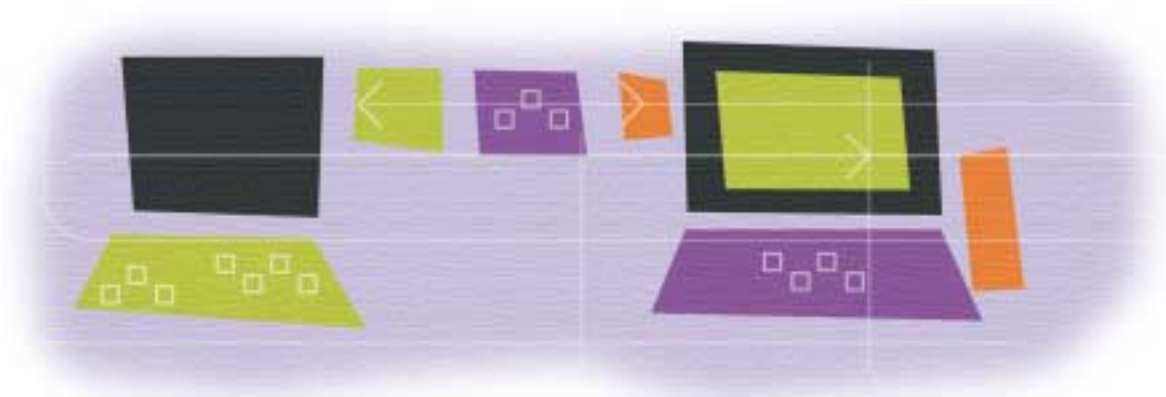
CHAPTER 6



Hardware and Software in the Enterprise

Objectives

As a manager, you'll face many decisions about using hardware and software to improve the performance of your firm. After completing this chapter, you will be able to answer the following questions:

1. What computer processing and storage capability does our organization need to handle its information and business transactions?
2. What arrangement of computers and computer processing would best benefit our organization?
3. What kinds of software and software tools do we need to run our business? What criteria should we use to select our software technology?
4. Of what new software technologies should we be aware? How would they benefit our organization?
5. How should we acquire and manage the firm's hardware and software assets?

Focus on the Features

Case Studies

Opening Case: *Nor-Cargo Revamps Its IT Infrastructure*

Window on Management: *The Case for Linux*

Window on Technology: *Application Integration to the Rescue*

Chapter-Ending Case: *Zurich North America Hunts Down Its IT Assets*

Hands-On Problem Solving

Application Software Exercise: *Spreadsheet Exercise: Evaluating Hardware and Software Options*

Dirt Bikes U.S.A: *Analyzing the Total Cost of Ownership (TCO) of Desktop Software Assets*

Electronic Business Project: *Planning and Budgeting for a Sales Conference*

Web Activities

www.prenhall.com/laudon | Internet Connection: Evaluating Computer Hardware Vendors | Interactive Study Guide | Additional Case Studies | International Resources

Nor-Cargo Revamps Its IT Infrastructure

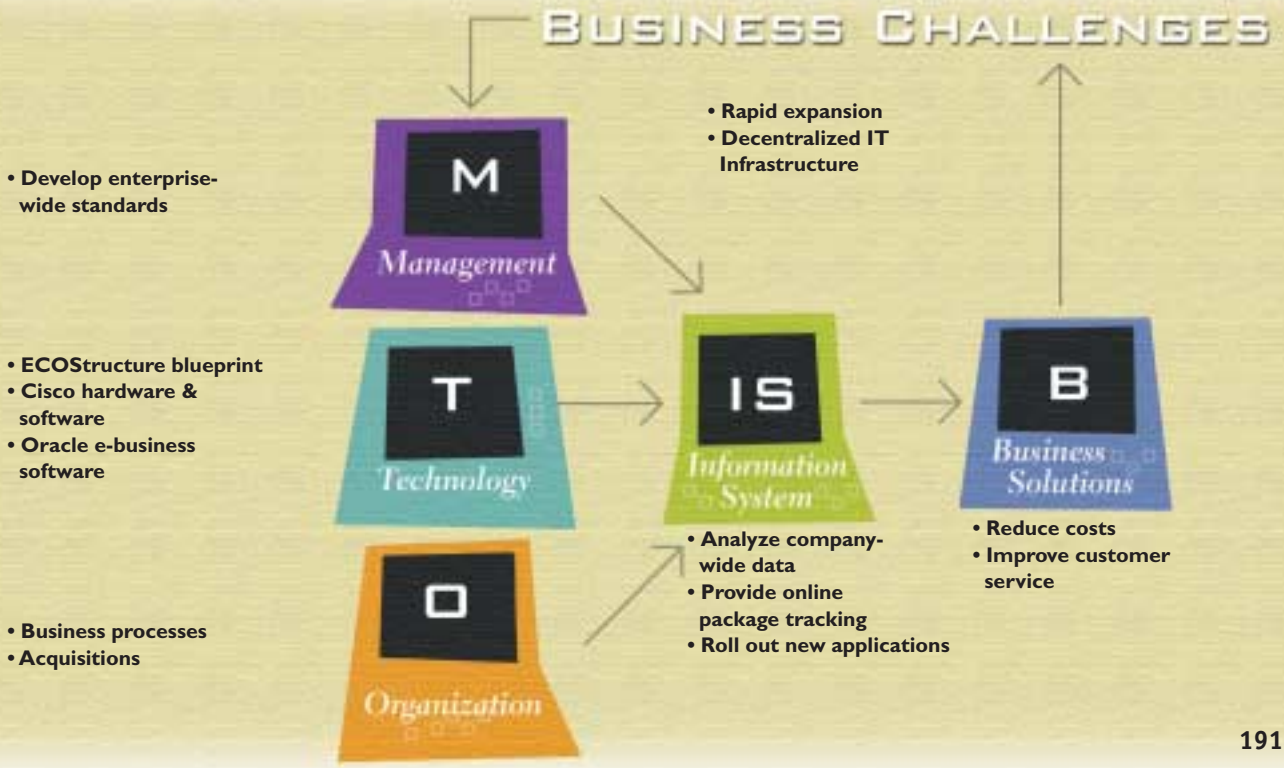
Nor-Cargo started out in 1920 as a small cargo services company that ran ships up and down the coast of Norway. About 15 years ago, it began expanding, acquiring dozens of other firms. Today Nor-Cargo is the largest transportation company in Norway, with $4.3 billion in annual revenue. Nor-Cargo operates from the Arctic Circle down to the European continent with eight areas of business, including package transportation, air and sea freight, freight forwarding, and third-party logistics.

This growth did not come without a price. Nor-Cargo's information technology (IT) infrastructure was challenged by all of its acquisitions, each with their own technology platforms; business processes; and applications for payroll, accounting, and customs. Lacking a centralized IT strategy, Nor-Cargo suffered from operational inefficiency, redundant resources, high software development costs, and limited coordination between all of its companies. Nor-Cargo had too many different operating systems and too many servers in a distributed environment, underutilizing its data storage capacity by 50 percent. All of these disparate systems forced Nor-Cargo to maintain separate information systems staff for many of the cities it serviced and prevented the company from responding rapidly to market changes.

Nor-Cargo management wanted to reduce the size of its information systems workforce by 20 percent each year. It also wanted a coordinated IT infrastructure that would allow it to consolidate data in a single repository. It used ECOstructure blueprints created by Cisco Systems, EMC, and Oracle Corporations to provide secure and new storage, networking, and software architectures that could accommodate growing computing requirements in the future.

Consultants from Rubik Consultants performed a total cost of ownership (TCO) analysis showing that Nor-Cargo should move from a distributed architecture to a centralized one where it could standardize on one application for each area of the company and take advantage of leading-edge logistics systems. The consultants recommended Nor-Cargo adopt a standardized network and IT platform as a common framework for its mission-critical systems. Oracle provided an integrated e-business software platform accessible to Nor-Cargo employees, suppliers, and customers through a Web interface. Cisco provided network security and management software and hardware.

After implementing the new infrastructure, Nor-Cargo could aggregate data from multiple sources, giving managers the ability to analyze the data. For example, management can now examine truck traffic patterns and use such data to make truck trips more cost efficient. Nor-Cargo can quickly roll out new applications over the infrastructure, including a Web-based bar code system



that lets customers track packages. Even though Nor-Cargo has not finished rolling out all of its applications, it has realized savings from improved communications, smaller information systems staff, and reductions in the number of its servers from 150 to 50.

Sources: Cisco Systems, "Case Study: Nor-Cargo Brings All Ships into One Port," *Maximizing the Data Center,* 2003; Eric J. Adams, "Streamline Delivery at Nor-Cargo," *Cisco IQ Magazine*, September/October 2002; and www.nor-cargo.no, accessed August 16, 2003.

MANAGEMENT CHALLENGES

Nor-Cargo found that its efficiency and competitiveness were hampered by poorly managed hardware and software technology that lacked the functionality for running its business. The company found it could lower operating costs and provide better services to customers by improving the selection and management of its hardware and software. In order to consolidate hardware and software assets and select appropriate technology, Nor-Cargo's management had to understand the capabilities of computer hardware and software technology, how to select hardware and software to meet current and future business requirements, and the financial and business rationale for its hardware and software investments. Computer hardware and software technologies can improve organizational performance, but they raise the following management challenges:

1. **The centralization versus decentralization debate.** A long-standing issue among information system managers and CEOs has been the question of how much to centralize or distribute computing resources. Should processing power and data be distributed to departments and divisions, or should they be concentrated at a single location using a large central computer? Should organizations deliver application software to users over networks from a central location or allow users to maintain software and data on their own desktop computers? Client/server and peer-to-peer computing facilitate decentralization, but network computers and mainframes support a centralized model. Which is the best for the organization? Each organization will have a different answer based on its own needs. Managers need to make sure that the computing model they select is compatible with organizational goals.
2. **The application backlog.** Advances in computer software have not kept pace with the breathtaking productivity gains in computer hardware. Developing software has become a major preoccupation for organizations. A great deal of software must be intricately crafted. Moreover, the software itself is only one component of a complete information system that must be carefully designed and coordinated with organizational and hardware components. The "software crisis" is actually part of a larger systems analysis, design, and implementation issue, which is discussed in detail later. Despite the gains from fourth-generation languages, personal desktop software tools, object-oriented programming, and software tools for the Web, many businesses continue to face a backlog of two to three years in developing the information systems they need, or they may not be able to develop them at all.

Although managers and business professionals do not need to be computer technology experts, they should have a basic understanding of the role of hardware and software in the organization's information technology (IT) infrastructure so that they can make technology decisions that promote organizational performance and productivity. This chapter surveys the capabilities of computer hardware and computer software, and highlights the major issues in the management of the firm's hardware and software assets.

6.1 COMPUTER HARDWARE AND INFORMATION TECHNOLOGY INFRASTRUCTURE

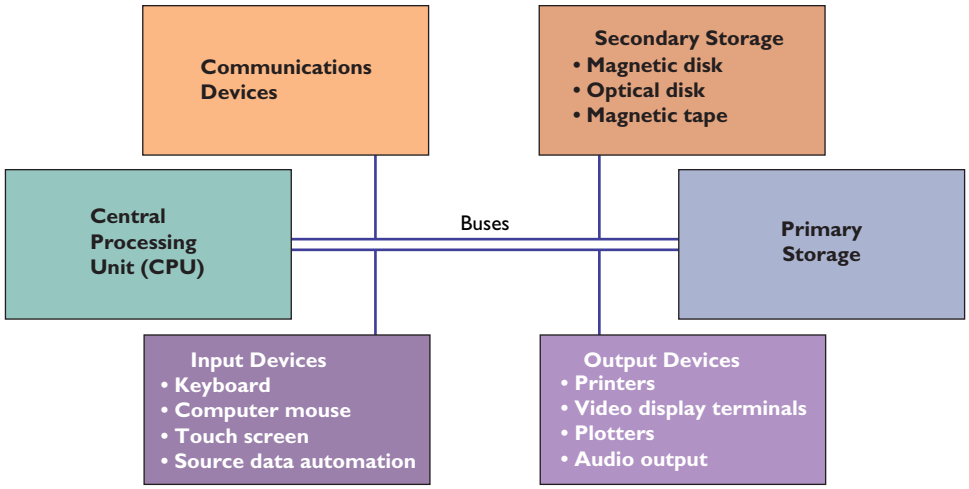
Computer hardware, which we defined in Chapter 1, provides the underlying physical foundation for the firm's IT infrastructure. Other infrastructure components—software, data, and networks—require computer hardware for their storage or operation.

computer
Physical device that takes data as an input, transforms the data by executing stored instructions, and outputs information to a number of devices.

THE COMPUTER SYSTEM

A **computer** is a physical device that takes data as input, transforms these data according to stored instructions, and outputs processed information. A contemporary computer system

FIGURE 6-1 *Hardware components of a computer system*



A contemporary computer system can be categorized into six major components. The central processing unit manipulates data and controls the other parts of the computer system; primary storage temporarily stores data and program instructions during processing; secondary storage stores data and instructions when they are not used in processing; input devices convert data and instructions for processing in the computer; output devices present data in a form that people can understand; and communications devices control the passing of information to and from communications networks.

consists of a central processing unit, primary storage, secondary storage, input devices, output devices, and communications devices (see Figure 6-1). The central processing unit manipulates raw data into a more useful form and controls the other parts of the computer system. Primary storage temporarily stores data and program instructions during processing, whereas secondary storage devices (magnetic and optical disks, magnetic tape) store data and programs when they are not being used in processing. Input devices, such as a keyboard or mouse, convert data and instructions into electronic form for input into the computer. Output devices, such as printers and video display terminals, convert electronic data produced by the computer system and display them in a form that people can understand. Communications devices provide connections between the computer and communications networks. Buses are circuitry paths for transmitting data and signals among the parts of the computer system.

In order for information to flow through a computer system and be in a form suitable for processing, all symbols, pictures, or words must be reduced to a string of binary digits. A binary digit is called a **bit** and represents either a 0 or a 1. In the computer, the presence of an electronic or magnetic signal means one, and its absence signifies zero. Digital computers operate directly with binary digits, either singly or strung together to form bytes. A string of eight bits that the computer stores as a unit is called a **byte.** Each byte can be used to store a decimal number, a symbol, a character, or part of a picture (see Figure 6-2).

bit
A binary digit representing the smallest unit of data in a computer system. It can only have one of two states, representing 0 or 1.

byte
A string of bits, usually eight, used to store one number or character in a computer system.

The CPU and Primary Storage

The **central processing unit (CPU)** is the part of the computer system where the manipulation of symbols, numbers, and letters occurs; it controls the other parts of the computer system (see Figure 6-3). Located near the CPU is **primary storage** (sometimes called primary memory or main memory), where data and program instructions are stored temporarily during processing. Buses provide pathways for transmitting data and signals between the CPU, primary storage, and the other devices in the computer system. The characteristics of the CPU and primary storage are very important in determining a computer's speed and capabilities.

Figure 6-3 also shows that the CPU consists of an arithmetic-logic unit and a control unit. The **arithmetic-logic unit (ALU)** performs the computer's principal logical and arithmetic operations. It adds, subtracts, multiplies, and divides, determining whether a number is positive, negative, or zero. In addition to performing arithmetic functions, an ALU must be able to determine when one quantity is greater than or less than another and when two quantities are equal. The ALU can perform logic operations on letters as well as numbers.

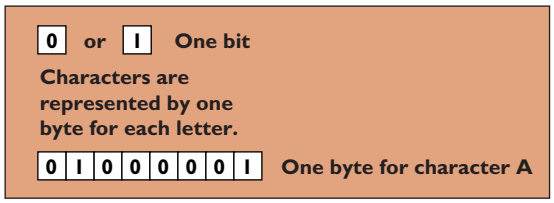
central processing unit (CPU)
Area of the computer system that manipulates symbols, numbers, and letters, and controls the other parts of the computer system.

primary storage
Part of the computer that temporarily stores program instructions and data being used by the instructions.

arithmetic-logic unit (ALU)
Component of the CPU that performs the computer's principal logic and arithmetic operations.

FIGURE 6-2 *Bits and bytes*

Bits are represented by either a 0 or 1. A string of eight bits constitutes a byte, which represents a character or number. Illustrated here is a byte representing the letter "A" using the ASCII binary coding standard.



control unit
Component of the CPU that controls and coordinates the other parts of the computer system.

machine cycle
Series of operations required to process a single machine instruction.

RAM (random access memory)
Primary storage of data or program instructions that can directly access any randomly chosen location in the same amount of time.

The **control unit** coordinates and controls the other parts of the computer system. It reads a stored program, one instruction at a time, and directs other components of the computer system to perform the program's required tasks. The series of operations required to process a single machine instruction is called the **machine cycle.**

Primary storage has three functions. It stores all or part of the software program that is being executed. Primary storage also stores the operating system programs that manage the operation of the computer (see Section 6.3). Finally, the primary storage area holds data that the program is using. Internal primary storage is often called **RAM,** or **random access memory.** It is called RAM because it can directly access any randomly chosen location in the same amount of time.

Primary memory is divided into storage locations called *bytes*. Each location contains a set of eight binary switches or devices, each of which can store one bit of information. The set of eight bits found in each storage location is sufficient to store one letter, one digit, or one special symbol (such as a $). Each byte has a unique address, similar to a mailbox, indicating where it is located in RAM. The computer can remember where the data in all of the bytes are located simply by keeping track of these addresses. Computer storage capacity is measured in bytes. Table 6-1 lists the primary measures of computer storage capacity and processing speed.

Primary storage is composed of *semiconductors*, which are integrated circuits made by printing thousands and even millions of tiny transistors on small silicon chips. There are several different kinds of semiconductor memory used in primary storage. RAM is used for short-term storage of data or program instructions. RAM is volatile: Its contents will be lost when the computer's electric supply is disrupted by a power outage or when the computer is

FIGURE 6-3 *The CPU and primary storage*

The CPU contains an arithmetic-logic unit and a control unit. Data and instructions are stored in unique addresses in primary storage that the CPU can access during processing. The data bus, address bus, and control bus transmit signals between the central processing unit, primary storage, and other devices in the computer system.

