STEM Applications

1. **MATH** Ohm's law states that voltage equals current times resistance, or $E = I \times R$. Rewrite this equation to find the current in a circuit if you know the voltage and resistance. Then use your equation to find the current in a 12 V circuit if the total resistance is 8 Ω.

2. **ENGINEERING** Design a lighting circuit for a public restroom in which the exterior light above the door stays lit all the time, but the interior light comes on only when the door is closed. Sketch a diagram for your design.

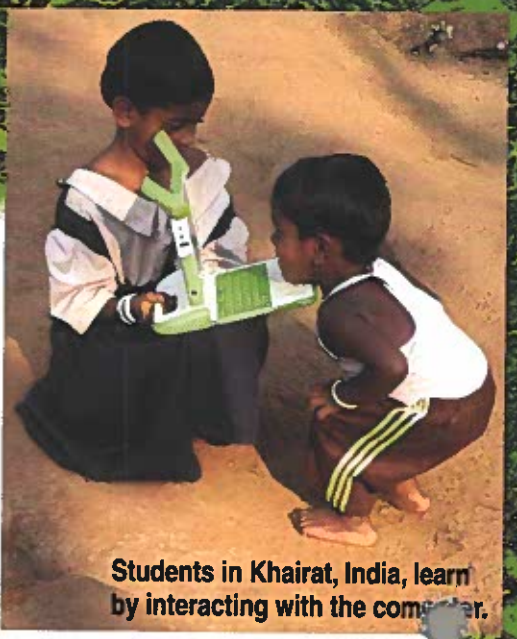
CHAPTER 13

Information and Communication Technology

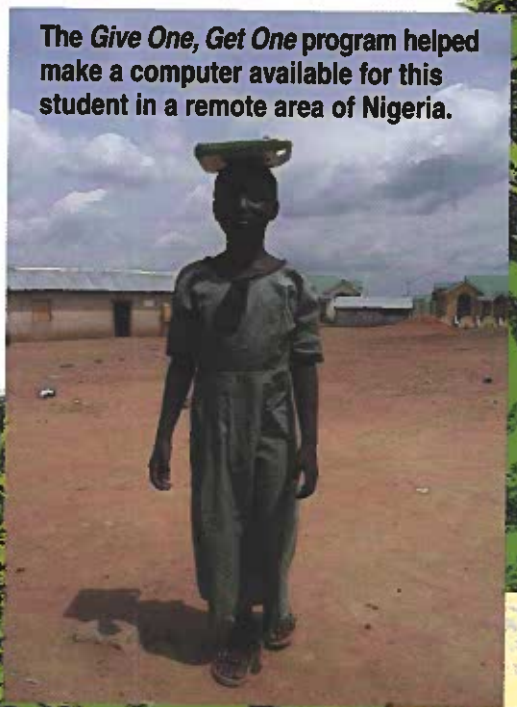
Better by Design

Nicholas Negroponte leads the One Laptop per Child design team

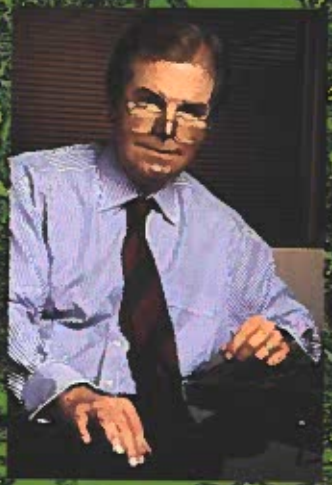
Nicholas Negroponte is a computer scientist who wants to provide every child worldwide with a laptop with software designed for joyful, self-empowered learning. To achieve this objective, the *One Laptop per Child* association has developed the XO laptop. The XO uses open-source software and has a video/still camera. Importantly, it contains no hazardous materials. The laptop can be recharged by human power using a crank, a pedal, or a pull-cord. The *Give One, Get One* program asks donors to pay $400 for two XOs: one XO laptop is sent to the purchaser and a second is sent to a student in a poor country.



Students in Khairat, India, learn by interacting with the computer.



The *Give One, Get One* program helped make a computer available for this student in a remote area of Nigeria.



"Computing is not about computers any more. It is about living."

Reading Target

Finding the Main Idea

As you read this chapter, look for the key points, or main ideas, in each part of the chapter. Then look for important details that support each main idea. After you have read the entire chapter, use the Reading Target graphic organizer at the end of the chapter to organize your thoughts about what you have read.

Key Terms

analog signals
binary digital code
bit
Bluetooth® technology
byte
central processing unit (CPU)
cloud computing
communication
communication technology
data
digital signals
distributed computing
feedback
haptic device
hardware
hypertext transfer protocol (HTTP)
information
information technology
media
microelectronics
modulate
motherboard
radio frequency identification (RFID)
retrieval
robotics
router
server
social media
software
storage
telecommunication technology
triangulation
virtual reality
Voice over Internet Protocol (VoIP)
Wi-Fi™ technology
World Wide Web (Web or WWW)

Objectives

After reading this chapter, you will be able to:

- Describe the components of a typical communication system.
- Explain difference between data and information.
- Give examples of information and communication technology systems.
- Compare conventional and modern examples of telecommunication technology.
- Describe the role of computer technology in information and communication systems.
- Explain why the Internet is considered the world's largest telecommunication system.

Useful Web sites:
wiki.laptop.org/go/Home
www.ted.com/index.php/talks/Nicholas_negroponte_on_one_laptop_per_child.html

Communication is any exchange of information. People, animals, and even machines communicate regularly. Talking is one form of communication. Writing is another. In fact, our society depends heavily on *communication technology*—the technology that allows us to communicate.

Communication Systems

Some communication systems consist of the people, machines, and methods that allow us to communicate. As you may recall from Chapter 3, some communication is verbal, and some is nonverbal. However, all communication systems have certain things in common. As shown in Figure 13-1, a complete communication system includes:

- **Source**—The person or machine that has a message to be delivered.
- **Encoder**—Device that changes the message into another form for transmission.
- **Transmitter**—Device that sends the encoded message toward its destination.
- **Medium**—The wired or wireless means used to send the information.
- **Receiver**—The device that accepts the encoded information and relays it to the decoder.
- **Decoder**—Device that translates the encoded message into an understandable form.
- **Destination**—The person or machine that receives the decoded message.

These seven steps are used to transmit and receive a message. In addition, messages may be placed in *storage* so that they can be retrieved at a later time. Voice mail is an example of a storage device.

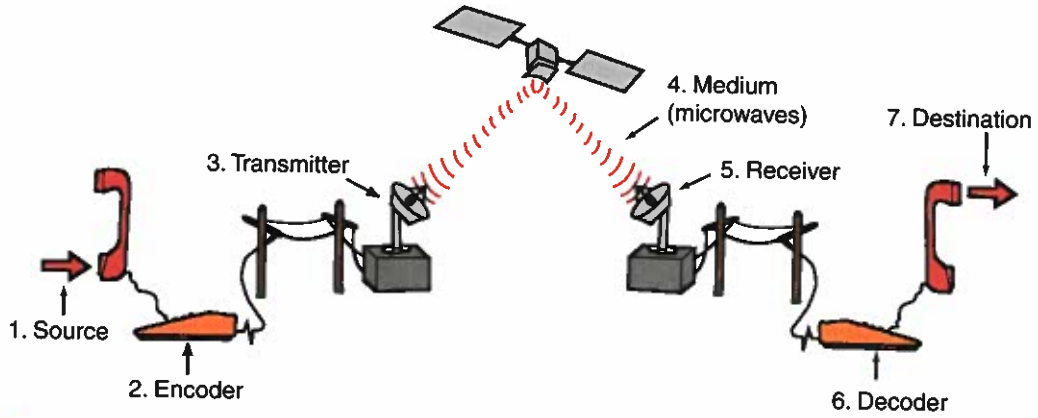


Figure 13-1. Talking to a friend on the phone is an example of using a communication system.

