CHAPTER 1

Introduction to PC Networking

Welcome to the world of personal computer (PC) networking. In this world, it is no longer enough to simply have and use PCs; today it is imperative that you also "get connected." The real power and usability of PCs becomes apparent only when they are linked so that they can communicate with one another. From the simple two-computer home or small office local-area network (LAN) to the ever-growing global Internet, networking is *the future* of computing, and that future is here today.

In many areas of the United States, the demand for trained networking professionals far exceeds the supply. According to projections of the U.S. Department of Labor, computer networking as an occupation has a bright future. Businesses and individuals are buying PCs, and those computers are linking within LANs and wide-area networks (WANs) at an astonishing pace. We literally are "networking the world."

Because network communications is quickly becoming a part of our lives, even those not directly involved in the information technology (IT) industry should know something about the basics of networking. Just as it would be difficult to function in today's world if you knew nothing about a telephone and its features, in the not-too-distant future, knowing how to "get on the network" will be a requirement for many individuals, both at work and at home.

A Brief History of PC Networking

The desire to communicate with others is a driving force among human beings, and the sophisticated means we have developed to communicate sets us apart from other species. From the moment it became possible to link two computers and get them to talk to one another, the concept of the Internet was inevitable.

In the early days of computing, computers were enormous machines that filled entire rooms—sometimes entire city blocks—and cost hundreds of thousands of dollars. Although these expensive behemoths had less processing power and memory than today's tiny handheld computers, they were state-of-the-art technology in the 1950s and 1960s. In a world in which human beings who were slow and prone to error had done calculations manually, the capabilities of the computer were amazing.

At the midpoint of the twentieth century, computers were still rare, exotic, mysterious machines owned only by large companies, governmental bodies, and educational institutions. For the most part, computers were standalone systems, isolated from one another.

In the 1940s, Thomas Watson, the chairman of IBM, said that a market existed in the world for approximately five computers. Even as recently as 1977, Ken Olson, president of Digital Equipment Corporation, said, “There is no reason anyone would want a computer in their home” (ISBC [International Small Business Consortium], www.isbc.com/isbc/business/wisdom.cfm). Of course, both have been proven not just wrong, but *very* wrong. However, no one would have predicted, even a decade ago, that PCs would proliferate as they have or that computer networking would become a mainstream topic.

The First Communications Networks

By the mid-1900s, electronic communications had been around for over a century and was being implemented in both Europe and the United States. These early networks took many forms and sent only coded signals. They later became capable of sending voice across the wire.

This section provides a rough time line of how the first networks were developed.

Telegraph Cables

In the early 1800s, the French developed the first optical telegraph network, which sent information at the blazing speed of 20 characters per second, and Samuel Morse demonstrated the electrical telegraph, which spurred the development of networked communications in the United States.

The Telephone Network: Circuit-Switching Technology

In the late 1800s, a vast telephone network began to be built. Technology leaders of the day, however, were no more farsighted than those of the early computer age. In 1876 an internal memo at Western Union stated that “This ’telephone’ has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us” (www.isbc.com/isbc/business/wisdom.cfm).

Despite that attitude, there were more than 50,000 telephone lines in the U.S. by 1880, and by 1960, telephone lines covered urban areas, and the telephone network became a global communications network.

A telephone system uses circuit-switching technology, in which a circuit, or virtual pathway, is established when one telephone connects to another on a network. This works well for voice transmission because the sounds being transferred over the wire flow at a relatively constant rate.

In a circuit-switched network, a connection is established, as shown in Figure 1-1. All signals are passed over this circuit for the duration of the session. If you disconnect and reconnect, a different circuit can be used, as represented by the dotted line.

Figure 1-1 *In a circuit-switched network, a connection is established, as represented by the solid line.*

The technology works less well for transfer of computer data, which has a tendency to be sent in bursts; that is, periods of high activity are interspersed with intervals of low activity or inactivity.

Packet-Switching Technology

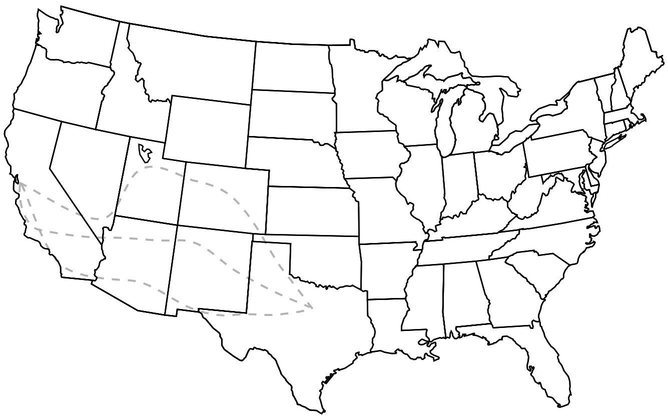
During the 1960s, the U.S. government became interested in developing a computer network that would enable systems at military installations and major educational institutions to communicate with one another. Because this was during the middle of the Cold War, they wanted the network to have robustness, reliability, and redundancy so that the network would survive a nuclear war.

Researchers working at the Massachusetts Institute of Technology (MIT), the RAND Institute, and the National Physical Laboratory (NPL) in England invented a new technology called *packet switching*, which worked better for bursty transmissions than did the traditional circuit-switching technologies. Their work created a foundation for the communications technology used on the Internet today.

In a packet-switched network, as shown in Figure 1-2, a connection is not established for the entire transmission. Instead, each individual packet of data can take a different path.

Communications from different sources can share the same line, rather than the line being dedicated to one end-to-end communication for the duration of a session, as is the case with circuit switching.