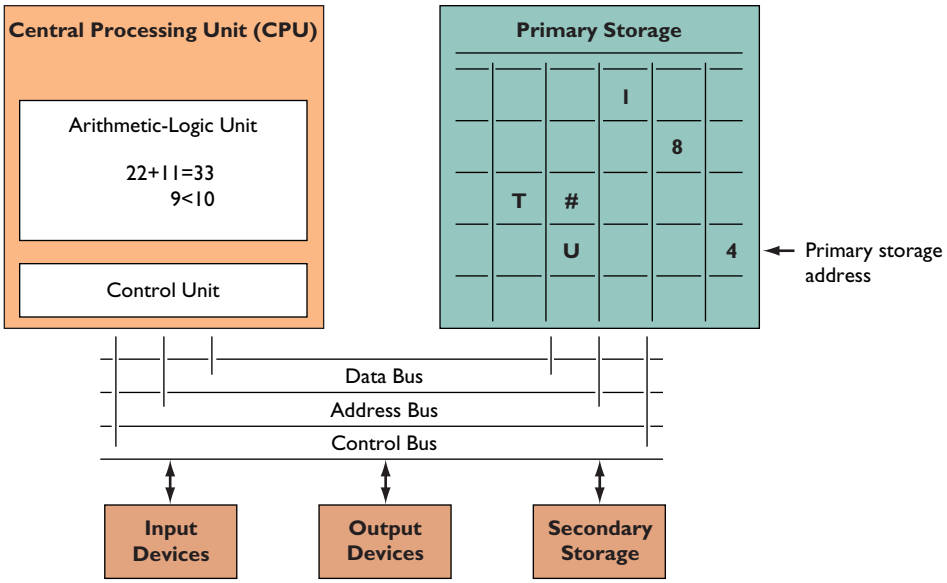


TABLE 6-1 *Key Measures of Computer Storage Capacity and Processing Speed*

STORAGE CAPACITY	
Byte	String of eight bits
Kilobyte	1,000 bytes (actually 1,024 storage positions)
Megabyte	1,000,000 bytes
Gigabyte	1,000,000,000 bytes
Terabyte	1,000,000,000,000 bytes
PROCESSING SPEED	
Microsecond	1/1,000,000 second
Nanosecond	1/1,000,000,000 second
Picosecond	1/1,000,000,000,000 second
MIPS	Millions of instructions per second

turned off. **ROM,** or **read-only memory,** can only be read from; it cannot be written to. ROM chips come from the manufacturer with programs already burned in, or stored. ROM is used in general-purpose computers to store important or frequently used programs.

ROM (read-only memory)
Semiconductor memory chips that contain program instructions. These chips can only be read from; they cannot be written to.

COMPUTER PROCESSING

The processing capability of the CPU plays a large role in determining the amount of work that a computer system can accomplish.

Microprocessors and Processing Power

Contemporary CPUs use semiconductor chips called **microprocessors,** which integrate all of the memory, logic, and control circuits for an entire CPU onto a single chip. The speed and performance of a computer's microprocessors help determine a computer's processing power and are based on the number of bits that can be processed at one time (*word length*); the amount of data that can be moved between the CPU, primary storage, and other devices (data bus width); and cycle speed, measured in **megahertz.** (Megahertz is abbreviated MHz and stands for millions of cycles per second.)

Microprocessors can be made faster by using **reduced instruction set computing (RISC)** in their design. Conventional chips, based on complex instruction set computing, have several hundred or more instructions hardwired into their circuitry, and they may take several clock cycles to execute a single instruction. If the little-used instructions are eliminated, the remaining instructions can execute much faster. RISC computers have only the most frequently used instructions embedded in them. A RISC CPU can execute most instructions in a single machine cycle and sometimes multiple instructions at the same time. RISC is often used in scientific and workstation computing.

microprocessor
Very large-scale integrated circuit technology that integrates the computer's memory, logic, and control on a single chip.

megahertz
A measure of cycle speed, or the pacing of events in a computer; one megahertz equals one million cycles per second.

reduced instruction set computing (RISC)
Technology used to enhance the speed of microprocessors by embedding only the most frequently used instructions on a chip.

Parallel Processing

Processing can also be sped up by linking several processors to work simultaneously on the same task. Figure 6-4 compares parallel processing to serial processing used in conventional computers. In **parallel processing,** multiple processing units (CPUs) break down a problem into smaller parts and work on it simultaneously. Getting a group of processors to attack the same problem at once requires both rethinking the problems and special software that can divide problems among different processors in the most efficient way possible, providing the needed data, and reassembling the many subtasks to reach an appropriate solution.

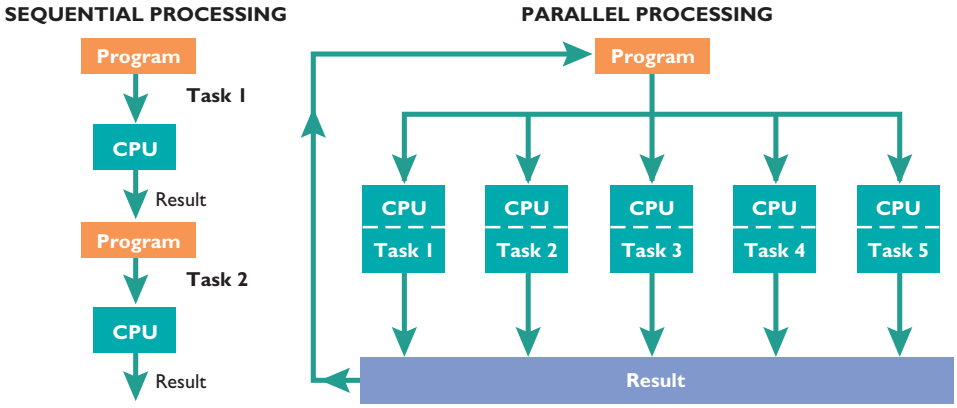
Massively parallel computers have huge networks of processor chips interwoven in complex and flexible ways to attack large computing problems. As opposed to parallel processing, where small numbers of powerful but expensive specialized chips are linked together, massively parallel machines link hundreds or even thousands of inexpensive, commonly used chips to break problems into many small pieces and solve them.

parallel processing
Type of processing in which more than one instruction can be processed at a time by breaking down a problem into smaller parts and processing them simultaneously with multiple processors.

massively parallel computers
Computers that use hundreds or thousands of processing chips to attack large computing problems simultaneously.

FIGURE 6-4 *Sequential and parallel processing*

During sequential processing, each task is assigned to one CPU that processes one instruction at a time. In parallel processing, multiple tasks are assigned to multiple processing units to expedite the result.



STORAGE, INPUT AND OUTPUT TECHNOLOGY

The capabilities of computer systems depend not only on the speed and capacity of the CPU but also on the speed, capacity, and design of storage, input, and output technology. Storage, input, and output devices are called *peripheral devices* because they are outside the main computer system unit.

Secondary Storage Technology

Electronic commerce and electronic business have made storage a strategic technology. Although electronic commerce and electronic business are reducing manual processes, data of all types must be stored electronically and available whenever needed. Most of the information used by a computer application is stored on secondary storage devices located outside of the primary storage area. **Secondary storage** is used for relatively long-term storage of data outside the CPU. Secondary storage is nonvolatile and retains data even when the computer is turned off. The most important secondary storage technologies are magnetic disk, optical disk, and magnetic tape.

secondary storage
Relatively long-term, nonvolatile storage of data outside the CPU and primary storage.

magnetic disk
A secondary storage medium in which data are stored by means of magnetized spots on a hard or floppy disk.

hard disk
Magnetic disk resembling a thin metallic platter; used in large computer systems and in most PCs.

floppy disk
Removable magnetic disk storage primarily used with PCs.

RAID (Redundant Array of Inexpensive Disks)
Disk storage technology to boost disk performance by packaging more than 100 smaller disk drives with a controller chip and specialized software in a single large unit to deliver data over multiple paths simultaneously.

Magnetic Disk The most widely used secondary storage medium today is **magnetic disk.** There are two kinds of magnetic disks: floppy disks (used in PCs) and **hard disks** (used on large commercial disk drives and PCs). Large mainframe or midrange computer systems have multiple hard disk drives because they require immense disk storage capacity in the gigabyte and terabyte range. PCs also use **floppy disks,** which are removable and portable, with lower storage capacities and access rates than hard disks. Removable disk drives are becoming popular backup storage alternatives for PC systems. Magnetic disks on both large and small computers permit direct access to individual records so that data stored on the disk can be directly accessed regardless of the order in which the data were originally recorded. Disk technology is useful for systems requiring rapid and direct access to data.

Disk drive performance can be further enhanced by using a disk technology called **RAID (Redundant Array of Inexpensive Disks).** RAID devices package more than a hundred disk drives, a controller chip, and specialized software into a single large unit. Traditional disk drives deliver data from the disk drive along a single path, but RAID delivers data over multiple paths simultaneously, improving disk access time and reliability. For most RAID systems, data on a failed disk can be restored automatically without the computer system having to be shut down.

Optical Disks Optical disks, also called compact disks or laser optical disks, use laser technology to store massive quantities of data in a highly compact form. They are available for both PCs and large computers. The most common optical disk system used with PCs is called

Secondary storage devices such as floppy disks, optical disks, and hard disks are used to store large quantities of data outside the CPU and primary storage. They provide direct access to data for easy retrieval.

CD-ROM (compact disk read-only memory). A 4.75-inch compact disk for PCs can store up to 660 megabytes, nearly 300 times more than a high-density floppy disk. Optical disks are most appropriate for applications where enormous quantities of unchanging data must be stored compactly for easy retrieval or for applications combining text, sound, and images.

CD-ROM is read-only storage. No new data can be written to it; it can only be read. *WORM (write once/read many)* and *CD-R (compact disk-recordable)* optical disk systems allow users to record data only once on an optical disk. Once written, the data cannot be erased but can be read indefinitely. **CD-RW (CD-ReWritable)** technology has been developed to allow users to create rewritable optical disks for applications requiring large volumes of storage where the information is only occasionally updated.

Digital video disks (DVDs), also called digital versatile disks, are optical disks the same size as CD-ROMs but of even higher capacity. They can hold a minimum of 4.7 gigabytes of data, enough to store a full-length, high-quality motion picture. DVDs are being used to store movies and multimedia applications using large amounts of video and graphics, but they may replace CD-ROMs because they can store large amounts of digitized text, graphics, audio, and video data. Initially, DVDs were read-only; writable and rewritable DVD drives and media are now available.

CD-ROM (compact disk read-only memory)
Read-only optical disk storage used for imaging, reference, and database applications with massive amounts of unchanging data and for multimedia.

CD-RW (CD-ReWritable)
Optical disk storage that can be rewritten many times by users.

digital video disk (DVD)
High-capacity optical storage medium that can store full-length videos and large amounts of data.

Magnetic Tape **Magnetic tape** is an older storage technology that still is employed for secondary storage of large quantities of data that are needed rapidly but not instantly. Magnetic tape is inexpensive and relatively stable. However, it stores data sequentially and is relatively slow compared to the speed of other secondary storage media. In order to find an individual record stored on magnetic tape, such as an employment record, the tape must be read from the beginning up to the location of the desired record.

magnetic tape
Inexpensive, older secondary-storage medium in which large volumes of information are stored sequentially by means of magnetized and nonmagnetized spots on tape.

Storage Networking To meet the escalating demand for data-intensive graphics, Web transactions, and other digital firm applications, the amount of data that companies need to store is doubling every 12 to 18 months. Companies are turning to new kinds of storage infrastructures to deal with the complexity and cost of mushrooming storage requirements.

Large companies have many different storage resources—disk drives, tape backup drives, RAID, and other devices that may be scattered in many different locations. This arrangement is expensive to manage and makes it difficult to access data across the enterprise. Storage networking technology enables firms to manage all of their storage resources centrally by providing an overall storage plan for all the storage devices in the enterprise.

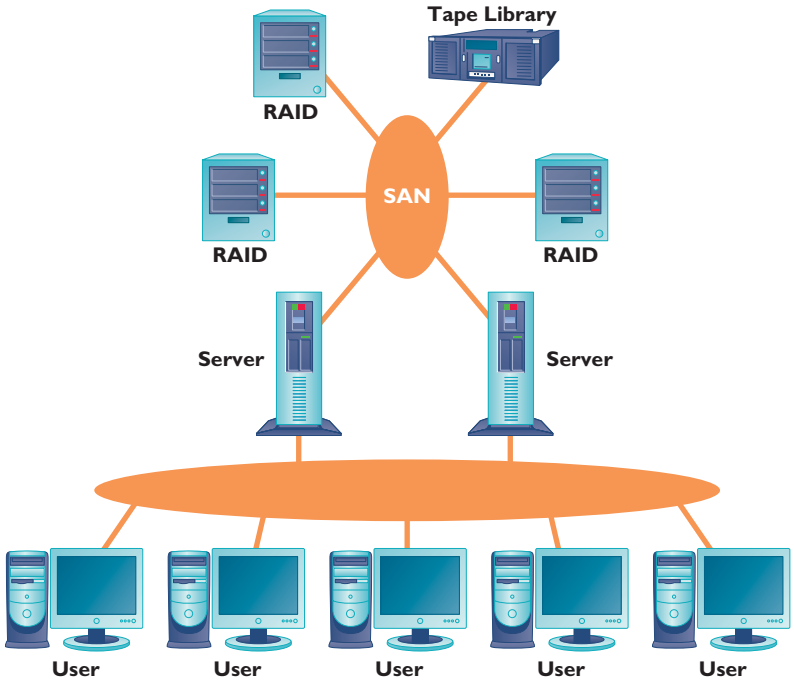
There are alternative storage networking arrangements. In *direct-attached storage*, storage devices are connected directly to individual servers and must be accessed through each server, which can create bottlenecks. **Network-attached storage (NAS)** overcomes this problem by attaching high-speed RAID storage devices to a network so that the devices in the network can access this storage through a specialized server dedicated to file service and storage. Storage-area networks (SANs) go one step further by placing multiple storage devices on a separate high-speed network dedicated to storage purposes. A **storage area network (SAN)** is a specialized high-speed network dedicated to storage that connects different kinds of storage devices, such as tape libraries and disk arrays. The SAN storage devices are located on their

network-attached storage (NAS)
Attaching high-speed RAID storage devices to a network so that the devices in the network can access these storage devices through a specialized server dedicated to file service and storage.

storage area network (SAN)
A high-speed network dedicated to storage that connects different kinds of storage devices, such as tape libraries and disk arrays so they can be shared by multiple servers.

FIGURE 6-5 *A storage area network (SAN)*

A typical SAN consists of a server, storage devices, and networking devices and is used strictly for storage. The SAN stores data on many different types of storage devices, providing data to the enterprise. The SAN supports communication between any server and the storage unit as well as between different storage devices in the network.



own network and connected using a high-transmission technology such as Fibre Channel. The network moves data among pools of servers and storage devices, creating an enterprise-wide infrastructure for data storage. The SAN creates a large central pool of storage that can be shared by multiple servers so that users can rapidly share data across the SAN. Figure 6-5 illustrates how a SAN works.

SANs can be expensive and difficult to manage, but they are very useful for companies that need to share information across applications and computing platforms. SANs can help these companies consolidate their storage resources and provide rapid data access for widely distributed users.

Input and Output Devices

Human beings interact with computer systems largely through input and output devices. Input devices gather data and convert them into electronic form for use by the computer, whereas output devices display data after they have been processed. Table 6-2 describes the principal input and output devices.

The principal input devices consist of keyboards, pointing devices (such as the computer mouse and touch screens), and source data automation technologies (optical and magnetic ink character recognition, pen-based input, digital scanners, audio input, and sensors), which capture data in computer-readable form at the time and place they are created. They also include **radio-frequency identification (RFID)** devices that use tiny tags with embedded microchips containing data about an item and its location to transmit radio signals over a short distance to special RFID readers. The RFID readers then pass the data over a network to a computer for processing. RFID is especially useful for tracking the locations of items as they move through the supply chain. The principal output devices are cathode ray tube terminals (CRTs), sometimes called video display terminals (VDTs), printers, and audio output.

radio-frequency identification (RFID)
Technology using tiny tags with embedded microchips containing data about an item and its location to transmit short-distance radio signals to special RFID readers that then pass the data on to a computer for processing.

TABLE 6-2 *Input and Output Devices*

Input Device	Description
Keyboard	Principal method of data entry for text and numerical data.
Computer mouse	Handheld device with point-and-click capabilities that is usually connected to the computer by a cable. The computer user can move the mouse around on a desktop to control the cursor's position on a computer display screen, pushing a button to select a command. Trackballs and touch pads often are used in place of the mouse as pointing devices on laptop PCs.
Touch screen	Device that allows users to enter limited amounts of data by touching the surface of a sensitized video display monitor with a finger or a pointer. Often found in information kiosks in retail stores, restaurants, and shopping malls.
Optical character recognition	Device that can translate specially designed marks, characters, and codes into digital form. The most widely used optical code is the *bar code*, which is used in point-of-sale systems in supermarkets and retail stores. The codes can include time, date, and location data in addition to identification data.
Magnetic ink character recognition (MICR)	Technology used primarily in check processing for the banking industry. Characters on the bottom of a check identify the bank, checking account, and check number and are preprinted using special magnetic ink. A MICR reader translates these characters into digital form for the computer.
Pen-based input	Handwriting-recognition devices, such as pen-based tablets, notebooks, and notepads, that convert the motion made by an electronic stylus pressing on a touch-sensitive tablet screen into digital form.
Digital scanner	Device that translates images, such as pictures or documents, into digital form; essential component of image-processing systems.
Audio input	Voice input devices that convert spoken words into digital form for processing by the computer. Microphones and tape cassette players can serve as input devices for music and other sounds.
Sensors	Devices that collect data directly from the environment for input into a computer system. For instance, today's farmers can use sensors to monitor the moisture of the soil in their fields to help them with irrigation.
Radio-frequency identification (RFID)	Devices that use tags with microchips to transmit information about items and their locations to special RFID readers. Useful for tracking items as they move through the supply chain.
Output Device	**Description**
Cathode ray tube (CRT)	Electronic gun that shoots a beam of electrons illuminating tiny points on a display screen. Laptop computers use flat panel displays, which are less bulky than CRT monitors.
Printers	Devices that produce a printed hard copy of information output. They include impact printers (such as dot matrix printers) and nonimpact printers (such as laser, inkjet, and thermal transfer printers).
Audio output	Voice output devices that convert digital output data back into intelligible speech. Other audio output, such as music, can be delivered by speakers connected to the computer.

