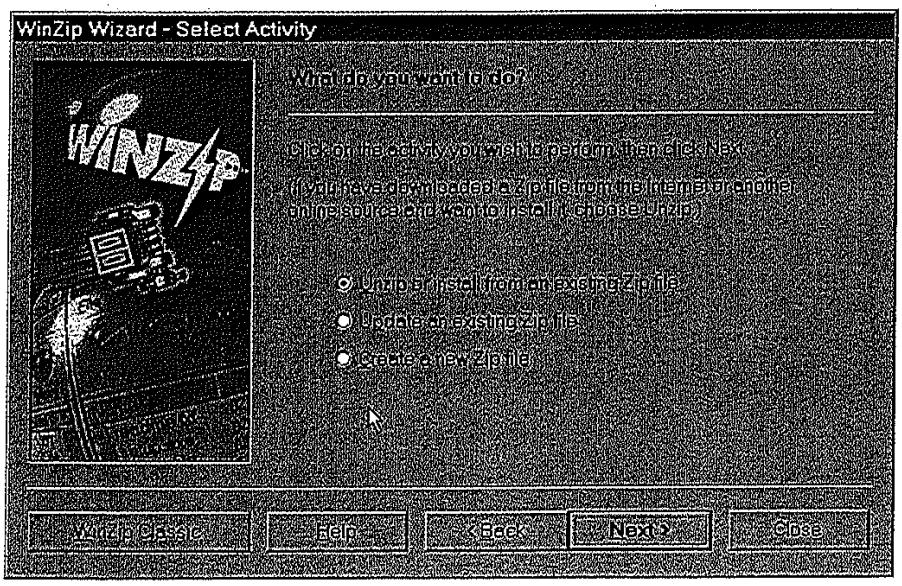
play from Windows Explorer, the file manager that comes with the Windows operating system.

BACKUP AND RESTORE Backing up files involves making duplicate copies and storing them in a safe place, in case anything happens to the originals. **Backup and restore** utilities allow you to make backups of entire hard drives or of selected directories. These backups could be made to diskettes but are normally stored on high-capacity media such as CD or tape (see Chapter 6, "Storage and Multimedia: The Facts and More," for more detail on these devices). Since the utility creates the backup files in a specialized format to minimize space requirements, the copies must be processed by the restore routine before you can use them. Rudimentary backup and restore utilities accompany most operating systems, but more capable utilities are provided with tape and CD devices or can be purchased separately.

FIGURE 2-13

WinZip®.

Winzip® is one of the best-known file compression utilities.



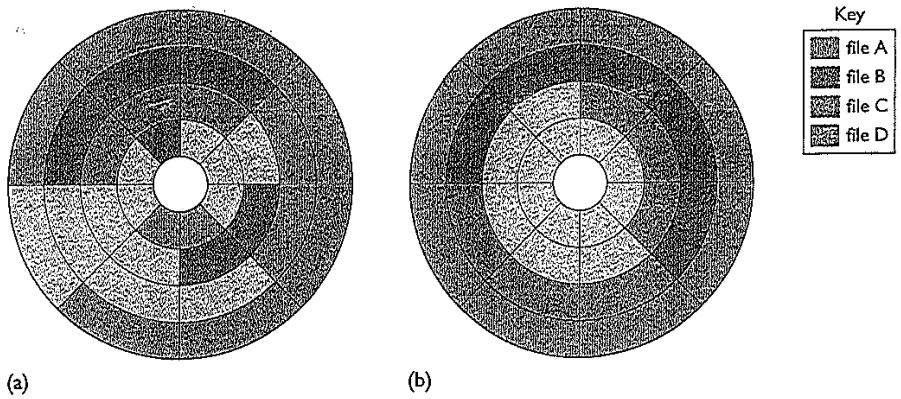


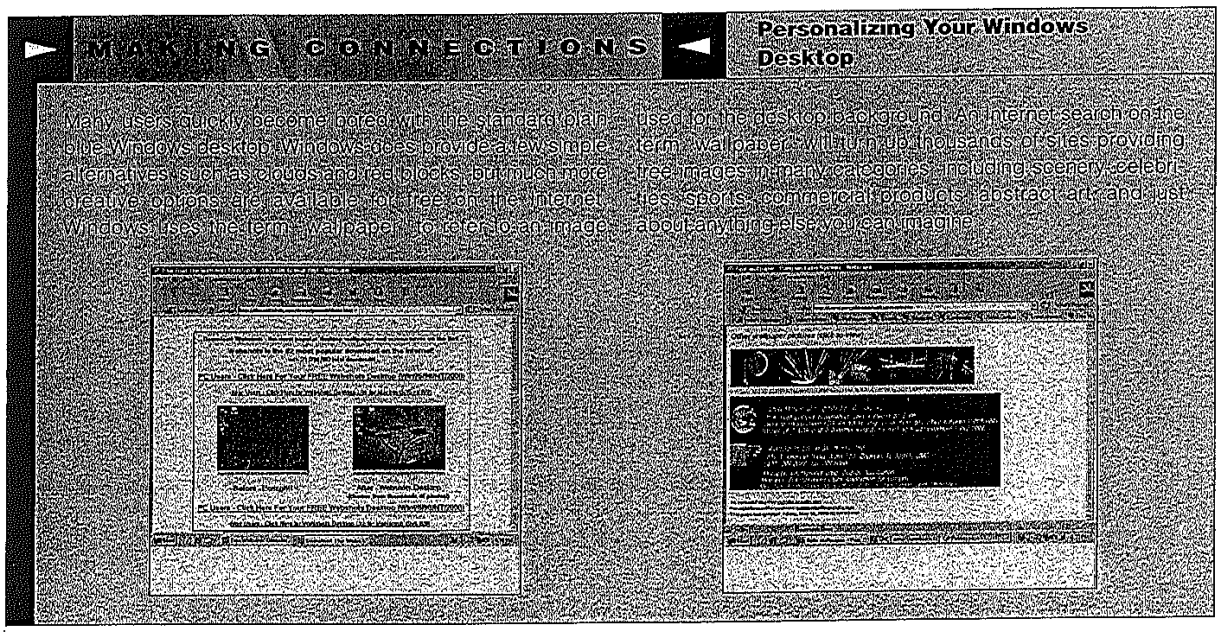
FIGURE 2-14

Disk defragmentation.

(a) Before defragmentation, portions of files are scattered over the disk surface, slowing access. (b) After defragmentation, each file is stored in a contiguous group of sectors.

FILE COMPRESSION A **file compression** utility reduces the amount of space required by a file. Compressed files take up less space on disk and also take less time to transmit across communication lines. Many files available for downloading from the Internet are in compressed format and must be uncompressed into their original form before they can be used. PKZIP™ and WinZip® are two popular file compression utilities (Figure 2-13).

DEFRAGMENTER When the operating system is looking for space in which to store a file, it cannot always find enough space in one place on the disk. It often has to store portions of a file in noncontiguous, or separated, disk locations. When this happens, the file is fragmented. Although this process makes efficient use of disk space, it slows down access to the file. If a lot of files are fragmented, the effect on system performance can be very noticeable. A **disk defragmenter** utility will reorganize the files on the disk so that all files are stored in contiguous locations. Windows' defragmenter utility is called, not surprisingly, Disk Defragmenter (Figure 2-14).



DEVICE DRIVERS The commands necessary to print a line on one manufacturer's laser printer are much different from the commands necessary to print the same line on another manufacturer's ink-jet printer. An operating system cannot possibly know the proper commands for every model of every type of peripheral device on the market. This problem is handled by small utilities called **device drivers.** A device driver accepts standard commands from the operating system and converts them into the proper format for the device it supports. Manufacturers provide device drivers for each of their products. Installing the product includes copying the appropriate driver(s) to your hard drive.

This chapter has discussed the software used to control the hardware and allow you to interact with the computer. In the next chapter, we will look at the software that you use to accomplish useful tasks, such as creating reports, keeping track of expenses, and coordinating group projects.

The Central Processing Unit:
What Goes on Inside the Computer

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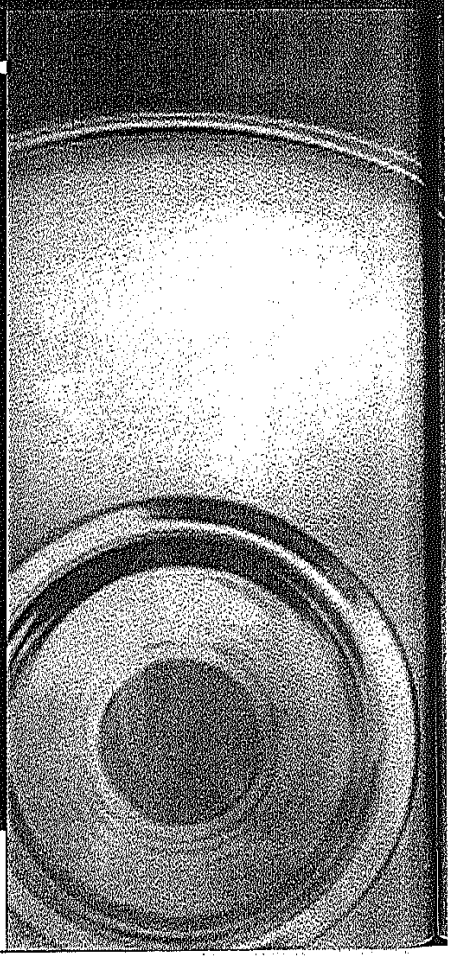

CHAPTER 4

LEARNING OBJECTIVES

- Identify the components of the central processing unit and explain how they work together and interact with memory.
- Describe how program instructions are executed by the computer.
- Explain how data is represented in the computer.
- Describe how the computer finds instructions and data.
- Describe the components of a microcomputer system unit's motherboard.
- List the measures of computer processing speed and explain the approaches that increase speed.

Mark Ong, who hoped to be a scriptwriter, planned a double major in creative writing and drama. In the summer before he entered college, he took a job as an intern editorial assistant, where he first used word processing. He decided that it would be helpful to have a personal computer of his own when he went to college in the fall. But he felt unsure of how to make a purchase. In fact, he felt that he did not even know what questions to ask. He discussed this with an office colleague, who casually noted that any computer setup comes with the "standard stuff"—a processor, keyboard, mouse, screen, disk drives—and that all Mark had to do was go to a computer store and pick one that fit his price range. Mark was not satisfied with this approach, especially in light of the advertisements he had seen in the local newspaper and in computer magazines.

Most advertisements displayed photos of personal computers, accompanied by cryptic descriptions of the total hardware package. A typical ad was worded this way: Pentium 4, 1.8GHz, 128MB RAM, 512KB cache, 1.44MB diskette drive, 16x DVD-ROM, 40GB hard drive. The price for this particular machine was pretty hefty—over $1800. Mark noticed that the ads for machines with lower numbers—for example, only 1.0GHz—also had lower price tags. Similarly, higher numbers meant higher price tags. Although he did recognize the disk drives, he had no idea what the other items were or why the numbers mattered. Clearly, there was more to a purchasing decision than selecting a system with the "standard stuff."

Mark cut out some of the ads and went to a nearby computer store. After asking a lot of questions he learned that Pentium III is a microprocessor type, that "GHz" stands for "gigahertz" and is a measurement of the microprocessor's speed, that RAM is the computer's memory, that cache is a kind of handy storage place for frequently used data and software instructions, and that "GB" is an abbreviation for "gigabytes," a measurement of storage size for the hard disk. Most important, Mark learned that the number variations mattered because they were factors in determining the computer's capacity and speed.

Many buyers do select their personal computer system merely on the basis of a sales pitch and price range. Those people could argue, with some justification, that they do not need to know all the computer buzzwords, any more than they need to know the technical details of their television sets or sound systems. They know that they do not have to understand a computer's innards to put it to work.

But there are rewards for those who want to dig a little deeper and learn a little more. Although this chapter is not designed to help you purchase a computer, it does provide some background information and gives you the foundation on which more computer knowledge can be built.

HARDWARE.

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THE CENTRAL PROCESSING UNIT

The computer does its primary work in a part of the machine we cannot see: a control center that converts data input to information output. This control center, called the **central processing unit (CPU),** is a highly complex, extensive set of electronic circuitry that executes stored program instructions. All computers, large and small, must have at least one central processing unit. As Figure 4-1 shows, the central processing unit consists of two parts: the *control unit* and the *arithmetic/logic unit.* Each part has a specific function.

Before examining the control unit and the arithmetic/logic unit in detail, consider data storage and its relationship to the central processing unit. Computers use two major types of storage: primary storage and secondary storage. The CPU interacts closely with primary storage, or memory, referring to it for both instructions and data. For this reason this chapter will discuss memory in the context of the central processing unit. Technically, however, memory is not part of the CPU.

Memory holds data only temporarily, while a program is working directly with it. Secondary storage holds permanent or semipermanent data on some external medium, such as a disk, until it is needed for processing by the computer. Since the physical attributes of secondary storage devices determine how data is organized on them, secondary storage and data organization will be discussed together in the chapter on storage.

Now let us consider the components of the central processing unit.

The Control Unit

The **control unit** contains circuitry that uses electrical signals to direct the entire computer system to carry out, or execute, stored program instructions. Like an orchestra leader, the control unit does not execute program instructions; rather, it directs other parts of the system to do so. The control unit must communicate with both the arithmetic/logic unit and memory.

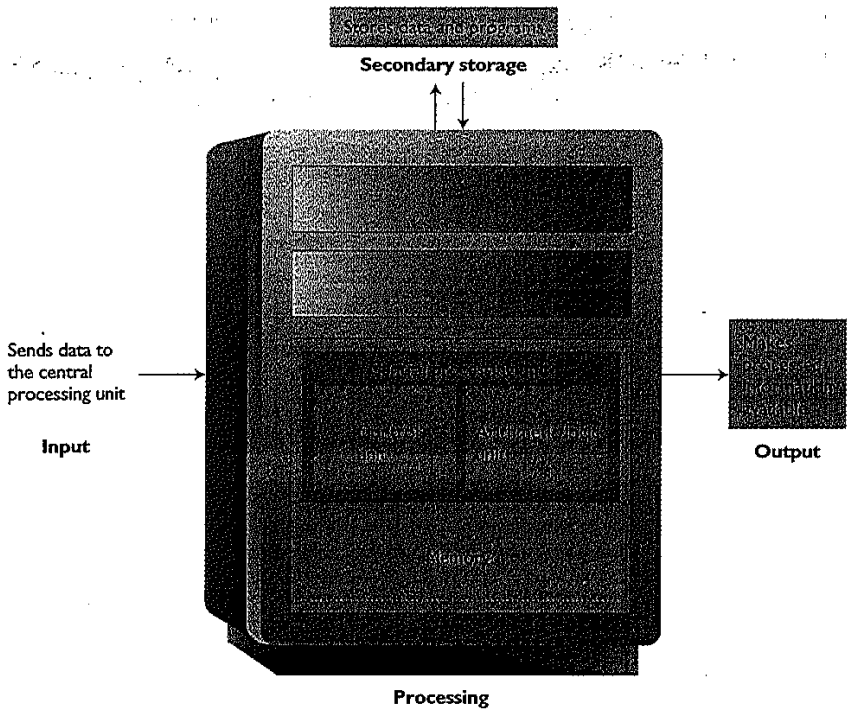


FIGURE 4-1

The central processing unit. The two parts of the central processing unit are the control unit and the arithmetic/logic unit. Memory holds data and instructions temporarily while the program they are part of is being executed. The CPU interacts closely with memory, referring to it for both instructions and data.

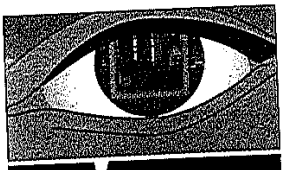
The Arithmetic/Logic Unit

The **arithmetic/logic unit (ALU)** contains the electronic circuitry that executes all arithmetic and logical operations.

The arithmetic/logic unit can perform four kinds of **arithmetic operations,** or mathematical calculations: addition, subtraction, multiplication, and division. As its name implies, the arithmetic/logic unit also performs **logical operations,** or comparisons. The unit can compare numbers, letters, or special characters to test the conditions described below. The computer can then take action based on whether the test produces a true or false result. This is a very important capability. It is by comparing that a computer is able to tell, for instance, whether there are unfilled seats on airplanes, whether charge card customers have exceeded their credit limits, or whether one candidate for Congress has more votes than another.

Logical operations can test for three conditions:

- **Equal-to condition.** In a test for the **equal-to condition,** the arithmetic/logic unit compares two values to determine if they are equal. For example, if the number of tickets sold equals the number of seats in the auditorium, then the concert is declared sold out.
- **Less-than condition.** To test for the **less-than condition,** the computer compares two values to determine if the first is less than the second. For example, if the number of speeding tickets on a driver's record is less than three, then the insurance rate is $425; otherwise, the rate is $500.
- **Greater-than condition.** In testing for the **greater-than condition,** the computer determines if the first value is greater than the second. For example, if the hours a person worked this week are greater than 40, then the program should multiply every extra hour by 1½ times the usual hourly wage to compute overtime pay.



Chips That See

No, we won't be inserting chips into your eyes any time soon. It's the other way around. The power to "see" is being given to chips. They are called imaging chips because they can see and respond to images that are put in front of them. An example on the market today is a machine at the checkout stand that is like the one that scans your groceries, but this one is for your fingertips. In just seconds, a computer with an imaging chip can compare your fingerprint with thousands on file and send a yes or no decision. This technology has been used to eliminate check fraud.

What might an imaging chip watch over? Technical futurists see several possibilities. Chips on airplanes could watch to ensure that the landing gear descends properly. Imaging chips in cars could detect the size of a passenger and adjust the force of the air bag accordingly. Surgeons could plant tiny chips in a patient's chest to watch over their handiwork in the critical hours following an operation.

In addition to these three basic conditions, the computer can test for less-than-or-equal-to, greater-than-or-equal-to, and less-than-or-greater-than conditions. Note that less-than-or-greater-than is the same as **not-equal-to.**

The symbols that programmers use to tell the computer which type of comparison to perform are called **relational operators.** The most common relational operators are the equal sign (=), the less-than symbol (<), and the greater-than symbol (>).

Registers: Temporary Storage Areas

Registers are special-purpose, high-speed, temporary storage areas for instructions or data. They are not a part of memory; rather, they are special additional storage locations located within the CPU itself that offer the advantage of speed. Registers work under the direction of the control unit to accept, hold, and transfer instructions or data and perform arithmetic or logical comparisons at high speed. The control unit uses a register the way a store owner uses a cash register—as a temporary, convenient place to store what is used in transactions.

Special-purpose registers have specific tasks, such as holding the instruction that is currently being executed or keeping track of where the next instruction to be executed is stored in memory. (Each storage location in memory is identified by an address, just as each house on a street has an address.) Some CPU designs include general-purpose registers, which the control unit can use for different tasks, as required.

Consider registers in the context of all the means of storage discussed so far. Registers hold data that is immediately related to the operation being executed. Memory is used to store data that will be used in the near future. Secondary storage holds data that may be needed later in the same program execution or perhaps at some more remote time in the future.

Now let us look at how a payroll program, for example, uses all three types of storage. Suppose the program is about to calculate an employee's gross pay by multiplying the hours worked by the rate of pay. The control unit has placed a copy of the data representing the hours worked and the data for the rate of pay in their respective registers. Other data related to that employee's salary calculation—overtime hours, bonuses, deductions, and so forth—is waiting nearby in memory. The data for other employees is available in secondary storage. As the computer finishes calculations for one employee, the data for the next employee is brought from secondary storage into memory and eventually into the registers.

MEMORY

Memory is also known as **primary storage, primary memory, main storage, internal storage,** and **main memory;** people in computer circles use all these terms interchangeably. Manufacturers often use the term **RAM,** which stands for random-access memory. Memory is the part of the computer that holds data and instructions for processing. Although closely associated with the central processing unit, memory is separate from it. Memory stores program instructions or data only as long as the program they pertain to is in operation. Keeping these items in memory when the program is not running is not feasible for these reasons:

- Most types of memory store items only while the computer is turned on; data is lost when the machine is turned off.
- If more than one program is running at once (usually the case on large computers and sometimes on small computers), a single program cannot lay exclusive claim to memory. There may not be room in memory to hold all the processed data.

- Secondary storage is more cost-effective than memory for storing large amounts of data.

The CPU cannot process data from an input device or disk directly; the data must first be available in memory. How do data and instructions get from an input or storage device into memory? The control unit sends them. Likewise, when the time is right, the control unit sends these items from memory to the arithmetic/logic unit, where an arithmetic operation or logical operation is performed. After being processed, the result is sent to memory, where it is held until it is ready to be released—sent—to an output or storage device.

The chief characteristic of memory is that it allows very fast access to instructions and data, no matter where the items are within it. A discussion of the physical components of memory—memory chips—appears later in this chapter.

HOW THE CPU EXECUTES PROGRAM INSTRUCTIONS

Let us examine the way in which the central processing unit, in association with memory, executes one instruction in a computer program. Many personal computers can execute instructions in less than one millionth of a second, whereas the speed demons known as supercomputers can execute instructions in less than one trillionth of a second.

Before an instruction can be executed, program instructions and data must be placed into memory from an input device or a secondary storage device. As Figure 4-2

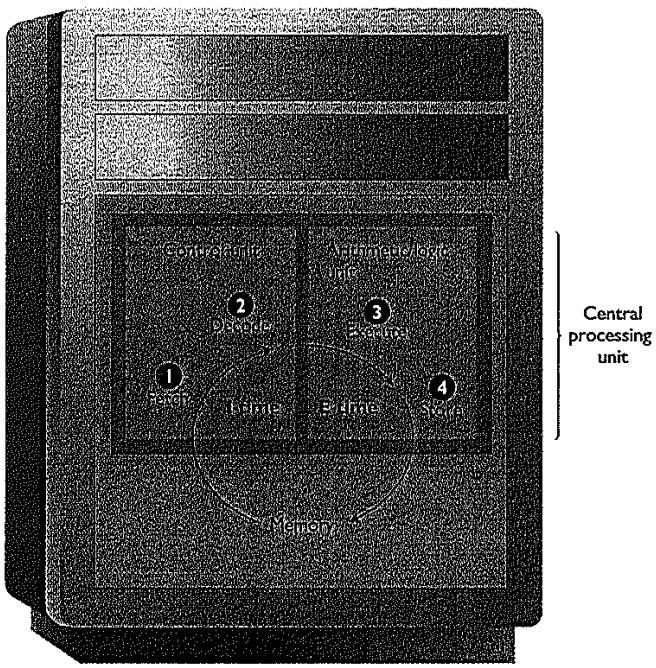


FIGURE 4-2

The machine cycle.

Program instructions and data are brought into memory from an external source, either an input device or a secondary storage medium. The machine cycle executes instructions one at a time, as described in the text.

shows, once the necessary data and instruction are in memory, the central processing unit performs the following four steps for each instruction:

1. The control unit fetches (gets) the instruction from memory and puts it into a register.
2. The control unit decodes the instruction (decides what it means) and determines the memory location of the data required. These first two steps together are called instruction time, or **I-time.**
3. The control unit moves the data from memory to registers in the arithmetic/logic unit. The arithmetic/logic unit executes the arithmetic or logical instruction. That is, the ALU is given control and performs the actual operation on the data.

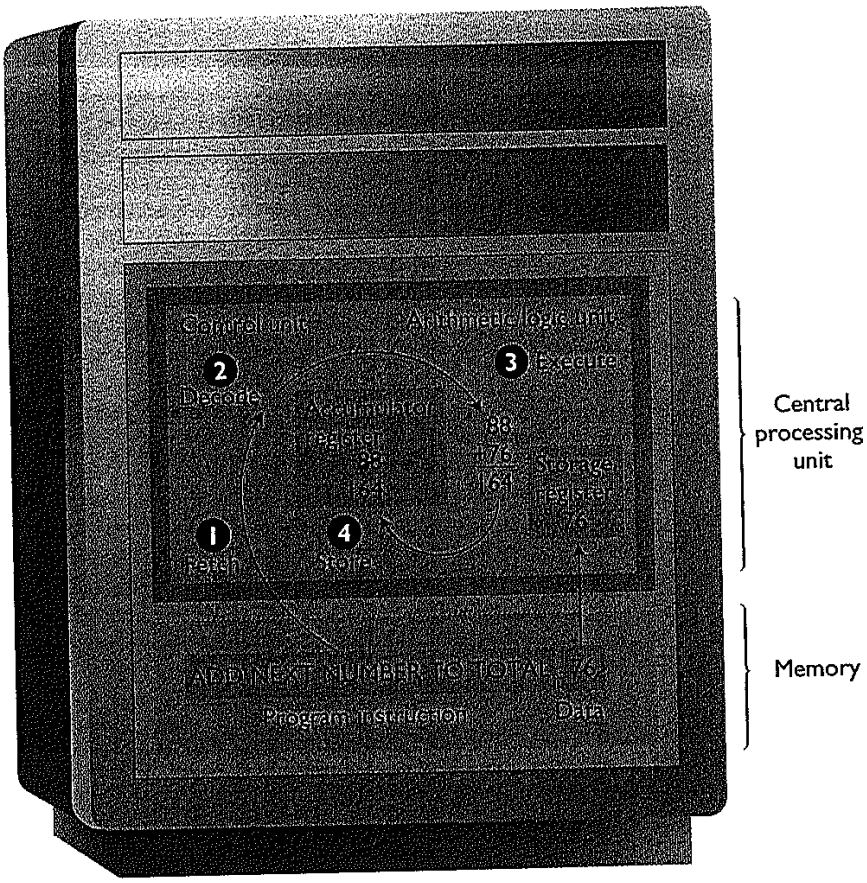


Figure 4-3

The machine cycle in action.

Suppose a program must find the average of five test scores. To do this, it must total the five scores and then divide the result by five. The program would begin by setting the total to 0; it then would add each of the five numbers, one at a time, to the total. Suppose the scores are 88, 76, 91, 83, and 87. In this figure the total has been set to 0, and then 88, the first test score, has been added to it. Now examine the machine cycle as it adds the next number, 76, to the total. Follow the four steps in the machine cycle. (1) Fetch: The control unit fetches the instruction from memory. (2) Decode: The control unit decodes the ADD instruction. It determines that addition must take place and gives instructions for the next number (76) to be placed in a register for this purpose. The total so far (88) is already in a register. (3) Execute: The next number (76) is placed into the register, and the ALU does the addition, increasing the total to 164. (4) Store: In this case the ALU stores the new total in the register instead of in memory, since more numbers still need to be added to it. When the new total (164) is placed in the register, it displaces the old total (88).

4. The control unit stores the result of this operation in memory or in a register. Steps 3 and 4 together are called execution time, or **E-time.**

The control unit eventually directs memory to send the result to an output device or a secondary storage device. The combination of I-time and E-time is called the **machine cycle.** Figure 4-3 shows an instruction going through the machine cycle.

Each central processing unit has an internal **system clock** that produces pulses at a fixed rate to synchronize all computer operations. Note that this is not the clock that the computer uses to keep track of the date and time—that's a separate chip. A single program instruction may be made up of a substantial number of subinstructions, each of which must take at least one machine cycle. Each type of central processing unit is designed to understand a specific group of instructions—such as ADD or MOVE—called the **instruction set.** Just as there are many different languages that people understand, so too are there many different instruction sets that different types of CPUs understand.

STORAGE LOCATIONS AND ADDRESSES: HOW THE CONTROL UNIT FINDS INSTRUCTIONS AND DATA

It is one thing to have instructions and data somewhere in memory and quite another for the control unit to be able to find them. How does it do this?

The location in memory for each instruction and each piece of data is identified by an address. That is, each location has an address number, like the mailboxes in front of an apartment house. And, like the mailboxes, the address numbers of the locations remain the same, but the contents (instructions and data) of the locations may change. That is, new instructions or new data may be placed in the locations when the old contents no longer need to be stored in memory. Unlike a mailbox, however, a memory location can hold only one instruction or piece of data at a time. When a new instruction or piece of data is placed in a memory location, that location's prior contents are destroyed.

Figure 4-4 shows how a program manipulates data in memory. A payroll program, for example, may give instructions to put the rate of pay in location 3 and the number of hours worked in location 6. To compute the employee's salary, then, instructions tell the computer to multiply the data in location 3 by the data in location 6 and move the result to location 8. The choice of locations is arbitrary—any locations that are not already spoken for can be used. Programmers using programming languages, however, do not have to worry about the actual address numbers, because each data address is referred to by a name. The name is called a **symbolic address.** In this example, the symbolic address names are Rate, Hours, and Salary.

DATA REPRESENTATION: ON/OFF

BINARY REPRESENTATION.

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We are accustomed to thinking of computers as complex mechanisms, but the fact is that these machines basically know only two things: on and off. This two-state on/off system is called a **binary system.** Using the two states—which can be represented by electricity turned on or off—the computer can construct sophisticated ways of representing data.

Let us look at one way in which the two states can be used to represent data. Whereas the decimal number system has a base of 10 (with the ten digits 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9), the binary system has a base of 2. This means it contains only two digits, 0 and 1, which correspond to the two states off and on. Combinations of 0s and 1s represent larger numbers (Figure 4-5).

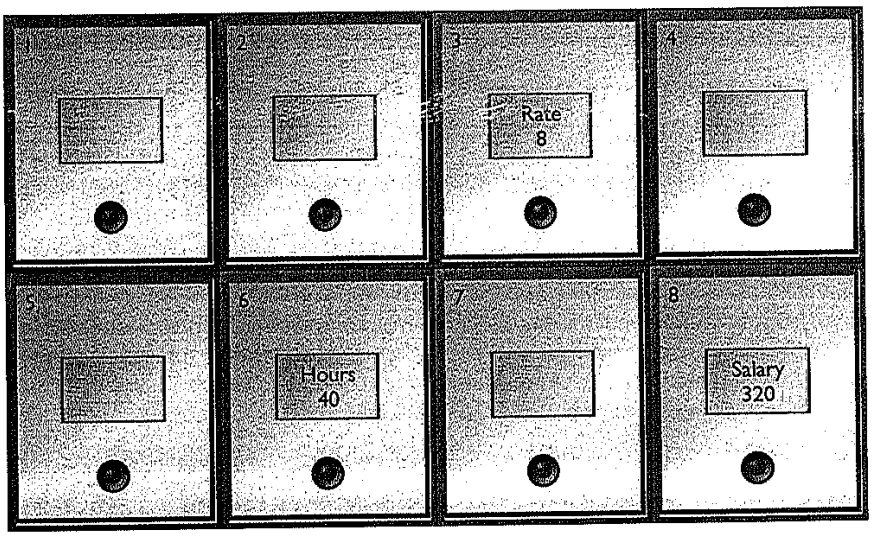

FIGURE 4-4

Addresses are like mailboxes.

The addresses of memory locations are like the identifying numbers on apartment house mailboxes. Suppose you want to compute someone's salary as the number of hours multiplied by the rate of pay. Rate ($8) goes in memory location 3, hours (40) in location 6, and the computed salary ($8 × 40 hours, or $320) in location 8. Therefore the addresses are 3, 6, and 8, but the contents are $8, 40, and $320, respectively. Note that the program instructions are to multiply the contents of location 3 by the contents of location 6 and move the result to location 8. (A computer language used by a programmer would use some kind of symbolic name for each location, such as Rate or Pay-Rate instead of the number 3.) The data items are the actual contents—what is stored in each location.

BINARY EQUIVALENT OF DECIMAL NUMBERS 0–15

Decimal	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111

FIGURE 4-5

Decimal and binary equivalents.

Seeing numbers from different systems side by side clarifies the patterns of progression. The two numbers in each row have the same value; they are simply expressed differently in different number systems.

Bits, Bytes, and Words

Each 0 or 1 in the binary system is called a **bit** (for *binary digit*). The bit is the basic unit for storing data in computer memory: 0 means off, 1 means on. Notice that since a bit is always either on or off, a bit in computer memory is always storing some kind of data—it can never be empty.

Since single bits by themselves cannot store all the numbers, letters, and special characters (such as $ and ?) that a computer must process, the bits are put together in a group called a **byte** (pronounced "bite"). Most computers today are designed to use 8-bit bytes. For text data, each byte usually stores one character of data—a letter, digit, or special character.

Computer manufacturers express the capacity of memory and storage in terms of the number of bytes they contain. The number of bytes can be expressed as **kilobytes.** "Kilo" represents 2 to the tenth power (2^{10}), or 1024. Kilobyte is abbreviated **KB,** or simply **K.** A kilobyte is 1024 bytes. In an older computer, a memory of 640K means that the computer can store 640 × 1024, or 655,360, bytes. Memory capacity today is stated in terms of **megabytes.** One megabyte, abbreviated **MB,** means roughly one million bytes. Personal computer memory may be 128MB and more. With secondary storage devices, manufacturers express capacity in terms of **gigabytes** (abbreviated **GB**)—billions of bytes. Also, mainframe memories are measured in gigabytes. Secondary storage systems on mainframes and networks often have **terabytes (TB)**—trillions of bytes of storage capacity. Figure 4-6 summarizes the terms used to specify memory and storage sizes.

A computer **word,** typically the size of a register, is defined as the number of bits that the CPU processes as a unit. The length of a word varies by CPU. Generally, the larger the word, the more powerful the computer. There was a time when word size alone could classify a computer. Word lengths have varied from 8 bits for very early personal computers to 32 or 64 bits for most personal computers today.

Coding Schemes

As we noted, a byte—a collection of bits—can represent a character of data. But just what particular set of bits is equivalent to which character? In theory we could each make up our own definitions, declaring certain bit patterns to represent certain characters. Needless to say, this would be about as practical as each person speaking his or her own special language. Since we need to communicate with the computer and with each other, it is appropriate that we use a common scheme for data representation. That is, there must be agreement on which groups of bits represent which characters.

Since each byte contains 8 bits, each of which can hold a 1 or 0, there are $2^8 = 256$ possible combinations of 1s and 0s in a byte. A **coding scheme** (or just **code**) assigns each one of those combinations to a specific character. The **ASCII** (pronounced "as-kee") code, which stands for American Standard Code for Information Interchange, is the most widely used code; it is used on virtually all personal computers and on many larger systems. An earlier version of ASCII used a 7-bit byte and could represent only 128 characters. Another code, **Extended Binary Coded**

Term	Abbreviation	Approximate Number of Bytes	Exact Number of Bytes
Kilobyte	K (or KB)	one thousand	1,024
Megabyte	MB	one million	1,048,576
Gigabyte	GB	one billion	1,073,741,824
Terabyte	TB	one trillion	1,099,511,627,776

◄ FIGURE 4-6

Storage sizes.

This table gives the terminology used to specify primary memory and secondary storage capacities.

FIGURE 4-7

The ASCII and EBCDIC codes.

(a) Shown are the ASCII and EBCDIC binary representations for selected characters. This is not the complete code; many characters are missing, such as lowercase letters and punctuation marks. The binary representations are in two columns of 4 bits each to improve readability.

Character	ASCII	EBCDIC
0	0011 0000	1111 0000
1	0011 0001	1111 0001
2	0011 0010	1111 0010
3	0011 0011	1111 0011
4	0011 0100	1111 0100
5	0011 0101	1111 0101
6	0011 0110	1111 0110
7	0011 0111	1111 0111
8	0011 1000	1111 1000
9	0011 1001	1111 1001
A	0100 0001	1100 0001
B	0100 0010	1100 0010
C	0100 0011	1100 0011
D	0100 0100	1100 0100
E	0100 0101	1100 0101
F	0100 0110	1100 0110
G	0100 0111	1100 0111
a	0110 0001	1000 0001
b	0110 0010	1000 0010
c	0110 0011	1000 0011
d	0110 0100	1000 0100
e	0110 0101	1000 0101
f	0110 0110	1000 0110
g	0110 0111	1000 0111
!	0010 0001	0101 1010
#	0010 0011	0111 1011
$	0010 0100	0101 1011
+	0010 1011	0100 1110

Decimal Interchange Code (EBCDIC, pronounced "ebb-see-dik"), is used primarily on IBM and IBM-compatible mainframes. Figure 4-7 shows the ASCII and EBCDIC codes for a selected set of characters.

The 256-character capability of ASCII and EBCDIC is sufficient for English and Western European languages, but is much too small to handle the many different alphabets used throughout the rest of the world. The **Unicode** coding scheme is designed to solve this problem. Unicode uses two bytes (16 bits) to represent one character. This gives it the capability of representing $2^{16} = 65{,}536$ different characters—more than enough for all the world's languages. Unicode is downward-compatible with ASCII, meaning that Unicode recognizes ASCII characters. Most new operating systems and software packages include support for Unicode.

THE SYSTEM UNIT

The **system unit** is the case that houses the electronic components of the computer system. The **motherboard,** the flat circuit board within the personal computer housing that holds the computer circuitry (Figure 4-8), is the main system unit component. The motherboard, also called the main circuit board, is a mass of chips and connections that organize the computer's activities. The central processing unit—the microprocessor—is the most important component of the motherboard. Most microcomputer system units also contain one or more storage devices, such as a hard drive, a floppy drive, and a CD-ROM or DVD-ROM drive. Some Apple Macintosh models include the system unit within the monitor housing.

Microprocessors

A miniaturized central processing unit can be etched on a chip, a tiny square of silicon. A central processing unit, or processor, on a chip is called a **microprocessor** (Figure 4-9). A microprocessor may be called a **logic chip** when it is used to control

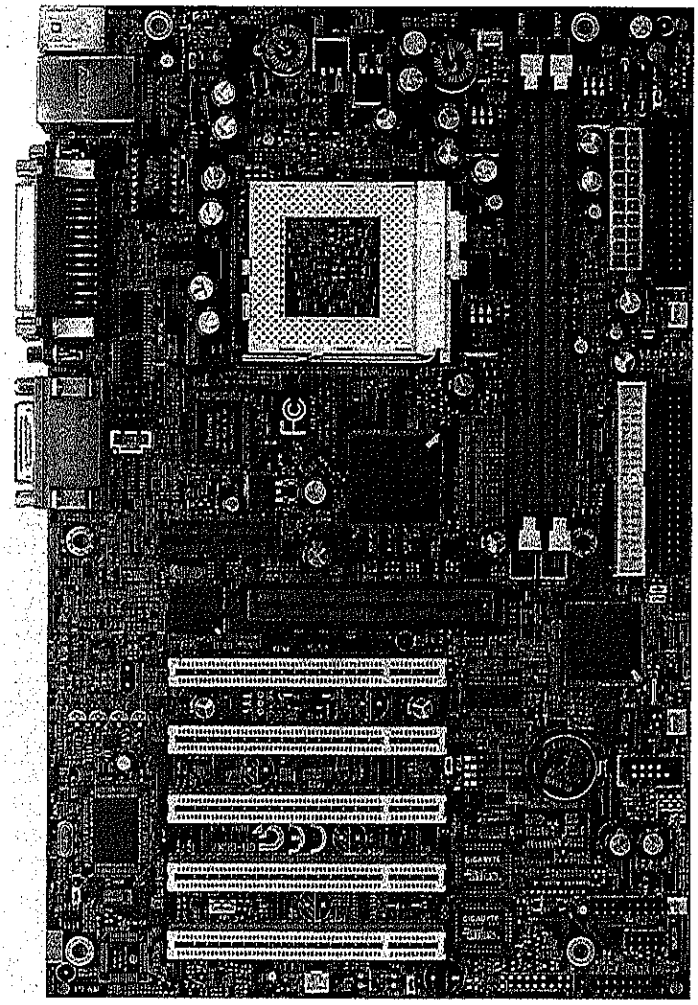

FIGURE 4-8

The Motherboard.

The motherboard is a flat circuit board that holds the computer circuitry, a mass of chips and connections that organize the computer's activities.

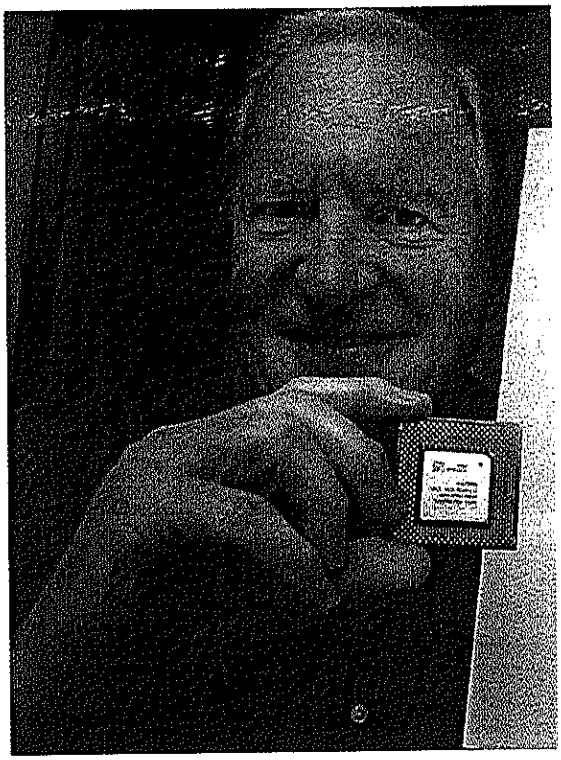

FIGURE 4-9

A Microprocessor.

A central processing unit, or processor, on a chip is called a microprocessor. Microprocessors contain millions of tiny transistors, electronic switches that may or may not allow current to pass through.

MAKING CONNECTIONS

Let Your Idle Computer Earn You Money

The SETI (Search for Extraterrestrial Intelligence) project uses the Arecibo Radio Telescope in Puerto Rico to scan the universe for radio signals generated by intelligent aliens. The project gathers huge amounts of digital data, far more than the project's computers were able to handle. In 1995, project leaders came up with an idea to both gain significant processing power and generate interest in SETI among the public. Their idea was to harness the idle CPU cycles of personal computers by distributing packets of their gathered data and letting individual PCs process that data during idle time. They developed client software that PC users could download from the Internet and install like a screensaver. When the PC is idle, that software will download digital radio data and process it, sending the results back to SETI. The organizers released the software in mid-1999, hoping to get 100,000 people to participate. In the first week, over 200,000 signed up, and the number exceeded 2,000,000 within a year, giving SETI the computing power of a supercomputer operating at over 12 trillion instructions per second.

How you might ask, will this allow you to make money from your idle computer? After all, the SETI project is done on a strictly voluntary basis. Well, it didn't take long for entrepreneurs to realize the moneymaking potential of all this unused computing power. By mid-2000, several companies had begun registering users with the promise of payment for any work done on the users' computers. In turn, that computing power is then sold to businesses on an as-needed basis. If you are the altruistic sort, they will allow you to donate some or all of your computer's work efforts to nonprofit agencies. Unfortunately, you don't get a tax deduction.

specialized devices (such as the fuel system of a car). Microprocessors contain tiny **transistors,** electronic switches that may or may not allow current to pass through. If current passes through, the switch is on, representing a 1 bit. If current does not pass through, the switch is off, representing a 0 bit. Thus combinations of transistors can stand for combinations of bits, which, as we noted earlier, represent digits, letters, and special characters.

The transistor is the basic building block of the microprocessor. Today's microprocessors contain millions of transistors. Microprocessors usually include these key components: a control unit and an arithmetic/logic unit (the central processing unit), registers, and the system clock. Notably missing is memory, which usually comes on its own chips.

How much smaller can a processor be? How much cheaper? How much faster? Three decades of extraordinary advances in technology have packed increasingly greater power onto increasingly smaller chips. Engineers can now imprint as much circuitry on a single chip as filled room-size computers in the early days of computing. But are engineers approaching the limits of smallness? Current development efforts focus on a three-dimensional chip that is built in layers. Chip capacities in the future do seem almost limitless.

In addition to factors such as increased speed, microprocessors have historically increased their power by swallowing up functions that were previously accomplished by other hardware. For example, in the 1980s, chipmaker Intel incorporated a math coprocessor, a separate chip favored by engineers, into its microprocessor. Currently, Intel's **Pentium** chip includes multimedia instructions that boost a computer's ability to produce graphics, video, and sound. The more functions that are combined on a microprocessor, the faster the computer runs, the cheaper it is to make, and the more reliable it is.

Intel's Pentium® microprocessor is the current workhorse in the PC marketplace, with the PIII and P4 models in most of the PCs sold today. Intel also produces the Celeron™ for lower-cost PCs and the Xeon™ and Itanium™ for high-end workstations and network servers. Several companies, notably Cyrix and AMD, make Intel-compatible microprocessors. In the past, these companies have tended to follow Intel, but lately they have been pushing the technology envelope, sometimes beating Intel to market with faster speeds and more advanced capabilities.

There are two other microprocessors of note in the non-Intel world. The **PowerPC** family of chips was designed through the cooperative efforts of Apple, IBM, and Motorola and is currently manufactured by both IBM and Motorola. The PowerPC's primary use is in the Apple Macintosh family of personal computers, but it is also used in servers and embedded systems. The **Alpha** microprocessor, produced by Compaq, is used in high-end servers and workstations.

Memory Components

The first part of this chapter described the central processing unit and how it works with memory. Next is an examination of the memory components. Historically, memory components have evolved from primitive vacuum tubes to today's modern semiconductors.

SEMICONDUCTOR MEMORY Most modern computers use **semiconductor memory** because it has several advantages: reliability, compactness, low cost, and lower power usage. Since semiconductor memory can be mass-produced economically, the cost of memory has been considerably reduced. Chip prices have fallen and risen and fallen again—all on the basis of a variety of economic and political factors—but they remain a bargain. Semiconductor memory is **volatile;** that is, it requires continuous electric current to represent data. If the current is interrupted, the data is lost.

Semiconductor memory is made up of thousands of very small circuits—pathways for electric currents—on a silicon chip. A chip is described as **monolithic** because all

Moore's Law Revisited

Back in 1965, a young engineer named Gordon Moore, one of Intel's cofounders, made a bold prediction that the density of transistors on a silicon chip, and therefore its processing power, would double every 18 months. Dr. Moore's prediction came to be known as Moore's Law and has held true for over 35 years. Some scientists are now predicting that Moore's Law will soon reach its limits, due to the technical problems that are encountered when circuit elements are only the size of a few atoms.

If Moore's Law is strictly interpreted to deal only with silicon chips, that may be true, although other scientists predict that progress can continue at the current rate until at least 2017. However, the most exciting possibilities arise if you focus on the concept of processing power rather than the silicon used to build the processor. Alternatives to silicon-based processors include DNA computing, molecular computing, and quantum computing. Although these technologies are much too complex to discuss here, they offer the possibility of computing advances far beyond Moore's Law.

the circuits on a single chip together constitute an inseparable unit of storage. Each circuit etched on a chip can be in one of two states: either conducting an electric current or not—on or off. The two states can be used to represent the binary digits 1 and 0. As we noted earlier, these digits can be combined to represent characters, thus making the memory chip a storage bin for data and instructions.

One important type of semiconductor design is called **complementary metal oxide semiconductor (CMOS).** This design is noted for using relatively little electricity. In personal computers, one use for CMOS is CMOS RAM; a small amount of memory that, thanks to battery power, retains data when the computer is shut off. Thus CMOS RAM can be used to store information your computer needs when it boots up, such as time, date, and hardware configuration data. When the computer is running, CMOS RAM can be updated, and the new contents will remain until changed again.

RAM AND ROM Memory keeps the instructions and data for whatever programs you happen to be using at the moment. Memory is referred to as **RAM—random-access memory—**in this discussion, both to emphasize its random function and to distinguish it from ROM. Data in memory can be accessed randomly, no matter where it is, in an easy and speedy manner. RAM is usually volatile; as we noted above, this means that its contents are lost once the power is shut off. RAM can be erased or written over at will by the computer software.

RAM can be of two types: static RAM **(SRAM)**—pronounced "ess-ram"—and dynamic RAM **(DRAM),** pronounced "dee-ram." DRAM must be constantly refreshed (recharged) by the central processing unit or it will lose its contents, hence the name dynamic. Static RAM will retain its contents without intervention from the CPU as long as power is maintained. Although SRAM is much faster, DRAM is used for most personal computer memory because of its size and cost advantages (Figure 4-10). Synchronous DRAM **(SDRAM,** pronounced "ess-dee-ram") is a faster type of DRAM used in most PCs today. An even newer technology, Rambus DRAM **(RDRAM,** pronounced "are-dee-ram"), is faster than SDRAM and will undoubtedly become popular once the cost declines. SRAM is used for special purposes that will be described shortly.

In recent years the amount of RAM storage in a personal computer has increased dramatically. An early personal computer, for example, was advertised with "a full 4K RAM." Now 128MB of RAM or even more is common. More memory has become a

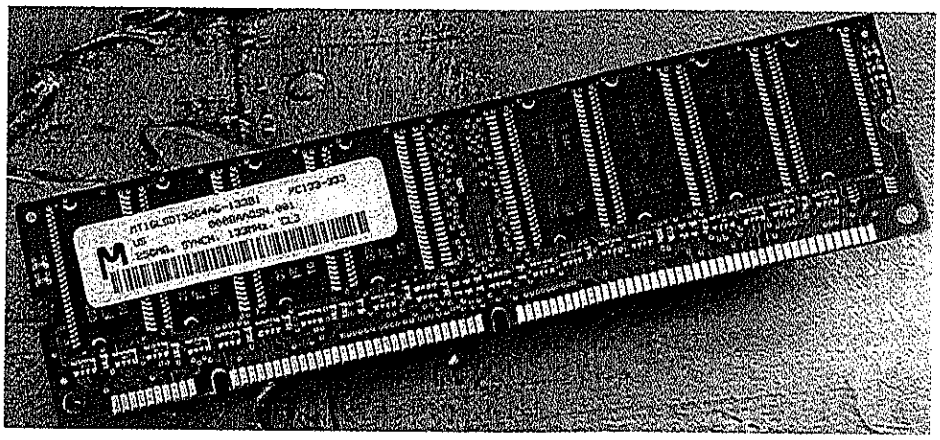

FIGURE 4-10

DRAM.

Dynamic RAM (DRAM) must be constantly refreshed (recharged) by the CPU or it will lose its contents. DRAM is used for most personal computer memory because of its size and cost advantages.

FOCUS ON ETHICS **Are You Being Watched?**

A side effect of the explosive growth in personal computers and communications technology is the amount and detail of personally identifying information that is transmitted and recorded. Some examples:

- Cell phones will contain Global Positioning System (GPS) receivers that can transmit the user's location to within a few feet.
- Some Intel CPUs contain a unique identifying number that could be used to pinpoint the specific PC that sent an e-mail message or downloaded a Web page.
- Electronic toll-road transponders routinely record the time and speed of the user's vehicle at each tollbooth.
- Free bar code scanners distributed with catalogs for on-line browsing transmit a special code that could identify the user.
- Cable and DSL modems have a unique Media Access Controller (MAC) address that an ISP can use to track the specific services and sites used by each customer.

Each of these technologies has potential benefits to the consumer and the industry, but each could pose a threat to your privacy. Cite one or more of the examples above and list as many benefits and as many drawbacks as you can. What sort of policies could industry, government, or individuals adopt that would help to ensure that the benefits of the selected technology outweigh the costs?

necessity because sophisticated personal computer software requires significant amounts of memory. Also, many users have several programs active at the same time, each using its own portion of memory. You can augment your personal computer's RAM by buying extra memory modules to plug into your computer's motherboard. Memory normally is packaged on circuit boards called **single in-line memory modules (SIMMs)** or **dual in-line memory modules (DIMMs),** depending on whether the memory chips are installed on one side or both sides of the board. The motherboard design determines the maximum amount of memory that you can install in your computer.

Read-only memory (ROM) contains programs and data that are permanently recorded into this type of memory at the factory; they can be read and used, but they cannot be changed by the user. For example, the boot routine that is activated when you turn your computer on is stored in ROM. ROM is nonvolatile—its contents do not disappear when the power is turned off.

By using specialized tools called ROM burners, the instructions within some ROM chips can be changed. These chips are known as **PROM** chips, or **programmable read-only memory** chips. There are other variations on ROM chips, depending on the methods used to alter them. Programming and altering ROM chips are the province of the computer engineer.

The System Bus

As is so often the case, the computer term "bus" is borrowed from its common meaning—a mode of transportation. A **bus line** (or just **bus**) is a set of parallel electrical paths that transport electrical signals. The **system bus,** usually copper tracing on the surface of the motherboard, transports data between the CPU and memory. The number of bits of data that can be carried at one time is called the *bus width,* which indicates the number of electrical paths. The greater the width, the more data can be carried at a time. Just as a four-lane expressway can move traffic faster than a two-lane road, wider buses allow faster data transmission. The system bus width is dependent on the CPU design and is normally is the same as the CPU's word size. A larger bus size means that:

- The CPU can transfer more data at a time, making the computer faster.
- The CPU can reference larger memory address numbers, allowing more memory.
- The CPU can support a greater number and variety of instructions.

In general, the larger the word size or bus width, the more powerful the computer. Bus speed is another factor that affects system performance. As with processor speed, bus speed is measured in megahertz (MHz). The faster the bus speed, the faster data travels through the system.

Expansion Buses

In addition to the system bus, the motherboard also contains several expansion buses. Some of these buses connect to **expansion slots** on the motherboard. By plugging **expansion boards** (also called **interface cards** or **adapter cards**) into these slots, you can connect various peripheral devices to your computer (see Figure 4-11). Other buses provide external connectors, called **ports,** for you to plug in peripherals such as a printer, a mouse, and a keyboard. Ports come in two basic types: serial and parallel. **Serial ports** transmit data one bit at a time, similar to cars on a one-lane road, and are typically used for slow-speed devices such as the mouse and keyboard. **Parallel ports** transmit groups of bits together, similar to a group of cars traveling side-by-side down a multilane highway, and are used for faster devices such as printers and scanners (see Figure 4-12).

GETTING PRACTICAL — **Should You Build Your Own Computer?**

Building your own computer may seem like a fanciful idea indeed, especially if you have not even decided whether to buy a computer that comes prepackaged. However, the option of building a computer, once the territory of hard-core techies, is now a possibility for mainstream consumers. Some people like the idea of the adventure, and they also like getting exactly the components they want rather than what a PC manufacturer has decided to include.

What skills do you need? And what equipment? Surprisingly, very little of either. You will not need to do anything as dramatic as soldering. In truth, your task is really to acquire and then assemble the various components, screwing and snapping them into place, rather like an electronic Lego set.

Let us begin with the shopping list. You will need a motherboard, microprocessor, RAM, case with a power supply, diskette drive, hard drive, video card, monitor, keyboard, and mouse. You will likely also want a modem, a CD-ROM or DVD-ROM drive, a sound card, and speakers. Now the question becomes which ones. A visit to your local electronics store can be a high-tech reconnaissance mission in which you can gather information from both salespeople and fellow customers. Be sure to check the store's return policy; you should be able to return any component unconditionally within a certain time frame. If reduced personal service is an acceptable trade-off for lower costs, you may prefer to buy from a mail-order house or an Internet site; check the advertising section of any major computer magazine. But do buy the major components from the same company to cut down on compatibility problems.

We do not have the space here to describe the components in detail, much less the assembly process. Detailed instructions, which you should read carefully, accompany each hardware item. You can get further advice from magazines, perhaps a local computer club, and the Internet.

Don't expect to save a lot of money. Profit margins are slim in the PC marketplace, and the PC manufacturers can buy components a lot cheaper than you can, so the total component cost will not be significantly less than what you would pay for a fully assembled computer. The real savings will come in the future when you are able to upgrade your computer on your own—adding more memory, a new microprocessor, a new hard drive, or whatever—rather than buying a new computer.

Building a computer can be a satisfying experience, but it is not for everyone. Generally speaking, if you have any doubts, don't do it.

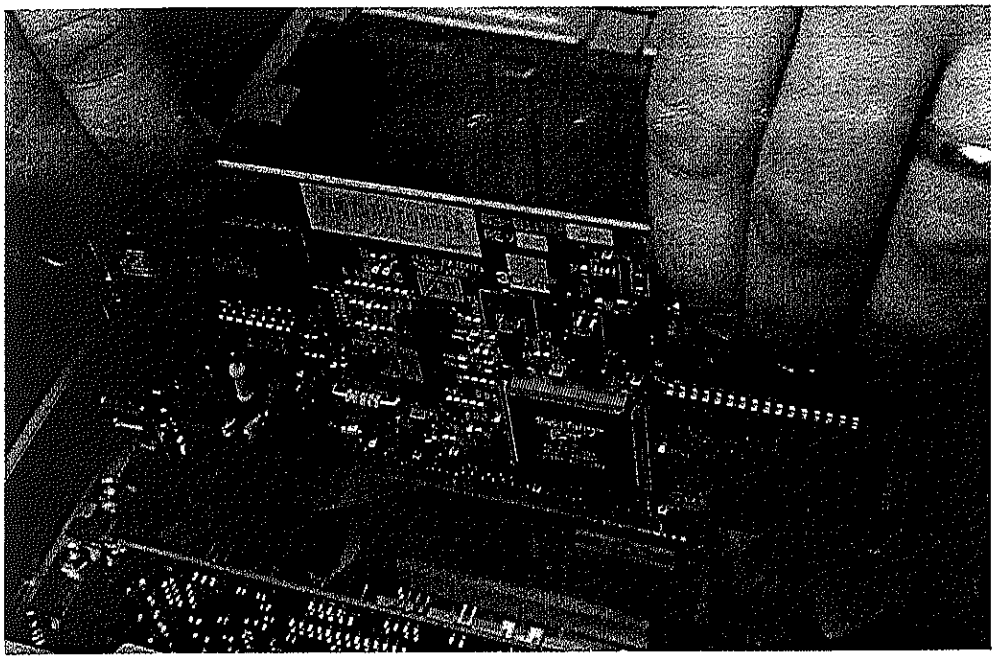

FIGURE 4-11

An Interface Card.

By plugging expansion boards (also called interface cards or adapter cards) into expansion slots on the computer's motherboard, you can connect various peripheral devices to your computer.

The following are buses and ports that are commonly found on personal computers:

- **Industry Standard Architecture (ISA) bus.** The oldest expansion bus still in common use, the **Industry Standard Architecture (ISA) bus** is used for slow-speed devices such as the mouse and modem.
- **Peripheral Component Interconnect (PCI) bus.** The **Peripheral Component Interconnect (PCI) bus** is a high-speed bus used to connect devices such as hard disks and network cards.
- **Accelerated Graphics Port (AGP).** The **Accelerated Graphics Port (AGP)** is a bus that is designed to provide a dedicated connection between memory and an AGP graphics card. The direct connection provides much faster video performance without interfering with other peripherals.
- **Universal Serial Bus (USB).** Access to the **Universal Serial Bus (USB)** is provided through a port on the back of the system unit. Devices with USB connectors can be daisy-chained (connected in a series) to each other and plugged into the USB port, eliminating the need for multiple expansion cards. USB devices are *hot-swappable*, meaning that you can connect and disconnect them without turning off the power to your computer.
- **IEEE 1394 bus.** Also referred to as FireWire, the **IEEE 1394 bus** is a high-speed bus that is normally used to connect video equipment to your computer. It is also accessed through a port on the back of the system unit.

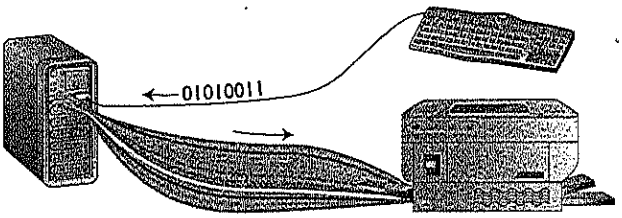

FIGURE 4-12

Serial and parallel transmission.

Serial ports, used for slower devices such as the keyboard, transmit bits one at a time. Parallel ports are used for higher-speed devices such as printers and transmit entire bytes at a time.

- **PC Card bus.** Access to **PC Card bus** is provided through a slot or slots in the computer case. The slot accepts credit card-sized PC Card devices and is normally found on laptops.

SPEED AND POWER

The characteristic of speed is universally associated with computers. Power is a derivative of speed as well as of other factors such as memory size. What makes a computer fast? Or, more to the point, what makes one computer faster than another? Several factors are involved, including microprocessor speed, bus line size, and the availability of cache. A user who is concerned about speed will want to address all of these. More sophisticated approaches to speed include flash memory, RISC computers, and parallel processing. A discussion of each of these factors follows.

Computer Processing Speeds

Although all computers are fast, there is a wide diversity of computer speeds. The execution of an instruction on a very slow (old) computer may be measured in less than a **millisecond,** which is one thousandth of a second, or perhaps in **microseconds,** each of which is one millionth of a second. Modern computers have reached the **nanosecond** range—one billionth of a second. Still to be broken is the **picosecond** barrier—one trillionth of a second (see Figure 4-13).

One way of comparing the performance of personal computers is by comparing their microprocessor speeds. Microprocessor speeds are determined by their clock speed and are usually expressed in **megahertz (MHz),** millions of machine cycles per second. Thus a personal computer that is listed at 500MHz has a processor capable of handling 500 million machine cycles per second. A top-speed personal computer can be much faster, with newer ones reaching **gigahertz (GHz**—billions of machine cycles per second) speeds. Direct comparison of clock speeds is meaningful only between identical microprocessors. Thus, while it is accurate to say that a Pentium III running at 800MHz is approximately one third faster than a Pentium III running at 600MHz, it is not at all correct to say that a 600MHz Pentium III is faster than a 400MHz PowerPC. This is due to the internal designs of the microprocessors—each accomplishes a different amount of work during each of its clock ticks.

Another measure of computer speed is **MIPS,** which stands for one million instructions per second. For example, a computer with speed of 0.5MIPS can execute 500,000 instructions per second. High-speed personal computers can perform at 100MIPS and higher. MIPS is often a more accurate measure than clock speed, because some computers can use each tick of the clock more efficiently than others.

Term	Abbreviation	Fraction of a Second
millisecond	ms	1/1,000 second
microsecond	μ	1/1,000,000 second
nanosecond	ns	1/1,000,000,000 second
picosecond	psec	1/1,000,000,000,000 second

FIGURE 4-13

Fractions of a second.

Note that each fraction is 1/1,000th of the fraction above it in the table.

A third measure of speed is the **megaflop,** which stands for one million floating-point operations per second. It measures the ability of the computer to perform complex mathematical operations.

Cache

In computer terminology **cache** (pronounced "cash") is a temporary storage area designed to speed up data transfer within the computer. In this section we will discuss memory cache. Disk cache will be covered in Chapter 6. **Memory cache** is a relatively small block of very fast memory designed for the specific purpose of speeding up the internal transfer of data and software instructions (see Figure 4-14). Think of cache as a selective memory: The data and instructions stored in cache are those that are most recently or most frequently used. When the processor first requests data or instructions, these must be retrieved from main memory, which delivers at a pace that is relatively slow in comparison with the speed of the microprocessor. As they are retrieved, those same data or instructions are stored in cache. The next time the microprocessor needs data or instructions, it looks first in cache; if the needed items can be found there, they can be transferred at a rate that far exceeds a trip from main memory. Of course, cache is not big enough to hold everything, so the wanted data or instructions might not be there. But there is a good chance that frequently used items will be in cache. Since the most frequently used data and instructions are kept in a handy place, the net result is an improvement in processing speed.

Caching is such a vital technique that microprocessors now offer **internal cache** built right into the processor. This is referred to as **Level 1 (L1)** cache and is the fastest sort, since it is right there for the microprocessor to access. However, cache memory takes up precious space and increases the cost of the microprocessor, so a processor would probably have no more than 128KB of L1 cache. Most computers also include **external,** or **Level 2 (L2), cache** on separate chips, probably 256KB or 512KB. L2 cache uses SRAM technology and is cheaper and slower than L1 cache but still much faster (and more expensive) than memory. L2 cache beyond 512KB has been shown to give little additional improvement in system performance.

Flash Memory

We have stated that memory is volatile—that it disappears when the power is turned off—hence the need for secondary storage to keep data on a more permanent basis. A long-standing speed problem has been the slow rate at which data is accessed from a secondary storage device such as a disk, a rate that is significantly slower than internal computer speeds. It seemed unimaginable that data might someday be stored on nonvolatile memory chips—nonvolatile RAM—close at hand. A breakthrough has emerged in the form of nonvolatile **flash memory.** Flash chips are currently being used in cellular phones, digital cameras, and digital music recorders, and they are replacing disks in some handheld computers.

FIGURE 4-14

Memory Cache.

Memory cache is a temporary storage area designed to speed up transfer of data instructions between memory and the CPU. Level 1 (L1) cache is built into the CPU, while Level 2 (L2) cache is on separate chips.

Flash memory chips are being produced in credit card-like packages, which are smaller than a disk drive and require only half the power; that is why they are being used in notebook computers and the handheld personal digital assistants.

RISC Technology: Less Is More

It flies in the face of computer tradition: Instead of reaching for more variety, more power, more everything-for-everyone, proponents of **RISC—reduced instruction set computing**—suggest that we could get by with a little less. In fact, RISC-based microprocessors offer only a small subset of instructions; the absence of bells and whistles increases speed. So there is a back-to-basics movement in computer design.

RISC supporters say that in conventional microprocessors, which are based on **complex instruction set computing (CISC),** many of the most complex instructions in the instruction set are rarely used. Those underused instructions, they note, are an impediment to speedy performance, often taking several clock cycles to execute. RISC computers, with their stripped-down instruction sets, zip through programs like racing cars—at speeds 4 to 10 times those of CISC computers. They do slow down, however, when they run into program operations that are normally handled by the complex instructions that were deleted from their instruction set. These operations have to be broken down into smaller steps and handled by a sequence of simple instructions, slowing execution speed. For programs with few operations requiring complex instructions, typically those in graphics and engineering areas, RISC computers have a significant performance advantage. Of the processors discussed earlier, the PowerPCs and Alphas use RISC designs, while Intel's Pentium family follows the CISC approach.

Parallel Processing

The ultimate speed solution is **parallel processing,** a method of using multiple processors at the same time. Consider the description of computer processing you have seen so far in this chapter: The processor gets an instruction from memory, acts on it, returns processed data to memory, and then repeats the process. This is conventional **serial processing,** the execution of one instruction at a time. A variation on this approach is **pipelining,** in which an instruction's actions—fetch, decode, execute, store—need not be complete before the next instruction is begun. For example, once fetch is complete for an instruction and it moves to decode, fetch is begun for the next instruction (Figure 4-15).