Figure 1-2 *Networked computers share data, software, and hardware resources.*



Circuit Switching Versus Packet Switching

The terms *circuit switching* and *packet switching* sound alike but have different meanings.

The public telephone system, sometimes referred to as POTS (plain old telephone service), is a switched-circuit communications network. When you place a telephone call in this type of network, only one physical path from your telephone to the one you're dialing is used for the duration of that call. This pathway, or *circuit,* is maintained for your exclusive use, until you end the connection by hanging up your telephone.

Note, however, that if you call the same friend at the same number tomorrow, and do so at the same location from which you placed today's call, the path is not necessarily the same. That's why the circuit is referred to as *switched*. It also explains why you can get a clear connection one day and noise and static on another.

With a packet-switching network, no dedicated pathway or circuit is established. Packet switching is sometimes referred to as a *connectionless* technology because of the lack of a dedicated pathway. If you transfer data, such as a word processing file, from your computer to another using a packet-switched network, each individual *packet* (that is, each small chunk of data) can take a different route. Although it all arrives at the same destination, it doesn't all travel the same path to get there. Internet traffic generally uses packet-switching technology.

The difference between circuit and packet switching can be compared to the different ways in which a large group of people traveling from Dallas to San Francisco can reach their destination. For example, circuit switching is similar to loading the entire group on a bus, a train, or an airplane. The route is plotted out, and the whole group travels over that same route.

Packet switching is like having each person travel in an automobile. The group is broken down into individual components as the data communication is broken into packets. Some travelers can take interstate highways, and others can use back roads. Some can drive straight through, and others can take a more roundabout path. Eventually, they all end up at the same destination. The group is put back together, just as packets are reassembled at the endpoint of the communication.

The ARPAnet

The first packet-switched computer network was conceived in the late 1960s, under the auspices of the U.S. Department of Defense (DoD). It was christened the ARPAnet (for Advanced Research Projects Agency network). The ARPAnet's first *node*, or connection point, was installed at the University of California at Los Angeles in 1969. In just three years, the network spread across the United States, and two years after that, it spread to Europe.

As the network grew, it split into two parts. The military called its part of the internetwork *Milnet,* and ARPAnet continued to be used to describe the part of the network that connected research and university sites. In the 1980s the Defense Data Network (a separate military network) and NSFNet (a network of scientific and academic sites funded by the National Science Foundation) replaced ARPAnet. Eventually this WAN grew into what we today call the Internet.

Yesterday's Networks

Computer networking didn't begin on such a large scale as the ARPAnet project; that is, the LAN came before the WAN. As computers became less expensive and more powerful, businesses of all sizes more commonly used them. Although the first machines were useful for only very limited types of data processing, as software development flourished, new programs enabled users to do much more than just collect and sort data.

With early mainframe systems, for instance, multiple users could access the same stored data from *terminals,* which were stations with input and output devices (for example, keyboards and monitors). These stations had no computing power of their own; they were points from which the mainframe computer could be accessed.

Using mainframes worked well in many respects, but they had several disadvantages when compared to smaller computers (then called microcomputers). Expense was one disadvantage; large mainframe systems cost far more than the so-called "personal" computers designed to sit on a desktop and function independently.

Another disadvantage of mainframes was the *single point of failure* concept. With mainframe computing, if the computer was down, it was down for everyone. Nobody could access data, and nobody who depended on the computer could get any work done. The use of individual PCs, on the other hand, circumvented this problem.

PCs were full-fledged computers that ran programs and performed tasks entirely on their own. They also provided some measure of *fault tolerance*, which is the capability of a system to continue to function and ensure data integrity when failures occur. If one employee's computer crashed, it didn't affect the capability of the rest of the employees, who had their own PCs, to continue working. In fact, if an employee had saved data to a floppy disk, he or she could move to a functioning machine and continue working.

These factors contributed to the increased popularity of PCs as a computing solution for small and large businesses (and everything in between). However, once everyone had a PC on the desktop, companies were faced with a dilemma: How could workers share information as they had with the old mainframe computing model? The solution was networking.

Disadvantages of Standalone Systems

In the early days of desktop PCs, networking hardware and software were not readily available, and many businesses used the machines as standalone systems. If all users needed to print documents on occasion, there were three possible ways to provide that ability:

- A printer could be attached to each machine. This was a costly solution because it necessitated buying multiple printers, even though it was unlikely that they all would be in use at the same time.
- The file to be printed could be saved to floppy disk and transferred to a machine that had an attached printer. This was a less-expensive option, but it was an inconvenience both to the person who had to go begging for a printer and to the person with the printer, whose work was interrupted while someone else used his or her machine to print.
- A printer could be moved from one workstation to another, depending on who needed to print. This was a somewhat cumbersome solution; nonetheless, it was widely implemented, using rolling printer carts that were wheeled around the office. Each move required that cables be disconnected and reconnected, and sometimes, a move involved software reconfiguration as well.

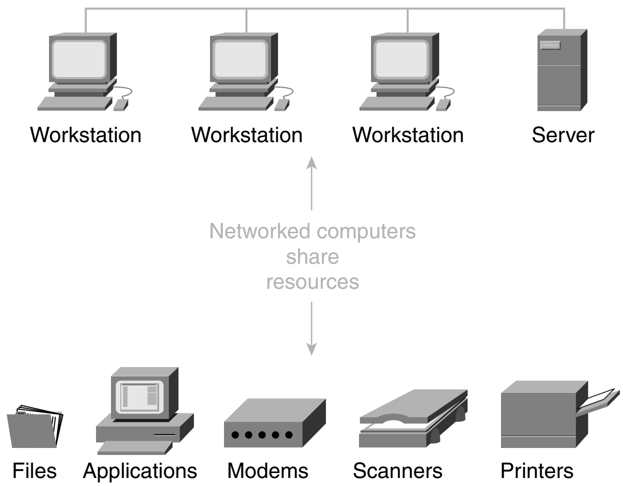
High cost, inconvenience, and extra work are the primary disadvantages of standalone, or non-networked, solutions.