Batch and Online Input and Processing

The manner in which data are input into the computer affects how the data can be processed. Information systems collect and process information in one of two ways: through batch or through online processing. In **batch processing,** transactions, such as orders or payroll time cards, are accumulated and stored in a group or batch until the time when, because of some reporting cycle, it is efficient or necessary to process them. Batch processing is found primarily in older systems where users need only occasional reports. In **online processing,** the user enters transactions into a device (such as a data entry keyboard or bar code reader) that is directly connected to the computer system. The transactions usually are processed immediately. Most processing today is online processing. Batch systems often use tape as a storage medium, whereas online processing systems use disk storage, which permits immediate access to specific items.

batch processing
A method of collecting and processing data in which transactions are accumulated and stored until a specified time when it is convenient or necessary to process them as a group.

online processing
A method of collecting and processing data in which transactions are entered directly into the computer system and processed immediately.

Interactive Multimedia

multimedia
The integration of two or more types of media, such as text, graphics, sound, voice, full-motion video, or animation, into a computer-based application.

The processing, input, output, and storage technologies we have just described can be used to create **multimedia** applications that integrate sound and full-motion video, or animation with graphics and text into a computer-based application. Multimedia is becoming the foundation of new consumer products and services, such as electronic books and newspapers, electronic classroom-presentation technologies, full-motion videoconferencing, imaging, graphics design tools, and video and voice mail. PCs today come with built-in multimedia capabilities, including high-resolution color monitors, CD-ROM drives, or DVD drives to store video, audio, and graphic data, and stereo speakers for amplifying audio output.

Interactive Web pages replete with graphics, sound, animation, and full-motion video have made multimedia popular on the Internet. For example, visitors to the CNN.com Web site can access news stories from CNN, photos, on-air transcripts, video clips, and audio clips. The video and audio clips are made available using **streaming technology,** which allows audio and video data to be processed as a steady and continuous stream as they are downloaded from the Web.

streaming technology
Technology for transferring data so that they can be processed as a steady and continuous stream.

MP3 (MPEG3)
Compression standard that can compress audio files for transfer over the Internet with virtually no loss in quality.

Multimedia Web sites are also being used to sell digital products, such as digitized music clips. A compression standard known as **MP3,** also called **MPEG3,** which stands for Motion Picture Experts Group, audio layer 3, can compress audio files down to one-tenth or one-twelfth of their original size with virtually no loss in quality. Visitors to Web sites such as MP3.com can download MP3 music clips over the Internet and play them on their own computers.

6.2 Categories of Computers and Computer Systems

Contemporary computers can be categorized as mainframes, midrange computers, PCs, workstations, and supercomputers. Managers need to understand the capabilities of each of these types of computers, and why some types are more appropriate for certain processing work than others.

mainframe
Largest category of computer, used for major business processing.

midrange computer
Middle-size computer that is capable of supporting the computing needs of smaller organizations or of managing networks of other computers.

Classifying Computers

A **mainframe** is the largest computer, a powerhouse with massive memory and extremely rapid processing power. It is used for very large business, scientific, or military applications where a computer must handle massive amounts of data or many complicated processes. A **midrange computer** is less powerful, less expensive, and smaller than a

World-traveled singer-songwriter-producer David Goldman's original songs encompass various musical styles including Blues, Acoustic Rock, Pop/Jazz, Latin, and Asian. One can preview tracks from his albums at the multimedia Web sites www.DavidGoldman.com or www.cdbaby/goldman.com.

mainframe but capable of supporting the computing needs of smaller organizations or of managing networks of other computers. Midrange computers can be **minicomputers,** which are used in systems for universities, factories, or research laboratories, or they can be **servers,** which are used for managing internal company networks or Web sites. Server computers are specifically optimized to support a computer network, enabling users to share files, software, peripheral devices (such as printers), or other network resources. Servers have large memory and disk-storage capacity, high-speed communications capabilities, and powerful CPUs.

Servers have become important components of firms' IT infrastructures because they provide the hardware platform for electronic commerce. By adding special software, they can be customized to deliver Web pages, process purchase and sale transactions, or exchange data with systems inside the company. Organizations with heavy electronic commerce requirements and massive Web sites are running their Web and electronic commerce applications on multiple servers in **server farms** in computing centers run by commercial vendors such as IBM.

A **personal computer (PC),** which is sometimes referred to as a *microcomputer*, is one that can be placed on a desktop or carried from room to room. Smaller laptop PCs are often used as portable desktops on the road. PCs are used as personal machines as well as in business. A **workstation** also fits on a desktop but has more powerful mathematical and graphics-processing capabilities than a PC and can perform more complicated tasks than a PC in the same amount of time. Workstations are used for scientific, engineering, and design work that requires powerful graphics or computational capabilities.

A **supercomputer** is a highly sophisticated and powerful computer that is used for tasks requiring extremely rapid and complex calculations with hundreds of thousands of variable factors. Supercomputers use parallel processors and traditionally have been used in scientific and military work, such as classified weapons research and weather forecasting, which use complex mathematical models. They are now starting to be used in business for the manipulation of vast quantities of data.

minicomputer
Middle-range computer used in systems for universities, factories, or research laboratories.

server
Computer specifically optimized to provide software and other resources to other computers over a network.

Internet Connection
The Internet Connection for this chapter will direct you to a series of Web sites where you can complete an exercise to survey the products and services of major computer hardware vendors and the use of Web sites in the computer hardware industry.

server farm
Large group of servers maintained by a commercial vendor and made available to subscribers for electronic commerce and other activities requiring heavy use of servers.

personal computer (PC)
Small desktop or portable computer.

workstation
Desktop computer with powerful graphics and mathematical capabilities and the ability to perform several complicated tasks at once.

supercomputer
Highly sophisticated and powerful computer that can perform very complex computations extremely rapidly.

COMPUTER NETWORKS AND CLIENT/SERVER COMPUTING

Today, stand-alone computers have been replaced by computers in networks for most processing tasks. The use of multiple computers linked by a communications network for processing is called **distributed processing.** In contrast with **centralized processing,** in which all processing is accomplished by one large central computer, distributed processing distributes the processing work among PCs, midrange computers, and mainframes linked together.

One widely used form of distributed processing is **client/server computing.** Client/server computing splits processing between "clients" and "servers." Both are on the network, but each machine is assigned functions it is best suited to perform. The **client** is the user point of entry for the required function and is normally a desktop computer, workstation, or laptop computer. The user generally interacts directly only with the client portion of the application, often to input data or retrieve data for further analysis. The *server* provides the client with services. The server could be a mainframe or another desktop computer, but specialized server computers are often used in this role. Servers store and process shared data and also perform back-end functions not visible to users, such as managing network activities. Figure 6-6 illustrates the client/server computing concept. Computing on the Internet uses the client/server model (see Chapter 9).

Figure 6-7 illustrates five different ways that the components of an application could be partitioned between the client and the server. The interface component is essentially the application interface—how the application appears visually to the user. The application logic component consists of the processing logic, which is shaped by the organization's business rules. (An example might be that a salaried employee is only to be paid monthly.) The data management component consists of the storage and management of the data used by

distributed processing
The distribution of computer processing work among multiple computers linked by a communications network.

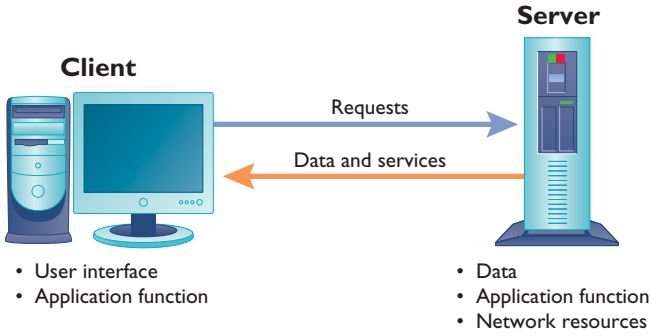
centralized processing
Processing that is accomplished by one large central computer.

client/server computing
A model for computing that splits processing between "clients" and "servers" on a network, assigning functions to the machine most able to perform the function.

client
The user point of entry for the required function in client/server computing. Normally a desktop computer, workstation, or laptop computer.

FIGURE 6-6 *Client/server computing*

In client/server computing, computer processing is split between client machines and server machines linked by a network. Users interface with the client machines.



the application. The exact division of tasks depends on the requirements of each application, including its processing needs, the number of users, and the available resources.

In some firms client/server networks with PCs have actually replaced mainframes and minicomputers. The process of transferring applications from large computers to smaller ones is called **downsizing.** Downsizing can potentially reduce computing costs because memory and processing power on a PC cost a fraction of their equivalent on a mainframe. The decision to downsize involves many factors in addition to the cost of computer hardware, including the need for new software, training, and perhaps new organizational procedures (see the discussion of total cost of ownership in Section 6.4).

downsizing
The process of transferring applications from large computers to smaller ones.

NETWORK COMPUTERS AND PEER-TO-PEER COMPUTING

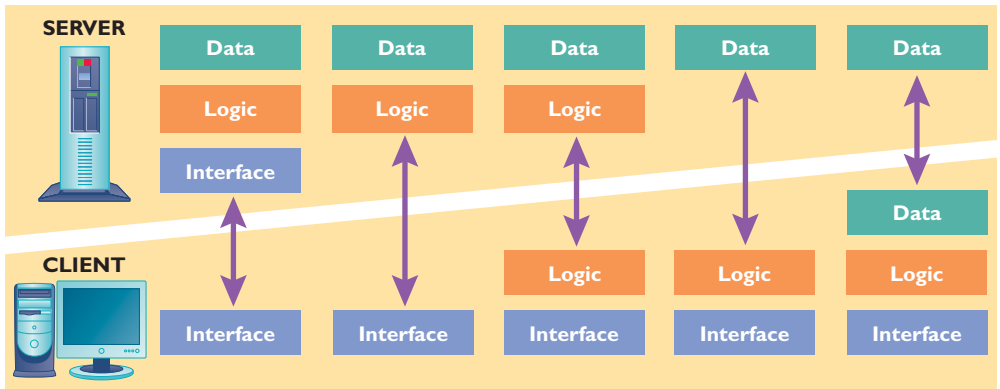
In one form of client/server computing, client processing and storage capabilities are so minimal that the bulk of computer processing occurs on the server. The term *thin client* is sometimes used to refer to the client in this arrangement. Thin clients with minimal memory, storage, and processor power that are designed to work on networks are called **network computers (NCs).** NC users download whatever software or data they need from a central computer over the Internet or an organization's internal network. The central computer also saves information for the user and makes it available for later retrieval, effectively eliminating the need for secondary storage devices such as hard disks, floppy disks, CD-ROMs, and their drives.

network computer (NC)
Simplified desktop computer that does not store software programs or data permanently. Users download whatever software or data they need from a central computer over the Internet or an organization's own internal network.

NC systems are less expensive and less complicated to maintain than PCs with local processing and storage, and NCs can be administered and updated from a central network server. Software programs and applications would not have to be purchased, installed, and upgraded for each user because software would be delivered and maintained from one cen-

FIGURE 6-7 *Types of client/server computing*

There are various ways in which an application's interface, logic, and data management components can be divided among the clients and servers in a network.



tral point. Network computers and centralized software distribution thus could increase management's control over the organization's computing function. However, if a network failure occurs, hundreds or thousands of employees would not be able to use their computers, whereas people could keep working if they had full-function PCs. Companies should closely examine how network computers might fit into their information technology infrastructure.

Peer-to-Peer Computing

Another form of distributed processing, called **peer-to-peer computing,** puts processing power back on users' desktops, linking these computers so that they can share processing tasks. Individual PCs, workstations, or other computers can share data, disk space, or processing power for a variety of tasks when they are linked in a network, including the Internet. The peer-to-peer computing model stands in contrast to the network computing model because processing power resides on individual desktops and these computers work together without a server or any central controlling authority.

peer-to-peer computing
Form of distributed processing that links computers via the Internet or private networks so that they can share data or processing tasks.

One form of peer-to-peer computing called **grid computing** uses special software to reclaim unused computing cycles on desktop computers in a network and harness them into a "virtual supercomputer" for solving large computational problems. Grid computing breaks down a large problem into small pieces that can run on many separate machines in a network that are organized into a computational grid. Computing resources can be shared over the grid with anyone authorized to use them, regardless of their location. When a firm needs additional processing capacity, that company could distribute its workload across a grid instead of having to purchase additional hardware. For example, Bank One distributed processing for massive risk-analytics used in its interest-rate derivatives trading business across a grid of 100 to 150 servers (Schmerken, 2003).

grid computing
Applying the resources of many computers in a network to a single problem.

Another peer-to-peer computing application that has gained some notoriety is the use of file-sharing systems, such as Kazaa for swapping music and other files. Chapter 5 and the case study concluding Chapter 4 discuss the ethical and business implications of these systems.

Each form of computer processing can provide benefits, depending on the business needs of the organization. Network computing might be appropriate for firms with highly centralized information technology infrastructures. Peer-to-peer computing could be very useful in workgroup collaboration for accelerating communication processes and reducing collaboration costs, but it can create self-organizing networks with unreliable and untrusted components that could be difficult for organizations to control (Kubiatowicz, 2003; Schoder and Fischbach, 2003).

6.3 Types of Software

To play a useful role in the firm's information technology infrastructure, computer hardware requires computer software. Chapter 1 defined computer *software* as the detailed instructions that control the operation of a computer system. Selecting appropriate software for the organization is a key management decision.

A software **program** is a series of statements or instructions to the computer. The process of writing or coding programs is termed *programming,* and individuals who specialize in this task are called *programmers*.

program
A series of statements or instructions to the computer.

There are two major types of software: system software and application software. Each kind performs a different function. **System software** is a set of generalized programs that manage the computer's resources, such as the central processor, communications links, and peripheral devices. Programmers who write system software are called *system programmers.*

system software
Generalized programs that manage the computer's resources, such as the central processor, communications links, and peripheral devices.

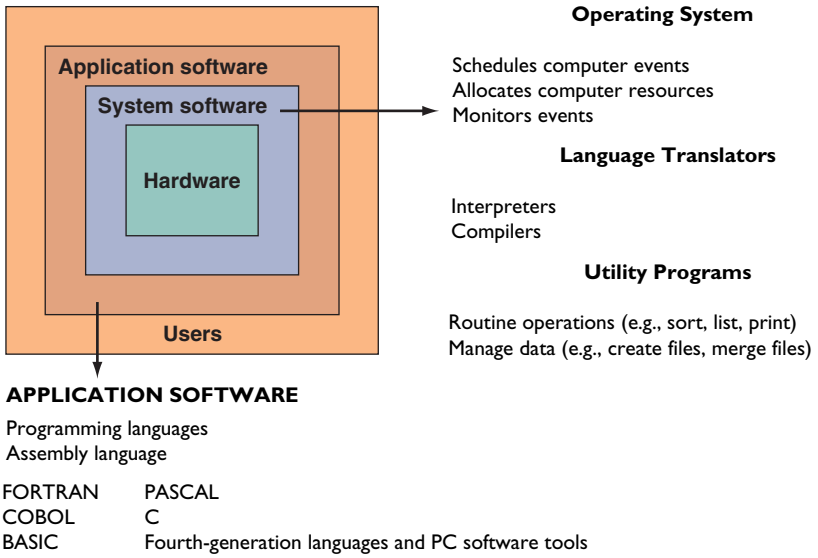
Application software describes the programs that are written for or by users to apply the computer to a specific task. Software for processing an order or generating a mailing list is application software. Programmers who write application software are called *application programmers*.

application software
Programs written for a specific application to perform functions specified by end users.

The types of software are interrelated and can be thought of as a set of nested boxes, each of which must interact closely with the other boxes surrounding it. Figure 6-8 illustrates this

FIGURE 6-8 *The major types of software*

The relationship between the system software, application software, and users can be illustrated by a series of nested boxes. System software—consisting of operating systems, language translators, and utility programs—controls access to the hardware. Application software, such as the programming languages and "fourth-generation" languages, must work through the system software to operate. The user interacts primarily with the application software.



relationship. The system software surrounds and controls access to the hardware. Application software must work through the system software in order to operate. End users work primarily with application software. Each type of software must be specially designed to a specific machine to ensure its compatibility.

System Software and PC Operating Systems

System software coordinates the various parts of the computer system and mediates between application software and computer hardware. The system software that manages and controls the computer's activities is called the **operating system.** Other system software consists of computer language translation programs that convert programming languages into machine language that can be understood by the computer and utility programs that perform common processing tasks.

operating system
The system software that manages and controls the activities of the computer.

The operating system is the computer system's chief manager. The operating system allocates and assigns system resources, schedules the use of computer resources and computer jobs, and monitors computer system activities. The operating system provides locations in primary memory for data and programs, and controls the input and output devices, such as printers, terminals, and telecommunication links. The operating system also coordinates the scheduling of work in various areas of the computer so that different parts of different jobs can be worked on at the same time. Finally, the operating system keeps track of each computer job and may also keep track of who is using the system, of what programs have been run, and of any unauthorized attempts to access the system. Operating system capabilities, such as multiprogramming, virtual storage, time-sharing, and multiprocessing, enable the computer to handle many different tasks and users at the same time. Table 6-3 describes these capabilities.

Language Translation and Utility Software

System software includes special language translator programs that translate high-level language programs written in programming languages, such as COBOL, FORTRAN, or C, into machine language that the computer can execute. The program in the high-level language before translation into machine language is called **source code.** A **compiler** translates source code into machine code called *object code*, which is linked to other object code modules and then executed by the computer. Some programming languages, such as BASIC, do not use a

source code
Program instructions written in a high-level language that must be translated into machine language to be executed by the computer.

compiler
Special system software that translates a high-level language into machine language for execution by the computer.

