PART

2

Information Technology Concepts

Chapter 3 Hardware: Input, Processing, and Output Devices

Chapter 4 Software: Systems and Application Software

Chapter 5 Database Systems and Business Intelligence

Chapter 6 Telecommunications and Networks

Chapter 7 The Internet, Intranets, and Extranets

CHAPTER

• 3 •

Hardware: Input, Processing, and Output Devices

PRINCIPLES	LEARNING OBJECTIVES
▪ **Computer hardware must be carefully selected to meet the evolving needs of the organization and its supporting information systems.**	▪ Describe the role of the central processing unit and main memory. ▪ State the advantages of multiprocessing and parallel computing systems, and provide examples of the types of problems they address. ▪ Describe the access methods, capacity, and portability of various secondary storage devices. ▪ Identify and discuss the speed, functionality, and importance of various input and output devices. ▪ Identify the characteristics of and discuss the usage of various classes of single-user and multiuser computer systems.
▪ **The computer hardware industry is rapidly changing and highly competitive, creating an environment ripe for technological breakthroughs.**	▪ Describe Moore's Law and discuss its implications for future computer hardware developments. ▪ Give an example of recent innovations in computer CPU chips, memory devices, and input/output devices.

Information Systems in the Global Economy
UB Spirits, India

UB Spirits Serves Up Success

The UB Group is a successful and growing international conglomerate based in Bangalore, India. The bright future of the conglomerate is illustrated by the rising steel and glass structures in the heart of Bangalore and known as UB City—a 7-acre high-rise business, shopping, and living community. The UB Group is invested in several industries including aviation, fertilizers, engineering, information technology, pharmaceuticals, and alcoholic beverages, or spirits. While this may sound like an unusual and even dangerous combination, the diverse business portfolio is making the UB Group billions of dollars.

The alcoholic beverage division of UB, called UB Spirits, is itself a successful international corporation made up of several successful distilleries: McDowell, Herbertsons, and Triumph Distillers and Vintners. Combined, these companies produce 140 brands, 15 of which are top-shelf classics. The brands are produced in 75 locations across India. UB Spirits dominates the Indian marketplace and ranks as the world's second largest distilled spirits corporation, with sales that exceed 60 million cases a year.

To comply with laws that control the distribution of alcoholic beverages in India and around the world, UB Spirits often must negotiate a selling price for their products with a national government. Because of this constraint, UB Spirits has to improve its profits by minimizing overhead and streamlining operations. One obvious waste of resources in the business was its outdated and bloated computer-based information systems. Each UB Spirits facility across India used its own information systems on its own servers——111 Microsoft Windows-based servers in all, which required constant attention. At the close of each month, the data from the disparate systems would be merged in a costly and lengthy process to produce corporate reports. It was clear to the decision makers at UB Spirits that if the company was going to grow, it would have to invest in a new system with state-of-the-art hardware.

As with many system overhauls, UB Spirits began by choosing an ERP software package before it decided on hardware. This is smart because different ERP solutions have varying hardware requirements. Working with IBM, the company selected SAP R/3, which includes information systems for every area of the business.

After selecting an ERP system, the company built the infrastructure on which the system would run. The main goal of the overhaul was to reduce the work required to maintain and administer the system. The company selected an IBM System i550 because it is powerful and simple to manage. The i550 server has multiple processors, up to 64 GB of memory, and up to 77 TB of disk storage. The i550 easily supports 400 UB Spirits users and 1.5 TB of corporate data. It can run all of the corporate systems and be accessed by 64 UB Spirits offices over a network.

By switching to a centralized server system, UB Spirits was able to replace 111 servers spread across India with one server located in its home office. The new system assisted UB Spirits in lowering manufacturing costs. It standardized business processes across the enterprise and accelerated monthly financial reporting. UB Spirits also reassigned 20 of its IT personnel from server administration to more productive projects.

UB Spirits found that the path to higher profits lay in centralizing its operations and investing in large, powerful servers. Other companies have found that they can accomplish more by distributing systems over many workstations in what is called grid computing. The hardware in which a business invests is intimately linked to the type of information system it implements. Creating an underlying infrastructure from hardware should support the evolving needs of the business and its information systems.

As you read this chapter, consider the following:

- How does the type of hardware a company purchases—the size and amount of computers—affect the way the company operates?
- Businesses are in constant fluctuation—growing, diversifying, acquiring, and always working to reduce costs. How do these conditions and requirements affect the purchase of the hardware on which information systems run?

Why Learn About Hardware?

Organizations invest in computer hardware to improve worker productivity, increase revenue, reduce costs, provide better customer service, speed up time-to-market, and enable collaboration among employees. Organizations that don't make wise hardware investments will be stuck with outdated equipment that is unreliable and cannot take advantage of the latest software advances. Such obsolete hardware can place an organization at a competitive disadvantage. Managers, no matter what their career field and educational background, are expected to help define the business needs that the hardware must support. In addition, managers must be able to ask good questions and evaluate options when considering hardware investments for their area of the business. Managers in marketing, sales, and human resources often help IS specialists assess opportunities to apply computer hardware and evaluate the options and features specified for the hardware. Managers in finance and accounting especially must keep an eye on the bottom line, guarding against overspending, yet be willing to invest in computer hardware when and where business conditions warrant it.

Today's use of technology is practical—it's intended to yield real business benefits, as demonstrated by UB Spirits. Employing information technology and providing additional processing capabilities can increase employee productivity, expand business opportunities, and allow for more flexibility. This chapter concentrates on the hardware component of a computer-based information system (CBIS). **Hardware** consists of any machinery (most of which uses digital circuits) that assists in the input, processing, storage, and output activities of an information system. When making hardware decisions, the overriding consideration of a business should be how hardware can support the objectives of the information system and the goals of the organization.

hardware
Any machinery (most of which uses digital circuits) that assists in the input, processing, storage, and output activities of an information system.

COMPUTER SYSTEMS: INTEGRATING THE POWER OF TECHNOLOGY

To assemble an effective and efficient system, you should select and organize components while understanding the trade-offs between overall system performance and cost, control, and complexity. For instance, in building a car, manufacturers try to match the intended use of the vehicle to its components. Racecars, for example, require special types of engines, transmissions, and tires. Selecting a transmission for a racecar requires balancing how much engine power can be delivered to the wheels (efficiency and effectiveness) with how expensive the transmission is (cost), how reliable it is (control), and how many gears it has (complexity). Similarly, organizations assemble computer systems so that they are effective, efficient, and well suited to the tasks that need to be performed.

People involved in selecting their organization's computer hardware must clearly understand current and future business requirements so they can make informed acquisition decisions. Consider the following examples of applying business knowledge to reach critical hardware decisions.

As auto manufacturers must match the intended use of a vehicle to its components, so too must business managers select the hardware components of an effective information system.

(Source: © Mark Jenkinson/ CORBIS.)

- Bosch Security Products provides and maintains physical security systems to control access and detect intrusions for the secure locations of large organizations such as the Dutch Army. For a single customer, Bosch might perform preventive maintenance on thousands of components to ensure that its system is working properly. Service technicians used to rely on a paper-intensive process that required them to fill out forms on the status of each device. The process was error prone and could not provide customers with the comprehensive reports they needed to verify that all necessary repairs and replacements had been completed. Maintenance technicians and their managers defined the requirements for a new and improved solution to meet the business needs. They then consulted with IS experts and chose a PDA-based device for data entry instead of a laptop device because it was lighter, easier to handle, and more resistant to rough handling.[1]
- The Iowa Health System is a network of physicians, hospitals, civic leaders, and local volunteers who serve more than 100 communities. To support patient care, it operates a multifacility Picture Archiving and Communications System in which they store and manage image data such as magnetic resonance images (MRIs). The storage capacity requirements of this system are rapidly growing to 1 million exams per year. Staff and administrators identified additional data storage needs for secure and redundant storage of patient data and to meet the United States Health Insurance Portability and Accountability Act of 1996 (HIPAA) requirements for data integrity. Taking these requirements, the IS staff selected and implemented an appropriate data storage solution that met all needs in a cost-effective manner.[2]

As these examples demonstrate, choosing the right computer hardware requires understanding its relationship to the information system and the needs of the organization. Furthermore, hardware objectives are subordinate to, but supportive of, the information system and the current and future needs of the organization.