What Is a Network, Anyway?

The *American Heritage Dictionary* defines a *network* as "a system of lines or channels that cross or interconnect." Earlier we mentioned the telegraph and telephone networks, and of course, we've all heard references to the television networks. Using the dictionary definition, we can call even the state highway system, or the railways that crisscross the country, a network.

That being said, what is a computer network? Simply, it is two or more devices linked for the purpose of sharing information, resources, or both. The link can be through cable (coaxial, twisted-pair, or fiber optics, as you'll learn later in this chapter), or it can be a wireless connection that uses radio signals, laser or infrared technology, or satellite transmission. The information and resources shared can be data files, application programs, printers, modems, or other hardware devices. See Figure 1-3 for an illustration.

Figure 1-3 *This time line shows significant events in PC networking history.*



Why Network Computers?

If the advantage of PCs were each user having an independent computer, why would we want to turn around and link them again? We link them because networked PCs give us, in many ways, the best of both worlds. Each user has independent processing power, but still can enjoy all the benefits of sharing. On the other hand, a company sees a significant cost savings when expensive, occasionally used peripherals are shared over the network. For example, an expensive color laser printer might be used only for special projects, yet many different members of the organization will need to print to it from time to time. With network access, it's easy for them to do so.

Benefits of Getting Connected

Many business owners and managers state that the primary reason for networking their PCs was the need to share printers, as described in the earlier example. Of course, once the systems were linked, people discovered the usefulness of being able to share much more than printers.

The cost involved in linking computers in a LAN—the network interface cards (NICs) for the computers, the cabling or wireless media, the hubs and other connectivity devices—often pays for itself many times over by reducing expenditures and lost production time.

Sharing Output Devices

As discussed, printers and other output devices can be shared on a network, saving time, money, and a great deal of aggravation. Items that can be shared include plotters, which are devices used to draw diagrams, and charts. They also include line-based graphics that use pens or electrostatic charges and toner. Fax machines, which can be either input or output devices, also are easy to share.

Sharing Input Devices

You can share scanners, digital cameras, and other input devices across the network. Because these devices, even more so than printers, are generally used on an occasional basis and are often relatively expensive, it makes sense to configure them for multiple users on the network.

Sharing Storage Devices

Networked computers can share the use of hard disks and floppy and CD-ROM drives. With this type of sharing, you can save files to the disk of another computer across the network if you run out of hard disk space on your computer. In addition, if your computer doesn't have a CD-ROM drive installed, you can access the shared CD drive of another computer. This ability to share also occurs with Zip and Jaz drives, magneto-optical drives, tape drives, and just about any other type of storage device that can be connected to a PC.

Sharing Modems and Internet Connections

Another important feature of networking is the ability of networked PCs to share modems, ISDN lines, cable modems, and DSL adapters. With the proper software—such as proxy or

Network Address Translation (NAT) software, which we discuss in detail in Chapter 9, "The Widest Area Network: The Global Internet"—an entire LAN can connect to the Internet through one phone line and a single ISP account.

Sharing Data and Applications

Hardware devices are not the only, or even the most important, resources that can be shared on a network. Data files and application programs also can be made available to multiple users. This sharing results in the efficient use of disk space and easier collaboration on multiuser projects. For example, if several managers need to access and revise a spreadsheet containing a department's budget, the file can be stored in a central location. After each manager makes the desired changes, the file can be saved to the network location so that the updated version is available for the next manager.

Application programs, such as word processing programs, can be installed to a network server. Users can connect to the share and run the application on their own machines, without using space on their local hard disks for the program files.

Be aware that software vendors' licensing agreements can require that you purchase additional licenses for each workstation that uses a network application, even though only one copy is actually installed and all users are accessing that same copy.

The Birth of the Internet

As mentioned previously, back in the 1960s, usable networking technologies became available, and in the early 1970s, the ARPAnet was created by a collaborative effort between the U.S. government (primarily the DoD) and several large universities.

The Role of the DoD

As the Cold War between the United States and the Soviet Union intensified in the 1960s, the DoD recognized the need to establish communications links between major U.S. military installations. The primary motivation was to maintain communications if a nuclear war resulted in mass destruction and breakdown of traditional communications channels. Major universities, such as the University of California and MIT, were already involved in networking projects too.

The DoD funded research sites throughout the United States, and in 1968, ARPA contracted with BNN, a private company, to build a network based on the packet-switching technology that had been developed for better transmission of computer data.

The 1970s: The Growth Spurt Begins

When the ARPAnet project began, no one anticipated that the network would grow to the extent it did. Throughout the 1970s, more nodes were added, both domestically and abroad.

The 1980s: More Is Better

In 1983, the ARPAnet network was split, and 68 of the 113 existing nodes were taken by Milnet, which was integrated with the Defense Data Network. The Defense Data Network had been created the previous year.

The Domain Name System (DNS) was introduced in 1984, providing a way to map "friendly" host names to IP addresses that was much more efficient and convenient than previous methods. We discuss these previous methods in Chapter 8, "Networking Protocols and Services." In 1984, there were more than 1000 host computers on the network.

During the last half of the 1980s, the networking picked up considerably. For instance, the NSF created supercomputer centers at Princeton, in Pittsburgh, at the University of California at San Diego, at the University of Illinois at Urbana-Champaign, and at Cornell. The Internet Engineering Task Force (IETF) also came into being during this time. By 1987, there were 10,000 hosts on the network, and by 1989, that number increased to over 100,000.