TABLE 6-3 *Operating System Capabilities*

Operating System Capability	Description
Multiprogramming	Multiple programs can share a computer system's resources at any one time through concurrent use of the CPU. Only one program is actually using the CPU at any given moment, but the input/output needs of other programs can be serviced at the same time.
Virtual storage	Handles programs more efficiently by breaking down the programs into tiny sections that are read into memory only when needed. The rest of each program is stored on disk until it is required. Virtual storage allows very large programs to be executed by small machines, or a large number of programs to be executed concurrently by a single machine.
Time-sharing	Allows many users to share computer processing resources simultaneously by allocating each of thousands of users a tiny slice of computer time to perform computing tasks and transferring processing from user to user. This arrangement permits many users to be connected to a CPU simultaneously, with each receiving only a tiny amount of CPU time.
Multiprocessing	Links together two or more CPUs to work in parallel in a single computer system. The operating system can assign multiple CPUs to execute different instructions from the same program or from different programs simultaneously, dividing the work between the CPUs.

compiler but an *interpreter*, which translates each source code statement one at a time into machine code as it executes.

System software includes *utility programs* for routine, repetitive tasks, such as copying, clearing primary storage, computing a square root, or sorting. Utility programs can be shared by all users of a computer system and can be used in many different information system applications when requested.

PC Operating Systems and Graphical User Interfaces

Like any other software, PC software is based on specific operating systems and computer hardware. Software written for one PC operating system generally cannot run on another. Table 6-4 compares the leading PC operating systems: Windows XP, Windows 2000, Windows Server 2003, Windows 98 and Windows Me, Windows CE, UNIX, Linux, the Macintosh operating system, and DOS.

When a user interacts with a computer, including a PC, the interaction is controlled by an operating system. A user communicates with an operating system through the user interface of that operating system. Contemporary PC operating systems use a **graphical user interface,** often called a **GUI,** which makes extensive use of icons, buttons, bars, and boxes to perform tasks. It has become the dominant model for the user interface of PC operating systems and for many types of application software.

graphical user interface (GUI)
The part of an operating system users interact with that uses graphic icons and the computer mouse to issue commands and make selections.

Microsoft's Windows family of operating systems provides a streamlined graphical user interface that arranges icons to provide instant access to common tasks. They can perform multiple programming tasks simultaneously and have powerful networking capabilities, including the capability to integrate fax, e-mail, and scheduling programs. They include tools for group collaboration, accessing information from the Internet, and creating and storing Web pages. **Windows XP** (for eXPerience), the most recent Windows operating system, is reliable, robust, and relatively easy to use. The Windows XP Home Edition is for home users and the Windows XP Professional Edition targets mobile and business users. **Windows 98** and *Windows Me* are earlier versions of this operating system for home users.

Windows XP
Powerful Windows operating system that provides reliability, robustness, and ease of use for both corporate and home PC users.

Windows 98
Earlier version of the Windows operating system that is closely integrated with the Internet.

Windows 2000 is used as an operating system for high-performance desktop and laptop computers and for network servers. Windows operating systems for network servers provide network management functions, including tools for creating and operating Web sites and other Internet services. In addition to Windows 2000, they include **Windows Server 2003,** the most recent Windows server product, and *Windows NT*, which is an earlier version of this software. There are multiple editions of these server operating systems to meet the needs of small businesses, medium and large businesses, and businesses that have massive computer

Windows 2000
Windows operating system for high-performance PCs and network servers. Supports networking, multitasking, multiprocessing, and Internet services.

Windows Server 2003
Most recent Windows operating system for servers.

TABLE 6-4 *Leading PC Operating Systems*

Operating System	Features
Windows XP	Reliable, robust operating system for powerful PCs with versions for both home and corporate users. Features support of the Internet, multimedia, and group collaboration, along with powerful networking, security, and corporate management capabilities.
Windows 2000	Operating system for PCs, workstations, and network servers. Supports multitasking, multiprocessing, intensive networking, and Internet services for corporate computing.
Windows Server 2003	Most recent Windows operating system for servers.
Windows 98/Me	Earlier versions of the Windows operating system for home users.
Windows CE	Pared-down version of the Windows operating system, including its graphical user interface, for handheld computers and wireless communication devices. Designed to run on small, handheld computers, personal digital assistants, wireless communication devices, and other information appliances.
UNIX	Used for powerful PCs, workstations, and network servers. Supports multitasking, multiuser processing, and networking. Is portable to different models of computer hardware.
Linux	Free, reliable alternative to UNIX and Windows operating systems that runs on many different types of computer hardware and can be modified by software developers.
Mac OS	Operating system for the Macintosh computer, featuring multitasking, powerful multimedia and networking capabilities, and a mouse-driven graphical user interface. Supports connecting to and publishing on the Internet.
DOS	16-bit operating system for older PCs based on the IBM PC standard. Does not support multitasking and limits the size of a program in memory to 640K.

centers and processing requirements. Windows Server 2003 has new functions to facilitate wireless connections to corporate networks, tools for Web services, and tighter links to Microsoft data management and desktop software products.

UNIX
Operating system for all types of computers, which is machine independent and supports multiuser processing, multitasking, and networking. Used in high-end workstations and servers.

UNIX is an interactive, multiuser, multitasking operating system developed by Bell Laboratories in 1969 to help scientific researchers share data. UNIX was designed to connect various machines together and is highly supportive of communications and networking. UNIX is often used on workstations and servers, and provides the reliability and scalability for running large systems on high-end servers. UNIX can run on many different kinds of computers and can be easily customized. Application programs that run under UNIX can be ported from one computer to run on a different computer with little modification.

UNIX is considered powerful but very complex, with a legion of commands. Graphical user interfaces have been developed for UNIX. UNIX also poses some security problems because multiple jobs and users can access the same file simultaneously. Vendors have developed different versions of UNIX that are incompatible, thereby limiting software portability.

Linux
Reliable and compactly designed operating system that is an offshoot of UNIX and that can run on many different hardware platforms and is available free or at very low cost. Used as alternative to UNIX and Windows NT.

Linux is a UNIX-like operating system that can be downloaded from the Internet free of charge or purchased for a small fee from companies that provide additional tools for the software. It is free, reliable, compactly designed, and capable of running on many different hardware platforms, including servers, handheld computers, and consumer electronics. Linux has become popular during the past few years among sophisticated computer users and businesses as a robust low-cost alternative to UNIX and the Windows operating systems. Major hardware and software vendors are starting to provide versions of their products that can run on Linux. The software instructions for Linux are available along with the operating system software, so software developers can modify the software to fit their particular needs. The Window on Management describes why business use of Linux is growing.

open-source software
Software that provides free access to its program code, allowing users to modify the program code to make improvements.

Linux is an example of **open-source software,** which provides all computer users with free access to its program code, so they can modify the code to fix errors or to make improvements. Open-source software, such as Linux, is not owned by any company or individual. A global network of programmers and users manages and modifies the software, usually without being paid to do so.

Microsoft Windows XP is a robust and easy-to-use operating system for corporate and home applications.

PROGRAMMING LANGUAGES AND CONTEMPORARY SOFTWARE TOOLS

Application software is primarily concerned with accomplishing the tasks of end users. Many different languages and software tools can be used to develop application software. Managers should understand which software tools and programming languages are appropriate for their organization's objectives.

Application Programming Languages for Business

The first generation of computer languages consisted of **machine language,** which required the programmer to write all program instructions in the 0s and 1s of binary code and to specify storage locations for every instruction and item of data used. Programming in machine language was a very slow, labor-intensive process. As computer hardware improved and processing speed and memory size increased, programming languages became progressively easier for humans to understand and use. From the mid-1950s to the mid-1970s, high-level programming languages emerged, allowing programs to be written with regular words using sentence-like statements.

Table 6-5 describes the major programming languages used for business and scientific work. Programmable languages for business applications include COBOL, C, C++, and Visual Basic. **COBOL (COmmon Business Oriented Language)** was developed in the early 1960s for processing large data files with alphanumeric characters (mixed alphabetic and numeric data) and for performing repetitive tasks, such as payroll. It is not well suited for complex, mathematical calculations but has been used for many business processing and reporting tasks. **C** is a powerful and efficient language developed in the early 1970s that combines machine portability with tight control and efficient use of computer resources. C is used primarily by professional programmers to create operating systems and application software, especially for PCs, and it can work on a variety of different computers. **C++** is a newer version of C that is object oriented. (See the discussion on object-oriented programming later in this section.) It has all the capabilities of C plus additional features for working with software objects. C++ is used for developing application software. **Visual Basic** is a widely used visual programming tool and environment for creating applications that run on Microsoft Windows. A **visual programming** language allows users to manipulate graphic or iconic elements to create programs. With Visual Basic, users develop programs by using a

machine language
A programming language consisting of the 1s and 0s of binary code.

COBOL (COmmon Business Oriented Language)
Programming language for business applications that can process large data files with alphanumeric characters.

C
A powerful programming language with tight control and efficiency of execution; portable across different microprocessors and used primarily with PCs.

C++
Object-oriented version of the C programming language.

Visual Basic
Widely used visual programming tool and environment for creating applications that run on Microsoft Windows.

visual programming
The construction of software programs by selecting and arranging graphic or iconic elements representing sections of program code.

WINDOW ON MANAGEMENT

The Case for Linux

Unilever is a $52 billion consumer products company, producing such well-known brands as Dove soap, Lipton tea, Breyers ice cream, Hellmann's mayonnaise, and Knorr soups. After years of running disparate UNIX systems on its global servers, the company is switching to Linux and Intel-standard hardware. Because of so many disparate systems and standards, the company faced escalating hardware and systems support costs. Standardizing on Linux will help Unilever, which operates computer systems in 80 countries, to lower its infrastructure costs. Unilever does not want to have to worry about operating system or hardware compatibility issues in all those countries.

Migrating from UNIX to Linux on its e-mail servers, Web servers, and security software applications will help Unilever simplify and standardize its IT infrastructure while providing increased performance. Colin Hope-Murray, Unilever's chief technology officer (CTO), says, "Every time we put in Linux, we are amazed and surprised at its speed and the reliability with which we can run it." He says it runs about three times faster than other popular operating systems and rarely, if ever, crashes. As Linux software matures, Unilever expects to use it for running its heavy-duty data management, customer relationship management, and enterprise resource planning systems.

Other companies are realizing similar benefits from switching to Linux. Frank Pipolo, the director of Internet operations for Internetworld.com, says his company has not had to reboot its server in the two years they have been using Linux. Linux has performed with such reliability that even many financial services firms are now running mission-critical systems on it. The life sciences industry, including hospitals, biotechnology firms, individual physicians, and government laboratories, has been attracted to Linux because of its need to integrate data from thousands of sources. Linux provides an open-standards–based technology that can be used for this purpose.

The major hardware and software vendors, including IBM, Hewlett-Packard, Dell, Compaq, Oracle, and SAP, now offer Linux-compatible versions of their products. About 25 countries have governmental initiatives promoting Linux and other open-source software, attracted by this operating system's reliability and low cost. China has adopted Linux as the mainstream operating system for its server computers, and the German government has turned to Linux to avoid being locked into a specific proprietary system. Linux continues to improve each day because a worldwide network of open-source programmers keeps developing new features and capabilities. Recent upgrades will make Linux easier to use for accessing large amounts of data and for running heavier processing loads. However, some businesses do not like the idea of having to constantly upgrade their systems when new versions of Linux come out so often.

The area of greatest success for Linux has been as a server operating system, where its use is expanding at a compounded annual rate near 30 percent. However, business application software that runs on Linux is in short supply and Linux has yet to make inroads into desktop applications. Although there are desktop productivity tools, such as Sun *StarOffice*, that work with Linux, many companies are reluctant to abandon Microsoft Office tools. Although *StarOffice* has a very low purchase price compared to Office, the costs of training end users in new desktop software may outweigh the savings from using Linux desktop tools. Linux on the desktop is confined primarily to workstations performing graphics-intensive processing.

To Think About: Should a company select Linux as an operating system for its major business applications? What are the management benefits Linux provides? What are the business as well as the technology issues that should be addressed when making that decision?

Sources: John Zipperer, "Linux Suits Up for the Enterprise," *Internet World Magazine*, April 1, 2003; Todd R. Weiss, "Unilever Dumping UNIX for Linux in Global Move," *Computerworld*, January 27, 2003; Larry Greenemeier, "Adolescent Angst," *Information Week*, June 2, 2003, and "Linux Makes Mainstream Moves, *Information Week*, January 20, 2003; Jennifer Maselli, "Linux Lags on the Desktop," *Information Week*, April 7, 2003; and Joshua Weinberger, "The One-Stop Shop?" *Baseline Magazine*, February 2003.

graphical user interface to choose and modify preselected sections of code written in the BASIC programming language.

Fourth-Generation Languages

fourth-generation language
A programming language that can be employed directly by end users or less-skilled programmers to develop computer applications more rapidly than conventional programming languages.

Fourth-generation languages consist of a variety of software tools that enable end users to develop software applications with minimal or no technical assistance or that enhance professional programmers' productivity. Fourth-generation languages tend to be nonprocedural, or less procedural, than conventional programming languages. Procedural languages require specification of the sequence of steps, or procedures, that tell the computer what to do and how to do it. Nonprocedural languages need only specify what has to be accomplished rather

TABLE 6-5 *Application Programming Languages*

Programming Language	Description
C	Used primarily by professional programmers to create operating systems and application software, especially for PCs. Combines machine portability with tight control and efficient use of computer resources and can work on a variety of different computers.
C++	Object-oriented version of C that is used for developing application software.
COBOL	Designed for business administration to process large data files with alphanumeric characters (mixed alphabetic and numeric data).
Visual Basic	Visual programming tool for creating applications running on Windows operating systems.
FORTRAN (FORmula TRANslator)	Useful for processing numeric data. Some business applications can be written in FORTRAN, but it is primarily used for scientific and engineering applications.
BASIC (Beginners All-Purpose Symbolic Instruction Code)	Developed in 1964 to teach students how to use computers. Easy to use but does few computer-processing tasks well, even though it does them all. Used primarily in education to teach programming.
Pascal	Developed in the late 1960s and used primarily in computer science courses to teach sound programming practices.
Assembly language	"Second-generation" language that is very close to machine language and is designed for a specific machine and specific microprocessors. Gives programmers great control, but it is difficult and costly to write and learn. Used primarily today in system software.

than provide details about how to carry out the task. Some of these nonprocedural languages are **natural languages** that enable users to communicate with the computer using conversational commands resembling human speech.

natural language
Nonprocedural language that enables users to communicate with the computer using conversational commands resembling human speech.

Table 6-6 shows that there are seven categories of fourth-generation languages: PC software tools, query languages, report generators, graphics languages, application generators, application software packages, and very high-level programming languages. The table shows the tools ordered in terms of ease of use by nonprogramming end users. End users are most likely to work with PC software tools and query languages. **Query languages** are software tools that provide immediate online answers to requests for information that are not predefined, such as "Who are the highest-performing sales representatives?" Query languages are often tied to data management software (described later in this chapter) and to database management systems (see Chapter 7).

query language
Software tool that provides immediate online answers to requests for information that are not predefined.

Contemporary Tools for Software Development

The need for businesses to fashion systems that are flexible or that can run over the Internet have stimulated approaches to software development based on object-oriented programming tools and new programming languages, such as Java, hypertext markup language (HTML), and eXtensible Markup Language (XML).

Object-Oriented Programming Traditional software development methods have treated data and procedures as independent components. A separate programming procedure must be written every time someone wants to take an action on a particular piece of data. The procedures act on data that the program passes to them.

Object-oriented programming combines data and the specific procedures that operate on those data into one object. The object combines data and program code. Instead of passing data to procedures, programs send a message for an object to perform an operation that is already embedded in it. (Procedures are termed *methods* in object-oriented languages.) The same message may be sent to many different objects, but each will implement that message differently. For example, an object-oriented financial application might have Customer objects sending debit and credit messages to Account objects. The Account objects in turn might maintain Cash-on-Hand, Accounts-Payable, and Accounts-Receivable objects.

object-oriented programming
An approach to software development that combines data and procedures into a single object.

TABLE 6-6 *Categories of Fourth-Generation Languages*

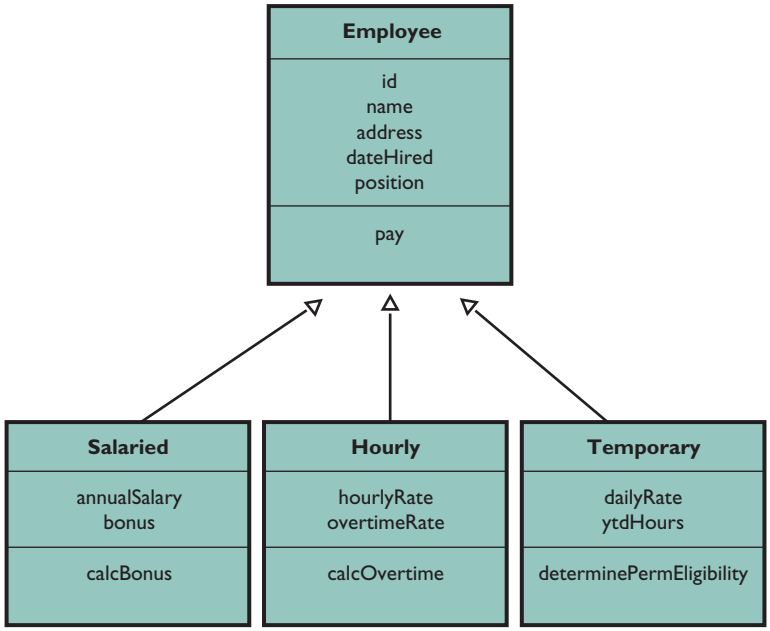
Fourth-Generation Tool	Description	Example	
PC software tools	General-purpose application software packages for PCs.	WordPerfect Microsoft Access	**Oriented toward end users**
Query language	Languages for retrieving data stored in databases or files. Capable of supporting requests for information that are not predefined.	SQL	
Report generator	Extract data from files or databases to create customized reports in a wide range of formats not routinely produced by an information system. Generally provide more control over the way data are formatted, organized, and displayed than query languages.	Crystal Reports	
Graphics language	Retrieve data from files or databases and display them in graphic format. Some graphics software can perform arithmetic or logical operations on data as well.	SAS Graph Systat	
Application generator	Contain preprogrammed modules that can generate entire applications, including Web sites, greatly speeding development. A user can specify what needs to be done, and the application generator will create the appropriate program code for input, validation, update, processing, and reporting.	FOCUS PowerBuilder Microsoft FrontPage	
Application software package	Software programs sold or leased by commercial vendors that eliminate the need for custom-written, in-house software.	PeopleSoft HCM SAP R/3	
Very high-level programming language	Generate program code with fewer instructions than conventional languages, such as COBOL or FORTRAN. Designed primarily as productivity tools for professional programmers.	APL Nomad2	**Oriented toward IS professionals**

An object's data are encapsulated from other parts of the system, so each object is an independent software building block that can be used in many different systems without changing the program code. Thus, object-oriented programming is expected to reduce the time and cost of writing software by producing program code or software chips that can be reused in other related systems. Productivity gains from object-oriented technology could be magnified if objects were stored in reusable software libraries and explicitly designed for reuse. However, such benefits are unlikely to be realized unless organizations develop appropriate standards and procedures for reuse (Kim and Stohr, 1998).