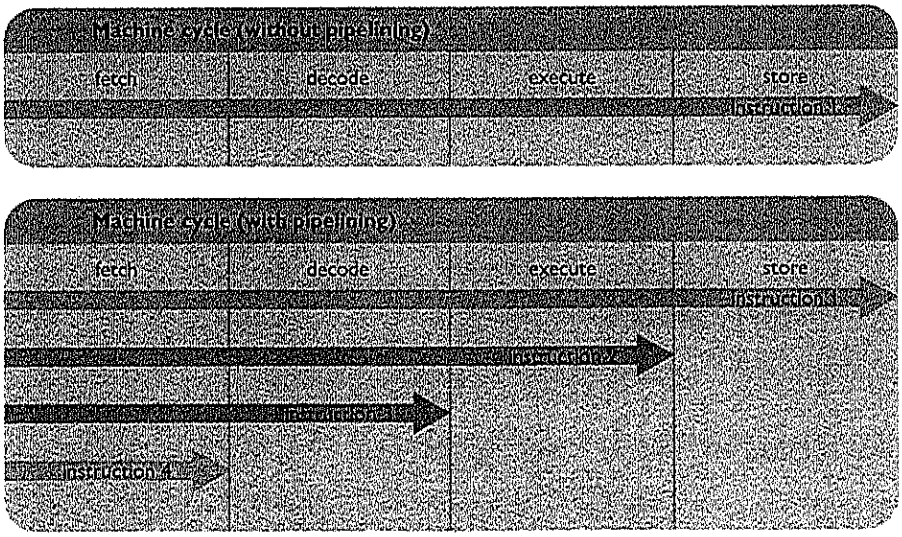

FIGURE 4-15

Pipelining.

Pipelining is a processing technique that feeds a new instruction into the CPU at every step of the processing cycle so that four or more instructions are worked on simultaneously.

The problem with the conventional computer is that the single electronic pathway, the bus line, acts like a bottleneck. The computer has a one-track mind because it is restricted to handling one piece of data at a time. For many applications, such as simulating the airflow around an entire airplane in flight, this is an exceedingly inefficient procedure. A better solution? Many processors, each with its own memory unit, working at the same time: parallel processing. Some computers using parallel processors are capable of operating in terms of **teraflops**—that is, trillions of floating-point instructions per second. Recall, for comparison, that a megaflop is a mere one million floating-point operations per second.

A number of computers containing parallel processors are being built and sold commercially. Some have a small number of processors, typically 4 to 16, and are used as network servers. Others use hundreds or even thousands of processors and fall within the realm of supercomputing.

▲

The future holds some exciting possibilities for computer chips. One day we may see computers that operate by using light (photonics) rather than electricity (electronics) to control their operation. Light travels faster and is less likely to be disrupted by electrical interference. And would you believe that someday computers might actually be grown as biological cultures? So-called biochips may replace today's silicon chip. As research continues, so will the surprises.

Whatever the design and processing strategy of a computer, its goal is the same: to turn raw input into useful output. Input and output are the topics of the next chapter.

Input and Output:
The User Connection

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CHAPTER 5

LEARNING OBJECTIVES

Describe the user relationship with computer input and output.

Explain how data is input into a computer system and differentiate among various input equipment.

Describe how a monitor works, and the characteristics that determine quality.

List and describe the different methods of computer output.

Differentiate among different kinds of printers.

Explain the function of a computer terminal and describe the types of terminals.

McKenna University long ago abandoned the practice of having students stand in line to register for classes. Now almost everything is handled by phoning a computer. Since these procedures save time and trouble, they suit Rose Sierra just fine. Rose did begin with a manual procedure when she first applied to the university. Her application, the source document, was prepared by her and, after she was accepted, scanned into the university's computer. From that point forward, Rose has communicated directly with the computer.

Rose can phone the computer and supply it with her data, using her Touch-Tone phone as a sort of miniature keyboard. Once the computer responds to the number she dials, she enters her Social Security number, followed by the unique personal identification number (PIN) assigned to her by the university. She can then follow the procedure to register for classes, entering class item numbers from the college's class schedule. Various options are available, such as taking a class for credit or audit, by entering a number from her telephone keypad. The computer delivers voice output, telling her she has—or has not—been accepted in a class. Once she has entered all classes, Rose can push other buttons for other options, such as hearing her class schedule, dropping a class, hearing the tuition amount owed, and paying by credit card.

Once Rose is registered, the computer will print her student identification card, complete with bar code, which she can pick up in the library.

The ID card is used for checking books out of the library and for making use of computer and science labs. The computer produces a lot of other output, such as class rosters for instructors and registration summaries, that are only indirectly related to Rose.

Rose is not particularly familiar with computer-related input/output terms such as source document, scan, keyboard, voice output, and bar code, nor does she need to be to register. But understanding these terms, and other terms related to input and output, will help users to navigate all sorts of computer systems.

HARDWARE.

Prentice Hall EXPLORE Generation IT

HOW USERS SEE INPUT AND OUTPUT

The central processing unit is the unseen part of a computer system; users are only dimly aware of it. But users are very much aware of the input and output associated with the computer. They submit input data to the computer to get processed information, the output.

Sometimes the output is an instant reaction to the input. Consider these examples:

- Zebra-striped bar codes on supermarket items provide input that permits instant retrieval of outputs—price and item name—right at the checkout counter.
- A forklift operator speaks directly to a computer through a microphone. Words such as *left*, *right*, and *lift* are the actual input data. The output is the computer's instant response, which causes the forklift to operate as requested.
- A sales representative uses an instrument that looks like a pen to enter an order on a special pad. The handwritten characters are displayed as "typed" text and are stored in the pad, which is actually a small computer.
- Factory workers input data by punching in on a time clock as they go from task to task. The time clock is connected to a computer. The outputs are their weekly paychecks and reports for management that summarize hours per project on a quarterly basis.

Input and output may be separated by time, distance, or both. Here are some examples:

- Data on checks is used as input to the bank computer, which eventually processes the data to prepare a bank statement once a month.
- Charge-card transactions in a retail store provide input data that is processed monthly to produce customer bills.
- Water sample data is collected at lake and river sites, keyed in at the environmental agency office, and used to produce reports that show patterns of water quality.

The examples in this section show the diversity of computer applications, but in all cases the process is the same: input–processing–output. This chapter examines input and output methods in detail.

INPUT: GETTING DATA FROM THE USER TO THE COMPUTER

Some input data can go directly to the computer for processing. Input in this category includes bar codes, speech that enters the computer through a microphone, and data entered by means of a device that converts motions to on-screen action. Some

MAKING CONNECTIONS ◄ Face to Face

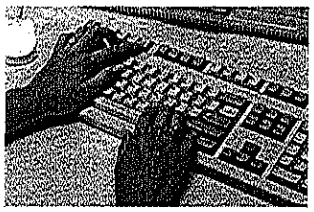
Perhaps you can send e-mail, and you may even have learned how to include a photograph. But can you talk face-to-face with someone using a computer connection? You can if you buy one of the video kits that have made the process easy and affordable. A typical kit includes a camera and software, both of which are easy to install. Shown here is Intel's *Create & Share Camera Pack*; note the camera atop the monitor. Of course, this works only if the party at the other end of your communication has a video setup too.

The technology for video telephones has been around for a long time, but it never caught on with the general public. Perhaps people didn't want to be seen with their hair in curlers or in their bathrobes. But computer video telephony is attractive, partly because it is inexpensive even over long distances and partly because it is still sufficiently novel that it is planned in advance—no curlers.

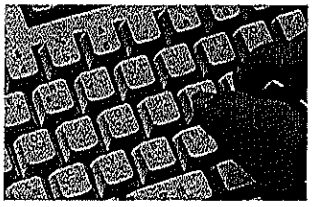
input data, however, go through a good deal of intermediate handling, such as when it is copied from a **source document** (jargon for the original written data) and translated to a medium that a machine can read, such as a magnetic disk. In either case the task is to gather data to be processed by the computer—sometimes called *raw data*—and convert it into an electronic form that the computer can understand. Conventional input devices include the keyboard, mouse, trackball, touchpad, and joystick, which are explained in the following sections.

Keyboard

A **keyboard,** which usually is similar to a typewriter keyboard, may be part of a personal computer or part of a terminal that is connected to a computer somewhere else (Figure 5-1a). Not all keyboards are traditional, however. A fast-food franchise such as McDonald's, for example, uses keyboards whose keys represent items such as large fries or a Big Mac. Even less traditional is the keyboard shown in Figure 5-1b, which is used to enter Chinese characters. Figure 5-2 shows the complete layout of a traditional keyboard.



(a)



(b)

FIGURE 5-1

Keyboards.

(a) A traditional computer keyboard. (b) Chinese characters are significantly more complicated than the letters and digits found on a standard keyboard. To enter Chinese characters into the computer system, one uses a special keyboard. Each letter key shows the characters that a user can type by holding down other keys while pressing that letter (as you would hold down a Shift key to make capital letters).

Pointing Devices

A **pointing device** is used to position a **pointer** on the screen. The pointer can have a number of shapes but is most often an arrow. A pointing device usually has one or more buttons or other mechanisms to indicate the action to take once the pointer has been positioned in the desired location. To modify text in an application such as word processing, you move the pointer to the desired place in the screen text, then click the button to set the **insertion point,** or **cursor.** (The insertion point can also be moved by pressing various keyboard keys.) The next text that is typed will begin at the insertion point. In graphics-based applications, you use the pointing device to control various drawing instruments, such as a paintbrush, pen, or eraser.

You can also use the pointing device to communicate commands to the operating system or an application program by clicking a button. In particular, a button is often used to click on an icon, a pictorial symbol on a screen; the **icon** represents a computer activity—a command to the computer—so clicking the icon invokes the command. The command may be to launch an application, such as word processing or a game, or to activate a feature within an application, such as underlining. The environment that permits communication with the computer by clicking on icons is referred to as a **graphical user interface (GUI).**

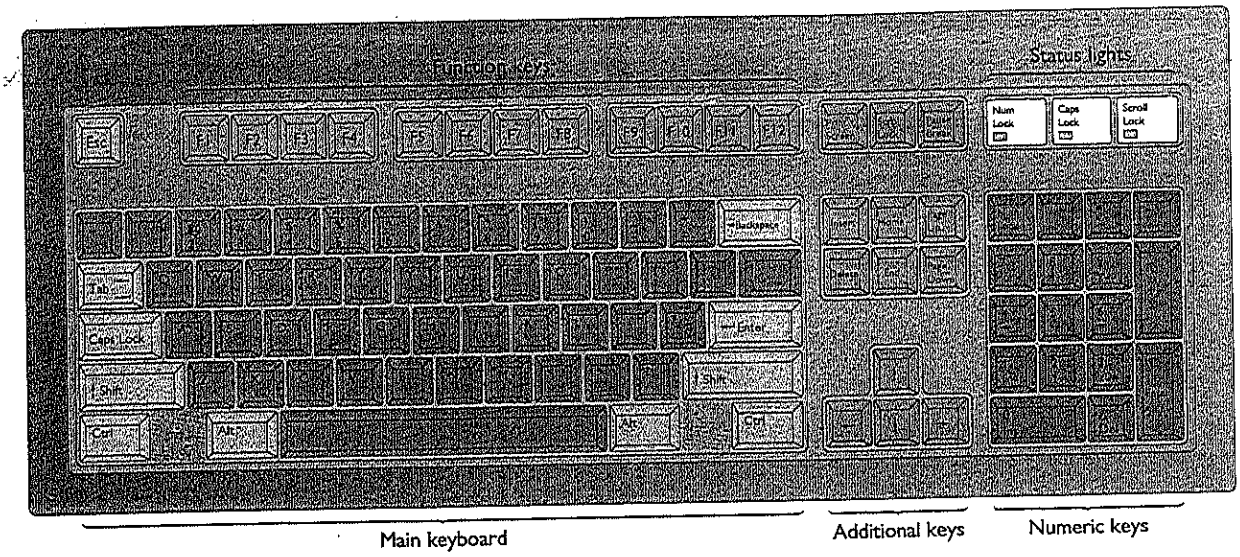


FIGURE 5-2

Finding your way around a keyboard.

Most personal computer keyboards have at least three main parts: function keys, the main keyboard in the center, and the numeric keys and status lights. Extended keyboards, such as the one shown here, have additional keys between the main keyboard and the numeric keys. **Function keys:** The function keys (highlighted in tan on the diagram) are an easy way to give certain commands to the computer. What each function key does is defined by the particular software you are using. Some keyboards have the function keys on the left instead of across the top. **Main keyboard:** The main keyboard includes the familiar keys found on a typewriter keyboard (dark blue), as well as some special command keys (light blue). The command keys have different uses that depend on the software being used. **Numeric keys:** The numeric keys (purple), serve one of two purposes, depending on the status of the Num Lock light. When the Num Lock light is on, these keys can be used to enter numeric data and mathematical symbols. When the Num Lock light is off, the numeric keys are used to move the cursor and perform other functions, as shown on the bottom of each key cap. The Num Lock key is used to toggle the Num Lock light on and off. **Additional keys:** Extended keyboards include additional keys (green) that duplicate the cursor movement functions of the numeric keys. Users who enter a lot of numeric data can leave their keyboards in the Num Lock mode and use these keys to control the cursor.

A number of different pointing devices are available for use on a computer. Your choice of device will depend both on personal preference and on the types of applications you use. Some of the most common pointing devices are described below.

MOUSE The mouse is by far the most common pointing device for personal computers. A **mouse** is a palm-sized device that is moved around on a flat surface to cause a corresponding movement of the pointer on the screen. A **mechanical mouse** has a small ball on its underside that rolls as the mouse is moved. Sensors inside the mouse determine the direction and distance of movement and signal the computer to move the pointer on the screen accordingly. An **optical mouse** uses a light beam to monitor mouse movement. Older models require a special mouse pad that has gridlines on its surface, but newer optical mice will work on almost any non-reflective surface. Most mice connect via cable to a port on the computer. A **wireless mouse,** by contrast, communicates through an infrared beam and so must have a clear path between the mouse and the infrared port on the PC. As mice have evolved, new features and new buttons have been added. Mice such as Microsoft's IntelliMouse offers an extra wheel, positioned between the two mouse buttons, that can be clicked like a button or rolled to affect the cursor (Figure 5-3). With software designed to be used with this mouse, it can move through a document line-by-line or page-by-page, zoom in on a special spreadsheet cell, or flip backwards through Web pages you have already seen. Some mice have up to five programmable buttons.

TRACKBALL The **trackball** is a variation on the mechanical mouse. You may have used a trackball to play a video game. The trackball is like an upside-down mechanical mouse—you roll the ball directly with your hand. Buttons are mounted along-side or below the ball. The popularity of the trackball surged with the advent of laptop computers, when traveling users found themselves without a flat surface on which to roll the traditional mouse. Trackballs are often built into portable computers, but they can also be used as separate input devices with any computer. (Figure 5-4).

TOUCHPAD A **touchpad** is a rectangular pressure-sensitive pad. Just slide your finger across the touchpad's surface, and corresponding pointer movements will be made on the screen. Buttons at the bottom of the unit serve the same functions as mouse buttons, but most touchpads also recognize a finger tap as a click. Stand-alone touchpads are available to use with any computer, but most are built into laptops.

POINTING STICK A **pointing stick** is a small pressure-sensitive post mounted in the center of the keyboard between the *G* and *H* keys (Figure 5-5). Pushing the post in one direction causes the pointer to move in that direction. The pointer stops moving when pressure is released. Buttons are located below the keyboard.

JOYSTICK A **joystick** is a short lever with a handgrip that resembles the floor-mounted gearshift in a sports car (Figure 5-6). The distance and speed of movement control the screen pointer's position. Pressing *triggers*, buttons on the lever, causes various actions to take place, depending on the software in use. Although the joystick is most often used with games such as flight simulators, it can be used as a mouse replacement.

GRAPHICS TABLET A **graphics tablet,** also called a **digitizing tablet,** is a rectangular board that contains an invisible grid of electronic dots (Figure 5-7). As the user moves a pen-like **stylus** or a mouse-like **puck** with crosshairs around the board, the dot locations that are passed over are sent to the computer. Architects and engineers use these tablets to trace or create precise drawings.

TOUCH SCREENS One way of getting input directly from the source is to have a human simply point to a selection. The edges of some **touch screens** emit horizon-

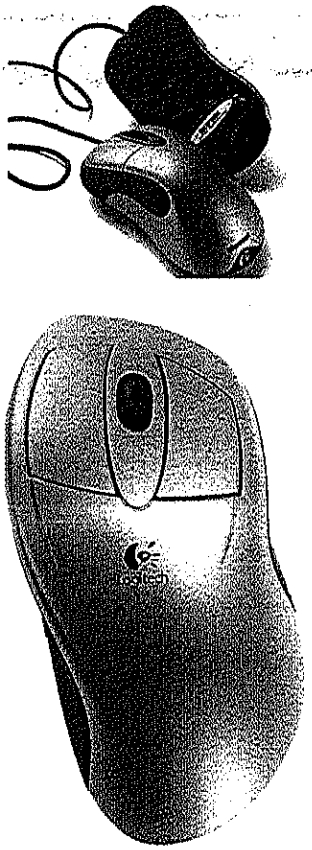
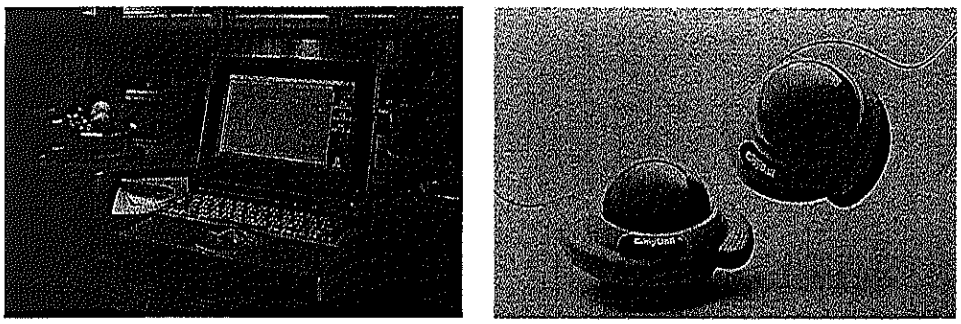


FIGURE 5-3

Mouse.

As the mouse is moved over a smooth surface, the pointer on the computer screen makes a corresponding movement.



(a) (b)

FIGURE 5-4

Trackball.

The rotation of the ball causes a corresponding movement of the pointer on the screen. (a) Trackballs are often used with laptop computers because, especially on an airplane, there may be no handy surface on which to roll a mouse. Notice that the ball is placed in the center, both for compactness and to accommodate both right- and left-handed users. (b) This trackball, which looks rather like an oversized egg, is called EasyBall because it can be grasped and manipulated by a child's small hand.

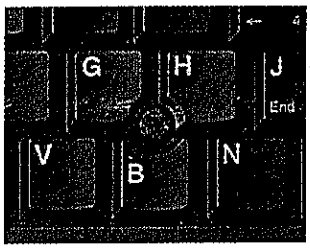


FIGURE 5-5

Pointing stick.

The keyboard uses a pointing stick embedded in its center to move the pointer on the screen.

tal and vertical beams of light that crisscross the screen. When a finger touches the screen, the interrupted light beams can pinpoint the location selected on the screen. Another type of touch screen senses finger pressure to determine the location. A variation of this concept has the user use a **light pen** for pointing. Light pens allow a greater level of precision in pinpointing screen locations. Some light pens require a special monitor; others will work with any monitor.

Kiosks—self-contained self-help stations often found in public places such as malls and supermarkets—offer a variety of services. A kiosk's touch screen is so easy to use that it attracts patrons (Figure 5-8). Wal-Mart, for example, uses kiosks to let customers find items such as auto parts. Many delicatessens use kiosks to let you point to salami on rye, among other selections. But the most widespread use of kiosks is in government offices. They are becoming sufficiently commonplace that people are no longer startled when a pleasant female voice from the kiosk screen says, "If you want to file for divorce, touch here." In fact, kiosks in California, Arizona, and Utah handle uncontested divorces, probates, evictions, small claims, and other legal matters.

PEN-BASED COMPUTING Small handheld computing devices often use an electronic pen, or stylus, to input data. The pen can be used as a pointer on the device's screen or to input data in handwritten form. Software translates the handwriting into characters that the computer can work with (Figure 5-9).

FIGURE 5-6

Joystick.

The joystick is most commonly used for playing action games.

Source Data Automation: Collecting Data Where It Starts

Efficient data input means reducing the number of intermediate steps required between the origination of data and its processing. This is best accomplished by **source data automation**—the use of special equipment to collect data at the source, as a by-product of the activity that generates the data, and send it directly to the computer. Recall, for example, the supermarket bar code, which can be used to send data about the product directly to the computer. Source data automation eliminates keying, thereby reducing costs and opportunities for human-introduced mistakes. Since data about a transaction is collected when and where the transaction takes place, source data automation also improves the speed of the input operation and is much less expensive than other methods.

For convenience this discussion is divided into the primary areas related to source data automation: magnetic-ink character recognition, scanners and other optical recognition devices, and even your own voice, finger, or eye.

Magnetic-Ink Character Recognition

Magnetic-ink character recognition, or **MICR** (pronounced "mike-er"), involves using a machine to read characters made of magnetized particles. The banking

FIGURE 5-7

Graphics tablet.

Architects and engineers often use graphics tablets to enter and make changes to technical drawings.

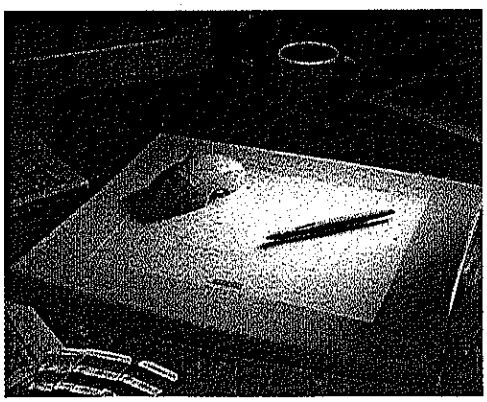


FIGURE 5-8

A Kiosk.

Kiosks use touch screens to provide information and services to the public. Kiosks are found in public places like malls, supermarkets, and banks.

industry is the predominant user of MICR equipment. Banks use the numbers encoded across the bottom of your personal check to route your check from the bank cashing the check to the bank where you have your account. Figure 5-10 shows what some of these numbers and symbols represent.

Most magnetic-ink characters are preprinted on your check. If you compare a check that you wrote that has been cashed and cleared by the bank with one that is still unused in your checkbook, you will note that the amount of the cashed check has been reproduced in magnetic characters in the lower-right corner. These characters were added by a person at the bank where the check was deposited by using a **MICR inscriber.**

Scanner

There was a time when the only way to transfer an existing document into the computer was to retype it. Now, however, an **optical scanner,** usually referred to as just a **scanner,** can convert text or even a drawing or picture into computer-recognizable data by using a form of optical recognition. **Optical recognition** systems use a light beam to scan input data and convert it into electrical signals, which are sent to the computer for processing. Optical recognition is by far the most common type of source input; just think of all those supermarket scanners.

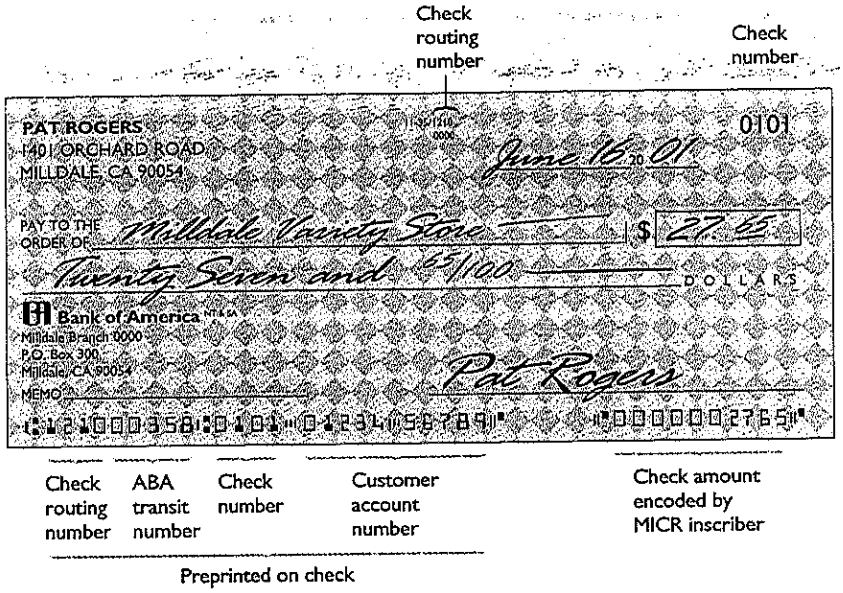
FIGURE 5-9

Electronic Pen.

Small hand-held computers often use an electronic pen, or stylus, to input data. The pen can be used as a pointer on the device's screen or to input data in handwritten form.

FIGURE 5-10

The symbols on your check. Magnetic-ink numbers and symbols run along the bottom of a check. The symbols on the left are preprinted. The MICR characters in the lower-right corner of a cashed check are entered by the bank that receives it; these numbers should correspond to the amount of the check.



Virtual Ads

If you've ever watched a baseball game on television, chances are you've seen a virtual ad—an ad that doesn't exist at the ballpark.

Prior to the event, an operator selects which advertisements to insert and chooses where in the stadium they will appear. During the broadcast, the system then automatically inserts the advertisement into position, correctly adjusted for the position of the television camera. The inserted images appear as if they actually exist in the stadium, even to the extent that players pass in front of—obscure—the inserted image.

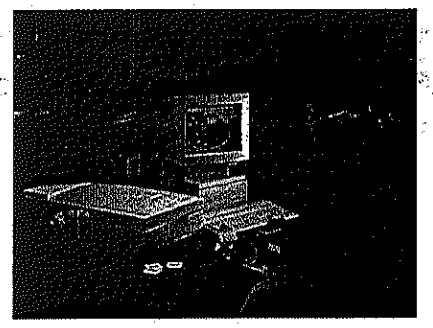
Unlike the usual 30-second television commercial, this ad may loom in front of a viewer for much of the game. Furthermore, advertisers can target local audiences, showing an ad for hot soup in Juneau while, in the same spot, showing an ad for cold soda in San Diego.

Now consider all those drawers filled with receipts, warranties, and old checks. If you would let the computer take care of them, you could save space and, even better, be able to find an item when you wanted it. Large businesses often use a process called **document imaging,** in which a scanner converts all incoming paper documents (invoices, order forms, etc.) to an electronic version, which can then be stored on disk, routed to the proper people, and retrieved when needed. But most consumers use a scanner to turn snapshots into images that can be printed, incorporated into a craft project, e-mailed, or posted on their Web site. Another popular use is converting printed documents, perhaps a letter or magazine article, into text that can be edited—changed or revised—by word processing software.

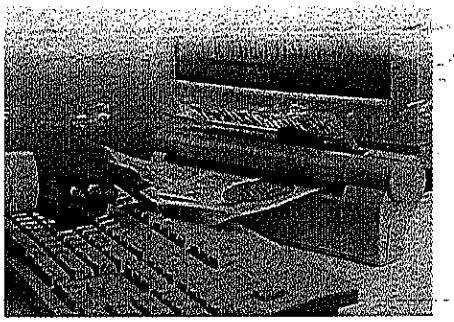
Business people also find imaging useful, since they can view an exact computer-produced replica of the original document at any time. Processed by related software, the words and numbers of the document can be manipulated by word processing and other software. The Internal Revenue Service uses imaging to process 17,000 tax returns per hour, a significant improvement over hand processing.

Optical scanners fall into three categories. A **flatbed scanner** typically scans one sheet at a time, though some offer an attachment for scanning multiple sheets. Flatbed scanners are space hogs, taking up about as much room as a tabletop copy machine (Figure 5-11a). The advantage of a flatbed scanner is that it can be used to scan bound documents, such as pages from books and other bulky items. In a **sheetfed scanner,** motorized rollers feed the sheet across the scanning head. A key attraction of sheetfed scanners is that they are usually designed to fit neatly between the keyboard and the monitor (Figure 5-11b). However, sheetfed scanners are less versatile than flatbed scanners and are more prone to errors. A **handheld scanner,** the least expensive and least accurate of the three, is a handy portable option. It is often difficult to get a good scan with a handheld scanner because the user must move the scanner in a straight line at a fixed rate. If the document being scanned is wider than the scanner, several passes must be made, and software must "stitch" the images together, a tedious and error-prone process.

Many users like scanners because they can use them to scan photographs directly into the computer. However, if you want to scan text and then be able to edit it using word processing, another step is involved. Since the result of a scan is simply a picture of the document being scanned, special software—usually called **OCR** software, for **optical character recognition**—must analyze the picture and convert it into characters. Most scanners come accompanied by OCR software.



(a)



(b)

FIGURE 5-11

Scanners.

Once an image has been scanned into the computer, it can be stored and used again, perhaps in a document that combines text with photos. (a) With a flatbed scanner, the image to be scanned is laid face down on the scanner, which looks something like a small copy machine. (b) Paper can be fed to the motorized rollers of a sheetfed scanner, which has the added advantage of fitting nicely between keyboard and monitor.

More Optical Recognition Methods

In addition to text and images, optical recognition can process data appearing in a variety of forms: optical marks, optical characters, bar codes, and even handwritten characters.

OPTICAL MARK RECOGNITION **Optical mark recognition (OMR)** is sometimes called **mark sensing** because a machine senses marks on a piece of paper. As a student, you may immediately recognize this approach as the technique used to score certain tests. Using a pencil, you make a mark in a specified box, circle, or space that corresponds to what you think is the answer. The answer sheet is then graded by an optical device that recognizes the locations of the marks and converts them to computer-recognizable electrical signals.

OPTICAL CHARACTER RECOGNITION **Optical character recognition (OCR)** devices also use a light source to read special characters and convert them into electrical signals to be sent to the central processing unit. The characters—letters, numbers, and special symbols—can be read by both humans and machines. They are often found on sales tags on store merchandise. A standard typeface for optical characters, called **OCR-A,** has been established by the American National Standards Institute (Figure 5-12).The handheld **wand reader** is a popular input device for reading OCR-A. Wands are being used more and more in libraries, hospitals, and factories, as well as in retail stores.

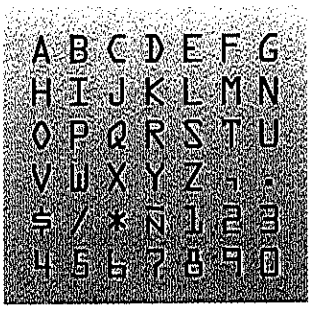
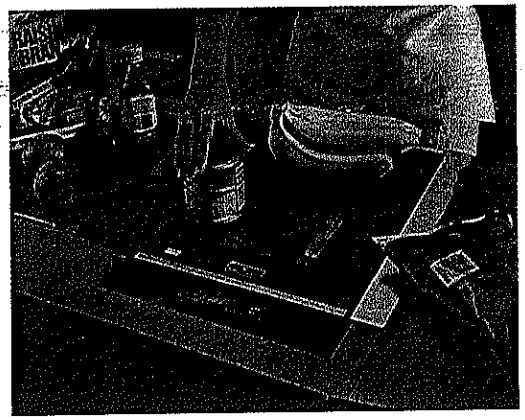


FIGURE 5-12

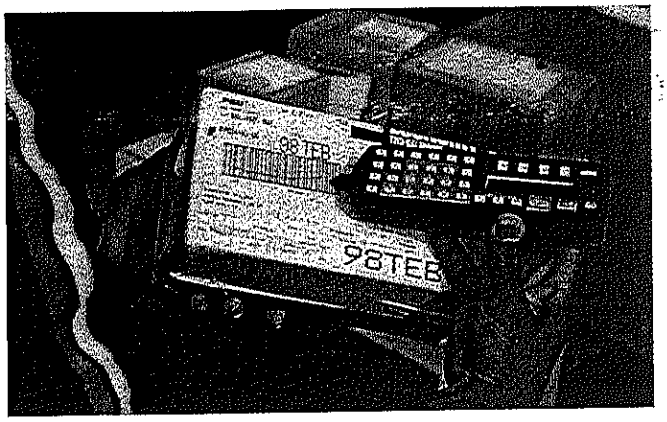
The OCR-A typeface.

This is a common typeface for optical character recognition.

BAR CODES Each product on the store shelf has its own unique number, which is part of the **Universal Product Code (UPC).** This code number is represented on the product label by a pattern of vertical marks, or bars, called **bar codes.** (UPC, by the way, is an agreed-on standard within the supermarket industry; many other kinds of bar codes exist. You need only look as far as the back cover of this book to see an example of another kind of bar code.) These stripes can be sensed and read by a **bar-code reader,** a photoelectric device that reads the code by means of reflected light. When you buy, say, a can of corn at the supermarket, the checker moves it past the bar-code reader (Figure 5-13a). The bar code merely identifies the product to the store's computer; the code does not contain the price, which may vary. The price is stored in a file that can be accessed by the computer. (Obviously, it is easier to change the price in the computer than it is to restamp the price on each can of corn.)



(a)



(b)

FIGURE 5-13

Bar codes.

(a) This photoelectric bar code scanner, often seen at supermarket checkout counters, reads the product's zebra-striped bar code. The bar code identifies the product for the store's computer, which retrieves price and description information. The price is then automatically rung up on the point-of-sale terminal. (b) FedEx uses a bar code system to identify and track packages in transit.

The computer returns the price; then a printer prints the item description and price on a paper tape for the customer. Some supermarkets are moving to do-it-yourself scanning, putting the bar-code reader—as well as the bagging—in the customer's hands.

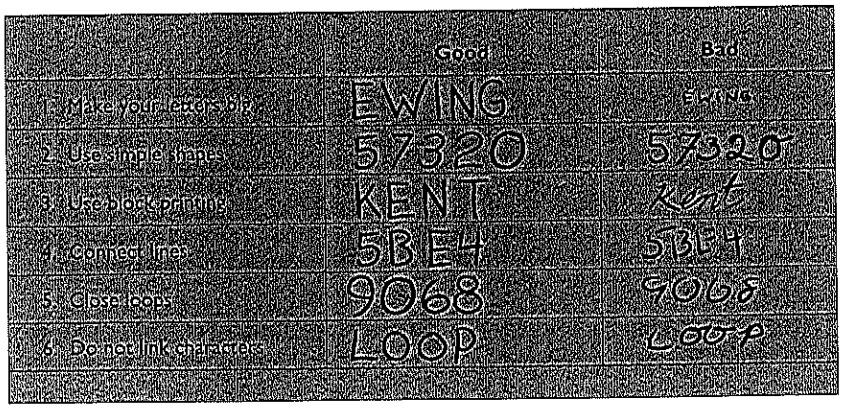
Although bar codes were once found primarily in supermarkets, there are a variety of other interesting applications. Bar coding has been described as an inexpensive and remarkably reliable way to get data into a computer. It is no wonder that virtually every industry has found a niche for bar codes. Federal Express, for example, attributes a large part of the corporation's success to the bar-coding system it uses to track packages (Figure 5-13b). Each package is uniquely identified by a 10-digit bar code, which is input to the computer at each point as the package travels through the system. An employee can use a computer terminal to query the location of a given shipment at any time; the sender can request a status report on a package or track the package on the FedEx Web site.

HANDWRITTEN CHARACTERS Machines that can read handwritten characters are yet another means of reducing the number of intermediate steps between capturing data and processing it. In many instances it is preferable to write the data and imme-

FIGURE 5-14

Handwritten characters.

Legibility is important in making handwritten characters readable by optical recognition systems.



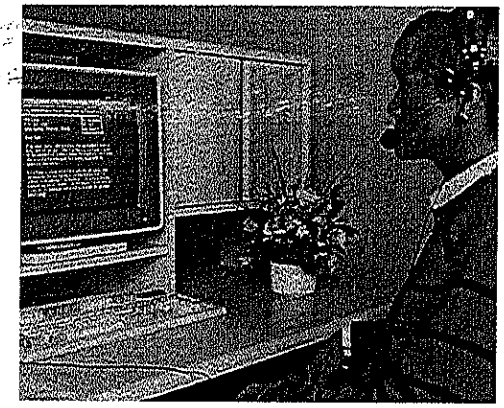


FIGURE 5-15

How voice input works.

The user speaks into a microphone or telephone. A chip on a board inside the computer analyzes the waveform of the word and changes it to binary numbers that the computer can understand. These digits are compared with the numbers in a stored vocabulary list; if a match is found, the corresponding word is displayed on the screen.

diately have it usable for processing rather than having data entry operators key it in later. However, not just any scrawl will do; the rules governing the size, completeness, and legibility of the handwriting are fairly rigid (Figure 5-14).

Voice Input

Speaking to a computer, known as **voice input** or **speech recognition,** is another form of source input. **Speech recognition devices** accept the spoken word through a microphone and convert it into binary code (0s and 1s) that can be understood by the computer (Figure 5-15). Typical users are the disabled, those with "busy hands" or hands too dirty for the keyboard, and those with no access to a keyboard. Uses for speech recognition include changing radio frequencies in airplane cockpits, placing a call on a car phone, asking for stock-market quotations over the phone, inspecting items moving along an assembly line, and allowing physically disabled users to issue commands (Figure 5-16).

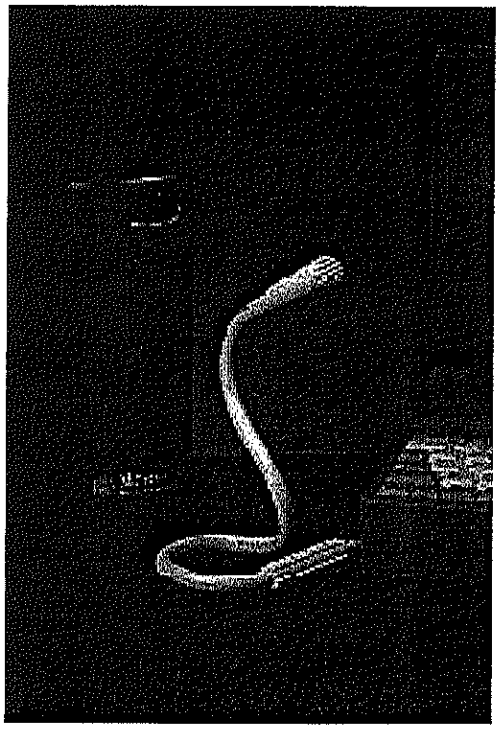
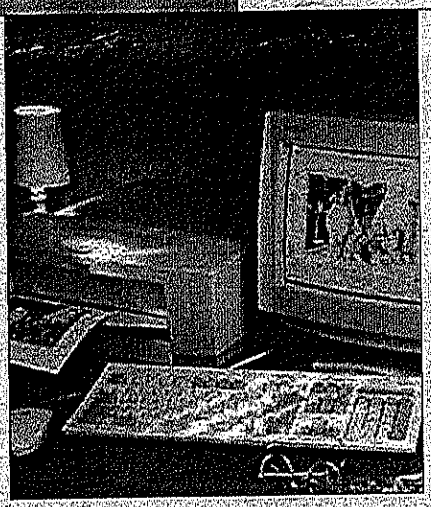


FIGURE 5-16

Microphone.

This twistable—and inexpensive—microphone is an input device for speech recognition.

GETTING PRACTICAL Digital Darkroom



Never mind the traditional darkroom, where a photo buff squints in dim red light while sloshing photos through smelly development chemicals. And, frankly, the results of all that sloshing, especially enlargements, probably would not be confused with professional work. But now that has changed. With the right computer equipment, you can be a professional—or close enough. You can make prints and enlargements that could not be differentiated from professional work without the aid of a magnifying glass.

First, let us consider the source of your pictures. How does one get the photos into the computer in the first place? There are several possibilities. A straightforward approach is to use a digital camera, storing the pictures in some computer-readable form—chip or card or disk—and transferring the images directly to the computer. If your photos were recorded on the camera's embedded chip, they can be transferred by means of a cable hooked up to your computer's serial port or USB port, a plug-like input in the back. Another choice is to scan photos into the computer; a good-quality scanner will maintain the quality of the photos.

Another possible photo-source is the Internet, which offers free images, some as part of clip-art collections. Keep in mind, however, that professional photos on Internet sites are probably fee-based. Therefore if your interest goes beyond casual snapshots, you can pay for and download images from professional services on the Internet. Whatever method you choose to input photos, the net result is that you then can edit and reproduce those photos.

Once you have the photos in digital form, you will probably want to use some photo-imaging software to manipulate them. Such software is an option rather than a necessity, but many people find that they like to improve or change their pictures in some way. However, despite a bit of photo manipulation by software, the printed photo image you hope for can be only as good as the image the program is given to work with.

Processing photographs at home is a trend in progress. People love to take pictures. People also love enlargements. Yet, mostly because of the high cost, only a tiny percentage of photos are enlarged. Home computer photography systems offer a new level of flexibility and creativity, enabling users to make professional-looking prints, reprints, and enlargements of photos that can be incorporated into personalized greeting cards, calendars, and postcards.

Most speech recognition systems are speaker-dependent—that is, they must be separately trained for each individual user. The speech recognition system "learns" the voice of the user, who speaks isolated words repeatedly. The voiced words the system "knows" are then recognizable in the future. Speaker-independent speech recognition systems are designed to recognize anyone's voice, but have a much more limited vocabulary.

Speech recognition systems that are limited to isolated words are called **discrete word systems,** and users must pause between words. These systems are very accurate and are often used to allow users to issue brief commands to the computer. However, they are very tedious and awkward to use for inputting large amounts of text, as in dictation. The technology for **continuous word systems,** which can interpret sustained speech so that users can speak almost normally, has improved dramatically in the last few years. A key advantage of delivering input to a computer in a normal speaking pattern is ease of use. It is faster and easier for most people to dic-

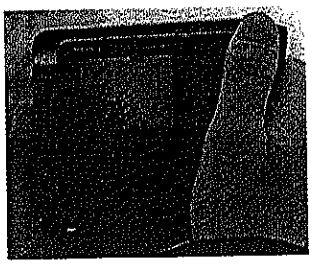


FIGURE 5-17

Digital camera.

Digital cameras do not use film. They store images internally and then send them via cable or disk to your computer.

FOCUS ON ETHICS **Web Cams**

Web cams (videocameras attached to computers that transmit images across the Internet every few seconds) have become very popular. They are featured on sites offering live or digitally recorded scenes of nature, buildings, vending machines, animals, people, and almost everything else. The widespread use of this technology poses some interesting ethical questions.

What do you think your rights should be if a Web cam captures your image? Should the Web cam operator have to inform you that your image has been taken? What locations, if any, should be off-limits to Web cams? Should there be different standards for public property, such as beaches, versus private property, such as shopping malls? Should your rights be any different if images in which you appear are resold?

This is an emerging area of the law. Research what legal rights and limitations may exist on the public use of Web cams in your city and state.

tate a letter than to key it in. Soon, most new personal computers will be equipped with speech recognition.

Although speech recognition has made great strides, the computer still has extreme difficulty in understanding the meaning of the words that are recognized. Teaching the computer to understand normal human speech is one of the major challenges facing computer scientists.

Digital Cameras

Point, shoot, edit, print; the steps that are noticeably missing are loading film and, later, trips to the photo-processing lab. A **digital camera** takes photos that it stores internally on a chip; there is no film (Figure 5-17). The photos can then be sent by cable directly to your computer; some cameras place the image on a removable card that can be added to an adapter and inserted into the computer's disk drive. Some cameras record images directly onto a diskette. Once in the computer, the photos can be edited with the software that accompanied the camera. When you are satisfied with a photo, you can print it. Photos printed on your everyday printer will not rival film-based images, but you may buy a special printer designed for photos that uses heavyweight coated paper and produces good results.

A particular advantage of digital cameras is their little LCD windows that let you see the photo you just took. If you do not like it, simply delete it and try again.

OUTPUT: INFORMATION FOR THE USER

As we noted earlier, computer output usually takes the form of screen or printer output. Other forms of output include voice, sound, and various forms of graphics output. Devices have even been designed to produce odors as computer output.

A computer system may be designed to produce several kinds of output. An example is a travel agency's computer system. If a customer asks about airline connections to, say, Toronto, Calgary, and Vancouver, the travel agent will probably make a few queries to the system and receive on-screen output indicating availability and pricing for the various flights. After the reservations have been confirmed, the agent can ask for printed output that includes the tickets, the traveler's itinerary, and the invoice. In addition, the agency's management may periodically receive printed reports and charts, such as monthly summaries of sales figures or pie charts of regional costs.

Computer Screen Technology

A user's first interaction with a computer screen may be to view the screen response to that user's input. When data is entered, it appears on the screen. The computer

response to that data—the output—also appears on the screen. The screen is part of the computer's **monitor,** which also includes the housing for its electrical components. Monitors usually include a stand that can be tilted or swiveled to allow the monitor to be easily adjusted to suit the user.

Screen output is known in the computer industry as **soft copy** because it is intangible and temporary, unlike **hard copy,** which is produced by a printer on paper, is tangible, and can be permanent.

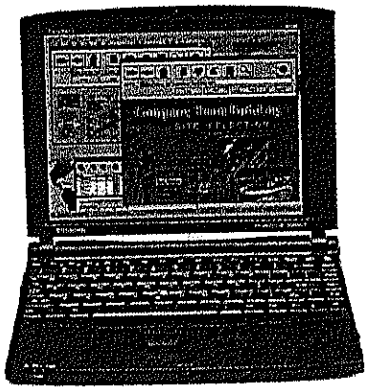
Computer screens come in many varieties (Figure 5-18), but the most common kind is the **cathode ray tube (CRT).** CRT monitors that display text and graphics are in common use today. Although most CRTs are color, some are **monochrome,** meaning that only one color, usually green or amber, appears on a contrasting background. Monochrome screens, which are less expensive than those with color, are used in business applications such as customer inquiry or order entry, which have no need for color.

Most CRT screens use a technology called **raster scanning,** a process of sweeping electron beams across the back of the screen. The backing of the screen display has a phosphorous coating that glows whenever it is hit by a beam of electrons. But the phosphorus does not glow for very long, so the image must be **refreshed** often. If the screen is not refreshed often enough, the fading screen image appears to flicker. A **scan rate**—the number of times the electron beam refreshes the screen—of 80 to 100 times per second is usually adequate to retain a clear screen image. This is essentially the same process used to produce television images.

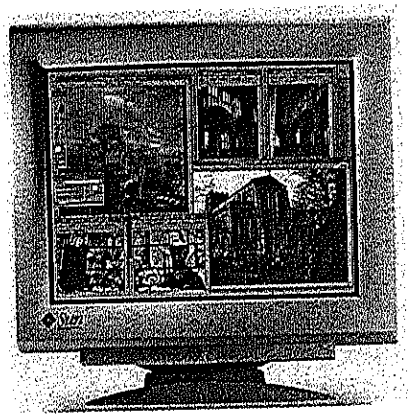
A CRT display has hundreds of horizontal lines, which are scanned from left to right and from top to bottom. On inexpensive monitors the screen is sometimes scanned in **interlaced** fashion: the odd-numbered lines on one pass of the electron beam and then the even-numbered lines on the next pass. This allows for a lower refresh rate without producing flicker. With text and fixed graphics displays, this scheme can work well. However, with animated graphics—especially images that move or change form rapidly—interlacing can produce an irritating flutter effect. Thus most screens today are advertised as **noninterlaced (NI),** that is, all lines are scanned on each pass.

A computer display screen that can be used for graphics is divided into dots that are called **addressable** because they can be addressed individually by the graphics software. Each dot can be illuminated individually on the screen. Each dot is referred to as a *pic*ture *el*ement, or **pixel.** The resolution of the screen—its clarity—is directly related to the number of pixels on the screen: The more pixels, the higher the resolution. Another factor of importance is **dot pitch,** the amount of space between the dots. The smaller the dot pitch, the better the quality of the screen image.

The electrical output signals that the control unit sends to the monitor have to be converted into the signals that control the monitor. This can be accomplished by



(a)



(b)

FIGURE 5-18

A variety of screens.

(a) Laptop computers, once limited to monochrome screens, now usually have color screens. (b) This high-resolution brilliance is available only on a color graphics display.

chips permanently affixed to the motherboard, but most computers have a **graphics card,** or **graphics adapter board,** plugged into an expansion slot. This approach allows the user to upgrade the graphics capability if desired. The graphics card and the monitor must be compatible to produce a high-quality image.

Graphic standards were established in the early years of the personal computer. The intention of standards is to agree on resolutions, colors, and so forth, to make it easier for the manufacturers of personal computers, monitors, graphics boards, and software to ensure that their products work together.

The standards in most common use today are SVGA and XGA. There are several varieties of **SVGA (Super Video Graphics Adapter),** each providing a different resolution: 800 (horizontal) × 600 (vertical) pixels, 1024 × 768, 1280 × 1024, and 1600 × 1200. All SVGA standards support a palette of 16 million colors, but the number of colors that can be displayed simultaneously is limited by the amount of video memory installed in a system. One SVGA system might display only 256 simultaneous colors while another displays the entire palette of 16 million colors.

XGA (extended graphics array) is a high-resolution graphics standard designed to replace older standards. It provides the same resolutions but supports more simultaneous colors. In addition, XGA allows monitors to be noninterlaced.

Is bigger really better? Screen sizes are measured diagonally. However, unlike television screens, computer screen size is not regulated. Manufacturers sometimes fudge a bit. When making comparisons, a user would do well to bring a ruler. A typical office worker who handles light word processing and spreadsheet duties will probably find a 15- or 17-inch screen adequate. A user who is involved with high-powered graphics will probably want a 19-inch screen. At the high end, screens can be purchased that are as large as television sets, 21 inches and up.

To answer the question, yes, bigger is usually better, but it is also more expensive and takes up more space on your desk. For your own personal computer, once you try a larger screen you will not want to go back. In addition to the reduced strain on the eyes, it is particularly useful for Web pages, page layout, graphics, and large photos and illustrations.

Flat-Panel Screens

Another type of screen technology is the **liquid crystal display (LCD),** a flat-panel display often seen on watches and calculators. LCD screens are commonly used on laptop computers. But flat-panel screens are getting bigger and are making their way to desktop computers (Figure 5-19). Although traditional CRT monitors get deeper as they get wider, flat-panel monitors maintain their depth—a superskinny few inches—regardless of screen size. LCD monitors can use one of two basic technologies—**active-matrix,** based on **TFT** (thin-film transistor technology), and **passive-matrix.** Passive-matrix technology uses fewer transistors and therefore is cheaper and uses less power, but TFT displays produce a brighter image and can be viewed from wider angles.

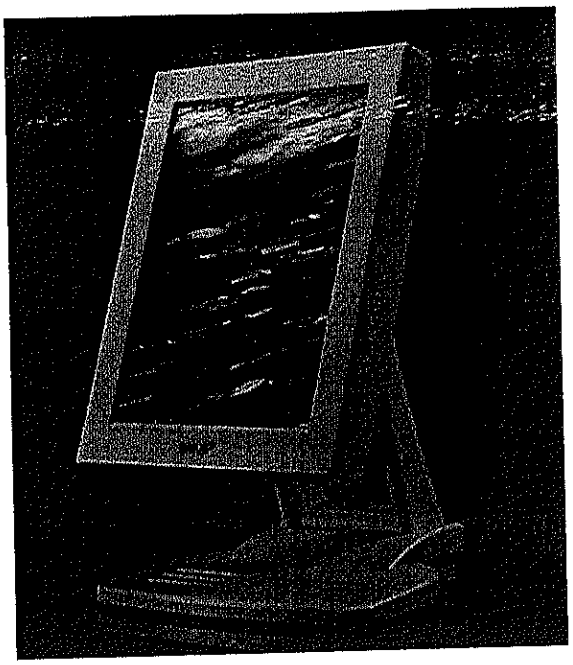
Flat-panel screens are wonderful to look at, with crisp, brilliant images. They are also easy on the eyes; they do not flicker but just brightly shine on. The full dimension of a flat-panel screen is usable, so a 15-inch flat-panel monitor has a viewing area nearly as large as that of a 17-inch CRT monitor. Although prices of flat-panel screens are coming down, they are still quite a bit higher than prices for equivalent-sized CRT monitors.

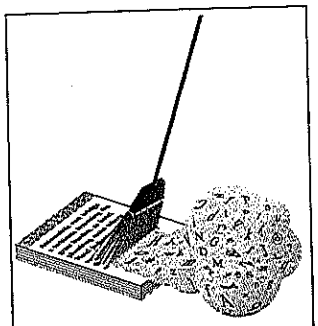
Printers

A **printer** is a device that produces information on paper output. Some older printers produce only letters and numbers, but most printers used with personal computers today can also produce information in graphic form. Most printers have two **orientation** settings: portrait and landscape mode. The default setting is **portrait mode,** in

FIGURE 5-19

Flat panel desktop monitor.
Flat panel screens are slim and present bright images.





Disappearing Act
It looks just like a copy machine. But unlike a copier, it does not add to the glut of paper in the office. In fact, it subtracts. The Decopier removes text and other detritus from the sheets of used paper that are fed to it.

The machine applies a nontoxic chemical at low heat to a sheet of printed paper to loosen up the toner and ink, then sweeps away the flakes. The paper emerges at the other end spanking new—or, at least, recycled.

which output, such as a memo, is printed in a vertical alignment, that is, with the longest dimension up and down. **Landscape mode** prints output "sideways," or horizontally, with the longest dimension across the width of the paper; this is especially useful for spreadsheets that have a lot of data across the sheet. Graphics images may be more suited for printing in one mode over another.

There are two ways of printing an image on paper: the impact method and the nonimpact method. An **impact printer** uses some sort of physical contact with the paper to produce an image, physically striking paper, ribbon, and print hammer together. Mainframe users who are more concerned about high volume than high quality usually use **line printers**—impact printers that print an entire line at a time. These users are likely to print lengthy reports, perhaps relating to payroll or costs, for internal use. Impact printers are needed when multiple copies of a report are printed; the impact carries the output through to the lower copies. Personal computer users who need to print multi-part forms can use **dot-matrix printers,** which have a print head consisting of one or more columns of pins. These pins form characters and images as a pattern of dots produced by the pins striking the ribbon against the paper as the print head moves back and forth across the paper. Dot-matrix printers used to be the primary type of printer found on microcomputer systems, but they have largely been replaced by ink-jet and laser printers.

A **nonimpact printer** places an image on a page without physically touching the page. The major technologies competing in the nonimpact market are laser and ink-jet, the two kinds of printers that you will find in your local computer store. **Laser printers** use a light beam to help transfer images to paper (Figure 5-20). Today's laser printers print 600 or 1200 **dots per inch (dpi),** producing extremely high-quality results. Laser printers print a page at a time at impressive speeds, using technology similar to that of a photocopier. Printing speeds of personal laser printers are generally around 8 to 10 **pages per minute (ppm),** while network laser printers are capable of between 35 and 50 ppm. Large organizations such as banks and insurance companies use expensive, high-volume laser printers that can produce reports at up to 1000 ppm. Low-end black-and-white laser printers for use with personal computers can now be purchased for a few hundred dollars. Color laser printers are more expensive.

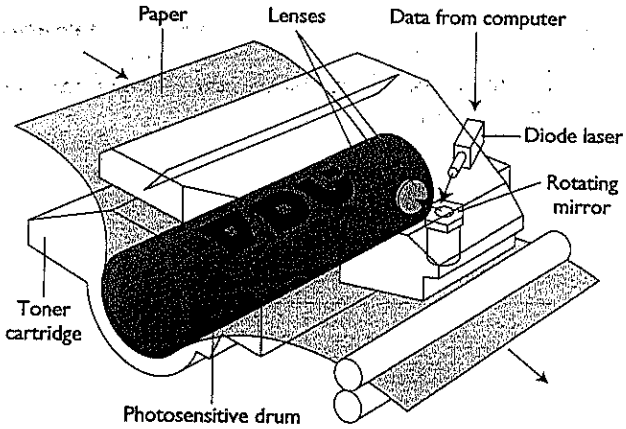


FIGURE 5-20

Laser printers.
A laser printer works like a photocopy machine. Using patterns of small dots, a laser beam conveys information from the computer to a positively charged drum inside the laser printer. Wherever an image is to be printed, the laser beam is turned on, causing the drum to become neutralized. As the drum passes by a toner cartridge, toner sticks to the neutral spots on the drum. The toner is then transferred from the drum to a piece of paper. In the final printing step, heat and pressure fuse the toner to the paper. The drum is then cleaned for the next pass.

Ink-jet printers, which spray ink from multiple jet nozzles, can print in both black and white and several different colors of ink to produce excellent graphics (Figure 5-21). However, the print quality of an ink-jet printer, though more than adequate, usually will not match that of a laser printer. Nor will the printing be as speedy. Furthermore, ink-jet printers need a fairly high quality of paper so that the ink does not smear or bleed. Nevertheless, low-end ink-jet printers, which cost a little more than a hundred dollars, are a bargain for users who want color output capability.

If you choose a color printer, whether ink-jet or laser, you will find that its colors are not perfect. The color you see on your computer screen is not necessarily the exact color you will see on the printed output. Nor is it likely to be the color you would see on a professional four-color offset printing press.

Choosing between a laser printer and an ink-jet printer comes down to a few factors. If printing speed is important to you or if the quality of the printed text is a top priority, you probably want a black-and-white laser printer. If you cannot resist the prospect of color and are not overly concerned about text quality or speed, an ink-jet may be your best choice. If you want it all, color laser printers are available, but in a higher price range.

Voice Output

We have already examined voice input in some detail. As you will see in this section, computers are frequently like people in the sense that they find it easier to talk than to listen. **Speech synthesis**—the process of enabling machines to talk to people—is much easier than speech recognition. "The key is in the ignition," your car says to you as you open the car door to get out. Machine voices are the product of **voice synthesizers** (also called **voice-output devices** or **audio-response units),** which convert data in main storage to vocalized sounds understandable to humans.

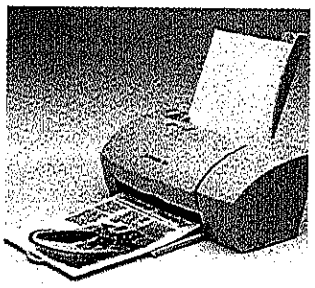
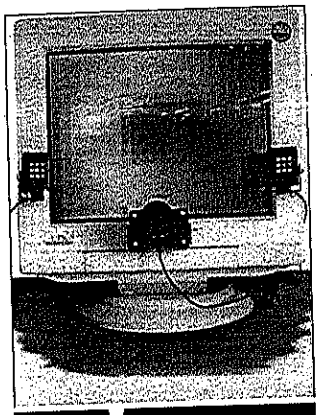


FIGURE 5-21

Ink-jet printers.
A color ink-jet printer is an affordable and popular addition to many computer systems.



The Eyes Have It
The computer can be a godsend for many people who have physical limitations. Various input devices have been developed to assist people with varying degrees of limitations. But what about the totally paralyzed, who lack the ability to do almost anything other than move their eyes? A system called the Eye Science Gaze Tracker allows users to perform mouse functions with their eyes. Two low-powered infrared LEDs mounted on the monitor illuminate the user's eye. The reflections from the eye are detected by a digital camera, which is also mounted on the monitor. By analyzing the image from the camera, software can determine where on the screen the user is looking and move the screen pointer accordingly. Mouse clicks can be simulated by slow eye blinks or by allowing the gaze to linger for a time on one location. No hardware has to be attached to the user, a big advantage over previous systems that required affixing electrodes to the eye muscles. The Gaze Tracker will even work with eyeglasses, though contact lenses can confuse it.

There are two basic approaches to getting a computer to talk. The first is **synthesis by analysis,** in which the device analyzes the input of an actual human voice speaking words, stores and processes the spoken sounds, and reproduces them as needed. The second approach to synthesizing speech is **synthesis by rule,** in which the device applies a complex set of linguistic rules to create artificial speech. Synthesis based on the human voice has the advantage of sounding more natural, but it is limited to the number of words stored in the computer.

Voice output has become common in such places as airline and bus terminals, banks, brokerage houses, and even some automobiles. It is typically used when an inquiry is followed by a short reply, such as a bank balance or flight time. Many businesses have found other creative uses for voice output over the telephone. Automatic telephone voices take surveys, inform customers that catalog orders are ready to be picked up, and perhaps remind consumers that they have not paid their bills.

Music Output and Other Sounds

In the past personal computer users occasionally sent primitive musical messages, feeble tones that wheezed from the computer's tiny internal speaker. Today's personal computers can be equipped with speakers placed on either side of the computer or, in some cases, mounted on the sides of the monitor or buried in the computer housing. Users want good-quality sound from certain kinds of software, especially the sophisticated offerings called *multimedia,* which include multiple sight and sound effects. Even the zap-and-crash sounds of action games deserve to be heard. To enhance the listening experience further, manufacturers are now producing sound cards containing sophisticated audio chips that, by varying the frequencies and timing of the sound waves as they reach the human ear, can fool the brain into thinking that it is hearing three-dimensional sound from two speakers.

MIDI (Musical Instrument Digital Interface), pronounced "mid-ee," is a set of rules designed for connecting devices that produce and process digital music signals. Devices that conform to the MIDI standard can communicate with each other and with a computer containing a MIDI interface. In much the same way that two computers communicate via modems, two musical devices can communicate via MIDI. The information exchanged between two MIDI devices is musical in nature. MIDI information tells a synthesizer, in its most basic mode, when to start and stop playing a specific note. Other information that is shared may include the volume and modulation of the note. A number of software programs are available for composing and editing music that conforms to the MIDI standard. They offer a variety of functions: For instance, when you play a tune on a keyboard connected to a computer, a music program can translate what you play into a written score. MIDI is supported by many makes of personal computer sound cards.

TERMINALS: COMBINING INPUT AND OUTPUT

A **terminal** is a device (or combination of devices) that combines both input and output capabilities. The simplest type of terminal, known as a **dumb terminal** because it has no processing capability, consists of a keyboard for input and a monitor for output and connects directly to a host computer. Everything that is typed into the keyboard is sent to the host for processing, which sends results back to the terminal screen to be displayed. An **intelligent terminal** combines a keyboard and monitor with memory and a processor, giving it the ability to perform limited processing functions. For example, an intelligent terminal could display an input form on the screen,

accept user input through the keyboard, perform editing and error-checking functions on the data (requesting reentry if necessary) and then send the entire set of data to the host computer for processing. When the results are sent back, the terminal could format and display those results on the screen.

A **point-of-sale (POS) terminal** is a combination of input and output devices designed to capture retail sales data at the point where the transaction takes place. The most familiar POS terminal is the supermarket checkout station. The primary input device is the bar code reader built into the counter. For items with no bar code, such as loose produce, the cashier can use a keyboard to enter the data. Checkout stations may also include a digital scale to weigh items sold by weight and a magnetic stripe reader to read credit card information. For output the station includes both a small screen display and a printer that prints the customer receipt. Another common POS terminal in retail stores uses a wand reader to read the merchandise code from the product tag and transmits it to the computer, which retrieves a description (and possibly the price, if it is not on the tag) of the item. A small printer produces a customer receipt that shows the item description and price. The computer calculates the subtotal, the sales tax (if any), and the total. This information is displayed on the screen and printed on the receipt.

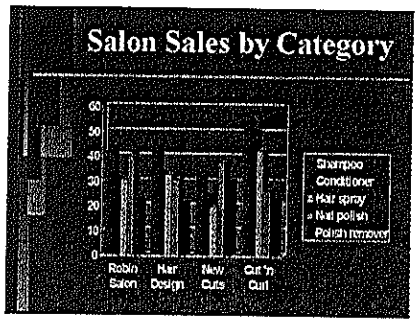
The raw purchase data captured by the POS terminal becomes valuable information when it is summarized by the computer system. This information can be used by the accounting department to keep track of how much money is taken in each day, by buyers to determine what merchandise should be reordered, and by the marketing department to analyze the effectiveness of its ad campaigns.

COMPUTER GRAPHICS

Now for everyone's favorite: computer graphics. You have probably seen the lines and charts of business graphics (Figure 5-22). Just about everyone has seen TV commercials or movies that use computer-produced animated graphics. Computer graphics can also be useful in education, science, sports, computer art, and more. But their most prevalent use today is still in business.

Business Graphics

Graphics can be a powerful way to impart information. Colorful graphics, maps, and charts can help managers compare data more easily, spot trends, and make decisions more quickly. Also, the use of color helps people get the picture—literally. Although color graphs and charts have been used in business for years, usually to make presentations to upper management or outside clients, the computer allows them to be rendered quickly, before information becomes outdated. Also, as the underlying data changes, the graphs and charts can be updated instantaneously. One user refers to business graphics as "computer-assisted insight." Business graphics will be discussed in more detail in Chapter 13.



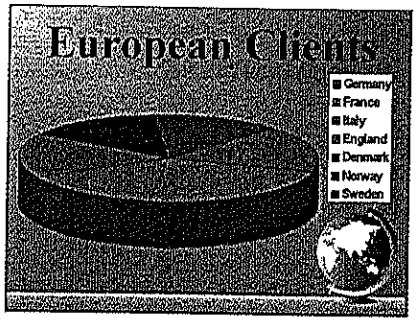


FIGURE 5-22

Business graphics.

These charts were made with powerful but easy-to-use graphics software.

Video Graphics

Video graphics can be as creative as an animated cartoon. Although they operate on the same principle as a moving picture or cartoon—one frame at a time in quick succession—**video graphics** are produced by computers. Video graphics have made their biggest splash on television, but many people do not realize that they are watching a computer at work. The next time you watch television, skip the trip to the kitchen and pay special attention to the commercials. If there is no live human in the advertisement (and perhaps even if there is), the moving objects you see, such as floating cars and bobbing electric razors, are doubtlessly computer output. Another fertile ground for video graphics is a television network's logo and theme. Accompanied by music and swooshing sounds, the network symbol spins and cavorts and turns itself inside out, all with the finesse that only a computer could supply.

Video graphics are well known to people who like to play arcade games; their input device is the joystick, which allows fingertip control of figures on the screen.

Computer-Aided Design/Computer-Aided Manufacturing

Computer graphics have become part and parcel of a field known by the abbreviation **CAD/CAM,** short for **computer-aided design/computer-aided manufacturing.** On the CAD side, computer software is used to create two- and three-dimensional designs of everything from hand tools to tractors to highway designs. Once the design is complete, additional software can perform various engineering tests, such as stress tests and performance analyses. The design data can then be passed to CAM systems, which use computers to control production equipment.

CAD/CAM provides a bridge between design (planning what a product will be) and manufacturing (actually making the planned product). As a manager at DaimlerChrysler said, "Many companies have design data and manufacturing data, and the two are never the same. At Chrysler, we have only one set of data that everyone dips into." Keeping data in one place, of course, makes changes easier and encourages consistency.

Computer-integrated manufacturing (CIM) integrates CAD/CAM and the entire manufacturing process. Production planning, scheduling, materials management, and production control are automated under computer control, providing a balanced, efficient production process.