Let's look at an example of a communication system. Suppose that you have an idea to meet in a specified chat room online with a friend from another country. You call your friend on the phone and say, "Let's meet online tonight in this chat room." Do you see the system? You are the source. The telephone encodes the message. Satellites transmit your message. A satellite dish acts as the receiver of your information and relays the message to your friend's phone, which decodes the message. Finally, your friend is the destination of the message.

Suppose your friend cannot meet online tonight. "Sorry, I can't. I must study tonight." Your friend provided you with *feedback*, which is a response to the receiver's question or statement. This proves that your message was heard and understood. Your friend then says, "But let's remember to do it Friday night." Then both of you will store the information in your mind. When Friday comes, you will remember to meet online. This is an example of *retrieval*.

Types of Messages

The type of communication system we use depends on the type of message to be sent. Some communication systems allow humans to communicate with other humans. Others transmit information from humans to machines, and still others allow machines to communicate information to humans or to other machines.

Messages intended for machines are very different from those meant for people. They may be computer programs to run computerized machine tools, or access codes or passwords for a secure Internet site. Machines can also send messages to humans. For example, if you leave a car door open while the engine is on, a light appears in the dashboard to inform you that the door is open. In some cars, a computerized voice tells you that the door is open.

The purpose of the message also affects its design. Politicians often state certain views on issues in order to gain the favor of the majority of the voters. Movie directors and writers make scary movies to draw people who love horror films to the movie theaters. Stand-up comedians draw people that love to laugh to comedy clubs. Musicians write and play certain styles of music to get more people to buy their songs.

Types of Media

You and millions of other people around the world use the Internet every day. You may use it to communicate with others, keep up with the news, check the weather, make travel plans, conduct business, shop, buy a ticket to a rock concert, entertain yourself, or learn new things. Staying connected has become so important that it is hard to get away from your computer and your Internet connection. You feel that you might miss an important e-mail message or some news you need to know.

It is likely that you have several other forms of *media*, or communication and information sources, in your home. These may include radios, televisions, newspapers, magazines, photographs, store catalogs, and a telephone directory. In these sources, information flows in one direction. It starts at a source, such as a newspaper, the television or radio, and flows to an audience. The audience cannot immediately interact with or comment on what is provided. See **Figure 13-2**.

Social media is any digital tool or service that uses the Internet. Examples include YouTube, Flickr®, Facebook®, MySpace™, message forums, message boards, blogs, wikis, and podcasts. These media lead to the formation of communities around shared interests. Using online tools, members of the audience can become involved, communicating and exchanging content. Each member in the conversation is both a member of the audience and an author. He or she can create, comment on, share, or remix content.

Today, social media is replacing older forms of media. For example, a critique of a concert appears not only in a newspaper, but also in blogs on a multitude of Web sites. In various ways, these sites become interactive. See **Figure 13-3**.

Information Technology

Imagine that your teacher has asked you to measure the height of all the students in your class and to record these heights in a list. You must also record, for each height, whether the person you measured is male or female. When you have completed this task, you have a set of facts, or *data*, about height and gender.

Now your teacher asks you to do three things with this data. First, divide the list into two separate lists: one for females and one for males. Second, calculate the average height of the females and the average height of the males. Third, write a statement that describes your results.

Figure 13-2. Reading a newspaper is an example of traditional media. What are the advantages and disadvantages of this form of communication?

Figure 13-3. Getting news and information from the Internet is an example of social media.

Suppose your results are as follows: The average height of the females is 5'6", and the average height of the males is 5'8". You now have some information. Your statement could read as follows: The average height of the sixteen males in my class is two inches greater than the average height of the fourteen females. See Figure 13-4.

Information is data that has been organized in a meaningful way. For example, your calculations in the above scenario helped you draw conclusions about the difference in height between the males and females in your class.

We are bombarded daily with huge amounts of data and information. We can remember some of this information, but much of it must be stored, processed, and communicated by machines. Today, computers are used for these purposes. *Information technology* is the computer-based technology used for storing and processing information.

Females (14)	Height (inches/cm)	Males (16)	Height (inches/cm)
Female 1	65/165	Male 1	70/178
Female 2	69/175	Male 2	69/175
Female 3	63/160	Male 3	72/183
Female 4	66/168	Male 4	67/170
Female 5	68/173	Male 5	68/173
Female 6	62/157	Male 6	69/175
Female 7	61/155	Male 7	69/175
Female 8	68/173	Male 8	66/168
Female 9	66/168	Male 9	71/180
Female 10	68/173	Male 10	66/168
Female 11	70/178	Male 11	62/157
Female 12	69/175	Male 12	68/173
Female 13	67/170	Male 13	65/165
Female 14	62/157	Male 14	67/170
		Male 15	70/178
		Male 16	69/175
Total (Σ)	Σ = 924/2346		Σ = 1088/2763
Average = Total ÷ # of females or males	924 ÷ 14 = 66"		1088 ÷ 16 = 68"
	2346 ÷ 14 = 168 cm		2763 ÷ 16 = 173 cm

Each height is one piece of data

Information

The average height of the sixteen males in my class is two inches (5 cm) greater than the average height of the fourteen females.

Figure 13-4. When you arrange data in a meaningful way, it becomes information.

Information and Communication Technology Systems

Information technology is closely related to communication technology, and the two are often used together. Computers are one of the most common forms of information and communication technology. Other forms include televisions, cameras, cell phones, and similar items. These technologies help us communicate both sounds and images.

The growth of information and communication technology is largely due to the development of microelectronics. *Microelectronics* is the use of very small versions of traditional electronics. Switches and circuits are made incredibly small. This has resulted from the invention of new manufacturing processes and the use of new materials.

Information and communication technology systems are found in many places. One common example is a modern office. In the office, documents are created and corrected on a computer using a word processing program. They are stored electronically. A document can be added to an e-mail message as an attachment and sent instantly to anywhere in the world. It can be sent electronically to a photocopy machine, many identical copies can be printed. Meanwhile, the employee may be speaking directly to someone on the other side of the world using a telephone. If the number is busy, the phone automatically redials until the line is free.

Department stores are another example of how machines can be linked in a system. Purchases are scanned by a sales assistant using a bar code reader. The scanner sends information from the bar code to a computer connected to the cash register. The system totals the amount owed. At the same time, it sends information on the sale to the store's headquarters. There, another computer uses the information to monitor inventory. Payment for the purchases is also processed electronically.

Figure 13-5. ATM machines allow us to access cash 24 hours a day. What impact does this have on people's shopping habits?

Even the banking industry uses electronic communication systems. See Figure 13-5. In addition to ATMs, where you can deposit checks and withdraw money, most banks now allow customers to do most banking tasks online. Customers can check their balances, transfer money between accounts, and pay bills using online banking. Some banks even allow customers to deposit checks using iPhone technology.

Information and communication today rely heavily on microelectronics, computer, and telecommunication technologies. These are combined into systems that:

- Create, collect, select, and transform information
- Send, receive, and store information
- Retrieve and display information
- Perform routine tasks

For example, a night watchman responsible for the security of a large building can monitor a closed-circuit television system. It receives, displays, and stores information about the condition of different parts of the building.

Hospitals are another example. They use electronic instruments to measure a patient's pulse, heartbeat, and other vital signs. See **Figure 13-6.** Most hospitals now track patient medications using electronic methods also.

The most important result of microelectronics is the microprocessor, or computer chip. See **Figure 13-7.** As you learned in Chapter 12, a computer chip is a tiny flake of silicon covered with microscopic electronic circuits. Chips can be mass-produced in the tens of thousands, which reduces the price per chip. A single chip costing less than a video game contains most of the switches and circuits needed by a computer.

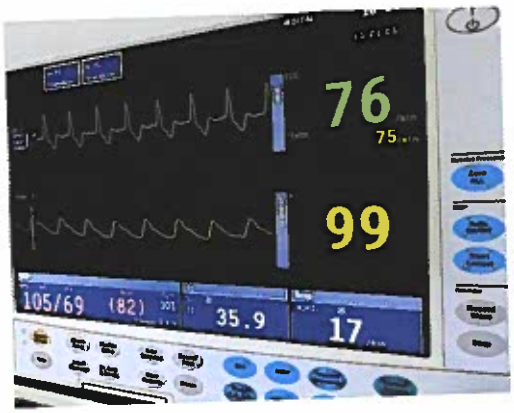


Figure 13-6. A cardiac monitor in a hospital tracks a patient's pulse, heart rhythm, and blood pressure, among other things. The monitor sounds an alarm if the patient's vital signs become abnormal.