Object-oriented programming is based on the concepts of *class* and *inheritance*. Program code is not written separately for every object but for classes, or general categories, of similar objects. Objects belonging to a certain class have the features of that class. Classes of objects in turn can inherit all the structure and behaviors of a more general class and then add variables and behaviors unique to each object. New classes of objects are created by choosing an existing class and specifying how the new class differs from the existing class, instead of starting from scratch each time.

We can see how class and inheritance work in Figure 6-9, which illustrates the relationships among classes concerning employees and how they are paid. Employee is the common ancestor, or superclass for the other three classes. Salaried, Hourly, and Temporary are subclasses of Employee. The class name is in the top compartment, the attributes for each class are in the middle portion of each box, and the list of operations is in the bottom portion of each box. The features that are shared by all employees (id [identification number], name, address, date hired, position, and pay) are stored in the employee superclass, whereas each subclass stores features that are specific to that particular type of employee. Specific to Hourly employees, for example, are their hourly rates and overtime rates. A solid line pointing from the subclass to the superclass is a generalization path showing that the subclasses Salaried, Hourly, and Temporary have common features that can be generalized into the superclass Employee.

FIGURE 6-9 *Class and inheritance*



This figure illustrates how classes inherit the common features of their superclass.

Java **Java** is a platform-independent, object-oriented programming language developed by Sun Microsystems. Java software is designed to run on any computer or computing device, regardless of the specific microprocessor or operating system it uses. A Macintosh PC, an IBM PC running Windows, a Sun server running UNIX, and even a smart cellular phone or personal digital assistant can share the same Java application.

Java
Programming language that can deliver only the software functionality needed for a particular task, such as a small applet downloaded from a network; can run on any computer and operating system.

Java can be used to create miniature programs called "applets" designed to reside on centralized network servers. The network delivers only the applets required for a specific function. With Java applets residing on a network, a user can download only the software functions and data that he or she needs to perform a particular task, such as analyzing the revenue from one sales territory. The user does not need to maintain large software programs or data files on his or her desktop machine.

Java is also a very robust language that can handle text, data, graphics, sound, and video, all within one program if needed. Java applets often are used to provide interactive capabilities for Web pages, such as animated cartoons or real-time news tickers, or functionality to calculate a loan payment schedule online in response to financial data input by the user. Java can also let PC users manipulate data on networked systems using Web browsers, (described later in this chapter) reducing the need to write specialized software. Increasingly, Java is being used for more complex e-commerce and e-business applications that require communication with an organization's back-end transaction processing systems.

Despite these benefits, Java has not yet fulfilled its early promise to revolutionize software development and use. Programs written in current versions of Java tend to run slower than "native" programs, although high-performance versions of Java are under development. Vendors such as Microsoft are supporting alternative versions of Java that include subtle differences that affect Java's performance in different pieces of hardware and operating systems.

Hypertext Markup Language (HTML) and XML **Hypertext markup language (HTML)** is a page description language for creating hypertext or hypermedia documents, such as Web pages. (See the discussions of hypermedia in Chapter 7 and of Web pages in Chapter 9.) HTML uses instructions called *tags* to specify how text, graphics, video, and sound are placed on a document and to create dynamic links to other documents and objects stored in the same or remote computers. Using these links, a user need only point at

hypertext markup language (HTML)
Page description language for creating Web pages and other hypermedia documents.

a highlighted keyword or graphic, click on it, and immediately be transported to another document.

HTML programs can be custom written, but they also can be created using the HTML authoring capabilities of Web browsers or of popular word processing, spreadsheet, data management, and presentation graphics software packages. HTML editors, such as Microsoft FrontPage and Adobe GoLive, are more powerful HTML authoring tool programs for creating Web pages.

XML (eXtensible Markup Language)
General-purpose language that describes the structure of a document and supports links to multiple documents, allowing data to be manipulated by the computer. Used for both Web and non-Web applications.

XML, which stands for **eXtensible Markup Language,** is a new specification originally designed to improve usefulness of Web documents. Whereas HTML only determines how text and images should be displayed on a Web document, XML describes what the data in these documents mean so the data can be used in computer programs. In XML, a number is not simply a number; the XML tag specifies whether the number represents a price, a date, or a ZIP code. Table 6-7 illustrates the differences between HTML and XML.

By tagging selected elements of the content of documents for their meanings, XML makes it possible for computers to automatically manipulate and interpret their data and perform operations on the data without human intervention. Web browsers and computer programs, such as order processing or enterprise software, can follow programmed rules for applying and displaying the data. XML provides a standard format for data exchange.

XML is becoming a serious technology for Web-based applications. The key to XML is the setting of standards (or vocabulary) that enable both sending and receiving parties to describe data the same way. Each standard is contained in an XML Document Type Definition (DTD), usually simply called a dictionary. For example, RosettaNet is an XML dictionary developed by 34 leading companies within the PC industry. It defines all properties of a personal computer, such as modems, monitors, and cache memory. As a result, the entire PC industry is now able to speak the same language. The entire supply chain of the industry can now easily be linked without requiring business partners or customers to use a particular programming language, application, or operating system to exchange data. Companies can also use XML to access and manipulate their own internal data without high software development costs.

XHTML (Extensible Hypertext Markup Language)
Hybrid of HTML and XML that provides more flexibility than HTML.

XHTML (Extensible Hypertext Markup Language) is a hybrid combining features of HTML and XML that has been recommended as a replacement for HTML by the World Wide Web Consortium (which works with business and government to create Web standards.) XHTML reformulates HTML with XML document-type definitions, giving it additional flexibility and the ability to create Web pages that can be read by many different computing platforms and Net display devices.

Application Software Packages and Productivity Software

software package
A prewritten, precoded, commercially available set of programs that eliminates the need to write software programs for certain functions.

Much of the software used in businesses today is not custom programmed but consists of application software packages and desktop productivity tools. A **software package** is a prewritten, precoded, commercially available set of programs that eliminates the need for individuals or organizations to write their own software programs for certain functions. There are software packages for system software, but most package software is application software.

Software packages that run on mainframes and larger computers usually require professional programmers for their installation and support. However, there are also application software packages developed explicitly for end users. Productivity software packages for word

TABLE 6-7 *Comparison of HTML and XML*

Plain English	HTML	XML
Subcompact	<TITLE>Automobile</TITLE>	<AUTOMOBILETYPE="Subcompact">
4 passenger	<LI>4 passenger	<PASSENGER UNIT="PASS">4</PASSENGER>
$16,800	<LI>$16,800	<PRICE CURRENCY="USD">$16,800</PRICE>

FIGURE 6-10 *Text and the spell-checking option in Microsoft Word*

Word processing software provides many easy-to-use options to create and output a text document to meet a user's specifications.

Source: Courtesy of Microsoft.

processing, spreadsheets, data management, presentation graphics, integrated software packages, e-mail, Web browsers, and groupware are the most widely used software tools among business and consumer users.

Word Processing Software

Word processing software stores text data electronically as a computer file rather than on paper. The word processing software allows the user to make changes in the document electronically in memory. This eliminates the need to retype an entire page to incorporate corrections. The software has formatting options to make changes in line spacing, margins, character size, and column width. Microsoft Word and WordPerfect are popular word processing packages. Figure 6-10 illustrates a Microsoft Word screen displaying text, spelling and grammar checking, and major menu options.

word processing software
Software for electronically creating, editing, formatting, and printing documents.

Most word processing software has advanced features that automate other writing tasks: spelling checkers, style checkers (to analyze grammar and punctuation), thesaurus programs, and mail merge programs, which link letters or other text documents with names and addresses in a mailing list. The newest versions of this software can create and access Web pages.

Businesses that need to create highly professional looking brochures, manuals, or books will likely use desktop publishing software for this purpose. **Desktop publishing** software provides more control over the placement of text, graphics, and photos in the layout of a page than does word processing software. Adobe PageMaker and QuarkXpress are two popular desktop publishing packages.

desktop publishing software
Software for producing professional-quality documents with capabilities for design, layout, and work with graphics

Spreadsheets

Electronic **spreadsheet** software provides computerized versions of traditional financial modeling tools, such as the accountant's columnar pad, pencil, and calculator. An electronic spreadsheet is organized into a grid of columns and rows. The power of the electronic spreadsheet is evident when one changes a value or values because all other related values on the spreadsheet will be automatically recomputed.

spreadsheet
Software displaying data in a grid of columns and rows, capable of easily recalculating numerical data.

Spreadsheets are valuable for applications in which numerous calculations with pieces of data must be related to each other. Spreadsheets also are useful for applications that require modeling and what-if analysis. After the user has constructed a set of mathematical relationships, the spreadsheet can be recalculated instantaneously using a different set of assumptions. A number of alternatives can easily be evaluated by changing one or two pieces of data without having to rekey in the rest of the worksheet. Many spreadsheet packages include

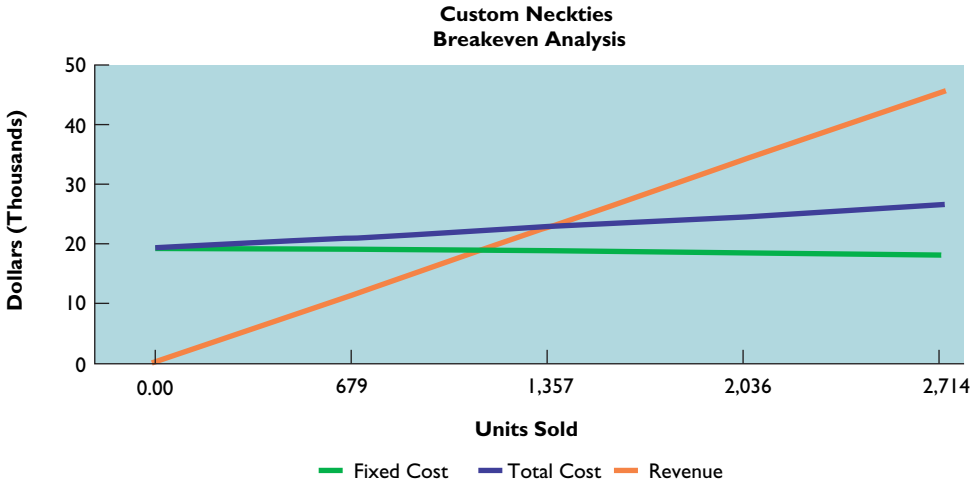
FIGURE 6-11 *Spreadsheet software*

Spreadsheet software organizes data into columns and rows for analysis and manipulation. Contemporary spreadsheet software provides graphing abilities for clear visual representation of the data in the spreadsheets. This sample break-even analysis is represented as numbers in a spreadsheet as well as a line graph for easy interpretation.

Total fixed cost	19,000.00
Variable cost per unit	3.00
Average sales price	17.00
Contribution margin	14.00
Breakeven point	1,357

Custom Neckties Pro Forma Income Statement

Units sold	0.00	679	1,357	2,036	2,714
Revenue	0	11,536	23,071	34,607	46,143
Fixed cost	19,000	19,000	19,000	19,000	19,000
Variable cost	0	2,036	4,071	6,107	8,143
Total cost	19,000	21,036	23,071	25,107	27,143
Profit/Loss	(19,000)	(9,500)	0	9,500	19,000



graphics functions that can present data in the form of line graphs, bar graphs, or pie charts. The most popular spreadsheet packages are Microsoft Excel and Lotus 1-2-3. The newest versions of this software can read and write Web files. Figure 6-11 illustrates the output from a spreadsheet for a break-even analysis and its accompanying graph.

Data Management Software

data management software
Software used for creating and manipulating lists, creating files and databases to store data, and combining information for reports.

Although spreadsheet programs are powerful tools for manipulating quantitative data, **data management software** is more suitable for creating and manipulating lists and for combining information from different files. PC database management packages have programming features and easy-to-learn menus that enable nonspecialists to build small information systems.

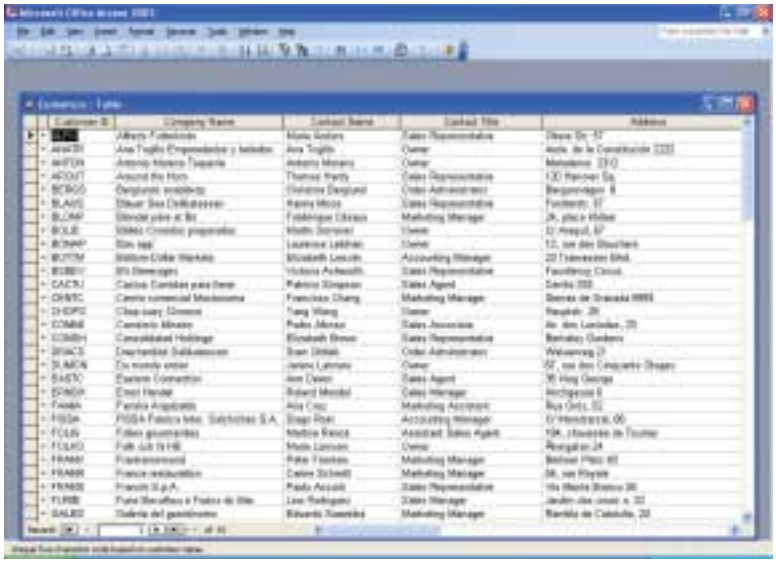
Data management software typically has facilities for creating files and databases and for storing, modifying, and manipulating data for reports and queries. A detailed treatment of data management software and database management systems can be found in Chapter 7. Popular database management software for the personal computer includes Microsoft Access, which has been enhanced to publish data on the Web. Figure 6-12 shows a screen from Microsoft Access illustrating some of its capabilities.

Presentation Graphics

presentation graphics
Software to create professional-quality graphics presentations that can incorporate charts, sound, animation, photos, and video clips.

Presentation graphics software allows users to create professional-quality graphics presentations. This software can convert numeric data into charts and other types of graphics and can include multimedia displays of sound, animation, photos, and video clips. The leading presentation graphics packages include capabilities for computer-generated slide shows and translating content for the Web. Microsoft PowerPoint, Lotus Freelance Graphics, and Aldus Persuasion are popular presentation graphics packages.

FIGURE 6-12 *Data management software*



This screen from Microsoft Access illustrates some of its powerful capabilities for managing and organizing information.

Integrated Software Packages and Software Suites

Integrated software packages combine the functions of the most important PC software packages, such as word processing, spreadsheets, presentation graphics, and data management. This integration provides a more general-purpose software tool and eliminates redundant data entry and data maintenance. For example, the break-even analysis spreadsheet illustrated in Figure 6-11 could be reformatted into a polished report with word processing software without separately keying the data into both programs. Although integrated packages can do many things well, they generally do not have the same power and depth as single-purpose packages.

integrated software package
A software package that combines two or more applications, such as word processing and spreadsheets, providing for easy transfer of data between them.

Integrated software packages should be distinguished from software suites, which are full-featured versions of application software sold as a unit. Microsoft Office is an example. There are different versions of Office for home and business users, but the core desktop tools include Word processing software; Excel spreadsheet software; Access database software; PowerPoint presentation graphics software; and Outlook, a set of tools for e-mail, scheduling, and contact management. **Office 2000** and **Office XP** contain capabilities to support

Office 2000, Office XP, and Office 2003
Integrated desktop productivity software suites with capabilities for supporting collaborative work on the Web or incorporating information from the Web into documents.

Users can create professional-looking electronic presentations incorporating text, diagrams, and other multimedia elements using presentation graphics software. This slide was created using Microsoft PowerPoint.

collaborative work on the Web, including the ability to manage multiple comments and revisions from several reviewers in a single document and the ability to automatically notify others about changes to documents. Documents created with Office tools can be viewed with a Web browser and published on the Web. Office XP users can automatically refresh their documents with information from the Web, such as stock quotes and news flashes, and manage their e-mail accounts from a single view. **Office 2003** includes tools for creating XML documents which can be linked to data in another application and for electronic note taking, as well as a Business Contact Manager customer relationship application for small businesses. Multiple Office 2003 users will be able to collaborate in the creation and revision of documents by sharing them as e-mail attachments and to control who has access to documents. Some Office 2003 capabilities are not on the desktop but must be accessed as services from the Microsoft server. *OpenOffice* (which can be downloaded over the Internet) and Sun Microsystems' *StarOffice* are low-cost alternatives to Microsoft Office tools that can run on Linux.

E-mail Software

electronic mail (e-mail)
The computer-to-computer exchange of messages.

Electronic mail (e-mail) is used for the computer-to-computer exchange of messages and is an important tool for communication and collaborative work. A person can use a networked computer to send notes or lengthier documents to a recipient on the same network or a different network. Many organizations operate their own electronic-mail systems, but communications companies, such as MCI and AT&T, offer these services, along with commercial online information services, such as America Online and public networks on the Internet.