The 1990s: The Net Becomes Big Business

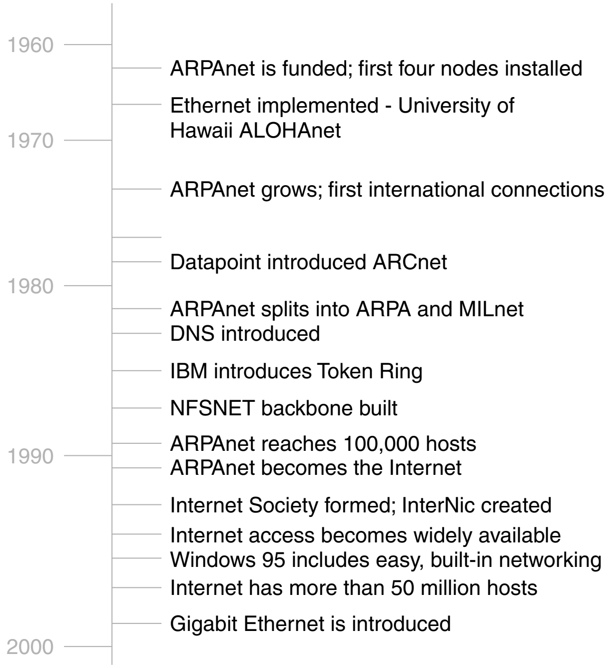
The phenomenal growth rate of the 1980s was nothing compared to what came in the 1990s. ARPAnet ceased to exist, and the Internet was "invented," with the U.S. government getting involved in pushing the development of the so-called information superhighway. The NSFnet backbone was upgraded to T3 speed (that is, 44.736 Mbps), and in 1991 it sent more than 1 trillion bytes per month. The Internet Society (ISOC) was formed, and in 1992 more than 1 million hosts existed on the Internet.

The 1990s was the decade that the Internet went commercial. As more and more college students and faculty, individual home users, and companies of all sizes got connected, the business world recognized the opportunity to reach a large and expanding affluent market. By 1995, online advertising had caught on, online banking had arrived, and you could even order a pizza over the Internet.

The last half of the last decade of the century ushered in new major developments almost on a daily basis. Streaming audio and video, "push" technologies, and Java and ActiveX scripting took advantage of higher-performance connectivity available at lower and lower prices. Domain names became big business, with particularly desirable names selling for upwards of $1 million. In December 1999, almost 1 billion sites existed on the Word Wide Web, with well over 50 million host computers participating in this great linking.

Figure 1-4 shows a time line of significant events in PC networking history.

Figure 1-4 *Smart house technology brings the network of the future home today.*



The Cost of Technology: More and More for Less and Less

As computer and networking technology have advanced over the past few decades, the cost of that increasingly sophisticated technology has fallen dramatically. Those falling prices are at least partially responsible for the rising popularity of connectivity solutions in the business world and in personal lives.

In the 1970s and 1980s, a PC that was considered state of the art for the time cost several thousand dollars. Online services existed, but with fees of $25 or more *per hour* of access, only big businesses and the wealthy could afford them. PC veterans still can remember the announcement of Prodigy's "bargain rates" of only $9.95 an hour for online access. This was at blazing speeds of 1200 or 2400 baud.

Today, of course, for under $1000, you can buy a computer system capable of doing much more, and doing it better and faster, than the $500,000 mainframe of 20 years ago. Internet access at speeds equivalent to T1 is available through DSL or cable modem for $30 to $40 per month, and the price is falling all the time. Basic Internet access at 56 kbps can be had for much less—even for free, if you can tolerate a bit of advertising taking up space on your screen.

PC Networking Today

As we enter the 2000s, we are on our way to networking the world (and beyond). The Net is beginning to permeate almost every area of our lives. We have computers at work, computers at home, and portable computers that we carry with us on airplanes and to the beach.

As always, where there are multiple computers, networking usually follows. Indeed, a primary function of many of these computers is to connect to the Internet. In this section, we look at some of the ways in which networked computers are changing our lives.

Home Computing

Home PCs are commonplace, and many of these PCs are being marketed specifically as e-machines, ready to connect to the Internet. Many households have multiple computers, and where two or more computers exist under the same roof, the desire to link them is sure to rear its head sooner or later. There is a new, booming market in home LAN technology, which uses wireless solutions or the house's telephone or electrical wiring in place of traditional Ethernet cabling.

Web Presence and E-commerce

Businesses of all sizes and types are finding that having a Web site is beneficial—or even essential—to their advertising strategies. Even small companies are turning to e-commerce (that is, selling their products or services directly over the Internet) as a cost-effective solution. Large corporations are running *enterprise networks* (that is, large multisite networks) that connect offices around the world to their own internal intranets as well as to the Internet.

High-Performance Business Solutions

As high-speed connectivity over fiber-optic and other fast media becomes commonplace, live videoconferencing is becoming a viable replacement for face-to-face meetings. Executives are staying in close touch with their offices even while traveling, thanks to the availability of remote dial-in access and virtual private networking. Employees at all levels of the organization are telecommuting, enjoying more flexibility in their work schedules while the company benefits from savings in facilities and onsite equipment. In addition, transfer of large data files can now be accomplished quickly and efficiently. Even traditional low-bandwidth activities such as scheduling and e-mail access are improved by emerging and affordable high-performance technologies.

Online Learning

Public schools are getting wired, and online learning is becoming a reality as major colleges and universities offer credit courses that can be completed either partially or wholly over the Internet. In addition, hardware and software vendors, led by big players such as Microsoft Corporation and Cisco Systems, are partnering with commercial and nonprofit organizations to bring networked computers and Internet access within the reach of almost everyone who wants it.