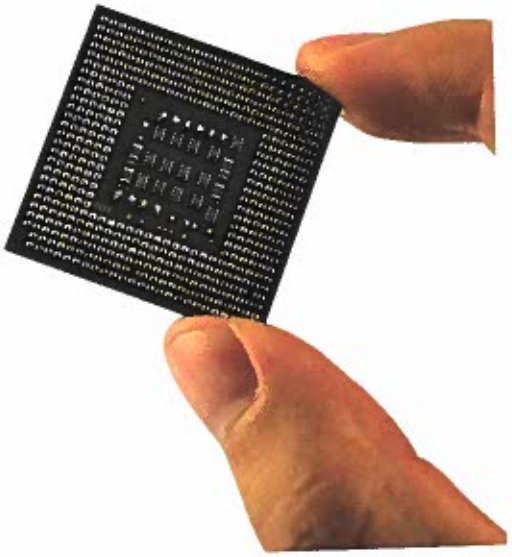


Figure 13-7. A single microprocessor may contain thousands of tiny components.

It may surprise you to learn that more than 90% of all microchips are *not* in desktop or laptop computers. They are in cars, homes, and industrial machines. They are around us to such an extent that we rarely notice them. For example, a microchip controls the antilock brakes on cars. In pacemakers, the miniature components on a chip time heartbeats. Microprocessors also set thermostats, switch DVDs on and off, pump gas, and control car engines. Robots and on-board computers in satellites rely on them. See **Figure 13-8.**

Telecommunication Technology

The other technology that has led to the growth of information and communication technologies is telecommunication. *Telecommunication technology* is a general term for technologies that can send information over distances. Radio, television, cell phones, landlines, and the Internet are all aspects of telecommunication.

Conventional Technologies

Conventional telecommunication technologies include landline telephone systems, local radio stations, and local and network television stations. These technologies are still in use today, along with newer technologies that may one day replace them.

Telephone

Originally, "landline" telephone systems were linked using copper telephone lines. Many of these have now been replaced by fiber optic cables. Fiber optic cables can carry light-coded messages over long distances. A fiber optic strand four-thousandths of an inch (0.1 mm) in diameter is capable of carrying 2000 two-way telephone conversations at once.

Figure 13-8. A GPS system is an example of a communication device that uses microchips to process information in real time.

See Figure 13-9. At the transmitter end of a fiber optic-cable network, telephone signals are converted into pulses of light. These pulses travel through the glass fibers to the receiver end. There, the pulses are converted back into electrical signals that are carried to a telephone or computer.

Radio

Local radio programs are transmitted using electromagnetic waves. The radio transmitter codes the sounds by changing the electromagnetic waves in some way. For example, some types of radio *modulate* (change) the amplitude, or height, of the waves. Others change the frequency of the waves, or number of waves per second. See Figure 13-10. The modified waves move through the air to a receiver that contains an antenna. The antenna converts the changes, or modulations, in the sound waves back into sound. The radio then amplifies the sound and sends it through a speaker so the listener can hear it.

Radio signals tend to weaken over distance. They can also be distorted by noise, or other electromagnetic fields in the area. This is why radio technology was originally a local medium only.

Television

The first United States standard for sending television audio and video signals was created by the National TV Standards Committee (NTSC) in 1941. The NTSC standard signals were sent as a continuous stream of information. These signals are called *analog signals*. Today, all television signals are transmitted in digital form. The audio and video are converted to binary code to form *digital signals*.

The two types of digital television are standard digital television (SDTV) and high-definition television (HDTV). SDTV is an improvement over the old analog television systems because the signal does not degrade, or weaken, over distance. Colors are truer and images are crisper, too. HDTV takes digital technology one step further. It uses more bits per second than SDTV. This results in better sound and picture resolution.

Figure 13-9. Fiber optic cables carry information coded as pulses of light. They can transmit data faster than copper wire, and they have a higher capacity.

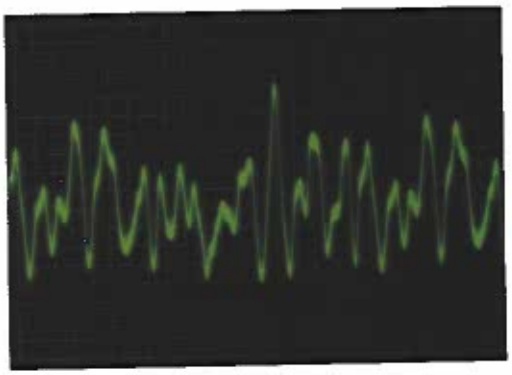


Figure 13-10. Electromagnetic waves can be modulated, or changed, to carry sounds.

Cellular Technology

Cell phones are really radios. In a typical analog cell phone system, the cell phone carrier divides the city into "cells" or areas. Each cell uses radio frequencies to transmit signals to and from your phone. The cells are small, usually only about 10 square miles (25.9 square kilometers). This size allows a city to reuse the same frequencies in different cells. Each cell has a transmission tower that receives and sends the radio signals. See **Figure 13-11**. As you move around in the city, the cell phone carrier's wireless network tracks the signal. When the signal starts getting weak, the network switches your phone automatically to another cell where the signal is stronger.

In a digital cell phone, voices are converted to binary code. The code is transmitted wirelessly to the phone on the receiving end. There, the binary code is converted back into voice so the person can hear what the caller is saying.

Satellite Technology

Satellite telephones use a technology that is similar to cellular technology. However, they send signals to satellites instead of cellular transmission towers. Satellite technology has the advantage that it can cover the entire Earth. See **Figure 13-12**. Signals may be transmitted from satellite to satellite before reaching their final destination. When they reach their destination, a satellite dish collects the signals and processes them, as shown in **Figure 13-13**.

Figure 13-11. A transmission tower with cellular antennas receives and transmits radio signals on the cellular frequencies assigned to its cell.

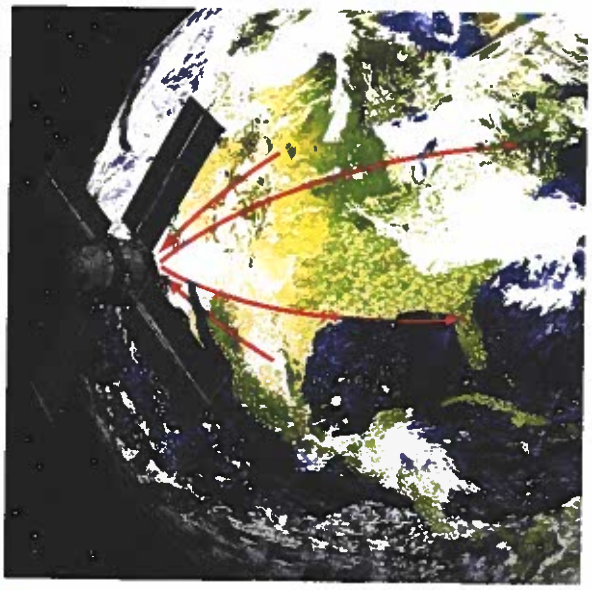


Figure 13-12. Satellite technology allows digital phone signals to be received by satellites orbiting the Earth. The satellite may send the signals to another location on Earth or to another satellite that is in a better position to transmit the signal back to Earth.

Communication satellites are now used for many different telecommunication needs. They can handle more information than cables. They can also transmit it faster. For this reason, many television and radio stations now use satellite signals.

Satellites are also used by global positioning systems (GPS). The GPS system in a vehicle calculates its position by measuring the amount of time satellite signals take to reach it. The system uses three satellites. Comparing the signals from three satellites narrows the possible location to a point where the signals from the three intersect. This method is called *triangulation*.