ETHICS AND DATA

Few people pause to ponder the relationship between ethics and data, but it is an important one. Once the data is in the computer, there are many ways in which it can be used, sold, or even altered. Data can also be input and stored in a great variety of ways. Consider these data ethics issues, all of which are at least debatable and most of which could be defensible in some situations:

- Is it ethically acceptable to use a computer to alter photographs? Is it ethical to substitute one person for another in a photograph? Should we be able to change pictures of ourselves? Of group photos from school or work? Is it ethical to use a computer to add a celebrity to a photo? Does it matter whether the celebrity is alive or dead?
- Suppose you perceive that the contents of certain e-mail messages may be of interest to a plaintiff who is suing your company. Is it ethical to erase the messages?

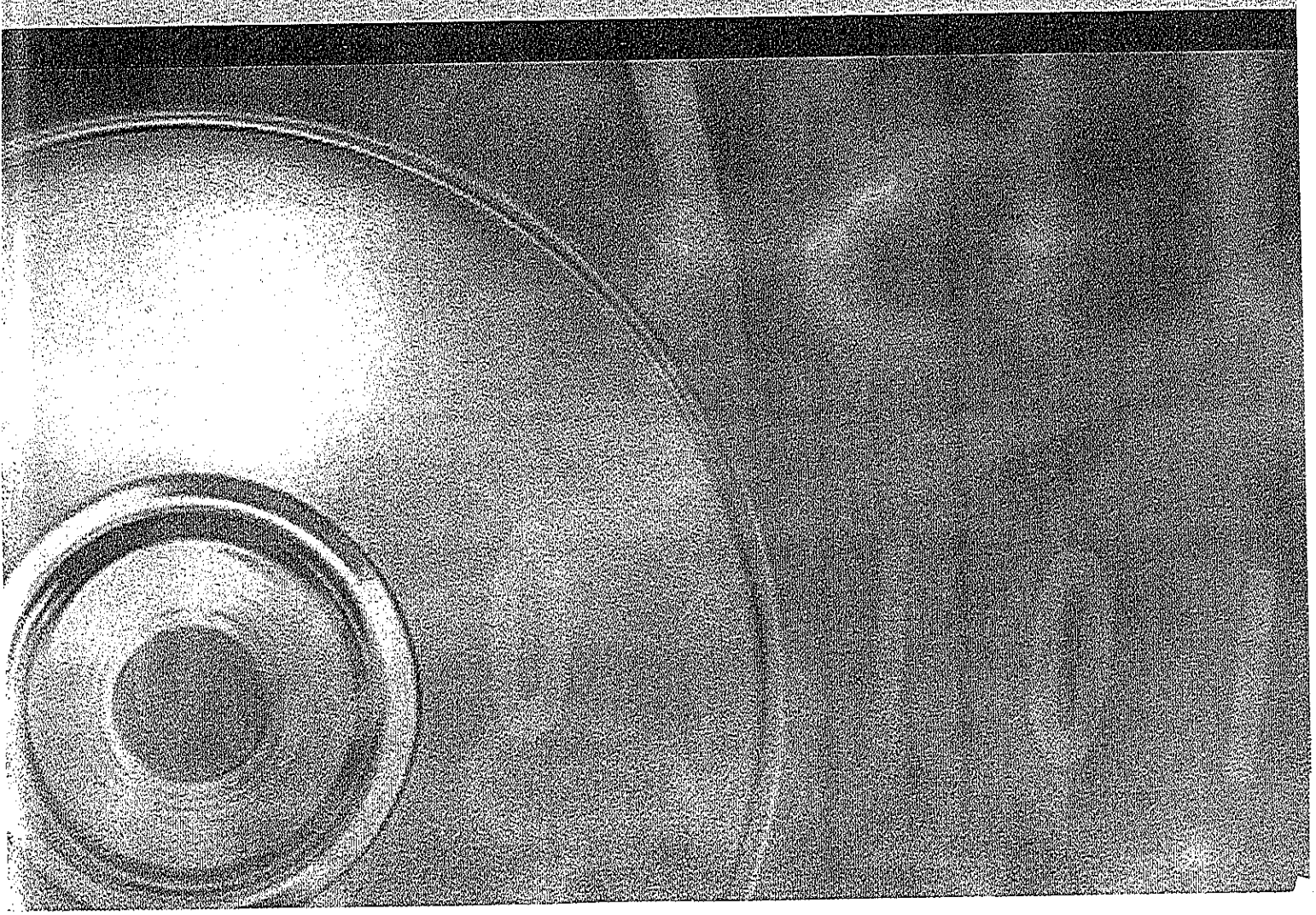
- A friend who has worked on a political campaign has a disk file of donors. Is it ethical to use that same list to solicit for your candidate?

Note that not all of these scenarios inherently require a computer. But the computer makes it that much easier.

▲

New forms of computer input and output are announced regularly, often with promises of multiple benefits and new ease of use. Part of the excitement of the computer world is that these promises are usually kept, and users reap the benefits directly. Input and output just keep getting better.

Storage and Multimedia:
The Facts and More



Storage and Multimedia:
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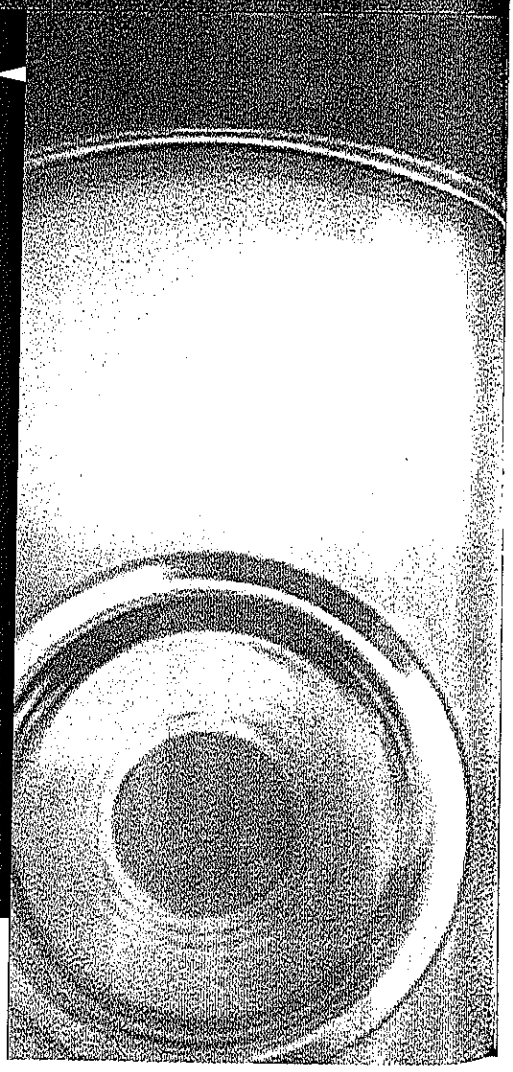


CHAPTER 6

LEARNING OBJECTIVES

- List the benefits of secondary storage.
- Identify and describe storage media that are available for personal computers.
- Differentiate among the principal types of secondary storage.
- Describe how data is stored on a disk.
- Discuss the benefits of multimedia.
- Explain how data is organized, accessed, and processed.

Cheri Urquhart, Tate Kirschner, and Taylor Russell met in college where they were studying to become architects. They did both undergraduate and graduate work together and then went their separate ways into the work force. But they remained in the same metropolitan area and kept in touch.

Seven years later, at a professional conference, their casual conversation over dinner turned serious, and they began to consider forming their own architectural firm. The details of accomplishing this were complex and involved many months of planning. Our concern here is what they decided to do about computers, particularly computer storage.

Architectural drawings are made with special software; the software alone takes up many millions of bytes of storage. In addition, the architectural drawings themselves are storage hogs. The three architects did not hesitate to include hard disks with many gigabytes of storage.

Another issue was the need to be able to produce computer-generated "walk-through" movies, simulated tours to show their clients the planned structure. For this they chose DVD-ROM, a type of high-capacity storage disk that can hold a full-length movie with room to spare.

Each of the architects already had a computer at home. They thought that they should upgrade the storage capacity of their individual computers so that they could bring work home. They also wanted some sort of

transfer storage device so that they could carry drawings on disk between home and office, they settled on the Zip drive, which holds a high-capacity diskette.

The situation just described is more complicated than the ones most people face. However, it is true that disk storage is an ongoing issue for most users—we can never seem to get enough. A rule of thumb among computer professionals is to estimate disk needs generously and then double that amount. But estimating future needs is rarely easy.

THE BENEFITS OF SECONDARY STORAGE

Picture, if you can, how many filing cabinet drawers would be required to hold the millions of files of, say, tax records kept by the Internal Revenue Service or archives of employee records kept by General Motors. The record storage rooms would have to be enormous. Computers, by contrast, permit storage on tape or disk in extremely compressed form. Storage capacity is unquestionably one of the most valuable assets of the computer.

Secondary storage, sometimes called **auxiliary storage,** is storage that is separate from the computer itself, where software and data can be stored on a semipermanent basis. Since memory, or primary storage, loses its contents when power is turned off, secondary storage is needed to save both data and programs for later use.

The benefits of secondary storage can be summarized as follows:

- **Space.** Organizations may store the equivalent of a roomful of data on sets of disks that take up less space than a breadbox. A simple diskette for a personal computer can hold the equivalent of 500 printed pages, or one book. An optical disk can hold the equivalent of approximately 500 books.
- **Reliability.** Data in secondary storage is basically safe, since secondary storage is physically reliable. (We should note, however, that disks sometimes fail.) Also, it is more difficult for untrained people to tamper with data on disk than with data stored on paper in a file cabinet.
- **Convenience.** With the help of a computer, authorized users can locate and access data quickly.
- **Economy.** Together, the three previous benefits indicate significant savings in storage costs. It is less expensive to store data on disk or tape (the principal means of secondary storage) than to buy and house filing cabinets. Data that is reliable and safe is less expensive to maintain than is data that is subject to errors. But the greatest savings can be found in the speed and convenience of filing and retrieving data.

These benefits apply to all the various secondary storage devices, but, as you will see, some devices are better than others. The discussion begins with a look at the various storage media, including those used for personal computers, and then moves to what it takes to get data organized and processed.

MAGNETIC DISK STORAGE

Diskettes and hard disks are magnetic media; that is, they are based on a technology of representing data as magnetized spots on the surface of a spinning disk—with a magnetized spot representing a 1 bit and the absence of such a spot representing a

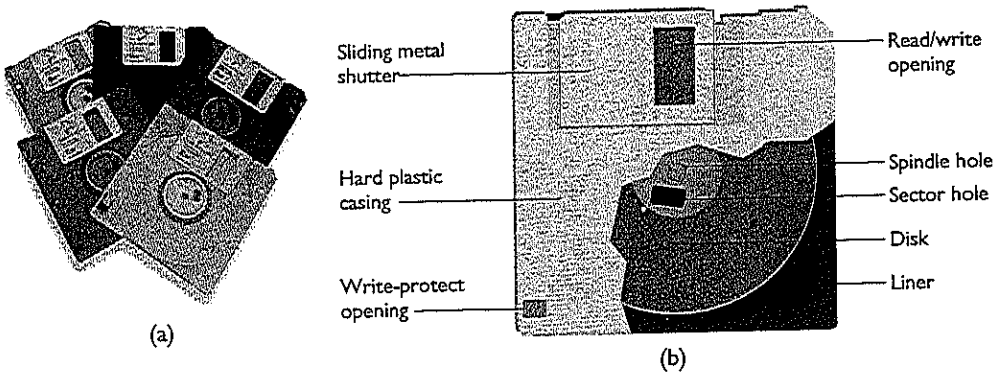


FIGURE 6-1

Diskette.

(a) These 3½-inch diskettes are protected by a rigid plastic exterior cover. (b) A cutaway view of a 3½-inch diskette.

0 bit. Reading data from the disk means converting the magnetized data to electrical impulses that can be sent to the processor. Writing data to disk is the opposite; it involves sending electrical impulses from the processor to be converted to magnetized spots on the disk.

Diskettes

A **diskette** is made of flexible Mylar and coated with iron oxide, a substance that can be magnetized. A diskette can record data as magnetized spots on tracks on its surface. Diskettes became popular along with the personal computer. Most computers use the 3½-inch diskette, whose capacity is 1.44 megabytes of data (Figure 6-1). The diskette has the protection of a hard plastic jacket and fits conveniently in a shirt pocket or purse. The key advantage of diskettes is portability. Diskettes easily transport data from one computer to another. Workers, for example, carry their files from office computer to home computer and back on a diskette instead of carrying a stack of papers in a briefcase. Students use the campus computers but keep their files on their own diskettes. Diskettes are also a convenient vehicle for backup: It is easy to place an extra copy of a hard disk file on a diskette.

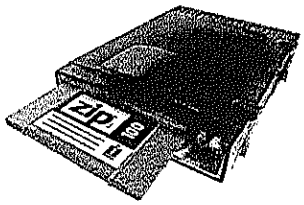
However, the venerable 3½-inch diskette, a standard for a decade, is being challenged. Two new high-capacity drives are challenging the standard floppy disk. One can store 120 megabytes per disk, while the other can store 200 megabytes. Although each uses its own high-capacity disk, they both can read and write to standard diskettes. However, the technology with a head start is Iomega's Zip drive, already installed by over 20 million users. The Zip drive holds 250-megabyte disks, 175 times the capacity of traditional diskettes (Figure 6-2). The disadvantage of the Zip drive is that it is not compatible with 3½-inch diskettes.

Even a high-capacity diskette can be problematic if, for example, you want to take a large file back and forth between your office and home computers. One possibility is **data compression,** the process of squeezing a big file into a small place. Compression can be as simple as removing all extra space characters, inserting a single repeat character to indicate a string of repeated characters, and substituting smaller data strings for frequently occurring characters. This kind of compression can reduce a text file to 50 percent of its original size. Compression is performed by a program that uses a formula to determine how to compress or decompress data. To be used again, the file must, of course, be uncompressed. Compression is also useful to speed up the transfer of files from one computer to another via data communications.

FIGURE 6-2

The Iomega Zip disk drive.

Shown here is a separate drive unit, but many users have their Zip drive installed in a bay in the computer's housing.



Hard Disks

A **hard disk** is a rigid platter coated with magnetic oxide that can be magnetized to represent data. Hard disks come in a variety of sizes. Several platters can be assembled into a **disk pack.** There are different types of disk packs, the number of platters varying by model. Each disk in the pack has top and bottom surfaces on which to

GETTING PRACTICAL — Diskette and CD Care

Although diskettes and CDs are fairly rugged, you should take precautions to protect them from damage.

General Guidelines

- CDs and diskettes will provide the best service if they are stored vertically. Don't stack them on top of each other or place heavy weight on them.
- Avoid extremes of temperature. The inside of a car on a hot, sunny day can be deadly.
- Insert and remove diskettes and CDs carefully—never force them into a drive. If you encounter difficulty in insertion, remove the item and try again, gently. If you still have problems, get help from a service technician.
- Keep diskettes and CDs away from food, drink, and smoke.

Diskette Care

- Keep diskettes away from magnets or anything that could generate a magnetic field. This includes stereo speakers and telephones.
- Don't touch the recording surface behind the metal slide.
- Be careful with disk labels. Loose labels or labels in several layers could become stuck inside the drive.

CD Care

- Store in a protective case—a jewel box or paper sleeve.
- Handle the CD by its edge. Avoid touching either surface.
- Don't write on the label side—you could destroy data.
- If necessary, clean the bottom (shiny) side with warm water and a soft cloth. Do not clean the label surface.

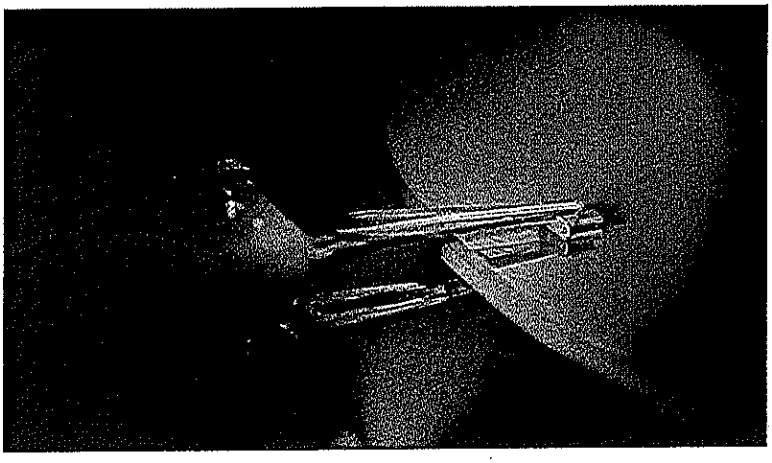
With proper care, both CDs and diskettes should have a long, trouble-free life. However, in the case of diskettes and writable CDs, be sure to back up any data you can't afford to lose.

record data, although some drives do not record data on the top of the top platter or on the bottom of the bottom platter.

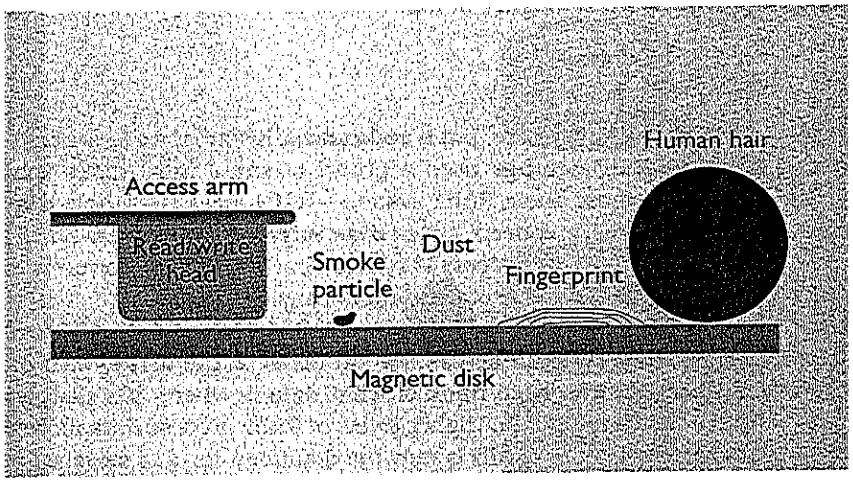
A **disk drive** is a device that allows data to be read from a disk or written to a disk. A disk pack is mounted on a disk drive that is a separate unit connected to the computer. Large computers have dozens or even hundreds of external disk drives; in contrast, the hard disk for a personal computer is contained within the computer housing. In a disk pack, all disks rotate at the same time, though only one disk is being read from or written to at any one time. The mechanism for reading or writing data to a disk is an **access arm;** it moves a read/write head into position over a particular location (Figure 6-3a). The **read/write head** on the end of the access arm hovers a few millionths of an inch above the platter but does not actually touch the surface. When a read/write head does accidentally touch the disk surface, it is called a **head crash,** and data will be destroyed. Data can also be destroyed if a read/write head encounters even minuscule foreign matter on the disk surface (Figure 6-3b). A disk pack has a set of access arms that slip in between the disks in the pack (Figure 6-3c). Two read/write heads are on each arm, one facing up to access the surface above it and one facing down to access the surface below it. All the arms move together as a unit; however, only one read/write head can operate at any one time.

Most disk packs combine the platters, access arms, and read/write heads in an airtight, sealed module. These disk packs are assembled in clean rooms so that even microscopic dust particles do not get on the disk surface.

Most hard disks for personal computers are sealed modules that mount in a 3½-inch bay within the computer's case (Figure 6-4). Hard disk capacity for personal computers has soared in recent years; older hard disks have capacities of hundreds of megabytes, but new ones offer tens of gigabytes of storage. Terabyte capacity is on the horizon.



(a)



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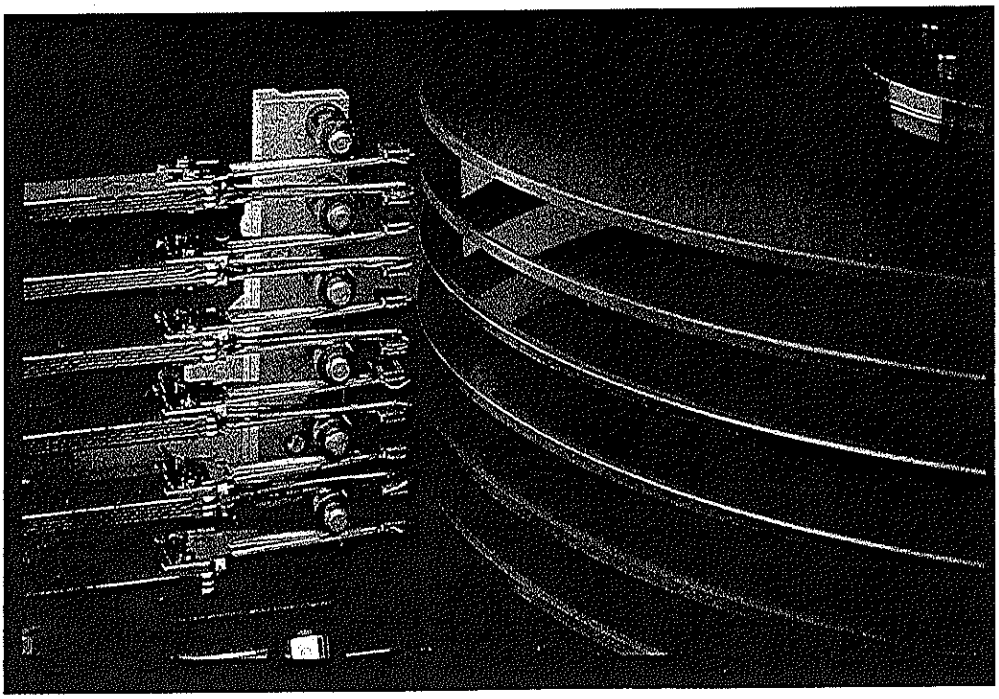


(c)

FIGURE 6-3

Read/write heads and access arms.

(a) This photo shows a read/write head on the end of an access arm poised over a hard disk. (b) When in operation, the read/write head comes very close to the surface of the disk. On a disk, particles as small as smoke, dust, a fingerprint, and a hair loom large. If the read/write head encounters one of these, a head crash occurs, destroying data and damaging the disk. (c) Note that there are two read/write heads on each access arm. Each arm slips between two disks in the disk pack. The access arms move simultaneously, but only one read/write head operates at any one time.

Although an individual probably cannot imagine generating enough output—letters, budgets, reports, pictures, and so forth—to fill a hard disk, software packages take up a lot of space and can make a dent rather quickly. Furthermore, graphics images and audio and video files require large amounts of disk space. Perhaps more important than capacity, however, is the speed advantage. Personal computer users find that accessing files on a hard disk is many times faster and much more convenient than accessing files on a diskette.

Removable hard disk systems are available for PCs. These systems consist of a drive that is installed either within the computer's case or in a separate case connected to the computer via a cable. The disk itself is contained in a cartridge that can be removed from the drive. Although the capacity of the removable cartridges is much greater than that of the high-capacity diskettes described above (up to 2-GB), they are not as spacious as the built-in hard disk systems on most PCs. Removable hard disk cartridges combine the portability advantages of diskettes with access speed close to that of the built-in systems. Their biggest disadvantage for home users is the expense of the cartridge—over $100. The Iomega Jaz drive is one of the more popular removable hard drive systems (Figure 6-4b).

Hard Disks in Groups

No storage system is completely safe, but a **redundant array of independent disks (RAID)** comes close. RAID storage uses a group of small hard disks that work together as a unit. The most basic RAID system—RAID level 1—simply duplicates data on separate disk drives, a concept called **disk mirroring** (Figure 6-5b). Thus no data is lost if one drive fails. This process is reliable but expensive. However, expense may not be an issue when the value of the data is considered.

Higher levels of RAID take a different approach called **data striping** (Figure 6-5c), which involves spreading the data across several disks in the array, with one disk used solely as a check disk to keep track of what data is where. If a disk fails, the check disk can reconstitute the data. Higher levels of RAID process data more quickly than simple data mirroring does. RAID is now the dominant form of storage for mainframe computer systems.

(a)

(b)

FIGURE 6-4

Hard disk for a personal computer.

(a) The innards of a 3½-inch hard disk with the access arm visible. (b) The Iomega Jaz hard disk drive with removable cartridge.

How Data Is Organized on a Disk

Several characteristics determine how data is physically organized on a disk. The characteristics that we consider here are tracks, sectors, clusters, and cylinders. Unless specifically noted, these concepts apply equally to diskettes and hard drives.

TRACK A **track** is the circular portion of the disk surface that passes under the read/write head as the disk rotates (Figure 6-6). The number of tracks on a particular disk's surface depends on how precisely the arm can position the read/write head. While the standard 1.44-MB floppy has 80 tracks on each of its two surfaces, a hard disk may have 1000 or more tracks on each surface of several platters.

SECTOR Each track on a disk is divided into **sectors** that hold a fixed number of bytes, typically 512 (Figure 6-7a). Data on the track is accessed by referring to the surface number, track number, and sector number where the data is stored.

The fact that a disk is circular presents a problem: The distance around the tracks on the outside of the disk is greater than that around the tracks on the inside. A given amount of data that takes up one inch of a track on the inside of a disk might be spread over several inches on a track near the outside of a disk. This means that the tracks on the outside are not storing data as efficiently.

Zone recording takes maximum advantage of the storage available by dividing a disk into zones and assigning more sectors to tracks in outer zones than to those in inner zones (Figure 6-7b). Since each sector on the disk holds the same amount of

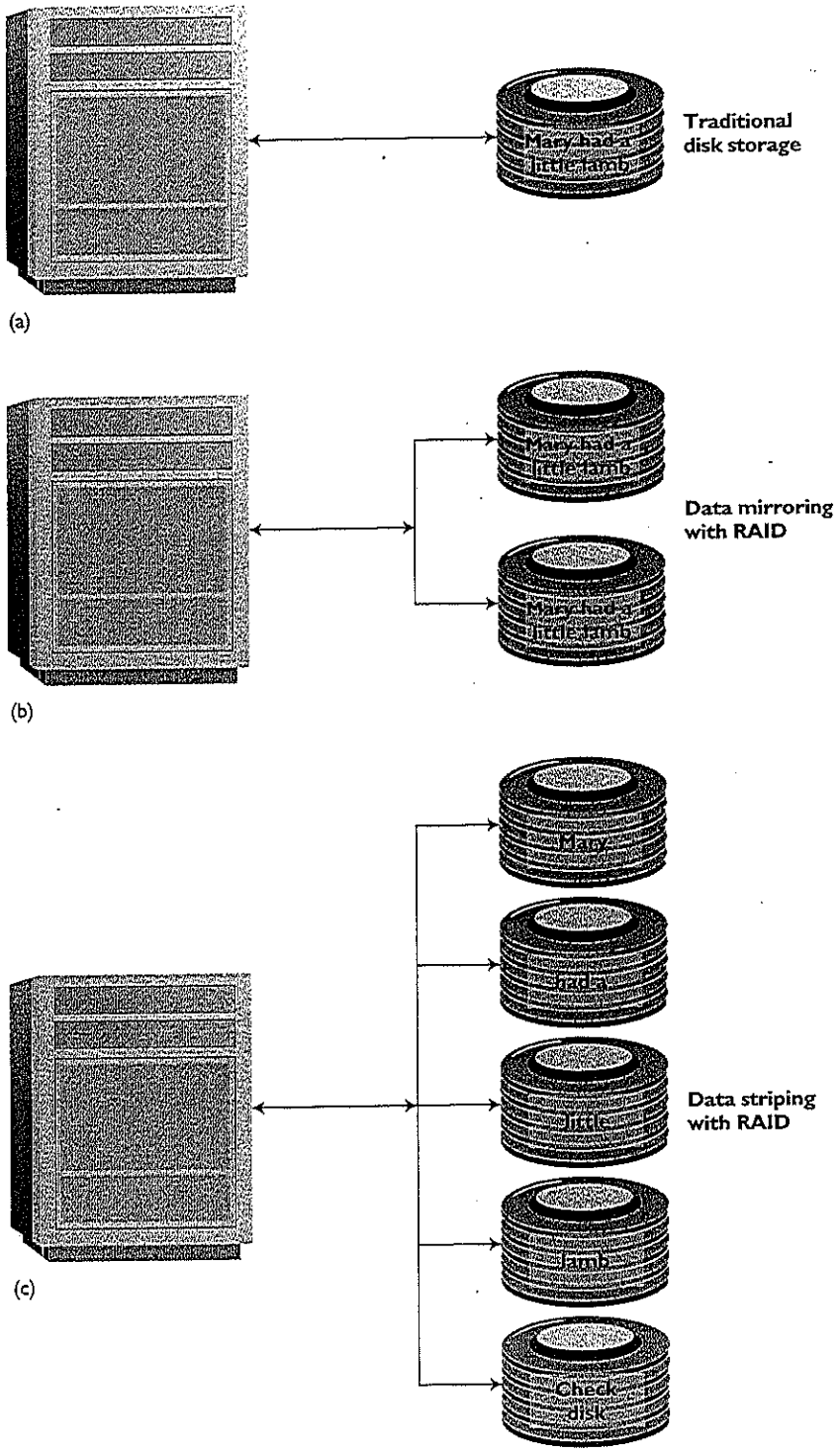


FIGURE 6-5

RAID storage.

(a) Data is stored on disk in traditional fashion. (b) Disk mirroring with RAID stores a duplicate copy of the data on a second disk. (c) In a system called data striping with RAID, data is scattered among several disks, with a check disk that keeps track of what data is where so that data lost on a bad disk can be re-created.

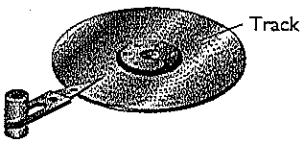


FIGURE 6-6

Tracks.

Each unique position of the read/write head results in a track on the disk surface. Each track contains the magnet representation of the binary ones and zeros.

data, more sectors mean more data storage than there would be if all tracks had the same number of sectors.

CLUSTERS A **cluster** is a fixed number of adjacent sectors that are treated as a unit of storage by the operating system. Clusters typically contain from two to eight sectors, depending on the operating system. Each file is stored in an integral number of clusters; even if a file is only a few bytes in length, it will be allocated an entire cluster.

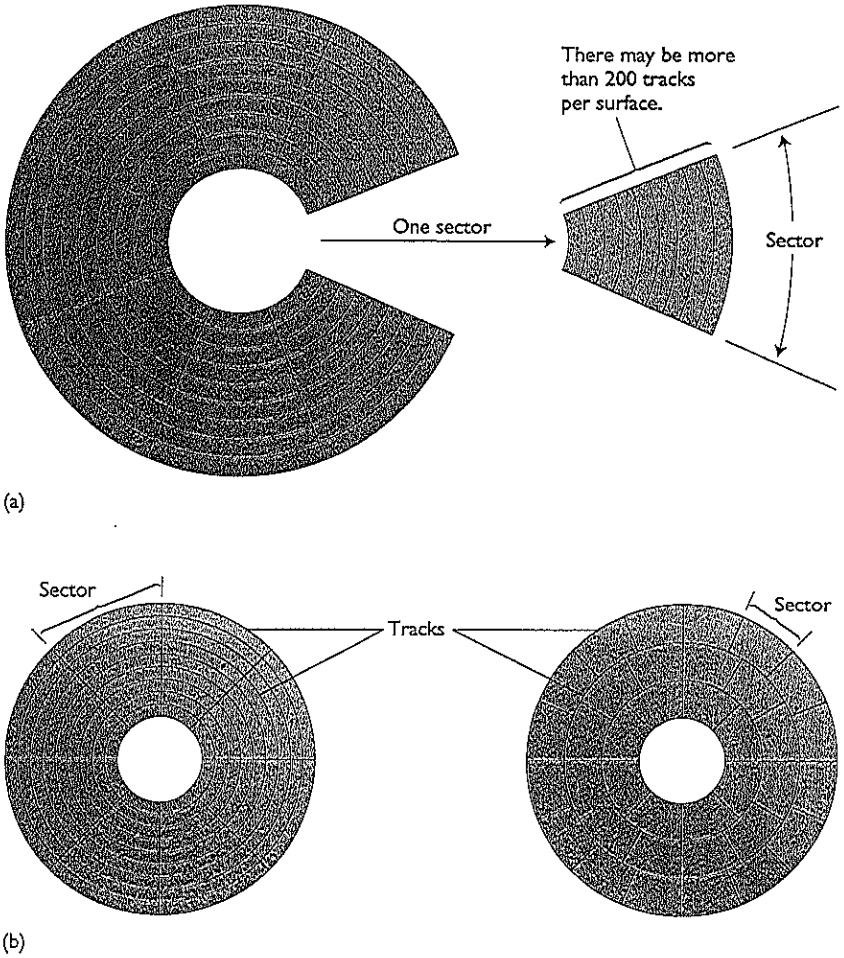
CYLINDER On a hard disk that has multiple platters, a **cylinder** consists of the track on each surface that is beneath the read/write head at a given position of the read/write arms (Figure 6-8). When a file is larger than the capacity of a single track, the operating system will store it in tracks within the same cylinder, rather than spreading it across tracks on the same platter. The purpose is to reduce the time it takes to move the access arms of a disk pack into position. Once the access arms are in position, they don't have to be moved to access additional tracks within the same cylinder.

To appreciate this, suppose you had an empty disk pack on which you wished to store a large file. You might be tempted to record the data horizontally—to start with the first surface and fill track 000, track 001, track 002, and so on and then move to the second surface and again fill tracks 000, 001, 002, and so forth. However, each new track and new surface would require movement of the access arms, a relatively slow mechanical process.

FIGURE 6-7

Sectors and zone recording.

(a) When data is organized by sector, the address is the surface, track, and sector where the data is stored. (b) If a disk is divided into traditional sectors, as shown here on the left, each track has the same number of sectors. Sectors near the outside of the disk are wider, but they hold the same amount of data as sectors near the inside. If the disk is divided into recording zones, as shown on the right, the tracks near the outside have more sectors than the tracks near the inside. Each sector holds the same amount of data, but since the outer zones have more sectors, the disk as a whole holds more data than the disk on the left.



Recording the data vertically, on the other hand, substantially reduces access arm movement. The data is recorded on the tracks that can be accessed by one positioning of the access arms—that is, on one cylinder. Instead of moving the access arm to the next track each time a track is filled, the arm needs to be moved only after all the tracks in a cylinder are filled. To visualize cylinder organization, pretend that a cylindrically shaped item, such as a tin can, is dropped straight down through all the disks in the disk pack. All the tracks thus encountered, in the same position on each disk surface, make up a cylinder.

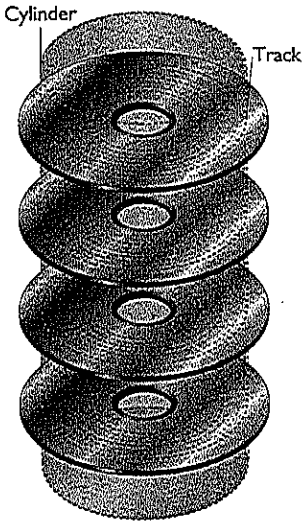


FIGURE 6-8

Cylinder data organization.
To visualize a cylinder on disk, imagine dropping a cylinder such as a tin can straight down through all the disks in a disk pack. Within cylinder 150, the track surfaces are vertically aligned and are numbered from top to bottom.

Disk Access Speed

Three primary factors determine **access time,** the time needed to access data directly on disk:

- **Seek time. Seek time** is the time it takes the access arm to get into position over a particular track. Keep in mind that all the access arms move as a unit, so they are simultaneously in position over a set of tracks that make up a cylinder.
- **Head switching.** The access arms on the access mechanism do not move separately; they move together, all at the same time. However, only one read/write head can operate at any one time. **Head switching** is the activation of a particular read/write head over a particular track on a particular surface. Since head switching takes place at electronic speed, the time it takes is negligible.
- **Rotational delay.** Once the access arm and read/write head are in position and ready to read or write data, the read/write head must wait for a short period until the desired data on the track rotates under it. On the average, this **rotational delay** is equal to one-half the time for a complete revolution of the disk.

Once the data has been found, the next step is **data transfer,** the process of transferring data between memory and the place on the disk track—from memory to the track if the computer is writing, from the track to memory if the computer is reading. One measure for the performance of disk drives is the average access time, which is usually measured in milliseconds (ms). On current hard disk drives, access time is under 10 ms. Another measure is the **data transfer rate,** which tells how fast data can be transferred once it has been found. This will usually be stated in terms of megabytes of data per second.

Disk caching can be used to improve the effective access time. When the disk drive reads data from disk, it will also read adjacent data and store it in an area of memory called the **disk cache.** When the next read instruction is issued, the drive will first check to see whether the desired data is in the disk cache. If it is, no physical read is necessary, greatly reducing access time. This is the same principle used in memory caching, which was discussed in Chapter 4.

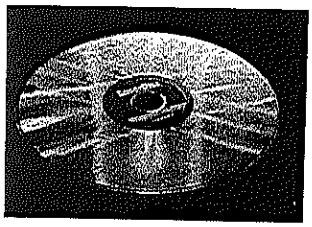
OPTICAL DISK STORAGE

The explosive growth in storage needs has driven the computer industry to provide inexpensive and compact storage with greater capacity. This demanding shopping list is a description of the **optical disk** (Figure 6-9a). The technology works like this: A laser hits a layer of metallic material spread over the surface of a disk. When data is being entered, heat from the laser produces tiny spots, or pits, on the disk surface. To read the data, the laser scans the disk, and a lens picks up light reflections from the spots. Optical storage technology is categorized according to its read/write capability. **Read-only media** are disks that are recorded by the manufacturer and can be read from but not written to by the user. Such a disk cannot, obviously, be used for your files, but manufacturers can use it to supply software. An applications software package could include a dozen diskettes or more; all these can fit on one optical disk

with room to spare. Furthermore, software can be more easily installed from a single optical disk than from a pile of diskettes.

Write-once, read-many media, also called **WORM media,** may be written to once. Once filled, a WORM disk becomes a read-only medium. A WORM disk is nonerasable. For applications that demand secure storage of original versions of valuable documents or data, such as legal records, the primary advantage of nonerasability is clear: Once they are recorded, no one can erase or modify them.

A hybrid type of disk, called **magneto-optical (MO),** combines the best features of magnetic and optical disk technologies. A magneto-optical disk has the high-volume capacity of an optical disk but can be written over like a magnetic disk. The disk surface is coated with plastic and embedded with magnetically sensitive metallic crystals. To write data, a laser beam melts a microscopic spot on the plastic surface, and a magnet aligns the crystals before the plastic cools. The crystals are aligned so that some reflect light and others do not. When the data is later read by a laser beam, only the crystals that reflect light are picked up.



(a)

(b)

FIGURE 6-9

tical disks.

Optical disks store data ng laser beam technology. Many laptop computers lude a CD-ROM drive. Lap- users can use CD-ROM ap- cations to make on-the-road sentations or can pop in a -ROM encyclopedia to find ne needed information.

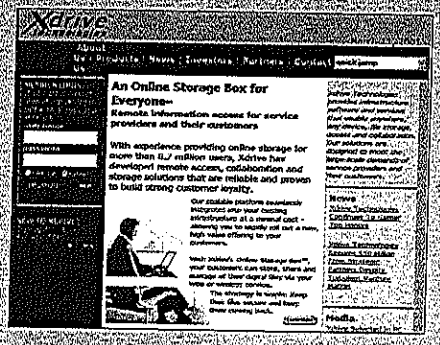
COMPACT DISKS

Compact disk (CD) technology is an optical technology that uses the same media used for audio CDs. In fact, with the proper software, computer CD drives can play audio CDs. There are several types of CD drives, categorized according to their ability to read and write CDs.

CD-ROM The **CD-ROM (compact disk read-only memory) drive** is capable only of reading data from CDs—it cannot record anything. CD-ROM has a major advantage over other optical disk designs: The disk format is identical to that of audio compact disks, so the same dust-free manufacturing plants that are now stamping out digital versions of Wynton Marsalis or the Backstreet Boys can easily convert to producing

MAKING CONNECTIONS — Internet Disk Drives

If you have ever used a PC on a local area network at school or work, you are probably familiar with the concept of network drives. A network drive is disk storage space located on a network server that is available for you to store data just as if it were on your own PC. Network drives enable you to back up data, share files with others on the network, and, in a school lab environment, access your files no matter which PC you use.



Several companies are making the ultimate network drive available even to users who aren't connected to a local area network, as long as they have an Internet connection. Companies such as X:drive, and Driveway will provide you with disk space on their Internet servers that you can use as an extension of your hard drive. You can place your data on your Internet drive and get to it from anywhere you can get Internet access—work, school, or even the public library. You can also allow others access to some or all of the data on your virtual drive, providing an easy method of sharing files that are too large to transport via floppy.

Another use of your Internet drive is for off-site backup. Storing an extra copy of valuable data files, such as your financial records, your Ph.D. thesis, or that Great American Novel you've been working on for years is great protection against a fire or flood that might destroy your PC and the backup copies stored on the shelf next to it. Most of these companies provide some space for free (25-MB is typical) and allow you to pay a monthly or yearly fee for additional space. One not-so-obvious limitation is the speed of your Internet connection—uploading and downloading multimegabyte files can take quite a while with a 56-kbps modem.

anything from software to a digitized encyclopedia. Furthermore, CD-ROM storage is substantial—up to 700 megabytes per disk, the equivalent of more than 450 standard 3½-inch diskettes. As the size of software applications has increased, CD-ROM has become the primary medium for software distribution.

CD-R Although CD-ROMs are read-only, a different technology called **CD-R (compact disc-recordable)** permits writing on optical disks—but just once; mistakes cannot be undone. CD-R technology requires a CD-R drive, special CD-R disks that look just like regular CDs except that they are marked "CD-R," and the accompanying CD-R software. Once a CD-R disk is written on, it can be read not only by the CD-R drive but also by any CD-ROM drive.

CD-RW Another variation, **CD-RW (compact disk-rewritable),** is more flexible, allowing you to erase and record over data multiple times. CD-RW technology requires a CD-RW drive, special CD-RW disks, and the CD-RW software. Some compatibility problems may be encountered in reading CD-RW disks on standard CD-ROM drives.

DVD-ROM

The new storage technology that outpaces all others is called **DVD-ROM,** for **digital versatile disk** (originally digital *video* disk). Think of a DVD, as it is called for short, as an overachieving CD-ROM. Although the two look the same, a DVD has up to 4.7-gigabyte capacity, almost seven times more than that of the highest-capacity CD-ROM. And that is just the plain variety. DVDs have two layers of information—one clear and one opaque—on a single side; this so-called double-layered DVD surface can hold about 8.5-GB. Furthermore, DVDs can be written on both sides, bumping the capacity to 17-GB. And a DVD-ROM drive can also read CD-ROMs. It is not surprising that DVD-ROM technology is being seen as a replacement for CD-ROMs over the next few years.

Operating very much like CD-ROM technology, DVD uses a laser beam to read microscopic spots that represent data. But DVD uses a laser with a shorter wavelength, permitting it to read more densely packed spots, thus increasing the disk capacity. The benefits of this storage capacity are many, including exquisite sound and the ability to hold full-length movies. Audio quality on DVD is comparable to that of current audio compact disks. DVDs will eventually hold high-volume business data. It is just a matter of time until all new personal computers will come with a DVD drive as standard equipment. The writable version of DVD is **DVD-RAM.** Under current standards, DVD-RAM stores 5.2-MB on a double-sided disk that is readable only by DVD-RAM drives.

If you have a CD-ROM or a DVD-ROM drive, you are on your way to one of the computer industry's great adventures: multimedia.

MULTIMEDIA

Multimedia stirs the imagination. For example, have you ever thought that you could see a film clip from *Gone with the Wind* on your computer screen? One could argue that such treats are already available on videocassette, but the computer version provides an added dimension for this and other movies: reviews by critics, photographs of movie stars, lists of Academy Awards, the possibility of user input, and much more. Software described as **multimedia** typically presents information with text, illustrations, photos, narration, music, animation, and film clips. Until the advent of the optical disk, placing this much data on a disk was impractical.

PostagePlus

Stamps from Your Computer

That's right—no more trips to the post office, no standing in line. Several sites on the Internet, including PostagePlus, shown here, let you pay for postage and store it right on your hard disk. When you need a stamp, you just print it on the envelope. Well, it does not look much like a real stamp, but the post office accepts it just the same.

Here is how it works. From your personal computer, you access a site that sells postage. You pay for postage, usually with a credit card. The postage company grants you permission to print a certain amount of postage, sending that amount and the stamp image to your "vault"—a file—on your hard disk. (Alternatively, some companies keep your account on their own files.) Then just print and mail.

The convenience is remarkable, but there are downsides: signup and monthly fees in addition to the postage—and fewer colorful stamps in circulation.

FOCUS ON ETHICS **Not So Fast**

When preparing a multimedia presentation, take a moment to reflect before adding music, images, or video clips. Have you obtained permission from the copyright owner to use the item? Even featuring statuary you have photographed in front of a civic structure might not be a simple matter. The artist who created the work of art could still own the copyright even if the statues themselves have been sold. In general, unless you created a work of art, you must consider ownership issues.

Locate examples of this sort of violation on the Internet. What justification do you think those who use copyrighted material without permission would give? Do you think their arguments are valid?

However, the large capacity of optical disks means that the kinds of data that take up huge amounts of storage space—photographs, music, and film clips—can now be readily accommodated.

Multimedia Requirements

To use multimedia software, you must have the proper hardware. In addition to the aforementioned CD-ROM or DVD-ROM drive, you also need a sound card or sound chip (installed internally) and speakers, which may be internal, that is, built into the computer housing or external, connected to the computer via cables. Special software accompanies the drive and sound card. In particular, if full-motion video is important to you, be sure that your computer is equipped to handle **MPEG (Motion Picture Experts Group),** a set of widely accepted video standards. Another video-related issue is the speed of the drive: The faster the better. The higher the drive speed, the faster the transfer of data and the smoother the video showing on the screen.

Should your next computer be a multimedia personal computer? Absolutely. There is no doubt that multimedia is the medium of choice for all kinds of software.

Multimedia Applications

If you take a moment to peruse the racks of multimedia software in your local store, you can see that most of the current offerings come under the categories of entertainment or education—or possibly both. You can study *and hear* works by Stravinsky or Schubert. You can explore the planets or the ocean bottom through film clips and narrations by experts. You can be "elected" to Congress, after which you tour the Capitol, decorate your office, hire staff, and vote on issues. You can study the battle of Gettysburg—and even change the outcome. You can study the Japanese language, seeing the symbols and hearing the intonation. You can buy multimedia versions of reference books, magazines, children's books, and entire novels.

But this is just the beginning. Businesses are already moving to this high-capacity environment for street atlases, national phone directories, and sales catalogs. Coming offerings will include every kind of standard business application, all tricked out with fancy animation, photos, and sound. Educators will be able to draw on the new sight and sound capabilities for everything from human anatomy to time travel. And just imagine the library of the future, consisting not only of the printed word but also of photos, film, animation, and sound recordings—all flowing from the computer.

MAGNETIC TAPE STORAGE

We saved magnetic tape storage for last because it has now taken a subordinate role in storage technology. **Magnetic tape** looks like the tape used in music cassettes—plastic tape with a magnetic coating. As in other magnetic media, data is stored as

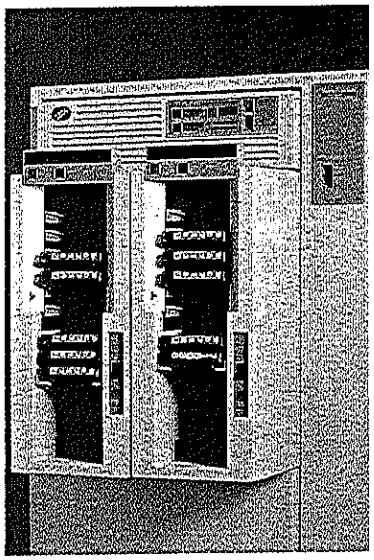


FIGURE 6-10

Magnetic tape units.

Tapes are always protected by glass from outside dust and dirt. These modern tape drives, called "stackers", accept several cassette tapes, each with its own supply and take-up reel.

extremely small magnetic spots. Tapes come in a number of forms, including ½-inch-wide tape wound on a reel, ¼-inch-wide tape in data cartridges and cassettes, and tapes that look like ordinary music cassettes but are designed to store data instead of music. Tape capacity is expressed in terms of **density,** which is the number of **characters per inch (cpi)** or **bytes per inch (bpi)** that can be stored on the tape.

Figure 6-10 shows a **magnetic tape unit** that might be used with a mainframe. The tape unit reads and writes data using a **read/write head.** When the computer is writing on the tape, the **erase head** first erases any data that was previously recorded on the tape.

Tape now has a limited role because disks have proved to be the superior storage medium. Disk data is quite reliable, especially within a sealed module. Furthermore, as we will show, disk data can be accessed directly, in contrast to sequential data on tape, which can be accessed only by passing by all the data ahead of it on the tape. Consequently, the primary role of tape today is as an inexpensive backup medium.

BACKUP SYSTEMS

Although a hard disk is an extremely reliable device, it is subject to electromechanical failures that cause loss of data, as well as physical damage from fire and natural disasters. Furthermore, data files, particularly those accessed by several users, are subject to errors introduced by users. There is also the possibility of errors introduced by software. With any method of data storage, a **backup system**—a way of storing data in more than one place to protect it from damage and errors—is vital. As we have already noted, magnetic tape is used primarily for backup purposes. For personal computer users, an easy and inexpensive way to back up a hard disk file is simply to copy it to a diskette or Zip disk whenever it is updated. But this is not practical for a system with many files or many users.

Personal computer users have the option of purchasing their own tape backup system, to be used on a regular basis for copying all data from hard disk to a high-capacity tape. Data thus saved can be restored to the hard disk later if needed. A key advantage of a tape backup system is that it can copy the entire hard disk to a single tape in minutes; also, with the availability of gigabytes of hard disk space, it is not really feasible to swap diskettes into and out of the machine. Furthermore, tape

backup can be scheduled to take place when you are not going to be using the computer. CD-R and CD-RW media can also be used for backup, but they are limited to storing less than 1GB of data, while tape cartridges with more than 10GB of storage capacity are available at reasonable cost.

Dupeless Dupeless

Dupeless
Is it possible that you have two copies of the same file on your hard disk? That second copy would, of course, take up extra space. To make the scenario even worse, suppose that you had a dozen copies of the same file. Is this even possible? Alas, yes.

This might seem surprising because people first think of files in terms of their own creations, and they know that they did not make multiple copies of the same file. But the duplicate files—and there likely are some—may appear as part of software you have added. Each software package comes complete with needed files, as if it were the only software you have. Thus, as you install new software, you will probably include files that you already have installed with other software.

A program called Dupeless, which can be downloaded from the Internet, ferrets out the extra files, notifies the user, and deletes them on command.

ORGANIZING AND ACCESSING STORED DATA

As users of computer systems, we offer data as we are instructed to do, such as punching in our identification code at an automated teller machine or perhaps filling out a form with our name and address. But data cannot be dumped helter-skelter into a computer. Some computer professional—probably a programmer or systems analyst—has to have planned how data from users will be received, organized, and stored and in what manner data will be processed by the computer.

This kind of storage goes beyond what you may have done to store a memo created in word processing. Organizations that store data usually need a lot of data on many subjects. For example, a charitable organization would probably need detailed information about donors, names and schedules of volunteers, and perhaps a schedule of fund-raising events. A factory would need to keep track of inventory (name, identification number, location, quantity, and so forth), the scheduled path of the product through the assembly line, records of quality-control checkpoints, and much more. All this data must be organized and stored according to a plan. First consider how data is organized.

Data: Getting Organized

To be processed by the computer, raw data is organized into characters, fields, records, files, and databases. First is the smallest element: the character.

- A **character** is a letter, digit, or special character (such as $, ?, or *).
- A **field** contains a set of related characters. For example, suppose that a health club is making address labels for a mailing. For each person it might have a member number field, a name field, a street address field, a city field, a state field, a zip code field, and a phone number field.
- A **record** is a collection of related fields. On the health club mailing list, one person's member number, name, address, city, state, zip code, and phone number constitute a record.
- A **file** is a collection of related records. All the member records for the health club compose a file. Figure 6-11 shows how data for a health club member might look.
- A **database** is a collection of interrelated files stored together with minimum redundancy. Specific data items can be retrieved for various applications. For instance, if the health club is opening a new outlet, it can pull out the names of people with zip codes near the new club and send them an announcement. Database concepts will be discussed in more detail in Chapter 14.

A field of particular interest is the **key,** a unique identifier for a record. It might seem at first that a name—of a person, say, or a product—would be a good key; however, since some names may be the same, a name field is not a good choice for a key. When a file is first computerized, existing description fields are seldom used as keys. Although a file describing people might use a Social Security number as the key, it is more likely that a new field will be developed that can be assigned unique values, such as customer number or product number.

In addition to organizing the expected data, a plan must be made to access the data on files.

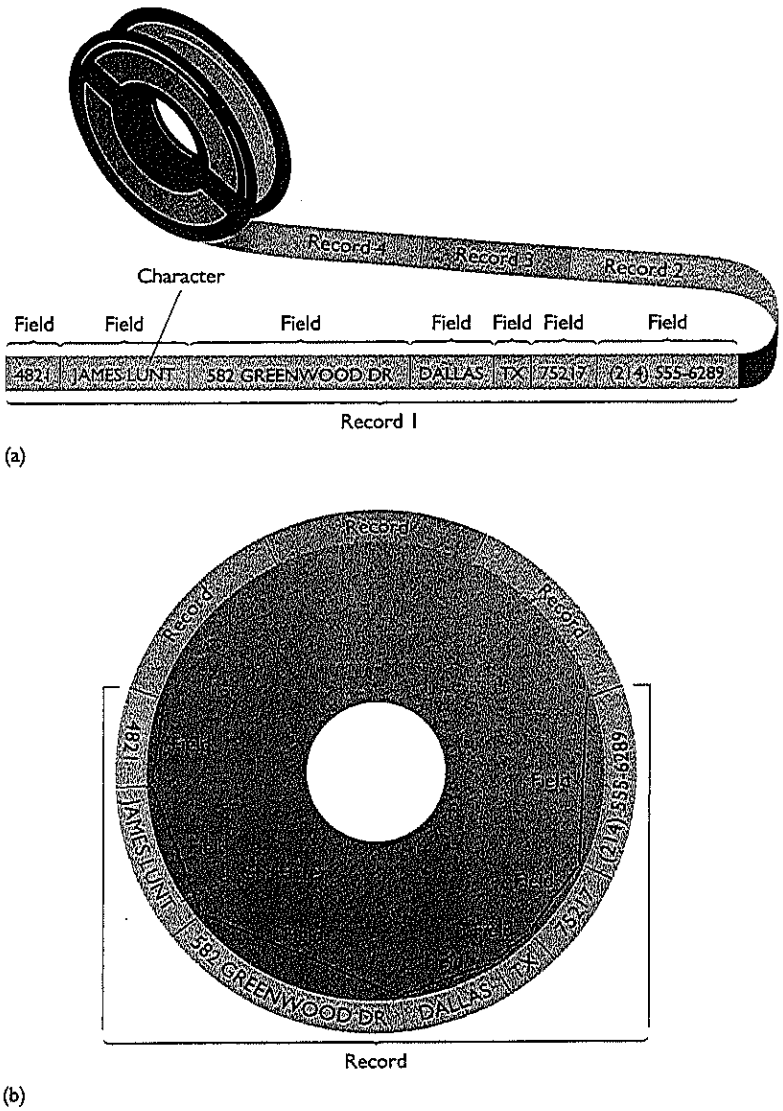


FIGURE 6-11

How data is organized.

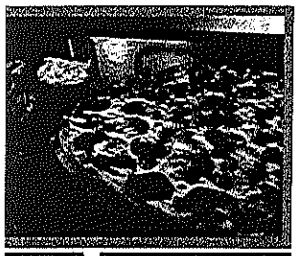
Whether stored on tape or on disk, data is organized into characters, fields, records, and files. A file is a collection of related records. These diagrams represent (a) magnetic tape and (b) magnetic disk.

The File Plan: An Overview

Now that you have a general idea of how data is organized, you are ready to look at the process used to decide how to place data on a storage medium. Consider this chain: (1) It is the application—payroll, airline reservations, inventory control, whatever—that determines how the data must be accessed by users. (2) Once an access method has been determined, it follows that there are certain ways in which the data must be organized so that the needed access is workable. (3) The organization method, in turn, limits the choice of storage medium. The discussion begins with an appreciation of application demands, then moves to a detailed look at organization and access.

The following application examples illustrate how an access decision might be made:

- A department store offers its customers charge accounts. When a customer makes a purchase, a sales clerk needs to be able to check the validity of the customer's account while the customer is waiting. The clerk needs immediate access to the individual customer record in the account file.
- A major oil company supplies its charge customers with credit cards, which it considers sufficient proof for purchase. The charge slips collected by gas stations are



You're on File at Domino's

If you consider what items of personal information might be stored on disk files, you may think of your Social Security records or perhaps the information stored with your bank account. But small businesses also know about you. They store information you readily provide on their own disk files.

For example, if you phone a Domino's outlet to order a pizza, your name, address, and phone number and the product you ordered will be recorded in the company's disk files. When you call again in the future, this information can be retrieved quickly by keying in your phone number. This saves time and effort and can speed your pizza on its way.

forwarded to the oil company, which processes them in order of account number. Unlike the retail example just given, the company does not need access to any one record at a specific time but merely needs access to all customer charge records when it is time to prepare bills.

- A city power and light company employee accepts reports of burned-out streetlights from residents over the phone. Using a key made up of unique address components, the clerk immediately finds the record for the offending streetlight and prints out a one-page report that is routed to repair units within 24 hours. To produce such quick service for an individual streetlight, the employee needs immediate access to the individual streetlight record.
- Airline flight attendants' schedules for the next month are computer-produced monthly and delivered to the attendants' home-base mailboxes. The schedules are put together from information based on flight records, and the entire file can be accessed monthly at the convenience of the airline and the computer-use plan.

As you can see, the question of access seems to come down to whether a particular record is needed right away, as it was in the first and third examples. This immediate need for a particular record means that access must be *direct*. It follows that the organization must also be direct, or at least *indexed*, and that the storage medium must be disk. Furthermore, the type of processing, a related topic, must be *transaction processing*. The critical distinction is whether or not immediate access to an individual record is needed. The following discussion examines all these topics in detail. Although the organization type is determined by the type of access required, the file must be organized before it can be accessed, so organization is the first topic.

File Organization: Three Methods

There are three major methods of organizing data files in secondary storage:

- Sequential file organization, in which records are stored in order by key
- Direct file organization, in which records are not physically stored in any special order
- Indexed file organization, in which records are stored sequentially but indexes are built into the file to allow a record to be accessed either sequentially or directly

SEQUENTIAL FILE ORGANIZATION **Sequential file organization** means that records are stored in order according to a key field. As we noted earlier, a file containing information on people will be in order by a key that uniquely identifies each person, such as Social Security number or customer number. If a particular record in a sequential file is wanted, all the prior records in the file must be read before the desired record is reached. Tape storage is limited to sequential file organization. Disk storage may be sequential, but records on disk can also be accessed directly.

DIRECT FILE ORGANIZATION **Direct file organization** (also called **random file organization**) allows **direct (random) access,** the ability to go directly to the desired record by using a record key; the computer does not have to read all preceding records in the file as it does if the records are arranged sequentially. Direct processing requires disk storage; in fact, a disk device is called a **direct-access storage device (DASD)** because the computer can go directly to the desired record on the disk. It is this ability to access any given record instantly that has made computer systems so convenient for people in service industries—for catalog order-takers determining whether a particular sweater is in stock, for example, or bank tellers checking individual bank balances. An added benefit of direct-access organization is the ability to read, change, and return a record to its same place on the disk; this is called **updating in place.**

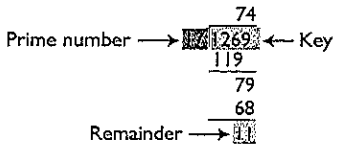


FIGURE 6-12

A hashing scheme.

Dividing the key number 1269 by the prime number 17 yields a remainder of 11, which can be used to indicate the address on a disk.

Obviously, if we have a completely blank area on the disk and can put records anywhere, there must be some predictable system for placing a record at a disk address and then retrieving the record at a subsequent time. In other words, once the record has been placed on a disk, it must be possible to find it again. This is done by choosing a certain formula to apply to the record key, thereby deriving a number to use as the disk address. The **hashing,** or **randomizing, algorithm** is the mathematical operation that is applied to a key to yield a number that represents the address. Even though the record keys are unique, it is possible for a hashing algorithm to produce the same disk address, called a **synonym,** for two different records; such an occurrence is called a **collision.** There are various ways to recover from a collision; one way is simply to use the next available record slot on the disk.

There are many different hashing schemes; although the example in Figure 6-12 is far too simple to be realistic, it can give you a general idea of how the process works. An example of how direct processing works is provided in Figure 6-13.

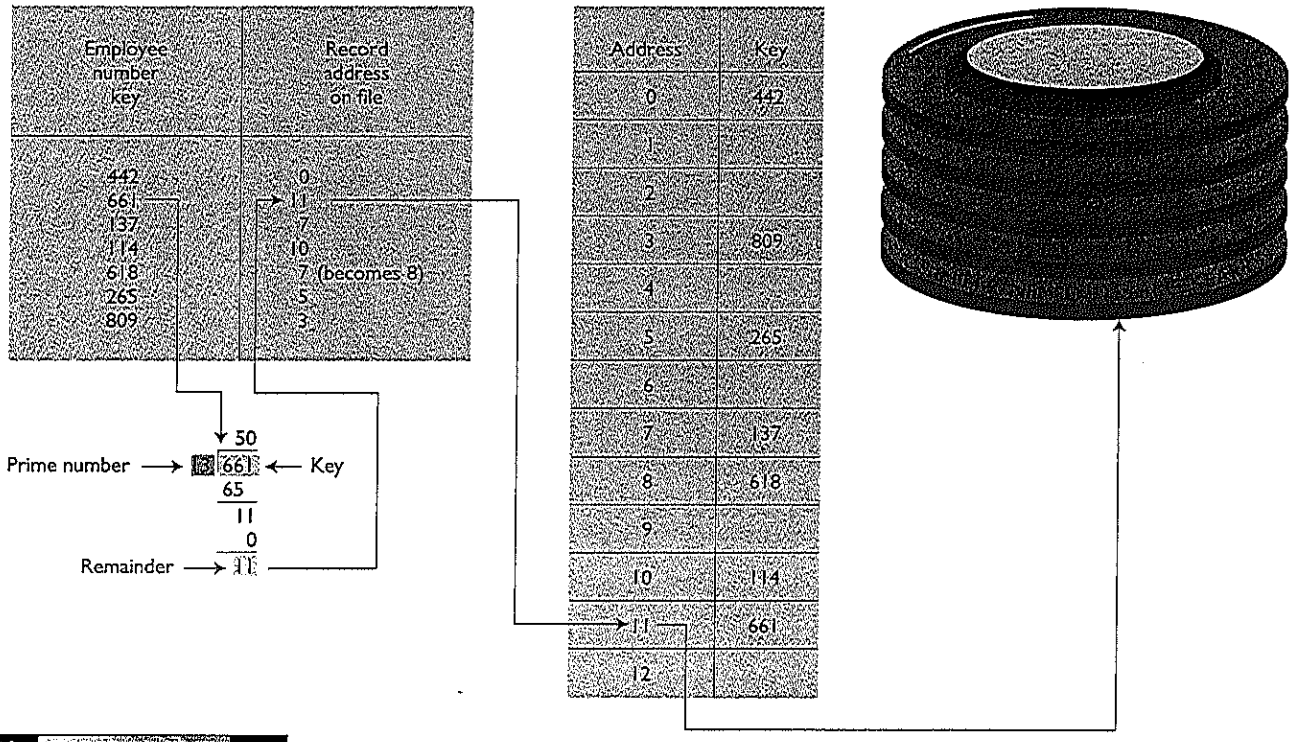
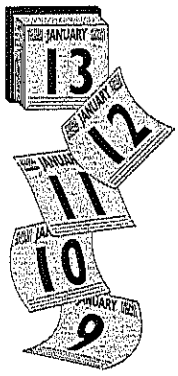


FIGURE 6-13

An example of direct access.

Assume that there are 13 addresses (0 through 12) available in the file. Dividing the key number 661, which is C. Kear's employee number, by the prime number 13 yields a remainder of 11. Thus, 11 is the address for key 661. However, for the key 618, dividing by 13 yields a remainder of 7, a synonym, since this address has already been used by the key 137, which also has a remainder of 7. Hence the address becomes the next location—that is, 8. Note, incidentally, that keys (and therefore records) need not appear in any particular order. (The 13 record locations available are, of course, too few to hold a normal file; a small number was used to keep the example simple.)



How Long Will It Last?

Although magnetic and optical media provide reliable long-term storage, they will eventually deteriorate. The following figures represent a conservative estimate of media lifetime; proper care and a little luck can extend the life by quite a bit. For comparison, the Dead Sea Scrolls, written on papyrus, are over 2000 years old, and many books over 400 years old can still be found in libraries' rare book collections.

- **Hard drive:** 3–5 years; mechanical components wear out.
- **Diskette:** 1 year of regular use; somewhat longer with careful storage.
- **Magnetic tape:** 3–5 years, up to 25 years possible.
- **CD-ROM:** 200 years (Obviously an estimate—it will be quite a while before we know for sure.)
- **CD-R:** 100–200 years; only 5–10 years shelf life before recording.
- **CR-RW:** 30 years; proper temperature is critical, as is avoiding sunlight.

INDEXED FILE ORGANIZATION **Indexed file organization** is a third method of file organization, and it represents a compromise between the sequential and direct methods. It is useful in applications in which a file needs to be processed sequentially but, in addition, access to individual records is needed.

An indexed file works as follows: Records are stored in the file in sequential order, but the file also contains an index. The index contains entries consisting of the key to each record stored on the file and the corresponding disk address for that record. The index is like a directory, with the keys to all records listed in order. For a record to be accessed directly, the record key must be located in the index; the address associated with the key is then used to access the record on the disk. Accessing the entire file of records sequentially is simply a matter of beginning with the first record and proceeding one at a time through the rest of the records.