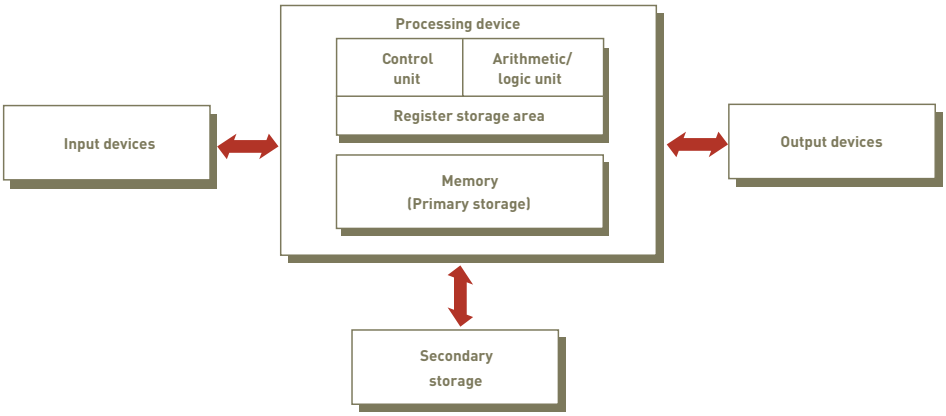
Hardware Components

Computer system hardware components include devices that perform input, processing, data storage, and output (see Figure 3.1). To understand how these hardware devices work together, consider an analogy from a paper-based office. Imagine a one-room office occupied by a single person named George. George (the processing device) can organize and manipulate data. George's mind (register storage) and his desk (primary storage) are places to temporarily store data. Filing cabinets fill the need for more permanent storage (secondary storage). In this analogy, the incoming and outgoing mail trays are sources of new data (input) or places to put the processed paperwork (output).

Figure 3.1

Hardware Components

These components include the input devices, output devices, primary and secondary storage devices, and the central processing unit (CPU). The control unit, the arithmetic/logic unit (ALU), and the register storage areas constitute the CPU.



central processing unit (CPU)
The part of the computer that consists of three associated elements: the arithmetic/logic unit, the control unit, and the register areas.

arithmetic/logic unit (ALU)
The part of the CPU that performs mathematical calculations and makes logical comparisons.

control unit
The part of the CPU that sequentially accesses program instructions, decodes them, and coordinates the flow of data in and out of the ALU, registers, primary storage, and even secondary storage and various output devices.

register
A high-speed storage area in the CPU used to temporarily hold small units of program instructions and data immediately before, during, and after execution by the CPU.

primary storage (main memory; memory)
The part of the computer that holds program instructions and data.

instruction time (I-time)
The time it takes to perform the fetch-instruction and decode-instruction steps of the instruction phase.

execution time (E-time)
The time it takes to execute an instruction and store the results.

Recall that any system must be able to process (organize and manipulate) data, and a computer system does so through an interplay between one or more central processing units and primary storage. Each **central processing unit** (**CPU**) consists of three associated elements: the arithmetic/logic unit, the control unit, and the register areas. The **arithmetic/logic unit** (**ALU**) performs mathematical calculations and makes logical comparisons. The **control unit** sequentially accesses program instructions, decodes them, and coordinates the flow of data in and out of the ALU, registers, primary storage, and even secondary storage and various output devices. **Registers** are high-speed storage areas used to temporarily hold small units of program instructions and data immediately before, during, and after execution by the CPU.

Primary storage, also called **main memory** or **memory**, is closely associated with the CPU. Memory holds program instructions and data immediately before or after the registers. To understand the function of processing and the interplay between the CPU and memory, let's examine the way a typical computer executes a program instruction.

Hardware Components in Action

Executing any machine-level instruction involves two phases: instruction and execution. During the instruction phase, a computer performs the following steps:

- **Step 1: Fetch instruction.** The computer reads the next program instruction to be executed and any necessary data into the processor.
- **Step 2: Decode instruction.** The instruction is decoded and passed to the appropriate processor execution unit. Each execution unit plays a different role: The arithmetic/logic unit performs all arithmetic operations, the floating-point unit deals with noninteger operations, the load/store unit manages the instructions that read or write to memory, the branch processing unit predicts the outcome of a branch instruction in an attempt to reduce disruptions in the flow of instructions and data into the processor, the memory-management unit translates an application's addresses into physical memory addresses, and the vector-processing unit handles vector-based instructions that accelerate graphics operations.

The time it takes to perform the instruction phase (Steps 1 and 2) is called the **instruction time** (**I-time**).

The second phase is execution. During the execution phase, a computer performs the following steps:

- **Step 3: Execute instruction.** The hardware element, now freshly fed with an instruction and data, carries out the instruction. This could involve making an arithmetic computation, logical comparison, bit shift, or vector operation.
- **Step 4: Store results.** The results are stored in registers or memory.

The time it takes to complete the execution phase (Steps 3 and 4) is called the **execution time** (**E-time**).

After both phases have been completed for one instruction, they are performed again for the second instruction, and so on. Completing the instruction phase followed by the execution phase is called a **machine cycle** (see Figure 3.2). Some processing units can speed processing by using **pipelining**, whereby the processing unit gets one instruction, decodes another, and executes a third at the same time. The Pentium 4 processor, for example, uses two execution unit pipelines. This means the processing unit can execute two instructions in a single machine cycle.

machine cycle
The instruction phase followed by the execution phase.

pipelining
A form of CPU operation in which multiple execution phases are performed in a single machine cycle.

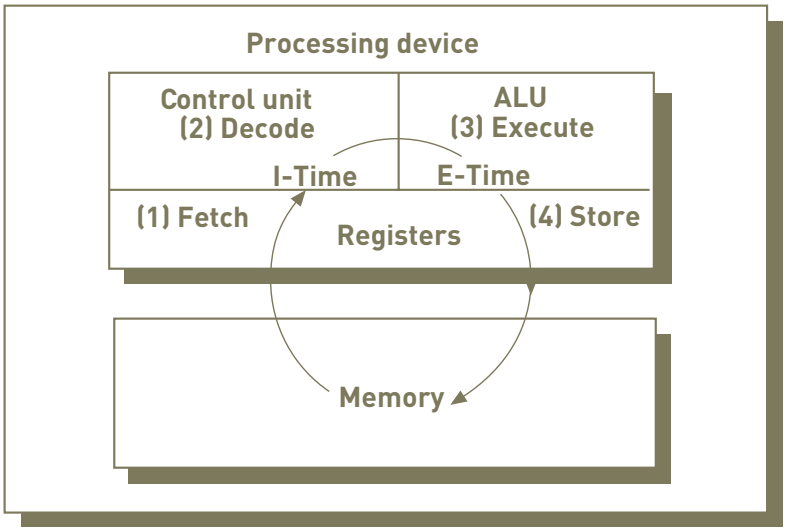


Figure 3.2

Execution of an Instruction

In the instruction phase, a program's instructions and any necessary data are read into the processor (1). Then the instruction is decoded so the central processor can understand what to do (2). In the execution phase, the ALU does what it is instructed to do, making either an arithmetic computation or a logical comparison (3). Then the results are stored in the registers or in memory (4). The instruction and execution phases together make up one machine cycle.

PROCESSING AND MEMORY DEVICES: POWER, SPEED, AND CAPACITY

The components responsible for processing—the CPU and memory—are housed together in the same box or cabinet, called the *system unit*. All other computer system devices, such as the monitor, secondary storage, and keyboard, are linked directly or indirectly into the system unit housing. In this section, we investigate the characteristics of these important devices.

Processing Characteristics and Functions

Because organizations want efficient processing and timely output, they use a variety of measures to gauge processing speed. These measures include the time it takes to complete a machine cycle and clock speed.