Tomorrow's Networks

At the end of this book, we look at emerging technologies in the networking field. Some of these are still on the drawing board, and others have been tested and found feasible in the lab or in limited scope in the field.

As political entities and large corporations get behind the push to develop new, better, and faster means of bringing networked communications into the daily lives of people at all socioeconomic levels, exciting new developments in both software and hardware are being announced on a regular basis. The way we work and play is being transformed, and optimists predict that international and cultural barriers will melt as global connectivity makes the world a smaller—or at least more accessible—place. Many people seek to establish shared technology centers that provide access and training to groups that traditionally have not had the opportunity to benefit from computer technology and connectivity.

Speculation about where networking is headed is an attempt to predict the unpredictable. Twenty years ago, many of the technologies we now take for granted were unthinkable to anyone but science fiction writers. It's likely that twenty years in the future, computing and networking will have gone in drastically new directions that we can't begin to imagine today. There are, however, some interesting possibilities on the horizon, as discussed in the following sections.

”Smart” Appliances and Homes

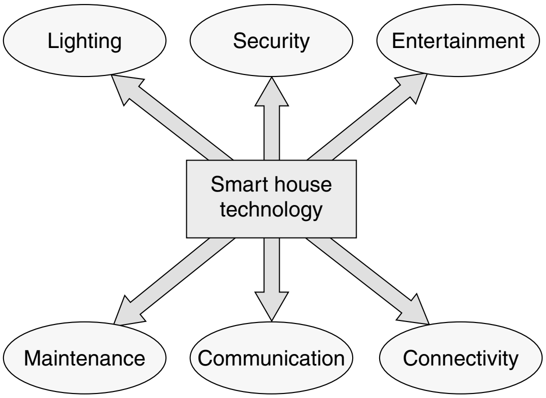
Although not yet widely available, the concept of smart appliances and homes is already a reality. You can buy kitchen appliances today that have embedded microprocessors, or miniature computers, that control temperature, cooking time, and so forth. The next step—and it's not a very big one—is connecting those tiny computers to a network so that you can issue commands remotely. It's likely that in the not-too-distant future, you will get online at the office, access your oven, and tell it what time to start preheating in preparation for your arrival home.

This concept logically leads to the next: the integrated smart house, which is computer-controlled and wired to a central network. The prime example of this is the multimillion-dollar estate of Microsoft chairman Bill Gates. This estate features computerized climate control and customized music "zones" that follow a person from room to room.

Numerous companies can make your present home smart by wiring it for Ethernet connectivity and by integrating your home computers with your phone, security, home theater, heating and air conditioning, and lighting systems. You can control these systems with the click of a mouse or even through voice command. Figure 1-5 illustrates some features currently available in smart house technology.

We discuss the house of the future a bit more in Chapter 19, "Tomorrow's Technologies."

Figure 1-5 *Smart house technology brings the network of the future home today.*



Phoning Home

Telephone technology has been quietly advancing over the past few decades. The developments in this area, however, have been marketed and integrated into our lives so smoothly and gradually that their impact has not received the sort of attention it might have otherwise.

Providers of mobile phones have built cellular- and satellite-based networks that now offer sophisticated services, such as wireless Internet access, at affordable prices. The technology is improving all the time.

Regular telephone companies (referred to within the industry as *telcos*), spurred by competition from cable TV companies, are implementing high-speed services for data transfer, such as Asynchronous Digital Subscriber Line (ADSL), at a cost low enough to market to home users.

Telephony applications are integrating the PC and the telephone in a variety of ways that allow for automatic answering, message storage, and message retrieval through the computer.

NOTE *Telephony* applications are those that combine telecommunications technologies with computing technologies. This includes implementations in accordance with the Telephony Applications Programmers Interface (TAPI) specifications and the standards of the Internet and Telecoms Convergence Consortium (ITC).

Internet phone programs using voice over IP enable you to bypass the telephone lines entirely (if you have an Internet connection through cable, wireless, or some other medium) to make long distance calls from your computer without paying long distance charges.

New operating systems, such as the latest version of Microsoft Windows, include support for IP telephony, which blends voice, video, and data transmission over TCP/IP connections with improved quality of service.

We take a closer look at personal communications systems of the future in Chapter 19.

The Wired Workplace

It seems that in any business facility you enter, there is a computer (or several) on every desktop, all of them linked to an internal LAN, the external Internet, and a few remote private networks for good measure. We can only wonder how the work environment of the future will be *more* network-centric than it is today.

The office of tomorrow will be even more reliant on network technology. As business environments are wired with fiber-optic and other high-performance media, increasing bandwidth and real-time video will make teleconferencing an attractive alternative to face-to-face meetings. It's likely that more and more employees will work from home. They will not, however, be isolated with their own little individual projects. Instead, they will share documents over the network to foster a more team-oriented environment.

As full-featured computers shrink in size while growing in capability, it will become easier to "take the office on the road." Handheld systems that today integrate e-mail, Web access, calendaring, and task management will no doubt in the future provide for on-the-go video on demand, voice communications, and notification services—combining the functions now performed by separate devices. No longer will you need to carry a palm computer, mobile phone, and pager; one machine, small enough to wear on your belt or slip into a purse, will do it all.

This universal connectivity and accessibility have the potential to increase the productivity of businesses of all types.

Schools of the Future

The future of education will be impacted by developments in networking technology. In fact, it is already commonplace for libraries from elementary to university level to include one or more Internet-connected computers for students.

The most dramatic effect of technology on schools is the availability of information on a scale that was never before possible. As more public and private schools get wired, the way in which students do research for papers will change. In fact, the very nature of those assignments can change as well, to require the inclusion of multimedia material.