PROCESSING STORED DATA

Once there is a plan for accessing the files, they can be processed. Most business file processing involves processing transactions to update a master file. A **transaction** is a business event that requires the business's records to be updated. A retail sale, the receipt of ordered goods, and the issuance of a paycheck are examples of transactions. A **master file** contains data that must be updated as transactions occur. Examples of master files are an inventory file, an employee file, and a customer file. There are several methods of processing data files in a computer system. The two main methods are batch processing (processing transaction data in groups at a more convenient later time) and transaction processing (processing transactions immediately, as they occur).

Batch Processing

Batch processing is a technique in which transactions are collected into groups, or batches, to be processed at a time when the computer may have few online users and thus be more accessible, often during the night. Unlike transaction processing, a topic that we will discuss momentarily, batch processing involves no direct user interaction. Let us consider updating the health club address-label file, a list of all members of the health club and their addresses. The **transaction file** contains all changes to be made to the master file: additions (transactions to create new master records for new members), deletions (transactions with instructions to delete master records of members who have resigned from the health club), and revisions (transactions to change items such as street addresses or phone numbers in fields in the master records). Periodically, perhaps monthly or weekly, the master file is **updated** with the changes called for in the transaction file. The result is a new, up-to-date master file (Figure 6-14).

In batch processing, before a transaction file is matched against a master file, the transaction file must be sorted (usually by computer) so that all the transactions are in sequential order according to a key field. In updating the health club address-label file, the key is the member number assigned by the health club. The records on the master file are already in order by key. Once the changes in the transaction file are sorted by key, the two files can be matched and the master file updated.

During processing, the computer matches the keys from the master and transaction files, carrying out the appropriate action to add, revise, or delete. At the end of processing, a newly updated master file is created; in addition, an error report is usually printed. The error report shows actions such as an attempt to update or delete a nonexistent record or an attempt to add a record that already exists.

The biggest advantage of batch processing is its efficiency. The biggest disadvantage is that the master file is current only immediately after processing.

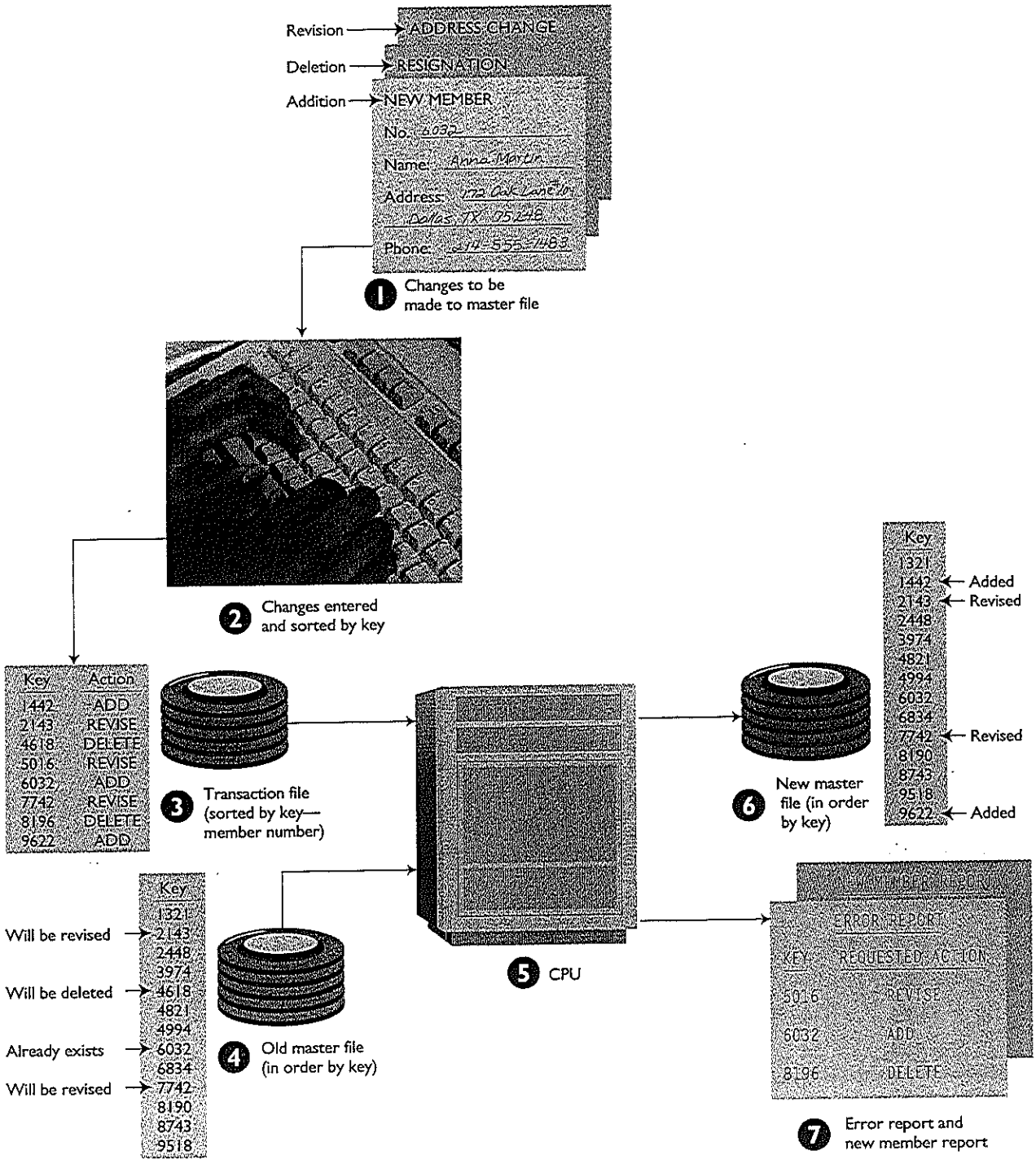


FIGURE 6-14

How batch processing works.

The purpose of this system is to update the health club's master address-label file. The updating will be done sequentially. (1) Changes to be made (additions, deletions, and revisions) are input with (2) a keyboard, sorted, and sent to a disk, where they are stored in (3) the transaction file. The transaction file contains records in sequential order, according to member number, from lowest to highest. The field used to identify the record is called the key; in this instance the key is the member number. (4) The master file is also organized by member number. (5) The computer matches transaction file data and master file data by member number to produce (6) a new master file and (7) an error report and a new member report. Note that since this was a sequential update, the new master file is a completely new file, not just the old file updated in place. The error report lists member numbers in the transaction file that were not in the master file and member numbers that were included in the transaction file as additions that were already in the master file.

Transaction Processing

Transaction processing is a technique of processing transactions—a bank withdrawal, an address change, a credit charge—in random order, that is, in any order in which they occur. Note that although batch processing also uses transactions, in that case they are grouped together for processing; the phrase *transaction processing* means that each transaction is handled immediately. Transaction processing is real-time processing. **Real-time processing** means that a transaction is processed fast enough for the result to come back and be acted on right away. For example, a teller at a bank can find out immediately what your bank balance is. For processing to be real-time, it must also be **online**—that is, the terminals must be connected directly to the computer. Transaction processing systems use disk storage because disks allow direct access to the desired record.

Advantages of transaction processing are immediate access to stored data (and thus immediate customer service) and immediate updating of the stored data. For example, a sales clerk could access the computer via a terminal to verify the customer's credit and also record the sale via the computer (Figure 6-15). Later, by the way, those updated records can be batch-processed to bill all customers.

Batch and Transaction Processing: The Best of Both Worlds

Numerous computer systems combine the best features of both methods of processing. Generally speaking, transaction processing is used for activities related to the current needs of people—especially workers and customers—as they go about their

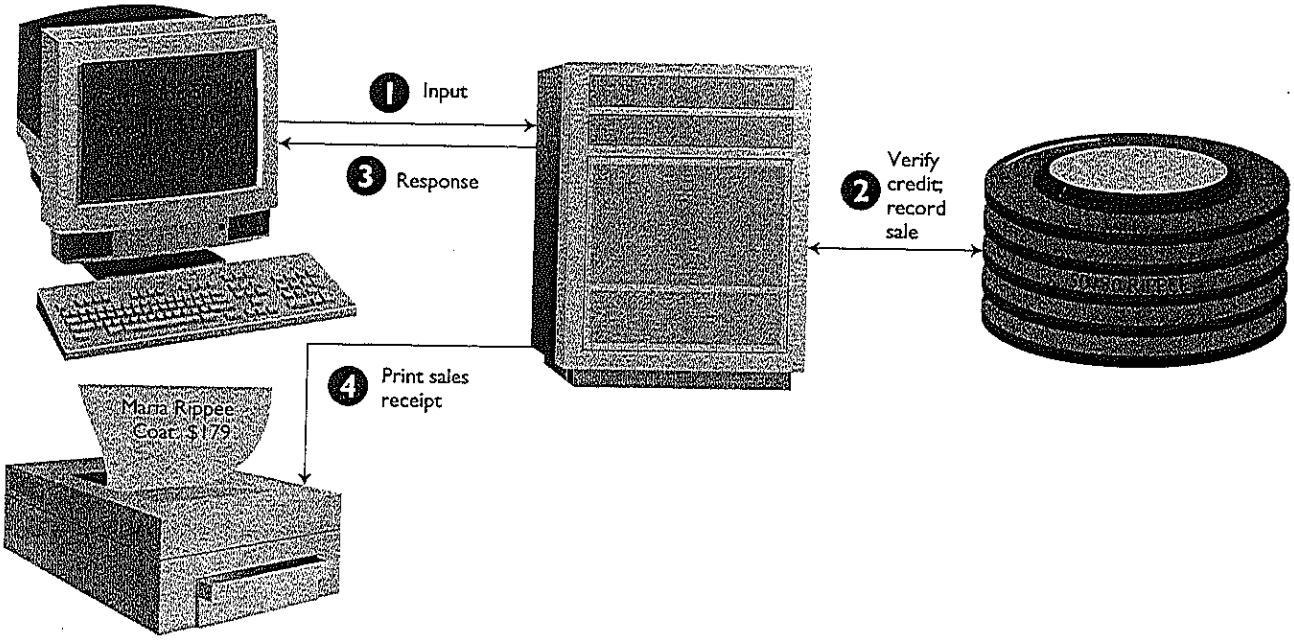


FIGURE 6-15

How transaction processing works.

The purposes of this retail sales system are to verify that a customer's credit is good, record the credit sale on the customer's record, and produce a sales receipt. Since customers may have the same name, the file is organized by customer account number rather than by name. Here Maria Rippee, account number 50130, wishes to purchase a coat for $179. (1) The sales clerk uses the terminal to input Maria's account number and the sale. (2) When the computer receives the data from the clerk, it uses the account number to find Maria's record on the disk file, verify her credit, and record the sale so that she will later be billed for it. (3) The computer returns an acceptance to the clerk's terminal. (4) The computer sends sales receipt information to the clerk's printer. All this is done within seconds while the customer is waiting. This example is necessarily simplified, but it shows a system that is real-time (immediate response) and online (directly connected to the computer).

daily lives. Batch processing, by comparison, can be done at any time, even in the middle of the night, without worrying about the convenience of the people who are ultimately affected by the processing.

A bank, for instance, may use transaction processing to check your balance and individually record your cash withdrawal transaction during the day at the teller window. However, the deposit that you leave in an envelope in an "instant" deposit drop may be recorded during the night by means of batch processing. Printing your bank statement is also a batch process. Most store systems also combine both methods: A point-of-sale terminal finds the individual item price as a sale is made and immediately updates inventory, while batch processing is used to produce daily and weekly sales reports.

Police license-plate checks for stolen cars work in the same way. As cars are sold throughout the state, the license numbers, owners' names, and so on, are updated in the motor vehicle department's master file, usually via batch processing on a nightly basis. But when police officers see a car that they suspect may be stolen, they can radio headquarters, where an operator with a terminal uses transaction processing to check the master file immediately to find out whether the car has been reported missing. Some officers have a laptop computer right in the car and can check the information themselves.

Auto junkyards, which often are computerized big businesses, can make an individual inquiry for a record of a specific part needed by a customer who is waiting on the phone or in person. As parts are sold, sales records are kept to update the files nightly using batch processing.

As you can see from these examples, both workers and customers eventually see the results of transaction processing in the reports output by batch processing. Managers will see further batch processing output in the form of information gathered and summarized about the processed transactions. Finally, new transaction processing is possible based on the results of previous batch processing.

▲

What is the future of storage? Perhaps holographic storage, which would be able to store thousands of pages on a device the size of a quarter and would be much faster than even the fastest hard drives. Whatever the technology, it seems likely that there will be greater storage capabilities in the future to hold the huge data files for law, medicine, science, education, business, and, of course, the government.

To have access to all that data from any location, we need data communications, the subject of the next chapter.

Networking:
Computer Connections

Networking: Computer Connections

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C H A P T E R

LEARNING OBJECTIVES

Describe the basic components of a network

Explain the methods of data transmission, including types of signals, modulation, and choices among transmission modes

Differentiate among the various kinds of communications links and appreciate the need for protocols

Describe various network configurations

List the components, types, and protocols of a local area network

Appreciate the complexity of networking

Describe some examples of networking

Miguel Santora owns a small but growing wholesale office supplies business in the Miami area. From the very beginning 10 years ago, Miguel's business has used computers, but only as stand-alone desktop tools. His two salespeople use word processing to prepare customer proposals and a database program to keep track of customer information. The office manager uses a simple accounting package to prepare payroll checks and maintain the general ledger. Miguel himself uses a spreadsheet program to keep track of inventory and a database program to store supplier information.

Two years ago, Miguel signed up with an Internet service and had modems installed in the salespeople's computers to allow them to communicate with their customers via e-mail. Shortly thereafter, he decided to get a modem for his own computer so that he could more easily keep track of bid requests posted on the Internet by the various local governments that were a major part of his customer base. He had to add two more telephone lines as he and the salespeople began to spend more time online. He briefly considered installing a network to connect the company's computers, but dismissed the idea as too expensive and complicated.

Last month, Miguel's son Carlos graduated from college with a degree in business, with a minor in information systems. Carlos immediately saw the need for a network and used his knowledge of LAN technology to

design and install a simple peer-to-peer LAN that allowed everyone in the office to communicate electronically with each other and to access the Internet at the same time without tying up the telephone lines.

You will not get enough detailed information from this chapter to design your own LAN as Carlos did, but you will gain an understanding of basic communications principals.

DATA COMMUNICATIONS

Mail, telephone, TV and radio, books, newspapers, and periodicals—these are the traditional ways in which users send and receive information. However, **data communications systems**—computer systems that transmit data over communications lines such as telephone lines or cables—have been evolving since the mid-1960s. Let us take a look at how they came about.

In the early days of computing, **centralized data processing** placed everything—all processing, hardware, and software—in one central location. But centralization proved inconvenient and inefficient. All input data had to be physically transported to the computer, and all processed material had to be picked up and delivered to the users. Insisting on centralized data processing was like insisting that all conversations between people occur face-to-face in one designated room.

In the late 1960s businesses began to use computers that were often at a distance from the central computer. These systems were clearly decentralized because the smaller computers could do some processing on their own, yet some also had access to the central computer. This new setup was labeled **distributed data processing**, which accommodates both remote access and remote processing. A typical application of a distributed data processing system is a business or organization with many locations—perhaps branch offices or retail outlets.

The whole picture of distributed data processing has changed dramatically with the advent of networks of personal computers. A **network** is a computer system that uses communications equipment to connect two or more computers and their resources. Distributed data processing systems are networks. Of particular interest in today's business world are local area networks (LANs), which are designed to share data and resources among several individual computer users in an office or building. Networking will be examined in more detail in later sections of this chapter.

The next section previews the components of a communications system, to give you an overview of how these components work together.

PUTTING TOGETHER A NETWORK: A FIRST LOOK

Even though the components needed to transmit data from one computer to another seem quite basic, the business of putting together a network can be extremely complex. This discussion begins with the initial components and then moves to the list of factors that a network designer needs to consider.

Getting Started

The basic configuration—how the components are put together—is rather straightforward, but there is a great variety of components to choose from, and the technology is ever changing. Assume that you have some data—a message—to transmit from one place to another. The basic components of a data communications system

that are used to transmit that message are (1) a sending device, (2) a communications link, and (3) a receiving device. Suppose, for example, that you work at a sporting goods store. You might want to send a message to the warehouse to inquire about a Wilson tennis racket, an item that you need for a customer. In this case the sending device is your computer terminal at the store, the communications link is the phone line, and the receiving device is the computer at the warehouse. However, as you will see later, there are many other possibilities.

There is another often-needed component that must be mentioned in this basic configuration, as you can see in Figure 7-1. This component is a modem, which is usually needed to convert computer data to signals that can be carried by the communications channel and vice versa. Modems will be discussed in detail shortly. (And, by the way, most modems now are internal, that is, plugged into an expansion slot within the computer's housing. We use the external variety in the illustration just to make a point.)

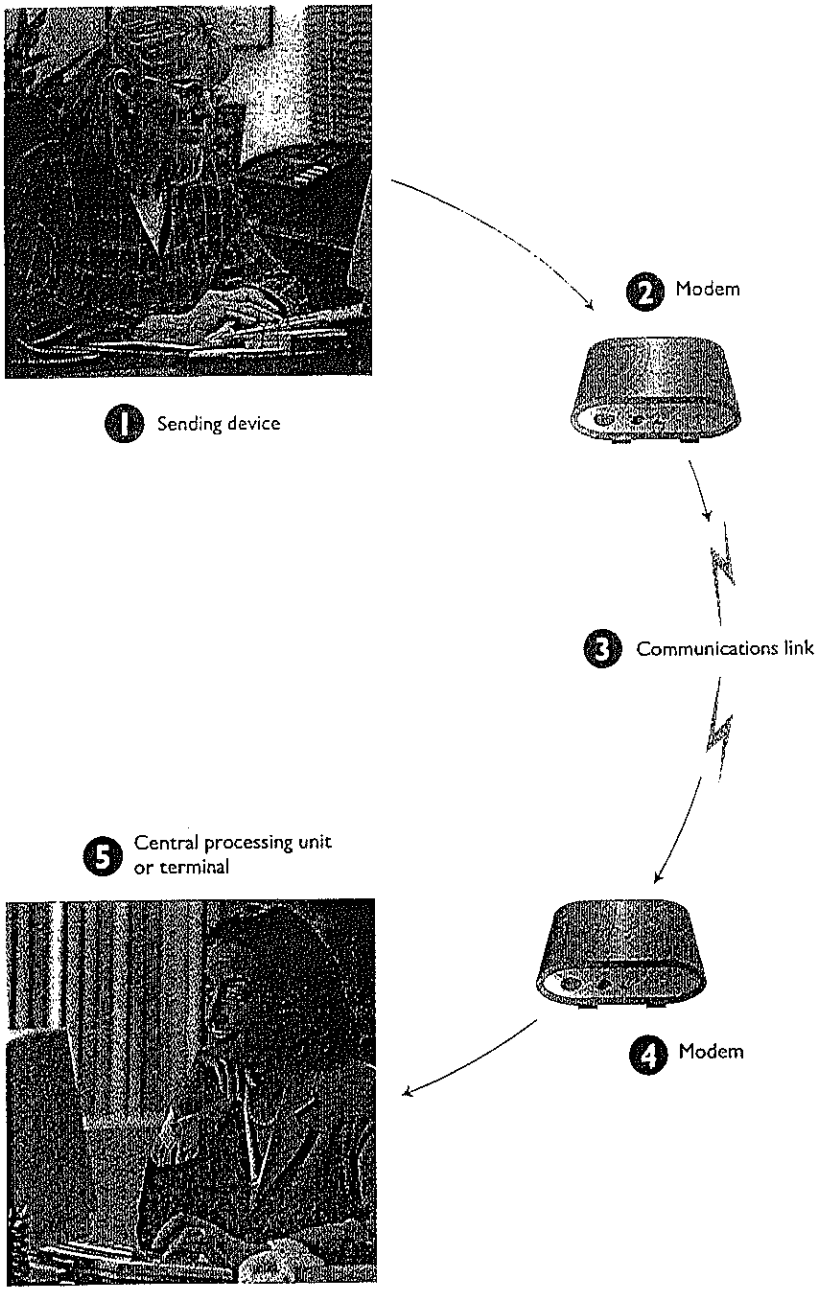


FIGURE 7-1

Communications system components.

Data originating from (1) a sending device is (2) converted by a modem to data that can be carried over (3) a communications link and (4) reconverted by a modem at the receiving end before (5) being received by the destination computer.

Network Design Considerations

The task of network design is a complex one, usually requiring the services of a professional specifically trained in that capacity. Although you cannot learn how to design a network in this brief chapter, you can ask some questions that can help you to appreciate what the designer must contemplate. Here is a list of questions that might occur to a customer who was considering installing a network; these questions also provide hints of what is to come in the chapter.

Question: I've heard that different kinds of modems and cables send data at different speeds. Does that matter?

Answer: Yes. The faster the better. Generally, faster means lower transmission costs too.

Question: Am I limited to communicating via the telephone system?

Answer: Not at all. There are all kinds of communications media, with varying degrees of speed, reliability, and cost. There are trade-offs. A lot depends on distance, too—you wouldn't choose a satellite, for example, to send a message to the office next door.

Question: So the geographical area of the network is a factor?

Answer: Definitely. In fact, network types are described by how far-flung they are: A *wide area network* might span the nation or even the globe, but a *local area network* would probably be campuswide or cover an office.

Question: Can I just cable the computers together and start sending data?

Answer: Not quite. You must decide on some sort of plan. There are various standard ways, called *topologies*, to physically lay out the computers and other elements of a network. Also available are standard software packages, which provide a set of rules, called a *protocol*, that defines how computers communicate.

Question: I know one of the advantages of networking is sharing disk files. Where are the files kept? And can any user get any file?

Answer: The files are usually kept on a particular computer, one that is more powerful than the other computers on the network. Access depends on the network setup. In some arrangements, for example, a user might be sent a whole file, but in others the user would be sent only the particular records needed to fulfill a request. The latter is called *client/server*, a popular alternative.

Question: This is getting complicated.

Answer: Yes.

These and other related considerations will be presented first, followed by an example of a complex network—or rather a set of networks. You need not understand all the details, but you will have an appreciation for the effort that is required to put together a network. Let us see how the components of a communications system work together, beginning with how data is transmitted.

DATA TRANSMISSION

A terminal or computer produces digital signals, which are simply the presence or absence of an electric pulse. The state of being on or off represents the binary number 1 or 0, respectively. Some communications lines accept digital transmission directly, and the trend in the communications industry is toward digital signals. However, most telephone lines through which these digital signals are sent were originally built for voice transmission, and voice transmission requires analog signals.

The next section describes these two types of transmission and then modems, which translate between them.

Digital and Analog Transmission

Digital transmission sends data as distinct pulses, either on or off, in much the same way that data travels through the computer. However, some communications media are not digital. Communications media such as telephone lines, coaxial cables, and microwave circuits are already in place for voice (analog) transmission. The easiest choice for most users is to piggyback on one of these. Therefore the most common communications devices all use **analog transmission,** a continuous electrical signal in the form of a wave.

To be sent over analog lines, a digital signal must first be converted to an analog form. It is converted by altering an analog signal, called a **carrier wave,** which has alterable characteristics (Figure 7-2a). One such characteristic is the **amplitude,** or height, of the wave, which can be increased to represent the binary number 1 (Figure 7-2b). Another characteristic that can be altered is the **frequency,** or number of times a wave repeats during a specific time interval; frequency can be increased to represent a 1 (Figure 7-2c).

Conversion from digital to analog signals is called **modulation,** and the reverse process—reconstructing the original digital message at the other end of the transmission—is called **demodulation.** An extra device is needed to make the conversions: a modem.

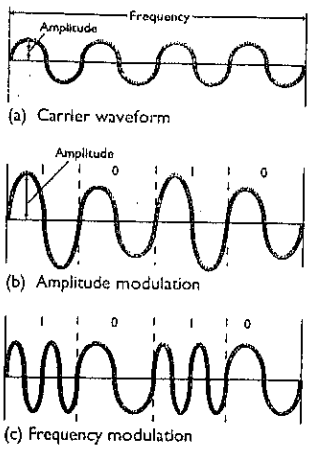


FIGURE 7-2

Analog signals.

(a) An analog carrier wave moves up and down in a continuous cycle. (b) The analog waveform can be converted to digital form through amplitude modulation. As is shown, the wave height is increased to represent a 1 or left the same to represent a 0. (c) In frequency modulation the amplitude of the wave stays the same but the frequency increases to indicate a 1 or stays the same to indicate a 0.

Modems

A **modem** is a device that converts a digital signal to an analog signal and vice versa (Figure 7-3). Modem is short for *mo*dulator/*dem*odulator.

TYPES OF MODEMS Modems vary in the way they connect to the telephone line. Most modems today are directly connected to the phone system by a cable that runs from the modem to the wall jack. A **direct-connect modem** is directly connected to the telephone line by means of a telephone jack. An **external modem** is separate from the computer. Its main advantage is that it can be used with a variety of computers. To have a modem that is literally out of sight, an **internal modem** board can be inserted into the computer; in fact, most personal computers today come with an internal modem as standard equipment.

Notebook and laptop computers without internal modems can use modems that come in the form of **PC cards,** originally known as PCMCIA cards, named for the Personal Computer Memory Card International Association. The credit card–sized PC

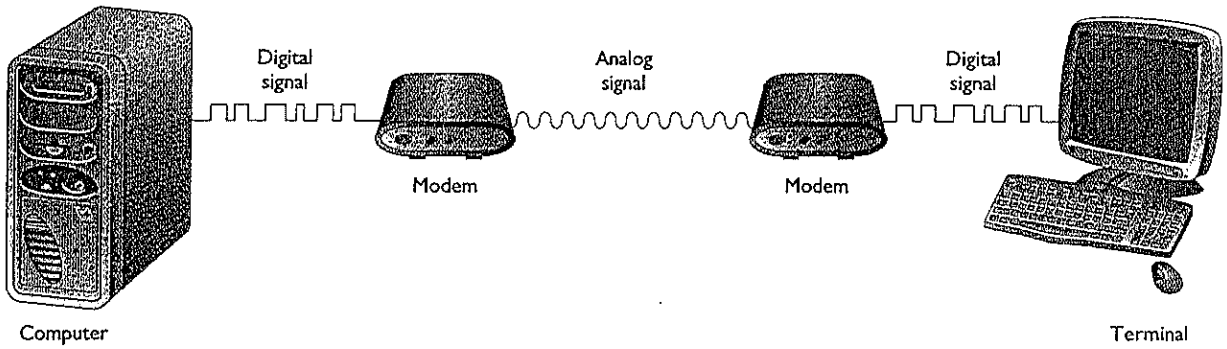


FIGURE 7-3

Modems.

Modems convert—modulate—digital data signals to analog signals for sending over communications links, then reverse the process—demodulate—at the other end.

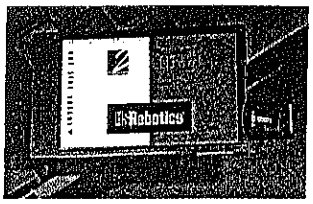


FIGURE 7-4

A PC card modem.

This PC card modem, although only the size of a credit card, packs a lot of power: data reception at 56,000 bytes per second. The card, shown here resting against a laptop keyboard, is slipped into a slot on the side of the laptop. Look closely at the right end of the modem and you can see the pop-out jack. So it goes in this order: Slide in the card, pop out the jack, and snap in the phone cord.

card slides into a slot in the computer (Figure 7-4). A cable runs from the PC card to the phone jack in the wall. PC cards and internal modems have given portable computers full connectivity capability outside the constraints of an office.

MODEM DATA SPEEDS The World Wide Web has given users an insatiable appetite for fast communications. This, as well as costs based on time use of services, provides strong incentives to transmit as quickly as possible. The old—some very old—standard modem speeds of 9600, 14,400, 28,800, and 33,600 **bits per second (bps)** have now been superseded by modems rated at 56,000 bps. Note, however, that because of FCC restrictions on power output, 56K modem receiving speeds are limited to 53 Kbps while transmission speeds top out at 31.2 Kbps. Line conditions and other variables often result in even lower speeds.

ISDN

As we noted earlier, communication via phone lines requires a modem to convert between the computer's digital signals and the analog signals used by phone lines. But what if another type of line could be used directly for digital transmission? One technology is called **Integrated Services Digital Network,** usually known by its acronym, **ISDN.** The attraction is that an ISDN adapter can move data at 128,000 bps, a vast speed improvement over any modem. Another advantage is that an ISDN circuit includes two phone lines, so a user can use one line to connect to the Internet and the other to talk on the phone at the same time. Still, ISDN is not a panacea. Although prices are coming down, initial costs are not inexpensive. You need both the adapter and phone service and possibly even a new phone line, depending on your current service. Also, monthly fees may be significant. Furthermore, ISDN is unavailable in some geographic areas.

Digital Subscriber Line

Digital subscriber line (DSL) service uses advanced electronics to send data over conventional copper telephone wires. Like traditional analog modems, DSL modems translate digital computer messages to analog signals to send over the lines and then convert the message back to digital signals at the destination. However, DSL spreads the analog signals over a large range of frequencies, acting as though dozens of modems were sending signals at the same time. xDSL is a catchall term for the varieties of DSL: ADSL, RADSL, and others. Since DSL lacks industry standards, various manufacturers are proposing their own variations. Currently, DSL service has a wide range of costs and speeds, depending on the variety and provider, but even the slowest speeds are many times faster than standard 56-K modems. Some providers offer a range of speeds, with pricing for the higher speeds aimed at the business market. DSL service can also share the line—you can use your telephone at the same time that you are surfing the Web. This saves the cost of an extra telephone line for Web access. Although prices vary, and special equipment is needed, the cost of basic DSL service is not much more than the cost of your current Internet service plus the cost of an extra line. However, to get DSL, you must be located within about three miles of your telephone company's switching office, and the DSL provider must have equipment installed in that office.

Cable Modems

Another approach, now available in limited markets but expanding rapidly, is the **cable modem,** a speedster that uses the coaxial television cables that are already in place without interrupting normal cable TV reception. Cable modems can be stunningly fast, receiving data at up to 10 million bps. Furthermore, a cable modem is always "on," like a TV channel, and does not require dialing or placing a call to get

started. However, all users on a cable segment share its capacity; as more households in a neighborhood use the service, everyone's speed decreases. One other problem is security. With relatively inexpensive equipment, anyone on a cable segment can view all the data traveling on that segment.

Cellular Modems

Cellular modems can be used to transmit data over the cellular telephone system. While this can be very useful for people on the move, the transmission speed is generally less than half what it would be on the regular telephone system. The use of cellular modems to connect to the Internet will be discussed in more detail in the next chapter.

Asynchronous and Synchronous Transmission

Sending data off to a far destination works only if the receiving device is ready to accept it. But *ready* means more than just available; the receiving device must be able to keep in step with the sending device. Two techniques that are commonly used to keep the sending and receiving units dancing to the same tune are asynchronous and synchronous transmission.

When **asynchronous transmission** (also called **start/stop transmission)** is used, a special start signal is transmitted at the beginning of each group of message bits—a group is usually just a single character. Likewise, a stop signal is sent at the end of the group of message bits (Figure 7-5a). When the receiving device gets the start signal, it sets up a timing mechanism to accept the group of message bits. This type of transmission is typically used for low-speed communications.

Synchronous transmission is a little trickier because a large block of characters is transmitted together in a continuous stream (Figure 7-5b). There are no call-to-action signals for each character. Instead, the sending and receiving devices are synchronized by having their internal clocks put in time with each other via a bit pattern transmitted at the beginning of the message. Furthermore, error-check bits are transmitted at the end of each message to make sure all characters were received properly. Synchronous transmission equipment is more complex and more expensive, but without all the start/stop bits, transmission is much faster.

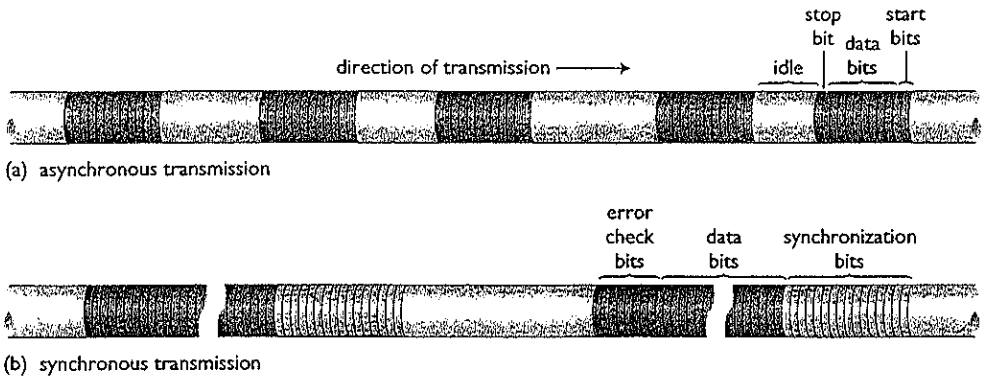


FIGURE 7-5

Asynchronous and synchronous transmission.

(a) Asynchronous transmission uses start/stop signals surrounding each character. (b) Page-width constraints preclude showing the true amount of continuous data that can be transmitted synchronously between start and stop characters. Unlike asynchronous transmission, which has one start/stop set per character, synchronous transmission can send many characters, even many messages, between one start/stop set. Note that synchronous transmission requires a set of error-check bits to make sure all characters were received properly.

Simplex, Half-Duplex, and Full-Duplex Transmission

Data transmission can be characterized as simplex, half-duplex, or full-duplex, depending on permissible directions of traffic flow: **Simplex transmission** sends data in one direction only; everyday examples are television broadcasting and arrival/departure screens at airports. **Half-duplex transmission** allows transmission in either direction but only one way at a time. An analogy is talk on a CB radio. In a bank a teller using half-duplex transmission can send the data about a deposit, and after it is received, the computer can send a confirmation reply. **Full-duplex transmission** allows transmission in both directions at once. An analogy is a telephone conversation in which, good manners aside, both parties can talk at the same time.

COMMUNICATIONS MEDIA

The cost for linking widely scattered computers is substantial, so it is worthwhile to examine the communications options. Telephone lines are the most convenient communications channel because an extensive system is already in place, but there are many other options. A **communications medium** is the physical means of data transmission. The range of frequencies that a medium can carry is known as its bandwidth; **bandwidth** is a measure of the capacity of the link.

Types of Communications Media

There are several types of communications media. Some may be familiar to you already.

WIRE PAIRS One of the most common communications media is the **wire pair,** also known as the **twisted pair.** Transmission of an electrical signal requires two conductors. In twisted pair wire, the two conductors are twisted around each other to reduce electrical interference and then sheathed in plastic. Multiple twisted pairs can be combined into a single cable (Figure 7-6a). Wire pairs are inexpensive. Furthermore, they are often used because they have already been installed in a building for other purposes or because they are already in use in telephone systems. However, they are susceptible to electrical interference, or noise. **Noise** is anything that causes distortion in the signal when it is received. High-voltage equipment, lightning, and even the sun can be sources of noise. Shielded twisted pair wiring has a metallic protective sheath, which reduces noise and increases the transmission speed capability.

COAXIAL CABLES Known for sending a strong signal, a **coaxial cable** consists of a center conductor wire surrounded by a layer of insulation, which in turn is surrounded by a braided outer conductor. The whole cable is then encased in a protective sheath (Figure 7-6b). Coaxial cable has much higher bandwidth and much less susceptibility to noise than does twisted pair wire. The cable that connects your TV to the cable TV system is the most common type of coaxial cable.

FIBER OPTICS Traditionally, most phone lines transmitted data electrically over wires made of metal, usually copper. These metal wires had to be protected from water and other corrosive substances. **Fiber-optic** technology eliminates this requirement (Figure 7-6c). Instead of using electricity to send data, fiber optics uses light. The cables are made of glass or plastic fibers, each thinner than a human hair, that can guide light beams for miles. Fiber-optic cable has much higher bandwidth than coaxial cable, yet the materials are substantially lighter and less expensive. Since it uses light rather than electricity, fiber-optic cable is immune to electrical noise and much more secure—any attempt at intercepting a signal would be easily noticed.

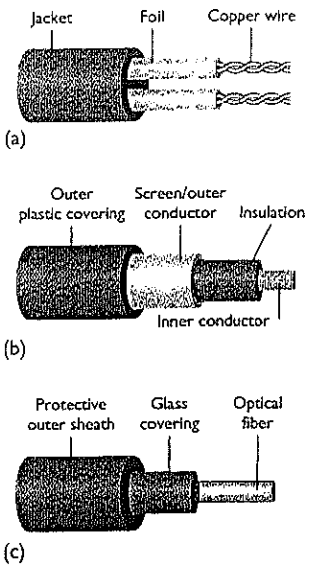


FIGURE 7-6

Communications links.

(a) Twisted-pair cable consists of pairs of wires twisted together, then grouped to form a cable, which is then insulated. (b) A coaxial cable is a single conductor wire surrounded by insulation. (c) Fiber optics consists of hairlike glass fibers that carry voice, television, and data signals.

MICROWAVE TRANSMISSION Another popular medium is **microwave transmission,** which uses what is called line-of-sight transmission of data signals through the atmosphere (Figure 7-7a). Since these signals cannot bend to follow the curvature of the earth, relay stations—often antennas in high places such as the tops of mountains and buildings—are positioned at points approximately 30 miles apart to continue the transmission. Microwave transmission offers high speed, cost-effectiveness, and ease of implementation. One problem is susceptibility to interference by weather conditions.

SATELLITE TRANSMISSION **Satellite transmission** is a form of microwave transmission in which a satellite acts as the relay station. Its basic components are **earth stations,** which send and receive signals, and a satellite component called a transponder (Figure 7-7b). The **transponder** receives the transmission from an earth station (the **uplink**), amplifies the signal, changes the frequency, and retransmits the data to a receiving earth station (the **downlink**). (The frequency is changed so that the weaker incoming signals will not be impaired by the stronger outgoing signals.) This entire process takes only a fraction of a second.

If a signal must travel thousands of miles, satellites are often part of the link. A message being sent around the world probably travels by cable or some other physical link only as far as the nearest earth-satellite transmission station (Figure 7-8). From there it is beamed to a satellite, which sends it back to another transmission station near the data destination. Communications satellites are launched into space, where they are suspended about 22,300 miles above the earth. Why 22,300 miles? That is where satellites reach geosynchronous orbit—the orbit that allows them to remain positioned over the same spot on the earth. However, not all satellites are in geosynchronous orbit; some are much closer to the earth.

MIXING AND MATCHING A network system is not limited to one kind of link and, in fact, often works in various combinations, especially over long distances. An office worker who needs data from a company computer on the opposite coast will most likely use wire pairs in the phone lines, followed by microwave and satellite transmission (Figure 7-9). Astonishingly, the trip across the country and back, with a brief stop to pick up the data, may take only a second or two.

Surf and Sleep

When you travel, what do you look for as the most important feature of a hotel room? A comfortable bed? A quiet room? Cable TV? Is a high-speed Internet connection on your list? If you travel on business a lot and have to maintain contact with your customers, your office, or your colleagues, it probably is.

By the time you read this, both the Hyatt International and Holiday Inn hotel chains say, every room in their hotels will be provided with an Ethernet socket. All you have to do is plug your laptop's network card in to get a broadband Internet connection. If you run into any problems, both chains will have around-the-clock tech support available. These two chains are not the only ones planning to provide this service. One market research firm estimates that 80% of hotel rooms will be wired by 2002.

Protocols

A **protocol** is a set of rules for the exchange of data between a terminal and a computer or between two computers. Think of a protocol as a sort of precommunication agreement about the form in which a message or data is to be sent and receipt is to be acknowledged. Protocols are handled by hardware and software related to the network, so users need worry only about their own data.

PROTOCOL COMMUNICATIONS Two devices must be able to ask each other questions (Are you ready to receive a message? Did you get my last message? Is there trouble at your end?) and to keep each other informed (I am sending data now.). Of course, we are referring here to binary codes, not actual words. In addition, the two devices must agree on how data is to be transferred, including data transmission speed and duplex setting. But this must be done in a formal way. When communication is desired among computers from different vendors (or even different models from the same vendor), the software development can be a nightmare because different vendors use different protocols. Standards help.

SETTING STANDARDS Standards are important in the computer industry; it saves money if users can all coordinate effectively. Communications standards exist and are constantly evolving and being updated for new communications forms. Perhaps the most important protocol is the one that makes Internet universality possible. Called **Transmission Control Protocol/Internet Protocol (TCP/IP),** this protocol

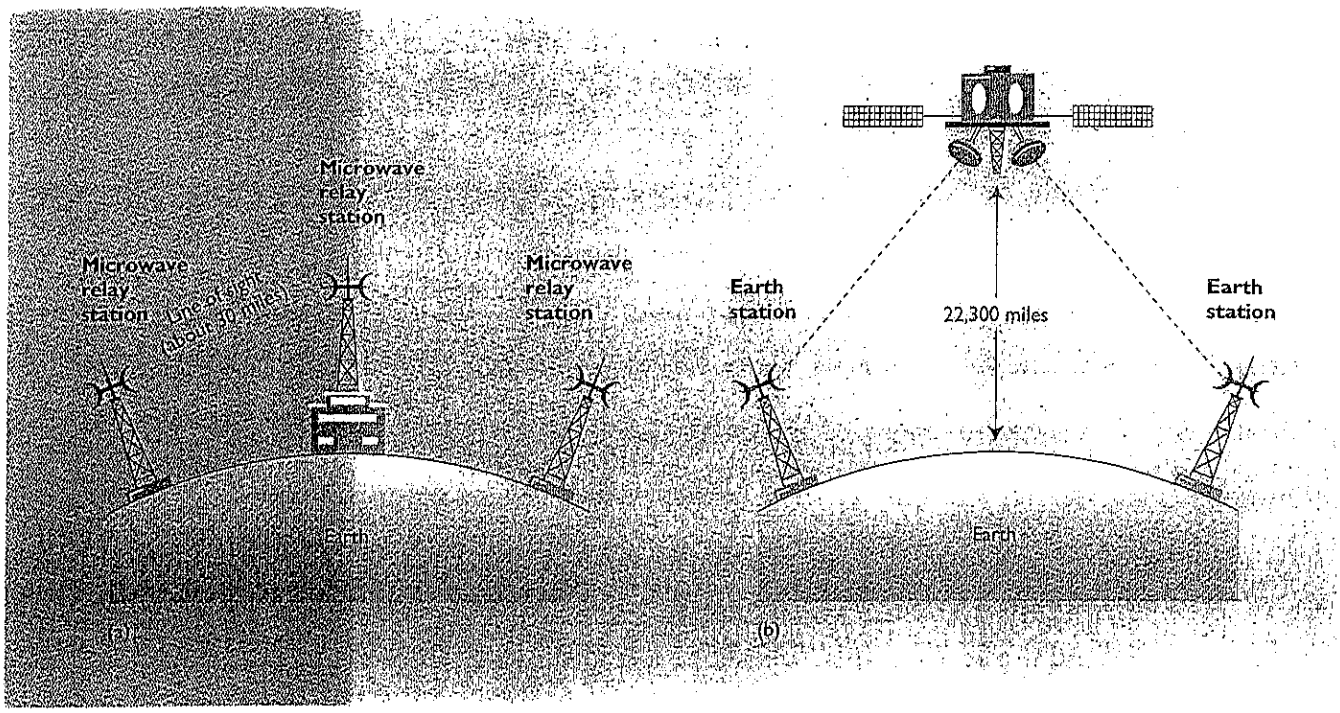


FIGURE 7-7

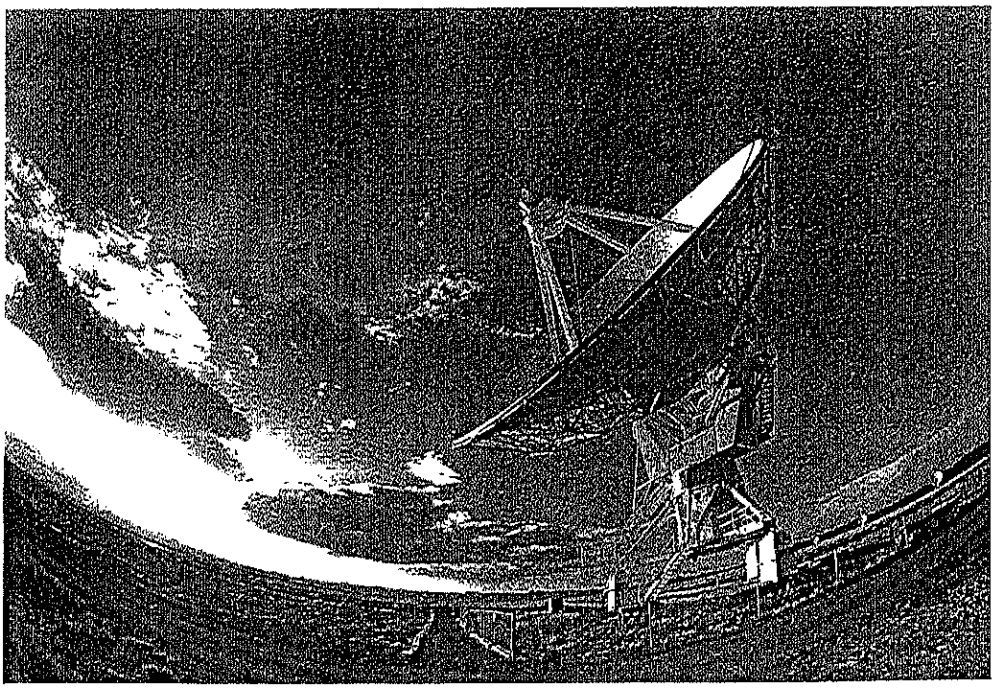
Microwave and satellite transmission.

(a) To relay microwave signals, dish-shaped antennas such as these are often located atop buildings, towers, and mountains. Microwave signals can follow a line-of-sight path only, so stations must relay this signal at regular intervals to avoid interference from the curvature of the earth. (b) In satellite transmission a satellite acts as a relay station and can transmit data signals from one earth station to another. A signal is sent from an earth station to the relay satellite, which changes the signal frequency before transmitting it to the next earth station.

FIGURE 7-8

A satellite dish.

A satellite dish is not usually the prettiest sight on the horizon, but a photographer has taken this shot of a dish with an exaggerating "fish-eye" lens, emphasizing the relationship between the dish and the signals that come from the satellite in space.



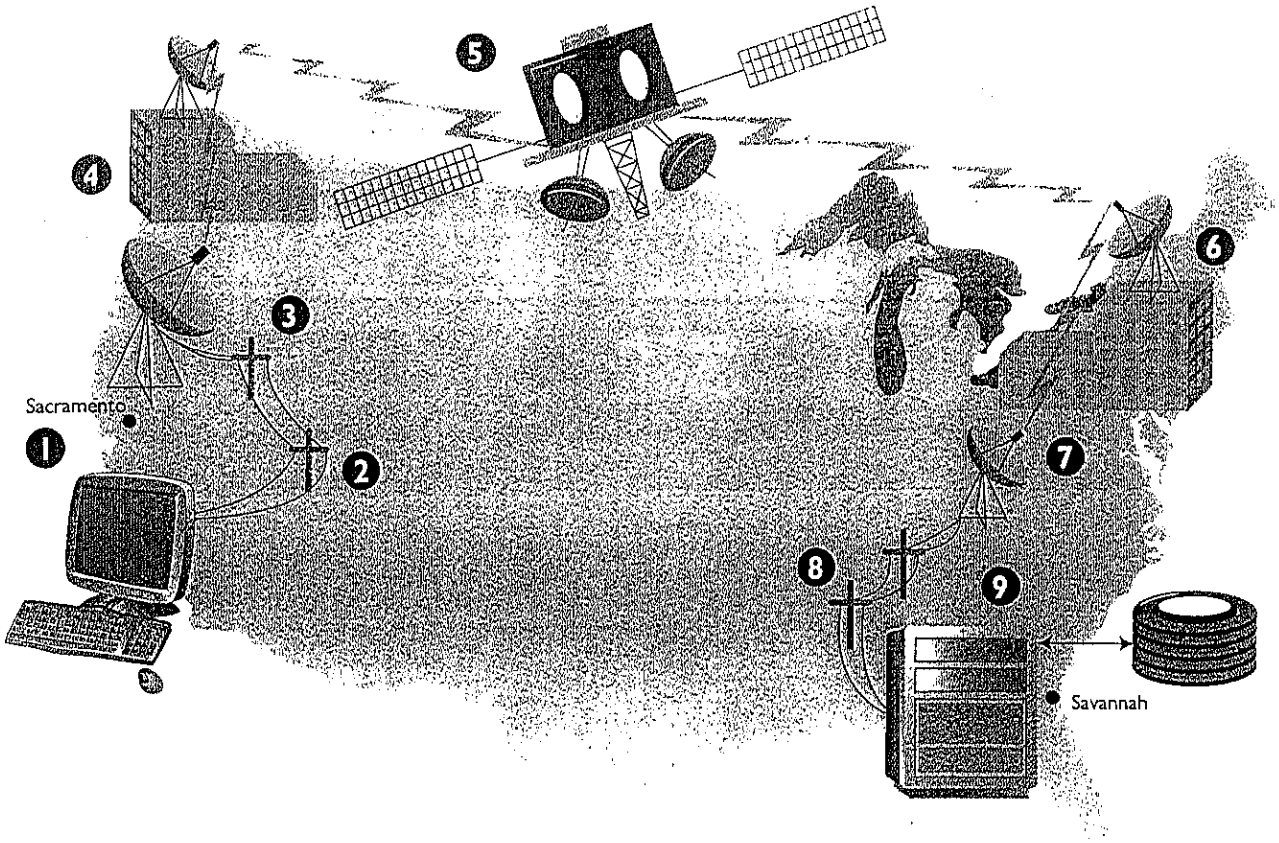


FIGURE 7-9

A variety of communications links.

Say that an accountant working in the Sacramento office needs certain tax records from the headquarters computer files in Savannah. One possibility for the route of the user request and the response is as follows: (1) The accountant makes the request for the records, which (2) goes out over the local phone system to (3) a nearby microwave station, which transmits the request to (4) the nearest earth-satellite transmission station, where (5) it is relayed to a satellite in space, which relays it back to earth (6) to an earth-satellite station near Savannah, where it is sent to (7) a microwave station and then (8) via the phone lines to (9) the headquarters computer. Once the tax records are retrieved from the Savannah computer files, the whole process is reversed as the requested records are sent back to Sacramento.

permits any computer at all to communicate with the Internet. This is rather like everyone in the world speaking one language.

NETWORK TOPOLOGIES

BUILDING A NETWORK

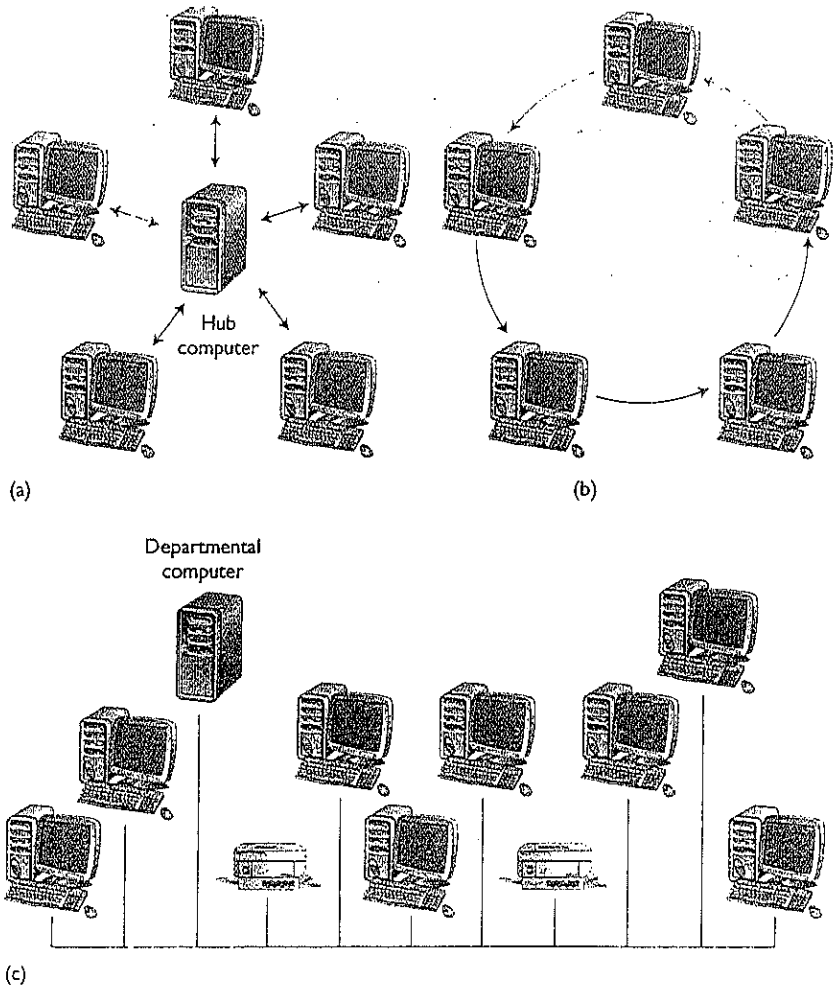
Prentice Hall EXPLORE Generation it

The physical layout of a network is called a **topology.** There are three common topologies: star, ring, and bus networks. In a network topology a component is called a **node,** which is usually a computer on a network. (The term "node" is also used to refer to any device that is connected to a network, including the server, computers, and peripheral devices such as printers.)

A **star network** has a central (hub) computer that is responsible for managing the network (Figure 7-10a). All messages are routed through the hub computer, which acts as a traffic cop to prevent collisions. Any connection failure between a node and the hub will not affect the overall system. However, if the hub computer fails, the network fails.

FIGURE 7-10

Topologies.
(a) The star network topology has a central computer that runs the network. (b) The ring network topology connects computers in a circular fashion. (c) The bus network topology connects all nodes in a line and can preserve the network if one computer fails.



A **ring network** links all nodes together in a circular chain (Figure 7-10b). Data messages travel in only one direction around the ring. Each node examines any data that passes by to see whether that node is the addressee; if not, the data is passed on to the next node in the ring. Since data travels in only one direction, there is no danger of data collision. However, if one node fails, the ring is broken and the entire network fails.

A **bus network** has a single line (the bus) to which all the network nodes are attached (Figure 7-10c). Computers on the network transmit data in the hope that it will not collide with data transmitted by other nodes; if this happens, the sending node simply tries again. Nodes can be attached to or detached from the network without affecting the network. Furthermore, if one node fails, it does not affect the rest of the network.

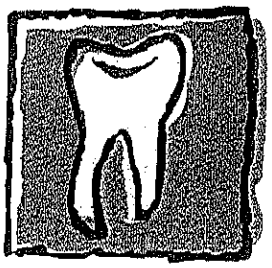
WIDE AREA NETWORKS

Networks can be classified by the geographical area they cover. The largest in scope is the **wide area network (WAN),** which can span the world or just link computers in adjacent cities.

Communication Services

A WAN typically uses communication services provided by **common carriers,** companies that are licensed by the Federal Communications Commission (FCC) to pro-

MAKING CONNECTIONS **Bluetooth**



Notebook computers, cellular phones, and personal digital assistants have certainly been a boon for travelers, especially business professionals. No matter what your job is, or where it takes you, there is a device you can carry that will make connectivity easier. There is just one problem: For every device you add to your mobile computing arsenal, you must have another wire, cradle, or adapter of some sort to connect that device to your personal computer, as well as software to make the two devices talk to each other. But how much more can your briefcase take before it explodes in a mass of tangled wires?

Short-Range Radio Technology

Instead, you could do away with the wires and insert small chips—radio chips. Suppose now that those devices in your briefcase can communicate with each other—wirelessly. The ability to have wireless connectivity around the globe is a powerful concept, but getting connected across a room is equally important. That is the premise behind Bluetooth, the code name for a low-cost, wireless communications solution based on short-range radio technology.

Scenarios

What could you actually do with Bluetooth? Here are some possibilities:

- Imagine that you are in a meeting with your notebook computer open in front of you. Suddenly, the cursor begins to blink, and a new e-mail message is displayed on the screen. Your computer is not plugged into anything, and your cellular phone is in your briefcase under the table, but you are receiving e-mail over the wireless network. This is possible because your notebook is communicating with your cell phone, which in turn is communicating with the wireless network via the Bluetooth technology radio chip.
- You could walk into your office, put your briefcase down, and have the notebook computer inside it automatically sense that it is in range of your desktop and initiate the exchange of data to update both systems.
- You could walk into a meeting and automatically send copies of your presentation to the computers of everyone in the room.

You could get off a plane with a cell phone in hand and a notebook computer in your carry-on luggage and transfer all the notebook's incoming and outgoing e-mail by simply pressing a couple of buttons on the phone. Data would be transferred between the notebook and the phone using Bluetooth; the phone would then transmit the notebook's data over the cellular phone network. You would not even need to remove the notebook from your carry-on bag.

How It Will Work

Bluetooth technology will use integrated radio transceivers built on tiny microchips about a half-inch square. Bluetooth chips will be embedded into both computer and communication devices. Thus begins the long-anticipated convergence of computing and communications. Bluetooth technology will use—bear with us for a minute—the 2.45-GHz ISM (Industrial Scientific Medical) frequency band of the radio spectrum, which is free and is not licensed by the Federal Communications Commission (FCC). This means that you will not have to get permission from the FCC to use the band and that Bluetooth devices can be used globally. Equipped with the radio chip, Bluetooth devices will be able to talk to one another—exchanging voice and data information—at data speeds up to 1MB per second, within a range of about 30 feet. Unlike existing infrared networking, the radio-based technology of Bluetooth will work when line of sight is not available; the connecting devices need not even be in the same room. Each device will have a unique 48-bit address. Built-in encryption and verification will be provided.

vide these services to the public. These services fall into two general categories: switched and dedicated. A **switched,** or **dial-up, service** establishes a temporary connection between two points when a call is placed. The connection remains in place for the duration of the call. When the call is ended, the connection is broken. The public telephone system, sometimes referred to as **plain old telephone service (POTS),** is the most common dial-up system. A **dedicated service** provides a permanent connection between two or more locations. Companies may build their own dedicated circuits using one or more of the media (cable, microwave, fiber optics, or satellite) described earlier, or they may lease dedicated circuits from a common carrier, in which case the circuits are referred to as **leased lines.** A company may lease standard telephone lines, ISDN or DSL lines, or larger-capacity digital lines. The two most common high-capacity digital lines are the T1 and T3 lines. The T1 line has a capacity of 1.54 Mbps, enough to carry 24 simultaneous voice connections. The T3 line combines the capacity of 28 T1 lines, or 43 Mbps. These lines are quite expensive

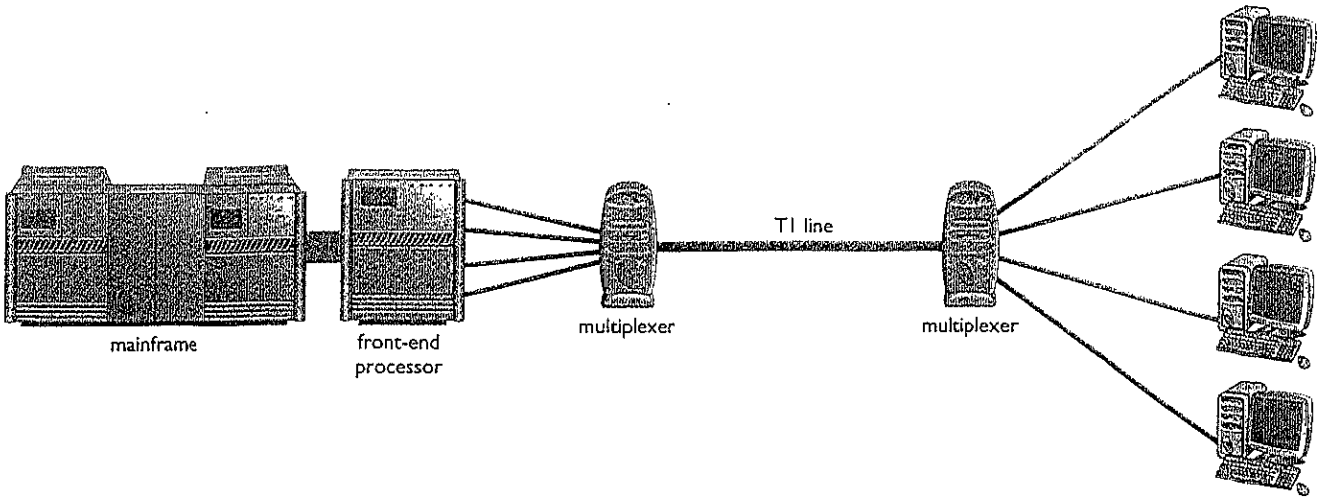


FIGURE 7-11

Multiplexer.

A multiplexer (MUX) combines the data from several slow-speed devices for transmission over a high-speed circuit.

and are justified only for high-volume continuous traffic. Choosing among all these service options is a very complex task, one performed by network design experts.

WAN Hardware and Software

WANs are normally controlled by one or more mainframe computers, called **host computers.** These host computers typically connect to the WAN through a **front-end processor (FEP),** which is actually a computer in itself. Its purpose is to relieve the host computer of some of the communications tasks and thus free it for processing applications programs. In addition, a front-end processor usually performs error detection and recovery functions. The multiplexer is another device that is often found in WANs. A **multiplexer** combines the data streams from a number of slow-speed devices, such as PCs or terminals, into a single data stream for transmission over a high-speed circuit, such as a T1 line (Figure 7-11.) A multiplexer on the other end of the transmission would be necessary to break the high-speed stream into its component parts for processing.

In business a personal computer sending data over a WAN is probably sending it to a mainframe computer. Since these larger computers are designed to be accessed by terminals, a personal computer can communicate with a mainframe only if the personal computer emulates, or imitates, a terminal. This is accomplished by using **terminal emulation software** on the personal computer. The larger computer then considers the personal computer or workstation as just another user input/output communications device—a terminal.

When smaller computers are connected to larger computers, the result is sometimes referred to as a **micro-to-mainframe** link. If a personal computer is being used as a terminal, **file transfer software** permits users to download data files from the host or upload data files to the host. To **download** a file means to retrieve it from another computer. To **upload,** a user sends a file to another computer.

LOCAL AREA NETWORKS

A **local area network (LAN)** is a collection of computers, usually personal computers, that share hardware, software, and data. In simple terms, LANs hook personal computers together through communications media so that each personal computer

can share the resources of the others. As the name implies, LANs cover short distances, such as within a campus, building, or office.

Local Area Network Components

LANs do not use the telephone network. Networks that are LANs are made up of a standard set of components:

- All networks need some system for interconnection. In some LANs the nodes are connected by a shared **network cable.** Low-cost LANs are connected with twisted wire pairs, but many LANs use coaxial cable or fiber optic cable, which may be more expensive but are faster. Some local area networks, however, are **wireless,** using infrared or low-power radio wave transmissions instead of cables. Wireless networks are easy to set up and reconfigure, since there are no cables to connect or disconnect, but they have slower transmission rates and limit the distance between nodes.
- A **network interface card,** sometimes called a **NIC,** connects each computer to the wiring in the network. A NIC is a circuit board that fits in one of the computer's internal expansion slots. The card contains circuitry that handles sending, receiving, and error checking of transmitted data.
- Similar networks can be connected by a **bridge,** a hardware/software combination that recognizes the messages on a network and passes on those addressed to nodes in other networks. For example, a fabric designer whose computer is part of a department LAN for a textile manufacturer could send cost data, via a bridge, to someone in the accounting department whose computer is part of another company LAN, one used for financial matters. It makes sense for each department, design and finance, to maintain separate networks because their interdepartmental communication is only occasional. A **router** is a special computer that directs communications traffic when several networks are connected together. If traffic is clogged on one path, the router can determine an alternative path. More recently, now that many networks have adopted the Internet protocol (IP), routers are being replaced with **IP switches,** which are less expensive and, since no protocol translation is needed, faster than routers.
- A **gateway** is a collection of hardware and software resources that lets a node communicate with a computer on another dissimilar network. One of the main tasks of a gateway is protocol conversion. For example, a gateway could connect an attorney on a local area network to a legal service offered through a wide area network.

Now let us move on to the types of local area networks. Two ways to organize the resources of a LAN are client/server and peer-to-peer.

Client/Server Networks

A **client/server** arrangement involves a **server,** the computer that controls the network. In particular, a server has hard disks holding shared files and often has the highest-quality printer, another resource to be shared (Figure 7-12). The clients are all the other computers on the network. Under the client/server arrangement, the clients sent requests for service to the server. The server fulfills the request and sends any results back to the client. A computer that has no disk storage ability and is used basically to send input to the server for processing and then receive the output is called a **thin client.** Sometimes the server and the client computer share processing. For example, a server, on request from the client, could search a database of cars in the state of Maryland and come up with a list of all Jeep Cherokees. This data could be passed on to the client computer, which could process the data further, perhaps looking for certain equipment or license plate letters. In this example the server is providing database service. This method can be contrasted with a **file server** rela-

The Networked Home

Networks aren't just for businesses anymore. As more and more families become multiple-PC households, the need for home networking grows.

Two possible approaches to home networking are borrowed from the office environment. You can connect all your computers with cables and set up a miniature Ethernet or you can set up a wireless network using low-power, high-frequency radio transceivers on each PC. However, if you find stringing a mess of cables all over the house unappealing and the wireless approach is too pricey, consider two other alternatives that use existing home wiring. One approach uses the phone lines in your house to transmit data between computers without interfering with normal telephone use. If you don't have telephone jacks near all your computers, you can use your home's electrical wiring to connect your computers. Special adapters plug into the computer's parallel port, then into any wall outlet.

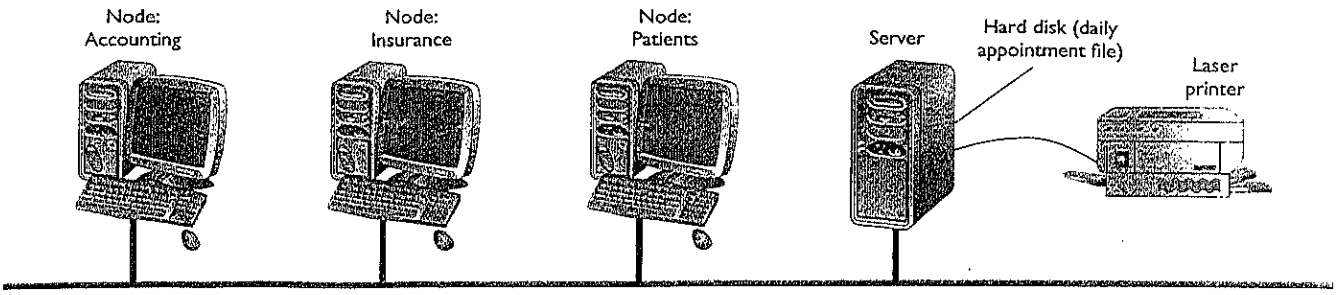


FIGURE 7-12

Server and peripheral hardware.