Machine Cycle Time

As you have seen, a computer executes an instruction during a machine cycle. The time in which a machine cycle occurs is measured in *nanoseconds* (one-billionth of 1 second) and *picoseconds* (one-trillionth of 1 second). Machine cycle time also can be measured by how many instructions are executed in 1 second. This measure, called **MIPS**, stands for millions of instructions per second. MIPS is another measure of speed for computer systems of all sizes.

MIPS
Millions of instructions per second, a measure of machine cycle time.

Clock Speed

Each CPU produces a series of electronic pulses at a predetermined rate, called the **clock speed**, which affects machine cycle time. The control unit in the CPU manages the stages of

clock speed
A series of electronic pulses produced at a predetermined rate that affects machine cycle time.

microcode
Predefined, elementary circuits and logical operations that the processor performs when it executes an instruction.

the machine cycle by following predetermined internal instructions, known as **microcode**. You can think of microcode as predefined, elementary circuits and logical operations that the processor performs when it executes an instruction. The control unit executes the microcode in accordance with the electronic cycle, or pulses of the CPU "clock." Each microcode instruction takes at least the same amount of time as the interval between pulses. The shorter the interval between pulses, the faster each microcode instruction can be executed.

Because the number of microcode instructions needed to execute a single program instruction—such as performing a calculation or printing results—can vary, the clock speed is not directly related to the true processing speed of the computer.

megahertz (MHz)
Millions of cycles per second.

gigahertz (GHz)
Billions of cycles per second.

Clock speed is often measured in **megahertz** (MHz, millions of cycles per second) or **gigahertz** (GHz, billions of cycles per second). One of the earliest microprocessors was the Intel 8080 with a clock speed of only 2 MHz. This microprocessor was used in the first IBM PC circa 1982. Twenty years later, the Pentium 4 processor had a clock speed of 3.2 GHz—1,600 times faster. Unfortunately, the faster the clock speed of the CPU, the more heat that is generated. This heat must be dissipated to avoid corruption of the data and instructions the computer is trying to process. Also, chips that run at higher temperatures need bigger heat sinks, fans, and other components to eliminate the excess heat. This increases the size of the computer, a problem for manufacturers of portable devices.

The excess heat created by a fast CPU can also be a safety issue. In the summer of 2006, Dell and Apple Computer, in conjunction with the U.S. Consumer Product Safety Commission, announced large recalls of laptop computer batteries. Additional recalls of batteries in Toshiba and Lenovo laptop computers followed. Under certain circumstances, these batteries could overheat and cause a fire or even an explosion.[3] For example, in February 2007, a battery-related fire broke out in the overhead bin of a JetBlue Airways flight. In March 2007, a battery overheated or ignited on an American Airlines aircraft. In both cases, fast-acting flight attendants quickly extinguished the fire and avoided disaster. In response to these accidents, some airlines now require that laptop users remove the computer's battery when plugged into the aircraft's power supply. Other airlines are asking passengers to be sure all loose batteries are stored in insulated bags or otherwise capped to prevent being shorted.

Chip and computer manufacturers are exploring various means to avoid heat problems in their new designs. Demand-based switching is a power management technology developed by Intel that varies the clock speed of the CPU so that it runs at the minimum speed necessary to allow optimum performance of the required operations. IBM and Hewlett-Packard (HP) are also experimenting with direct jet impingement, a technique that deploys an array of tiny nozzles and a distributed return architecture (spray water on, funnel it off) to spray cooling water on the back of the processor.

Manufacturers of portable electronic devices such as computers and cell phones are also seeking more effective sources of energy as portable devices grow increasingly power hungry. A number of companies are exploring the substitution of fuel cells for lithium ion batteries to provide additional, longer-lasting power. Fuel cells generate electricity by consuming fuel (often methanol) while traditional batteries store electricity and release it through a chemical reaction. A spent fuel cell is replenished in moments by simply refilling its reservoir or by replacing the spent fuel cartridge with a fresh one. The use of micro fuel cells based on volatile alcohol will be limited until regulatory restrictions against transporting them on aircraft are lifted.

Cell Broadband Engine Architecture (or simply Cell) is a microprocessor architecture that provides power-efficient, cost-effective, and high-performance processing for a wide range of applications. The Cell is an example of innovation across multiple organizations. A team from IBM Research joined forces with teams from IBM Systems Technology Group, Sony, and Toshiba to provide a breakthrough in performance for consumer applications. The Cell can be used as a component in high-definition displays, recording equipment, and computer entertainment systems. The first commercial application of the Cell was in the Sony PlayStation 3 game console, where it performs at the rate of 2 trillion calculations per second. Toshiba plans to incorporate Cell in high-definition (HD) TV sets. IBM plans to use Cell processors as add-on cards to enhance the performance of the IBM System z9 mainframe computers.[4]

Physical Characteristics of the CPU

Most CPUs are collections of digital circuits imprinted on silicon wafers, or chips, each no bigger than the tip of a pencil eraser. To turn a digital circuit on or off within the CPU, electrical current must flow through a medium (usually silicon) from point A to point B. The speed the current travels between points can be increased by reducing the distance between the points or reducing the resistance of the medium to the electrical current.

Reducing the distance between points has resulted in ever smaller chips, with the circuits packed closer together. In the 1960s, shortly after patenting the integrated circuit, Gordon Moore, former chairman of the board of Intel (the largest microprocessor chip maker), hypothesized that progress in chip manufacturing ought to make it possible to double the number of transistors (the microscopic on/off switches) on a chip roughly every two years. When actual results bore out his idea, the doubling of transistor densities on a single chip every two years became known as **Moore's Law**, and this "rule of thumb" has become a goal that chip manufacturers have met for over four decades. As shown in Figure 3.3, the number of transistors on a chip continues to climb.

Moore's Law
A hypothesis stating that transistor densities on a single chip double every two years.

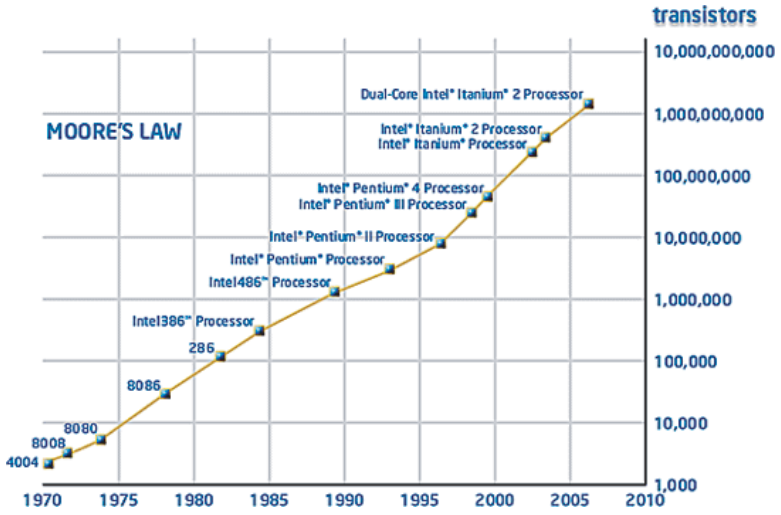


Figure 3.3

Moore's Law

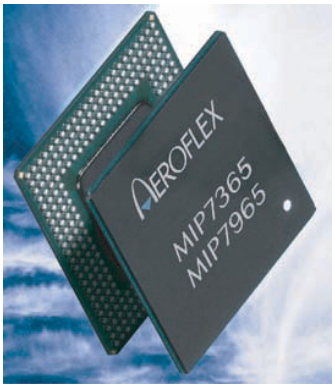
Transistor densities on a single chip double about every two years.

(Source: Intel Web site Moore's Law: Made Real by Intel Innovation, *www.intel.com/technology/mooreslaw/?iid=search*, accessed January 9, 2008.)

In what Gordon Moore touted as "the biggest change in transistor technology in 40 years,"[5] Intel created its next generation 45-nanometer (one-billionth of a meter) Penryn chip—so small that more than 2 million such transistors can fit in the period at the end of this sentence. The new Core 2 processor chips enable extremely high processing speeds at very low power usage. The design is based on a new material called "high-k." The material replaces the thin layer of silicon dioxide insulation that electrically isolates the transistor's gate from the channel through which current flows when the transistor is on.[6] Intel is on track to deliver a 32-nanometer chip in 2009.