Web browsers and PC software suites have e-mail capabilities, but specialized e-mail software packages are also available for use on the Internet. In addition to providing electronic messaging, e-mail software has capabilities for routing messages to multiple recipients, message forwarding, and attaching text documents or multimedia to messages.

Web Browsers

Web browser
An easy-to-use software tool for accessing the World Wide Web and the Internet.

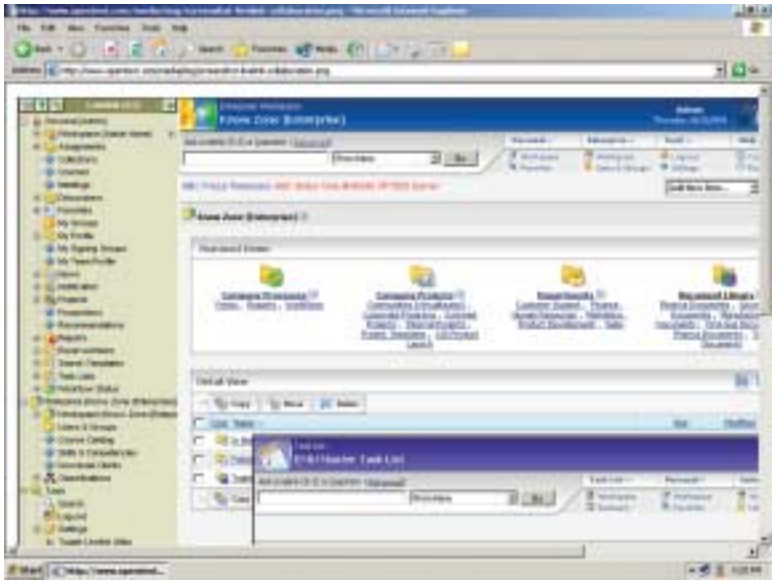
Web browsers are easy-to-use software tools for displaying Web pages and for accessing the Web and other Internet resources. Web browser software features a point-and-click graphical user interface that can be employed throughout the Internet to access and display information stored on computers at other Internet sites. Browsers can display or present graphics, audio, and video information as well as traditional text, and they allow you to click on-screen buttons or highlighted words to link to related Web sites. Web browsers have become the primary interface for accessing the Internet or for using networked systems based on Internet technology. You can see examples of Web browser software by looking at the illustrations of Web pages in each chapter of this text.

The leading commercial Web browser is Microsoft's Internet Explorer. It includes capabilities for using e-mail, file transfer, online discussion groups and bulletin boards, and other Internet services.

Groupware

groupware
Software that provides functions and services that support the collaborative activities of workgroups.

Groupware provides functions and services to support the collaborative activities of workgroups. Groupware includes software for group writing and commenting, information-sharing, electronic meetings, scheduling, and e-mail and a network to connect the members of the group as they work on their own desktop computers, often in widely scattered locations. Any group member can review the ideas of others at any time and add to them, or individuals can post a document for others to comment on or edit. Leading commercial groupware products include Lotus Notes and OpenText's LiveLink, and they have been enhanced so that they can be integrated with the Internet or private intranets. Groove is a new groupware tool based on peer-to-peer technology, which enables people to work directly with other people over the Internet without going through a central server. Business versions of Microsoft's Office 2003 software suite feature Web-based groupware services.



OpenText LiveLink provides a Web-based environment for group collaboration, with capabilities for online meeting and calendaring, storing and sharing documents, and managing project teams and work spaces.

SOFTWARE FOR ENTERPRISE INTEGRATION AND E-BUSINESS

Chapters 2 and 3 discussed the growing organizational need to integrate functions and business processes to improve control, coordination, and responsiveness by allowing data and information to flow freely between different parts of the organization. Poorly integrated applications can create costly inefficiencies or slow customer service that become competitive liabilities. Alternative software solutions are available to promote enterprise integration.

One alternative, which we introduced in Chapter 2, is to replace isolated systems that cannot exchange data with enterprise applications for customer relationship management, supply chain management, knowledge management, and enterprise systems, that integrate multiple business processes. Chapter 10 provides a detailed description of these enterprise applications and their roles in digitally integrating the enterprise.

Enterprise applications are one of many paths to achieving integration. There are also alternative software solutions that allow firms to achieve some measure of integration from their existing systems. Most firms cannot jettison all of their legacy systems and create enterprise-wide integration from scratch. A **legacy system** is a system that has been in existence for a long time and that continues to be used to avoid the high cost of replacing or redesigning it. Nor do all firms want to get rid of their existing business processes underlying their legacy systems in order to use the business processes defined by enterprise systems and other enterprise applications. Many existing legacy mainframe applications are essential to daily operations and very risky to change, and they can be made more useful if their information and business logic can be integrated with other applications. One way to integrate various legacy applications is to use special software called **middleware** to create an interface or bridge between two different systems. Middleware is software that connects two otherwise separate applications, allowing them to communicate with each other and to pass data between them. Middleware may consist of custom software written in-house or a software package.

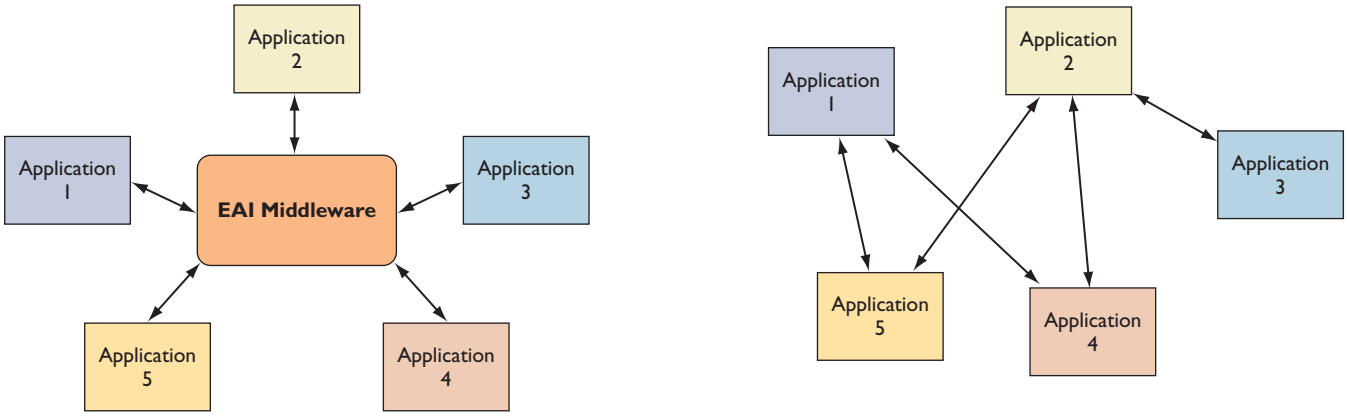
legacy system
A system that has been in existence for a long time and that continues to be used to avoid the high cost of replacing or redesigning it.

middleware
Software that connects two disparate applications, allowing them to communicate with each other and to exchange data.

Instead of custom-writing software to connect one application to another, companies can now purchase **enterprise application integration (EAI) software** to connect disparate applications or application clusters. This software uses special middleware enabling multiple systems to exchange data through a single software hub rather than building countless custom software interfaces to link each system (see Figure 6-13). There are a variety of commercial EAI software products, some featuring tools to link applications together through business process modeling. The software allows system builders to model their business processes graphically and define the rules that applications should follow to make these processes

enterprise application integration (EAI) software
Software that works with specific software platforms to tie together multiple applications to support enterprise integration.

FIGURE 6-13 *Enterprise application integration (EAI) software versus traditional integration*



EAI software (a) uses special middleware that creates a common platform through which all applications can freely communicate with each other. EAI requires much less programming than traditional point-to-point integration (b).

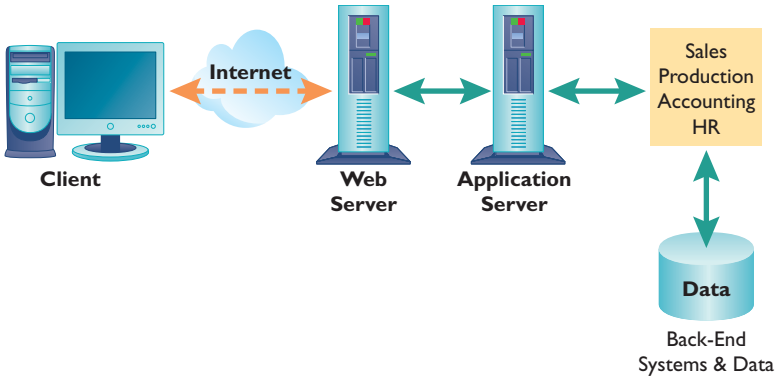
work. The software then generates the underlying program instructions to link existing applications to each other so they can exchange data via messages governed by the rules of the business processes. (An example of these rules might be "When an order has been placed, the order application should tell the accounting system to send an invoice and should tell shipping to send the order to the customer.") WebMethods, Tibco, CrossWorlds, SeeBeyond, BEA, and Vitria are leading enterprise application integration software vendors. Although EAI software does not require as extensive organizational change or programming as the software for enterprise systems, behavioral changes are still required to make this level of integration work properly (Lee, Siau, and Hong, 2003).

Enterprise application integration software tools are product specific, meaning that they can only work with certain pieces of application software and operating systems. For example, one EAI tool to connect a specific piece of sales order entry software to manufacturing, shipping, and billing applications might not work with another vendor's order entry software. Web services provide a standardized alternative for dealing with integration. **Web services** use XML and other open software and communication standards for exchanging information between two different systems, regardless of the operating systems or programming languages on which they are based. They can be used to build open standard Web-based applications linking systems of two different organizations, and they can also be used to create applications that link disparate systems within a single company. Web services are not tied to any one operating system or programming language and different applications can use them to communicate with each other in a standard way without time-consuming custom coding. For example, the health insurer Cigna Corporation created a special Web site called MyCigna.com that enables users to track claims, order medications, compare drugs and hospitals by cost, and change physicians online. Cigna uses Web services to pull out this information from a number of different computer systems. Yellow Transportation, a trucking company based in Overland, Kansas, uses Web services to provide shipping rates and schedules from its internal systems to customers connected to the Internet (Salkever, 2003). Chapter 13 provides more detail on Web services and the ways they can be used to build new information systems.

Web services
Set of universal standards using Internet technology for integrating different applications from different sources without time-consuming custom coding. Used for linking systems of different organizations or for linking disparate systems within the same organization.

Middleware also plays an important role in the infrastructure typically used for e-commerce and e-business. Review Figure 6-6, which illustrates a *two-tier client/server architecture* in which an application's interface, business logic, and data management components are split

FIGURE 6-14 *A multitiered architecture for e-commerce and e-business*



This multitiered architecture has middle layers for servicing Web page requests and for providing services to link user clients with a back-end layer of corporate systems and their data. In this particular architecture, the application server runs on its own dedicated hardware.

between client and server and the client communicates directly with the server. This had been a very popular architecture for distributed computing. However, e-commerce and e-business require much more functionality, such as the ability to access and deliver Web pages, to respond to user requests for data from a company's product catalog, to take customer orders using Web page interfaces, or even to adjust advertising on the user's display screen based on the user's characteristics. Figure 6-14 illustrates a *multitiered architecture*, which has additional middle layers between the user client layer and the back-end layer housing data management services. In the middle layers are various pieces of software for servicing requests for Web pages, for executing business logic, and for accessing data. A **Web server** is the software for locating and managing stored Web pages. It locates the Web pages requested by a user on the computer where they are stored and delivers the Web pages to the user's computer. An **application server** is middleware software that handles all application operations between a user and an organization's back-end business systems. In an Internet/intranet environment, it can be used to link the Web server to back-end systems and data repositories, supplying the business logic for handling all application operations, including transaction processing and data access. The application server takes requests from the Web server, runs the business logic to process transactions based on those requests, and provides connectivity to the organization's back-end systems. For example, such middleware would allow users to request data (such as an order) from the actual transaction system (such as an order processing system) housing the data using forms displayed on a Web browser, and it would enable the Web server to return dynamic Web pages based on information users request. The application server may reside on the same computer as the Web server or on its own dedicated computer. Application servers eliminate much of the need for custom programming, saving companies much time and cost in developing Web systems and in managing and updating them. Chapters 7 and 9 provide more detail on other pieces of software that are used in multitiered client/server architectures for e-commerce and e-business.

Web server
Software that manages requests for Web pages on the computer where they are stored and that delivers the page to the user's computer.

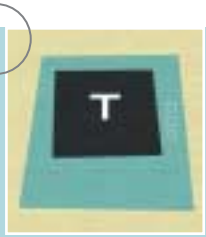
application server
Software in a mult-tiered network that provides the business logic for handling all application operations between a user and an organization's back-end business systems.

The Window on Technology provides some examples of companies using XML, Web services, and middleware tools to integrate their existing applications.

6.4 MANAGING HARDWARE AND SOFTWARE ASSETS

Selection and use of computer hardware and software technology can have a profound impact on business performance. Computer hardware and software, thus, represent important organizational assets that must be properly managed. We now describe the most important issues in managing hardware and software technology assets: understanding the new technology requirements for electronic commerce and the digital firm, determining the total cost of technology assets, and determining whether to own and maintain technology assets or use external technology service providers for the firm's IT infrastructure.

WINDOW ON TECHNOLOGY



Application Integration to the Rescue

In January 2000, Aviall, a supplier of airplane parts and components based in the Dallas–Fort Worth, Texas, area had lost control of its inventory. After Aviall installed Lawson Software to keep track of the availability and prices of the 360,000 parts it buys and sells to airplane operators, the wrong parts went to the wrong customers. In some instances, customers even received empty boxes. Aviall's price tracking software could not work with its warehouse management and inventory control software from Catalyst International, or its purchasing forecasting software from Xelus. Sales plummeted.

Joe Lacik, Aviall's recently hired CIO, was charged with finding a way to get the Lawson, Xelus, and Catalyst software to exchange data correctly and to make sure that the data could also be exchanged with data from Aviall's new customer service software from Siebel Systems and its Web commerce software from BroadVision. New Era Networks of Englewood, Colorado, a Sybase subsidiary specializing in enterprise application integration solutions, supplied Lacik with a solution. New Era Networks tools include XML-based application "adapters," which enable middleware to connect to specific enterprise applications and legacy systems without extensive programming. The adapter figures out common pieces of data among the different software systems and transfers each piece of required data between the two programs, making sure it ends up in the right place so that each program can process the data. Using the New Era middleware, Aviall was able to link the Lawson and Siebel software so that a sales representative could assure a customer that an order could be filled by pulling information on prices and parts availability from the Lawson system. Linking the Xelus and Catalyst systems eliminated the "empty box" problem by ensuring the right parts got to the right customers at the right time.

UNC Health Care, a nonprofit hospital and medical care network affiliated with the University of North Carolina, is using Web services to integrate multiple systems, including clinical systems and systems for human resources, payroll, and financial reporting. Its goal is to link into central portals all the forms and tasks required in each part of the business, and it is using IBM's WebSphere development tools to get the job done. In the past, UNC had to install and integrate an application in three steps. It had to analyze the connecting points between the applications that needed to be integrated, write the software code needed to connect the applications, and put the connections together. UNC's information systems staff can bypass the first two steps when they integrate using Web services. And if they want to install additional programs and make them interact with existing applications, they can connect them to WebSphere to make them compatible with back-end systems. However, because the new Web services make applications more interoperational, a mistake in one application could affect others more easily than if applications had been linked point to point.

To Think About: How can enterprise application integration and Web services technology provide value for organizations? What management, organization, and technology issues should be addressed when making the decision about whether to use these technologies?

Sources: Tom Steinert Threlkeld, "Outside the Box," *Baseline Magazine*, January 2003; Eileen Colkin Cuneo, "TECH-DRIVEN: How Web Services Could Change IT Jobs," *Information Week*, April 21, 2003; and "Enterprise Integration," www.sybase.com/solutions, accessed April 23, 2003.

HARDWARE TECHNOLOGY REQUIREMENTS FOR ELECTRONIC COMMERCE AND THE DIGITAL FIRM

Electronic commerce and electronic business are placing heavy new demands on hardware technology because organizations are replacing so many manual and paper-based processes with electronic ones. Much larger processing and storage resources are required to process and store the surging digital transactions flowing between different parts of the firm, and between the firm and its customers and suppliers. Many people using a Web site simultaneously place great strains on a computer system, as does hosting large numbers of interactive Web pages with data-intensive graphics or video.

capacity planning
The process of predicting when a computer hardware system becomes saturated to ensure that adequate computing resources are available for work of different priorities and that the firm has enough computing power for its current and future needs.

Capacity Planning and Scalability

Managers and information systems specialists now need to pay more attention to hardware capacity planning and scalability than they did in the past. **Capacity planning** is the process of predicting when a computer hardware system becomes saturated. It considers factors such

as the maximum number of users that the system can accommodate at one time; the impact of existing and future software applications; and performance measures, such as minimum response time for processing business transactions. Capacity planning ensures that the firm has enough computing power for its current and future needs. For example, the Nasdaq Stock Market performs ongoing capacity planning to identify peaks in the volume of stock trading transactions and to ensure it has enough computing capacity to handle large surges in volume when trading is very heavy.

Although capacity planning is performed by information systems specialists, input from business managers is essential. Business managers need to determine acceptable levels of computer response time and availability for the firm's mission-critical systems to maintain the level of business performance they expect. New applications, mergers and acquisitions, and changes in business volume all impact computer workload and must be considered when planning hardware capacity.

Scalability refers the ability of a computer, product, or system to expand to serve a large number of users without breaking down. Electronic commerce and electronic business both call for scalable IT infrastructures that have the capacity to grow with the business as the size of a Web site and number of visitors increase. Organizations must make sure they have sufficient computer processing, storage, and network resources to handle surging volumes of digital transactions and to make such data immediately available online.

scalability
The ability of a computer, product, or system to expand to serve a larger number of users without breaking down.