In this network for a clinic with seven doctors, the daily appointment records for patients are kept on the hard disk associated with the server. Workers who, using their own computers, deal with accounting, insurance, and patient records can access the daily appointment file to update their own files.

tionship, in which the server transmits the entire file to the client, which does all its own processing. In the Jeep example, the entire car file would be sent to the client, instead of just the extracted Jeep Cherokee records (Figure 7-13). Other types of services that a server might provide to clients include print services and file storage services. In large LANs, separate servers might provide each of these services.

Client/server has attracted a lot of attention because a well-designed system reduces the volume of data traffic on the network and allows faster response for each client computer. Also, since the server does most of the heavy work, less-expensive computers can be used as nodes.

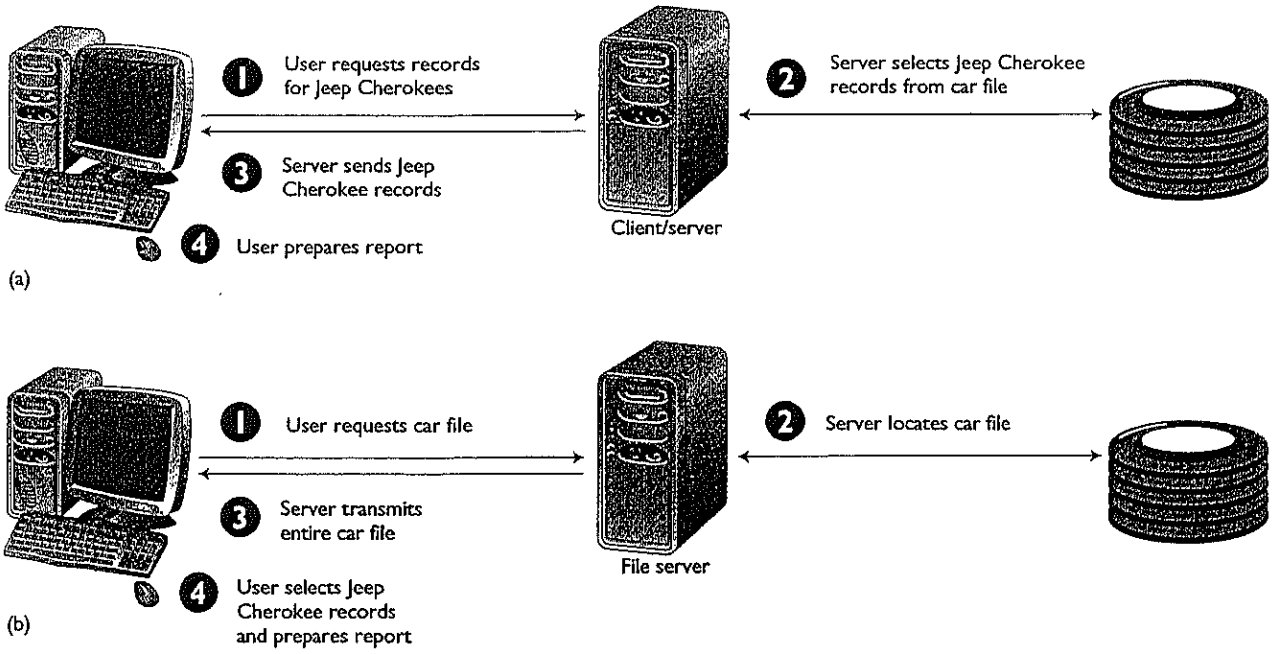


FIGURE 7-13

Client/server contrasted with file server.

(a) In a client/server relationship, (1) a user makes a request to the server to select only Jeep Cherokee records from a state car file; (2) the server does so and (3) sends the records back to the user, who (4) uses those specific records to prepare a report. (b) In a file server relationship, (1) a user asks for the entire state car file, which (2) the server locates and then (3) transmits to the user, who then (4) selects the Jeep Cherokee records and prepares a report. The client/server setup places most of the processing burden on the more powerful server and also significantly reduces the amount of data being transferred between server and user.

Peer-to-Peer Networks

All computers in a **peer-to-peer** arrangement have equal status; no one computer is in control. With files and peripheral devices distributed across several computers, users share one another's data and devices as needed. Peer-to-peer networks are common in small offices with perhaps a dozen personal computers. The main disadvantage is lack of speed—peer-to-peer networks slow down under heavy use. Many networks are hybrids, containing elements of both client/server and peer-to-peer arrangements.

Local Area Network Protocols

As we have already noted, networks must have a set of rules—protocols—that are used to access the network and send data. Recall that a protocol is embedded in the network software. The two most common network protocols for LANs are Ethernet and the Token Ring network.

Ethernet, the network protocol that dominates the industry, uses a high-speed network cable. Ethernet uses a bus topology and is inexpensive and relatively simple to set up. Since all the computers in a LAN use the same cable to transmit and receive data, they must follow a set of rules about when to communicate; otherwise, two or more computers could transmit at the same time, causing garbled or lost messages. Operating much like a party line, a computer "listens" to determine whether the cable is in use before transmitting data. If the cable is in use, the computer must wait. When the cable is free from other transmissions, the computer can begin transmitting immediately. This transmission method is called by the fancy name **carrier sense multiple access with collision detection,** or **CSMA/CD.**

If by chance two computers transmit data at the same time, the messages collide. When a **collision** occurs, the data is destroyed and the resulting electrical noise is sensed by the transmitting computers. Each computer waits a random period of time (a small fraction of a second) and then transmits again. Since the wait period for each computer is random, it is unlikely that they will begin transmitting again at the same time. However, either may have a collision with another transmitting computer. When too many computers are attempting to transmit too many messages, many collisions occur and performance is degraded.

A **Token Ring network,** which is closely associated with IBM, works on the concept of a ring network topology, using a token—a kind of electronic signal. The method of controlling access to the shared network cable is called **token passing.** The idea is similar to the New York City subway: If you want to ride—transmit data—you must have a token. However, unlike the subway, only one token is available. The token circulates from computer to computer along the ring-shaped LAN.

When a computer on the network wishes to transmit, it waits for an empty token, then attaches its message to the token and transmits. The receiving computer strips the token from the message and sends the token back onto the network. Since only one token is circulating around the network, only one device is able to access the network at a time. Some larger networks allow for multiple tokens, permitting more than one message at a time to be transmitted.

THE WORK OF NETWORKING

The use of automation in the office is as varied as the offices themselves. As a general definition, however, **office automation** is the use of technology to help people do their jobs better and faster. Much automated office innovation is based on communications technology. This section begins with several important office technology topics: electronic mail, facsimile technology, groupware, teleconferencing, and electronic data interchange.

Social Spam

Lots of people like Spam, but few folks like "spam," the nickname for unsolicited commercial junk mail. But there is another junk mail problem, which has been largely unaddressed by the media. What do we do with the funny lists and jokes from friends? These are commonly sent to everyone on a person's e-mail address list, often with a note such as "I thought this was hilarious." In fairly short order, you will be getting several "hilarious" messages a day. There are thousands of such lists and jokes, and they whirl around the Internet with incredible speed.

What to do? If you are receiving such messages at work, it is fairly easy to write to the senders and say that you must cut down on personal messages at work. Another approach, whether at work or at home, is to plead overload: "Sorry, I barely have time to get through all my e-mail."

Electronic Mail

Electronic mail, or **e-mail,** is the process of sending a message directly from one computer to another, where it is stored until the recipient chooses to receive it. A user can send data to a colleague downstairs, a message across town to that person who is never available for phone calls, a query to the headquarters office in Switzerland, and even memos simultaneously to regional sales managers in Chicago, Raleigh, and San Antonio. Electronic mail users shower it with praise. It can reach many people with the same message, it reduces the paper flood, and it does not interrupt meetings the way a ringing phone does. Since e-mail does not require both participants to be present at the time of transmission, it is a boon to people who work on the same project but live in different time zones.

Facsimile Technology

Operating something like a copy machine connected to a telephone, **facsimile technology** uses computer technology and communications links to send graphics, charts, text, and even signatures almost anywhere in the world. The drawing—or whatever—is placed in the facsimile machine at one end, where it is digitized. A built-in modem converts the digital signal to analog form and transmits it through the telephone system, where it is received and reassembled at the other end to form a nearly identical version of the original picture. All this takes only minutes—or less. Facsimile is not only faster than overnight delivery services, it is less expensive. Facsimile is abbreviated **fax,** as in "I sent a fax to the Chicago office." The word "fax" is also used as a verb, as in "I faxed her the contract."

Personal computer users can send and receive faxes directly by means of a **fax modem,** which also performs the usual modem functions. Virtually all modems sold today have fax capability. A user can send computer-generated text and graphics as a fax. When a fax comes in, it can be reviewed on the computer screen and printed out only if necessary. Be aware that a fax transmission is basically a "picture" of the original. For the recipient of a faxed document to process it with word processing software, the document must first be converted into text using optical character recognition (OCR) software.

Groupware

Groupware is any kind of software that lets a group of people share things or track things together. The data that the workers share is in a database on disk. But the key to their being able to share that data is their access to it via communications lines. We mention groupware to emphasize the role of communications systems in letting people, who may be in far-flung locations, work together.

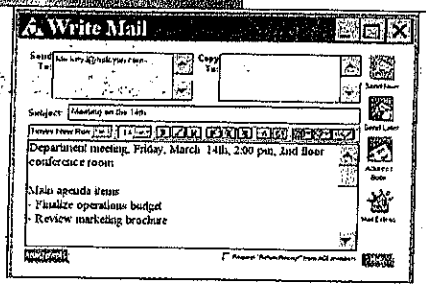
Teleconferencing

An office automation development with cost-saving potential is **teleconferencing,** a method of using technology to bring people and ideas together despite geographic barriers. There are several varieties of teleconferencing, but most common today is **videoconferencing,** whose components usually include a large screen, video cameras that can send live pictures, and an online computer system to record communication among participants (Figure 7-14). Although this setup is expensive to rent and even more expensive to own, the costs seem trivial when compared with travel expenses—airfare, lodging, meals—for in-person meetings.

Videoconferencing has some drawbacks. Some people are uncomfortable about their appearance on camera. A more serious fear is that the loss of personal contact will detract from some business functions, especially those related to sales or negotiations.

GETTING PRACTICAL

Everything You Always Wanted to Know About E-Mail



- **I know generally what hardware and software need to be in place for e-mail, but how do I get in on the action?** You must first sign up with an online service, Internet service provider, or e-mail service, probably giving a credit card number for monthly payments and then being prompted to make up your own e-mail address and password. Thus established, you will probably click a screen icon to invoke your e-mail service whenever you want it.
- **I don't know how I actually send e-mail.** Your e-mail service or e-mail software will provide menus of choices, one of which is to write e-mail. The look of the screen may vary, but generally, all e-mail write systems have the same elements—a place for the e-mail address of the recipient, a place to put the message title, and a place for you to type your message. You can see these three elements on the America Online (AOL) screen shown here.
- **That's it?** Well, some e-mail software will let you get a bit fancier if you wish. For example, as you can see here, AOL offers buttons for changing fonts, checking spelling, adding a photo, and so on.
- **How does my message get to the recipient?** First, you click a Send button—in this case, Send Now if you are online (connected to AOL) or Send Later if you are offline. AOL, or whatever service you are using, will take care of delivery.
- **How do I know someone's e-mail address?** Just ask. You will have a collection of your friends' and colleagues' addresses in no time. And since you are not expected to memorize them, just keep them in the clickable address book. There are also several Internet e-mail directories where you can look up people's e-mail addresses.
- **How do I get my own e-mail?** It varies by the service, of course, but generally, when you go online, you will be informed that you have mail; AOL intones the famous "You've got mail!" In offices where users are online to their company servers all day, a quiet chiming sound may indicate that new mail has arrived. Other systems simply display a small window on the screen, with a message that mail has arrived. You click the list of mail and click each item to read it. You may also, of course, choose to ignore it.
- **Can I just stay online for hours writing e-mail?** Theoretically, yes, but it is not a good idea. You would be tying up a connection unnecessarily. You can write your e-mail offline and then, once the mail is ready, go online and send it. Most people write—and read—their e-mail offline.
- **Can I get free e-mail?** Probably. You may be able to hook up to your college system. You will likely have e-mail at your place of work, although your employer may limit personal messages. You can get free e-mail on your personal computer from several sources, notably Juno, which will set you up on its own server in return for supplying some personal information used for marketing.

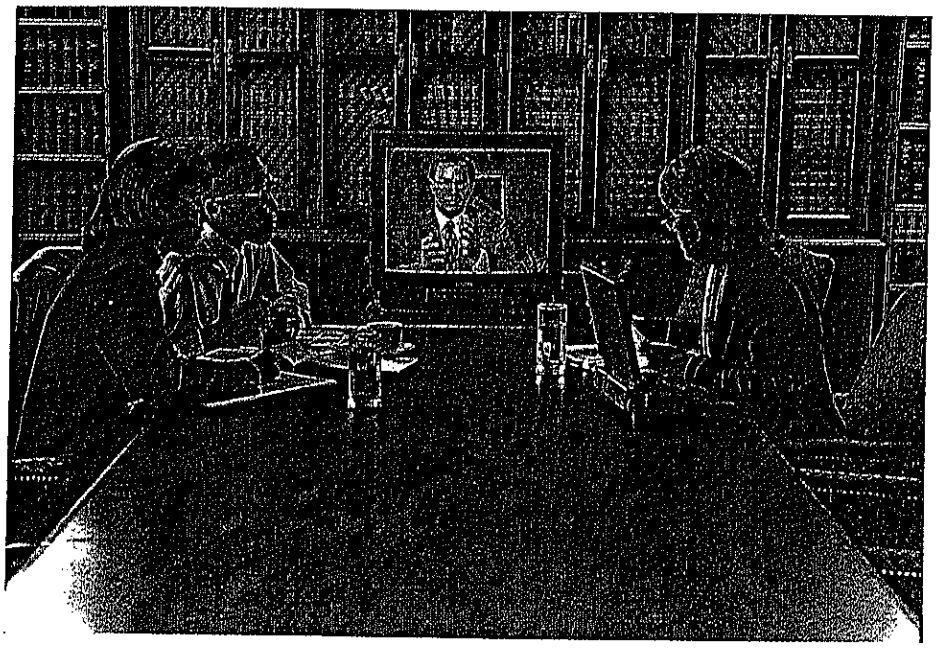


FIGURE 7-14

A videoconferencing system.
Geographically distant groups can hold a meeting with the help of videoconferencing. A camera transmits images of local participants for the benefit of distant viewers.

Electronic Data Interchange

Businesses use a great deal of paper in transmitting orders. One method that has been devised to cut down on paperwork is **electronic data interchange (EDI).** EDI is a series of standard formats that allow businesses to transmit invoices, purchase orders, and the like electronically. In addition to eliminating paper-based ordering forms, EDI can help to eliminate errors in transmitting orders that result from transcription mistakes made by people. Since EDI orders go directly from one computer to another, the tedious process of filling out a form at one end and then keying it into the computer at the other end is eliminated. Many firms use EDI to reduce paperwork and personnel costs. Some large firms, especially discounters such as Wal-Mart, require their suppliers to adopt EDI and, in fact, have direct computer hookups with their suppliers.

Electronic Fund Transfers: Instant Banking

Using **electronic fund transfer (EFT),** people can pay for goods and services by having funds transferred from various accounts electronically, using computer technology. One of the most visible manifestations of EFT is the **ATM—the automated teller machine** that people use to obtain cash quickly. A high-volume EFT application is the disbursement of millions of Social Security payments by the government directly into the recipients' checking accounts.

Computer Commuting

A logical outcome of computer networks is **telecommuting,** the substitution of communications and computers for the commute to work (Figure 7-15). That is, a telecommuter works at home on a personal computer and probably uses the computer to communicate with office colleagues or customers. In fact, some telecommuters are able to link directly to the company's network. Many telecommuters stay home two or three days a week and come in to the office the other days. Time in the office permits the needed face-to-face communication with fellow workers and also provides a sense of participation and continuity. Approximately 20 million people are classified as telecommuters.

The Internet

The Internet, as we indicated earlier in this book, is not just another online activity. The other topics discussed in this section pale in comparison. The Internet is considered by many to be the defining technology of the beginning of the twenty-first cen-

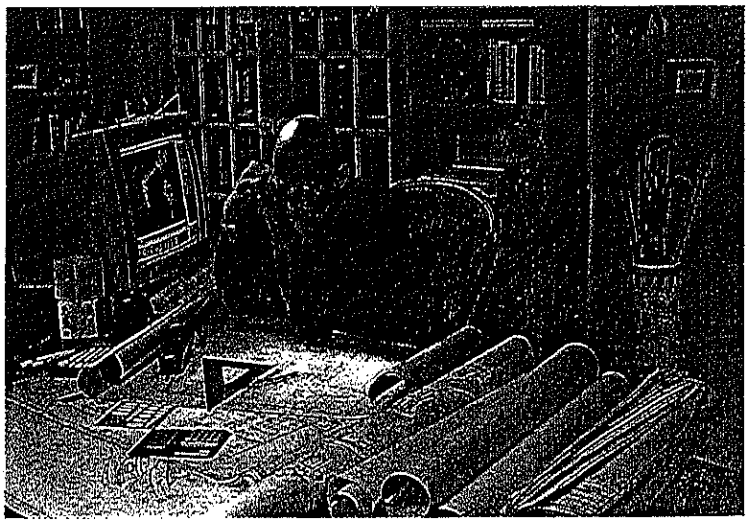


FIGURE 7-15

Telecommuting.
Using CAD/CAM software, this architect works at home four days a week. He goes in to the office one day a week for meetings and conferences.

FOCUS ON ETHICS **What's in a Name?**

Internet domain names such as www.prenhall.com are valuable commodities. Businesses want short, memorable names that Web surfers will clearly connect to their company name or their products. Suppose you were appointed to the Internet Committee on Assigned Names and Numbers(ICANN) and were asked to decide who should get to control various domain names. How would you decide the following cases? Why?

1. Two long-established organizations have competing claims to a domain name that contains their initials. For example, the World Wrestling Federation and the World Wildlife Fund might both want wwf.com.
2. Someone has registered a domain name identical to that of a well-established company, except that the new name takes advantage of a common typo. For instance, imagine that a company wants to register www.prenhall.com to collect "hits" from readers of this text who make typographical errors.
3. A group of disgruntled customers of MegaMerger Corporation want to register www.megamergercorpstinks.com. MegaMerger says this should be stopped.
4. MegaMerger Corporation wants to buy 150 domain names (www.megamergerisevil.com, www.megamergeristoobig.com, etc.) to prevent unhappy customers, disgruntled employees or Internet troublemakers from using them.

tury, and it may well hold that status for several years. Since we are devoting separate chapters and features exclusively to the Internet, we mention it here only to make the list complete.

THE COMPLEXITY OF NETWORKS

Networks can be designed in an amazing variety of ways, from a simple in-office group of three personal computers connected to a shared printer to a global spread including thousands of personal computers, servers, and mainframes. The latter, of course, would not be a single network but, instead, a collection of connected networks. You have already glimpsed the complexity of networks. Now let us consider a set of networks for a toy manufacturer (Figure 7-16).

The toy company has a bus LAN for the marketing department, consisting of six personal computers, a modem used by outside field representatives to call in for price data, and a server with a shared laser printer and shared marketing program and data files. The LAN for the design department, also a bus network, consists of three personal computers and a server with shared printer and shared files. Both LANs use the Ethernet protocol and have client/server relationships. The design department sometimes sends its in-progress work to the marketing representatives for their evaluation; similarly, the marketing department sends new ideas from the field to the design department. The two departments communicate, one LAN to another, via a bridge. It makes sense to have two separate LANs, rather than one big LAN, because the two departments need to communicate with each other only occasionally.

In addition to communicating with each other, users on each LAN, both marketing and design, occasionally need to communicate with the mainframe computer, which can be accessed through a gateway. All communications for the mainframe are handled by the front-end processor. Users in the purchasing, administrative, and personnel departments have terminals that are connected directly to the mainframe computer. The mainframe also has T1 connection to the Internet, which it uses to communicate with the mainframe computer at corporate headquarters in another state.

Network factors that add to complexity but are not specifically addressed in Figure 7-16 include the electronic data interchange setups between the toy manufacturer's purchasing department and seven of its major customers and the availability of electronic mail throughout the networks.

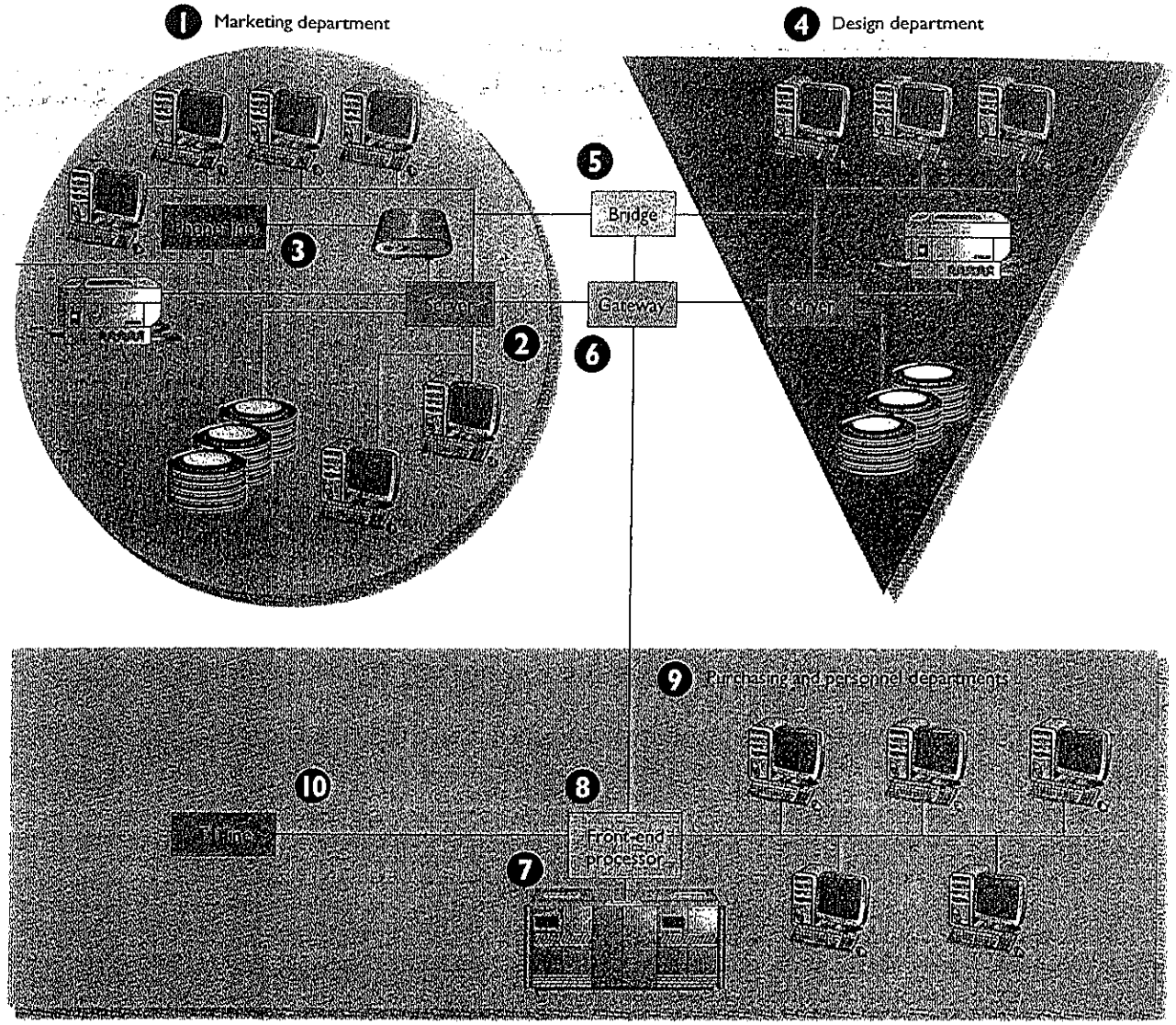


FIGURE 7-16

Example of a network.

In this set of networks for a toy manufacturer, (1) the marketing department has a bus LAN whose six personal computers use a shared printer. Both program and data files are stored with the (2) server. Note (3) the modem that accepts outside inquiries from field representatives. (4) The design department, with just three personal computers, has a similar LAN. The two LANs can communicate via (5) a bridge. Either LAN, via (6) a gateway, can access (7) the mainframe computer, which uses (8) a front-end processor to handle communications. Users in (9) the purchasing and personnel departments have terminals attached directly to the mainframe computer. The mainframe computer also has (10) a T1 connection to the mainframe at the headquarters office in another state.

▲

The near future in data communications is not difficult to see. The demand for services is just beginning to swell. Electronic mail already pervades the office and the campus and is growing rapidly in the home. Expect instant access to all manner of information from a variety of convenient locations. Prepare to become blasé about communications services available in your own home and everywhere you go.

4

The Internet:
A Resource for All of Us

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CHAPTER 8

LEARNING OBJECTIVES

Briefly describe the history of the Internet.

Explain what is needed to get on the Internet.

Describe generally what an Internet service provider does.

Describe the rudimentary functions of a browser.

Describe how to search the Internet.

List and describe the non-Web parts of the Internet.

Explain some of the ongoing problems associated with the Internet.

Whitney Bonilla had heard about the Internet, although she did not know quite what it was. She thought it had something to do with connecting to other people in other places. She also thought that it somehow contained a lot of information, information that might be handy for research for her college papers. She was right on both counts.

During her first week on campus, Whitney set out to hunt down the Internet. She discovered that there were several computer labs on campus and that one specialized in helping students get started on the Internet. But Whitney needed a lab pass to gain entry. A lab pass, for a fee, entitled a student to a certain number of hours on the Internet. The lab passes went first to students enrolled in computer classes and then to other students on a first-come, first-served basis. Unfortunately, Whitney was not among the first and was not able to get a pass at all.

All was not lost, however. Whitney found Internet access at the main library on campus. A librarian (who liked to call herself a "cybrarian") offered an hour-long beginners' class, repeated every day at noon and available to any student. Although subsequent computer access was limited to 30 minutes per session and no more than twice a week, Whitney found this sufficient to get her feet wet. She learned to get on the Internet, to move from site to site, and to find what she wanted.

She registered at the earliest possible date for the following quarter and included a beginning Internet course in her class schedule. She also got a lab pass.

Army or Education? Both!
The U.S. Army's strongest competitors for recruits are institutions of higher learning. Rather than fighting them, the Army has decided to join them—in a big way! Its Army University Access Online project plans to provide all one million of its soldiers (and their spouses) with access to a comprehensive array of college and university online courses. In addition, each soldier would receive a laptop computer, a printer, and an ISP account, enabling soldiers to pursue their education wherever duty takes them. In addition to attracting recruits who might otherwise bypass military service, the Army hopes to have its forces better prepared for the battlefield of the future.

THE INTERNET AS A PHENOMENON

The Internet exploded into the public consciousness in the mid-1990s. Because of its nature, it is impossible to determine exactly how many people are connected, but all estimates agree that the growth rate of Internet sites and Internet users can only be described as unprecedented. One reliable study stated that the number of host computers on the Internet grew from 43.2 million in 1999 to 72.4 million in 2000, a 68 percent increase in one year! Another study estimated the number of individuals using the Internet worldwide to be about 333 million. Consider that the telephone took 91 years to reach 100 million users and television took 54 years to reach the same level, while the Internet more than tripled that number of users in its first 10 years of public availability.

These are dramatic numbers, but the effect on people's lives is, and will be, even more dramatic. E-commerce is growing rapidly. Busy people can do much of their shopping online, even buying groceries for next-day delivery. Many workers telecommute via the Internet at least a few days a week. Internet-based startup companies have created thousands of new millionaires. By some estimates, information technology and Internet-based development have accounted for over half the economic growth in the United States in the past several years. This chapter and the next will look at the technologies involved in individual and business uses of the Internet and discuss some of the trends for its future.

DON'T KNOW MUCH ABOUT HISTORY

The history of the Internet bears telling. It is mercifully short. The reason that there is little to say is that the Internet slumbered and stuttered for approximately 20 years before the general public even knew it existed. It was started by obscure military and university people as a vehicle for their own purposes. They never in their wildest dreams thought that it would become the international giant it is today. Let us look back briefly, to understand their point of view.

First Stirrings at the Department of Defense

Ever heard of a fallout shelter? In the cold war of the 1950s, people worried about a nuclear attack whose radiation aftereffects—fallout—would be devastating. Some people built underground shelters, usually under their own houses or in their backyards, to protect themselves. It was in this climate of fear that the U.S. Department of Defense became concerned that a single nuclear bomb could wipe out its computing capabilities. Working with the Rand Corporation, they decided to rely on not one but several computers, geographically dispersed, and networked together. No one computer would be in charge.

A message to be sent to another computer would be divided up into **packets,** each labeled with its destination address. Each packet would wind its way individually through the network, probably taking a different route from the other packets but each heading in the direction of its destination and eventually being reconstituted into the original message at the end of the journey. The idea was that even if one computer was knocked out, the others could still carry on by using alternative routes. A packet can travel a variety of paths; the chosen path does not matter as long as the packet reaches its destination. The software that took care of the packets was **Transmission Control Protocol/Internet Protocol (TCP/IP).** TCP does the packeting and reassembling of the message. The IP part of the protocol handles the addressing, seeing to it that packets are routed across multiple computers.

The new set of connections was called **ARPANet,** an acronym that stands for Advanced Research Projects Agency Network. The year was 1969. Before long, com-

puters from research universities and defense contractors joined the network. But the network was limited to people who had some technical expertise—a major reason why it was not yet of particular interest to the general public.

Tim and Marc

Tim Berners-Lee is arguably the pivotal figure in the surging popularity of the Internet: He made it easy. In 1990 Dr. Berners-Lee, a physicist at a laboratory for particle physics in Geneva, Switzerland, perceived that his work would be easier if he and his far-flung colleagues could easily link to one another's computers (Figure 8-1). He saw the set of links from computer to computer to computer as a spider's web; hence the name **Web.** The **CERN site,** the particle physics laboratory where Dr. Berners-Lee worked, is considered the birthplace of the **World Wide Web.**

A **link** on a Web site is easy to see: It is either colored text called **hypertext** or an icon or image called a **hyperregion** (Figure 8-2). A mouse click on the link appears to transport the user to the site represented by the link, and in common parlance one speaks of moving or transferring to the new site; actually, data from the new site is transferred to the user's computer.

A **browser** is interface software that is used to explore the Internet. **Marc Andreessen** was a college student when, in 1993, he led a team that invented the first graphical browser (Figure 8-3). Until then, browsers such as Lynx were text-only. Andreessen's browser, named **Mosaic,** featured a graphical interface so that users could see and click on pictures as well as text. This made Web page multimedia possible. For the viewing public, the Internet now offered both easy movement with Dr. Berners-Lee's links and attractive images and a graphical interface provided by Mosaic. Today there are several competitive browsers, one of which is Netscape Communicator, produced by a company founded by Marc Andreessen and others. Netscape, Inc. was later purchased by America Online.

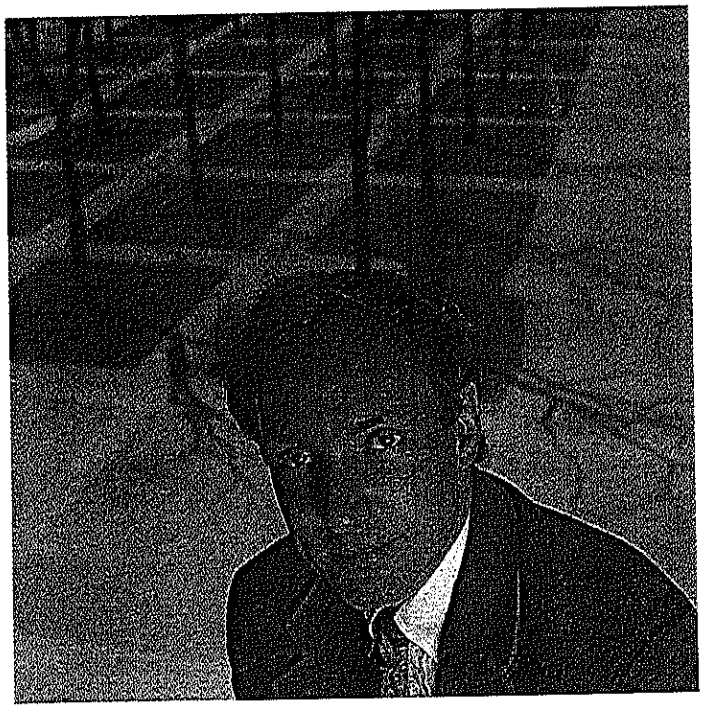


FIGURE 8-1

Dr. Tim Berners-Lee.
Working at the CERN particle physics lab in Geneva, Switzerland, Dr. Berners-Lee invented a method of linking from site to site so that he could easily communicate with his colleagues worldwide. Thus was born the World Wide Web or, simply, the Web.

FIGURE 8-2

Links.

On this screen showing Earthweb's home page, the underlined blue words are hypertext links and the rectangular images to the left of each hypertext link are hyperregion links.

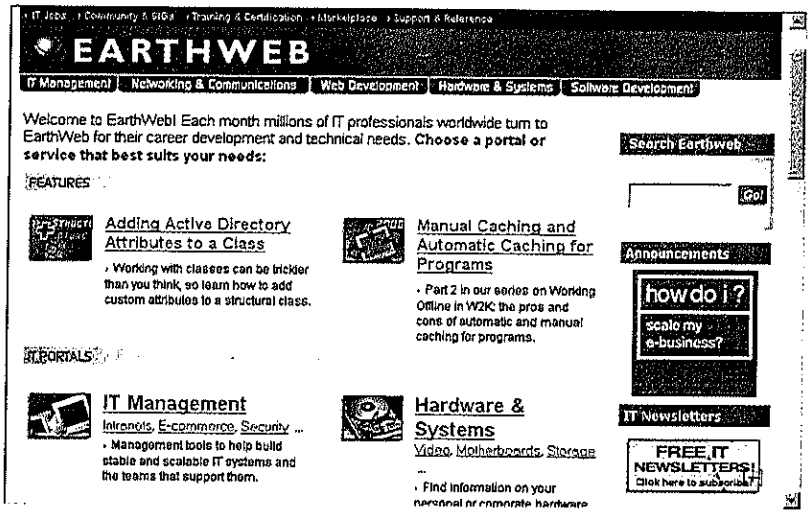
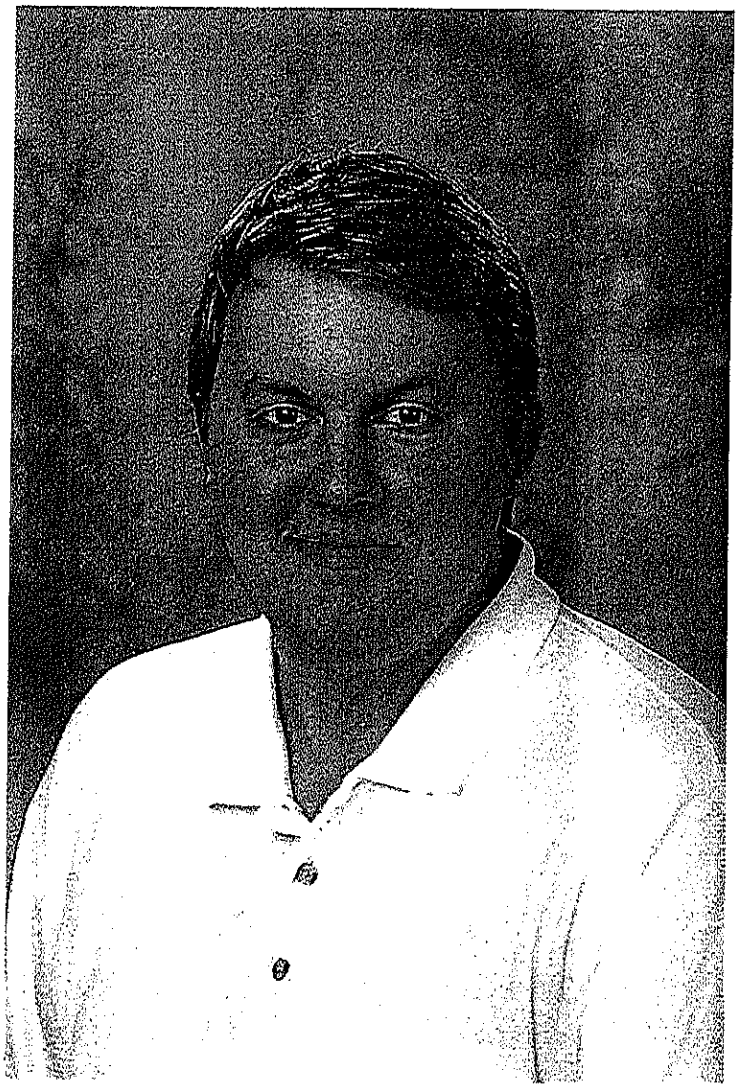


FIGURE 8-3

Marc Andreessen.

As a student, Marc Andreessen led a team of college students that developed the first graphical browser, called Mosaic. He later developed a commercial product, the Netscape Navigator browser (later Netscape Communicator), which was an instant success.



The Internet Surges Ahead

TCP/IP is software in the public domain. Since no one was really in charge of the network, there was no one to stop others from just barging in and linking up wherever they could. The network became steadily more valuable as it embraced more and more networks. Meanwhile, corporate networks, especially LANs of personal computers, were growing apace. Companies and organizations, noting an opportunity for greater communication and access to information, hooked their entire networks to the burgeoning network. A new name, taken from the name of the TCP/IP protocol, evolved: the Internet. The original ARPANet eventually disappeared altogether. Its users hardly noticed. Its functions continued and improved under the broader Internet.

In summary, the emergence of the Internet is due to four factors: (1) the universal TCP/IP standard, (2) the web-like ability to link from site to site, (3) the ease of use provided by the browser's graphical interface, and (4) the growth of personal computers and their local area networks that could be connected to the Internet.

Although statistics and projections vary, the growth of the Internet has been swift and unprecedented. No one thinks it is a fad. Almost everyone agrees that it is a true technological revolution. It continues to evolve.

GETTING STARTED

History is interesting, but most people want to know how to use the Internet, or at least how to get started. We cannot be specific here because many factors—computers, servers, browsers, and more—vary from place to place and time to time. But we can talk about overall strategy and what the various services and software applications have to offer.

The Internet Service Provider and the Browser

An Internet user needs a computer with a modem (or possibly a network interface) and its related software, an Internet service provider, and a browser. An **Internet service provider (ISP)** provides the server computer and the software to connect to the Internet. If you are accessing the Internet from a school, an organization, or a workplace, it is likely that these elements are already in place. Your only task would be to activate the browser and know how to use it.

If you wish to access the Internet from your own personal computer, one possibility is to sign up for an **online service,** (also called an **information utility**) such as America Online, that includes Internet access. The Internet service provider and browser are included in the package, and thus Internet access is available to you as soon as you have signed up for the online service. The main difference between an ISP and an online service is that an ISP is a vehicle to access the Internet, but an online service offers, in addition, members-only services and information. Online services provide content on every conceivable topic, all in a colorful, clickable environment that even a child can use. Content includes news, weather, shopping, games, educational materials, electronic mail, forums, financial information, and software product support. You will probably prefer an online service over an ISP if you are new to the online experience, if most of your friends and colleagues use the same online service, if people of different skill levels will use your computer to go online, or if you want to control what your children see online.

Approximately two-thirds of Internet users connect via an online service; the other one-third use an ISP. People who prefer an ISP are usually less interested in the managed resources of an online service and more interested in a freewheeling Internet experience that they can control themselves. You probably want an ISP if you prefer a different browser, plan to use a special communications link such as DSL, or want to put up a complex Web site.

If you elect to go directly to an Internet service provider, you will first need to select one. Some people seek advice from friends; others begin with advertisements in their phone books or the business section of the newspaper. Note the Getting Practical feature called "Choosing an Internet Service Provider." Once you have arranged to pay the fees (possibly an installation fee and certainly a monthly fee), you will set up your ISP interaction according to your provider's directions. The ISP may provide a disk that, once inserted into your computer's disk drive, will automatically set up the software, dial up the ISP, and set up your account, all with minimal input from you.

The next step is to configure the browser software on your computer. If you bought your computer within the last few years, you probably already have a browser installed. If not, you can purchase a browser in your local software retail outlet or, if you have some other online access vehicle, possibly download it free from the browser vendor's Web site. As you are configuring the browser, you will be asked for information about your ISP, for which your ISP will have prepared you. (An ISP typically furnishes several pages of detailed instructions.) Once you are set up, you invoke the browser as you would any software on your computer, and it will begin by dialing the Internet service provider for you. You are on your way to the Internet experience.

The Browser in Action

As we mentioned earlier, a browser is software used to explore the Internet. When they first came on the scene, graphical browsers were a great leap forward in Internet friendliness. A number of browsers are available, some better organized and more useful than others. Two popular browsers are Netscape Communicator and Microsoft's Internet Explorer.

When you run your browser software, it will dial up the Internet service provider and, once successfully connected, display either the **home page**—initial page—of the Web site for the company that created your particular browser or some other site designated by your ISP. The browser shows three parts on the screen: two very obvious chunks and a third that is just a line at the bottom (Figure 8-4). The top part is the browser control panel, consisting of lines of menus and buttons, to be described momentarily. The lower part, by far the largest part of the screen, is the browser display window. At the very bottom of the screen is a status line, which indicates the progress of data being transferred as you move from site to site. The status line may also show other messages, depending on the browser. The browser control panel at the top stays the same—except for the changing address of the visited site—as you travel from site to site through the Web; the browser display window changes, showing, in turn, each new Internet site you visit. Note, by the way, that it is common to refer to "going to a site," but in actual fact you are going nowhere; the information from the site is coming to you. The data from the "visited" site is sent from its source computer across the Internet to your computer.

When you first start the browser, the Web site window generally shows material according to the browser vendor's wishes, usually useful information and possibly advertisements for their products. (However, most browsers allow you to change the first page you see when you sign on to one of your own preference.) Note that the site display is not limited to the size of your screen; your screen size merely determines how much of the site you can see at one time. The page can be **scrolled**—moved up and down—by using the **scroll bar** on the right; simply press your mouse button over a scroll bar arrow to see the page move. If the site display is wider than your screen a scroll bar at the bottom allows you to move the page right and left. As you move the page, note that the browser control panel stays in place; it is always available no matter what the browser display window shows.

Browser Functions and Features

Next, let us examine the functions of the browser control panel. You can follow along on Figure 8-4 as you read these descriptions. Again, this discussion is necessarily generic and may vary from browser to browser. First, note the browser's welcome banner, touting its own name and logo, across the top of the screen. Next, usually off to the right, is the browser logo shown in Figure 8-4. The logo is active—shimmering, changing colors, rotating, *something*—when it wants to let you know that it is in the process of moving you to a new site. Since this sometimes takes a while, it would be disconcerting to stare at a static screen and wonder whether anything is happening. Note also that the status line at the bottom of the page provides information about the progress in contacting and receiving data from the desired site. If the transfer to the new site takes too long, you can cancel the move by clicking the browser's Stop button.

MENUS AND BUTTONS Using a mouse lets you issue commands through a set of **menus,** a series of choices normally laid out across the top of the screen. The menus

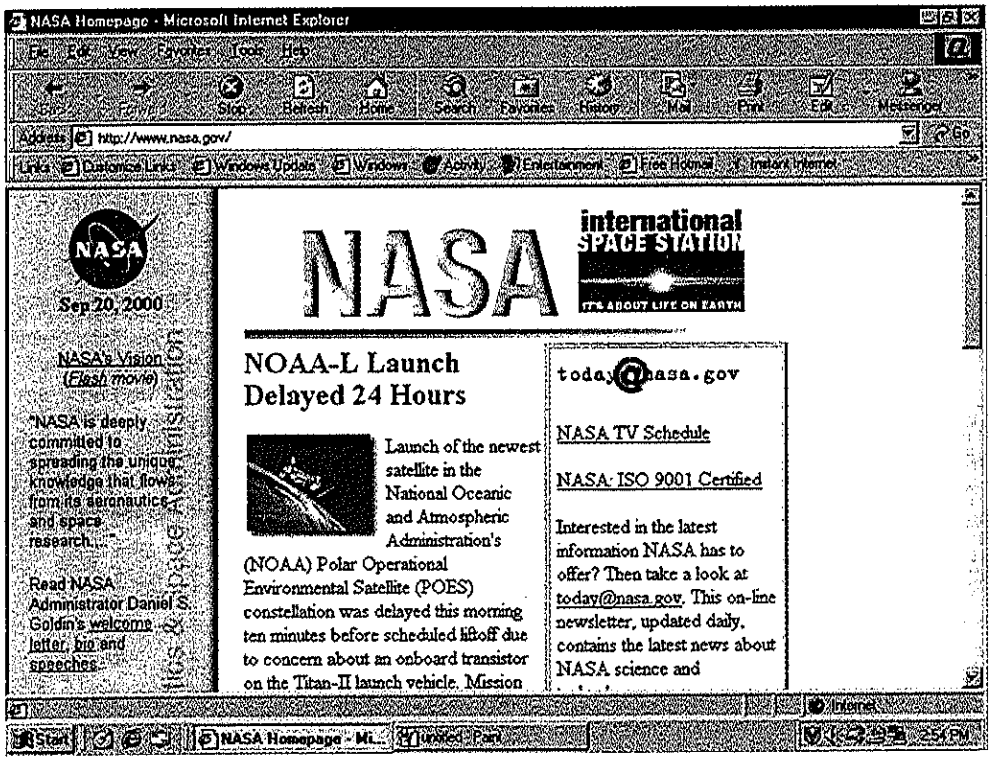
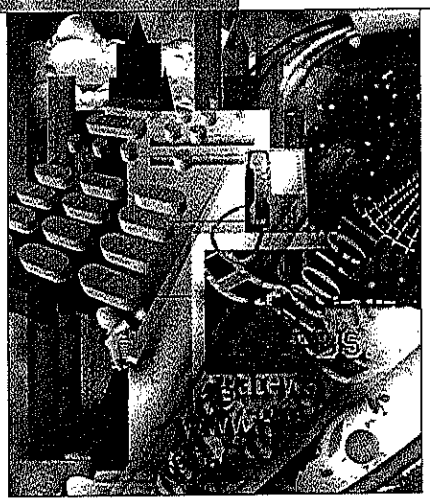


FIGURE 8-4

Browser control panel.

Most browsers offer pretty much the same functions; the example here is a popular browser called Internet Explorer. Just below the browser's welcome banner, showing the name of the Web site and browser display, is a set of pull-down menus; each such menu has several submenus. Just below the menus is a line of buttons. The buttons grouped to the left refer to the current Web site in the browser display window: Back (go to the previous site), Forward (go forward to the next site, assuming you already went back), Stop (stop an incoming site that is taking too long to load or that, after just a brief look, you wish to see no further), Refresh (redo the current site), and Home (return to browser's home page). The middle buttons are Search (find sites on the Web), Favorites (keep a list of sites to which one might return), History (lists of sites you visited, by week and by day), and Channels (a list of Web sites chosen to deliver content from the Internet to your computer). The buttons on the right are Fullscreen (let the browser display window take up the entire screen), Mail (get e-mail if you are set up on an account) and Print (print the content of the current site). Below the button line is the Address window, which contains the URL of the site in the browser display window.

GETTING PRACTICAL — Choosing an Internet Service Provider



If you have decided that you want to connect your computer to the Internet directly via an Internet service provider, you have to choose among many offerings. Many ISPs are national in scope; others are regional or local services. The best rates generally come from local ISPs. Local ISPs are usually what are called retail ISPs; that is, they deal primarily with individuals and small businesses.

You can begin by checking the Yellow Pages of your local phone directory, which probably has listings under "Internet." Also check out ISP advertisements in monthly computer magazines and, in urban areas, in your local newspaper. Many advertisements include a toll-free number that you can call for free software and a free trial subscription of a month or of a certain number of online hours.

An online resource called The List is by far the most comprehensive and useful list of ISPs (http://www.thelist.com). It is, of course, available only to people who are already able to get online, but you should be able to access it through your school or local library Internet connections. It features thousands of ISPs and is searchable by state, province (in Canada), and telephone area code.

If you are willing to put up with advertisements appearing on your screen as you surf, consider one of the free ISPs. A search on "free ISP" on any of the search engines should turn up a number of candidates. Check their Web pages to see if they have local access numbers in your area.

Here are some further tips:

- Look for an ISP whose access is only a local phone call away. Otherwise, long-distance charges will figure prominently in your monthly phone bill. Even if a seemingly toll-free number is offered, the provider will recoup the cost in charges to you.
- If you plan on traveling with a laptop, consider one of the national ISPs that have local numbers all over the country.
- If you plan on using one of the faster access methods, such as ISDN, DSL, or cable modem, you need to find out whether the ISP offers that service.
- Ideally, find a provider with software that will automate the registration process. Configuring the right connections on your own is not a trivial task.
- Figure out how likely you are to want to get help. At the very least, ask for the phone numbers and hours of the help line. If help is available only via e-mail, take your business elsewhere.
- ISPs are volatile. Make sure your contract includes terms that let you opt out if your ISP wants to transfer your account to a different ISP or if your ISP is bought out. For that matter, make sure you can opt out for your own reasons.

Finally, don't fall for an unrealistic bargain. Like anything else, if it sounds too good to be true, it probably is. You will probably find that a "bargain" service is oversubscribed, underpowered, and prone to busy signals. Even worse, your call for technical help may garner only a "this number has been disconnected" message. Stability is worth something.

are called **pull-down menus** because each initial choice, when clicked with a mouse, reveals lower-level choices that pull down like a window shade from the initial selection at the top of the screen. You can also invoke commands using **buttons** for functions such as Print to print the current page, Home to return to the browser home page, and—perhaps the ones you will use the most—Back and Forward to help you retrace sites you have recently visited. If you rest the cursor over a button for just a few seconds, a small text message will reveal its function. Note that all functions are listed in the pull-down menus; the buttons are just convenient shortcuts for the most commonly used functions.

URL The location slot, sometimes called the address window, will usually contain a **Uniform Resource Locator (URL),** a rather messy-looking string of letters and symbols, which is the unique address of a Web page or file on the Internet. An URL (pronounced "earl" or, alternatively, "U-R-L") has a particular format (Figure 8-5). A Web page URL begins with the protocol *http*, which stands for **HyperText Transfer Protocol.** This protocol is the means of communicating by using links, the clickable

URL:

http://www.intel.com/pressroom/index.htm

Protocol | ISP address (domain) | Path, directory, file name

FIGURE 8-5

A dissected URL.

The Uniform Resource Locator represents a unique address of an Internet site or file. Whenever you are looking at a Web site, you can see its URL near the top of the screen in the browser's control panel, in the location (address) slot. The example here shows a Web address for the Intel host, using a file called index.htm in the pressroom directory.

text or image that transports a user to the desired site. Next comes the **domain name,** which is the address of the Internet service provider or other host (ISPs, by the way, must register each domain name and pay an ongoing fee). The last part of the domain name, "com" in Figure 8-5, is called a **top-level domain** and represents the purpose of the organization or entity—in this case, "com" for "commercial." In some cases, the top-level domain name is a two-letter code that stands for the country of origin. Note the usage of top-level domain names in Figure 8-6. The last part of the URL, often the

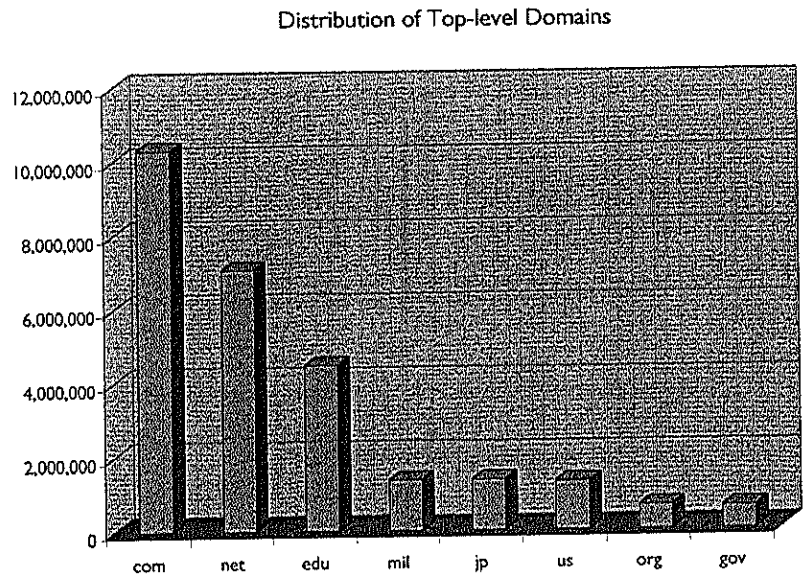


FIGURE 8-6

Distribution of top-level domain names.

A glance at the chart shows that the majority of Web sites, worldwide, have the top-level domain "com"; that is, they are business sites. Sites using "net" are often business sites too. The other domains shown here are "edu" for education; "mil" for military; "jp" for Japan; "us" for United States, for those wishing to distinguish it from sites in other countries; "org" for nonprofit organizations; and "gov" for government. Country domains use two letters; typical examples are "fi" (Finland), "uk" (United Kingdom), "de" (Germany), "ca" (Canada), "au" (Australia), "nl" (Netherlands), and "se" (Sweden). In November 2000, seven new top-level domain names were approved for use beginning in early 2001, although legal challenges may delay their implementation. The new names are: ".biz" for business sites; ".pro" for professionals such as lawyers, doctors and accountants; ".name" for personal sites; ".aero"; ".coop"; ".info"; and "museum."

Cyber Radio
Can't find any local radio stations that play your kind of music? If you've got a PC with a sound card and speakers, check out the Internet. Many traditional radio stations are now broadcasting their programs online, reaching beyond their local area to the whole world. Also, there are over 2000 "radio" stations that exist only in cyberspace, ranging from Spinner.com, which has over 120 channels, each dedicated to a specific format (oldies, jazz, bluegrass, etc.) to GoGaGa, whose programs (some live) defy categorization. If you still can't find something you like, try Imagine Radio, where you select your own playlist.

most complex, contains directories and file names that zero in on a very specific part of a site. Parts of the URL to the right of the domain, that is, the directory and file names, are case-sensitive; that is, you must type uppercase or lowercase characters exactly as indicated.

Most sites have a home page that acts as a directory by linking to what are often numerous pages of content. That home page is typically accessed by using a short URL that ends with the domain name. Also, many advertised URLs neglect to even mention the "*http://*" part of their address, partly because newer browser versions supply the "*http://*" for you.

No one likes to type URLs. There are several ways to avoid it. The easy way, of course, is simply to click links to move from one site to another. Another way is to click a pre-stored link on your browser's **hot list**—called Bookmarks, Favorites, or something similar—where you can store your favorite sites and their URLs.

FRAMES Most browsers support a concept called **frames,** which allow a given page to be divided into rectangular sections, each of which can operate independently of the others (Figure 8-7). It is like having several small pages on the same screen; some may be static, and others may be scrolled up and down. The advantage is that a site can offer several different functions or areas of focus. A disadvantage of frames is that a small screen, notably a laptop screen, may look cluttered. A classic approach to frames is the three-frame look: a static title frame across the top and a left-side navigation frame that targets the main content frame to the right.

COMPETITION Not just functional buttons, but buttons that illuminate when the cursor passes over them. Not just English, but French, German, and Italian. Not just

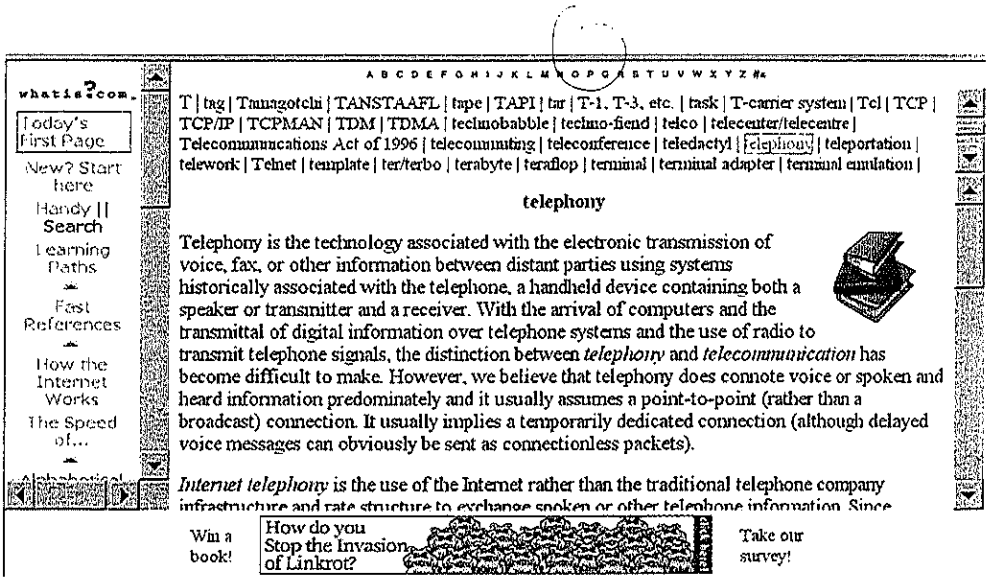


FIGURE 8-7

Frames.

This unusual site, WhatIs, has a total of five separate rectangular sections, called frames. The site is designed to offer computer-related definitions. The narrow frame across the top contains a row of clickable alphabet letters, which cause the frame just below to change; in this example the letter T has been clicked in the top frame, calling up the list of terms beginning with T. The list of terms is scrollable, up and down, as are the frames along the left side and also the center section. Note that each of these three frames has its own scroll bar. Once a term has been highlighted, its definition will appear in the large frame below; in this case the word "telephony" is defined. A fifth frame, across the bottom, holds a banner advertisement.

frames, but borderless frames. You begin to get the idea. As browsers compete to be the best, they get fancier. And we, the users, get more browser functionality. In fact, some browsers are considered a whole suite of programs, including rich software tools for communicating and sharing information and offering support for mail, security, collaboration, and Web page authoring.

PLUG-INS In addition to the browsers themselves, various vendors offer **plug-ins,** software that enhances the value of a browser by increasing its functionality or features. Typical plug-ins can enhance a site's audio-video experience or improve image viewing. Most plug-ins can be downloaded from their own Web sites. Once the plug-in is downloaded and installed, usually a simple procedure, the browser can automatically handle the newly enabled features. An example of a plug-in is Adobe Acrobat Reader, which is used to display and print documents that have been created in Portable Document Format (PDF). Since everything from product descriptions to IRS forms is on the Web in PDF, it is important that a browser be equipped to handle the format. Perhaps the most popular plug-in is Shockwave, from a company named Macromedia. Shockwave permits viewing sites that include quality animation and other effects.

Java

In the early days of the Web, everything presented on a Web page was static, composed of material that had already been prepared. A user was basically accessing the electronic version of a printed page. Even though that access was certainly a convenience, the content of the Web page offered nothing innovative—until Java. It is Java that permits the dancing icons, sound clips, flashing messages, banners that scroll across the page—and much more. **Java** is a programming language, developed by Sun Microsystems, that is used to write software that can run on any machine, hence its appeal to the multifaceted Internet.

The programs that provide multimedia effects, the moving images and sound clips on a Web page, are called **applets,** a sort of abbreviation for "little applications" (Figure 8-8). Applets can make Web pages perform virtually any task—display animations, receive input, perform calculations, and so forth. Java also provides the possibility of dynamic interaction, in which the user can receive immediate feedback and the programs actually do things on their own.

Microsoft provides a feature called **ActiveX controls** that provides capabilities similar to Java applets. To benefit from Java applets or ActiveX controls, a user must have a browser that is capable of running either or both, as, indeed, the most popular browsers are. If you are thus equipped, you will doubtless see many applets and controls in action as you cruise the Web. One word of caution: Both Java applets and ActiveX controls present some security risks, so some users set their browsers to deactivate them.

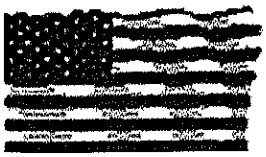


FIGURE 8-8

Applets.

Applets are extremely common on Web sites; you probably will see a great variety. In these simple applets the flag waves, the WOW bounces, and the cow's propeller spins.

FOCUS ON ETHICS **Internet Cheating: Old Problem, New Game**

Users of some online, multiplayer games have discovered that they can modify the copy of the game program installed on their PC to let them do better in the game. Examples include starting the game with special powers that aren't available to other users, making walls transparent to "see" other players when they are supposed to be hidden, and generally being able to break other game rules.

Since no money is involved, what's wrong with cheating in these online games? What do you think the consequences might be?

Moving from Site to Site

There are several ways to leave your browser's home page and start moving to other sites. Most browsers provide a list of clickable categories, such as sports, weather, news, technology, and even comic strips. Also a button click away are lists of new sites, "cool" sites, and various comprehensive directories. All of these come under the category of—yes—browsing.

But suppose you have something more specific in mind. If you know the URL for a desired site, delete the current URL in the location box, then type in the new one—carefully—and press Enter on the keyboard. You will be moved to the site just as if you had clicked a link. Sometimes—too often—an URL does not work. That is, a message is returned saying "Unable to Locate Server" or, simply, "Not Found." The former may mean that you typed the URL incorrectly. The latter probably means that the specific site you want is no longer on that ISP. People and companies do move their sites around, from ISP to ISP, and they do not always provide a forwarding address.

Keep in mind that moving from site to site, whether by link or by URL, is not magic. Although the movement from site to site is relatively effortless for the user, all the concepts described here are in play. That is, link requests move from your computer to your server and across networks of computers, all using TCP/IP, until the destination site is reached. Then the process is reversed, carrying the requested information back to your computer.

Wireless Internet Access

In the last year there has been explosive growth in the number of people using mobile handheld devices to access the Internet. These devices include text pagers, personal digital assistants (PDAs), pocket computers, and even Web-enabled cellular phones. Some use a pen-based system to enter characters through the screen, while others are equipped with a miniature keyboard. All have a limited display area that makes it difficult to browse the Web as you would with your PC. However, they are adequate for sending and receiving e-mail, checking weather forecasts, making airline reservations, and many other functions that mobile professionals find useful. To access the Web with these devices, you must establish an account with a wireless access service provider and, if your device is not already so equipped, buy a cellular modem card or adapter. Many wireless access providers use the **Wireless Application Protocol (WAP)** to convert Web pages into a format that is more compatible with the limited capabilities of handheld devices. Access speeds are much slower than even a basic telephone modem connection, but since very few graphics are transmitted, most users find the speed adequate. Evolving wireless standards promise significant speed increases in the not-too-distant future.

SEARCHING THE INTERNET

Although a browser, true to its name, lets a user browse by listing clickable categories of information—sports, business, kids, whatever—most users soon want to

find something specific. A **search engine** is software, usually located at its own Web site, that lets a user specify search terms; the search engine then finds sites that fit those terms. A browser usually offers links to one or more search engines, or a user can simply link to the site of a favorite search engine.

A search engine does not actually go out to the Web and "look around" each time a search is requested. Instead, the search engine, over time, builds a database of searchable terms that can be matched to certain Web sites. To build this database, a search engine uses software called a **spider** (also called a robot, or just bot) to follow links across the Web, calling up pages and automatically indexing to a database some or all the words on the page. In addition, sites are submitted by their owners to the search engine, which indexes them.

As the result of a search request, the search engine will present a list of sites in some format, which varies by search engine. In fact, the nature of the search varies according to the search engine. Initially, users are astonished at the number of sites found by the search engine, often thousands and perhaps tens of thousands.

Hot Search Engines

The title of this section is somewhat facetious, since a new "hot" search engine can show up overnight. Furthermore, some early search engines, less than half-a-dozen years old, are considered hackneyed and dull. Nevertheless, of the dozens of search engines in existence, a list of a few useful search engines is appropriate. Note that the use of these search engines is free, although you will, of course, encounter some advertising. Table 8-1 offers a comparison chart.

TABLE 8-1 A selection of Internet search tools

Directories	
Yahoo!	Well-organized categories let the user switch from browsing to searching in a certain area; but finds only keywords, not any word on a site
NetGuide	Reviews entries before including, links to articles written for NetGuide
Search Engines	
AltaVista	Very fast; indexes every word on every page of every site; searches Usenet too; excellent for custom searches
Excite	Good returns for simple searches; provides related hints and an array of extra content. Also includes directory
Google	Results ranked by algorithm based on number of links from other pages
HotBot	Fast; unique search options let you restrict searches; very comprehensive; excels at finding current news
Infoseek	Searches not only the Web but also newsgroups, FAQs, and e-mail addresses; extras such as foreign language searching and searching by geographical region
Lycos	Numerous search options, a comprehensive directory, and good returns on simple searches
Northern Light	Powerful and well organized; groups results by subject, type, source, and language
Metasearch Sites	
MetaCrawler	Accepts search terms and submits to several popular search engines; eliminates duplicates and ranks by relevancy
Dogpile	Well-designed, easy-to-use interface; can search Usenet

Although it might seem that the same search query ought to produce the same list of sites no matter what the search engine, this is hardly the case. Search engines vary widely in size, content, and search methodology. Keeping this in mind, serious researchers sometimes put the same query to each of several search engines and expect to be given a somewhat different list of sites from each. The ultimate search method, called a **metasearch,** uses software that searches the search engines. That is, it runs your query on several different search engines, probably the top seven or eight, simultaneously. Table 8-1 also lists several of the metasearch engines.

Internet Directories

Yahoo, one of the most popular "search engines" on the Internet, really isn't a search engine at all, but rather a directory. A **directory** is the work of human researchers, who sift through sites and organize them by content categories, allowing you to quickly focus on a group of sites that interest you. Many smaller directories concentrate on specific content areas, such as art and artists, and even rate listed sites for quality. Of course, any rating is the subjective judgment of the people who compile the directory. Several directories are included in Table 8-1.