Moore's Law enables chip makers to improve performance by putting more transistors on the same size chip and at the same time reduce the amount of power required to get work done. Furthermore, since the chips are smaller, chip manufacturers can cut more chips from a single silicon wafer and thus reduce the cost per chip. As silicon-based components and computers gain in performance, they become cheaper to produce, and therefore more plentiful, more powerful, and more a part of our everyday lives.

Intel has defined a new manufacturing strategy to introduce chips and manufacturing technologies every two years. Intel refers to this as their "tick-tock" strategy, which will drive Intel to make smaller changes to its chip designs more frequently. Intel needs this kind of continuous improvement effort to avoid getting caught off guard as it did early in the twenty-first century when AMD introduced a new chip architecture that yielded significant improvement and power efficiency over Intel chips.[7]



The Aeroflex MIP7000 family of MIPS processors provides high-performance and low-power solutions for microprocessor products.

(Source: Courtesy of Aeroflex Incorporated.)

Researchers are taking many approaches to continue to improve the performance of computers including using sophisticated tri-gate transistors, forming tiny computer circuits from carbon nanotubes only a nanometer in diameter, and extreme miniaturization using radio waves to manipulate atoms into executing a simple computer program. IBM developed technology to send information between processors using light pulses instead of electrical signals. If the technology proves practical, it could lead to microprocessors that are 100 times faster and that require one-tenth the power of today's processors.[8]

Memory Characteristics and Functions

Main memory is located physically close to the CPU, but not on the CPU chip itself. It provides the CPU with a working storage area for program instructions and data. The chief feature of memory is that it rapidly provides the data and instructions to the CPU.

Storage Capacity

Like the CPU, memory devices contain thousands of circuits imprinted on a silicon chip. Each circuit is either conducting electrical current (on) or not conducting current (off). Data is stored in memory as a combination of on or off circuit states. Usually, 8 bits are used to represent a character, such as the letter *A*. Eight bits together form a **byte (B)**. In most cases, storage capacity is measured in bytes, with 1 byte equivalent to one character of data. The contents of the Library of Congress, with over 126 million items and 530 miles of bookshelves, would require about 20 petabytes of digital storage. Table 3.1 lists units for measuring computer storage.

byte (B)
Eight bits that together represent a single character of data.

Table 3.1
Computer Storage Units

Name	Abbreviation	Number of Bytes
Byte	B	1
Kilobyte	KB	2^{10} or approximately 1,024 bytes
Megabyte	MB	2^{20} or 1,024 kilobytes (about 1 million)
Gigabyte	GB	2^{30} or 1,024 megabytes (about 1 billion)
Terabyte	TB	2^{40} or 1,024 gigabytes (about 1 trillion)
Petabyte	PB	2^{50} or 1,024 terabytes (about 1 quadrillion)
Exabyte	EB	2^{60} or 1,024 petabytes (about 1 quintillion)

Types of Memory

Computer memory can take several forms, as shown in Table 3.2. Instructions or data can be temporarily stored in and read from **random access memory (RAM)**. With the current design of RAM chips, they are volatile storage devices, meaning they lose their contents if the current is turned off or disrupted (as in a power surge, brownout, or electrical noise generated by lightning or nearby machines). RAM chips are mounted directly on the computer's main circuit board or in other chips mounted on peripheral cards that plug into the main circuit board. These RAM chips consist of millions of switches that are sensitive to changes in electric current.

random access memory (RAM)
A form of memory in which instructions or data can be temporarily stored.

Memory Type	Abbreviation	Name	Description
Volatile	**RAM**	**Random access memory**	**Volatile storage devices that lose their contents if the current is turned off or disrupted.**
	SRAM	Static Random Access Memory	Byte-addressable storage used for high-speed registers and caches.
	DRAM	Dynamic Random Access Memory	Byte-addressable storage used for the main memory in a computer.
	DDR SDRAM	Double Data Rate Synchronous Dynamic Random Access Memory	An improved form of DRAM.
Nonvolatile	**ROM**	**Read-only memory**	**Nonvolatile storage devices that do not lose their contents if the current is turned off or disrupted.**
	PROM	Programmable read-only memory	Memory used to hold data and instructions that can never be changed. PROMs are programmed in an external device like EPROMs.
	EPROM	Erasable programmable read-only memory	Programmable ROM that can be erased and reused. Erasure is caused by shining an intense ultraviolet light through a window that is designed into the memory chip. EPROM chips are initially written in an external programmer device and must be removed from the circuit board and placed back in the device for reprogramming.
	EEPROM	Electrically erasable programmable read-only memory	User-modifiable read-only memory that can be erased and reprogrammed repeatedly through the application of higher than normal electrical voltage.
	Flash		Used for storage modules for USB drives and digital camera memory cards. Able to erase a block of data in a flash.
	NOR Flash		Flash memory that supports 1-byte random access so that machine instructions can be fetched and executed directly from the flash chip just like computers fetch instructions from main memory.
	NAND Flash		Flash Translation Layer software enables NAND flash memory cards and USB drives to look like a regular disk drive to the operating system.
	FeRAM		Can hold data in memory even when the power is disconnected and offers the higher speed of SDRAM.
	PCM	Phase Change Memory	One of a number of new memory technologies that may eventually replace flash memory.
	MRAM	Magnetoresistive random access memory	A nonvolatile random access memory chip based on magnetic polarization that reads and writes data faster than flash memory.

Table 3.2
Types of Memory Chips

RAM comes in many varieties. Static Random Access Memory (SRAM) is byte-addressable storage used for high-speed registers and caches. Dynamic Random Access Memory (DRAM) is byte-addressable storage used for the main memory in a computer. Double Data Rate Synchronous Dynamic Random Access Memory (DDR SDRAM) is an improved form of DRAM that effectively doubles the rate at which data can be moved in and out of main memory. Other forms of memory include DDR2 SDRAM and DDR3 SDRAM.

Read-only memory (ROM), another type of memory, is nonvolatile, meaning that its contents are not lost if the power is turned off or interrupted. ROM provides permanent storage for data and instructions that do not change, such as programs and data from the computer manufacturer, including the instructions that tell the computer how to start up when power is turned on.

read-only memory (ROM)
A nonvolatile form of memory.

Chip manufacturers are competing to develop a nonvolatile memory chip that requires minimal power, offers extremely fast write speed, and can store data accurately even after a large number of write-erase cycles. Such a chip could eliminate the need for RAM and simplify and speed up memory processing.[9] PCM, FeRAM, and MRAM are three potential approaches to provide such a memory device.

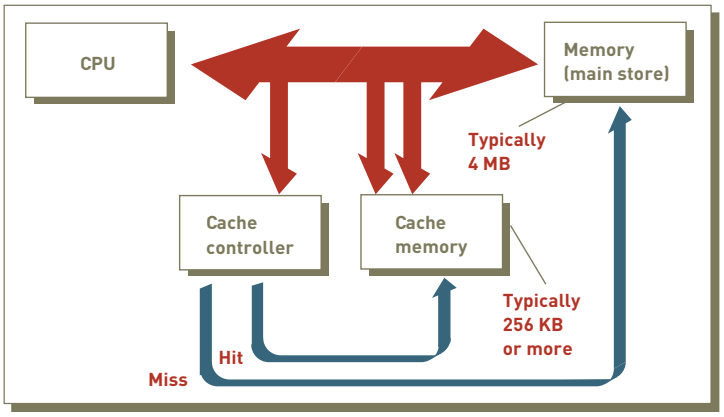
cache memory
A type of high-speed memory that a processor can access more rapidly than main memory.

Although microprocessor speed has doubled every 24 months over the past decade, memory performance has not kept pace. In effect, memory has become the principal bottleneck to system performance. The use of **cache memory**, a type of high-speed memory that a processor can access more rapidly than main memory (see Figure 3.4), helps to ease this bottleneck. Frequently used data is stored in easily accessible cache memory instead of slower memory such as RAM. Because cache memory holds less data, the CPU can access the desired data and instructions more quickly than selecting from the larger set in main memory. Thus, the CPU can execute instructions faster, improving the overall performance of the computer system. Cache memory is available in three forms. The Level 1 (L1) cache is on the CPU chip. The Level 2 (L2) cache memory can be accessed by the CPU over a high-speed dedicated interface. The latest processors go a step further and place the L2 cache directly on the CPU chip itself and provide high-speed support for a tertiary Level 3 (L3) external cache.