Total Cost of Ownership (TCO) of Technology Assets

The purchase and maintenance of computer hardware and software is but one of a series of cost components that managers must consider when selecting and managing hardware and software technology assets. The actual cost of owning technology resources includes the original cost of acquiring and installing computer hardware and software, as well as ongoing administration costs for hardware and software upgrades, maintenance, technical support, training, and even utility and real estate costs for running and housing the technology. The **total cost of ownership (TCO)** model can be used to analyze these direct and indirect costs to help firms determine the actual cost of specific technology implementations.

total cost of ownership (TCO)
Designates the total cost of owning technology resources, including initial purchase costs, the cost of hardware and software upgrades, maintenance, technical support, and training.

Hardware and software acquisition costs account for only about 20 percent of TCO, so managers must pay close attention to administration costs to understand the full cost of the firm's hardware and software. It is possible to reduce some of these administration costs through better management. The investment bank Morgan Stanley estimated that businesses spent $130 billion in the past two years on unnecessary technology expenditures (Phillips, 2002). Many large firms are saddled with redundant, incompatible hardware and software because their departments and divisions have been allowed to make their own technology purchases. Their information technology infrastructures are excessively unwieldy and expensive to administer.

These firms could reduce their TCO through greater centralization and standardization of their hardware and software resources (as did Nor-Cargo in the chapter-opening case). Companies could reduce the size of the information systems staff required to support their infrastructure if the firm minimized the number of different computer models and pieces of software that employees are allowed to use. In a centralized infrastructure, systems can be administered from a central location and troubleshooting can be performed from that location (David, Schuff, and St. Louis, 2002). Table 6-8 describes the most important TCO components to consider in a TCO analysis.

When all these cost components are considered, the TCO for a PC might run up to three times the original purchase price of the equipment. "Hidden costs" for support staff, downtime, and additional network management can make distributed client/server architectures—especially those incorporating handheld computers and wireless devices—more expensive than centralized mainframe architectures.

TABLE 6-8 *Total Cost of Ownership (TCO) Cost Components*

Hardware acquisition	Purchase price of computer hardware equipment, including computers, terminals, storage, and printers
Software acquisition	Purchase or license of software for each user
Installation	Cost to install computers and software
Training	Cost to provide training to information systems specialists and end users
Support	Cost to provide ongoing technical support, help desks, and so forth
Maintenance	Cost to upgrade the hardware and software
Infrastructure	Cost to acquire, maintain, and support related infrastructure, such as networks and specialized equipment (including storage backup units)
Downtime	Lost productivity if hardware or software failures cause the system to be unavailable for processing and user tasks
Space and energy	Real estate and utility costs for housing and providing power for the technology

RENT OR BUILD DECISIONS: USING TECHNOLOGY SERVICE PROVIDERS

Some of the most important questions facing managers are "How should we acquire and maintain our technology assets? Should we build and run them ourselves or acquire them from outside sources?" In the past, most companies built and ran their own computer facilities and developed their own software. Today, more and more companies are obtaining their hardware and software technology from external service vendors. Online services for storage and for running application software have become especially attractive options for many firms.

Online Storage Service Providers

storage service provider (SSP)
Third-party provider that rents out storage space to subscribers over the Web, allowing customers to store and access their data without having to purchase and maintain their own storage technology.

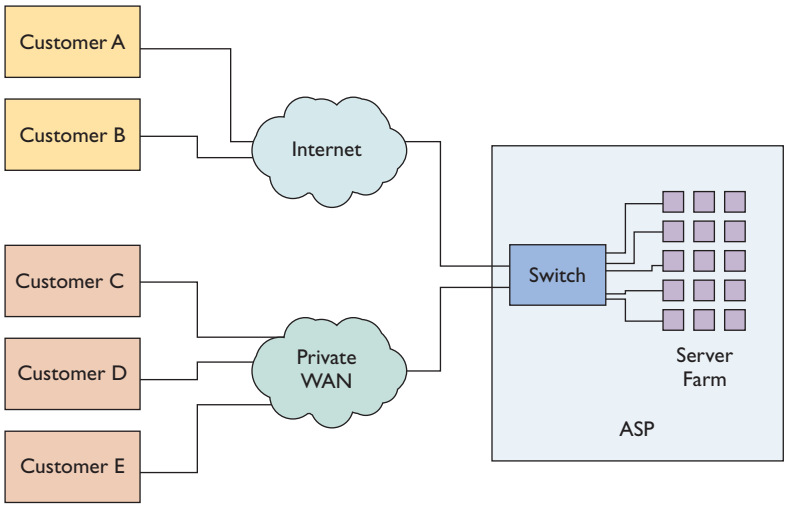
Some companies are using storage service providers (SSPs) to replace or supplement their own in-house storage infrastructure. A **storage service provider (SSP)** is a third-party provider that rents out storage space to subscribers over the Web. Storage service providers sell storage as a pay-per-use utility, allowing customers to store their data on remote computers accessed via networks without having to purchase and maintain their own storage infrastructure and storage support staff. To be successful, SSPs must offer very high availability and reliability and also must keep up with the latest technology. SSPs are responsible for monitoring the stored data and for managing their own capacity, response time, and reliability.

Application Service Providers (ASPs)

application service provider (ASP)
Company providing software that can be rented by other companies over the Web or a private network.

Section 6.2 described hardware capabilities for providing data and software programs to desktop computers and over networks. It is clear that software will be increasingly delivered and used over networks. Online application service providers (ASPs) are springing up to provide these software services over the Web and over private networks. An **application service provider (ASP)** is a business that delivers and manages applications and computer services from remote computer centers to multiple users via the Internet or a private network. Instead of buying and installing software programs, subscribing companies can rent the same functions from these services. Users pay for the use of this software either on a subscription or per transaction basis. The ASP's solution combines package software applications and all of the related hardware, system software, network, and other infrastructure services that the customer otherwise would have to purchase, integrate, and manage

FIGURE 6-15 *Model of an Application Service Provider (ASP)*



ASPs provide economies of scale by remotely running software applications for many subscribing companies. Applications are transmitted over the Internet or a private network to user client computers.

independently. The ASP customer interacts with a single entity instead of an array of technologies and service vendors.

The "time-sharing" services of the 1970s, which ran applications such as payroll on their computers for other companies, were an earlier version of this application hosting. But today's ASPs run a wider array of applications than these earlier services and deliver many of these software services over the Web. At Web-based services, servers perform the bulk of the processing and the only essential program needed by users is a desktop computer running either thin client software or a Web browser. Figure 6-15 illustrates one model of an ASP. The ASP hosts applications at its own site, often on servers in a server farm. Servers are not dedicated to specific customers but are assigned applications based on available capacity. The application is then transmitted to the customer via the Internet or a private Wide-Area Network (WAN—see Chapter 8).

Large and medium-size businesses are using ASPs for enterprise systems, sales force automation, or financial management, and small businesses are using them for functions such as invoicing, tax calculations, electronic calendars, and accounting. ASP vendors are starting to provide tools to integrate the applications they manage with clients' internal systems or with applications hosted by different vendors (McDougall, 2003).

Companies are turning to this "software service" model as an alternative to developing their own software. Some companies will find it much easier to "rent" software from another firm and avoid the expense and difficulty of installing, operating, and maintaining the hardware and software for complex systems, such as enterprise resource planning (ERP) systems (Walsh, 2003). The ASP contracts guarantee a level of service and support to ensure that the software is available and working at all times. Today's Internet-driven business environment is changing so rapidly that getting a system up and running in three months instead of six could mean the difference between success and failure. Application service providers also enable small and medium-size companies to use applications that they otherwise could not afford.

Companies considering the software service model need to carefully assess application service provider costs and benefits, weighing all management, organizational, and technology issues, including the ASP's ability to integrate with existing systems and deliver the level of service and performance it has promised (Susarla, Barua, and Whinston, 2003). In some cases, the cost of renting software can add up to more than purchasing and maintaining the application in-house. Yet there may be benefits to paying more for software through an ASP if this decision allows the company to focus on core business issues instead of technology challenges. More detail on application service providers can be found in Chapter 13.

TABLE 6-9 *Examples of Technology Service Providers*

Type of Service Provider	Description	Example
Storage service provider	Provides online access over networks to storage devices and storage area network technology.	IBM Managed Storage Services (MSS)
Application service provider	Uses centrally managed facilities to host and manage access to package applications delivered over networks on a subscription basis.	Corio Inc. offers a suite of hosted enterprise application software over a network for a fixed monthly fee.
Management service provider	Manages combinations of applications, networks, systems, storage, and security, as well as providing Web site and systems performance monitoring to subscribers over the Internet.	Totality, SevenSpace/Nuclio
Business continuity service provider	Defines and documents procedures for planning and recovering from system malfunctions that threaten vital business operations.	Comdisco disaster recovery, rapid recovery, and continuous Web availability services

Other Types of Service Providers

Other types of specialized service providers provide additional resources for helping organizations manage their technology assets. *Management service providers* can be enlisted to manage combinations of applications, networks, storage, and security, as well as to provide Web site and systems performance monitoring. *Business continuity service providers* offer disaster recovery and continuous Web availability services to help firms continue essential operations when their systems malfunction (see Chapter 15). Table 6-9 provides examples of the major types of technology service providers.

MAKE IT YOUR BUSINESS

Finance and Accounting

One of the earliest tasks assigned to computers was automating calculations for finance and accounting, and these functions have remained high-priority targets for computerization. Many application software packages for individuals as well as for large businesses support financial processes, such as corporate accounting, tax calculations, payroll processing, or investment planning. Calculating the total cost of ownership (TCO) of technology assets usually requires models and expertise supplied by finance and accounting. You can find examples of finance and accounting applications on pages 193–194, 210, and 232–233.

Human Resources

Hardware and software technologies are changing very rapidly, providing many new productivity tools to employees and powerful software packages and services for the human resources department. Employees will need frequent retraining in order to use these tools effectively. You can find examples of human resources applications on pages 232-233.

Manufacturing and Production

Many manufacturing applications are based on client/server networks, which use networked computers to control the flow of work on the factory floor. Handheld computers and bar code scanners are widely used to track items in inventory and to track package shipments. XML provides a set of standards through which all systems of participants in an industry supply chain can exchange data with each other without high expenditures for specialized translation programs and middleware. You can find examples of manufacturing and production applications on pages 193-194 and 222.

Sales and Marketing

Sales and marketing has benefited from hardware and software technologies that provide customers and sales staff with rapid access to information, responses to customer questions, and order taking. Web browser software provides an easy-to-use interface for accessing product information or placing orders over the Web, whereas e-mail software is a quick and inexpensive tool for answering customer queries. Web sites can be enhanced with Java applets that allow users to perform calculations or view interactive product demonstrations on using standard Web browser software. You can find examples of sales and marketing applications on page 222.

Utility Computing

Many of the service providers we have just described lease information technology services using long-term fixed price contracts. IBM is championing a **utility computing** model in which companies pay technology service providers only for the amount of computing power and services they use, much as they would pay for electricity. In this "pay-as-you-go" model of computing, which is sometimes called on-demand computing or usage-based pricing, customers would pay more or less for server capacity and storage, depending on how much of these resources they actually used during a specified time period. The pay-as-you-go model could help firms reduce expenditures for excess computing capacity that may only be needed during peak business periods as well as expenditures for full-time information systems support personnel, floor space, and backup computers. IBM offers a full range of usage-based services, including server capacity, storage space, software applications, and Web hosting. Other vendors, including Hewlett-Packard, Sun Microsystems, and Electronic Data Systems (EDS), also offer some utility computing services.

utility computing
Model of computing in which companies pay only for the information technology resources they actually use during a specified time period. Also called on-demand computing or usage-based pricing.

SUMMARY

1. *What computer processing and storage capability does our organization need to handle its information and business transactions?*

Managers should understand the alternative computer hardware technologies available for processing and storing information so that they can select the right technologies for their businesses. Modern computer systems have six major components: a central processing unit (CPU), primary storage, input devices, output devices, secondary storage, and communications devices. All of these components need to work together to process information for the organization. The CPU is the part of the computer where the manipulation of symbols, numbers, and letters occurs. The CPU has two components: an arithmetic-logic unit and a control unit.

The CPU is closely tied to primary memory, or primary storage, which stores data and program instructions temporarily before and after processing. Several different kinds of semiconductor memory chips are used with primary storage: RAM (random access memory) is used for short-term storage of data and program instructions, and ROM (read-only memory) permanently stores important program instructions.

Computer processing power depends in part on the speed of their microprocessors, which integrate the computer's logic and control on a single chip. Most conventional computers process one instruction at time, but computers with parallel processing can process multiple instructions simultaneously. The principal secondary storage technologies are magnetic disk, optical disk, and magnetic tape. Optical disks can store vast amounts of data compactly. CD-ROM disk systems can only be read from, but CD-RW (rewritable) optical disk systems are now available.

The principal input devices are keyboards, computer mice, touch screens, magnetic ink and optical character recognition devices, pen-based instruments, digital scanners, sensors, audio input devices, and radio-frequency identification devices. The principal output devices are cathode ray tube terminals, printers, and audio output devices. In batch processing, transactions are accumulated and stored in a group until the time when it is efficient or necessary to process them. In online processing, the user enters transactions into a device that is directly connected to the computer system. The transactions are usually processed immediately. Multimedia integrates two or more types of media, such as text, graphics, sound, voice, full-motion video, still video, and/or animation into a computer-based application.

2. *What arrangement of computers and computer processing would best benefit our organization?*

Managers should understand the capabilities of various categories of computers and arrangements of computer processing. The type of computer and arrangement of processing power that should be used by the business depends on the nature of the organization and its problems.

Computers are categorized as mainframes, midrange computers, PCs, workstations, or supercomputers. Mainframes are the largest computers; midrange computers can be minicomputers used in factory, university, or research lab systems, or servers providing software and other resources to computers on a network. PCs are desktop or laptop machines; workstations are desktop machines with powerful mathematical and graphic capabilities; and supercomputers are sophisticated, powerful computers that can perform massive and complex

computations rapidly. Because of continuing advances in microprocessor technology, the distinctions between these types of computers are constantly changing.

Computers can be networked together to distribute processing among different machines. In the client/server model of computing, computer processing is split between "clients" and "servers" connected via a network. The exact division of tasks between client and server depends on the application. Network computers are pared-down desktop machines with minimal or no local storage and processing capacity. They obtain most or all of their software and data from a central network server. Whereas network computers help organizations maintain central control over computing, peer-to-peer computing puts processing power back on users' desktops, linking individual PCs, workstations, or other computers through the Internet or private networks to share data, disk space, and processing power for a variety of tasks. Grid computing is a form of peer-to-peer computing that breaks down problems into small pieces that can run on many separate machines organized into a computational grid.

3. *What kind of software and software tools do we need to run our business? What criteria should we use to select our software technology?*

Managers should understand the capabilities of various types of software so they can select software technologies that provide the greatest benefit for their firms. There are two major types of software: system software and application software. System software coordinates the various parts of the computer system and mediates between application software and computer hardware. Application software is used by application programmers and some end users to develop specific business applications.

The system software that manages and controls the activities of the computer is called the operating system. The operating system acts as the chief manager of the information system, allocating, assigning, and scheduling system resources, and monitoring the use of the computer. Multiprogramming, multiprocessing, virtual storage, and time-sharing are operating system capabilities that enable computer system resources to be used more efficiently. Other system software includes computer-language translation programs that convert programming languages into machine language and utility programs that perform common processing tasks.

PC operating systems have developed sophisticated capabilities such as multitasking and support for multiple users on networks. Leading PC operating systems include Windows XP, Windows 98 and Windows Me, Windows Server 2003 and Windows 2000, Windows CE, UNIX, Linux, the Macintosh operating system, and DOS. PC operating systems and many kinds of application software now use graphical user interfaces.

The general trend in software is toward user-friendly, high-level languages that both increase professional programmer productivity and make it possible for end users to work directly with information systems. The principal programming languages used in business include COBOL, C, C++, and Visual Basic, and each is designed to solve specific types of problems. Fourth-generation languages are less procedural than conventional programming languages and enable end users to perform many software tasks that previously required technical specialists. They include popular PC software tools, such as word processing, spreadsheet, data management, presentation graphics, and e-mail software, along with Web browsers and groupware. Enterprise software, middleware, and enterprise application integration software are all software tools for promoting enterprise-wide integration of business processes and information system applications.

Software selection should be based on criteria such as efficiency, compatibility with the organization's technology platform, vendor support, and whether the software tool is appropriate for the problems and tasks of the organization.

4. *What new software technologies are available? How would they benefit our organization?*

Object-oriented programming tools and new programming languages such as Java, hypertext markup language (HTML), and eXtensible Markup Language (XML), can help firms create software rapidly and efficiently and produce applications based on the Internet or data in Web sites. Object-oriented programming combines data and procedures into one object, which can act as an independent software building block. Each object can be used in many different systems without changing program code.

Java is an object-oriented programming language. It can deliver precisely the software functionality needed for a particular task as a small applet that is downloaded from a network. Java can run on any computer and operating system. HTML is a page description language for creating Web pages. XML is a language for creating structured documents in which data are tagged for meanings. The tagged data in XML documents and Web pages can be manipulated and used by other computer systems. XML can thus be used to exchange data between Web sites and different legacy systems within a firm and between the systems of different partners in a supply chain.

Enterprise application integration (EAI) software and Web services can be used to integrate disparate applications. EAI software enables multiple systems to exchange data through a single hub to support new business processes without extensive custom programming, but it works with specific applications and operating systems. Web services use open standards to link disparate systems belonging to a single organization or to multiple organizations and can be used with any type of application and operating system software.

5. *How should we acquire and manage the firm's hardware and software assets?*

Computer hardware and software technology can either enhance or impede organizational performance. Both hardware and software are major organizational assets that must be carefully managed. Electronic commerce and electronic business have put new strategic emphasis on technologies that can store vast quantities of transaction data and make them immediately available online. Managers and information systems specialists need to pay special attention to hardware capacity planning and scalability to ensure that the firm has enough computing power for its current and future needs.