Think **Green**

Space Trash

In 1957, the former Soviet Union sent the first satellite into orbit around the Earth. Since then, hundreds of satellites have been launched. Many of them broken or obsolete. When they are no longer useful, satellites become "space trash." What happens to them?

If they are in a low orbit (close to Earth), they eventually fall back to Earth. Although some of the smaller pieces burn up before they reach the ground, other pieces hit the Earth's surface. This poses a danger to humans if the satellite hits a populated area. Satellites in a higher orbit continue to circle the Earth. This may not sound like a big issue at first. However, it does cause problems. The biggest danger is that it may hit satellites that are still working or collide with spacecraft traveling to or from the International Space Station. Space trash, like working satellites, travels at speeds exceeding 20,000 miles per hour (32,200 kilometers per hour). Even a small particle traveling at such speeds can damage sensitive equipment.

NASA keeps track of space trash to help guide our current satellites and the space station around it. This is a good short-term solution. As we abandon more and more equipment in space, however, the problem will only get worse.

What can we do to prevent the buildup of trash in space? Governments all over the world are studying this problem. They have not yet found a solution that is practical, but the problem will have to be dealt with soon. Do some research and find out what has been proposed so far. Evaluate the different proposals. Can you think of any other ideas that might work? As a student, you may not be able to do much to solve this problem right now. You *can* remain informed, however. Someone in your generation may find the answer that will help keep Earth and the space surrounding it clean and safe.

Computer Technology

A computer is really just a machine that can accept information, process the information, and then output the result. It can perform these actions at very high speeds. Computers can also store and retrieve both raw and processed data.

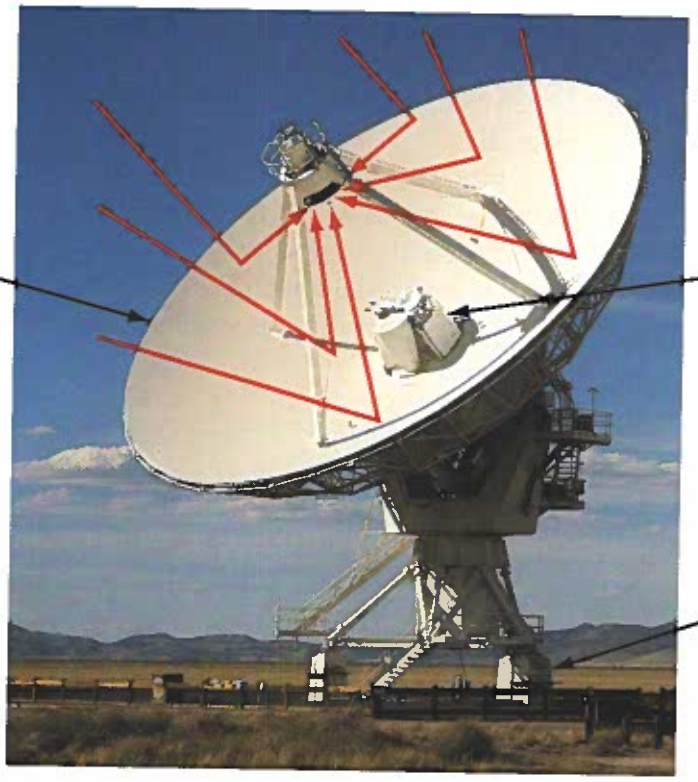


Figure 13-13. When satellites direct signals to Earth, the signals are collected by a dish-shaped satellite receiver.

Computer Processes

Information processed by a computer must be input in a form that the computer can handle. Computers use a simple code of electrical signals. There are only two signals in this code, on and off. These are written as 1s and 0s. This is called a *binary digital code*. Binary means two, and digital means number. Inside the computer, an on condition is used to represent a 1. An off condition represents a 0. This is similar to the logic gates described in Chapter 12.

To provide for more than two possible states, signals are combined to produce patterns. Imagine a set of four lightbulbs, as shown in **Figure 13-14**. Each one can be turned on or off. Each of these bulbs can be assigned a value.

In the binary system, each digit has a value twice as large as the one on its right. The bulbs are therefore assigned values of 8, 4, 2, and 1. When a bulb is off, it represents 0. When it is switched on, a bulb represents the value assigned to that position. The values are added together. In **Figure 13-14**, the first bulb (1) and the third bulb (4) are on. This represents the number 5, because 1 + 4 = 5. If the first bulb is off and the second, third and fourth are on, the number represented is 14, because 2 + 4 + 8 = 14. This group of four bulbs can represent any number from 0 (all off) to 15 (all on).

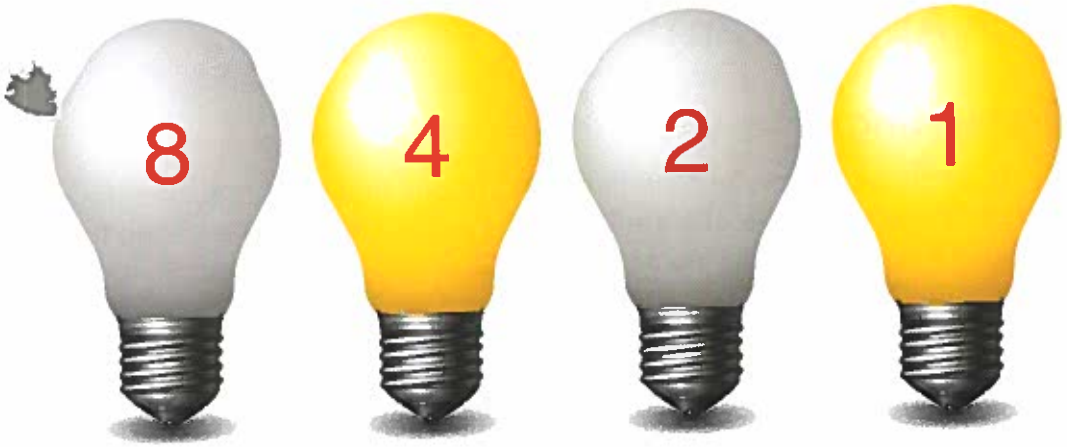


Figure 13-14. You can think of binary values as a series of light bulbs that are either on (1) or off (2).

Each on or off signal is known as a ***bit***, which is short for "binary digit." When bits are used in groups, the groups are called *words*. The example in **Figure 13-14** uses a four-bit word. Since computers need to work with numbers larger than 15, a system of eight-bit words is used, as shown in **Figure 13-15**. Each eight-bit word is a ***byte***.

Types of Computers

Until the 1940s, computers were largely mechanical devices. World War II presented a new challenge: how to crack secret enemy codes that changed three times a day. Using the ideas of mathematician Alan Turing, a computer called Colossus was made in 1943. It used 2000 vacuum tubes. Intercepted messages were fed into Colossus as symbols on paper tape. The computer processed them at the rate of 25,000 characters per second. However, the Colossus machine was limited to breaking codes. The first electronic computer capable of tackling many different jobs was ENIAC in 1945. See **Figure 13-16**.

Place Value	128	64	32	16	8	4	2	1
Binary No.	1	1	0	1	1	0	1	0

128
64
16
8
2
218

Figure 13-15. The byte 11011010 represents the number 218.

Math Application

Converting Binary Numbers

To understand how to read binary numbers, first look at our normal system of numbers. We use the base 10 number system. It is called that because it consists of ten numbers: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. The columns determine whether the numbers are multiplied by 1, 10, 100, 1000, and so on. For example, consider the number 265. The 5 is in the 1s column (5 × 1). The 6 is in the 10s column (6 ×10), and the number 2 is in the 100s column (2 × 100).

The binary system is similar in that each column represents a value. However, it also has a major difference. In our base 10 system, we can count from 0 to 9 before we move to the next column. The binary system has only two numbers, so there are only two possibilities for any column: 0 or 1.

To convert a base 10 number to binary, make a table similar to the one below. It consists of the top row (Place Value) of the table in **Figure 13-15**. Starting from the left, compare each number to the number to be converted. Select the first column that shows a number that is equal to or smaller than the base 10 number to be converted.