Figure 3.4

Cache Memory

Processors can access this type of high-speed memory faster than main memory. Located on or near the CPU chip, cache memory works with main memory. A cache controller determines how often the data is used, transfers frequently used data to cache memory, and then deletes the data when it goes out of use.



When the processor needs to execute an instruction, the instruction's operation code indicates whether the data will be in a register or in memory. If the operation code specifies a register as the source, it is taken from there. Otherwise, the processor looks for the data in the L1 cache, then the L2 cache, and then the L3 cache. If the data is not in any cache, the CPU requests the data from main memory. If the data is not even stored in main memory, the system has to retrieve the data from secondary storage. It can take from one to three clock cycles to fetch information from the L1 cache, while the CPU waits and does nothing. It takes 6 to 12 cycles to get data from an L2 cache on the processor chip. It can take dozens of cycles to fetch data from an L3 cache and hundreds of cycles to fetch data from secondary storage. Because this hierarchical arrangement of memory helps the CPU find data faster, it bridges a widening gap between processor speeds, which are increasing at roughly 50 percent per year, and DRAM access rates, which are climbing at only 5 percent per year.

Memory capacity contributes to the effectiveness of a CBIS. The specific applications of a CBIS determine the amount of memory required for a computer system. For example, complex processing problems, such as computer-assisted product design, require more memory than simpler tasks such as word processing. Also, because computer systems have different types of memory, they might need other programs to control how memory is accessed and used. In other cases, the computer system can be configured to maximize memory usage. Before purchasing additional memory, an organization should address all these considerations.

Multiprocessing

Generally, **multiprocessing** involves the simultaneous execution of two or more instructions at the same time. One form of multiprocessing uses coprocessors. A **coprocessor** speeds processing by executing specific types of instructions while the CPU works on another processing activity. Coprocessors can be internal or external to the CPU and can have different clock speeds than the CPU. Each type of coprocessor performs a specific function. For example, a math coprocessor chip speeds mathematical calculations, and a graphics coprocessor chip decreases the time it takes to manipulate graphics.

multiprocessing
The simultaneous execution of two or more instructions at the same time.

coprocessor
The part of the computer that speeds processing by executing specific types of instructions while the CPU works on another processing activity.

A **multicore microprocessor** combines two or more independent processors into a single computer so that they can share the workload and boost processing capacity. In addition, a dual-core processor enables people to perform multiple tasks simultaneously, such as playing a game and burning a CD. The use of low clock speed, multicore processors with a shared cache (rather than separate dedicated caches for each processor core) is another approach to reduce the heat generated by the computer without reducing its processing power. For example, the Intel Dual Core processor runs at 1.66 MHz compared to the single core Pentium 4 processor, which runs at 3.2 GHz. AMD and Intel are battling for leadership in the multicore processor marketplace.

multicore microprocessor
A microprocessor that combines two or more independent processors into a single computer so they can share the workload and improve processing capacity.

Both Intel and AMD have improved on dual processors by introducing new quad-core chips. However, a major need for basic research in computer science is to develop software that can actually take advantage of four processors. The processor manufacturers are working with software developers to create new multithreaded applications and next-generation games that will use the capabilities of the quad-core processor. "Industry has basically thrown a Hail Mary," warns David Patterson, a pioneering computer scientist at the University of California, Berkeley, referring to the hardware shift. "The whole industry is betting on parallel computing. They've thrown it, but the big problem is catching it."[10]

Multicore systems are most effective when they run programs that can split their workload among multiple CPUs. Such applications include working with large databases and multimedia. Intel has introduced Viiv (rhymes with five), a marketing initiative that combines Intel products including the Core 2 Quad processor with additional hardware and software to build an extremely powerful multimedia computer capable of running the highly processing-intensive applications associated with high-definition entertainment, including the following:[11]

- Full 1080P video playback of movie clips, media streams, and HD video cameras
- High-quality audio for surround-sound capabilities from movies and music
- Fast, extremely high-quality photo editing, retouching, and publishing
- Capability to watch, record, and pause live TV

AMD has countered with its new quad-core Opteron processor. AMD also plans to catch up to Intel by building its first 45-nanometer chips in 2008.[12] AMD is counting on a project it calls Fusion, which will combine a graphics processing unit and a CPU on the same chip, and is expected in late 2008.[13]

When selecting a CPU, organizations must balance the benefits of processing speed with energy requirements and cost. CPUs with faster clock speeds and shorter machine cycle times require more energy to dissipate the heat generated by the CPU and are bulkier and more expensive than slower ones.

Parallel Computing

Parallel computing is the simultaneous execution of the same task on multiple processors to obtain results faster. Systems with thousands of such processors are known as **massively parallel processing systems**. The processors might communicate with one another to coordinate when executing a computer program, or they might run independently of one another but under the direction of another processor that distributes the work to the other processors and collects their processing results. The dual-core processors mentioned earlier are a simple form of parallel computing.

parallel computing
The simultaneous execution of the same task on multiple processors to obtain results faster.

massively parallel processing systems
A form of multiprocessing that speeds processing by linking hundreds or thousands of processors to operate at the same time, or in parallel, with each processor having its own bus, memory, disks, copy of the operating system, and applications.

In response to higher fuel prices and the desire to reduce carbon dioxide emissions, auto manufacturers are introducing smaller models. However, consumers are concerned about the

safety of these smaller cars. To address these concerns, automobile engineers use finite element modeling and massively parallel processing computer systems to simulate crashes. Such simulations are much less expensive than using actual cars and crash dummies. Also, the speed and accuracy of the computer simulations allows for many more crash tests at an earlier stage in the design than using physical crashes with crash dummies. As a result, engineers gain confidence earlier in the design process that their car will pass federal safety standards, enabling them to bring the car to market sooner.[14]

grid computing
The use of a collection of computers, often owned by multiple individuals or organizations, to work in a coordinated manner to solve a common problem.

Grid computing is the use of a collection of computers, often owned by multiple individuals or organizations, to work in a coordinated manner to solve a common problem. Grid computing is a low-cost approach to parallel computing. The grid can include dozens, hundreds, or even thousands of computers that run collectively to solve extremely large processing problems. Key to the success of grid computing is a central server that acts as the grid leader and traffic monitor. This controlling server divides the computing task into subtasks and assigns the work to computers on the grid that have (at least temporarily) surplus processing power. The central server also monitors the processing, and if a member of the grid fails to complete a subtask, it restarts or reassigns the task. When all the subtasks are completed, the controlling server combines the results and advances to the next task until the whole job is completed.

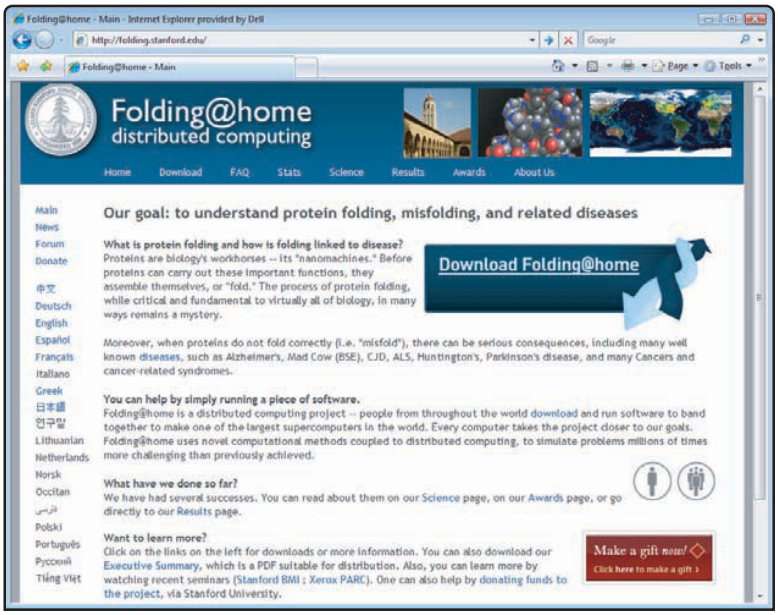
European and Asian researchers are using a grid consisting of some 40,000 computers spread across 45 countries to combat the deadly bird flu. Ulf Dahlsten, a member of the Information Society and Media Directorate-General of the European Commission, used the success of grid computing in battling this potential pandemic to point out the breakthroughs that are being made in drug discovery. "Computer grids have achieved a productivity increase of more than 6,000 percent in the identification of potential new drugs. Three hundred thousand molecules have already been screened using the grid. Of these, 123 potential inhibitors were identified, of which seven have now been shown to act as inhibitors in in-vitro laboratory tests. This is a 6 percent success rate compared to typical values of around 0.1 percent using classical drug discovery methods."[15]