Narrowing the Search

A simple one-word search will yield many sites, most of which will be irrelevant to your purposes. Suppose, for example, you are considering a driving trip through Utah. If you submit the word *Utah* as your search criterion, you will retrieve everything from Utah Lake to the Utah Jazz basketball team. The trick is to customize your search criteria. In this case, adding the word *vacation* to the search criteria will produce a list that begins with various hotels and parks in Utah. You can refine and narrow your search repeatedly.

There are more sophisticated methods for narrowing your search and for getting it right the first time. Different search engines offer different methods. Take a look at the search site's page, and you will probably see a clickable phrase such as Custom Search, Advanced Search, or Options. Click the phrase to see how your request can be made to order. For example, the AltaVista search engine permits quotation marks. If you type *"World Trade Center"* as your search criterion, you will get results that focus on that institution. If, instead, you type *World, Trade,* and *Center* as just three words in a row, the search engine will find every instance of each of the three words, alone and in combination—possibly several thousand sites. Alas, even the quote method is imperfect. For example, a site on a completely different topic will show up if the phrase *World Trade Center* appears anywhere on the site.

Most search engines offer operators with special functions based on a mathematical system called **Boolean logic.** The operators that are most commonly used are AND, OR, and NOT. The words can be further qualified with parentheses. AND means both; OR means either or both. Used correctly, these simple words can reduce search output to a dozen relevant sites instead of thousands of unrelated ones. Consider these examples: You want information on the companies called Cirrus and Intel. Type in *Cirrus* OR *Intel* for output that gives any site that mentions either or both companies. Suppose you need the population of the country of Jordan. If you key *Jordan,* you will see many sites for Michael Jordan, among others. Instead, key *Jordan* AND NOT *Michael.* Most requests combine several terms and operators. For example, suppose you want to go to college in Illinois but want to live in a town smaller than Chicago, and you want to inquire about tuition. Try *Illinois* AND NOT *Chicago* AND (*college* OR *university*) AND *tuition* AND *admission.* This query is quite specific, and it will produce mostly desired sites.

Other ways of refining search results are to specify the language (e.g., English or Russian) of the site, its most recent update, and whether the page includes an image or audio or video.

Search Engine Limitations

Search engines are known for turning up too much information, hence the need for Boolean terms and other methods to fine-tune the results. It is perhaps counterintuitive, then, to realize that search engines examine only a fraction of the Web. The Web's vastness simply foils even the best search engines. The two search engines that have the broadest coverage, HotBot and AltaVista, search only about a third of all the pages on the Web. Some search engines cover less than 20 percent of available Web pages. That leaves page after page, floating out there somewhere, unreachable by anyone who lacks the specific Web address.

Furthermore, the problem is going to get worse. The Web has approximately 700 million pages, and millions of pages are added every year. It is probably impossible to index the entire Web. The futility of trying to build giant databases of Web pages will probably lead to a trend toward smaller, specialized search sites. For instance, HotBot now runs a special search engine called NewsBot that constantly patrols a special set of news-related sites. With a concentrated effort, such a site can be made smarter and more thorough in its own field. Some services avoid the issue entirely by providing only highlights of the Web. For now the best bet for users who are hunting down some elusive piece of information is to use a metasearch site or manually submit the request to multiple search engines. Using a half-dozen search engines approximately doubles the results obtained with the most prolific individual search engine.

BRANCHING OUT

Although the World Wide Web is usually the focus of any Internet discussion, there are other parts of the Internet that deserve attention. All of them, in fact, predate the Web. One way to identify such sites is to observe the protocol. Instead of *http*, which you may be accustomed to seeing used for Web sites, you may see *news* or *ftp*.

Newsgroups

Usenet is an informal network of computers that allows the posting and reading of messages in newsgroups that focus on specific topics. A more informal name is simply **newsgroups.** Topics of newsgroup discussions cover almost any subject you could imagine. If you have a passion for herbal remedies, for Macintosh computers, or for Chinese politics, you can find not just one person but an entire group of people who share your interest and have something to say about it. Today there are more than 20,000 newsgroups offering conversation and, in some cases, files to download. Participating in newsgroups requires software called a **newsreader.** This software is included in most browsers, but some newsgroup participants prefer to use standalone newsreaders with lots of extra features.

Think of a Usenet as a series of bulletin boards, each devoted to a specific topic. If you happen along, you can read other people's postings. If you wish to respond to a message or just contribute your own original thought, you leave a message. The process is just about that simple. Once you find a newsgroup that interests you, a suggested rule is that you observe the newsgroup for a while, an activity called **lurking,** before you jump in. That is, just read messages without writing any. That way you will get the flavor of the group before you participate and learn what kind of discussion is customary and what is discouraged.

In many newsgroups anyone can post messages about anything, whether or not it relates to the topic of the newsgroup. Some people take perverse delight in posting messages attacking others, often in the crudest terms. This type of message, referred to as a **flame,** can provoke a **flame war,** back-and-forth exchanges of flames. To avoid problems with flames and inappropriate material, some newsgroups are moderated. In a **moderated newsgroup,** all postings are first sent to a **moderator,** who decides whether the message is appropriate for posting.

FTP: Downloading Files

You already know that you can access files that reside on remote computers through the Internet and view them on your own computer screen. That is, you are allowed to look at them. But what if you wanted to keep a file; that is, what if you wanted your own copy of a file on your own computer? It may be possible to download—get—the file from the distant computer and place it on the hard disk of the computer you are using.

Whether or not a file is available for downloading depends on two things: (1) whether you are allowed to download files to the hard disk of the computer you are using and (2) whether the file you want is available for copying. Whether or not you are permitted to download files to the computer you are using may depend on the availability of disk space, which is at a premium in some locations. Of course, if you are using your own personal computer, you may do whatever you like.

Many computer files are proprietary, and a user who wants them must have an account on that computer and a password. However, all kinds of files—programs, text, graphics images, even sounds—are available to be copied without restriction. The free files are public archives, often associated with an educational institution or government.

There are many reasons you might want someone else's file. Perhaps, for example, a colleague in another city has just written a 150-page grant proposal and wants to send it to you; it is not convenient to send large files via e-mail. Perhaps you want some NASA space photos or some game software. Perhaps you have nothing particular in mind but, knowing that free stuff is out there, you simply go to a popular FTP site and look around. You can also upload—send your own files to another computer—but most people do a lot more downloading than uploading.

Computers on the Internet have a standard way to transfer copies of files, a program called **FTP,** for **file transfer protocol.** The term has become so common that FTP is often used as a verb, as in "Jack FTP-ed that file this morning." Most downloading is done by a method called **anonymous FTP.** This means that instead of having to identify yourself with a proper account on the remote computer, you can simply call yourself Anonymous. Also, instead of a password, you just use your e-mail address. This is merely background information; your browser will do all this work for you when you indicate that you want to transfer to an FTP site to select a file and download it.

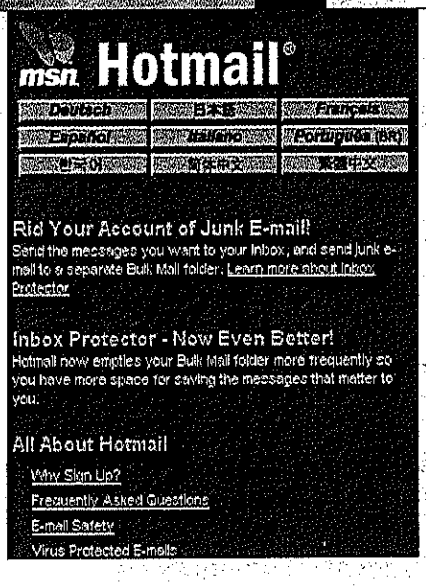
Telnet: Using Remote Computers

Many applications on large systems require users to access a host computer through a terminal. **Telnet** is a protocol that allows remote users to use their PC to log onto a host computer system over the Internet and use it as if they were sitting at one of that system's local terminals. Usually, the user has to have an account on the host system and enter an appropriate user ID and password. However, some systems are set up to allow *guest* logins, for which no prior account is necessary. Most Web browsers include Telnet capability.

MAKING CONNECTIONS ◄ **Free Internet E-Mail Accounts**

You probably already have an e-mail account provided by your ISP, employer, or school. So why do you need another one? Consider the following:

- You graduate from college, change employers, or decide to find a better ISP. All three situations result in a change of e-mail address and the resulting bother and possible confusion in notifying all your correspondents.
- Your employer doesn't approve of employees using business e-mail accounts for personal communications. And remember, most employers keep e-mail messages in log files, even after you delete them.
- You would like the convenience of checking your e-mail no matter where you are—a friend's house, the library, home, or at work.
- You don't have your own Internet access or e-mail address, relying instead on friends' computers or those at the local library.



In all of these situations a free Internet e-mail account could be just the answer. A number of sites now provide these accounts. The granddaddy of all is Hotmail, now offered by MSN. Most Internet portals, such as Yahoo! and Excite, include free e-mail to encourage you to keep returning. And some other sites, such as Ziplip, exist for the sole purpose of providing free e-mail.

To establish your free account, visit the site and click on the link that says, "Register for free e-mail" or something similar. The resulting screen(s) will ask you to enter registration information, including your choices for a user name and password. Unless it's a brand-new service, don't expect to find any neat names left—they're already spoken for. If you choose a user name that somebody else already has, you'll be asked to choose again, often with some alternatives offered. Once you settle on an available name and fill in the required registration information, you're all set. You can send and retrieve e-mail from any computer that is logged onto the Internet just by visiting your e-mail site and signing on with your user name and password.

The following are some things to look for in choosing a free e-mail provider:

- What is their privacy policy? What do they do with the personal data you provide when you register? Most use that data to provide targeted ads when you visit the site, but some may sell the data (including your e-mail address) to others. Some, such as Ziplip, require no personal data at all. There should be a link labeled "Privacy Policy" or something similar on the site. Read it!
- How easy is the service to use? Some are easy and intuitive; others require a lot more work to understand. All have a Help link, but not all Help is that helpful. The easiest way to evaluate ease of use is to sign up for an account and use it several times. After all, it's free. If you find it doesn't suit you, you can try another service.
- What features are supported? Some providers allow you to create a group address, so that a single message will be sent to everyone in the group. Providers also vary in the amount of storage provided for old e-mail. If you save everything, this could be important.

E-Mail

E-mail, already discussed in the chapter on networking, is the most-used feature of the Internet, used by even more people than the Web. Before the Internet, e-mail users were limited to communicating only with others on the same network. As a network of networks, the Internet has made it possible for any user connected to the Internet to send e-mail to anyone else on the Internet. This is similar to the telephone system. No matter what company provides your local telephone service, you can call anyone in the world, since all telephone companies are now connected to each other.

If you are connected to the Internet through your employer's or school's network, that network will provide a **mail server** that collects and stores your e-mail in a **mailbox** that you can access at your convenience. Some networks will send an audible alarm (usually a soft chime) or display a small message box on your screen for a

Online Travel Resources

Planning a trip? Most people are aware of the online reservation systems of the airlines, major hotel chains, and car rental agencies. But the Internet can aid your travel plans in many other ways. For instance, if the major hotels don't interest you, try the Bed & Breakfast Channel (*bbchannel.com*)—it lists over 19,000 bed-and-breakfast inns throughout the United States, most including photos. If your plans include overseas travel, check out the Centers for Disease Control Travel Advisory (*cdc.gov/travel*) for required inoculations and strategies to avoid any local health problems at your destination. You also might want to visit the Universal Currency Converter site (*xe.net/currency*) to find out the current rate of monetary exchange and Travlang (*travlang.com*) to pick up some useful foreign words and phrases. Travlang even supplies sound clips to help with the proper pronunciation.

brief period when new mail arrives. If you connect to the Internet through an ISP, the mail server resides on the ISP's computer, and you will have to check periodically for new mail. Your **e-mail address** consists of the user name assigned to you by your ISP or network administrator, followed by the @ symbol, then the domain name of your mail server.

E-mail client software on your PC allows you to retrieve, create, send, store, print, and delete your e-mail messages. Additional features include an address book, from which you can select addressees for new mail, and the ability to attach files containing graphics, audio, video, and computer programs to your e-mail. Be aware, however, that for security reasons, some networks will block some or all attachments from incoming messages. Basic e-mail client software is included with most browsers, but many people use separate e-mail software that include advanced features such as **filters** that can direct incoming e-mail to specific folders and even reject spam.

NOT QUITE PERFECT YET

The Internet has been heaped with well-deserved praise. But still there are concerns. To begin with, no one really knows exactly who is out there on the Internet and what they are doing online. It's a little worrisome. On the other hand, many users find the freewheeling, no-controls aspect of the Internet appealing. Many fear government censorship attempts, such as the Communications Decency Act of 1996, which was declared unconstitutional by the Supreme Court, and the Child Online Protection Act of 1998, which a federal court has blocked from enforcement pending a Supreme Court ruling on constitutionality.

Behavior Problems

There really are some behavior problems on the Internet. But there are behavior problems in any aspect of society, from the playground to the boardroom. Those who abuse the Internet are, relatively speaking, small in number. Even so, solutions to the problems posed by abusers include a proposed ratings system and filtering software for parental control of the types of sites or newsgroups accessed by children.

Meanwhile, the community of Internet users has made serious efforts to monitor behavior on the Internet. One consistent effort is **netiquette,** which refers to appropriate behavior in network communications. For example, users are admonished not to type in caps (IT'S LIKE SHOUTING). Netiquette rules are published on several sites and in every book about the Internet.

Useless, Overburdened, and Misinformed

Some people consider some home pages useless. In fact, there is a site called Useless Pages that maintains a listing of pages the site manager deems useless. However, many people are willing to pay for the connection to a Web server to promote a home page they fancy, whatever anyone else may think. Others put out birth or wedding announcements, complete with photos. One useless page does nothing except count the number of times that page is accessed. At the other end of the spectrum are sites that apparently have so much value that their popularity renders them mostly inaccessible. Any list of "cool" sites, a favorite Web word, is likely to be crowded.

There are no guarantees. The Internet is full of misinformation. Just because something is on the Internet does not mean that it is true. If someone steps up to announce that the government uses black helicopters to spy on us or that tapes

sound better if you soak them in water first, you need not accept such information as fact. It's not that people intend to be wrong, it's just that they sometimes are. If you are doing serious research on the Internet, be sure to back it up with other sources, especially non-Internet sources.

▲

The Internet is interesting and even fun. Perhaps the best aspect of the Internet is that even a novice computer user can learn how to move from site to site on the Internet with relative ease.

Security and Privacy:
Computers and the Internet

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C H A P T E R

LEARNING OBJECTIVES

Explain the different types of computer crime and the difficulties of discovery and prosecution.

Describe the aspects of securing corporate data, including software and data security, disaster recovery plans, and security legislation.

Describe in general terms how viruses work, the damage they can cause, and procedures used to prevent this damage.

Explain the threats to personal privacy posed by computers and the Internet. Describe actions you can take to maximize your privacy.

At Wolfe-Straus, a company that manufactures particleboard, they have a high awareness of computer security. Potential hires are carefully screened. Employees know better than to reveal their computer passwords. Diskettes holding data are never left lying around. Important files are backed up on a regular basis. Outdated reports with sensitive data are fed to the shredder. And so forth and so on.

How is it, then, that a thief was able to walk off with the entire employee personnel file? Stolen reports? Illicit Internet access? No, it was really a simple matter. Using a screwdriver, the thief was able to remove and steal the entire hard drive from a personal computer.

The file contained employee names, addresses, birth dates, Social Security numbers, salaries, and home phone numbers. The company had to warn its 577 employees that their personal data had been compromised. That information could be used to apply for fraudulent credit cards in the employees' names or to gain access to other information about them. Even worse, the stolen hard disk contained the bank account numbers of retired workers who opted for direct-deposit pension checks. Managers could only shake their heads and hope that they were faced with a relatively stupid criminal who wanted just the $200 hardware rather than a smart criminal who would recognize that the data could be worth hundreds of thousands of dollars.

Security personnel considered several options to prevent such incidents in the future, including keeping all data on server disks in locked

rooms, passwording all files, using hard drives that required special tools for detachment, and placing cages around desktop machines when not in use. They settled on a triple plan: using file passwords, placing important files on servers only, and placing other personal computer files on removable hard drives that could be locked away at night.

A FIRST LOOK AT SECURITY AND PRIVACY

There was a time when security and privacy issues related to computers were easily managed: You simply locked the computer room door. Those centralized days are, of course, long gone. Now, in theory, anyone can hook up to any computer from any location. In light of data communications access, the first issue is security. The vast files of computer-stored information must be kept secure—safe from destruction, accidental damage, theft, and even espionage.

A second issue is privacy. Private data—salaries, medical information, Social Security numbers, bank balances, and much more—must be kept from prying eyes. The problems are many, and the solutions complex. The escalating expansion of the Internet has only heightened the existing problems and added new problems of its own. These issues and more will be addressed in this chapter.

COMPUTER CRIME

It was 5 o'clock in the morning, and 14-year-old Randy Miller was startled to see a man climbing in his bedroom window. "FBI," the man announced, "and that computer is mine." So ended a computer caper in San Diego in which 23 teenagers, ages 13 to 17, had used their home computers to invade computer systems as far away as Massachusetts. The teenagers were **hackers,** people who attempt to gain access to computer systems illegally, usually from a personal computer, via a data communications network.

The term "hacker" used to mean a person with significant computer expertise, but the term has taken on the more sinister meaning with the advent of computer miscreants. In this case the hackers did not use the system to steal money or property. But they did create fictitious accounts and destroyed or changed some data files. The FBI's entry through the bedroom window was calculated: The agents figured that, given even a moment's warning, the teenagers were clever enough to alert each other via computer.

This story—except for the boy's name—is true. Hackers ply their craft for a variety of reasons but most often to show off for their peers or to harass people they do not like.

You will probably not be surprised to learn that hackers have invaded Web sites. These vandals show up with what amounts to a digital spray can, defacing sites with taunting boasts, graffiti, and their own private jokes. Although the victims feel violated, the perpetrators view their activities as mere pranks. In reality such activity is antisocial and can result in great expense.

Hackers and Other Miscreants

Hacking has long been thought the domain of teenagers with time on their hands. The pattern is changing, however. A recent government survey showed that the computer systems of over half of the largest U.S. corporations had been invaded, but not by teenagers. Most intruders were competitors attempting to steal proprietary infor-

mation. Even more astounding, federal investigators told a U.S. Senate hearing that the U.S. Department of Defense computers are attacked more than 200,000 times per year. Most worrisome is the emerging computer attack abilities of other nations, which, in a worst-case scenario, could seriously degrade the nation's ability to deploy and sustain military forces.

Hackers ply their craft by surprisingly low-tech means. Using what is called **social engineering,** a tongue-in-cheek term for con artist actions, hackers simply persuade unsuspecting people to give away their passwords over the phone. Recognizing the problem, employers are educating their employees to be alert to such scams.

Hackers are only a small fraction of the security problem. The most serious losses are caused by electronic pickpockets, who are usually a good deal older and not so harmless. Consider these examples:

- A brokerage clerk sat at his terminal in Denver and, with a few taps of the keys, transformed 1700 shares of his own stock, worth $1.50 per share, to the same number of shares in another company worth 10 times that much.
- A keyboard operator in Oakland, California, changed some delivery addresses to divert several thousand dollars' worth of department store goods into the hands of accomplices.
- A ticket clerk at the Arizona Veteran's Memorial Coliseum issued full-price basketball tickets for admission and then used her computer to record the sales as half-price tickets and pocketed the difference.

These stories illustrate that computer crime is not always flashy, front-page news about geniuses getting away with millions of dollars. These people were ordinary employees in ordinary businesses—committing computer crimes.

The problem of computer crime has been aggravated in recent years by increased access to computers. More employees now have access to computers on their jobs. In fact, computer crime is often just white-collar crime with a new medium: Every time an employee is trained on the computer at work, he or she also gains knowledge that—potentially—could be used to harm the company.

The Changing Face of Computer Crime

Computer crime once fell into a few simple categories, such as theft of software or destruction of data. The dramatically increased access to networks has changed the focus to damage that can be done by unscrupulous people with online access. The most frequently reported computer crimes fall into these categories:

- **Credit card fraud.** Customer numbers are floating all over public and private networks, in varying states of protection. Some are captured and used fraudulently.
- **Data communications fraud.** This category covers a broad spectrum, including piggybacking on someone else's network, the use of an office network for personal purposes, and computer-directed diversion of funds.
- **Unauthorized access to computer files.** This general snooping category covers everything from accessing confidential employee records to the theft of trade secrets and product pricing structures.
- **Unlawful copying of copyrighted software.** Whether the casual sharing of copyrighted software among friends or assembly-line copying by organized crime, unlawful copying incurs major losses for software vendors.

Some "Bad Guy" Tricks

Although the emphasis in this chapter is on preventing rather than committing crime, being familiar with the terms and methods computer criminals use is part of

GETTING PRACTICAL — Protecting Your PC

How vulnerable is your PC to a hacker attack? If you connect to the Internet via a dial-up line to your ISP and spend an hour or two at a time surfing and checking e-mail, you aren't in too much danger. But if you have a cable or DSL connection and leave your computer running most of the time, your PC is a prime target, especially if you use Windows 95/98.

When you are online, your computer's IP address allows it to receive data. ISPs assign a temporary IP address each time a dial-up connection is established. This makes it difficult for hackers to find you. However, since cable and DSL connections are "always on" whenever your computer is powered up, your ISP assigns you a permanent IP address, making you an easy target. Also, Windows 95/98 security is notoriously weak, especially in its standard configuration. Its many short-comings are well known to hackers.

So what can you do to protect yourself? First, install a strong personal firewall. A firewall is software that blocks attack attempts via the Internet. Until recently, firewalls were expensive, complex software packages used to protect company networks from intrusion. But recently, several good, inexpensive (less than $50) firewall programs for PCs have become available.

Second, plug the security holes in Windows. An Internet search using *Windows* and *security* as keywords will turn up several good Internet sites that describe how to tweak the network and file-sharing settings in Windows and eliminate the major security problems.

Third, use passwords on your system. By picking longer passwords that combine both numbers and letters and changing them monthly, you can make it much more difficult for any hacker who manages to breach your defenses.

As small home networks become more common, the future trend is for firewalls that run on dedicated hardware devices connected between the Internet and the network. These will be much more secure than firewall software on a general-purpose PC.

being a prudent computer user. Many of these words or phrases have made their way into the general vocabulary.

- **Bomb.** A **bomb** causes a program to trigger damage under certain conditions; it is usually set to go off at a later date—perhaps after the perpetrator has left the company. Bombs are sometimes planted in software that is to be used by the general public. Shareware, which is less rigorously monitored than commercial software, has been known as a source of bombs.
- **Data diddling.** The unattractive term **"data diddling"** refers to changing data before or as it enters the system—for example, a course grade or hours worked. Auditors who are monitoring a computer system cannot limit themselves to the computer processing itself; they must verify the accuracy of the source data.
- **Denial of service (DOS) attack.** A **DOS attack** occurs when hackers bombard a site with more requests for service that it can possibly handle, preventing legitimate users from accessing the site. Through the use of Trojan horse programs (see next page) planted on unsuspecting sites around the Internet, hackers can cause the attacks to come from many different sites simultaneously. During a four-day period in February 2000, DOS attacks crippled the servers of such sites as Yahoo!, Amazon.com, eBay, CNN.com, and E*Trade for up to four hours each.
- **Piggybacking.** The term fits: In **piggybacking,** an illicit user "rides" into the system on the back of another user. The original user gives some sort of identification, probably a password, to access the system. Then, if the legitimate user does not exit the system properly, the intruder may have access to systems and files by simply continuing where the original user has left off.
- **Salami technique.** The name **salami** given to this embezzlement technique reflects the small "slices" of money that may be squirreled away undetected from a large financial system. In one famous case a bank employee commandeered the extra amounts when accounts were rounded to dollars and cents after interest was computed. For example, if interest was computed to be $77.0829, the interest was reported as $77.08, and the $0.0029 added to the unauthorized salami account. Done hundreds of times over thousands of accounts, these small amounts add up. This particular scheme, by the way, would not work today; bank auditors are much too savvy for anything this overt.

- **Scavenging.** The simple approach of **scavenging** is still all too common, even in this day of shredders. Scavengers simply search company trash cans and dumpsters for printouts containing not-for-distribution information, perhaps even a gold mine of credit card numbers. It is not even unusual for thieves to get account numbers and other information from the garbage and recycling bins of individuals, hence the popularity of personal home shredders.
- **Trapdoor.** A **trapdoor** is an illicit program that is left within a completed legitimate program. It allows subsequent unauthorized—and unknown—entry by the perpetrator, who then has the ability to make changes to the program. This technique is not available to the average person. The programmer who has the skills to do it can cause great damage, from altering the method of program processing to destroying records and files.
- **Trojan horse.** A **Trojan horse** involves illegal instructions covertly placed in the middle of a legitimate program. The program does do something useful but also, via the Trojan horse instructions, does something destructive in the background.
- **Zapping.** The generic term **"zapping"** refers to a variety of software, probably illicitly acquired, designed to bypass all security systems.

In summary, there are multiple opportunities for scoundrels to cause havoc in and around computer systems. It is up to employees and individuals at all levels to recognize the danger and protect their assets.

White-Hat Hackers

Perhaps you saw the movie *Sneakers*, in which Robert Redford, in the opening scene, appears to be in the process of robbing a bank. But, no, Mr. Redford is actually executing a test of the bank's security system. This is a common scene at today's banks and in any other organization that depends on computer networks.

Faced with threats on every side, most network-laced companies have chosen a proactive stance. Rather than waiting for the hackers, snoops, and thieves to show up, they hire professionals to beat them to it. Called **white-hat hackers,** tiger teams, or sometimes "intrusion testers" or "hackers for hire," these highly trained technical people are paid to try to break into a computer system before anyone else does.

Using the same kind of finesse and tricks that a hacker might, white-hat hackers exploit the system weaknesses. Once such chinks are revealed, they can be sealed or protected. The hacker's first approach, typically, is to access the company's system from the Internet. The quality of security varies from company to company. Sometimes security is fairly tight; other times, as one hacker put it, "It's a cakewalk."

Sometimes companies will hire one company to establish security and then hire white-hat hackers to try to defeat it. The company might not even alert its own employees to the hacker activities, preferring to see whether the intrusions are detected and, if so, how employees react.

Discovery and Prosecution

Prosecuting the computer criminal is difficult for several reasons. To begin with, discovery is often difficult. Many times the crime simply goes undetected. In addition, crimes that are detected are—an estimated 85 percent of the time—never reported to the authorities. By law, banks have to make a report when their computer systems have been compromised, but other businesses do not. Often these businesses choose not to report such crimes because they are worried about their reputations and credibility in the community.

Even if a computer crime is detected, prosecution is by no means assured. There are a number of reasons for this. First, some law enforcement agencies do not fully understand the complexities of computer-related fraud. Second, few prosecutors are qualified to handle computer crime cases. Third, judges and juries are not always

FOCUS ON ETHICS **Hackers as Good Samaritans?**

Is there any positive side to hacking? Read and respond to the following quote from Eric Corley, editor of 2600 Magazine: "Hackers, in their idealistic naivete, reveal the facts that they discover, without regard for money, corporate secrets or government coverups. . . . If a non-classified site is hacked, I don't see the harm unless something is damaged in some way. Remember, the security hole was already there. If a hacker finds it, it's far more likely the people running the system will learn of the hole. If a criminal or someone with an ulterior motive (espionage, etc.) finds the hole first, it's likely to remain secret for much longer and the harm will be far greater."

1. What do you think of the argument that hackers revealing security holes is a social good?
2. Unauthorized access to a computer system, classified or not, is illegal. Is there any ethical distinction between breaking in and damaging a computer system and breaking in just to look around?
3. On the Internet or in the print media, find some recent examples of hacking incidents. Do you think anything positive will happen as a result of the episodes you found?

educated about computers and might not understand the nature of the violation or the seriousness of the crime.

In short, the chances of having a computer crime go undetected are, unfortunately, good. And if it is detected, the chances that the criminal will suffer no consequences are also good: A computer criminal might not go to jail, might not be found guilty if prosecuted, and might not even be prosecuted.

But this situation is changing. Since Congress passed the **Computer Fraud and Abuse Act** in 1986, there has been a growing awareness of computer crime on the national level. This law is supplemented by state statutes; most states have passed some form of computer crime law. Computer criminals who are successfully prosecuted are subject to fines, jail time, and confiscation of their computer equipment.

Computer Forensics

"I'll lose my job if they find out what I sent you." Most companies keep copies of all e-mail that is sent and received, and most do spot checks of the contents. When the above statement was discovered among an employee's outgoing messages, a company security officer wondered whether she had uncovered corporate espionage. Was the message sender giving away—or perhaps selling—company secrets? In this case it was easy to find out: The security officer simply extracted the attachment that had been sent with the message. It turned out to be pornographic material—and the employee did indeed lose his job over this incident.

Checking an already-identified e-mail message stored on disk is relatively straightforward, but finding other kinds of data is trickier. The data of interest may be in a deleted file or stored with a phony file name or disguised in some other manner. But such data is not safely hidden from professionals known as forensic experts. A relatively new field, **computer forensics** refers to uncovering computer-stored information suitable for use in courts of law.

Computer forensics has been used in both criminal and civil cases, in applications as varied as murder, blackmail, and counterfeiting. Each computer forensic examination is unique in its purpose and, possibly, method of approach. One company might need to trace missing inventory, while another might be responding to a court-ordered subpoena for e-mail messages containing sexual harassment language.

An unsophisticated perpetrator might get a tip that he or she is being investigated and delete the related files before anyone can examine the computer. This is a plaintiff's (or prosecutor's) delight: Not only can the deleted files be reconstructed; the accused party has displayed guilty behavior.

FIGURE 11-1

Forensics experts.

Private firms offer their computer forensics services for hire and advertise on their own Web sites.

Some computer forensics experts have set up shop and are for hire, perhaps even advertising on their own Web sites (Figure 11-1). But most such experts are on the staffs of police departments and law firms.

SECURITY: PLAYING IT SAFE

As you can see from the previous sections, companies and organizations have been vulnerable in the matter of computer security. **Security** is a system of safeguards designed to protect a computer system and data from deliberate or accidental damage or access by unauthorized persons. That means safeguarding the system against such threats as natural disasters, fire, accidents, vandalism, theft or destruction of data, industrial espionage, and hackers.

Identification and Access: Who Goes There?

How does a computer system detect whether you are the person who should be allowed access to it? Various means have been devised to give access to authorized people without compromising the system. These means fall into four broad categories: what you have, what you know, what you do, and what you are.

- **What you have.** You might have a key, badge, token, or plastic card to give you physical access to the computer room or to a locked-up terminal or personal computer. A card with a magnetized strip, for example, can give you access to your bank account via a remote cash machine. Taking this a step further, some employees begin each business day by donning an **active badge,** a clip-on identification card with an embedded computer chip. The badge signals its wearer's location—legal or otherwise—by sending out infrared signals, which are read by sensors sprinkled throughout the building.
- **What you know.** Standard what-you-know items are a password or an identification number for your bank cash machine. Cipher locks on doors require that you know the correct combination of numbers.
- **What you do.** In their daily lives people often sign documents as a way of proving who they are. Though a signature is difficult to copy, forgery is not impossible. Today, software can verify both scanned and online signatures.

Cyberwarfare

Many science fiction authors have written about wars conducted primarily by computers, but most of their tales have been set far into the future. This type of conflict, dubbed cyberwarfare, could happen sooner than most people think.

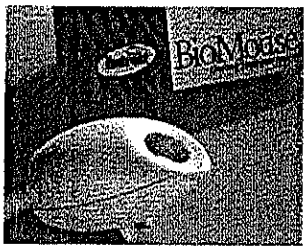
All major countries and many smaller ones have been developing cyberwarfare capabilities for a number of years. The United States has consolidated its offensive cyberwarfare programs at the U.S. Space Command in Colorado. China is considering creation of a fourth branch of its armed forces devoted to information warfare. And a Russian general has compared the disruptive effects of a computer attack on a transportation or electrical grid to that of a nuclear weapon.

Smaller countries have already begun employing cyberattacks to disrupt their enemies. Myanmar's military junta has used (ineffectively, at best) an e-mail virus to attempt to disrupt dissidents' Web activities. Azerbaijan, a former Soviet republic, has been identified as the source of attacks on Armenian Web sites. Since Internet access in Azerbaijan is tightly controlled, government responsibility for the attacks was strongly suspected. Armenian retaliation against Azerbaijani sites followed quickly.

FIGURE 11-2

BioMouse.

The BioMouse, a product of American Biometric, is a fingerprint authentication system. The system consists of a mouse/scanner, shown here, and related software. A user "trains" the mouse by inserting fingers, one at a time.



- **What you are.** Now it gets interesting. Some security systems use **biometrics,** the science of measuring individual body characteristics. Fingerprinting might seem to be old news, but not when you simply insert your finger into an identification machine (Figure 11-2). Some systems use the characteristics of the entire hand. Another approach is identification by voice pattern. Even newer is the concept of identification by the retina of the eye, which has a pattern that is harder to duplicate than a voiceprint, or by the entire face, which draws its uniqueness from heat radiating from blood vessels (Figure 11-3).

When Disaster Strikes: What Do You Have to Lose?

Computer installations of any kind can be struck by natural disasters or by disasters of human origin, which can lead to security violations. What kinds of problems might this cause an organization?

Your first thoughts might be of the hardware—the computer and its related equipment. But loss of hardware is not a major problem in itself; the loss will probably be covered by insurance, and the hardware can be replaced. The true problem with hardware loss is the diminished processing ability that exists while managers find a substitute facility and return the installation to its former state. The ability to continue processing data is critical. Some information industries, such as banking, would literally go out of business in a matter of days if their computer operations were suspended. Loss of software should not be a problem if the organization has heeded industry warnings—and used common sense—to make backup copies of program files.

A more important problem is the loss of data. Imagine trying to reassemble lost or destroyed files of customer records, accounts receivable, or design data for a new airplane. The costs would be staggering. Software and data security will be presented in more detail later in this chapter. First, consider an overview of disaster recovery, the steps to restoring processing ability.

Disaster Recovery Plan

A **disaster recovery plan** is a method of restoring computer processing operations and data files if operations are halted or files are damaged by major destruction. There are various approaches. Some organizations revert temporarily to manual services, but life without the computer can be difficult indeed. Others arrange to buy time at a service bureau, but this is inconvenient for companies in remote or rural areas. If a single act, such as a fire, destroys your computing facility, it is possible that a mutual aid pact will help you get back on your feet. In such a plan, two or more companies agree to lend each other computing power if one of them has a problem. This would be of little help, however, if there were a regional disaster and many companies needed assistance.

FIGURE 11-3

Identification.

A person's entire face is used for identification in some security systems. Identification is based on a unique pattern of heat radiating from an individual's facial blood vessels.

Banks and other organizations with survival dependence on computers sometimes form a **consortium,** a joint venture to support a complete computer facility. Such a facility is completely available and routinely tested but used only in the event of a disaster. Among these facilities, a **hot site** is a fully equipped computer center, with hardware, environmental controls, security, and communications facilities. A **cold site** is an environmentally suitable empty shell in which a company can install its own computer system.

The use of such a facility or any type of recovery at all depends on advance planning—specifically, the disaster recovery plan. The idea of such a plan is that everything except the hardware has been stored in a safe place somewhere else. The storage location should be several miles away so that it will not be affected by local physical forces, such as a hurricane. Typical items stored at the backup site are program and data files, program listings, program and operating systems documentation, hardware inventory lists, output forms, and a copy of the disaster plan manual.

The disaster recovery plan should include a list of priorities identifying the programs that must be up and running first, plans for notifying employees of changes in locations and procedures, a list of needed equipment and where it can be obtained, a list of alternative computing facilities, and procedures for handling input and output data in a different environment.

Software Security

Software security has been an industry concern for years. Initially, there were many questions: Who owns custom-made software? Is the owner the person who wrote the program or the company for which the author wrote the program? What is to prevent a programmer from taking copies of programs from one job to another? The answer to these questions is well established. If the author of the software—the programmer—is in the employ of the organization, the software belongs to the organization, not the programmer. The programmer may not take the software along to the next job. If the programmer is a consultant, however, the ownership of the software that is produced should be specified in the contract; otherwise, the parties enter extremely murky legal waters.

Data Security

We have discussed the security of hardware and software. Now consider the security of data, which is one of an organization's most important assets. Here too there must be planning for security. Usually, this is done by security officers who are part of top management.

What steps can be taken to prevent theft or alteration of data? There are several data protection techniques; these will not individually (or even collectively) guarantee security, but they make a good start.

SECURED WASTE Discarded printouts, printer ribbons, and the like can be sources of information to unauthorized people. This kind of waste can be made secure by the use of shredders or locked trash barrels.

INTERNAL CONTROLS Internal controls are controls that are planned as part of the computer system. One example is a transaction log. This is a file of all accesses or attempted accesses to certain data.

AUDITOR CHECKS Most companies have auditors go over the financial books. In the course of their duties, auditors frequently review computer programs and data. From a data security standpoint, auditors might also check to see who has accessed data during periods when that data is not usually used. Today auditors can use off-the-shelf audit software, programs that assess the validity and accuracy of the system's operations and output.

APPLICANT SCREENING The weakest link in any computer security system is the people in it. At the very least, employers should verify the facts that job applicants list on their résumés to help weed out dishonest applicants before they are hired. Employees who are hired for sensitive positions should undergo complete background checks.

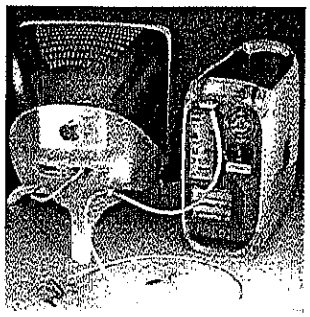
PASSWORDS A password is a secret word, number, or combination of the two that must be typed on the keyboard to gain access to a computer system. Cracking passwords is the most prevalent method of illicit entry to computer systems.

BUILT-IN SOFTWARE PROTECTION Software can be built into operating systems in ways that restrict access to the computer system. One form of software protection

FIGURE 11-4

Cable lock.

Physical security is provided by using a cable lock to fasten the PC to the desktop.



is a system that matches a user number against a number assigned to the data being accessed. If a person does not get access, it is recorded that he or she tried to tap into some area for which that person was not authorized. Another form of software protection is a user profile: Information is stored about each user, including the files to which the user has legitimate access.

Personal Computer Security

One summer evening two men in coveralls with company logos backed a truck up to the building that housed a university computer lab. They showed the lab assistant, a part-time student, an authorization slip to move 23 personal computers to another lab on campus. The assistant was surprised but not shocked, since lab use was light in the summer semester. The computers were moved, all right, but not to another lab.

There is an active market for stolen personal computers and their internal components. As this unfortunate tale indicates, personal computer security breaches can be pretty basic. One simple, though not foolproof, remedy is to secure personal computer hardware in place with locks and cables (see Figure 11-4). Also, most personal computers have an individual cover lock that prevents access to internal components.

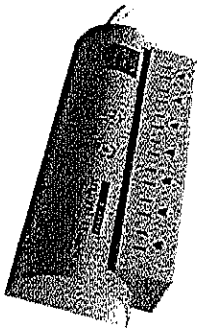
Although personal computers aren't as environmentally sensitive as larger computers, users should avoid eating, drinking, and smoking around them. Occasional cleaning, such as vacuuming the keyboard, is recommended.

Several precautions can be taken to protect disk data. One is to use a **surge protector,** a device that prevents electrical problems from affecting computer data files. The computer is plugged into the surge protector, which is plugged into the outlet (Figure 11-5a). An **uninterruptible power supply (UPS)** includes both surge protection and battery backup, which allows you to continue operating your PC during power loss or brownouts (Figure 11-5b). Inexpensive UPSs provide five to ten minutes of battery power, enough to allow you to save and close all files and shut down the system without loss of data. More expensive units can supply power for a half-hour or more. Diskettes should be under lock and key. The most critical precaution, however, is to back up your files regularly and systematically.

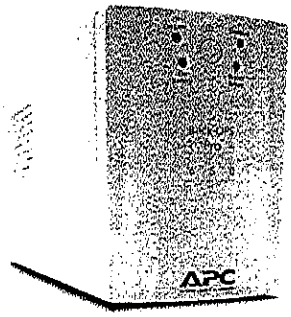
FIGURE 11-5

Protection from power problems.

(a) A surge protector protects the computer from overvoltages caused by power surges. (b) An uninterruptible power supply (UPS) provides battery backup in case of brownouts or power failures.



(a)



(b)

Prepare for the Worst: Back Up Your Files

Although organizations recognize the value of data and have procedures in place for backing up data files on a regular basis, personal computer users are not as devoted to this activity. In fact, one wonders why, with continuous admonishments and readily available procedures, some people still leave their precious files unprotected.

WHAT COULD GO WRONG? If you use software incorrectly or simply input data incorrectly, it might be some time before the resulting erroneous data is detected. You then need to go back to the time when the data files were still acceptable. Sometimes the software itself can harm data, or a hard disk could physically malfunction, making your files inaccessible. Although none of these mishaps are too likely, they certainly do happen. It is even less likely that you would lose your hard disk files to fire or flood, but this is also possible. The most likely scenario is that you will accidentally delete some files yourself. (Deleted files, can probably be recovered using utility software if the action is taken right away, before other data is written over the deleted files.) Finally, there is always the possibility of your files being infected with a virus. Experts estimate that average users experience a significant disk loss once every year.

WAYS TO BACK UP FILES Some people simply make another copy of their hard disk files on diskette.

A better way is to back up all your files on a tape. Backing up to a tape drive, CD-RW, or DVD-RAM is safer and faster. You can also use software that will automatically back up all your files at a certain time of day, or on command.

Sophisticated users place their files on a mirror hard disk, which simply makes a second copy of everything you put on the original disk; this approach, as you might expect, is expensive.

Backup software generally provides three types of backup. A **full backup** copies everything from the hard drive. A **differential backup** copies all files that have been changed since the last full backup. An **incremental backup** copies only those files that have been changed since either the last full backup or the last incremental backup. A comprehensive backup plan involves periodic full backups, complemented by either incremental or differential backups. With the differential approach, the restoration process requires the use of two backup files: the last full backup followed by the most recent differential backup. Restoration using the incremental approach can require a number of files—the last full backup followed by each incremental backup performed since the full backup.

VIRUSES: NOTORIOUS PESTS

"Worms" and "viruses" are rather unpleasant terms that have entered the jargon of the computer industry to describe some of the insidious ways in which computer systems can be invaded.

A **worm** is a program that transfers itself from computer to computer over a network and plants itself as a separate file on the target computer's disks.

Worms are rare, however. The ongoing nuisance is the virus, which, as its name suggests, is contagious. A **virus** is a set of illicit instructions that passes itself on to other programs with which it comes into contact. In its most basic form, a virus is the digital equivalent of vandalism. It can change or delete files, display words or obscene messages, or produce bizarre screen effects. In its most vindictive form, a virus can slowly sabotage a computer system and remain undetected for months, contaminating data or, in the case of the famous Michelangelo virus, wiping out your entire hard drive. A virus may be dealt with by means of a **vaccine,** or **antivirus,** a computer program that stops the spread of a virus and often eradicates it. However, a **retrovirus** has the ability to fight back and may even delete antivirus software.

You might wonder who produces viruses. At one point, the mischief makers were mostly curious young men. Now, virus makers are older and actually trade notes and tips on the Internet. They do what they do, psychologists say, mostly to impress their friends. Experts have estimated that there are hundreds of virus writers worldwide. However, although there are thousands of known viruses, most of the damage is caused by only a dozen or so (Table 11-1).

Transmitting a Virus

Consider this typical example. A programmer secretly inserts a few viral instructions into a game called Kriss-Kross, which she then offers free to others via the Internet. Any takers download the game to their own computers. Now each time a user runs Kriss-Kross—that is, loads it into memory—the virus is loaded too. The virus stays in memory, infecting any other program that is loaded until the computer is turned off. The virus has now spread to other programs, and the process can be repeated again and again. In fact, each newly infected program becomes a virus carrier. Although many viruses are transmitted in just this way via networks, another common method is by passing diskettes from computer to computer (Figure 11-6).

Here is another typical scenario. An office worker puts a copy of a report on a diskette and slips it into her briefcase to take home. After shooing her children away from the new game they are playing on the computer, she sits down to work on the report. She does not know that a virus, borne by the kids' new software, has infected the diskette. When she takes the diskette back to work, the virus is transmitted from her computer to the entire office network.

TABLE 11-1 Typical Viruses

Name	Unpleasant consequences
Form	Causes a clicking noise in the computer's keyboard on the 18th day of the month; it may also corrupt data on diskettes.
Melissa	A macro virus distributed as an e-mail attachment that, when opened, disables a number of safeguards in *Word 97* or *Word 2000*, and, if the user has the *Microsoft Outlook* e-mail program, causes the virus to be resent to the first 50 people in the user's address book.
Ripper	Corrupts data written to a hard disk approximately one time out of a thousand.
Junkie	Infects disk files and also causes memory conflicts.
MDMA	Affects *Microsoft Word* files; can delete files.
Anti-CMOS	Wipes out information stored on the chip containing the computer's configuration data; however, the data can be restored.
Concept	Transferred from one *Microsoft Word* file to another if both are in memory at the same time; also transferred by e-mail attachments. Causes a file to be saved in the template directory instead of where it belongs; confuses users, who do not know what happened to the most recent version of the file.
Monkey	Makes it appear as if your hard disk has crashed, even though it has not. If you try to boot a Windows machine, it locks up; you can boot from a diskette, but then it cannot find the hard drive.
Cookie monster	Shows screen message I WANT A COOKIE! and locks up the computer until you type FIG NEWTON.
One_Half	Encrypts the hard disk so that only the virus can read the data there; when the encryption is half completed, it flashes One_Half on the screen. If you try to remove the virus without the proper antivirus software, you lose the encryption key and thus your data.
Wazzu	Benign versions merely reset the screen colors; more destructive ones reformat the hard drive, thus losing all file data.
Michelangelo	Destroys all data on the hard disk on March 6, Michelangelo's birthday.
Cascade	Picks random text characters and drops them to the bottom of the screen.
Jerusalem	Deletes any program executed on Friday the 13th.

The most insidious viruses attach to the operating system. One virus, called Cascade, causes random text letters to "drop" to a pile at the bottom of the screen (Figure 11-7). Viruses attached to the operating system itself have greater potential for mischief.

A relative newcomer to the virus scene is the macro virus, which uses a program's own macro programming language, typically *Microsoft Word*, to distribute itself. A macro virus infects a document by being carried as a macro program. When you open the document that has the virus, any other documents that are opened in the same session may become infected by the virus. This also applies to an infected document that you may have received as an e-mail attachment.

Damage from Viruses

Some viruses are benign, more on the order of pranks, but many cause serious damage. Even the benign ones can cause confusion and possibly panic, leading to lost time and effort. Many viruses remain dormant until triggered by some activity. For example, a virus called Jerusalem B activates itself every Friday the 13th and pro-

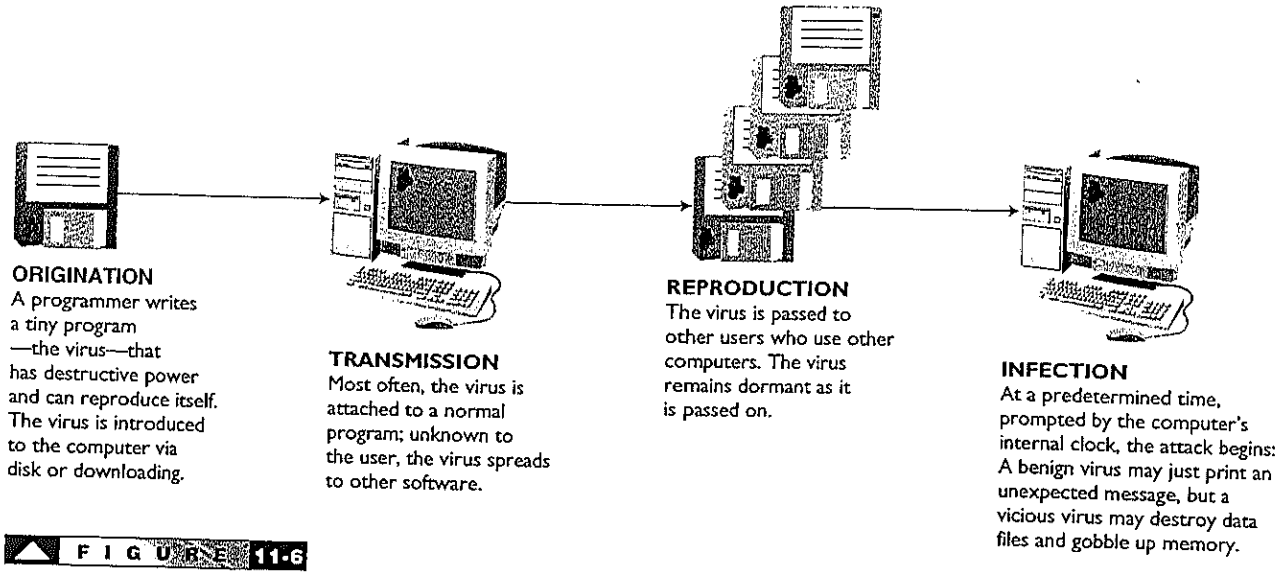


FIGURE 11-6

An example of a virus invasion.

ceeds to erase any file you try to load from your disk. Another virus includes instructions to add 1 to a counter each time the virus is copied to another disk. When the counter reaches 4, the virus erases all data files. This is not the end of the destruction, of course; the three other copied disks have also been infected.

Virus Myths

Viruses are merely programs written to create copies of themselves and to attach these copies to other programs. The only way any virus can infect your computer is by executing one of these programs or by booting from a diskette containing an infected boot sector. Almost no one boots from a diskette, preferring instead to use the operating system on the hard disk. However, it is fairly common to boot the computer when a diskette is accidentally left in the drive. Even though you receive the "Non-system disk" error message and remove the diskette, the damage may have been done.

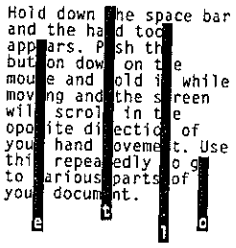
Keeping in mind that a virus must be in an executable program (including an executable macro program within a document) or booted from a diskette, it is possible to debunk some virus myths:

- You cannot get a virus by simply being online, by surfing the Internet, or even from your own local area network. You could, of course, download a program and then, by executing it, get a virus.
- Although most e-mail viruses are in attachments that must be opened, it is possible for a virus to be activated in some versions of *Microsoft Outlook* by simply viewing an e-mail.
- Data is not executed, so you cannot get a virus from data, including graphics files. However, beware of graphics files that include a viewer program; that program could contain a virus.

FIGURE 11-7

The Cascade virus.

This virus attaches itself to the operating system and causes random letters in text to "drop" to a pile at the bottom of the screen display.



Virus Prevention

A word about prevention is in order. The most powerful weapon at your disposal is antivirus software. But it is not sufficient to pick up an antivirus package from the store and install it on your computer. That is just the beginning. New viruses appear

regularly. Companies that specialize in virus detection, such as Symantec and McAfee, maintain Web sites from which you can download prevention measures and fixes for the most recently discovered viruses. Antivirus software will scan your hard disk every time you boot the computer or, if you prefer, at regularly scheduled intervals.

Although there have been isolated instances of viruses in commercial software, viruses tend to show up on free software or software acquired from friends or the Internet. Use a commonsense approach to new files. Never install a program unless the diskette comes in a sealed package. Be especially wary of software that arrives unexpectedly from companies with which you have not done business. Use virus-scanning software to check any file or document, no matter what the source, before loading it onto your hard disk. If your own diskette was used in another computer, scan it to see whether it caught a virus. Avoid using programs that may be stolen or whose origin is unclear.

PRIVACY: KEEPING PERSONAL INFORMATION PERSONAL

Think about the forms you have willingly filled out: paperwork for loans or charge accounts, orders for merchandise through the mail, magazine subscription orders, applications for schools and jobs and clubs, and on and on. There may be some forms you have filled out with less delight—tax forms, military draft registration, a court petition, an insurance claim, or a form for a stay in the hospital. And remember all the people who got your name and address from your check—fund raisers, advertisers, and petitioners. These lists may not have covered all the ways in which you have supplied data, but you can know with certainty where it all goes: straight to computer files.

Passing Your Data Around

Where is your data now? Has it been shared, rented, sold? Who sees it? Will it ever be deleted? Or, to put it more bluntly, is *anything* private anymore? In some cases one can only guess at the answers. It is difficult to say where your data is now, and bureaucracies are not eager to enlighten you. The data may have been moved to other files without your knowledge. In fact, much of the data is most definitely passed around, as anyone with a mailbox can attest. Even some online services sell their subscriber lists, neatly ordered by zip code and computer type.

As for who sees your personal data, the answers are not comforting. Government agencies, for example, regularly share data that was originally filed for some other purpose. Consider IRS records, which are compared with student loan records to intercept refunds to former students who have defaulted on their loans. The IRS created a storm of controversy by announcing a plan to use commercial direct-mail lists to locate tax evaders. Many people are worried about the consequences of this kind of sharing (Figure 11-8). For one thing, few of us can be certain that data about us, good or bad, is deleted when it has served its legitimate purpose.

The unfortunate fact is that for very little money, anybody can learn anything about anybody—through massive databases. There are matters that you want to keep private. You have the right to do so. Although you can do little to stop data about you from circulating through computers, there are some laws that give you access to some of it. Let us see what kind of protection is available to help preserve privacy.

Privacy Legislation

Significant legislation relating to privacy began with the **Fair Credit Reporting Act** in 1970. This law allows you to have access to and gives you the right to challenge

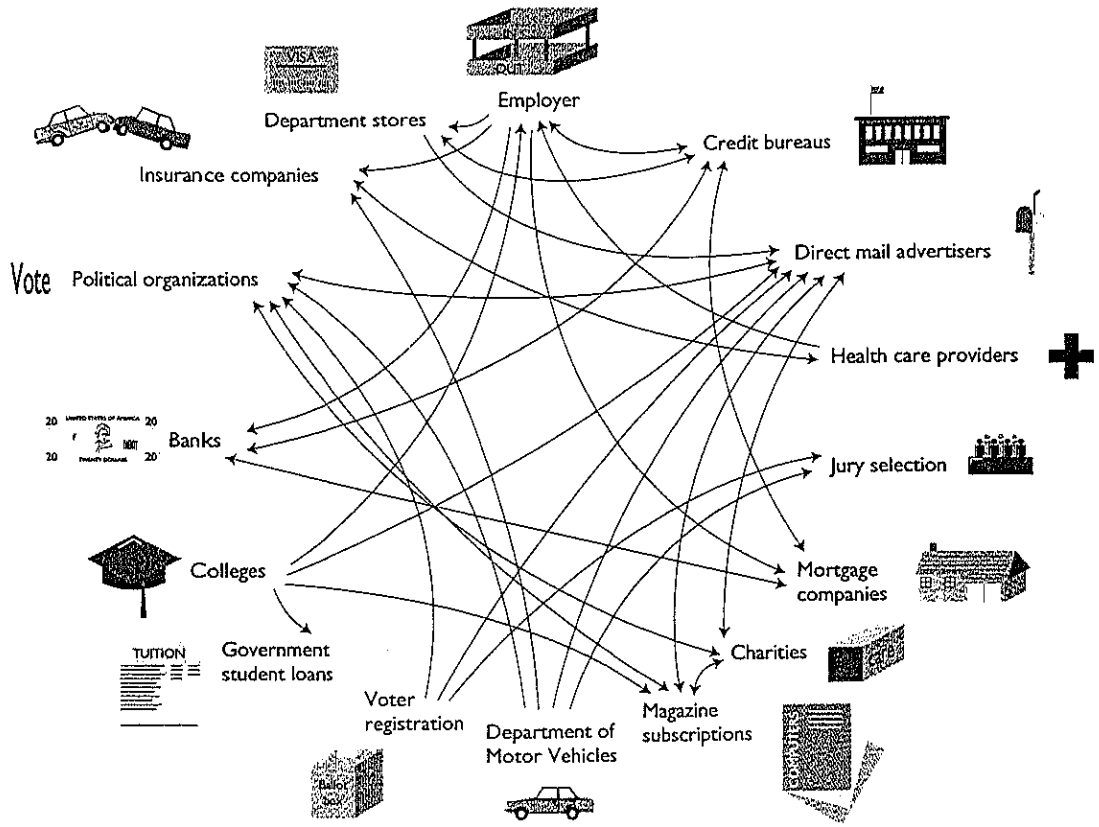


FIGURE 11-8

Potential paths of data.

When an organization acquires data about you, it is often shared with—or sold to—other organizations.

your credit records. In fact, this access must be given to you free of charge if you have been denied credit. Businesses usually contribute financial information about their customers to a credit bureau, which gives them the right to review a person's prior credit record with other companies. Before the Fair Credit Reporting Act, many people were—without explanation—turned down for credit because of inaccurate financial records about them. Because of the act, people may now check their records to make sure they are accurate.

The **Freedom of Information Act** was also passed in 1970. This landmark legislation allows ordinary citizens to have access to data about them that was gathered by federal agencies (although sometimes a lawsuit has been necessary to pry data loose).

The most significant legislation protecting the privacy of individuals is the **Federal Privacy Act** of 1974. This act stipulates that there can be no secret personal files; individuals must be allowed to know what is stored in files about them and how the data is used, and they must be able to correct it. The law applies not only to government agencies but also to private contractors dealing with government agencies. These organizations cannot obtain data willy-nilly, for no specific purpose; they must justify the need to obtain it.

A more recent law is the **Video Privacy Protection Act** of 1988, which prevents retailers from disclosing a person's video rental records without a court order; privacy supporters want the same rule for medical and insurance files. Another step in that direction is the **Computer Matching and Privacy Protection Act** of 1988, which prevents the government from comparing certain records in an attempt to find a match. However, most comparisons are still unregulated.

MAKING CONNECTIONS — **You Have No Privacy Whatsoever**

No privacy on the company e-mail, that is. Your employer can snoop into messages you send or receive even if you think you erased them. You have erased them only from their current hard drive location; copies are still in the company's computer files. In fact, most companies archive all such files on tape and store them for the foreseeable future. Companies may fail to convey to employees the message that e-mail, as a company communications channel, is not private. Employees are often startled, after the fact, to discover that their messages have been intercepted.

Furthermore, some people specialize in extracting deleted messages for use as evidence in court. E-mail can be a dangerous time bomb because litigators argue that, more than any other kind of written communication, e-mail reflects the real, unedited thoughts of the writer. This candid form of corporate communication increasingly is providing the most incriminating evidence used against companies in litigation. In fact, internal company e-mails provided some of the most damaging evidence in the government's antitrust case against Microsoft.

What to do? It is certainly degrading to have something you thought was private waved in front of you as evidence of malingering. As one computer expert put it, if nothing is private, just say so. Companies have begun doing exactly that. The company policy on e-mail is—or should be—expressed in a clear, written document and routinely disseminated to all employees. However, even that step is probably insufficient. People tend to forget or get complacent. Reminders should be given through the usual company conduits—bulletin boards, posters, and so forth.

What about the e-mail you send and receive at home—do you at least have privacy in your own home? Maybe not. You certainly cannot count on it if the computer of the party at the other end is in an office. And keep in mind that messages sent across the Internet hop from computer to computer, with (depending on the service used) the sender having little say about its route. There are many vulnerable spots along the way. Also, your ISP will keep backup tapes of e-mail for some period of time, during which your e-mails would be subject to subpoena by the authorities.

THE INTERNET: SECURITY AND PRIVACY PROBLEMS

Networks, whether connected to the Internet or not, pose unique security and privacy problems. Many people have access to the system, often from remote locations. Clearly, questions arise: If it is so easy for authorized people to get data, what is to stop unauthorized people from tapping it? Organizations must be concerned about unauthorized people intercepting data in transit, whether hackers, thieves, or industrial spies.

One fundamental approach to network security is to set up a computer with **firewall** software. This computer's sole purpose is to talk to the outside world (see Figure 11-9). All traffic between an organization's internal network and the Internet goes through the firewall. The firewall protects the organization from unauthorized access and can also be configured to prevent internal users from accessing inappropriate Internet sites.

Encryption

Data being sent over communications lines may be protected by scrambling the messages—that is, putting them in code that can be broken only by the person receiving the message. The scrambling process is referred to as **encryption,** and uses a code called the **encryption key** to convert the message into an unreadable form. The message can be decrypted only by someone with the proper key. The American National Standards Institute has endorsed a process called the **Data Encryption Standard (DES),** a standardized **private key encryption** system by which senders and

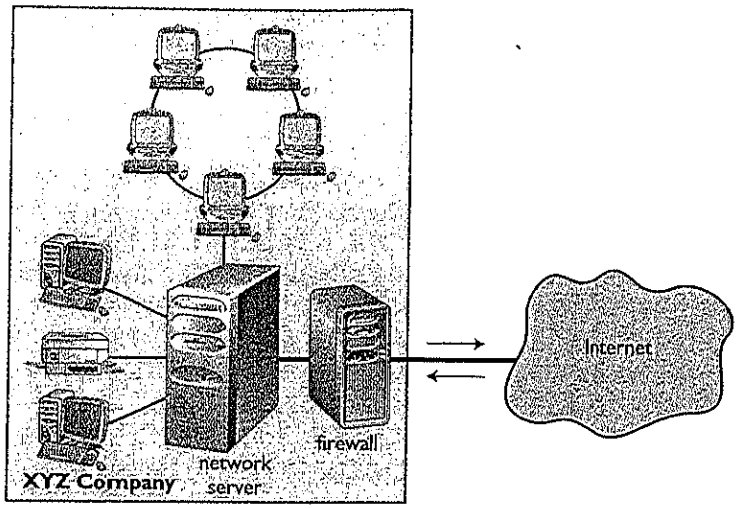


FIGURE 11-9

Firewall.

A firewall protects an organization from unauthorized access and can also be configured to prevent internal users from accessing inappropriate Internet sites.

receivers encrypt and decrypt their messages using the same shared key. One problem with this type of encryption is the difficulty of safely arranging for both parties to share a key without having it intercepted by third parties.

Public key encryption systems solve this problem by using a pair of keys generated by the encryption software. Messages that are encrypted by one of the keys can be decrypted only by the other key of the pair. The receiver keeps one key private and makes the other public. Anyone can encrypt a message to the receiver using the public key. Only the receiver can decrypt the message using the private key. **RSA,** named after its inventors, Rivest, Shamir, and Adleman, is the most common public key encryption system. In addition to being used in several encryption programs, RSA technology is also built into the latest versions of both Microsoft Internet Explorer and Netscape Navigator.

Privacy Problems for Networked Employees

Although employees do not have expectations of total privacy at the office, they are often shocked when they discover that the boss has been spying on them via the network, even their comings and goings on the Internet. The boss, of course, is not spying at all, merely "monitoring." This debate has been heightened by the advent of software that lets managers check up on networked employees without their ever knowing that they are under surveillance. With a flick of a mouse button, the boss can silently pull up an employee's current computer screen.

Surveillance software is not limited to checking screens. It can also check on e-mail, count the number of keystrokes per minute, note the length of a worker's breaks, and monitor what computer files are used and for how long.

Worker associations complain that workers who are monitored suffer much higher degrees of stress and anxiety than nonmonitored workers. However, vendors defend their products by saying that they are not "spy software" but rather products designed for training, monitoring resources, and helping employees. Privacy groups are lobbying legislators at both the state and federal levels to enact legislation that requires employers to at least alert employees that they are being monitored.

People who feel invaded at work might be shocked to find out that they are also being watched when online—in the supposed privacy of their homes. This time it is not the boss but the Web site owners who are watching.

You Are Being Watched

It might seem to be the ultimate in privacy invasion. When you visit a Web site, it can easily collect the city you are calling from, the site from which you just came, and, of

Guard Dog

What about those cookies that are constantly being put on your hard drive? Are you just going to sit still for this kind of invasion? Not if Guard Dog has anything to say about it. Once installed, Guard Dog software is ever vigilant and informs you (woofs, actually) whenever a Web site you are visiting tries to put a cookie file on your hard drive. You may not only decline, but also inform Guard Dog that you will never accept a cookie from that site.

Guard Dog offers other functions, such as cleaning up your URL history and guarding against incoming viruses. Guard Dog cannot protect against everything, but it can take a healthy bite out of security invasions.

course, everything you do while you are at the site. Software can also discover and record the hardware and software you use. Software can even monitor a user's **click stream,** the series of mouse clicks that link from site to site. Thus a history of what a user chooses to view on the Web can be recorded and used for a variety of purposes by managers and marketers.

Many Web servers store information about you in a small file called a **cookie.** This file is actually stored on your own hard drive and sent back to the server by your browser each time you revisit that site. Cookies can be used to store your viewing preferences so that the server can personalize the Web site appearance each time you access the site. Online shopping sites use cookies to keep track of your shopping cart contents until you check out, and some allow you to maintain "wish lists" for up to 90 days. Secure sites such as online brokerages put a temporary cookie on your system when you log on using your password. This allows you to access multiple pages at that site during a single visit without having to reenter your password for each page. These are all beneficial uses for cookies.

A more controversial use of cookies involves tracking your surfing habits so that you can be targeted for certain types of advertisements. Advertising companies such as Doubleclick have agreements with large numbers of Web sites allowing them to place cookies on your computer whenever you visit any of the affiliated sites. By examining the cookies it has placed on your system, Doubleclick can determine which sites you have visited, deduce your interests and preferences, and choose the advertisements you see when you visit a site. For instance, if you have just looked at several sites selling ski equipment and are now at an airline reservations site looking at flights to Colorado, you might very well see an ad for an Aspen ski resort in one corner of your screen.

Browser preferences can be set to refuse all cookies or to warn you when a site attempts to store a cookie on your computer and allow you to choose whether or not to accept it, but most users are unaware of this feature. You can also download software that will let you manage the cookies on your hard drive, deleting the ones placed there by advertising companies.

To combat perceived threats to the Internet user's privacy, the World Wide Web Consortium (W3C—the group responsible for developing Web standards) has proposed the **Platform for Privacy Preferences Project (P3P),** a set of standards that allows a Web site server to transmit its privacy policies electronically to the user. Users can configure their software with their privacy preferences, including what personal information they are willing to provide, and the software will determine whether the Web site meets the users' requirements. P3P is supported by a pantheon of Internet giants, including Microsoft, Netscape, America Online, IBM, AT&T, Hewlett-Packard, and many others. However, participation by Web sites is voluntary, and no laws force sites to follow the privacy policies they post. Only time will tell whether P3P will inspire sufficient confidence among users to become a lasting standard.