Take the number 5, for example. Four is the largest number that is smaller than 5, so write a 1 in the 4s column and subtract 4 from 5. This leaves you with 1. Still reading from the left, what is the next column that is equal to or smaller than 1? It is not the 2s column, so write a 0 in the 2s column. The 1s column is equal to 1, so write a 1 in the 1s column. Subtracting 1 from 1 leaves 0, so the conversion is now complete. The number 5 in base 10 equals 101 in binary: 1 + 0 + 4 = 5. Check your work by adding up the column values, as shown.

Place Value	128	64	32	16	8	4	2	1
						1	0	1

4
0
+ 1
5

Converting Binary Numbers *(continued)*

To convert a binary number to a base 10 number, first create the same kind of table you made for the conversion to binary. This time, however, write the binary number in the columns, as shown in the example below. In this example, we are using the binary number 11001. Write the 1s and 0s in the columns, starting at the right (1s) column and working to the left. Then add the values of the columns to arrive at the base 10 number.

Place Value	128	64	32	16	8	4	2	1
				1	1	0	0	1

16
8
0
0
+ 1
25

Math Activity

Practice converting numbers between base 10 and binary.

1. Convert the following binary numbers into base 10 numbers.
   A. 111
   B. 1011
   C. 01010
   D. 00110011
2. Convert the following base 10 numbers into binary numbers.
   A. 4
   B. 20
   C. 35
   D. 70
   E. 101

Figure 13-16. ENIAC stands for "Electronic Numerical Integrator and Computer." It was designed to calculate ballistic firing tables. However, it was fully programmable, so it could perform many other tasks as well.

Today, computers are available in a range of sizes and abilities. Most homes have at least one laptop or desktop computer. Businesses often have networks of powerful desktop computers that are sometimes called *workstations*. Larger businesses that need more computing power may use a more powerful minicomputer. Research companies, college research facilities, and other organizations that need to work with a large amount of data may use a mainframe or supercomputer. For example, weather forecasting requires a supercomputer.

In the past, supercomputers were very large, expensive computers. Today, the Virginia Tech Terascale Cluster is one of the fastest computers in the world. It is not really a single computer, however. It is actually a group, or cluster, of 1,100 Apple Macintosh computers. Problems are broken into smaller chunks and distributed among the computers. This is known as ***distributed computing***. This approach is used by companies such as Akamai, which provides distributed file storage and retrieval around the world. When you download a movie clip or a big file from a Web site, you are probably receiving it from this type of distributed system.

Computer Components

Computing involves three stages: input, processing, and output. Figure 13-17 shows a variety of devices used at each stage. Increasingly, the input and output devices are wireless. Computer components include both hardware and software.

Hardware includes all the physical parts of the computer. This includes the ***central processing unit (CPU)***, input devices, and output devices. It also includes temporary and permanent memory and the physical parts necessary to support sound and graphics. These parts are often located on circuit boards that plug into the ***motherboard***, which contains the main circuitry of the CPU. You may hear these circuit boards referred to as *boards* or *cards*.

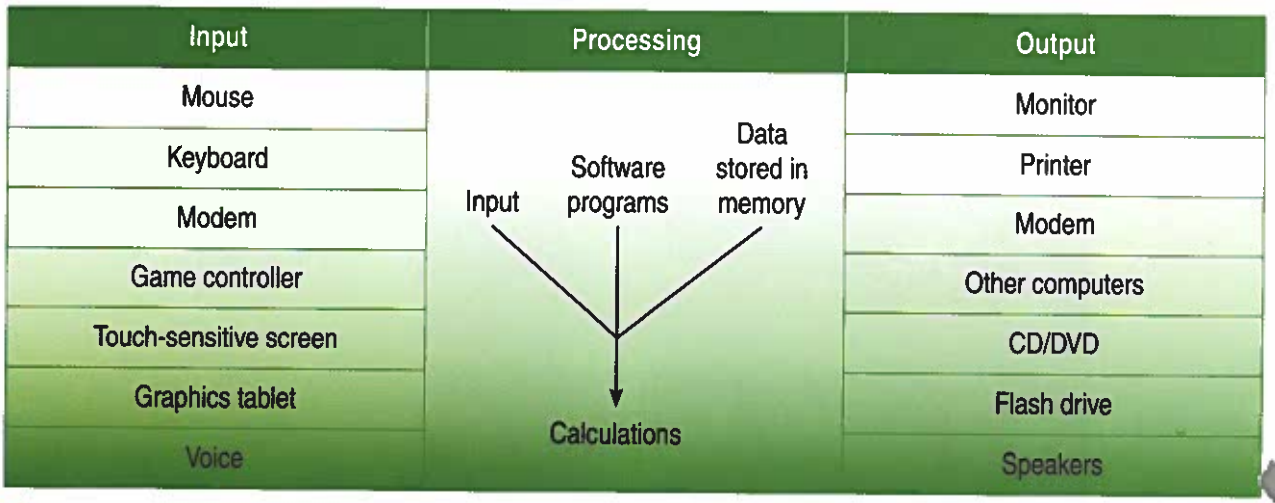


Figure 13-17. Computers can have many different input and output devices. The devices that are used depend on the user's needs and preferences.

Computers that are not networked must have some type of storage device, such as hard disk drive. Networked computers may also have storage devices. However, some businesses use a common *server* on which all work is stored. The individual computer consoles, or workstations, access the server using the network.

Software includes all of the programs used to direct the operation of a computer. It includes the operating system and application software. The operating system, such as Windows 7 or Mac OS 10, provides an interface between the hardware and the application software. Application software, such as Adobe® Photoshop® or Microsoft® Office, allows you to use the computer to perform specific tasks.

Bar Code and RFID Technologies

Bar codes are also being used to access information. See **Figure 13-18.** Bar codes are a series of thin and thick lines that can be read by a photo diode in a laser scanner. The barcode reader reads the black spaces, which absorb the light, as 1s. It reads the white spaces, which reflect the light, as 0s.

A more recent method of identification is called *radio frequency identification (RFID)*. RFID tags are tiny microchips equipped with radio transmitters. They can be attached to product packaging. They can also be implanted in dogs and cats, or even in humans. The chips store information ranging from product color and expiration date to medical records and ownership details.

Wireless Technology

Computers, entertainment systems, and telephones can communicate with each other using a variety of connections. These include physical elements such as electrical wires and component cables. They also include wireless technologies such as Bluetooth and Wi-Fi.

Figure 13-18. A bar code contains encoded information about a specific product. Warehouse workers often use bar code systems to help track orders and inventory.

Bluetooth technology is a short-range technology that connects electronic devices without the clutter of cables. It has a maximum range of only about 100 feet. It is therefore used to connect devices over short distances, such as within a person's home. One advantage of Bluetooth is that it keeps transmission power extremely low. This helps save battery power in portable devices such as cell phones and GPS units.

Many people also use *Wi-Fi technology* to connect computers in different rooms. Wi-Fi has a larger range than Bluetooth—as much as 300 feet. It is used for high-speed Internet access when cables are not an option. For example, many restaurants, hotels, and even airports now offer Wi-Fi connections to their customers. See **Figure 13-19**. It is also used to connect computers to a local area network (LAN). A LAN may cover a small physical area, like a home or office. It can also cover a small group of buildings, such as a university or an airport.

Wireless technology carries signals on radio waves. A computer with wireless capability sends and receives radio signals from a router. A *router* is a device that allows two or more different networks to communicate. It manages communication between the computer and the Internet.

More and more devices are using wireless connections. Some digital cameras can upload photographs to a computer wirelessly. The keyboard and mouse used with many desktop computers are wireless. Smart meters send readings of how much electricity a house consumes. The Kindle™ is an electronic book that can download books wirelessly. Using services such as iTunes, you can download music and rent or buy movies whenever and wherever you have a wireless device and a wireless connection.

Another recent development in wireless technology is virtual input using lasers. The Magic Cube and evoMouse shown in **Figure 13-20** are laser devices that act as a virtual keyboard and mouse. The Magic Cube laser projects an image of a keyboard onto a flat surface such as a desk or table. When you touch a key on the keyboard, an optical sensor interprets the position of your finger. It sends the information about which key you pressed to the computer. With the evoMouse, your finger acts as the "mouse." The optical sensor tracks the movement of your hand and finger.