Folding@home is a grid computing project with more than 1 million people around the world downloading and running software to form one of the largest supercomputers in the world. To carry out their various functions, proteins self-assemble into a particular shape in a process called "folding." The goal of the Folding@home project is to research protein folding and misfolding and gain an understanding of how this protein behavior is related to diseases such as Alzheimer's, Parkinson's, and many forms of cancer. It takes a single computer about one day to simulate a nanosecond ($1/1{,}000{,}000^{th}$ of a second) in the life of a protein. The folding process takes about 10,000 nanoseconds. Thus, 10,000 days (30 years) are required to simulate a single folding! The Folding@home group has developed ways to speed up the simulation of protein folding by dividing the work among over 100,000 processors.[16] In September 2007, with more than half a million PlayStation 3 consoles participating on the grid, the combined computing power exceeded 1×10^{15} floating-point operations per second—more than twice the speed of the world's fastest stand-alone supercomputer.[17]

The most frequent uses for parallel computing include modeling, simulation, and analyzing large amounts of data. Chrysler uses high-performance computers consisting of some 1,650 cores to simulate racecar performance and identify opportunities for improvement in the car's design and operation. The ability to develop more complete fluid dynamic models of the extreme conditions associated with vehicles traveling at 190 mph has led to improvements not only in racecars but in passenger cars as well. For example, simulations show how a racecar traveling behind another car receives restricted airflow, which can affect engine performance. This finding can be reapplied to the design of passenger cars to deal with the restricted airflow they receive when traveling behind a large truck.[18]

cloud computing
Using a giant cluster of computers to serve as a host to run applications that require high-performance computing.

Cloud computing involves using a giant cluster of computers that serves as a host to run applications that require high-performance computing. Cloud computing supports a wider variety of applications than grid computing and pools computing resources so they can be managed primarily by software rather than people. IBM and Google have provided hardware, software, and services to many universities so that students and faculty can explore cloud



By installing the Folding@home screen saver program on their personal computers, more than 1 million people around the world contribute their idle CPU time to research diseases such as Alzheimer's, Parkinson's, and many forms of cancer.

(Source: *http://folding.stanford.edu/*)

computing and massively parallel computing. For example, University of Washington students use the Google cluster to scan millions of changes made to the online encyclopedia Wikipedia to identify spam.[19] Amazon.com offers the Elastic Compute Cloud as a service that provides users with a highly expandable computing capacity for Web site development and operations.[20] Some industry observers think that Google is planning a bold move into the delivery of applications for businesses and consumers. Indeed, CEO Eric Schmidt has stated that "Most people who run small businesses would like to throw out their infrastructure and use ours for $50 per year." Several *Fortune* 1000 companies are running Google Apps pilots to test the concept of running their applications on the world's most efficient supercomputer—the Google cloud computer. Companies are asking whether Google, IBM, Amazon.com, or others can provide a cheaper, more reliable, more secure, more flexible, and more powerful alternative through cloud computing. Would effective cloud computing encourage companies to abandon large components of their IT infrastructure?[21]

SECONDARY STORAGE

Driven by factors such as needing to retain more data longer to meet government regulatory concerns, store new forms of digital data such as audio and video, and keep systems running under the onslaught of increasing volumes of e-mail, the amount of data that companies store digitally is increasing at a rate of close to 100 percent per year. As an extreme example, the Large Hadron Collider (LHC) located near Geneva, Switzerland, will be the world's largest and highest-energy particle accelerator when it becomes operational mid-2008. The LHC is an essential tool of physicists in their search for a Grand Unified Theory that would unify three of the four fundamental forces of the universe: electromagnetism, the strong force, and the weak force. Proving this theory would also explain why the remaining force, gravitation, is so weak compared to the other three forces. The LHC project is expected to produce 15 petabytes of data each year.[22]

Storing data safely and effectively is critical to an organization's success. Recognizing this, Wal-Mart operates one of the largest collections of customer data in the world to hold data from 800 million transactions generated by its 30 million customers each day. The amount of data stored is about 1 petabyte and is used to analyze in-store sales to determine the ideal mix of items and the optimal placement of products within each store to maximize sales.[23]

Jim Scantlin, Director of Enterprise Information Management, states: "At Wal-Mart, we never underestimate the importance of investing in innovative solutions that will improve our ability to understand and anticipate our customers' needs."[24]

When determining the best method of data storage, the best overall solution is likely a combination of different storage options. **Secondary storage**, also called *permanent storage*, serves this purpose.

secondary storage (permanent storage)
Devices that store larger amounts of data, instructions, and information more permanently than allowed with main memory.

Compared with memory, secondary storage offers the advantages of nonvolatility, greater capacity, and greater economy. On a cost-per-megabyte basis, most forms of secondary storage are considerably less expensive than primary memory (see Table 3.3). The selection of secondary storage media and devices requires understanding their primary characteristics—access method, capacity, and portability.

Table 3.3

Cost Comparison for Various Forms of Storage

All forms of secondary storage cost considerably less per megabyte of capacity than SDRAM, although they have slower access times. A data cartridge costs about $.21 per gigabyte, while SDRAM can cost around $49 per gigabyte—over 200 times more expensive.

(Source: Office Depot Web site, *www.officedepot.com*, January 18, 2008.)

Description	Cost	Storage Capacity (GB)	Cost Per GB
72 GB DAT 72 data cartridge	$14.95	72	$0.21
10 - 4.7 GB DVD+R disks	$9.95	47	$0.21
20 GB 4 MM backup data tape	$16.99	20	$0.85
120 GB portable hard drive	$139.99	120	$1.16
25 GB Rewritable Blu-ray disk	$29.99	25	$1.20
9.1 GB Write Once Read Many optical disk	$69.95	9.1	$7.69
1 GB flash drive	$7.99	1	$7.99
512 MB DDR2 SDRAM memory upgrade	$24.99	0.512	$48.81

As with other computer system components, the access methods, storage capacities, and portability required of secondary storage media are determined by the information system's objectives. An objective of a credit card company's information system, for example MasterCard or Visa, might be to rapidly retrieve stored customer data to approve customer purchases. In this case, a fast access method is critical. In other cases, such as equipping the Coca-Cola field salesforce with pocket-sized personal computers, portability and storage capacity might be major considerations in selecting and using secondary storage media and devices.

Storage media that allow faster access are generally more expensive than slower media. The cost of additional storage capacity and portability vary widely, but they are also factors to consider. In addition to cost and portability, organizations must address security issues to allow only authorized people to access sensitive data and critical programs. Because the data and programs kept in secondary storage devices are so critical to most organizations, all of these issues merit careful consideration.

Access Methods

sequential access
A retrieval method in which data must be accessed in the order in which it is stored.

direct access
A retrieval method in which data can be retrieved without the need to read and discard other data.

sequential access storage device (SASD)
A device used to sequentially access secondary storage data.

direct access storage device (DASD)
A device used for direct access of secondary storage data.

Data and information access can be either sequential or direct. **Sequential access** means that data must be accessed in the order in which it is stored. For example, inventory data might be stored sequentially by part number, such as 100, 101, 102, and so on. If you want to retrieve information on part number 125, you must read and discard all the data relating to parts 001 through 124.