New learning methodologies that involve more of the senses are likely to become more popular. At the lower age levels, this can mean educational interactive games that engage the attention of students and contribute to the development of hand-eye coordination.

At the college and university levels, offsite learning seems to be the trend. Students can attend class through computer, downloading assigned reading material, submitting completed assignments through e-mail, and participating in class discussions through live chat. There are already a small percentage of courses offered in this way, and we expect that in the next decade, this will become a standard way to gain college credit or even complete degrees.

Networking Health Care

The advancement of computer and networking technology will make an enormous impact in medicine and health care. The most obvious benefit of networking to the healthcare industry is the capability of physicians to share patient records and diagnostic and treatment information.

Other ambitious and exciting developments are already taking place or are expected to become reality in the near future. For instance, long-distance surgery—in which the physician performing the operation from a remote location controls the robotic device that is actually operating on the patient—has been successful in experimental situations.

A related concept is the tele-examination, in which the physician conducts a preliminary physical exam over two-way video, perhaps aided by a proxy or stand-in such as a physician's assistant or nurse practitioner who is actually with the patient. The idea of telemedicine is especially attractive in rural areas where physicians are in short supply.

Technology and the Law

Legal research and courtroom procedures have become more efficient because of networking and the subsequent improvement in record keeping and information sharing abilities.

Law enforcement, in particular, has put the new technologies to work. Many police agencies now have mobile data terminals (MDTs) installed in squad cars, allowing officers to quickly and directly access criminal history files, license records, and departmental references and resources. MDTs also make it possible for officers to communicate with one another over the network in a fashion that is more secure than broadcasting over open radio channels. Departments are also making use of global positioning system (GPS) technology, combined with computer-aided dispatch, to provide accurate information to dispatchers and supervisors at the station about where each unit is located at any given time. This gives command staff more control for better deployment of officers.

Intergalactic Networking?

Now that Internet connectivity has permeated almost every corner of the globe, the next logical step is to network the final frontier: outer space. The idea is not as futuristic as it sounds; in fact, computer communications are already sending signals to satellites orbiting high over the earth, and there are projects underway that broadcast signals into deep space in hopes of catching the attention of life, if it exists, on other planets.

Computers on Earth already control the activities of unmanned space missions and play a huge role in the journeys of manned shuttles. Networked communications make interplanetary exploration feasible.

A Brief Overview of Networking Terminology

When you visit another country, the first task to tackle is learning the language. The same is true of entering a new area of study or a new career field.

Computer networking, like most professions, has its own jargon, such as technical terms, abbreviations, and acronyms, that can, at first glance, look as foreign to the uninitiated as does the alphabet of a country halfway around the world.

Without a good grasp of the terminology, you will have difficulty understanding the concepts and processes in this book. This section gives you a head start on deciphering some of the tech talk in this and other introductory guides to networking and network operating systems.

This is not intended to be a comprehensive glossary of networking terms, but a quick reference that defines and briefly discusses some of the most important and most basic words, phrases, and acronyms that enable you to navigate through the next few chapters.

Each definition is expanded on in the chapters that follow. Please refer to the glossary for a more comprehensive list of definitions.

Concept-Related Terminology

networking model—A networking model is a graphical representation of the processes involved in network communications. The popular models represent these processes as layers or levels; thus, they are called *layered models.* The most commonly referenced are the Open System Interconnection (OSI) seven-layer model, the four-layer DoD model (sometimes called the TCP/IP networking model), and the Microsoft Windows networking model. We discuss each in detail in Chapter 2, "Categorizing Networks."

client/server networking—In computer networking terms, a *client* computer is one that sends a request to another computer for access to its data or resources. The computer that responds to that request and shares its data or resources over the network is called the *server*. In a *peer-to-peer network* (also called a *workgroup*), all computers on the network act as both clients and servers. In a *server-based network* (sometimes called a client/server network, and in Microsoft Windows networking, called a *domain*), there is a dedicated server computer running special server software, which performs user authentication/security functions. We discuss both peer-to-peer and server-based networking in Chapter 2.

Network Hardware-Related Terminology

NIC—It is pronounced "nick" and refers to the network interface card, also called the network adapter card (but for some reason never called a NAC), or just the network interface. This card typically goes into an ISA, PCI, or PCMCIA (PC card) slot in a computer and connects to the network *medium*, which in turn is connected to other computers on the network.

media—Media are the means by which signals are sent from one computer to another by cable or *wireless* means.

wireless media—Wireless media, such as the radio, laser, infrared, and satellite/microwave technologies, carry signals from one computer to another without a permanent tangible physical connection (cable).

coax—Coaxial cable, or coax, is similar to cable TV cable, which is copper-cored cable surrounded by a heavy shielding that is used to connect computers in a network. Either thin or thick coax can be used.

twisted-pair—Twisted-pair is a type of cabling, also used for telephone communications, that consists of pairs of copper wires twisted inside an outer jacket. There are two basic types: UTP (unshielded twisted pair) and STP (shielded twisted pair). UTP is the most commonly used cabling in modern Ethernet networks. It comes in different category ratings depending on whether it is considered voice or data grade and the transmission speed it supports. "Cat 5" refers to a category 5 rating, which can be used for voice (telephone) or data and which supports speeds up to 100 Mbps.

plenum—The plenum in a building is the space between a false ceiling and the floor above, through which cabling can be run. *Plenum-grade* cable, often called plenum cable, refers to cable with an outer jacket made of Teflon or other material that complies with fire and building codes for installation in the plenum area.