Figure 13-19. Offering a Wi-Fi Internet connection helps restaurants attract businesspeople who might otherwise not have time to eat at a restaurant.

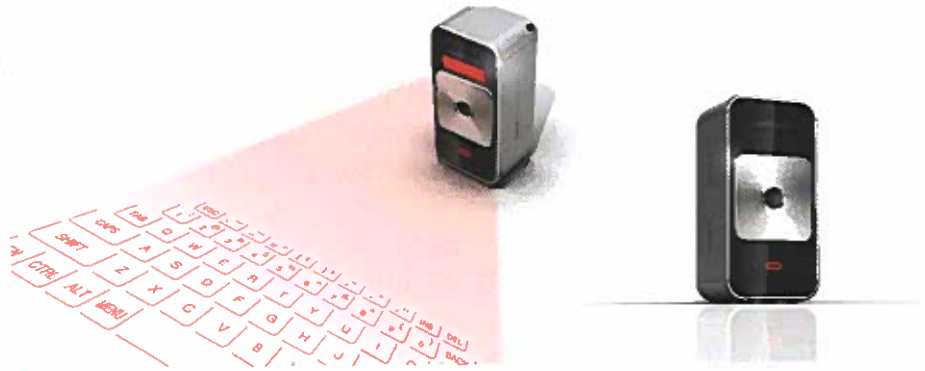


Figure 13-20. A laser projection keyboard combines laser technology with an optical sensor and infrared technology.

It provides all the same functions as a typical mouse, including scrolling and zooming as well as the standard clicking and double-clicking. Because it tracks your finger or hand movement, you can even use this device as a handwriting recognition device.

Cloud Technology

Imagine that you have recently purchased a new laptop computer. Instead of installing software programs for word processing, spreadsheets, and databases, you need only load one application: a Web browser. Welcome to cloud computing! *Cloud computing* is a form of distributed computing. See **Figure 13-21**. It uses the Internet to provide the software users need for all their applications, including text files, spreadsheets, presentations, e-mail, and Web page development. The "cloud" network stores all of the files and content centrally. To make content available to many users at the same time, it distributes the tasks among many different source computers. Because hundreds of computers work in parallel to provide the service, cloud computing speeds up processing and access time.

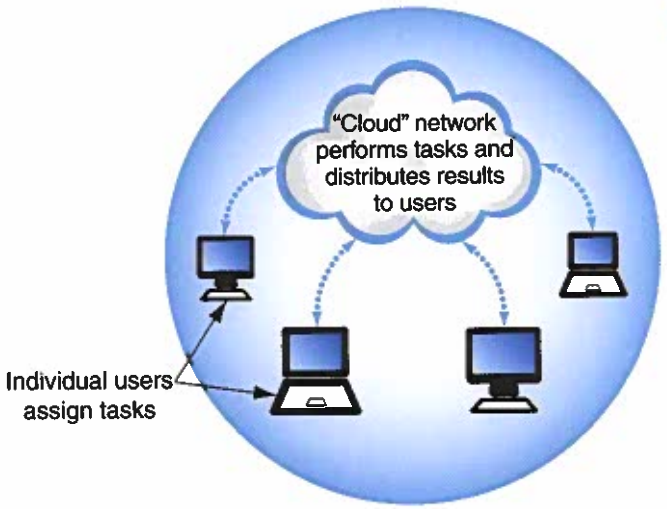


Figure 13-21. In cloud computing, the "cloud" network performs tasks by distributing them to networked computers. The results are sent to the controlling computer in the cloud. From there, the results are sent to the individual who requested the information.

Robotics

A robot is a computer that can interact with its environment. A true robot is one that can perceive its environment and respond automatically, without human control. The field of *robotics* is the development of technology and applications for robots.

Today, robots can look very different from one another. Some are mobile, and others are stationary. See **Figure 13-22**. Industrial machines often look like arms. Robots used to explore the ocean floor may look like miniature submarines. Drones look like small airplanes.

All robots have three main parts:

- Mechanical parts to do the work
- Computer electronics to control movement
- Software to provide instruction

Advances in robotics allow us to use robots instead of people for jobs that are dangerous or boring. For example, robots can be used in deep underwater explorations. They were used to help clean up the Gulf oil spill in 2010. They are also used in nuclear power plants to clean up radioactive spills and perform other high-risk tasks.

In industry, robots are used in many different ways. Robots with machine vision check bottles and jars to make sure they are filled to the right level. They can package products and stack them onto pallets ready for shipment. They can also perform high-precision work, such as placing tiny parts on circuit boards. In some cases, different types of robots are used together to perform tasks. For example, in some car assembly plants, a large robot can lift a small one inside a vehicle to assemble parts.

Figure 13-22. This industrial robot forms the soles of athletic shoes. The end effector, or working end, of the robotic arm is shaped to accept the shoe form.

Other robotic technologies provide robots for use in the home. For example, robotic vacuum cleaners are now commonly available. Robots can be used to wash floors, clean swimming pools, clear out gutters, and cut the lawn. Home entertainment robots, such as robotic pets, contain advanced vision, sound, and movement systems. Robotic "assistants" can be used for housekeeping and home care. See **Figure 13-23.**

Virtual Reality

Virtual reality is an environment that is created by a computer. The computer delivers sights, sounds, and sometimes tactile (touch) inputs that make an artificial environment seem real. The inputs can be real or imaginary.

In some systems, the user enters a virtual world by putting on special glasses or a head-mounted display. See **Figure 13-24.** The display contains two screens. By showing images on both screens, the display produces an image that appears to be three-dimensional (3D). The display also contains a stereo speaker system. Pilots take training in flight simulators while wearing helmet systems that immerse them in computer-generated airspace. Athletes can be immersed in an environment that simulates the course they will be steering or jumping.

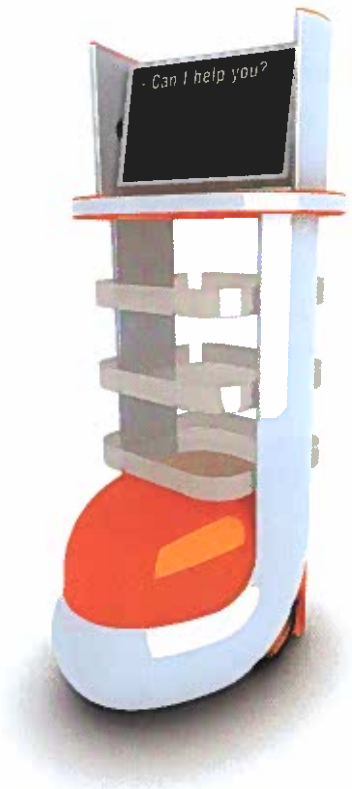


Figure 13-23. Some retirement homes now have robotic assistants that can move around, interact with people, and perform simple tasks for them.

Figure 13-24. Many virtual reality systems use a headset or glasses to place the user in an artificial reality.

Virtual reality systems may also include a *haptic device* such as a wired glove. See Figure 13-25. The device provides a physical feedback to user motions. This technology allows the user to work with objects in a virtual environment. The user can "touch" and even move virtual objects. The computerized haptic device provides mechanical pressure that makes the experience seem real.

Another type of virtual system, called CAVE, consists of an entire room. CAVE stands for "Cave Automatic Virtual Environment," but the room itself is also called a CAVE. The CAVE is similar to a theater, except the input surrounds you. Computer-controlled images appear on the walls of the room, and sometimes on the floor and ceiling as well. These images use 3D graphics. Users wearing 3D glasses can see objects not only on the walls, but also freestanding in the middle of the room. See Figure 13-26. Multiple speakers provide sound input. Users can walk around the room and experience the "reality" from any point of view. Computers track the location of the user and update the displays and sounds accordingly.