They also need to balance the costs and benefits of owning and maintaining their own hardware and software versus renting these assets from external service providers. Online storage service providers (SSPs) rent out storage space to subscribers over the Web, selling computer storage as a pay-per-use utility. Application service providers (ASPs) rent out software applications and computer services from remote computer centers to subscribers over the Internet or private networks. In a utility computing model, companies pay technology service providers only for the amount of computing power and services that they actually use.

Calculating the total cost of ownership (TCO) of the organization's technology assets can help provide managers with the information they need to manage these assets and decide whether to rent or own these assets. The total cost of owning technology resources includes not only the original cost of computer hardware and software but also costs for hardware and software upgrades, maintenance, technical support, and training.

Key Terms

Application server, 221
Application service provider (ASP), 224
Application software, 225
Arithmetic-logic unit (ALU), 195
Batch processing, 201
Bit, 195
Byte, 195
C, 209
C++, 209
Capacity planning, 222
CD-ROM (compact disk read-only memory), 199
CD-RW (CD-ReWritable), 199
Central processing unit (CPU), 195
Centralized processing, 203
Client, 203
Client/server computing, 203
COBOL (COmmon Business Oriented Language), 209
Compiler, 206
Computer, 194
Control unit, 196
Data management software, 216
Desktop publishing software, 215
Digital video disk (DVD), 199
Distributed processing, 203
Downsizing, 204
Electronic mail (e-mail), 218
Enterprise application integration (EAI) software, 219
Floppy disk, 198
Fourth-generation language, 210
Graphical user interface (GUI), 207
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Office 2000, Office XP, and Office 2003, 217
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Windows Server 2003, 207
Windows XP, 207
Word processing software, 215
Workstation, 203
XHTML (Extensible Hypertext Markup Language), 214
XML (eXtensible Markup Language), 214

Review Questions

1. *What are the components of a contemporary computer system?*
2. *Name the major components of the CPU and the function of each.*
3. *Distinguish between serial, parallel, and massively parallel processing.*
4. *List the most important secondary storage media. What are the strengths and limitations of each?*

5. *List and describe the major computer input and output devices.*
6. *What is the difference between batch and online processing?*
7. *What is multimedia? What technologies are involved?*
8. *What is the difference between a mainframe, a minicomputer, a server, and a PC? Between a PC and a workstation?*
9. *Compare the client/server, network computer, and peer-to-peer models of computing.*
10. *What are the major types of software? How do they differ in terms of users and uses?*
11. *What is the operating system of a computer? What does it do? What roles do multiprogramming, virtual storage, time-sharing, and multiprocessing play in the operation of an information system?*
12. *List and describe the major PC operating systems.*
13. *List and describe the major application programming languages. How do they differ from fourth-generation languages?*
14. *What is object-oriented programming? How does it differ from conventional software development?*
15. *What are Java, HTML, and XML? Compare their capabilities. Why are they becoming important?*
16. *Name and describe the most important PC productivity software tools.*
17. *Name and describe the kinds of software that can be used for enterprise integration and e-business.*
18. *List and describe the principal issues in managing hardware and software assets.*

Discussion Questions

1. *Why is selecting computer hardware and software for the organization an important management decision? What management, organization, and technology issues should be considered when selecting computer hardware?*
2. *Should organizations use application service providers (ASPs) and storage service providers (SSPs) for all their software and storage needs? Why or why not? What management, organization, and technology factors should be considered when making this decision?*

Application Software Exercise: Spreadsheet Exercise: Evaluating Computer Hardware and Software Options

You have been asked to obtain pricing information on hardware and software for an office of 30 people. Using the Internet, get pricing for 30 PC desktop systems (monitors, computers, and keyboards) manufactured by IBM, Dell, and Compaq as listed at their respective corporate Web sites. (For the purposes of this exercise, ignore the fact that desktop systems usually come with preloaded software packages.) Also obtain pricing on 15 monochrome desktop printers manufactured by Hewlett-Packard and by Xerox. Each desktop system must satisfy the minimum specifications shown in the following table:

Minimum Desktop Specifications

Processor speed (in gigahertz)	2 GHz
Hard drive (in gigabytes)	40 GB
RAM (in megabytes)	256 MB
CD-ROM speed	48 speed
Monitor (diagonal measurement)	17 inches

Each desktop printer must satisfy the minimum specifications shown in the following table:

Minimum Monochrome Printer Specifications

Print speed (pages per minute)	12
Print quality	600 x 600
Network ready?	Yes
Maximum price/unit	$1,000

After getting pricing on the desktop systems and printers, obtain pricing on 30 copies of Microsoft's Office XP or Office 2003, the most recent versions of Corel's WordPerfect Office and IBM's Lotus SmartSuite application packages, and on 30 copies of Microsoft Windows XP Professional edition. The application software suite packages come in various versions, so be sure that each package contains programs for word processing, spreadsheet analysis, database analysis, graphics preparation, and e-mail.

Prepare a spreadsheet showing your research results for the desktop systems, for the printers, and for the software. Use your spreadsheet software to determine the desktop system, printer, and software combination that will offer both the best performance and pricing per worker. Since every two workers will share one printer (15 printers/30 systems), assume only half a printer cost per worker in the spreadsheet. Assume that your company will take the standard warranty and service contract offered by each product's manufacturer.

DIRT BIKES U.S.A.:
Analyzing the Total Cost of Ownership (TCO) of Desktop Software Assets

Software requirements: Spreadsheet software
Web browser software
Electronic presentation software (optional)

Dirt Bikes would like to replace the desktop office productivity software used by its corporate administrative staff, consisting of its controller, accountant, administrative assistant, two human resources specialists, and three secretaries—a total of eight users. These employees need a suite that has word processing, spreadsheet, database, electronic presentation, and e-mail software tools. Occasionally, they would like to use these software tools to publish Web pages or to access data from the Internet. Use the Web to research and compare the pricing and capabilities of either Microsoft Office 2003 or Office XP versus Sun *StarOffice*.

1. Use your spreadsheet software to create a matrix comparing the prices of each software suite as well as their functionality. Identify the lowest-price system that meets Dirt Bikes' requirements.
2. You have learned that hardware and software purchase costs only represent part of the total cost of ownership (TCO) of technology assets and that there are additional cost components to consider. For this particular software system, assume that one-time installation costs $25 per user, one-time training will cost $100 per user, annual technical support will cost 30 percent of initial purchase costs, and annual downtime another 15 percent of purchase costs. What is the total cost of ownership of Dirt Bikes' new desktop productivity systems over a three-year period?
3. (Optional) If possible, use electronic presentation software to summarize your findings for management.

ELECTRONIC BUSINESS PROJECT:
Planning and Budgeting for a Sales Conference

The Foremost Composite Materials Company is planning a two-day sales conference for October 15–16, starting with a reception on the evening of October 14. The conference consists of all-day meetings that the entire sales force, numbering 125 sales representatives and their 16 managers, must attend. Each sales representative requires his or her own room and the company needs two common meeting rooms, one large enough to hold the entire sales force plus a few visitors (200) and the other able to hold half the force. Management has set a budget of $75,000 for the representatives' room rentals. The hotel must also have such services as overhead and computer projectors as well as business center and banquet facilities. It also should have facilities for the company reps to be able to do work in their rooms and to enjoy themselves in a swimming pool or gym facility. The company would like to hold the conference in either Miami or New Orleans.

Foremost usually likes to hold such meetings in Hilton- or Marriott-owned hotels. Use their sites, Hilton.com (www.hilton.com) and Marriott.com (www.marriott.com) to select a hotel in whichever of these cities that would enable the company to hold its sales conference within its budget. Other features you should use to help select a hotel include convenience to the airport and to areas of interest to tourists (such as New Orleans' French Quarter or Miami's South Beach) in case some employees would like to take an extra day or two to vacation. Link to the two sites' home pages, and search them to find a hotel that meets Foremost's sales conference requirements. Once you have selected the hotel, locate flights arriving the afternoon prior to the conference because the attendees will need to check in the day before and attend your reception the evening prior to the conference. Your attendees will be coming from Los Angeles (54), San Francisco (32), Seattle (22), Chicago (19), and Pittsburgh (14). Determine costs of each airline ticket from these cities. When you are finished, draw up a budget for the conference. The budget will include the cost of each airline ticket, the room cost, and $40 per attendee per day for food.

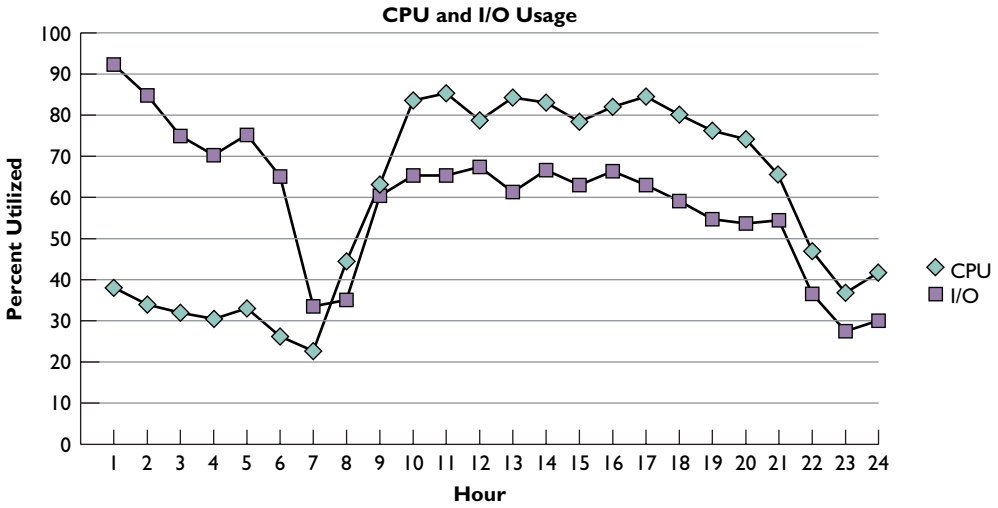
What was your final budget? Which did you select as the best hotel for the sales conference and why? How did you find the flights?

GROUP PROJECT:
Capacity Planning for E-Commerce and E-Business

Your company implemented its own electronic commerce site using its own hardware and software, and business is growing rapidly. The company Web site has not experienced any outages, and customers are always able to have requests for information or purchase transactions processed very rapidly. Your information systems department has instituted a formal operations review program that continuously monitors key indicators of system usage that affect processing

capacity and response time. The following report for management illustrates two of those indicators: daily CPU usage and daily I/O usage for the system (hours are for U.S. Eastern Standard Time I/O.) usage measures the number of times a disk has been read.

Your server supports primarily U.S. customers who access the Web site during the day and early evening. I/O usage should be kept below 70 percent if the CPU is very busy so that the CPU does not waste machine cycles looking for data. I/O usage is high between 1 A.M. and 6 A.M. because the firm backs up its data stored on disk when the CPU is not busy.



Daily CPU and I/O usage (hours are for U.S. Eastern Standard Time).

1. Anticipated e-commerce business over the next year is expected to increase CPU usage and I/O usage by 20 percent between 1 P.M. and 9 P.M. and by 10 percent during the rest of the day. Does your company have enough processing capacity to handle this increased load?
2. What would happen if your organization did not attend to capacity issues?
3. If possible, use electronic presentation software to present your findings.

CASE STUDY:
Zurich North America Hunts Down Its IT Assets

Asset management of information technology is an often-ignored specialty, but Toronto-based Zurich North America Canada has turned to it as one more area where the company is attempting to reduce its costs. Zurich North America is a leading commercial property-casualty insurance provider serving the multinational, middle market, and small business sectors in Canada and the United States. The company is the Canadian arm of Zurich North America, which in turn is a subsidiary of the Zurich Financial Services Group headquartered in Zurich, Switzerland. The Zurich group, which was established in 1872, is an insurance-based financial services provider with more than 70,000 employees in more than 60 countries around the world. It mostly handles insurance for corporations. The company has a very high credit rating—A.M. Best rates its bonds as A (excellent), and Standard & Poor's rates them as A+ (strong). Nonetheless, it encountered financial problems arising from what its CEO James J. Schiro calls "weak and fragile equity markets and record low interest rates." As a result, the company reported major financial losses in 2001 and 2002. The Canadian arm shared in these problems, which is one reason that ING Canada acquired Zurich Canada's personal property and casualty insurance operations. But Zurich Canada still needs to find ways to cut its costs.

When John Fort became Zurich North American Canada's CIO in 2002, his first task was to determine where the money was going. Like so many other companies in the 1990s, Zurich Canada's information technology procurement was decentralized, allowing different departments and groups to purchase the same items at different prices. The company's senior management did not know how its money was being spent on technology. Zurich's information systems group had not been keeping good records on its purchases so management could not tell what hardware and software had cost and for what the technology was currently being used. When Fort became CIO, Nikki Cule, who was supervisor of technology asset management, observed, "We were doing a lot of the right things but also a lot of the wrong things."

For example, two different units were purchasing software, so that while one unit purchased full office software packages for $900 each, the other unit was purchasing licenses to use the software at a price of only $200 each. In another

example, the company was licensing four separate COBOL compilers at $30,000 annually for each copy, but COBOL use was declining. In this case, an investigation revealed that the company did still need three compilers but not four, and that one investigation saved the company $30,000 each year. The company needed not only to centralize this information so that the extra expenditures could be eliminated but also someone to find out what each piece of software and hardware was used for and why it was necessary. Fort said, "Not only have we found that we don't need a particular piece of software any more," but, he continued, "we've also found that we were running jobs with it [even though] no one was using the results." And so, he concluded, "Not only are you paying for an asset, but in some cases that asset is doing something that's of no use to the organization." Centralizing not only the information on what was being purchased but also what it was used for would likely enable the company's asset management group to save thousands of dollars annually.

To make matters even worse, a lot of the hardware and software was not purchased but instead was being leased. In 1999, the then-CIO, Kerry Long, realized that a number of hardware and software assets were coming off lease, and yet the department did not know why the assets had been leased or what changes had been made that may have made a renewal of a lease unnecessary. IT did not even know what department or even which city each asset was used in or who was using it or why. The leasing companies had systems to monitor what they had leased out, and they were very willing to give this software to the companies leasing their hardware and software (in this case Zurich Canada). However, Cule said, "These tools were great at keeping track of what was important to the leasing company, but not necessarily what was important to us." Her point was this: "The kinds of information we needed weren't there." Her conclusion: "We realized the substantial cost if we didn't get our act together, so we quickly had to figure out what was off lease and how to deal with it."

The leasing companies had built their own tracking software using Lotus Notes groupware, and Zurich IT decided that its company should use the same software to build its own tracking system, which it called Zurich Asset Manager or ZAM. The reason Cule and her staff decided to use Lotus Notes was that it "was something that everybody in Zurich had access to." She saw it as a valuable tool, giving the example that "the tech support people in our Vancouver office could go into ZAM and see what was in their office, and if they switched equipment they could update the database." When they were building ZAM, Cule's group included processes to move, add, and change records on their software and hardware. The result was that, with ZAM, when something was going off lease, the staff seldom had to track the item down, find out who had it and what, if anything, it was being used for. If the IT technicians kept ZAM current, the information would be easily available. Later on, Cule estimated that the result has been that the system had become 80 to 90 percent accurate. ZAM was subsequently assigned to track fax machines, cell phones, and pagers.

The issue that Cule and her staff did have to face at first was to get ZAM to work properly, which meant to get the IT staff everywhere to use it, to keep it up-to-date, and to make changes when necessary. They had been successful in explaining its importance to the whole IT staff, so, according to Fort, "Our users are saying 'If I'm not playing the game I'm going to end up paying more than I need to pay.' So they now understand the importance of this, and they're all becoming amateur asset managers." He further observed, "They've become extremely interested in helping us do a great job of tracking assets and making sure that records are accurate. We're not all the way there yet, but at least they're on board." Cule sees herself as also having another role in ensuring people use ZAM. Her view is that, "People don't like the fact that they can't have two computers, but it costs a lot to have a laptop in addition to a desktop." So her job, as she sees it, is to play cop.

John Fort summed the whole issue up this way: "Just tracking your assets isn't good enough. You have to know why you have that asset—what value it delivers to the business. If you can't answer that question," he continued, "then you'd better find a way to answer it. You have to birddog your assets to the point of 'why.'" He concluded, "If we spend a dollar on an unnecessary compiler, that's a dollar we can't spend on something the business can really use. So it's the value quotient of the asset that we're adding to the task." Why now? It was triggered by the enormous amounts being spent on technology without understanding its value.

Fort and Cule concluded that they had learned some valuable lessons. One was that they needed to think ahead: Don't consider only the beginning, the purchase or lease. Think about what can happen in two or three years. A second lesson they learned was to put good processes in place. Without the processes, such as ZAM, things become hidden, and a lot of work will be needed to unearth that information, and probably that will never happen. They also concluded that they want to learn from others, and so, for example, they attend all the meetings of the Canadian Software Asset Management Users Group. Another lesson Fort particularly stressed is to persevere because the effort will pay for itself many times over. Cule emphasized the need to shamelessly promote your effort so that management and staff know about it and understand its value. You need to show that you are actually saving the company real dollars by your effort. Finally, Fort focused on the need for everyone to know the value of their assets: Know its shelf life, know when to replace it, when to move it on, and when to eliminate it.

Sources: David Carey, "The Case of the Elusive Assets," http://www.itworldcanada.com/, February 2003; Canadian Software Asset Management Users Group, "Company Profile," *Technology Asset Management Inc.*, April 2003; Press Release, "2002 Results and Progress on 2003 Restructuring Program," *Zurich North America*, February 27, 2003; and ING Press Release, "ING, Zurich Granted Regulatory Approvals for Strategic Alliance," http://www.ingcanada.com, January 25, 2002.

CASE STUDY QUESTIONS

1. Evaluate Zurich North America Canada using the value chain and competitive forces models. Why did IT asset management become so important to this company?
2. Why did Zurich North America have problems managing its hardware and software assets? How serious were these problems? What management, organization, and technology factors were responsible for those problems?
3. How did Zurich North America solve its asset management problem? What managerial and technology tools did it use?