Junk E-Mail

Privacy invasion in the form of junk e-mail has become, unfortunately, a common event. The volume of junk e-mail will only soar as more marketers discover how cheap it is. A postal mailing to a million people costs about $800,000, including postage and printing. Internet marketers can reach the same number of people by making a phone call and paying a few hundred dollars for time spent online. The software that makes mass advertising—called **spamming**—possible both gathers e-mail addresses and sends e-mail messages for marketers, thousands and thousands every day. One of the most annoying aspects of e-mail is that, unlike postal junk mail, which at least arrives at no cost to you, a user who pays for online usage may be paying for part of the cost of junk e-mail delivery. Furthermore, the spammers are often devious, using subject lines that appear to indicate personal messages or a reply to "Your request for information."

Enraged spam recipients sometimes respond to the perpetrator by **flaming,** sending insulting messages in return. Experienced spammers, however, have probably already abandoned the originating site and moved to another one. If you want to maximize your privacy and reduce your chances of getting junk e-mail, be careful where you leave your e-mail address. A prime source of e-mail addresses is newsgroup messages, whose e-mail addresses will likely be gathered up and sold. Further, Internet business sites entice visitors to supply personal data that can be used for marketing and promotion. An e-mail address is their most treasured commodity.

There is no sure protection from junk e-mail, but there are ways to minimize it. One approach is to use **filter software,** which gives you some control over what messages will be accepted. The filter software already knows that you do not want messages whose titles are "Lose 30 pounds in 10 days!!!" or "Earn $$$$ at home!" In addition to eliminating the obvious, you may add your own list of screening words. You may even state the exact e-mail addresses from which you will accept mail. Some ISPs provide easy-to-use filters for customers who wish to reduce the amount of unwanted e-mail they receive.

Your online service will let you make up several online names if you wish. Most experts recommend that you use a separate name for surfing the Internet, then simply ignore any mail that comes in for that name. More spam-fighting advice from experts includes never filing a "member's profile" with your online service, not filling in registration forms at Web sites unless the purveyor promises not to sell or exchange your information, and never, never responding to a spammer. Don't even reply to messages that promise to remove your name from their mailing list; spammers use such replies to verify working e-mail addresses, and your response could lead to more spam.

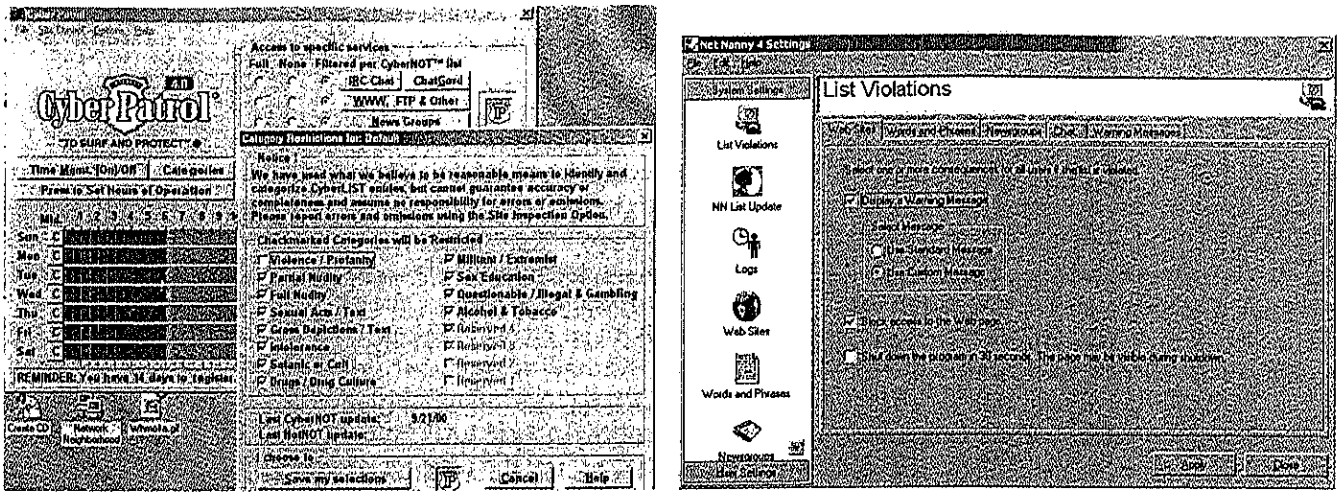
The federal government has been unable to produce antispamming legislation, but the individual states are starting to take up the slack. The first such law with teeth was passed by the state of Washington in 1998. The law specifically bans unsolicited commercial e-mail that has misleading information in the subject line, disguises the path it took across the Internet, or contains an invalid reply address. Suits brought by the state have sought $2000 for each piece of unsolicited commercial e-mail sent to Washington residents in violation of the law.

Protecting Children

The Internet has opened up wonderful new opportunities for children—help with homework, dazzling new adventure games, and a chance to strike up conversations with new friends in other countries. Millions of youngsters are surfing and chatting and e-mailing. But cyberspace can be a mixed blessing for children, who may also be exposed to its less savory elements. Concerned parents are taking steps to monitor their children's use of the Internet.

The most widely used online service, America Online, gives parents control of usage. The parent can create extra sign-in names and tailor privileges to each child. Younger children, for example, can be limited to AOL's kids' area, which includes its own kids' Web browser. Another possibility is blocking software, a product that tries to act as a high-tech chaperone (Figure 11-10). **Blocking software** typically keeps children away from its own updatable list of objectionable sites and avoids sites with other objectionable material such as foul language or sites requesting name, phone number, or credit card number. Blocking software cannot be totally effective because the Web changes too fast for any software staff to maintain a complete list of objectionable sites. Also, some blocking software has been criticized for being overzealous, blocking access to innocuous sites. One product even blocked access to the infant care site BabyZone!

The best monitoring technique may be to avoid having a computer in a child's bedroom. Instead, the computer might be located in a more public, high-traffic location, such as the family room or kitchen.



(a) (b)

FIGURE 11-10

Blocking software.

Both (a) Cyber Patrol and (b) Net Nanny software let parents control online access and block entry to objectionable sites.

Government Intervention?

The invasion of privacy online, especially through the Internet, may be that rare problem that, in the opinion of some communications experts, requires government intervention. Such laws would have to carefully carve out a middle ground between preserving new opportunities for the legitimate needs of business people, researchers, and investigators on the one hand and preserving the right to privacy on the other.

Congress passed the Communications Decency Act in 1996, attempting to target, in particular, people who preyed on children on the Internet. The law caused a firestorm on the Internet, with many sites displaying the "blue ribbon" of free speech. The U.S. Supreme Court struck down the law for vagueness.

But more laws have been passed since that time, and others are likely to follow. The **Children's Online Privacy Protection Act (COPPA)** requires Web sites that target children under age 13 to post a privacy policy that clearly states what information they collect and set up parental notification and consent systems before gathering information from the children. Its provisions took effect in April 2000.

ETHICS AND PRIVACY

As we have already noted, just about everything there is to know about you is already in a computer file—more likely several computer files. The thorny issues center on the appropriate ethical treatment of that data by those who control it or merely have access to it. It is not unlikely that in the course of your career, you yourself will see personal data about other people. Consider these scenarios:

- Suppose that, as a programmer, you work on software that uses the company personnel files. Is it legitimate to look up salary data for people you know? If you see such data in the normal course of your work, is it appropriate to let those individuals know that you saw it?
- Suppose that you had access to data about bank loan applications, some of which appeared in test reports on which you are working. If someone takes these from

your desktop while you are on your lunch break, is this an ethical breach on your part?

- Suppose that you are a programmer for a medical organization, and in the normal course of your work, you see records about a celebrity. Is it ethical to describe the medical treatment to your friends, saying that it is a celebrity but not giving the name? Is it ethical to mention that the named celebrity uses your clinic, without giving any medical details?

These descriptions involve programmers, who are likely to see considerable private data over the course of a career. But people in many walks of life—accountants, tellers, nurses, contractors, and more—see data that resides on a computer. All of us need to respect the privacy of personal data.

The issues raised in this chapter are often the ones that we think of after the fact, when it is too late. Security and privacy factors are somewhat like insurance that we wish we did not have to buy. But we do buy insurance for our homes, cars, and lives because we know that we cannot risk being without it. The computer industry also knows that it cannot risk being without safeguards for security and privacy. As a computer user, you will share responsibility for addressing these issues.

toysmart.com
Click on your child's potential

Do Privacy Policies Really Work?

When Toysmart.com, a company selling educational and nonviolent children's toys online, ran into financial difficulty in the summer of 2000, it attempted to sell all its assets. The major asset was its customer database, which included names, addresses, billing information, shopping preferences, and family profiles that contained children's names and birth dates.

Over a year earlier, Toysmart had posted a privacy policy on its Web site stating that information collected from customers would never be shared with third parties. The FTC filed a lawsuit to prevent the sale of the customer database and soon reached an agreement with Toysmart that would allow the sale only as part of a sale of the entire Web site to a qualified buyer that would continue to operate the business.

Although most privacy advocates hailed the FTC's prompt action to protect customer privacy, some thought that, given the original policy statement, customers should have been given notice of any sale of their information and have the opportunity to decline.

Word Processing and Desktop Publishing:

Printing It

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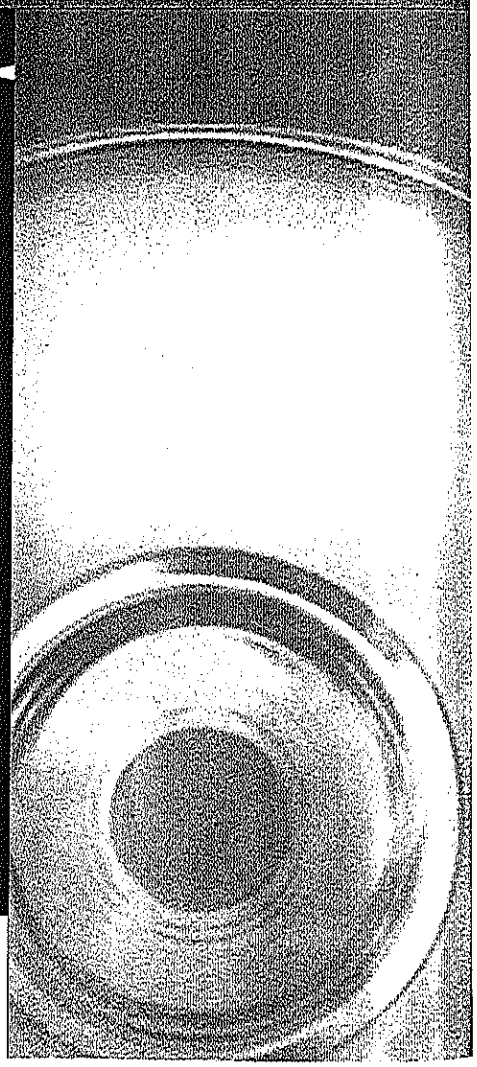


CHAPTER 12

LEARNING OBJECTIVES

- Explain the need for word processing
- List and describe the basic features of word processing programs
- Describe how spelling checkers and thesaurus programs work
- Explain the value of collaboration using word processing and the Web
- Describe the advantages of desktop publishing
- Define desktop publishing terminology

Jane Duffin, a physical therapist in the Mount Tahoma School District, appreciates the interaction between her students and computers. In particular, she has observed them using software that was specially designed to help physically challenged students to communicate.

Until recently, however, Jane has done most of her own paperwork by hand. Other items, primarily the dreaded end-of-year reports, were typed and retyped by a secretary using a typewriter. For Jane everything changed the day the district administrators announced that professional employees would get their own computers to take home with them. The administrators also required them to take a series of classes on how to use the computer software.

Jane learned word processing, software that let her prepare and print text documents such as memos and reports. She made her first tentative foray into word processing by typing a memo. She was not concerned about typing mistakes she made, but simply corrected them on screen before she printed the memo.

That was the beginning. With a speed that surprised her, Jane found herself moving all her paperwork to the computer: individualized child service plans, bus schedules, academic and physical progress reports, and her own time records for each child. At first Jane composed what she wanted to communicate on paper and then keyed it into the word processing program. Before long she became comfortable enough to com-

pose directly on the computer. Furthermore, she saw her overall communication improve as she wrote memos to parents, teachers, doctors, and staff members.

A few months later, Jane decided to use her word processing skills to tackle the annual grant proposal document. In past years the entire proposal, running some 40 pages, had to be typed from scratch. This was true even though much of the proposal was the same from year to year. A word-processed document can be handled differently. Only new or changed material has to be keyed in, and then the entire document can be printed as if new. Relishing the thought of how easy it was going to be next year, Jane set out to produce the grant proposal in word-processed form.

Jane could also improve the document's attractiveness by using features such as boldface, underlining, and even graphics. Best of all, she could make the document look professionally printed by choosing an attractive typeface—font—from her word processing package.

Jane is still a busy physical therapist. But thanks to her computer and its word processing software, she has more time for her first love: children.

WORD PROCESSING AS A TOOL

Word processing software lets you create, edit, format, store, retrieve, and print a *text document.* Let us examine each part of the definition. A text document is any text that can be keyed in, such as a memo. *Creation* is the original composing and keying in of the document. *Editing* is making changes to the document to fix errors or improve its content—for example, deleting a sentence, correcting a misspelled name, or moving a paragraph. *Formatting* refers to adjusting the appearance of the document to make it look appropriate and attractive. For example, you might want to center a heading, make wider margins, or use double spacing. *Storing* the document means saving it on disk so that it can be accessed on demand. (Although beginners usually think only in terms of saving the completed document, all users, whether experienced or inexperienced, should save a document at regular intervals as it is being keyed to avoid losing work if something should go wrong.) *Retrieving* the document means bringing the stored document from disk back into computer memory so that it can be used again or changed in some way. *Printing* is producing the document on paper, using a printer connected to the computer.

A word processing package is a sophisticated tool with many options. This chapter discusses several of them. First, here is an overview of how word processing works.

AN OVERVIEW: HOW WORD PROCESSING WORKS

Think of the computer's screen as a page of typing paper. When you type, you can see the line of text you are typing on the screen—it looks just like a line of typing on paper. You are not really typing on the screen, of course; the screen merely displays what you are entering into memory. As you type, the program displays the **insertion point,** or **cursor,** to show where the next character you type will appear on the screen. The insertion point is usually a blinking dash or line or rectangle that you can easily see. Although this chapter examines word processing in a general way that applies to any word processing software, occasionally, as here, a point will be demonstrated with *Microsoft Word 2000* (Figure 12-1).

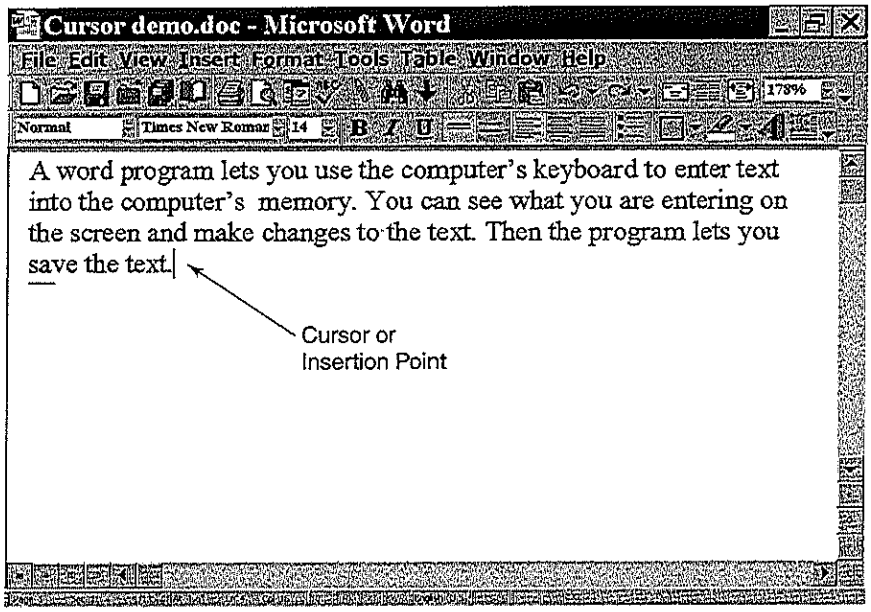


FIGURE 12-1

Entering text with word processing software.

As you type in your text, the position of the cursor (the vertical line just to the right of the last word on the screen) shows where the next character will be placed.

Scrolling

A word processing program lets you type page after page of material. Most programs show a horizontal line on the screen to mark where one printed page will end and another will begin; this line does not appear on the printed document. Most word processing programs also display, at the bottom of the screen, the number of the page on which you are currently typing and also an indicator of the line you're on, either by line number or by inches from the top of the printed page. Although the screen display size is limited, your document size is not. As you add new lines at the bottom of the screen, the lines you typed earlier move up the screen. Eventually, the first line you typed disappears off the top of the screen. However, the line has not disappeared from the document or from the computer's memory.

To see lines that have disappeared from the top, you can move the cursor up to the top of the screen and press the up arrow key; lines that had disappeared drop back down onto the screen. You can also use a mouse to accomplish the same thing by clicking over the up arrow of the scroll bar to the right of the screen. You can use opposite movements to send screen lines in the upward direction. This process, called **scrolling,** lets you see any part of the document—but only one screen at a time.

No Need to Worry about the Right Side

After you start to type the first line of a document, you will eventually get to the right edge of the document. If there is not enough room at the end of a line to complete the word you are typing, the program automatically moves that word to the left margin of the next line down. This feature is called **word wrap.** With word wrap you do not have to push a carriage return key (on the computer, the Enter key) at the end of each line as you would with a typewriter; in fact, you should *not* press Enter at the end of a line, or the word wrap feature will not work properly. You should press Enter only when you want a blank line or to signal the end of a paragraph.

Easy Corrections

What if you make a mistake while you are keying? No problem: Move the cursor to the position of the error and make the correction. Use the **Backspace key** to delete characters to the left of the cursor, or use the **Delete key** to delete the character

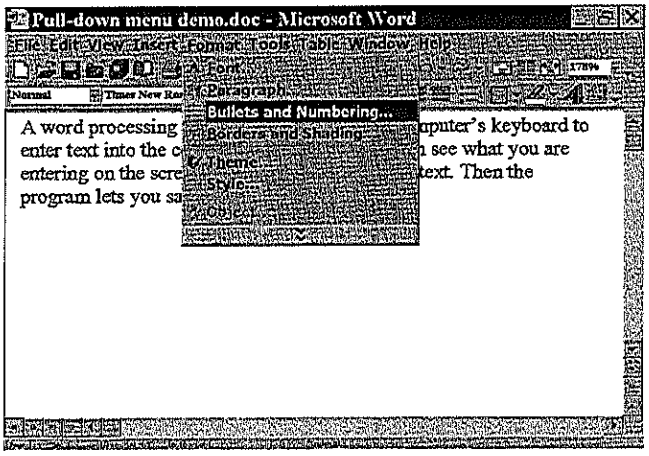
under the cursor or just to the right of the cursor. Word processing programs let you delete characters or whole words, lines, or paragraphs that you have already typed; the resulting spaces are closed up automatically.

Sometimes people delete parts of a document and immediately regret it. Accidental or incorrect deletions can usually be repaired with the **Undo command,** usually shown as a reverse arrow on the toolbar. Undo reverses the effect of the previous action and returns the document to its condition just before that operation. High-performance word processing programs offer the ability to undo more than one previous operation.

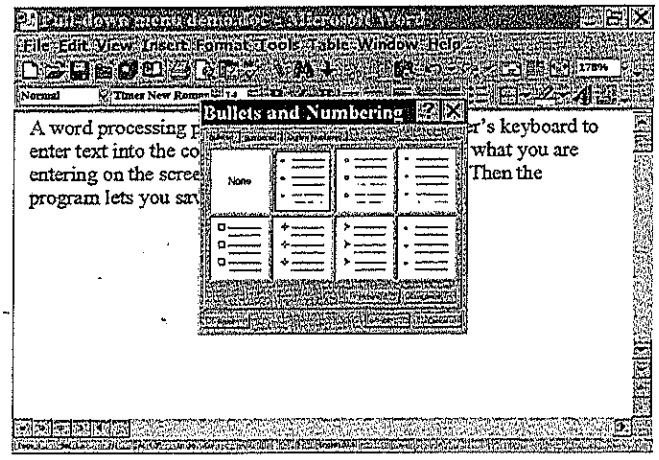
You can also insert new characters in the middle of a line or a word without typing over (and erasing) the characters that are already there. The program automatically moves the existing characters to the right of the insertion as you type the new characters and rewraps the text. However, if you wish, the word processing program also lets you *overtype* (replace) characters you typed before.

Menus and Buttons: At Your Command

Most word processing packages permit commands to be given via **menus,** a set of choices normally laid out across the top of the screen. The menus are called **pull-down menus** because each initial choice, when clicked with a mouse, reveals lower-level choices that pull down like a window shade from the initial selection at the top of the screen. For example, an initial selection of Format may reveal several submenus; the submenu Bullets and Numbering has its own set of selections (Figure 12-2). A



(a)



(b)

FIGURE 12-2

Pull-down menus.

(a) When the Format menu is clicked with a mouse, a submenu of choices appears. The submenu Bullets and Numbering is highlighted. If it is clicked, the submenu shown in part (b) appears. (b) Some submenus have their own submenus; here, the submenu Bullets and Numbering has further selections. Note also the vertical scroll bar on the right side of the screen. When a mouse is used to click one of the large up or down arrows on the scroll bar, the document moves up or down, respectively. You can also use the mouse to drag the rectangle within the scroll bar up and down, and the document will scroll accordingly.

mouse user can also invoke commands by using **buttons.** A **toolbar** is a collection of such buttons, usually shown across the top of the screen just below the pull-down menus (Figure 12-2). There are different kinds of toolbars for different application programs and even a variety of toolbars within the same software. As an example of button functions, the top leftmost buttons on the screen in Figure 12-2b let you begin a new document (the white paper button), open an existing document (the file folder button), or save a document (the diskette button). You can discover the meaning of any button by resting your mouse on it; an explanatory phrase will soon appear.

WORD PROCESSING FEATURES

All word processing users begin by learning the basics: Invoke the word processing software, key in the document, change the document, and save and print the document. However, most users also come to appreciate the various features offered by word processing software (Figure 12-3).

Formatting

The most commonly used features are those that control the **format**—the physical appearance of the document. Format refers to centering, margins, tabs and indents, justification, line spacing, emphasis, and all the other factors that affect appearance. Note the examples in Figure 12-3 as some formatting options are described.

VERTICAL CENTERING A short document such as a memo starts out bunched at the top of the page. **Vertical centering** adjusts the top and bottom margins so that the text is centered vertically on the printed page. This eliminates the need to calculate the exact number of lines to leave at the top and bottom, a necessary process if you are using a typewriter.

MAKING CONNECTIONS ◄ The Virtual Office

The word virtual is applied in various computer settings, but it always means the same thing: the appearance of something that really does not exist. The computer somehow masks the reality and permits benefits similar to those offered by the real thing. In this discussion of the virtual office, the office as we know it—a physical place with a desk and a chair and office supplies—does not actually exist. But its functions do exist.

Consider the way Nora Mathison runs her sprinkler installation business in Phoenix. She relies on a toll-free phone number, voice mail, a cellular phone, and a notebook computer with a fax modem. No building, no office, no desk.

Nora advertises her toll-free number in the Yellow Pages; potential customers in the urban/suburban area can call the number without charge. When they do, they are advised to leave a voice mail message. Nora, working on site in some customer's yard, can retrieve her voice mail messages and return the calls on her cell phone. She can use software on her notebook computer to work up a bid right at a customer site, or she can do the work later and fax the results to the customer. She also uses the notebook computer for scheduling, work flow, and billing.

In addition to convenience the virtual office can minimize start-up costs for fledgling entrepreneurs. For business people who spend most of their time out of the office anyway, the virtual office is an ongoing asset.

Chapter 1 — Header

Enlarged typeface — **COMMUNITY CRIME PREVENTION AND SAFETY** — Centered heading

Line graphic

Underline — Statement of goals: Citizens must share the responsibility for prevention of crime and for their own safety. Law enforcement and government agencies cannot and should not handle it alone.[1] — Sans serif typeface

Block indent

Reference to footnote

Numbered outline

I. Home Security
- A. Outside your home
- B. Doors and windows
- C. Locks
- D. Property marking
- E. Inventory sheet

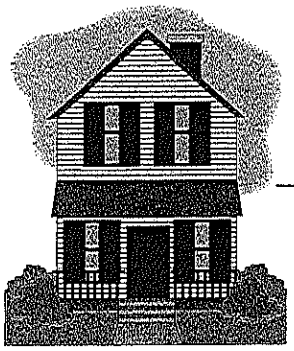
II. General Safety
- A. Safety in your home
- B. Safety in your neighborhood
- C. Going on vacation

Boldface — **Security overview.** Burglary is a crime of opportunity—perhaps a weak door or an unlocked window. Most burglars use unsophisticated methods to gain entry, using simple force on an easy target. Citizens can use preventive strategies to make their homes secure. — Ragged right text

Superscript — **Safety overview.** Safety is a broad topic, running the gamut from keeping your chimney clean to having a fire escape plan to wrapping your water pipes when the temperature dips below 32°. Safety is of particular concern when people are going on vacation. Planning ahead will prevent many problems. — Fully justified text

HOME SECURITY CHECKLIST

Bulleted checklist
- ☐ Strong exterior doors
- ☐ Deadbolt locks
- ☐ Door peephole
- ☐ Windows secured
- ☐ Timed lights
- ☐ Lighted entrances
- ☐ Shrubs trimmed



Inserted graphic image

Italic

Footnote — [1] *Blockwatch: Community Crime Prevention*, Seattle Police Department Crime Prevention Division, 2001.

Pagination

FIGURE 12-3

Word processing features.

Although it is not possible to show all word processing features on a single page, this page illustrates many of the capabilities that are available.

LINE CENTERING Any line can be individually **centered** between the left and right margins of the page. Headings and titles are usually centered; other lines, such as addresses, may also be appropriately centered.

MARGINS Some settings, called **default settings,** are used automatically by the word processing program; they can be overridden by the user. The default left and right margins are usually 1¼ inches wide. Documents are often typed using the default margin settings. However, if the document would look better with narrower or wider margins, the margin settings can be changed accordingly. When the margin settings are changed, word processing software automatically adjusts the text to fit the new margins. This process is called **automatic reformatting.**

TABS AND INDENTATION It is common to **tab** just once to begin a paragraph. Some users need a set of tab positions across the page to make items align. It is also possible to **indent** an entire paragraph and even to indent it from two sides so that it stands out.

JUSTIFICATION The evenness of text at the side margins is called **justification.** A document of several paragraphs is often most attractive if it is **fully justified,** that is, has an even margin down each side. The program adjusts each line so that it ends exactly at the right margin, spacing the words evenly. There are occasions—perhaps to spot any unintentional spaces—when only left justification is desired; this is referred to as **ragged-right** text because of the uneven appearance of the unjustified right side.

LINE SPACING Most of the time you will want your documents—letters, memos, reports—to be single-spaced. But on occasion you will find that it is convenient or necessary to double-space or even triple-space a document. Word processing lets you do this with ease.

BOLDFACE, ITALIC, AND UNDERLINING Certain words or phrases, or even entire paragraphs, can be given emphasis by using a darker text known as **boldface** text, or by using the slanted type called *italic*, or by <u>underlining</u> important words. Some style guidelines still require underlining in special circumstances, and all modern word processing programs support it. However, underlining is something of an anachronism, given the italics, boldface, and special font features of modern word processing programs. Italics or boldface is probably a better choice than underlining for emphasizing text.

FONTS Most word processing packages offer dozens of fonts. In fact, you can easily see what they look like by using a pull-down menu (Figure 12-4). A **font** is a set of characters—letters, punctuation, and numbers—of the same design. Figure 12-5 shows some fonts in a large enough size that you can get a better idea of the variety. Everyday fonts can generally be grouped into serif and sans serif fonts ("sans" means "without"). In a **serif** font, each character includes small marks called serifs, which are thought to help the eye travel more easily from character to character, making reading easier. A **sans serif** font is clean and stark, with no serif marks (Figure 12-6). In this book the main text uses a serif font, but the margin notes and figure captions use a sans serif font.

Most fonts available today are **scalable** fonts. This means that they can be set to almost any size without the individual letters appearing ragged or irregular. Fonts that use the trade name TrueType are always scalable. Most word processing programs let you dress up your text by adding color and three-dimensional effects (Figure 12-7).

FIGURE 12-4

Pull-down fonts.

Notice that the font name is written in the style of the font, an easy way to see what you are getting.

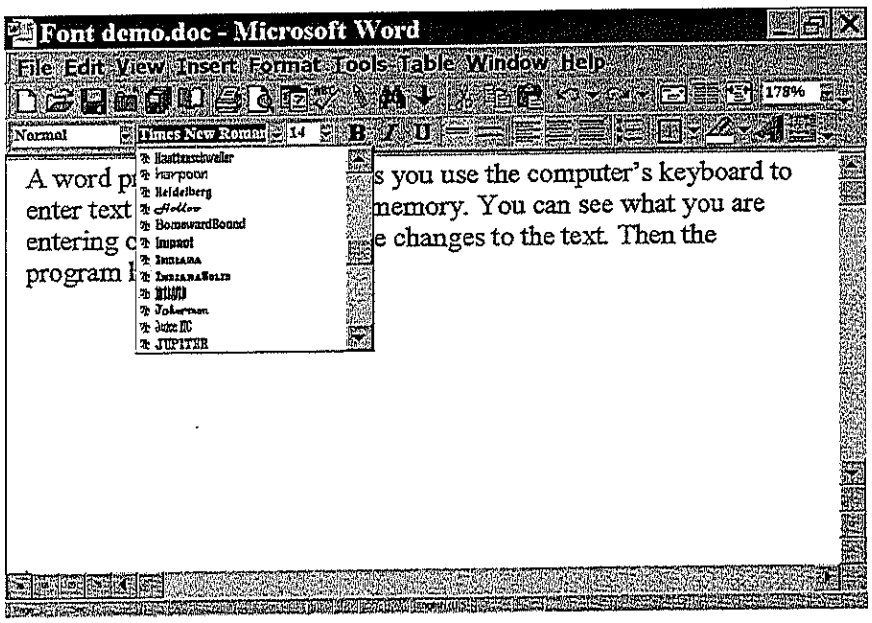


FIGURE 12-5

Various fonts.

These fonts, just ten of hundreds of possibilities, can serve a purpose or just whimsy. As you can see, some are more easily read than others.

FIGURE 12-6

Comparing serif and sans serif fonts.

(a) This popular serif font is called Times New Roman.
(b) This sans serif font is called Helvetica Light.

(a) The quick brown fox jumped over the lazy dog.

(b) The quick brown fox jumped over the lazy dog.

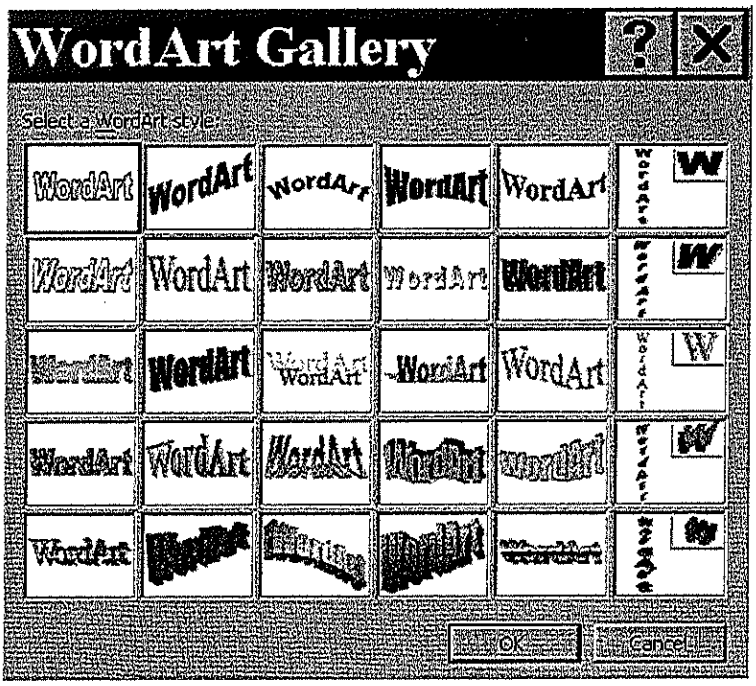


FIGURE 12-7

Three-dimensional fonts.

Using one of several choices from *Microsoft Word*'s WordArt menu, shown here, a user can turn ordinary text into something special.

Squeezing or Stretching a Document

There are times when you want certain text to fit into a certain space. For example, an instructor could suggest that a term paper be at least 10 double-spaced pages, or a potential employer could request a résumé of no more than two pages. Or perhaps the problem is something as simple as taking a memo that runs three pages plus two lines and reducing it to just three pages. There are several ways to use word processing features to adjust the length of a document:

- Adjust the margins, both sides and top and bottom, making them larger to stretch the number of pages or smaller to reduce the number.
- Try different line spacing. One-and-a-half line spacing, available with most word processing programs, looks quite similar to double spacing.
- Experiment with fonts. Some take up much less room than others at the same point size. And, of course, point size is a variable that you can adjust.

Note the variation in size in the two versions of the letter in Figure 12-8.

Printing Envelopes

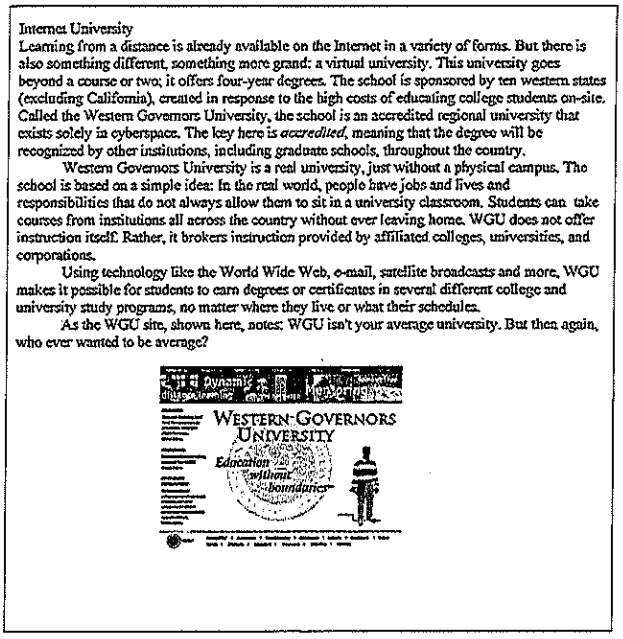
After printing your computer-produced letter, you carefully fold it in thirds with nice even creases, slip it into an envelope that matches the paper, and then proceed to chicken-scratch the address onto it. The professional look falls through in this scenario. Using your computer to address and print the envelope adds that finishing touch.

It is not that difficult to do. Every word processing program offers a way to produce envelopes that look as good as the letters they contain. Here, generally, is how it is done. Find the Envelope command on one of your program's pull-down menus (Figure 12-9a). That menu will cause a window to be displayed (Figure 12-9b), giving you the opportunity to type in the recipient's address; the address will be there automatically if you highlighted it in the letter before you invoked the Envelope command. There is also space to type your return address. You can set your address as the default return address and not have to type it each time; this can, of course, be overridden when you need to use another address. The return address can be omitted

FIGURE 12-8

Stretching a document.

It is fairly easy to stretch or compress a document by varying margins, fonts, and line spacing. (a) This document is bunched at the top and poorly presented altogether. (b) The same document has been arranged more suitably on the page by making the side and top margins wider and increasing the font size from 12 to 14. While we were at it, we used full justification, moved the image to the center of the document, and made the title more attractive using the program's WordArt feature. We also centered the title.



Internet University

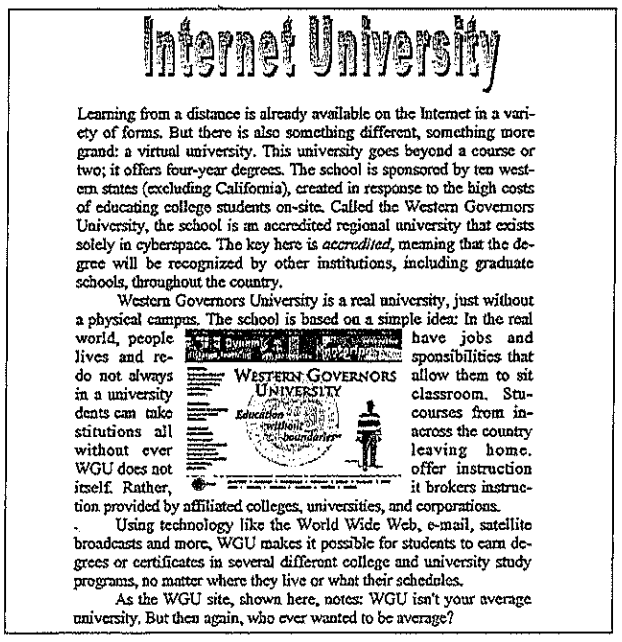
Learning from a distance is already available on the Internet in a variety of forms. But there is also something different, something more grand: a virtual university. This university goes beyond a course or two; it offers four-year degrees. The school is sponsored by ten western states (excluding California), created in response to the high costs of educating college students on-site. Called the Western Governors University, the school is an accredited regional university that exists solely in cyberspace. The key here is *accredited*, meaning that the degree will be recognized by other institutions, including graduate schools, throughout the country.

Western Governors University is a real university, just without a physical campus. The school is based on a simple idea: In the real world, people have jobs and lives and responsibilities that do not always allow them to sit in a university classroom. Students can take courses from institutions all across the country without ever leaving home. WGU does not offer instruction itself. Rather, it brokers instruction provided by affiliated colleges, universities, and corporations.

Using technology like the World Wide Web, e-mail, satellite broadcasts and more, WGU makes it possible for students to earn degrees or certificates in several different college and university study programs, no matter where they live or what their schedules.

As the WGU site, shown here, notes: WGU isn't your average university. But then again, who ever wanted to be average?

(a)



Internet University

Learning from a distance is already available on the Internet in a variety of forms. But there is also something different, something more grand: a virtual university. This university goes beyond a course or two; it offers four-year degrees. The school is sponsored by ten western states (excluding California), created in response to the high costs of educating college students on-site. Called the Western Governors University, the school is an accredited regional university that exists solely in cyberspace. The key here is *accredited*, meaning that the degree will be recognized by other institutions, including graduate schools, throughout the country.

Western Governors University is a real university, just without a physical campus. The school is based on a simple idea: In the real world, people have jobs and lives and responsibilities that do not always allow them to sit in a university classroom. Students can take courses from institutions all across the country without ever leaving home. WGU does not offer instruction itself. Rather, it brokers instruction provided by affiliated colleges, universities, and corporations.

Using technology like the World Wide Web, e-mail, satellite broadcasts and more, WGU makes it possible for students to earn degrees or certificates in several different college and university study programs, no matter where they live or what their schedules.

As the WGU site, shown here, notes: WGU isn't your average university. But then again, who ever wanted to be average?

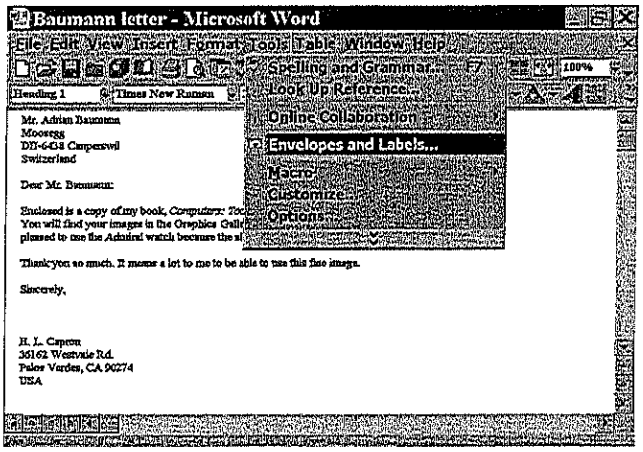
(b)

altogether if you are using an envelope with a preprinted return address. Most word processing programs also include the postal bar code that provides automatic routing of your letter to its destination.

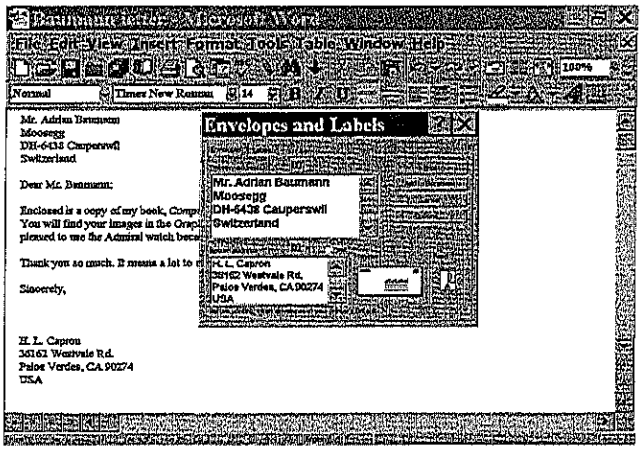
The software will offer a variety of options, such as different fonts and font sizes, envelope size, and the manner in which the envelope is fed into the printer. The tricky part is getting the envelope into the printer correctly; we must refer you to the manual that matches your printer—or, even better, suggest that you have someone show you. When everything is ready, click the Print button in the Envelope window shown in Figure 12-9b. The envelope comes out of the printer ready to be stamped and mailed.

Other Important Features

Popular word processing packages offer more features than most people use. Although it is not possible to discuss every feature here, this list contains a few that you might find handy.



(a)



(b)

FIGURE 12-9

Printing an envelope.

To print an envelope, (a) find the Envelope command on a menu, (b) invoke the command to see the window for addresses and options, and after completing the necessary steps, click Print to produce the printed envelope.

SEARCH Imagine that you are working with a 97-page study called "Western Shorebirds," all nicely prepared as a word-processed document. There has been an additional sighting of the white-rumped sandpiper, and it has fallen to you to make a change in the report. You could, of course, leaf through the printed report to find out where to put the change. Alternatively, you could scroll the report on the screen, hoping to see the words "white-rumped sandpiper" pass by. The fast and easy way, however, is to use the **search command,** also called the **find command.** Just invoke the search command, key in the word or words you are looking for, and the exact page and place where it is located will appear on the screen.

FIND AND REPLACE Suppose you type a long report in which you repeatedly and incorrectly spell the name of a client as "Mr. McDonald." To make a change, you could search for each individual occurrence of "McDonald," replacing each incorrect "Mc" with the correct "Mac." There is, however, a more efficient way—using the **find-and-replace function.** You make a single request to replace one word or phrase with another. Then the find-and-replace command quickly searches through the entire document, finding each instance of the word or phrase and replacing it with the word or phrase that you designated. Most word processing programs also offer **conditional replace,** which asks you to verify each replacement before it is carried out.

PAGINATION **Pagination,** that is, displaying page numbers in a document, is a normal need for most users. Word processing programs offer every imaginable paging option, permitting the page number to be located at the top or bottom of the page and to the left, right, or center, or even alternating left and right.

PRINT PREVIEW Many users call **print preview** their favorite feature. With a single command a user can view on the screen in reduced size an entire page, two facing pages, or even several consecutive pages. This gives a better overall view than the limited number of lines available on a screen.

FOOTNOTES To insert a **footnote,** a user need only give the footnote command and type the footnote text. The word processing program keeps track of space needed and automatically renumbers if a new footnote is added. Footnotes can easily be converted to endnotes and vice versa.

HEADERS AND FOOTERS Unlike footnotes, which appear just once, **headers** (top of the page) and **footers** (bottom of the page) appear on every page of a document (see Figure 12-3). A number of variations are available, including placement, size, and font. Footers are commonly used for the page number. In addition to page numbers, most word processing programs can automatically insert other useful information into headers or footers. Examples include the date and time the document was last modified and the file name under which the document is stored on disk.

Text Blocks: Moving, Copying, and Deleting

Text block techniques comprise a powerful set of tools. A **text block** is a unit of text in a document. A text block can consist of one or more words, phrases, sentences, paragraphs, or even pages. Text blocks can be moved, copied, or deleted.

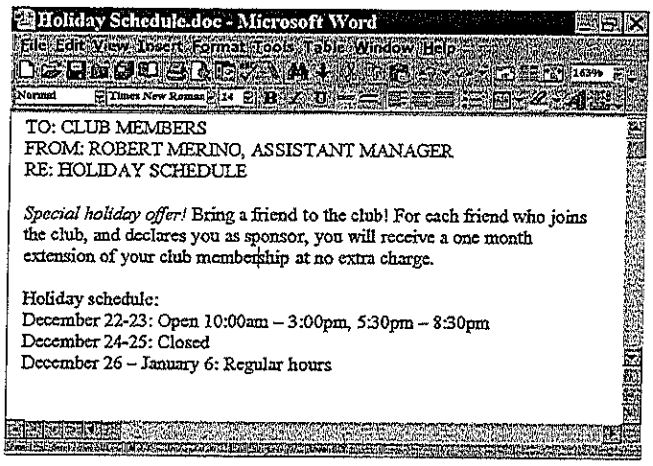
Consider this example. Robert Merino is the manager of the Warren Nautilus Club, a fitness center seven blocks from the state university he attends. Last December, just before the student holidays, Robert used word processing to dash off a notice to the members, informing them of changes in the holiday schedule (Figure 12-10a).

Now, four months later, Robert wants to produce a similar notice regarding schedule changes during spring break. Rather than beginning anew, Robert will retrieve his old document from the disk and key in the changes. After Robert has given the command to retrieve the document, the current version of the notice, just as he saved it on disk, is loaded into memory and displayed on the screen. Robert plans to make changes so that the new notice will be as shown in Figure 12-10b. In particular, Robert uses text block commands to move a paragraph.

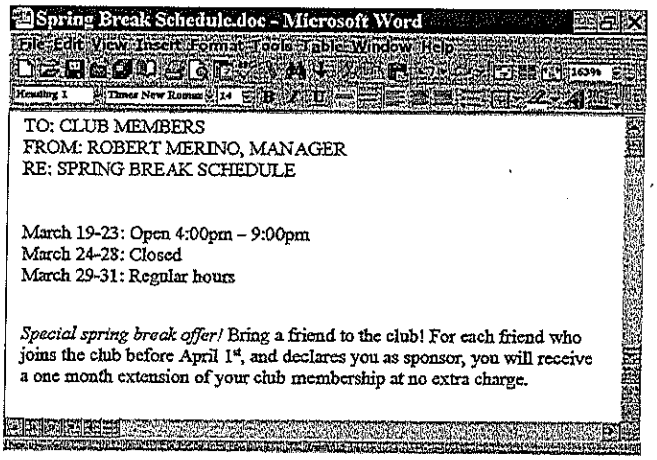
MARKING A TEXT BLOCK Whenever action is to be taken on a block of text, that block must first be **marked,** which is a form of identification. Marking a block is sometimes called **selection,** since you are selecting text with which to work. A block is usually marked by placing the mouse at the beginning of the block, holding the mouse button down, and dragging the mouse to the end of the block. In Robert's memo the block to be marked is the paragraph with the special offer. On the screen the marked block is now highlighted, probably by **reverse video**—the print in the marked text is the color of the normal background and the background is the color of the normal text. Once the block is marked, it can be moved, copied, or deleted.

MOVING A TEXT BLOCK Moving a block of text removes it from its original location and places it in another location. The block still appears only once in the document. Moving a block from one location to another is also called **cutting and pasting,** a reference to what you literally would have to do if you were working with a document on paper. Most word processing programs use the actual words "Cut" and "Paste" as command names: The Cut command removes the block from its old location, and the Paste command places the block in its new location, as indicated by the cursor location. To summarize the move operation: (1) mark the block, (2) cut, (3) move the cursor to the new destination, and (4) paste.

COPYING A TEXT BLOCK The copy command leaves the block intact in its original location but also inserts it in a designated new location; now there are two copies of the block. Typical commands for copying a block are copy and paste. To summarize



(a)



(b)

FIGURE 12-10

Moving a text block.

(a) Robert's original memo. (b) Robert begins by deleting "ASSISTANT" so that his title reflects his recent promotion to manager. He next uses the find-and-replace command to change each mention of December to March. He takes a few moments to delete the old dates and times, add the new ones, and add April 1 as the deadline for the new member promotion. Finally, since the notice is supposed to be about the changed schedule, he uses text block commands to move the special offer paragraph to the end of the notice. The result is the revised memo shown here.

the copy operation: (1) mark the block, (2) copy, (3) move the cursor to the new destination, and (4) paste.

DELETING A TEXT BLOCK Deleting a block of text is easy. In fact, it has already been described. Once a block is marked and cut, it is effectively deleted. An easy alternative is to mark a block and then press the Delete key.

SPELLING CHECKER AND THESAURUS PROGRAMS

A **spelling checker** program finds spelling errors you might have made when typing a document. The program compares each word in your document to the words it has in its dictionary. If the spelling checker finds a word that is not in its list, it assumes that you have misspelled or mistyped that word. The spelling checker draws attention to the offending word in some way, perhaps by reversing the screen colors or underlining in a different color. When you position the cursor on that word, the spelling checker displays words from its dictionary that are close in spelling or sound to the word you typed (Figure 12-11). If you recognize the correct spelling of the highlighted word in the list you are given, you can replace the incorrect word with the correct word from the list.

Spelling checkers often do not recognize proper names (such as "Ms. Verwys"), acronyms (e.g., "NASA"), or technical words specific to some disciplines (e.g., "orthotroid"). So you must decide whether the word is actually misspelled. If it is, you

Help!

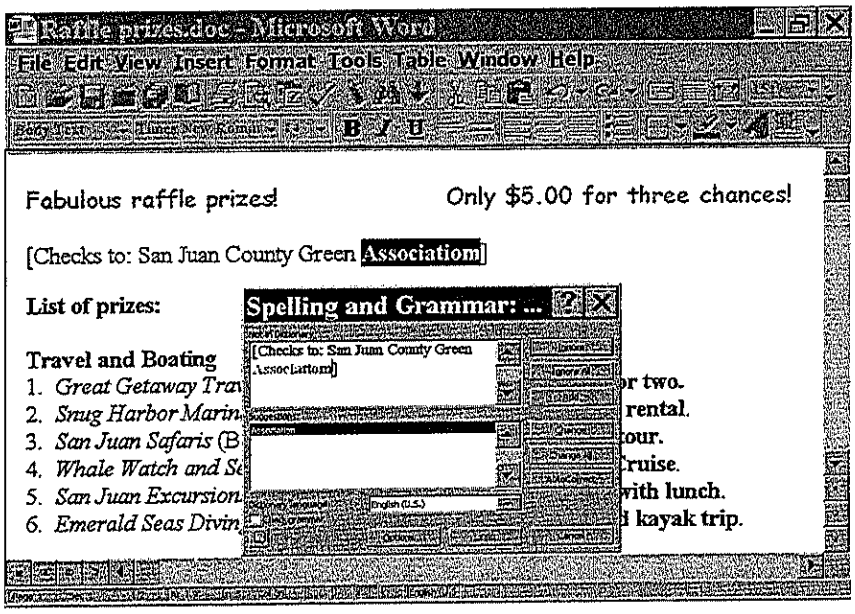
I have a spelling checker,
It came with my pea sea.
It plainly marks four my revue
Mistake I cannot see.
I ran this program threw it,
I'm sure your pleas two no.
Its letter perfect in it's weigh
My checker tolled me sew.

This little ditty circulating among office workers reveals the limitations of spelling checkers. Moral of the story: The spelling checker can indeed help, but human checkers must also help themselves.

FIGURE 12-11

Spelling checker.

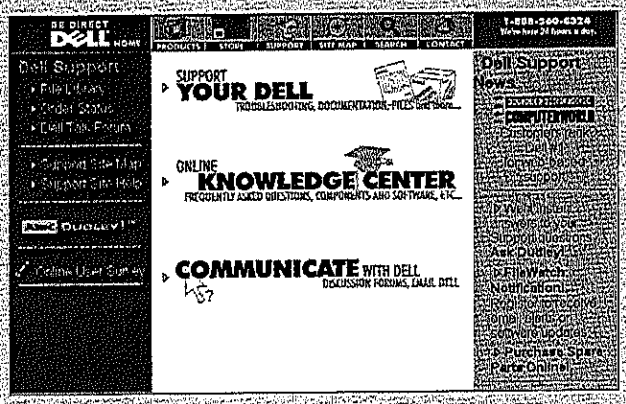
The highlighted word, "associatiom," is misspelled, so the spelling checker offers an alternative—"association"—in the suggestion window. In this case, selecting Change replaces the misspelled word with the correct spelling.

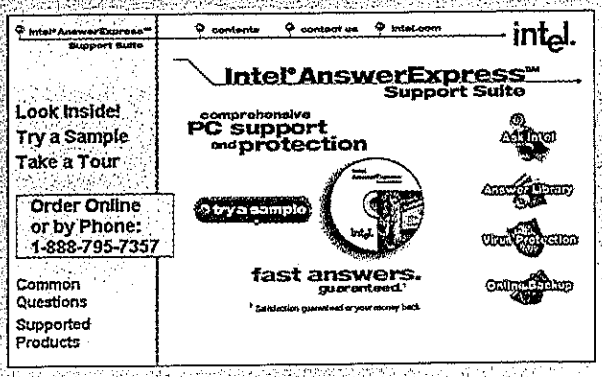


GETTING PRACTICAL — Getting Help

Sooner or later most computer users need some help with hardware or software. Help is usually available in a variety of forms. All reputable vendors, whether of hardware or software, have their own Web sites to offer support, such as those shown here for Intel and Dell. Vendors encourage users to go first for help to their Web sites. A support site typically offers lists of frequently asked questions (with answers), software fixes that can be downloaded, and an e-mail service you can use to send specific questions to their technical staff.

Many users prefer to get help directly over the phone from staff employed by the hardware or software maker. Typically, assistance is free for a certain time period, perhaps 90 days from the first phone call, but later there is a charge to the user. However, if the help line is not a toll-free number, then you may run up long-distance charges. To make the best use of your time on the phone, do some advance preparation. Before you call, do the following:





- Place your phone near your computer and be sitting at your computer as you call.
- If you are an established customer, have your customer number handy.
- Know your computer type, model, and serial number and the version of your software package.
- Write down the exact wording of any error messages.
- Be prepared to press phone buttons in response to directions and then to wait—perhaps many minutes—to be connected to a live person who can help you.

When you call, do the following:

- Give identifying information when asked.
- State the problem clearly.
- Tell the technician what you have already tried.
- Be ready to explore solutions on the computer as you talk.

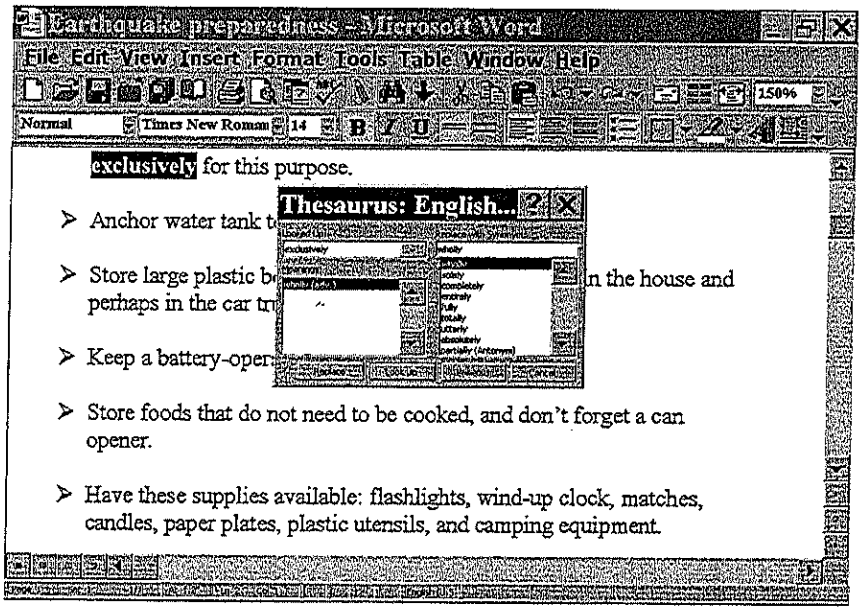


FIGURE 12-12

A thesaurus program.

The words on the list are synonyms for the highlighted word, "exclusively."

can correct it easily with the word processing software. If the word is correct, the software lets you signal that the word is acceptable and, if you wish, even add it to the dictionary.

A **thesaurus** program offers synonyms (words with the same meaning) and antonyms (words with the opposite meaning) for common words. Suppose you find a word in your document that you have used too frequently or that does not seem suitable. Place the cursor on the word. Then click the menu or button that activates the thesaurus program. The program provides a list of synonyms for the word you want to replace (Figure 12-12). A click on the chosen new word replaces the word in your document with the synonym you prefer. It is easy, and even painlessly educational.

WORD PROCESSING AND THE WEB

The World Wide Web can be used as a universal communications vehicle because all computers use the same protocol. Users can send messages to one another despite differences among their computers. However, instead of just relaying messages, users have taken the next logical step: collaboration on the same document by using the Web.

Suppose, for example, that three nutritionists, in different offices, are working on a paper to show the results of their joint study. They want to be able to massage the document as it is passed among them over the Web. They do not want to learn HTML, the language of Web pages. They just want to work in the usual way, writing a word-processed document. There are ways to use e-mail to collaborate on word-processed documents, but an easier way is to use the HTML feature provided by the word-processing programs themselves. In short, write the text in the usual way, but click a couple of extra buttons to save it as a Web page that can be accessed by others.

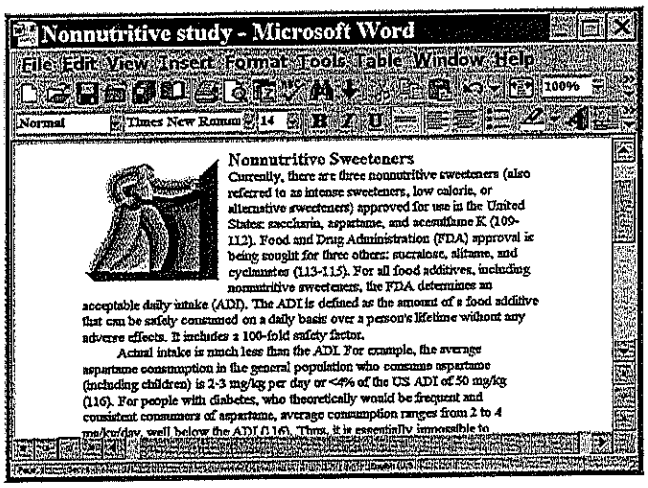
Figure 12-13a shows a word-processed document. With a different save option, the document can be saved as a Web page (Figure 12-13b). When the document is made available on a Web page, others can access it and view it as a regular word-processed document while making changes or adding comments. One approach is to have the originator password-protect the document in such a way that viewers can add comments but not change the original content.

Web options in word processing and other applications programs can be quite powerful. The details of the topic are beyond the scope of this book. For now, you simply need to be aware of the possibilities.

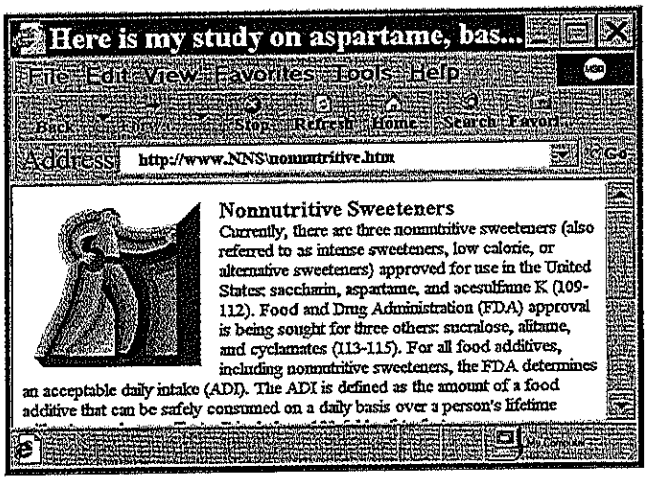
FIGURE 12-13

Word processing and the Web.

Look-alikes? Not quite. Look in the upper-left corners for the clue, and then compare the toolbars. (a) This is the original text, saved as a word-processed document. (b) This is the same document, saved as a Web page.



(a)

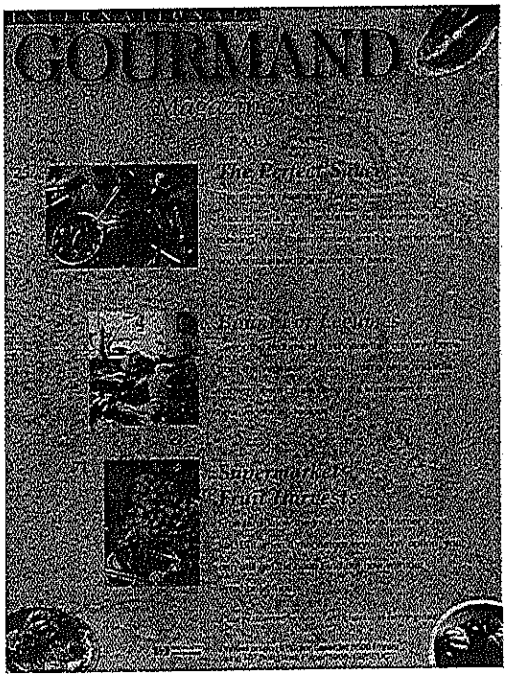


(b)

FIGURE 12-14

Desktop publishing.

With desktop publishing software and a high-quality laser printer, you can create professional-looking newsletters and documents.



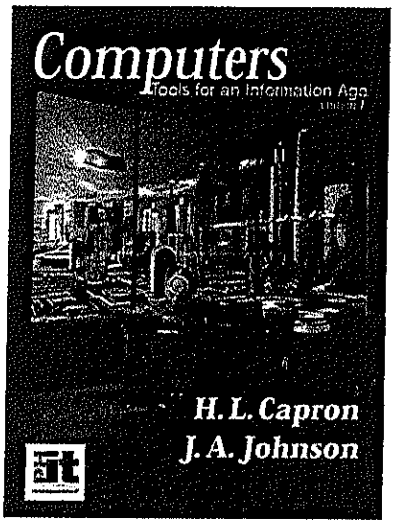


FIGURE 12-15

High-end desktop publishing.
The cover of this book was produced with the latest computer technology.

DESKTOP PUBLISHING: AN OVERVIEW

Would you like to be able to produce well-designed pages that combine elaborate charts and graphics with text and headlines in a variety of fonts? You can, with a technology called **desktop publishing.** You can use desktop publishing software to design sophisticated pages and, with a high-quality printer, print a professional-looking final document (Figure 12-14).

Unlike word processing, desktop publishing gives you the ability to decide where you want text and pictures on a page, what fonts to use, and what other design elements to include. Desktop publishing fills the gap between word processing and professional typesetting (Figure 12-15).

THE PUBLISHING PROCESS

Desktop publishing gives the user full control over the editing and design of the document. Desktop publishing also eliminates the time-consuming measuring and cutting and pasting that are involved in traditional production techniques.

The Art of Design

One part of the design of a document is **page layout**—how the text and pictures are arranged on the page. For example, magazine publishers have found that text organized in columns and separated by a solid vertical line is an effective page layout. If pictures are used, they must be inserted into the text. Picture size needs to be adjusted for proper fit on the page. In addition to page layout, designers must take into account such factors as headings, type sizes, and fonts. Are general headings used? Do separate sections or articles need their own subheadings? Does the size of the type need to be increased or decreased to fit a story into a predetermined space? What is the best font to use? Should more than one kind of font be used on a page?

To help you understand how some of these decisions are made, it is necessary to discuss some of the publishing terminology involved.

Fonts: Sizes and Styles

The type that a printer uses is described by its size, font, weight, and style. **Type size** is measured by a standard system that uses points. A **point** equals 1/72 inch. Point size is measured from the top of the letter that rises the highest above the baseline (a letter such as *h* or *l*) to the bottom of the letter that descends the lowest (a letter such as *g* or *y*). Figure 12-16 shows type in different sizes.

Times New Roman (12)

Times New Roman (18)

Times New Roman (24)

Times New Roman (36)

Times New Roman (48)

FIGURE 12-16

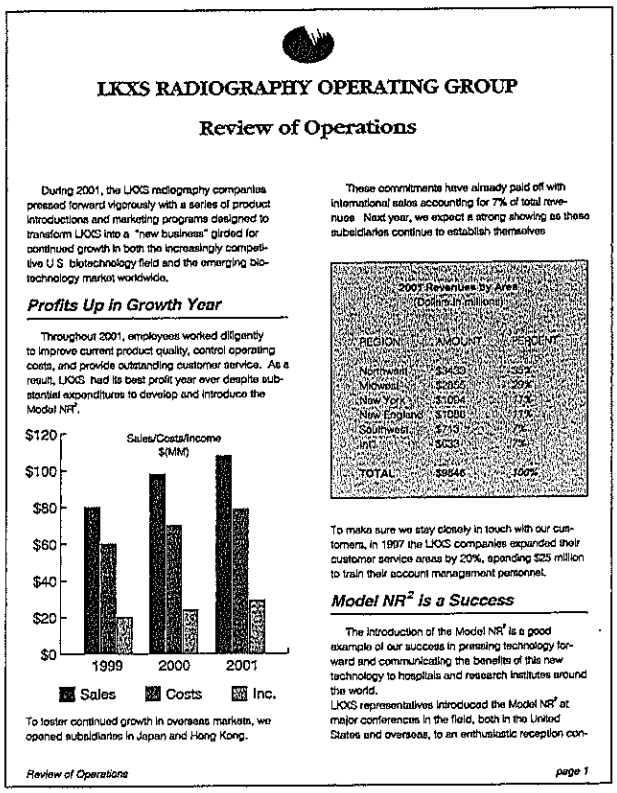
Different point sizes.

This figure shows a variety of different point sizes in a popular font called Times New Roman. The smallest shown here, point size 12, is often used for long text passages, such as correspondence. The larger sizes probably would be used only for headings or titles.

The shapes of the letters and numbers in a published document are determined by the font selected. Recall that a font is a set of characters of the same design. A font can be printed in a specific **weight,** such as boldface, which is heavier or darker than usual, or in a specific **style,** such as italic. Changes in font provide emphasis and variety.