PVC—In the context of network hardware and cabling, PVC stands for polyvinyl chloride, the material out of which the jacket on non-plenum-grade cable is made. It is less expensive than plenum-grade materials but does not meet most safety codes for installation in the ceiling because it gives off a poisonous gas when burned.

fiber optics—Often shorted to just *fiber*, fiber optics refers to cabling that has a core made of strands of glass or plastic (instead of copper), through which light pulses carry signals. Fiber has many advantages over copper in terms of transmission speed and signal integrity over distance; however, it is more expensive and more difficult to work with.

connectivity devices—This term refers to several different device types, all of which are used to connect cable segments, connect two or more smaller networks (or subnets) into a larger network, or divide a large network into smaller ones. The term encompasses repeaters, hubs, switches, bridges, routers, and brouters. Each is discussed in detail in Chapter 7, "Physical Components of the Network."

Software-Related Terminology

protocol—A network protocol is a set of rules by which computers communicate. Protocols are sometimes compared to languages, but a better analogy is that the protocol is like the syntax of a language, which is the order in which processes occur. There are many different types of computer protocols. A *protocol stack* refers to two or more protocols working together. The term *protocol suite* describes a set of several protocols that perform different functions related to different aspects of the communication process.

NOS—*NOS*, which stands for network operating system, usually refers to server software, such as Windows NT, Windows 2000 Server, Novell NetWare, and UNIX. The term sometimes refers to the networking components of a client operating system such as Windows 95 or the Macintosh OS.

client operating system—Also referred to as the desktop operating system, *client operating system* refers to the operating system software that runs on the network's workstations, which access the server and/or log onto the network as clients.

hybrid network—A hybrid network (also called a multivendor network) is one in which the software products of different vendors interoperate, especially in regard to the server operating systems. For example, a network that has Windows NT domain controllers, NetWare file servers, and a UNIX Web server is a hybrid network.

Design and Topology Terminology

LAN—A local-area network (LAN) is a network that is confined to a limited geographic area. This can be a room, a floor, a building, or even an entire campus.

WAN—A wide-area network (WAN) is made up of interconnected LANs. It spans wide geographic areas by using WAN links such as telephone lines or satellite technology to connect computers in different cities, countries, or even different continents.

MAN—A MAN (metropolitan-area network) is a network that is between the LAN and the WAN in size. This is a network that covers roughly the area of a large city or metropolitan area.

physical topology—This refers to the layout or physical shape of the network, whether the computers are arranged so that cabling goes from one to another in a linear fashion (linear bus topology), the last connects back to the first to form a ring (ring topology), the systems "meet in the middle" by connecting to a central hub (star topology), or multiple redundant connections make pathways (mesh topology). The characteristics of each are discussed in Chapter 3, "Networking Concepts, Models, and Standards."

logical topology—The logical topology is the path that signals take from one computer to another. This can correspond to the physical topology. For instance, a network can be a physical *star,* in which each computer connects to a central hub, but inside the hub, the data can travel in a circle, making it a *logical ring.* The difference between physical and logical topologies is discussed in Chapter 3.

Measurement-Related Terminology

bit—The smallest unit of data in a computer. A bit equals 1 or 0, and it is the binary format in which data is processed by computers.

byte—A byte is a unit of measure used to describe the size of a data file, the amount of space on a disk or other storage medium, or the amount of data being sent over a network. 1 byte generally equals 8 bits of data.

KB (kilobyte)—A kilobyte is approximately 1000 bytes (actually, it's 1024 bytes). It can be abbreviated as "K."

KBps (kilobytes per second)—This is a standard measurement of the amount of data transferred over a network connection.

kbps (kilobits per second)—This is a standard measurement of the amount of data transferred over a network connection.

MB (megabyte)—A megabyte is approximately 1 million bytes (actually 1,048,576). A megabyte is sometimes referred to as a "meg."

MBps (megabytes per second)—This is a standard measurement of the amount of data transferred over a network connection.

Mbps (megabits per second)—This is a standard measurement of the amount of data transferred over a network connection.

Hz (Hertz)—A unit of frequency. It is the rate of change in the state or cycle in a sound wave, alternating current, or other cyclical waveform. It has one cycle per second and is used to describe the speed of a computer's microprocessor.

MHz (megahertz)—One million cycles per second. This is a common measurement of the speed of a processing chip such as a computer's microprocessor.

GHz (gigahertz)—One thousand million, or 1 billion (1,000,000,000), cycles per second. This is a common measurement of the speed of a processing chip such as a computer's microprocessor.

NOTE A common error is confusing KB with kb and MB with Mb. Remember to do the proper calculations when comparing transmission speeds that are measured in KB with those measured in kb. For example, modem software usually shows your connection speed in *kilobits* per second (for example, 45 kbps). However, popular browsers display file-download speeds in *kilobytes* per second, meaning with a 45 kbps connection, your download speed would be a maximum of 5.76 KBps. In practice, you cannot reach this download speed because of other factors consuming bandwidth at the same time. We discuss data transfer rates in more detail in Chapter 7.

NOTE PC processors are getting faster all the time. The microprocessors used on PCs in the 1980s typically ran under 10 MHz (the original IBM PC was 4.77 MHz). As the year 2000 began, PC processors approached the speed of 1 GHz.

What This Book Covers and What It Doesn't

This book provides an overview of networking fundamentals and popular server and client operating systems in use on networks today. Because the scope is broad, we are not able to go into the depth or detail on individual topics in a manner possible in more specialized books.

Throughout the book, we provide a resource list at the end of each chapter to point you toward sources of more detailed information on each of the topics introduced.

Networking Certifications

Because of the shortage of qualified professionals and the high demand for personnel in the networking industry, certification has become a popular means of measuring basic knowledge and qualifications, especially for entry-level positions. Many organizations offer certification examinations to test your grasp of networking technologies.