The Internet

The Internet connects millions of computers around the world. It is currently the world's largest and most diverse telecommunication system. In fact, the Internet is a network that is made up of many other networks. Information is transmitted over the Internet using computer languages called *protocols*.

World Wide Web

One such protocol is the *hypertext transfer protocol (HTTP)*. This protocol allows us to send and receive all kinds of files over the Internet. It can transmit text, graphics, photographs, sound, and video files, among others.

Figure 13-25. The sensors on a haptic glove allow you to touch objects in a virtual world.

Figure 13-26. This man is playing a virtual game of football using a CAVE virtual reality system.

The *World Wide Web (Web* or *WWW)* consists of all of the processes that use HTTP to transmit information over the Internet. We use Web browsers such as Internet Explorer or Safari to search for and display Web sites. See Figure 13-27.

The Web contains millions of Web sites. The fastest way to search for specific Web sites is to use a search engine, such as Alta Vista™, Google™, or Yahoo!™. By entering key words or phrases, you can display a list of matching Web pages almost instantaneously. Not all search engines use the same method to search the Web. Therefore, they may display different results. For the most possible matches, you can use a meta-search engine. This is a search engine that enters your key words into other search engines to find matches. Examples include Mamma® and Dogpile®. To access a search engine, type its address at the top of your browser. The address is usually the name of the site plus ".com." For example, to access the Dogpile meta-search engine, type "dogpile.com."

Other Internet Uses

We also use other kinds of Internet protocols. For example, we use SMPT, or simple mail transfer protocol, to send and receive e-mail. File transfer protocol, or FTP, allows the exchange of large files between computers.

Figure 13-27. The World Wide Web allows us to find, display, and even create Web pages. This man is accessing templates developed to help people create their own Web pages.

Another protocol that is gaining popularity is *Voice over Internet Protocol (VoIP)*. This protocol converts voice signals into a digital format that can be sent over the Internet. VoIP allows people to use their Internet connection to place telephone calls. The audio quality is similar to that of a cell phone. However, VoIP is much less expensive for making long-distance calls.

The Internet is also helping people who are hearing impaired. Instant messaging (IM) is a convenient way to carry out online conversations. Chat rooms are becoming one of the main ways that members of the deaf community communicate among themselves or with the hearing population. IM is available for the laptop, pager, or cell phone.

Copyright Issues

The availability of so much information on-line has led to questions about what is free and what is copyrighted. This includes text, graphics, and even computer programs available on the Internet. While you must pay for software produced by Microsoft, other software, including the Linux operating system, can be used by anyone without charge. This free software (also known as open-source software) is becoming increasingly available. Applications including the Firefox web-browser and Wikipedia, the on-line encyclopedia that anyone can edit, are examples of applications that are free.

However, most of what you find on the Internet is copyrighted material. Using this material without permission is called *plagiarism*. Plagiarism is against the law and carries heavy fines. Therefore, if teachers find out that students have plagiarized material, they may give a failing grade for that work. If you do not know whether something is copyrighted, assume that it is. You can use the material for reference, but do not copy it word-for-word.

End Note

In the last century, communication technology has changed dramatically. At the beginning of the 20th century, telephones were relatively new. Computers and even televisions had not been invented yet. People depended on radio for news. They processed most types of information without the help of technology.

Today, almost all of our communication and information sources involve complex technologies such as cellular and satellite technology. We use the Internet to download movies, ringtones for our phones, and music for our MP3 devices. We use e-mail to stay in touch with family and friends. A cell phone is no longer simply a telephone. It is a multipurpose computer. For example, a smart phone can take photographs. It includes games and text services that allow people to send and receive e-mail and text messages.

Experimental optical microchips are now on the market. Particles of light, rather than electrons, are used to control and power circuits. Switches conduct light instead of electricity. Optical technology is much faster than the technology used in computers today. The use of optical technology will make computers faster. This will pave the way for more realistic virtual worlds, among other exciting inventions and innovations.

Computer electronics are currently limited by the size of their microelectronics. In the future, microprocessors embedded in computers and other machines will likely be made of materials other than silicon. Future computers will depend on nanotechnology. Today's computer chips contain approximately 40 million transistors. Through nanotechnology, that same chip would hold about one billion transistors. As these chips become more powerful, the size of components will shrink. It will then be possible to embed them in any device, even the clothes that we wear.

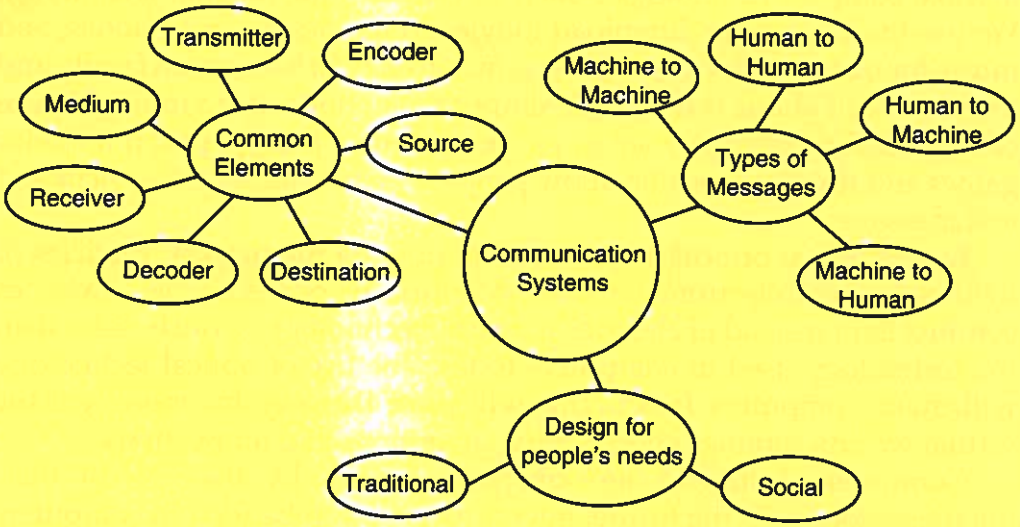
Summary

- All communication systems contain some elements in common.
- Information technology helps us store and process the large amount of data and information we receive every day.
- Information and communication technology systems are made possible by microelectronics.
- Telecommunication includes conventional technologies such as radio and television, as well as newer technologies such as satellite technology.
- Computer technology enables all communication and information systems.
- The Internet is the world's largest and most diverse telecommunication system.

Reading Target

Finding the Main Idea

Create a bubble graph for each main idea in this chapter. Place the main idea in a central circle or "bubble." Then place the supporting details in smaller bubbles surrounding the main idea. A bubble graph for the first part of the chapter is shown here as an example.



Test Your Knowledge

Write your answers to these review questions on a separate sheet of paper.

1. What seven elements do all communication systems have in common?
2. What four types of communication systems do we use to send messages?
3. What is the difference between data and information?
4. Explain the importance of microelectronics to communication and information technology.
5. What is telecommunication technology?
6. Name an advantage of satellite communication.
7. What is the difference between a bit and a byte?
8. What is the difference between Bluetooth and Wi-Fi technology?
9. What is the purpose of the hypertext transfer protocol used on the Internet?
10. What is plagiarism, and how can you avoid it?

Critical Thinking

1. Cloud technology is so-named because the actual distribution of tasks is hidden from the user. What are the advantages of this? What are the disadvantages?
2. As virtual reality systems become more affordable, it is possible that people will spend more and more time in virtual "worlds." For example, you could take a virtual vacation without leaving your home. What implications might this have for society? What effect might it have on communication?
3. Information available on the Internet may be true. However, it may *not* be true. How can you tell the difference? Describe a method of checking information you find on the Internet.
4. Many people like to play the type of computer game that simulates the real world. Why do they like to simulate the real world, when they can experience what is real?