As shown in Figure 12-17a, varying the size and style of the type used in a publication can improve the appearance of a page and draw attention to the most important sections. However, using too many different fonts or using clashing fonts can create a page that is unattractive and hard to read (Figure 12-17b). Combine fonts with discretion.

Most printers used in desktop publishing store a selection of fonts in a ROM chip in the printer. These are called the printer's **internal fonts.** Also, most desktop publishing programs provide a **font library** on a disk. A font library contains a wide selection of type fonts called **soft fonts.** A soft font can be sent, or downloaded, from



LKXS RADIOGRAPHY OPERATING GROUP

Review of Operations

During 2001, the LKXS radiography companies pressed forward vigorously with a series of product introductions and marketing programs designed to transform LKXS into a "new business" girded for continued growth in both the increasingly competitive U S biotechnology field and the emerging biotechnology market worldwide.

Profits Up in Growth Year

Throughout 2001, employees worked diligently to improve current product quality, control operating costs, and provide outstanding customer service. As a result, LKXS had its best profit year ever despite substantial expenditures to develop and introduce the Model NR².

To foster continued growth in overseas markets, we opened subsidiaries in Japan and Hong Kong.

These commitments have already paid off with international sales accounting for 7% of total revenues. Next year, we expect a strong showing as these subsidiaries continue to establish themselves.

2001 Revenues by Area
(Dollars in millions)

REGION	AMOUNT	PERCENT
Northwest	$3430	35%
Midwest	$2855	29%
New York	$1094	11%
New England	$1088	11%
Southwest	$713	7%
Int'l	$633	7%
TOTAL	$9846	100%

To make sure we stay closely in touch with our customers, in 1997 the LKXS companies expanded their customer service areas by 20%, spending $25 million to train their account management personnel.

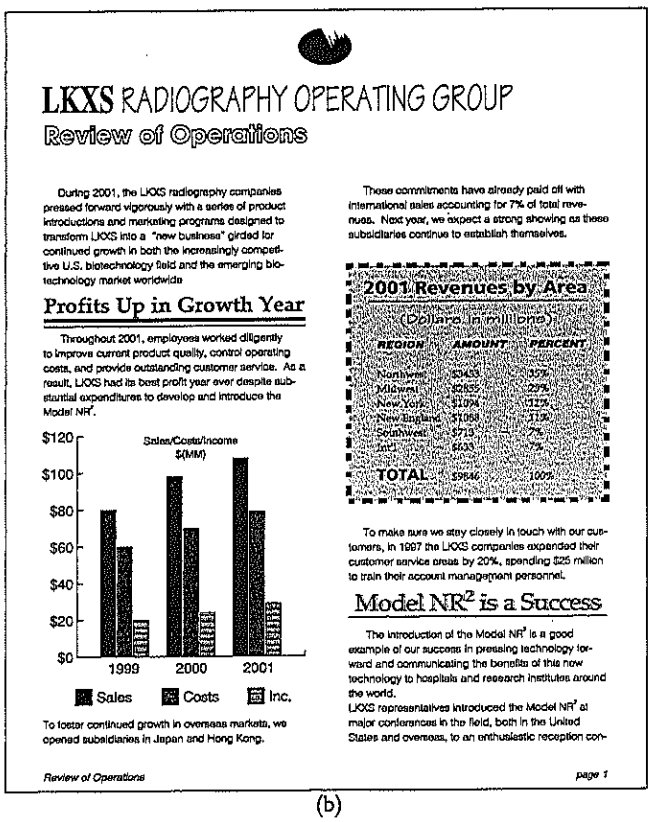
Model NR² is a Success

The introduction of the Model NR² is a good example of our success in pressing technology forward and communicating the benefits of this new technology to hospitals and research institutes around the world.

LKXS representatives introduced the Model NR² at major conferences in the field, both in the United States and overseas, to an enthusiastic reception con-

Review of Operations *page 1*

(a)



LKXS RADIOGRAPHY OPERATING GROUP

Review of Operations

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Review of Operations *page 1*

(b)

FIGURE 12-17

Sample designs.

(a) This example uses complementary fonts to produce a professional-looking document. (b) The same page created with clashing fonts and other distractions.

the font library on the hard drive to the computer, from which it then can be sent to the printer.

Principles of Good Typography

Word processing and desktop publishing programs put many different fonts at your disposal, but you can overwhelm a document if you use overly fancy fonts or too many fonts. A general rule is "less is better." The guidelines that follow promote a clean and attractive look for your document:

- Use only two or three fonts in a document.
- Be conservative: Limit the use of decorative or unusual fonts. In particular, use stylized fonts such as Benguiat or *Brush* or Lemonade only for signs and titles, never for passages of text.
- Use different sizes and styles of one font to distinguish between different heading levels, rather than using several different fonts.
- Never type text body in all capital letters.
- Do not use type that is too small to read easily just to fit everything on one page.
- Use a sans serif font only for short text passages; for long passages use a serif font, which is easier to read.
- Use italic or boldface, rather than underlining, for emphasis.

These simple guidelines almost guarantee an attractive document.

Leading and Kerning

Two terms that you will encounter when you begin desktop publishing are "leading" and "kerning." **Leading** (pronounced "ledding") refers to the spacing between the lines of type on a page. Leading is measured vertically from the base of one line of type to the base of the line above it. The greater the leading, the more white space there is between lines. Leading, just like type size, is measured in points.

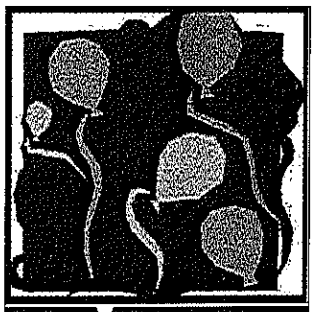
Kerning refers to adjusting the space between the characters in a word. In desktop publishing software, each font has a default kerning. An example of kerning is shown in Figure 12-18.

Halftones

Halftones, which resemble photographs, appear in newspapers, magazines, books, and documents produced by desktop publishing. Halftones are representations made up of black dots printed on white paper. Varying the number and size of dots in a given space produces shades of gray. As you can see in Figure 12-19, the smaller the dot pattern used, the clearer the halftone.

Using Desktop Publishing Software

The page composition program is the key ingredient of a desktop publishing system. **Page composition programs,** also called **page makeup programs,** let you design each page on the computer screen. You can determine the number and the width of



Personal Greetings

Computers have opened up all sorts of possibilities for homemade, personal greetings. Several software packages are available to help you make banners, flyers, calendars, and greeting cards. You need not have any artistic talent—many images and preplanned designs are available as part of the software. In fact, all you really need in addition to a computer is some software and a color printer.

Even more popular are the many Web sites that offer postcards and greetings cards that you can send online to a friend. These free services let you choose a card (such as the balloons shown here, from the Acme Postcard site), select a message from their list (Happy Birthday, Congratulations, and so forth) and personalize it with your own message. Most sites will also let you include music to be delivered with the card.

(a) Unkerned: WAVE

(b) Kerned: WAVE

FIGURE 12-18

Kerning.

(a) In this example the space between the characters is not altered. (b) Kerning, or adjusting the space between the characters, can improve the overall appearance of the word.

FIGURE 12-19

Halftones.

Halftones consist of a series of dots. Reducing the size of the dots makes the resulting halftone clearer.

the columns of text to be printed on the page. You can also indicate where pictures, charts, graphs, and headlines are to be placed. Once you have created the page design, you can use the page composition program to insert text and graphics into it. Text may be keyed as you prepare the page or imported as a file created by a word processing program. Page composition programs also let you move blocks of text and pictures around on your page. If you are not satisfied with the way the page looks, you can change the size of the type or the pictures.

Most desktop publishing programs offer **templates,** predetermined page designs that you can use quickly by filling in your own text. Templates that are typically offered include those for newsletters, flyers, greeting cards, banners, calendars, and even business forms. Page composition programs can also integrate **clip art**—images available for public use—into your publication to enliven your text. Most desktop publishing programs include a library of clip art. You can purchase disks of additional clip art or find clip art for free or a small fee on many Web sites. Figure 12-20 shows examples of illustrations in a clip art library.

ERGONOMIC CONSIDERATIONS

Can all this computing be good for you? Are there any unhealthy side effects? The computer seems harmless enough. How bad can it be, sitting in a padded chair in a climate-controlled office? Health questions have been raised by the people who sit all day in front of computer screens. Does the monitor produce harmful emissions?

FOCUS ON ETHICS — But I Did It on My Own Time

Companies typically claim ownership of all patents and copyrights—that is, all intellectual property—that an employee may develop. This is true even if the work is not job-related and is done with personal resources or the employee's own time.

1. Is it ever ethical for an employee to use the employer's software or hardware to pursue independent work?
2. When would it be ethical for an employee to claim a patent or copyright for work done with his or her own resources and on his or her own time? If possible, determine what the law on this topic is in your state.
3. When is it ethical for an employer to claim a patent or copyright for work done independently by an employee? What if your company manufactures RAM chips but you have written a book on word processing, for instance?

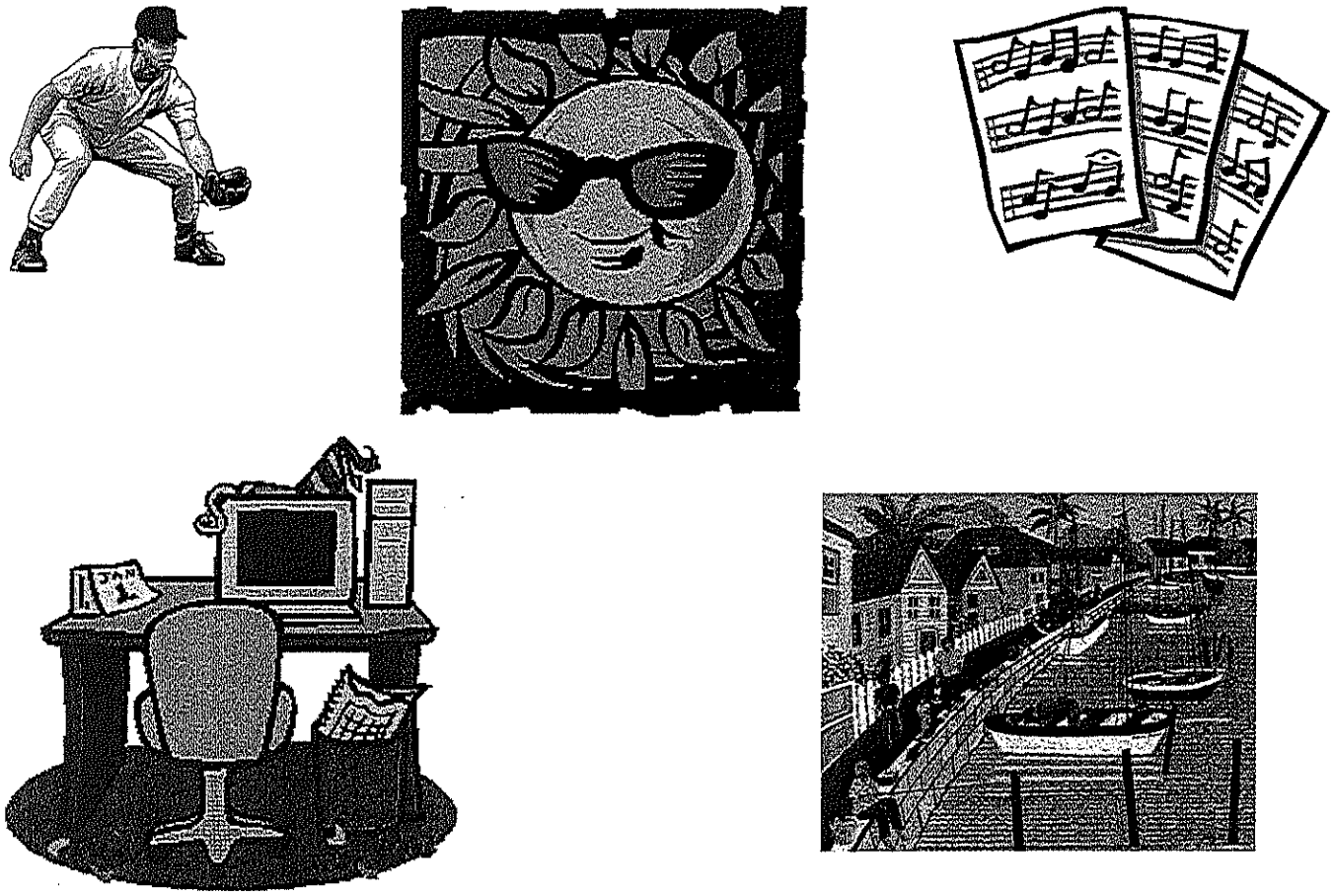


FIGURE 12-20

Clip art.

Word processing and desktop publishing programs include clip art with the software and make further art available for downloading from an affiliated Web site. Clip art can also be purchased separately from other vendors. Much clip art is mundane—primitive sketches of familiar items such as pencils, stars, and grinning pumpkins. However, software makers have hired commercial artists to improve the look of clip art, resulting in a greater sophistication and variety.

What about eyestrain? And what about the age-old back problem? Then there is repetitive strain injury (RSI), which may affect workers who hold their hands over a keyboard. RSI is caused by speed, repetition, awkward positioning, and holding a static position for a long period of time.

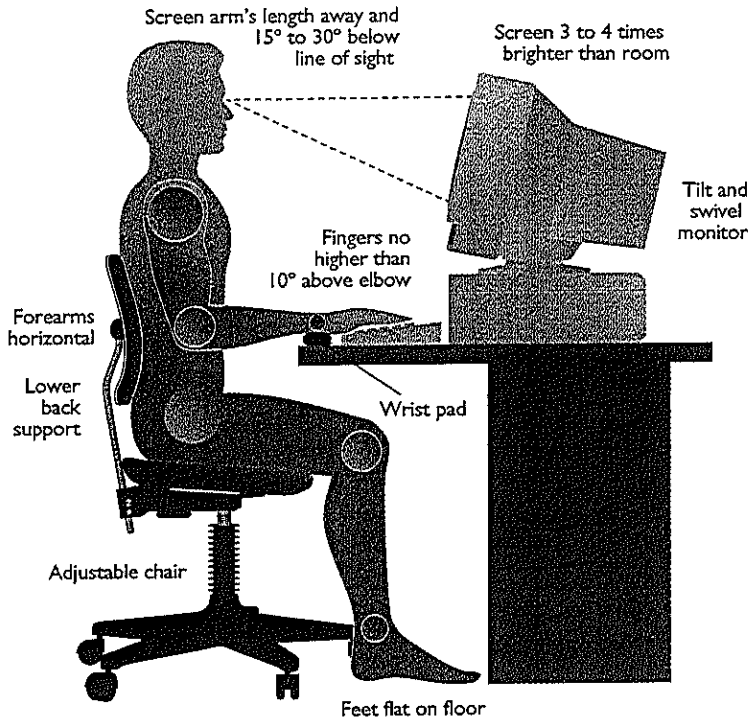
Ergonomic Equipment

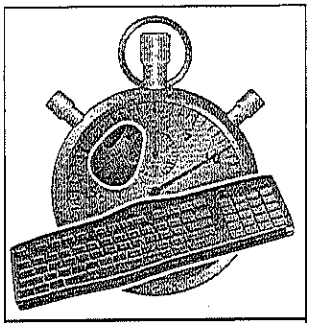
Workers can do a number of things to take care of themselves. A good place to begin is with an ergonomically designed workstation. In its formal sense, ergonomics is the use of research in designing systems, programs, or devices that are appropriate to use for their intended purposes. In the context of computers, **ergonomics** refers to human factors related to the use of computers. Begin with a pneumatically adjustable chair with five feet at its base and a monitor that can be tilted and swiveled to suit the user. A properly designed workstation takes a variety of factors into account, such as the distance from the eyes to the screen and the angle of the arms and wrists (Figure 12-21).

FIGURE 12-21

An ergonomically designed workstation.

Start with the right equipment, such as an adjustable chair and a monitor that can be tilted and swiveled. It is up to the worker to sit in the proper manner—back supported, feet flat on the floor, and so forth.





Take That Break!

One of the best ways for computer users to avoid repetitive strain injuries is to take frequent rest breaks. Unfortunately, many of us get so wrapped up in our work that we neglect this important preventive measure. A program called *Ergonomic Timer* by Tropical Software is just what the doctor ordered. This program monitors mouse clicks, keystrokes, and elapsed work time to remind you when a break is due. A countdown timer even lets you know when the break is over.

Ergonomic Behavior

Experts recommend these steps to prevent injury:

- Turn the screen away from the window to reduce glare, and cover your screen with a glare deflector. Turn off overhead lights; illuminate your work area with a lamp.
- Place the keyboard low enough to avoid arm and wrist fatigue. Do not bend your wrists when you type. Use an inexpensive raised wrist rest. Do not rest your wrists on a sharp edge.
- Position the seat back so that your lower back is supported.
- Sit with your feet firmly on the floor.
- Enlarge fonts so that they are easier to see; you can return them to their normal size before printing the document.
- Most important of all, take a break. At the least, exercise at your desk, occasionally rotating your wrists, rolling your shoulders, and stretching. Better yet, get up and walk around at regular intervals.
- Finally, keep your fingernails short, or at least not long.

Repetitive strain injuries seem to be aggravated by overall job stress. Among the psychological and environmental factors that increase risk are long commutes, dissatisfaction with management, and the occurrence of stressful events in one's personal life. Even so, most computer-related health problems can be avoided with proper attention to your physical well-being at the computer.

▲

By now you should be convinced that word processing is probably essential for your career and, further, that desktop publishing is a valuable tool for individuals as well as businesses.

Spreadsheets and Business Graphics:

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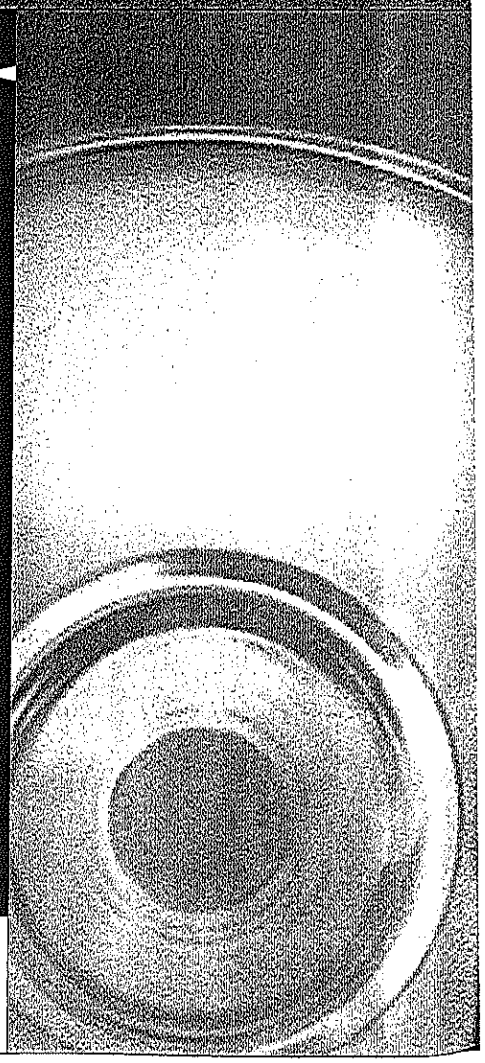


CHAPTER 13

LEARNING OBJECTIVES

- Describe the advantages of spreadsheets
- List several applications for spreadsheets
- Explain the underlying principles of electronic spreadsheet use
- Describe how to set up and modify a spreadsheet
- Describe the advantages of business graphics
- Differentiate between analytical graphics and presentation graphics
- Identify the elements of standard charts and graphs

In his first year in college Tom Zielkowski took an introductory computer class that included a hands-on component for word processing, spreadsheets, and databases. He breezed through the word processing part but he didn't get spreadsheets at first. What did rows and columns of numbers have to do with anything in the real world? And who wants to key in a whole bunch of numbers?

Tom came to understand two important notions. The first was that spreadsheets were good for helping to plan ahead because numbers in a spreadsheet can be changed to see what results the changes might cause—the famous "What if" approach. The second, and even more attractive, fact was that he could get the computer to do some of the work.

Tom needed a secondhand car. He decided to see how the spreadsheet could help him predict how much money he would have, varying the amount he might use from his current bank savings, the amount he might put away per month, and the number of months he would have to save. The spreadsheet here shows the results. Tom typed in the first two columns, and the computer produced the results in the last two columns based on formulas that Tom supplied.

Savings in bank	Savings per month	Total in 12 mo	Total in 24 mo
$2,000	$100	$3,200	$4,400
$2,000	$200	$4,400	$6,800
$3,000	$100	$4,200	$5,400
$3,000	$200	$5,400	$7,800

This example is so trivial that it probably could be completed with a pencil in a shorter time than it would take to submit the spreadsheet to the computer. Nevertheless, it shows that you can use a spreadsheet to show the results of changes and to make the computer do most of the work. This chapter provides some information on how that happens.

THE NATURE OF SPREADSHEETS

For hundreds, even thousands, of years businesses have used numbers to keep track of performance. For all but the last 20 or so years, manipulating all those numbers has been a tedious, error-prone process. Businesses used manual, paper-based **spreadsheets** to organize data in a grid of rows and columns (Figure 13-1a).

Unfortunately, creating a large spreadsheet manually is time-consuming and tedious, even when you use a calculator or copy results from a computer printout. Another problem with manual spreadsheets is that making a mistake is too easy. If

FIGURE 13-1

Manual versus electronic spreadsheets.

(a) This manual spreadsheet is a typical spreadsheet consisting of rows and columns. (b) The same spreadsheet created with a spreadsheet program.

	JAN.	FEB.	MAR.	APR.	TOTAL
SALES	1750	1501	1519	1430	6200
COST OF GOODS SOLD	964	980	932	943	3819
GROSS MARGIN	786	521	587	487	2381
NET EXPENSE	98	93	82	110	383
ADM EXPENSE	77	79	69	88	313
MISC EXPENSE	28	45	31	31	135
TOTAL EXPENSES	203	217	182	229	831
AVERAGE EXPENSE	68	72	61	76	277
NET BEFORE TAXES	583	304	405	258	1550
FEDERAL TAXES	303	158	211	134	806
NET AFTER TAX	280	146	194	124	744

(a)

Microsoft Excel - Net after taxes

File Edit View Insert Format Tools Data Window Help

	JAN.	FEB.	MAR.	APR.	TOTAL
Sales	$1,750	$1,501	$1,519	$1,430	$6,200
Cost of goods sold	964	980	932	943	3819
Gross margin	786	521	587	487	2381
Net expense	98	93	82	110	383
Adm. expense	77	79	69	88	313
Misc. expense	28	45	31	31	135
Total expenses	203	217	182	229	831
Average expenses	68	72	61	76	277
Net before tax	583	304	405	258	1550
Federal tax	303	158	211	134	806
Net after tax	$280	$146	$194	$124	$744

Sheet1 Sheet2 Sheet3

(b)

you do not discover the mistake, the consequences can be serious. If you discover the mistake after the spreadsheet is finished, you must manually redo all the calculations that used the wrong number.

Electronic Spreadsheets

APPLICATION SOFTWARE

Prentice Hall EXPLORE Generation it

In 1979 Bob Frankston and Dan Bricklin introduced VisiCalc, the first electronic spreadsheet program, for the Apple II microcomputer. VisiCalc single-handedly changed the business world's perception of the personal computer from being an interesting toy to being an indispensable tool for financial analysis. An **electronic spreadsheet,** or **worksheet,** is a computerized version of a paper spreadsheet (Figure 13-1b). Working with a spreadsheet on a computer eliminates much of the toil of setting up a manual spreadsheet. In general, an electronic spreadsheet works like this: You enter the data you want on your spreadsheet and then key in the types of calculations you need. The electronic spreadsheet program automatically does all the calculations for you, completely error-free, and produces the results in your spreadsheet. You can print a copy of the spreadsheet and store the data on your disk so that the spreadsheet can be used again. By the way, although this chapter examines spreadsheets in a general way, we will illustrate spreadsheets using software called *Microsoft Excel 2000,* as shown in Figure 13-1b. Thus, although the screen is realistic, our area of concern is merely the spreadsheet, not the various menus and buttons that come with this specific software.

By far the greatest labor-saving aspect of the electronic spreadsheet is **automatic recalculation:** When you change one value or calculation on your spreadsheet, all dependent values on the spreadsheet are automatically recalculated to reflect the change. Suppose, to use a common example, that one entry on a spreadsheet is RATE, another is HOURS, and another is SALARY, which is the product of RATE and HOURS. Values for RATE and HOURS will be entered, but SALARY will be calculated by the spreadsheet software. But what if RATE changes or was entered incorrectly? RATE can be entered anew, but the person entering the data need not worry about SALARY because the spreadsheet will recalculate SALARY using the new value for RATE. Although this example might seem trivial, the automatic recalculation principle has significant consequences for large, complex spreadsheets. A change in a single value could affect dozens or even hundreds of calculations, which, happily, the spreadsheet will perform automatically.

"What-If" Analysis

Automatic recalculation is valuable for more than just fixing mistakes. If a number is changed—not because it is incorrect but because a user wants to see different results—related calculations will also be changed at the same time. This ability to change a number and have the change automatically reflected throughout the spreadsheet is the foundation of **"what-if" analysis**—the process of changing one or more spreadsheet values and observing the resulting calculated effect. Consider these examples:

- What if a soap manufacturer were to reduce the price of a certain brand by 5 percent? How would the net profit be affected? What if the price were reduced by 10 percent? By 15 percent?
- What if a general contractor were to subcontract with several workers but one of them reneged and the contractor had to hire someone more expensive? How would that affect the total cost?
- What if the prime lending rate were raised or lowered? How would this affect interest moneys for the bank or the cost of a loan for bank customers?

Once the initial spreadsheet is set up, any of these "what-if" scenarios can be answered by changing one value and examining the new, recalculated results.

Planning Your Spreadsheet

Unless you are an experienced spreadsheet user, you will want to take time to plan your spreadsheet before you invoke the spreadsheet software.

1. Determine the results you want to display on your spreadsheet by mapping the spreadsheet out on paper.
2. Determine the data you have to input to your spreadsheet to calculate the results you want.
3. Write down the names of the input and output values that you will use in your spreadsheet and the equations you will use. Record the exact form in which you will enter them in your spreadsheet.
4. Write down the formulas for converting the spreadsheet's inputs to its outputs.

SPREADSHEET FUNDAMENTALS

Before you can learn how to use a spreadsheet, you must understand some basic spreadsheet features. The characteristics and definitions that follow are common to all spreadsheet programs.

Cells and Cell Addresses

Figure 13-2 shows one type of spreadsheet—a teacher's grade sheet. Notice that the spreadsheet is divided into rows (horizontal) and columns (vertical). The rows have numeric labels, and the columns have alphabetic labels. There are actually more rows and columns than you can see on the screen. Some spreadsheets have thousands of rows and hundreds of columns—probably more than you will ever need to use.

The intersection of a row and column forms a cell. A **cell** is a storage area on a spreadsheet. When referring to a cell, you use the letter and number of the intersecting column and row. For example, in Figure 13-2, cell B7 is the intersection of column B and row 7—the grade of 25 for Vedder on Quiz 1. This reference name is known as the **cell address,** or **cell reference.** Notice that the alphabetic column designation always precedes the row number: B7, not 7B. After column Z, the column labels are AA, AB, and so on. Most spreadsheet programs go to at least column IV, 256 columns in all.

On a spreadsheet one cell is always known as the **active cell,** or **current cell.** When a cell is active, you can enter data or edit that cell's contents. Typically, the active cell is marked by highlighting in reverse video or with a heavy border drawn around it. The active cell in Figure 13-2 is cell A1.

You can use a mouse or the cursor movement (arrow) keys to scroll through a spreadsheet both vertically and horizontally.

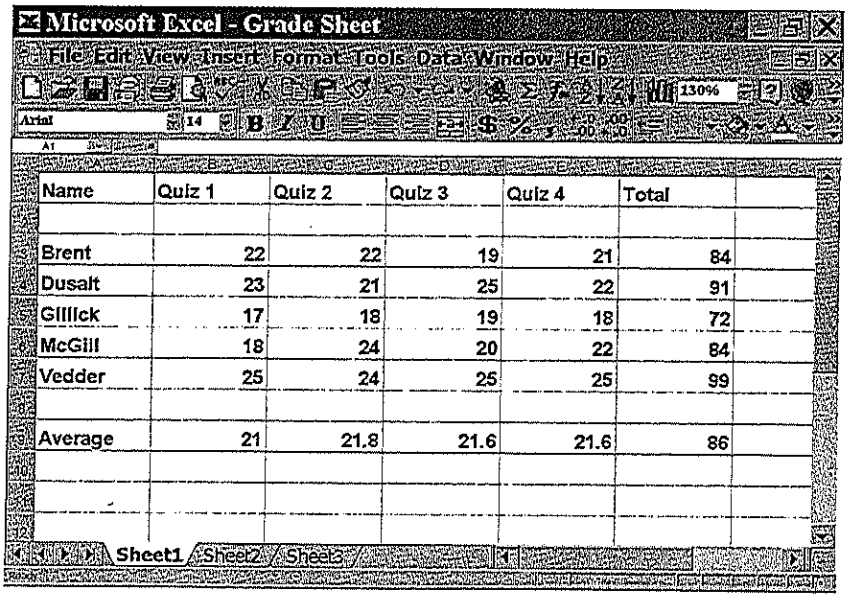
Contents of Cells: Labels, Values, and Formulas

Each cell can contain one of three types of information: a label, a value, or a formula. A **label** provides descriptive text information about entries in the spreadsheet, such as a person's name. A cell that contains a label is not generally used to perform mathematical calculations. For example, in Figure 13-2, cells A1, A9, and F1, among

FIGURE 13-2

Anatomy of a spreadsheet screen.

This screen shows a typical spreadsheet—a teacher's grade sheet. It shows space for 12 rows numbered down the side and 7 columns labeled A through G. The intersection of a row and column forms a cell. Here, cell A1 is the active cell—the cell into which a user may key data. Only one cell may be active at a given time.



Name	Quiz 1	Quiz 2	Quiz 3	Quiz 4	Total
Brent	22	22	19	21	84
Dusalt	23	21	25	22	91
Gillick	17	18	19	18	72
McGill	18	24	20	22	84
Vedder	25	24	25	25	99
Average	21	21.8	21.6	21.6	86

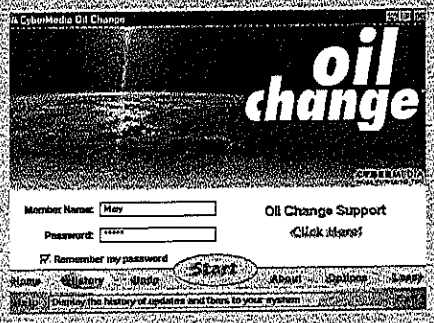
MAKING CONNECTIONS ◄ Updating Software Online

When you buy packaged software from a store, it may have been on the shelf for some time. Even if you download software from the Internet, it will soon be out of date, or at least it will not benefit from subsequent improvements such as fixes and the latest upgrades. These changes, almost always free, are available on Web sites associated with the software. What to do?

Well, you could check out the Web site for each of your software packages on a regular basis and see whether they offer any extra downloads. They probably do. But, even more likely, you will not get around to doing the checking and downloading. *Oil Change*, a service of McAfee's Online Clinic, available on McAfee's Web site, will perform this task for you.

Oil Change identifies all the applications software on your hard disk, hunts down the latest updates, and provides a list of possible changes. Once you select which ones you want, or simply accept them all, *Oil Change* downloads and makes the changes.

MCAFEE.COM
The Place for Your PC



others, contain labels. A **value** is an actual number that is entered into a cell to be used in calculations. In Figure 13-2, for example, cell B3 contains a value.

A **formula** is an instruction to the program to calculate a number. A formula generally contains cell addresses and one or more arithmetic operators: a plus sign (+) to add, a minus sign (−) to subtract, an asterisk (*) to multiply, and a slash (/) to divide. When you use a formula rather than entering the calculated result, the software can automatically recalculate the result if you need to change any of the values on which the formula is based.

In addition to the types of calculations just mentioned, a formula can include one or more functions. A **function** is like a preprogrammed formula. Two common functions are the SUM function, which adds numbers together, and the AVG function, which calculates the average of a group of numbers. Most spreadsheet programs contain many functions for a variety of uses, from mathematics to statistics to financial applications. A formula or function does not appear in the cell; instead, the cell shows the result of the formula or function. The result is called the **displayed value** of the cell. The formula or function is the **content** of the cell.

Ranges

Sometimes it is necessary to specify a range of cells in order to build a formula or perform a function. A **range** is a group of one or more adjacent cells occurring in a rectangular shape; the program treats the range as a unit during an operation. Figure 13-3 shows some ranges. To define a range, you must indicate the upper-left and lower-right cells of the block. Depending on the particular spreadsheet software you are using, the cell addresses are separated by a colon or by two periods. For example, in Figure 13-2, the Quiz 1 range is B3:B7 (or B3..B7), and the Brent quiz range is B3:E3 (or B3..E3).

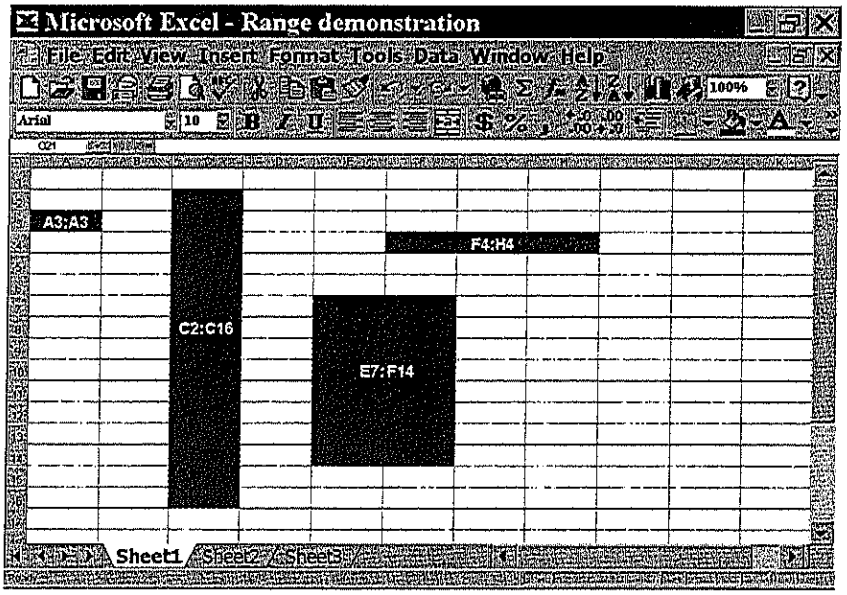
SPREADSHEET FEATURES

Once spreadsheet users master the basics, they are usually eager to learn the extra features, especially formatting and graphics, that make their work more useful or

FIGURE 13-3

Ranges.

A range is a group of one or more cells arranged in a rectangle. You can name a range or refer to it by using the addresses of the upper-left and lower-right cells in the group.



attractive. Formatting features take a worksheet beyond the historically plain page full of numbers. Here is a partial list of features you will probably find included with spreadsheet software:

- **Column width.** Columns containing labels—words—usually need to be wider than columns for numbers. Note, for example, that the leftmost column in Figure 13-1b is wider than the other columns to accommodate the data. Columns can also be made narrower. (Incidentally, although less common, it is also possible to alter the height of a row.)
- **Headings.** If a heading is desired, it can be created as a wide column and can even be centered.
- **Number symbols.** If appropriate, a number value can be shown with a dollar sign ($), a percent sign (%), and/or commas and decimal places, as desired.
- **Appearance of data.** Spreadsheet data can be presented in one of many available fonts and in boldface or italic. Furthermore, data can be centered within the cell or can be justified right or left within the cell. Often an entire column of cells will be justified right or left. In Figure 13-2, for example, all data in column A is left-justified, whereas data in columns B through F are right-justified.
- **Printing.** When a user is developing and experimenting with a spreadsheet, he or she is looking at the spreadsheet on the screen. But the finished product, or even a series of variations of the product, will probably be printed for distribution and examination. Spreadsheet software offers several printing options. For example, a spreadsheet may be centered on the printed page. Margins may be altered. The entire page may be printed sideways, that is, horizontally instead of vertically. Vertical and horizontal grid lines may be hidden on the printed spreadsheet.
- **Security.** In a business environment many spreadsheets are developed by experts for use by novices, who simply enter numeric data in the proper cells and view the results. If the user mistakenly enters a number in a cell that contains a formula, the formula will be destroyed. That formula will no longer provide an automatic update when the data it relied on is changed, producing incorrect results. The spreadsheet developer can use security options to prevent the user from accidentally entering data into the wrong cells. Password protection can also be used to prevent unauthorized alteration of formulas or data.

- **Decoration.** Many spreadsheet packages include decorative features, such as borders, color options, and clip art.

The change from numbers to pictures—graphics—is a refreshing variation. Most spreadsheet software makes it fairly easy to switch from numbers to pictures. That is, once you prepare a spreadsheet, you can show your results in graphic form. The value of business graphics will be discussed in detail later in the chapter.

A PROBLEM FOR A SPREADSHEET

Gina Hagen, at age eight, was an entrepreneur. One hot summer day she borrowed some sugar and lemons from the kitchen and stirred up a pitcher of lemonade, which she proceeded to sell from a stand in front of her house. By the end of the day, she had gone through three pitchers and had taken in $12.75. Her joy subsided, however, when her mother explained that a business person has to pay for supplies—in this case, the sugar and lemons. But Gina was not deterred for long. In her growing-up years, she sold birdhouses, a neighborhood newsletter, and sequined hair barrettes. In the process, she learned that it was important to keep good business records.

A New Business

When Gina attended Ballard Community College, she noticed that the only beverages available were milk, coffee, and canned soft drinks. Thinking back to her early days, Gina got permission to set up a lemonade stand on campus. In addition to fresh lemonade, she sold bagels and homemade cookies. The stand was soon successful, and Gina eventually hired other students to manage stands on nearby campuses: Aurora, Eastlake, and Phinney.

Using Spreadsheets for the Business

When Gina took a computer applications course at the college, she decided that spreadsheets were appropriate for keeping track of her business. She began by comparing sales for the four campuses for the fourth quarter of the year. She sketched her spreadsheet on paper (Figure 13-4). As she started the spreadsheet software, Gina decided that she would also add some headings. In her first draft of the spreadsheet, Gina keyed in the campus names in column A and the campus sales for each of the three months in columns B, C, and D.

Gina does not, of course, have to compute totals—the spreadsheet software will do that. In fact, the obvious solution is to key formulas using the SUM function to compute both column and row totals. In cell E6, for example, Gina keys =SUM(B6:D6). This instructs the software to sum the values in cells B6, C6, and D6 and place the resulting sum in cell E6. Even though she typed a formula in the cell, the result is a value, in this case 4671 (Figure 13-5). Keep in mind that the resulting value in any cell containing a formula will change if any of the values in the cells referenced in that formula change. For cell E6 the resulting value would change if there were a change to the values in cell B6, C6, or D6. The other cells containing totals (E5, E7, E8, B10, C10, D10, and E10) also contain formulas that will calculate values. Cell E10, by the way, could sum up either column E (=SUM(E5:E8)) or row 10 (=SUM(B10:D10)). The result is the same either way.

Gina has been saving her spreadsheet on disk as she goes along. Now that the basic spreadsheet is complete, Gina saves it one more time and then prints it.

Changing the Spreadsheet: Automatic Recalculation

Gina has discovered an error in her spreadsheet: Cell D6, rather than containing 1430, should be 1502. Again using her spreadsheet software, she needs merely to

Spreadsheets in the Home

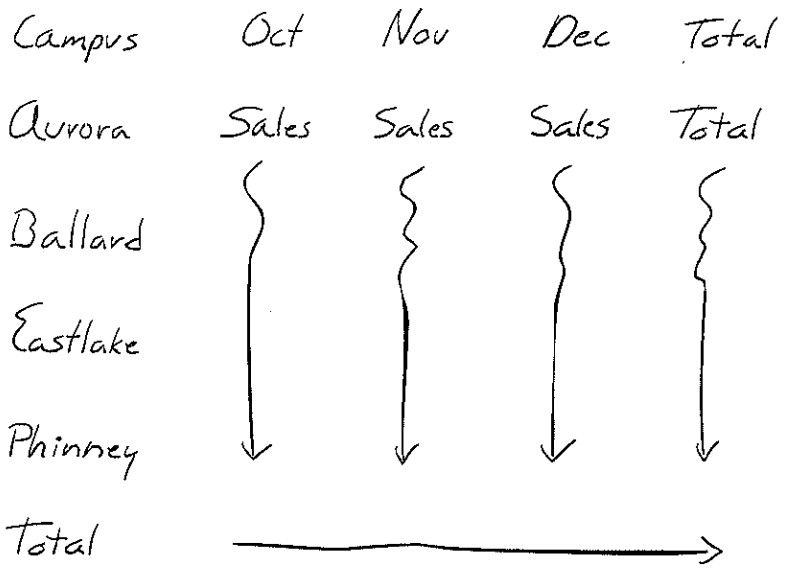
Family budgeting is the most common home use for spreadsheets. However, some people are more interested in "what-if" scenarios for which spreadsheets are the perfect tool. Here are some examples that users have dreamed up:

- What if I go back to work . . . is it really worth it? You can factor in all the expenses of employment—travel, wardrobe, child care, taxes, and other disbursements—and compare the total against the income received.
- What if I start my own business . . . can I make a go of it? Although estimates may be sketchy at best, a budding entrepreneur can approximate expenses (for materials, tools, equipment, office rental, and so forth) and compare them with anticipated revenues from clients over different periods of time.
- What if I jump into the stock market . . . or stick to a more conservative investment approach? A popular sport among investors is running dollar amounts and anticipated growth rates of various investment opportunities through spreadsheets. The results may give them a glimpse of their future financial picture.
- What if I save $50 per month for my child's education . . . how much money would be saved (with accumulated interest) by the time the child is 18? What if I were to save $75 or $100 per month?

FIGURE 13-4

Spreadsheet planning.

A sketch of a spreadsheet is useful before invoking the software. This plan includes one row per campus and the monthly totals, and one column for the campus names, each month's sales, and the campus totals.



retrieve the spreadsheet from disk and make the single change to cell D6 (Figure 13-6). Note, however, that cell D6 is used for the totals calculations in cells E6 and D10. Furthermore, because either column E or row 10 is used to compute the final total in E10, either changed cell E6 or changed cell D10 will cause a change in the value calculated in cell E10. All these changes are made by the spreadsheet software automatically. Indeed, note the changed values in cells E6, D10, and E10—all the result of a single change to cell D6.

Formatting and Printing

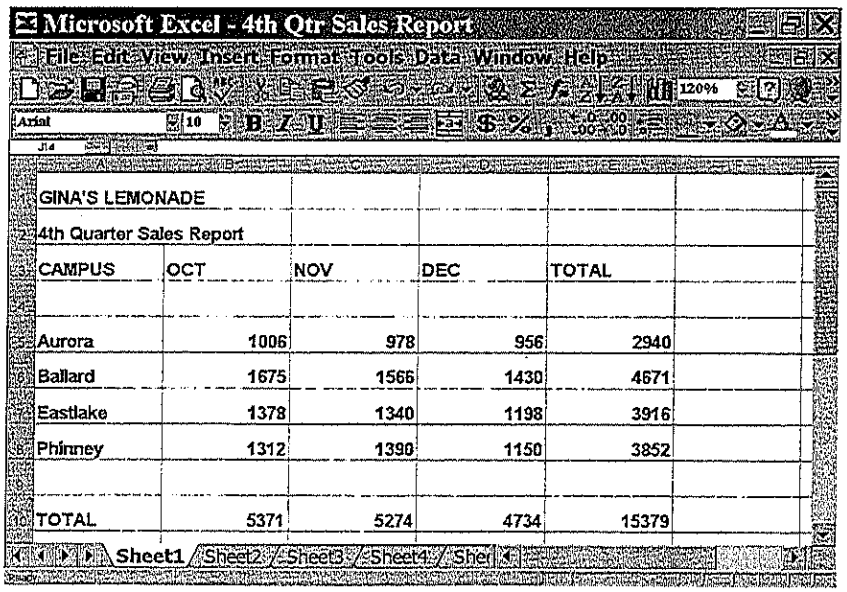
Now that Gina is satisfied with her spreadsheet calculations, she decides to make some formatting changes and then print the spreadsheet. She uses the spreadsheet software to make the changes (to see the changes, you can look ahead to Figure 13-7a). Here is a list of the changes she wants to make:

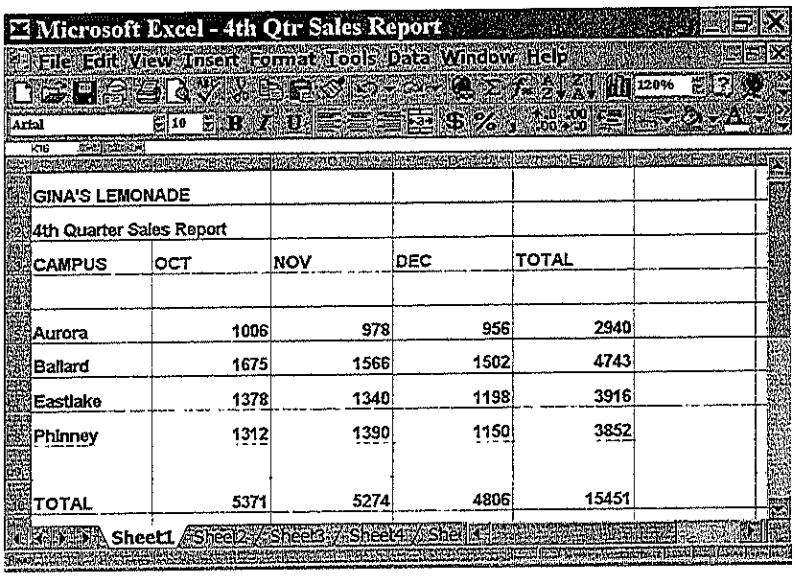
- Center the two major headings.
- Use a different font on the two major headings and change them to boldface.

FIGURE 13-5

First draft of sales spreadsheet.

This initial look at Gina's spreadsheet shows the headings and data keyed into the spreadsheet. Gina keyed formulas that include the SUM function in cells E5, E6, E7, E8, B10, C10, D10, and E10. Later, Gina will make a change to a data item. She will also format the spreadsheet to improve its appearance; for example, the month headings (OCT, NOV, and so forth) need to be centered over their appropriate columns.





GINA'S LEMONADE				
4th Quarter Sales Report				
CAMPUS	OCT	NOV	DEC	TOTAL
Aurora	1006	978	956	2940
Ballard	1675	1566	1502	4743
Eastlake	1378	1340	1198	3916
Phinney	1312	1390	1150	3852
TOTAL	5371	5274	4806	15451

FIGURE 13-6

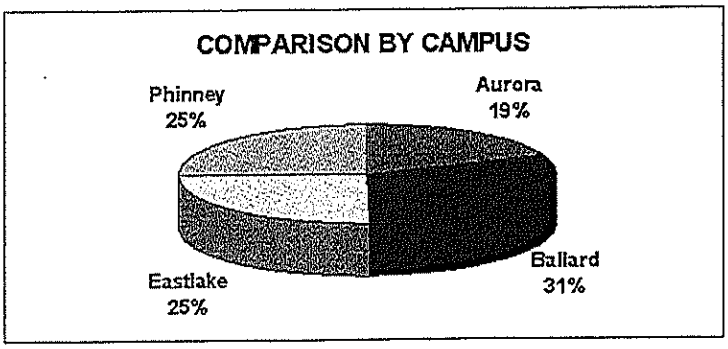
The altered spreadsheet, reflecting automatic recalculations.

Gina changed the value in cell D6, causing an automatic change to calculated values in cells E6, D10, and E10.

- Center CAMPUS, OCT, NOV, DEC, and both TOTAL labels, each within its own cell, and boldface each label.
- Put each campus name in italic.
- Present the sales figures as currency by adding dollar signs ($) and decimal points.
- Use a vertical double border to separate the campus names from the sales figures, a horizontal double border to separate the headings from the sales figures, and a single horizontal border to separate the top two heading rows from the rest of the spreadsheet.
- Remove the spreadsheet grid lines.

GINA'S LEMONADE 4th Quarter Sales Report				
CAMPUS	OCT	NOV	DEC	TOTAL
Aurora	$ 1,006.00	$ 978.00	$ 956.00	$ 2,940.00
Ballard	$ 1,675.00	$ 1,566.00	$ 1,502.00	$ 4,743.00
Eastlake	$ 1,378.00	$ 1,340.00	$ 1,198.00	$ 3,916.00
Phinney	$ 1,312.00	$ 1,390.00	$ 1,150.00	$ 3,852.00
TOTAL	$ 5,371.00	$ 5,274.00	$ 4,806.00	$ 15,451.00

(a)



(b)

FIGURE 13-7

The finished spreadsheet and a matching graph.

(a) On the final version of her spreadsheet, printed here, Gina has boldfaced and centered the headings and changed their fonts, added vertical and horizontal borders, used italics and boldface on certain cells, and expressed the sales figures as currency. (b) This simple pie chart shows the figures from the rightmost column of the spreadsheet, the campus totals, as percentages of total sales.

GETTING PRACTICAL — Spreadsheet Tips

Serious users of spreadsheets employ many, or even most, of the hundreds of options that are available with spreadsheet software. More ordinary mortals probably use only the basic features. But even minimalists like to use an extra gimmick now and again. Here are a few that are easy and handy:

- **Do it all at once.** If you have an action to apply to the entire spreadsheet, such as changing row height or adding background color, select the entire sheet by clicking the upper-left-hand cell-like space where the row designation meets the column designation (above 1, to the left of A). Then the action you choose will apply to the entire spreadsheet. Similarly, you can click on the row number to select the entire row or the column letter to designate an entire column.
- **Taller and wider.** Spreadsheets look better if they are not crowded. So find the Format menu and change the row height and perhaps the column width. This is especially helpful if you selected the entire spreadsheet first. A common scenario, however, is to improve the row height for the entire spreadsheet but to set the column width according to the width of the data content. You can, of course, make everything smaller instead if you must fit a lot of data on a page.
- **Go the max.** Use the MAX function to find the highest, the longest, the most expensive, and so forth—the maximum. Suppose, for example, that an expense spreadsheet lists the cost of meals by day along row 15, with a different column, B through F, for Monday through Friday. To determine the most expensive meal, use = MAX(B15:F15).
- **Drag data.** Highlight any cell. In its lower-right corner you can see a tiny square, called the fill handle. If you wish to duplicate data from one cell to any adjacent cell, simply drag its fill handle to the cell you want to fill with duplicate data. Suppose, for example, that you are making calculations on each row that always include 40 in one cell. Place 40 in the cell at the top of the appropriate column. Now drag it down the column to the other rows. Now all cells in that column have the value 40 in them.
- **Add a new row or column.** Sometimes people get partway through a spreadsheet and realize that they forgot, or want to add, a new row or column in the middle. Click the number of the row that you want to be below the new blank row. Find the Insert menu and click Row; a new blank row appears above the row you designated. A new column is added to the left of the selected column. With each row or column addition, all rows or columns, and all calculations based on cells, are renumbered automatically.
- **Map it.** Spreadsheet software offers a variety of maps, such as the one of the countries of the world shown here. You can add extras, such as marking regions by name and color and adding "pins" for points of interest.

Note that the printed result need not include the alphabetic column labels or the numeric row labels (Figure 13-7a).

A Graph from Spreadsheet Data

Gina decides to make a chart to contrast the sales totals among the four campuses. These figures already exist in the last column of the spreadsheet, cells E5 through E8. Using the software's charting capability, Gina can select those cells and then request a three-dimensional pie chart to display them. She decides to specify that the sales figures be shown as percentages of total sales and that each pie wedge be further labeled with the campus name, supplied from column A on the spreadsheet. After adding a title, "Comparison by Campus," Gina saves and prints the finished chart (Figure 13-7b).

BUSINESS GRAPHICS

Graphics can show words and numbers and data in ways that are meaningful and quickly understood. This is the key reason they are valuable. Personal computers give people the capability to store and use data about their businesses. These same users, however, sometimes find it difficult to convey this information to others—managers or clients—in a meaningful way. **Business graphics**—graphics that represent data in a visual, easily understood format—provide an answer to this problem.

FOCUS ON ETHICS **Lies and Spreadsheets**

While electronic spreadsheets have made the actual computation of business and financial reports largely automatic, they have done little, if anything, to prevent fraud and misrepresentation. In fact, spreadsheets may have made misrepresentation more common by luring readers into a false sense of security based on the high accuracy of the calculations but ignoring mistaken underlying assumptions. Consider the ethical implications of these situations and indicate what you think the companies should do to correct them.

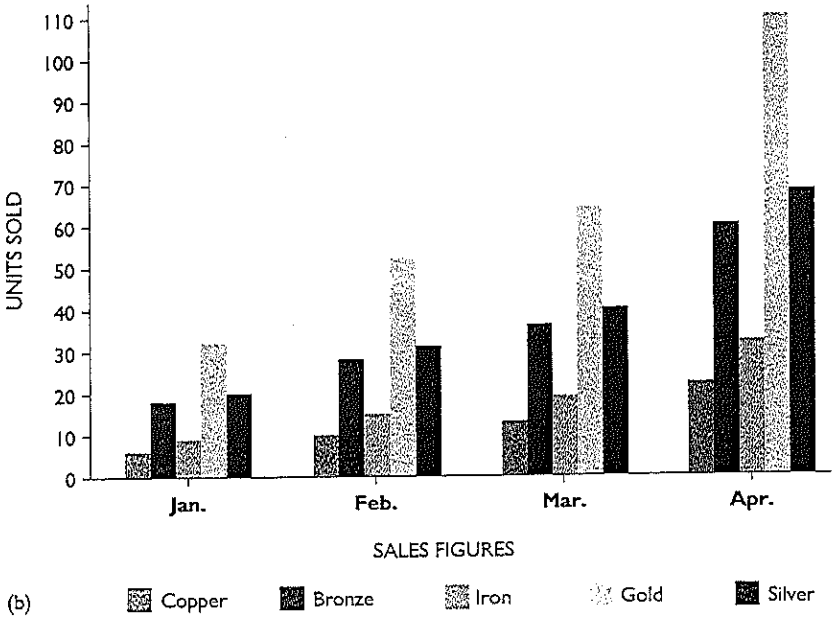
1. A company shows graphs of increased revenue but omits graphics showing significantly increased expenses.
2. The "productivity" column for last year was calculated on the basis of 200 employees working average 42-hour weeks, but the "productivity" column for this year is based on 150 employees working average 50-hour weeks.
3. Your ISP reports adding 1000 new subscribers this quarter. It does not mention how many previous subscribers dropped out during the same period.
4. An Internet startup company claims over 1 million Web page "hits" and goes on to project that 95 percent of these are potential customers.

Why Use Graphics?

Graphics generate and sustain the interest of an audience by brightening up any lesson, report, or business document. In addition, graphics can help to get a point across by presenting numeric data (Figure 13-8a) in one simple, clear graph (Figure 13-8b). What is more, that simple graph can reveal a trend that could be lost if it were buried in long columns of numbers. In addition, a presenter who uses graphics

	Units Sold Each Month			
Material	**Jan.**	**Feb.**	**Mar.**	**Apr.**
Copper	6	10	13	22
Bronze	18	28	36	60
Iron	9	15	19	32
Gold	32	52	64	110
Silver	20	32	40	68
Totals:	85	137	172	292

(a)



(b)

FIGURE 13-8

Business graphics.

(a) A large amount of data can be translated into (b) one simple, clear bar graph.

often appears more prepared and organized than one who does not. To sum up, most people use business graphics software for two reasons: (1) to view and analyze data and (2) to make a positive impression during a presentation. To satisfy these different needs, two types of business graphics programs have been developed: analytical graphics and presentation graphics.

Analytical Graphics

Analytical graphics programs are designed to help users analyze and understand specific data. Sometimes called analysis-oriented graphics programs, these programs use already-entered spreadsheet or database data to construct and display line, bar, and pie chart graphs (Figures 13-9a through 13-9c). Spreadsheet software usually provides this option.

Although analytical graphics programs do a good job of producing simple graphs, these programs are too limited and inflexible for a user who needs to prepare elaborate presentations. For example, analytical graphics programs let you choose from only a small number of graph types, and the formatting features—graph size, color, and lettering—are limited. These restrictions may be of little concern to some users, but those who require sophisticated graphics will want to consider presentation graphics.

Presentation Graphics

Presentation graphics programs are also called **business-quality graphics.** These programs let you produce charts, graphs, and other visual aids that look as if they were prepared by a professional graphic artist (Figure 13-9d through 13-9f). However, you can control the appearance of the product when you create it yourself, and you can produce graphics faster and make last-minute changes if necessary.

Most presentation graphics programs help you do several kinds of tasks:

- Edit and enhance charts, such as analytical graphs, created by other programs.
- Create charts, diagrams, drawings, and text slides from scratch.

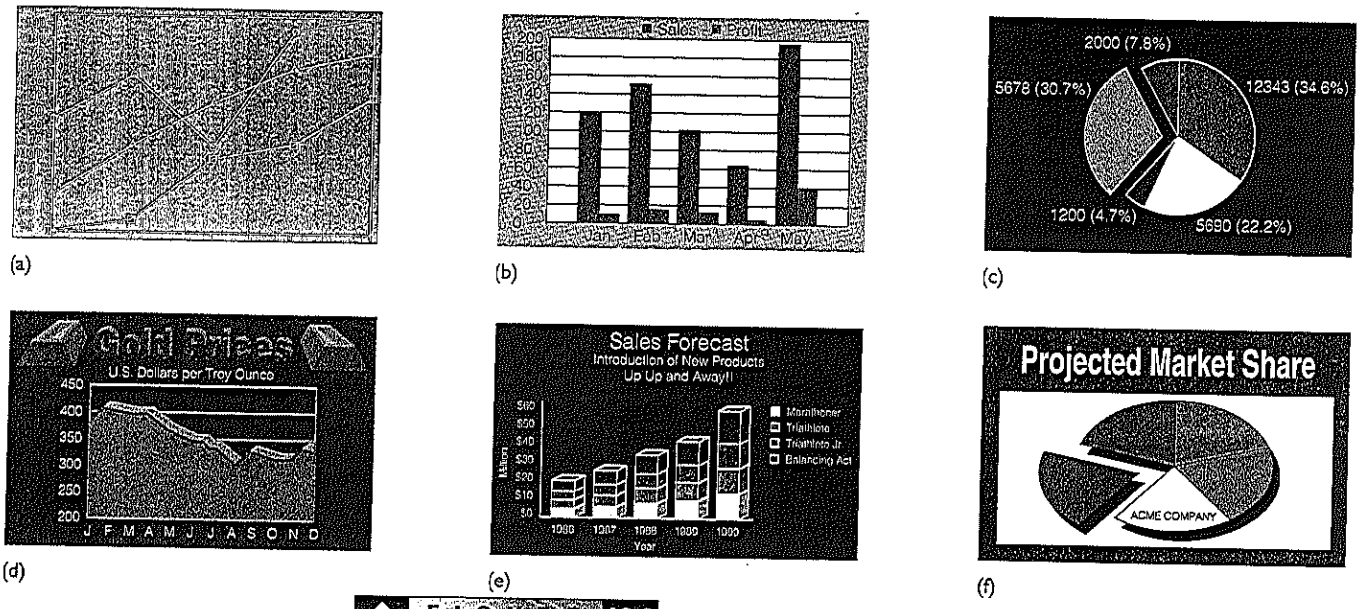


FIGURE 13-9

Analytical graphics compared with presentation graphics.

Analytical graphics (a, b, and c) are certainly serviceable, but they lack the clarity and appeal of presentation graphics (d, e, and f). Compare the line graphs (a and d), bar graphs (b and e), and pie charts (c and f).

- Use a library of symbols, drawings, and pictures called **clip art** that comes with the graphics program.
- Permit an animated presentation so that, for example, letters of a title can swoop in one by one to create a dynamic effect.
- Use small files that come with the program to add sounds—chimes, applause, swoosh, and even thunk—to your presentation.

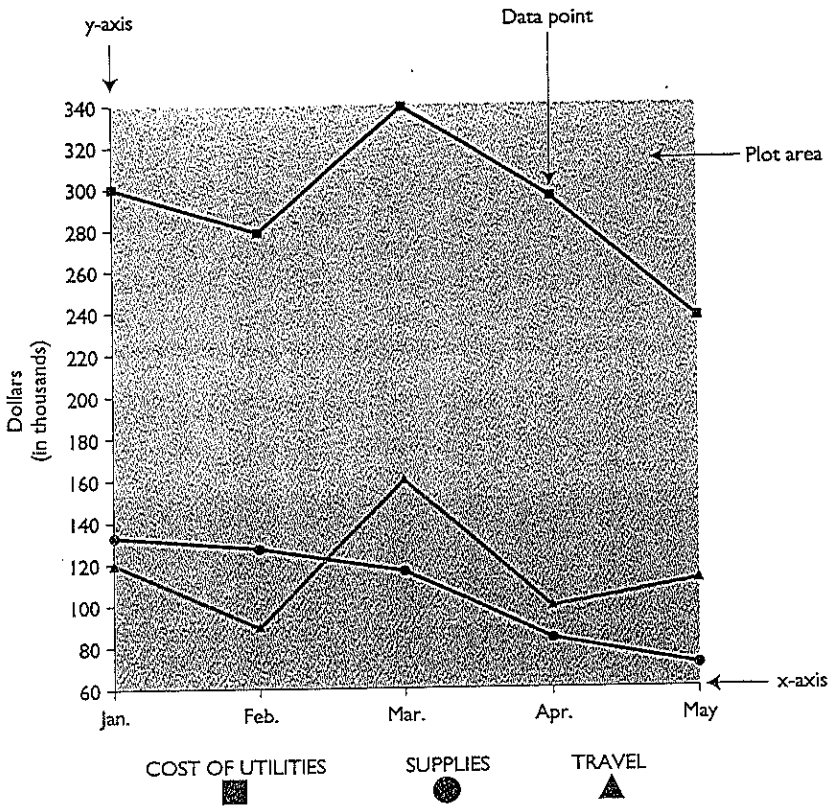
Although graphics hardware requirements vary, be aware that to use presentation graphics you will need a high-resolution color monitor, possibly a color printer, and perhaps some method of transferring your computer-produced results to slides or transparencies or to a projector that can show computer screen output on a wall screen.

SOME GRAPHICS TERMINOLOGY

To use a graphics program successfully, you should know some basic concepts and design principles. Let us begin by exploring the types of graphs you can create.

Line Graphs

One of the most useful ways of showing trends or cycles over a period of time is to use a **line graph.** For example, the graph in Figure 13-10 shows company costs for utilities, supplies, and travel during a five-month period. Line graphs are appropriate when there are many values or complex data. In the business section of a newspaper, line graphs are used to show complex trends in gross national product, stock prices, or employment changes over a period of time. Also, corporate profits and losses are often illustrated by line graphs.



Spreadsheet Errors

Spreadsheets have greatly reduced the tedium of number crunching for many people. However, a lack of proper controls on the development and use of spreadsheets has resulted in a situation in which many business decisions are being made on the basis of faulty data. A study by researchers at IBM's Thomas Watson Research Center discovered that over 44 percent of the spreadsheets developed by highly experienced spreadsheet users had errors in them. Research by Coopers & Lybrand (now PricewaterhouseCoopers) in London showed that over 90 percent of all spreadsheets with more than 150 rows contained at least one significant formula mistake. Following are two documented consequences of spreadsheet errors:

- Because of an incorrect formula for assessing equipment salvage value, a small Midwestern firm's estimated federal taxes were off by $5000.
- A Dallas oil and gas company's spreadsheet error resulted in millions of dollars being lost. Several executives were fired.

FIGURE 13-10

A line graph.

Line graphs are useful for showing trends over a period of time. In many analytical programs, different symbols are used to show the different types of data being plotted.

Notice, in Figure 13-10, the line that runs vertically on the left and the one that runs horizontally across the bottom; each line is called an **axis** (plural: axes). The horizontal line, called the **x-axis,** often represents units of time, such as days, months, or years; it can also represent characteristics, such as model number, brand name, or country. The vertical line, called the **y-axis,** usually shows measured values or amounts, such as dollars, staffing levels, or units sold. The area above the x-axis and to the right of the x-axis is called the **plot area**—the space in which the graph is plotted, or drawn.

Graphics programs automatically scale (arrange the units or numbers on) the x-axis and y-axis so that the graph of your data is nicely proportioned and easy to read. When you become proficient in using a graphics program, you can select your own scaling for the axes. Each dot or symbol on a line graph represents a single numeric quantity called a **data point.** You must specify the data to be plotted on the graph; many graphs are produced from the data stored in the rows and columns of spreadsheet files. This data is usually referred to as the set of **values.** The items that the data points describe are called **variables.** For example, in Figure 13-10 the variable Utilities includes the values 300, 280, 340, 300, and 240; the top line in the plot area shows how these values are graphed.

To make the graph easier to read and understand, **labels** are used to identify the categories along the x-axis and the units along the y-axis. **Titles** summarize the information in the graph and are used to increase comprehension. Every graph should have a title. It is surprisingly difficult to recall the exact meaning of an untitled chart that was produced just a few weeks before. For this reason most programs support not only titling the entire graph but adding separate titles to the individual axes as well.

Bar Graphs

Bar graphs are used for graphing the same kinds of data that line graphs represent. They are often used to illustrate multiple comparisons, such as sales, expenses, and production activities. Notice in Figure 13-9b that **bar graphs** shade a rectangular area up to the height of the point being plotted, creating a bar. These graphs can be striking and informative when they are simple. Bar graphs are useful for presentations because the comparisons are easy to absorb.

Pie Charts

Representing just a single value for each variable, a **pie chart** shows how various values make up a whole. These charts really look like pies; the whole amount is represented by a circle, and each wedge of the pie—a portion of the whole—represents a value. Figure 13-9c shows a pie chart.

Pie charts can show only the data for one time period, such as a single month. However, of all the graphics, the pie chart does the best job of showing the proportions for different variables. If a pie chart for expenses, for example, showed that more than half went for rent, that half-pie is easy to spot. Figure 13-9f shows one of the wedges pulled slightly away from the pie for emphasis. This type of pie chart is called an **exploded pie chart.**

▲

The most common applications software, word processing, deals with communicating with words. This chapter has addressed a subject that tends to be of more interest to businesses than to individuals: analyzing and communicating with numbers.