Direct access means that data can be retrieved directly, without the need to pass by other data in sequence. With direct access, it is possible to go directly to and access the needed data—for example, part number 125—without having to read through parts 001 through 124. For this reason, direct access is usually faster than sequential access. The devices used only to access secondary storage data sequentially are simply called **sequential access storage devices** (**SASDs**); those used for direct access are called **direct access storage devices** (**DASDs**).

Devices

The most common forms of secondary storage include magnetic tapes, magnetic disks, virtual tapes, and optical discs. In general, magnetic tapes are the oldest storage medium, while optical discs are the most recent. Some of these media (magnetic tape) allow only sequential access, while others (magnetic and optical discs) provide direct and sequential access. Figure 3.5 shows one type of secondary storage media.

Figure 3.5

Secondary Storage

Secondary storage devices such as magnetic tapes and disks, optical discs, CD-ROMs, and DVDs are used to store data for easy retrieval at a later date.

(Source: Courtesy of Imation Corp.)

Magnetic Tape

Magnetic tape is a type of sequential secondary storage medium, now used primarily for storing backups. Similar to the tape found in audio- and videocassettes, magnetic tape is a Mylar film coated with iron oxide. Portions of the tape are magnetized to represent bits. If the computer needs to read data from the middle of a reel of tape, it must first pass all the tape before the desired piece of data—one disadvantage of magnetic tape. When information is needed, it can take time to retrieve the proper tape and mount it on the tape reader to get the relevant data into the computer. Despite the falling prices of hard drives, tape storage is still a popular choice for low-cost data backup for off-site storage in the event of a disaster. Not surprisingly, the U.S. federal government is the largest user of magnetic tape in the world, buying over 1 million reels of tape each year for use by such organizations as the Internal Revenue Service, National Oceanic and Atmospheric Administration, the Federal Reserve Bank, and the various branches of the military.[25]

magnetic tape
A secondary storage medium; Mylar film coated with iron oxide with portions of the tape magnetized to represent bits.

Technology is improving to provide tape storage devices with greater capacities and faster transfer speeds. In addition, the bulky tape drives used to read and write on large reels of tapes in the early days of computing have been replaced with tape cartridge devices measuring a few millimeters in diameter, requiring much less floor space and allowing hundreds of tapes to be stored in a small area.

Magnetic Disks

Magnetic disks are also coated with iron oxide; they can be thin metallic platters (hard disks, see Figure 3.6) or Mylar film (diskettes). As with magnetic tape, magnetic disks represent bits using small magnetized areas. When reading from or writing to a disk, the disk's read/write head can go directly to the desired piece of data. Thus, the disk is a direct-access storage medium. Because direct access allows fast data retrieval, this type of storage is ideal for companies that need to respond quickly to customer requests, such as airlines and credit card firms. For example, if a manager needs information on the credit history of a customer or the seat availability on a particular flight, the information can be obtained in seconds if the data is stored on a direct access storage device.

magnetic disk
A common secondary storage medium, with bits represented by magnetized areas.

Figure 3.6

Hard Disk

Hard disks provide direct access to stored data. The read/write head can move directly to the location of a desired piece of data, dramatically reducing access times as compared with magnetic tape.

(Source: Courtesy of Seagate Technology.)

Magnetic disk storage varies widely in capacity and portability. Removable magnetic disks, such as diskettes or Zip disks, are nearly obsolete. Hard disks, though

more costly and less portable, are more popular because of their greater storage capacity and quicker access time. The Iomega REV Loader 560, shown in Figure 3.7, is a storage device that holds up to eight removable 70 GB discs, each housed in a shock-resistant plastic case about the size of a 3.5-inch floppy disk. The device works well for anyone rotating off-site backups of critical data. Tape has been giving way to the external hard drive as the preferred backup medium for small businesses. However, if you need off-site copies of your data, hauling home a heavy, fragile hard drive seems less than ideal. You could use an online backup service, but for more than a few gigabytes, speed and expense become problems. Burning to DVDs might offer a solution, except a single disc holds only 4.7 GB (or 9 GB for the few people who have dual-layer drives), making capacity an issue.[26] Hitachi has announced a 500 GB 2.5-inch hard drive for portable computers.[27]

Figure 3.7

Iomega REV Loader 560

(Source: Courtesy of Iomega Corporation.)

RAID

Putting an organization's data online involves a serious business risk—the loss of critical data can put a corporation out of business. The concern is that the most critical mechanical components inside a disk storage device—the disk drives, the fans, and other input/output devices—can break (like most things that move).

redundant array of independent/inexpensive disks (RAID)
A method of storing data that generates extra bits of data from existing data, allowing the system to create a "reconstruction map" so that if a hard drive fails, the system can rebuild lost data.

Organizations now require that their data-storage devices be fault tolerant—they can continue with little or no loss of performance if one or more key components fails. A **redundant array of independent/inexpensive disks (RAID)** is a method of storing data that generates extra bits of data from existing data, allowing the system to create a "reconstruction map" so that if a hard drive fails, it can rebuild lost data. With this approach, data is split and stored on different physical disk drives using a technique called *striping* to evenly distribute the data. RAID technology has been applied to storage systems to improve system performance and reliability.

disk mirroring
A process of storing data that provides an exact copy that protects users fully in the event of data loss.

RAID can be implemented in several ways. In the simplest form, RAID subsystems duplicate data on drives. This process, called **disk mirroring**, provides an exact copy that protects users fully in the event of data loss. However, to keep complete duplicates of current backups, organizations need to double the amount of their storage capacity. Thus, disk mirroring is expensive. Other RAID methods are less expensive because they only partly duplicate the data, allowing storage managers to minimize the amount of extra disk space (or overhead) they must purchase to protect data. Optional second drives for personal computer users who need to mirror critical data are available for less than $100.

Medkinetics is a small (12 employees) business that automates collecting and submitting for approval of information about a doctor's qualifications. Jim Cox, founder and president of Medkinetics, says: "The high availability of data is also really important to us." The firm employs terabytes of inexpensive but secure RAID storage.[28]

Virtual Tape

Virtual tape is a storage technology that manages less frequently needed data so that it appears to be stored entirely on tape cartridges, although some parts might actually be located on faster hard disks. The software associated with a virtual tape system is sometimes called a *virtual tape server*. Virtual tape can be used with a sophisticated storage-management system that moves data to slower but less costly forms of storage media as people use the data less often. Virtual tape technology can decrease data access time, lower the total cost of ownership, and reduce the amount of floor space consumed by tape operations. IBM and Storage Technology are well-established vendors of virtual tape systems. One organization that uses a virtual tape system is the Girl Scouts of the USA, which operates a major data center that holds data on 4 million active members of the organization. The amount of data is roughly half a terabyte but is expected to grow at a rate of 25 percent per year as the length of time that data is kept is expanded from ten years to indefinite. The organization uses an REO 9500D virtual tape library from Overland Storage Inc. at a cost of $65,400 for 3.75 terabytes of storage capacity.[29]

virtual tape
A storage device that manages less frequently needed data so that it appears to be stored entirely on tape cartridges, although some parts of it might actually be located on faster hard disks.

Optical Discs

Another type of secondary storage medium is the **optical disc**. An optical disc is simply a rigid disk of plastic onto which data is recorded by special lasers that physically burn pits in the disk. Data is directly accessed from the disc by an optical disc device, which operates much like a stereo's compact disc player. This optical disc device uses a low-power laser that measures the difference in reflected light caused by a pit (or lack thereof) on the disc.

A common optical disc is the **compact disc read-only memory (CD-ROM)** with a storage capacity of 740 MB of data. After data is recorded on a CD-ROM, it cannot be modified—the disc is "read-only." A CD burner, the informal name for a CD recorder, is a device that can record data to a compact disc. *CD-recordable (CD-R)* and *CD-rewritable (CD-RW)* are the two most common types of drives that can write CDs, either once (in the case of CD-R) or repeatedly (in the case of CD-RW). CD-rewritable (CD-RW) technology allows PC users to back up data on CDs.

optical disc
A rigid disc of plastic onto which data is recorded by special lasers that physically burn pits in the disc.

compact disc read-only memory (CD-ROM)
A common form of optical disc on which data, once it has been recorded, cannot be modified.