Apply Your Knowledge

1. From your own community, give three examples of old information technology and three examples of new information technology.
2. Look through one issue of a newspaper. Cut out all the references to micro-electronics. Try to find references from each section of the newspaper, including the advertisements.
3. Use a computer equipped with drawing software to draw a block diagram to show the major components of a telecommunication system. Explain how the computer can be used to manage information about system components.
4. Selecting the right television for your home is not an easy task. Assume that a friend or relative has asked for your advice on the purchase of a new television. Make a summary of the advantages and disadvantages of as many different types of TVs as are available in your local stores.
5. Humanlike robots that can communicate with their owners are sometimes shown in newspapers and magazines. Identify robots designed for use in homes and describe their capabilities.
6. Video games have been around for decades. Find out who made the first video game and when. Then make a timeline of the most important developments in video games since then.

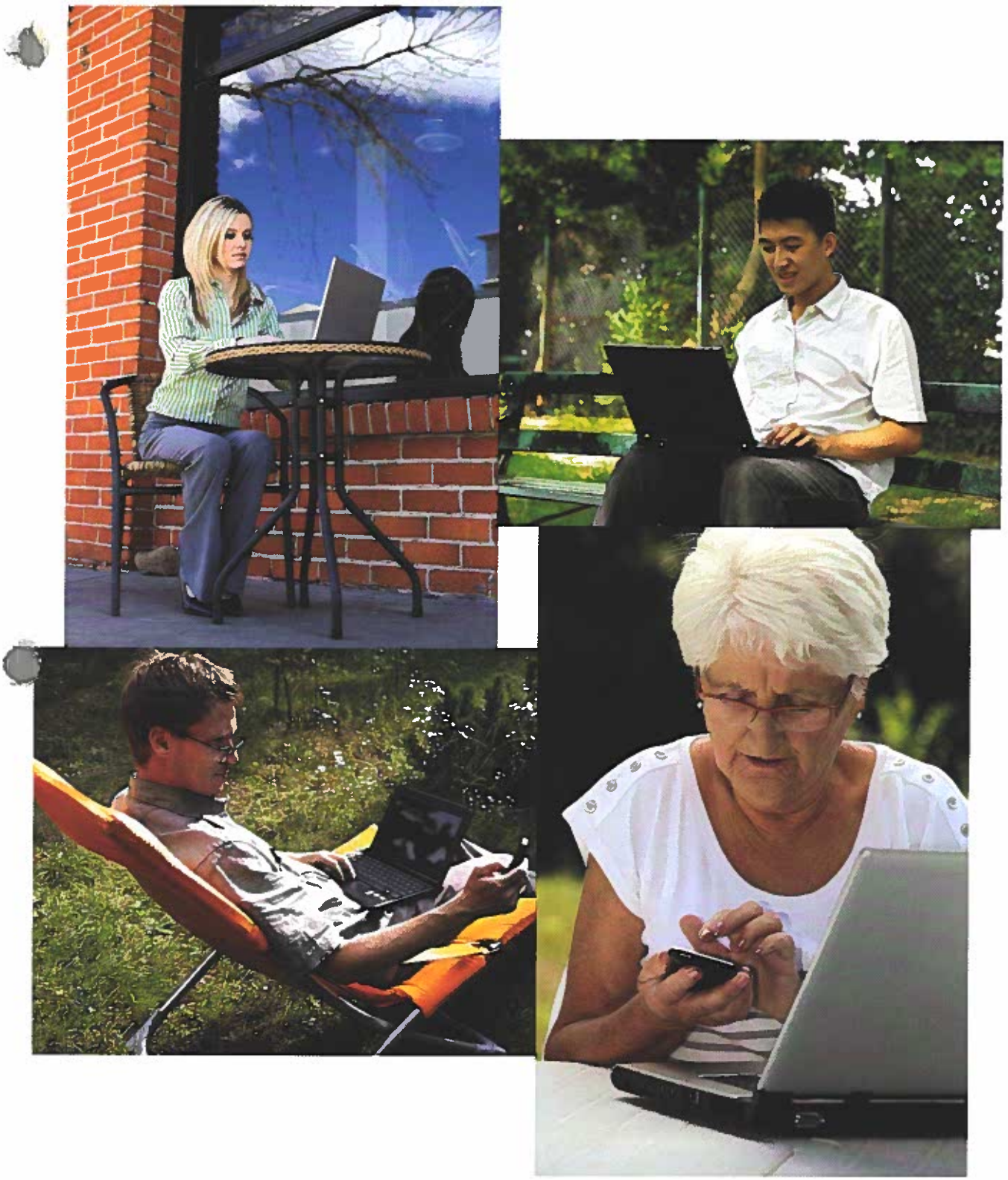
Apply Your Knowledge *(Continued)*

7. Research one career related to the information you have studied in this chapter. Create a report that states the following:
   - The occupation you selected
   - The education requirements to enter this occupation
   - The possibilities for promotion to a higher level
   - What someone with this career does on a daily basis
   - The earning potential for someone with this career

   You might find this information on the Internet or in your library. If possible, interview a person who already works in this field to answer the five points. Finally, state why you might or might not be interested in pursuing this occupation when you finish school.

STEM Applications

1. **ENGINEERING** Home theaters achieve great sound and visual effects when they are well designed. Research the conditions that make an ideal room for a home theater, including the floor plan, furnishings, natural and artificial light, and wiring and ventilation requirements. Then design a room for a home theater. Specify the equipment that would be used in the room.
2. **SCIENCE** Research the basic components of a communication satellite. Use common materials such as toothpicks and printer paper to create a model of a communication satellite. Be ready to explain what each part of the satellite does.
3. **MATH** With a friend or classmate, design a secret code based on the binary number system. Be careful not to tell anyone else what your code is. Then design a message written in your code and display it for the class. Can anyone "break" your code?
4. **ENGINEERING** Design a robotic device that can skim leaves from the surface of a body of water, such as a swimming pool. Think carefully about all of the design considerations. Will it be free-moving or stationary? How will it be powered? How will it work? What materials will be needed? Write a report describing your device. Include sketches to show what it will look like.



How might information and communication technology change our idea of what an office should be? What effects might this have on businesses, the environment, and society in general?

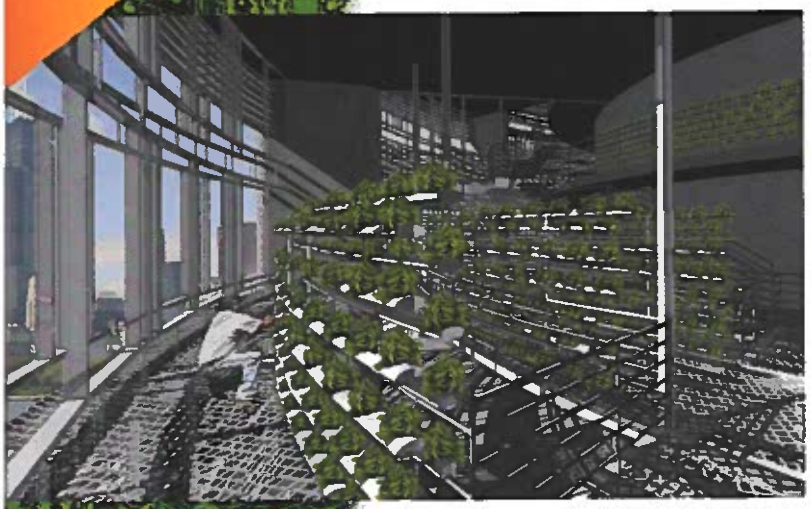
CHAPTER 14

Agricultural, Medical, and Biotechnology

Better by Design

Dickson Despommier and Blake Kurasek design vertical farms

What if you could eat food grown only a few blocks from where you live? Dr. Dickson Despommier has proposed building vertical farms in cities. Crops would be grown using mineral nutrient solutions without soil (hydroponics). Some crops could also be grown in air by spraying the plant's roots with a nutrient-rich solution (aeroponics). Vertical farms have many advantages. For example, crops could be grown year-round. Crops would not fail because of bad weather. Vertical farms would also require less land. Building on Dickson's scientific work, Blake Kurasek has designed "living skyscrapers." In these buildings, produce grown in the building can supply its occupants and a surrounding population.



Shipping food over long distances can be avoided by growing food near the consumer.

"Over the next 50 years, population growth will require an additional area the size of Brazil to grow sufficient food. This amount of high-quality land is simply not available."