Vendor-Specific Certifications

Some certification programs are *vendor-specific;* exam candidates are tested on their abilities with particular hardware or software products and are expected to know the "party line" and answer exam questions in keeping with the particular vendor's philosophy and focus. Many of these certifications, such as the Cisco CCIE and the Microsoft MCSE, are well respected in the industry.

NOTE Vendor-specific certifications are useful for demonstrating specific capabilities with a particular company's products and in many instances are desired or even required by employers.

Some of the most popular vendor-specific certification programs include the following:

- Cisco Certified Network Associate (CCNA), Cisco Certified Network Professional (CCNP), and Cisco Certified Internetwork Expert (CCIE)
- Microsoft Certified Professional (MCP) and Microsoft Certified Systems Engineer (MCSE)
- Novell Certified NetWare Administrator (CNA) and Novell Certified NetWare Engineer (CNE)

Other companies, such as Sun, Lotus, IBM, and RedHat and other Linux vendors, also offer certification exams for their networking software. There are also vendor-specific hardware certifications offered by IBM, Compaq Computers, Digital Equipment Corporation, and others.

Non-Vendor-Specific Certifications

Non-vendor-specific certification programs attempt to measure general knowledge and skills applicable to the networking products of a wide range of vendors.

The most popular non-vendor-specific networking skills certification is Network+, which is offered by the Computing Technology Industry Association (CompTIA). This association also developed the vendor-neutral A+ PC hardware technician's exam.

Non-vendor-specific certifications are useful for demonstrating a broad base of knowledge and skills pertaining to generic networking concepts, practices, and terminology.

This Book and Certification

This book was designed to give you a broad overview of the essential elements of PC networking. It can serve as an introductory guide for those new to the IT industry and those who plan to seek vendor-specific certification such as the CCNA, MCSE, or CNA.

It can also be used as a study guide, in conjunction with other preparatory material, for the Network+ exam. We have covered all topics included in the exam objectives. We also have covered the objectives specified by Microsoft for the Networking Essentials exam, which is generally prescribed as the first of the six exams required to obtain the MCSE under the Windows NT 4.0 track.

NOTE The Network+ certification was supported and sponsored by such companies as Microsoft, Novell, IBM, Lotus, and many more.

Although the new Windows 2000 MCSE certification track does not include an exam devoted exclusively to networking essentials, much of the material in this book is useful in studying for the Windows 2000 core examination 70-216, *Implementing and Administering a Microsoft Windows 2000 Network Infrastructure*.

Summary

This chapter introduced you to the world of computer networking and how standalone systems began to be linked into networks. You learned about early LANs and the development of the ARPAnet, which was the joint DoD/university project that became today's global Internet.

This chapter touched on some of the ways in which technologies are affecting our lives, and it provided an overview of some of the concepts that are explored in depth in later chapters of this book. You learned some common networking terms and about the role of technical certifications in the networking industry.

In upcoming chapters, you will build on this information as you learn about the models and standards on which today's networks are built. We will go under the hoods of small LANs and complex WANs, and you will become familiar with the signaling methods, architectures, hardware, protocol operating systems, and services that provide the foundation of modern networking.

You will learn about hot topics such as security and troubleshooting, and we will discuss specialty areas such as remote access, virtual private networking, and thin client networking. We will look at emerging technologies that promise that the networks of the future will be even more fascinating, and more practically useful, than the networks of today.

Further Reading

An excellent Web-based resource for definitions of networking terms and acronyms is www.whatis.com.

A good reference for additional information about the history of networking is www.silkroad.com/net-history.html.

For more information about CompTIA and the Network+ certification program, see CompTIA's Web site at www.comptia.com.

For more information about vendor-specific certification training and exams, see the following Web sites:

- Cisco: www.cisco.com/warp/public/10/wwtraining/certprog
- Microsoft: www.microsoft.com/train_cert
- Novell: education.novell.com/certinfo

Review Questions

The following questions test your knowledge on the material covered in this chapter. Be sure to read each question carefully and select the *best* correct answer or answers.

1 What was the early implementation of networking technology developed by the French in the early 1800s?

a The telephone network

b The optical telegraph network

c The Ethernet network

d The ARPAnet

2 What is the name of the technology that the telephone network uses?

a Packet switching

b Layer 2 switching

c Layer 3 switching

- **d** Circuit switching

3 What is the technology that works best for bursty data transmissions?

- **a** Packet switching
- **b** Analog transmission
- **c** Circuit switching
- **d** Switchboard technology

4 Which of the following is a disadvantage of mainframe-based networks? (Select all that apply.)

- **a** The mainframe hardware is more expensive than PC hardware.
- **b** Mainframes are incapable of processing the large amounts of data that are processed by PC servers.
- **c** Mainframes represent a single point of failure.
- **d** Mainframe terminals are less secure than networked PCs.

5 Which of the following can be shared across a computer network? (Select all that apply.)

- **a** Data
- **b** Applications
- **c** Printers
- **d** Modems

6 Which of the following is classified as an input device? (Select all that apply.)

- **a** Plotter
- **b** Fax machine
- **c** Digital camera
- **d** Printer

7 What is the name of the method introduced in the 1980s to provide a means for mapping friendly host names to IP addresses?

- **a** DoD
- **b** DHCP

- **c** DSL
- **d** DNS

8 What are the applications that combine telecommunications and computer technologies called?

- **a** Computel technologies
- **b** Telephony technologies
- **c** TPI technologies
- **d** ITC technologies

9 What type of computer sends a request to another computer for access to its data or resources?

- **a** Server
- **b** Workstation
- **c** Client
- **d** Terminal

10 What is the set of rules by which computers communicate?

- **a** Protocol
- **b** Media type
- **c** Byte
- **d** Topology