Digital Video Disc

A **digital video disc (DVD)** looks like a CD but can store about 135 minutes of digital video or several gigabytes of data (see Figure 3.8). Software, video games, and movies are often stored or distributed on DVDs. At a data transfer rate of 1.352 MB/second, the access speed of a DVD drive is faster than that of the typical CD-ROM drive.

DVDs have replaced recordable and rewritable CD discs (CD-R and CD-RW) as the preferred format for sharing movies and photos. Whereas a CD can hold about 740 MB of data, a single-sided DVD can hold 4.7 GB, with double-sided DVDs having a capacity of 9.4 GB. Unfortunately, DVD manufacturers haven't agreed on a recording standard, so several types of recorders and discs are currently in use. Recordings can be made on record-once discs (DVD-R and DVD+R) or on rewritable discs (DVD-RW, DVD+RW, and DVD-RAM). Not all types of rewritable DVDs are compatible with other types.

Figure 3.8
Digital Video Disc and Player
DVDs look like CDs but have a greater storage capacity and can transfer data at a faster rate.
(Source: Courtesy of Toshiba America Information Systems.)

The Blu-ray high-definition video-disc format based on blue-laser technology stores at least three times as much data as a DVD now holds. The primary use for this new format is in home entertainment equipment to store high-definition video, though this format can also store computer data.

digital video disc (DVD)
A storage medium used to store digital video or computer data.

Holographic Disc

Holographic Versatile Disc (HVD) is an advanced optical disc technology still in the research stage that would store more data than even the Blu-ray optical disc system. One approach to HVD records data through the depth of the storage media in three dimensions by splitting

a laser beam in two—the signal beam carries the data, and the reference beam positions where the data is written and reads it. HVD can transfer data at the rate of 1 Gigabit per second and store 1 terabyte (TB) of data on a single optical disk.[30]

Enterprise Storage Options

Businesses increasingly need to store large amounts of data created throughout the organization. Such large secondary storage is called *enterprise storage* and comes in three forms: attached storage, network-attached storage (NAS), and storage area networks (SANs).

Attached Storage

Attached storage methods include the tape, hard disks, and optical devices discussed previously, which are connected directly to a single computer. Attached storage methods, though simple and cost-effective for single users and small groups, do not allow systems to share storage, and they make it difficult to back up data.

Because of the limitations of attached storage, firms are turning to network-attached storage (NAS) and storage area networks (SANs). These alternative forms of enterprise data storage enable an organization to share data-storage resources among a much larger number of computers and users, resulting in improved storage efficiency and greater cost-effectiveness. In addition, they simplify data backup and reduce the risk of downtime. Nearly one-third of system downtime is a direct result of data-storage failures, so eliminating storage problems as a cause of downtime is a major advantage.

Network-Attached Storage

network-attached storage (NAS)
Storage devices that attach to a network instead of to a single computer.

Network-attached storage (**NAS**) employs storage devices that attach to a network instead of to a single computer. NAS includes software to manage storage access and file management and relieve the users' computers of those tasks. The result is that both application software and files can be served faster because they are not competing for the same processor resources. Computer users can share and access the same information, even if they are using different types of computers. Common applications for NAS include consolidated storage, Internet and e-commerce applications, and digital media.

The University of North Carolina (UNC) Hospital employs 2,000 physicians, over 5,000 staff members, and operates on a $600 million budget. It uses a state-of-the-art Picture Archiving and Communications System (PACS) to manage x-rays, CAT scans, and MRIs in a digital form instead of more traditional x-ray film. The system improves patient care and facilitates teaching by streamlining access to critical information. However, the sheer volume of data was causing UNC to struggle with its inefficient local storage devices. Data from over 200,000 radiology procedures each year requiring 4–5 TB of data storage was overwhelming the existing system. UNC recently converted to a centralized NAS data solution that now allows it to consolidate data onto fewer servers and storage devices and reduce the effort required to manage data. More importantly, the NAS solution enables rapid retrieval of patient information, saving doctors time, which can mean the difference between life and death in the operating room.[31]

Storage Area Network

storage area network (SAN)
The technology that provides high-speed connections between data-storage devices and computers over a network.

A **storage area network** (**SAN**) is a special-purpose, high-speed network that provides direct connections between data-storage devices and computers across the enterprise (see Figure 3.9). A SAN also integrates different types of storage subsystems, such as multiple RAID storage devices and magnetic tape backup systems, into a single storage system. Use of a SAN loads the network traffic associated with storage onto a separate network. The data can then be copied to a remote location, making it easier for companies to create backups and implement disaster recovery policies.

Using a SAN, an organization can centralize the people, policies, procedures, and practices for managing storage, and a data-storage manager can apply the data consistently across an enterprise. This centralization eliminates inconsistent treatment of data by different system administrators and users, providing efficient and cost-effective data-storage practices.

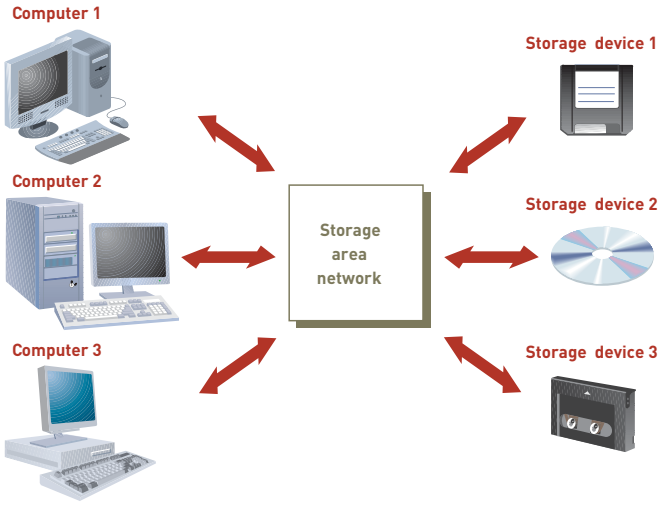


Figure 3.9

Storage Area Network

A SAN provides high-speed connections between data-storage devices and computers over a network.

The Navy's Surface Combat Systems Center in Wallops Island, Virginia, uses a SAN to hold 168 TB of data with data spread across more than 200 hard drives.[32] The Bombay Company designs and markets home furnishings and decorative accessories via 422 retail outlets, catalogs, and the Internet. The firm implemented 1.5 TB of SAN data storage to effectively hold its inventory data.[33]

A fundamental difference between NAS and SAN is that NAS uses file input/output, which defines data as complete containers of information, while SAN deals with block input/output, which is based on subsets of data smaller than a file. SAN manufacturers include EMC, Hitachi Data Systems Corporation, Xiotech, and IBM.

As organizations set up large-scale SANs, they use more computers and network connections, which become difficult to manage. In response, software tools designed to automate storage using previously defined policies are finding a place in the enterprise. Known as **policy-based storage management**, the software products from industry leaders such as Veritas Software Corporation, Legato Systems, Inc., EMC, and IBM automatically allocate storage space to users, balance the loads on servers and disks, and reroute networks when systems go down—all based on policies set up by system administrators.

policy-based storage management
Automation of storage using previously defined policies.

The trend in secondary storage is toward higher capacity, increased portability, and automated storage management. Organizations should select a type of storage based on their needs and resources. In general, storing large amounts of data and information and providing users with quick access makes an organization more efficient. Businesses can also choose pay-per-use services, where they rent space on massive storage devices housed either at a service provider (e.g., Hewlett-Packard or IBM) or on the customer's premises, paying only for the amount of storage they use. This approach is sensible for organizations with wildly fluctuating storage needs, such as those involved in the testing of new drugs or developing software.

INPUT AND OUTPUT DEVICES: THE GATEWAY TO COMPUTER SYSTEMS

Your first experience with computers is usually through input and output devices. These devices are the gateways to the computer system—you use them to provide data and instructions to the computer and receive results from it. Input and output devices are part of a computer's user interface, which includes other hardware devices and software that allow you to interact with a computer system.

As with other computer system components, an organization should keep their business goals in mind when selecting input and output devices. For example, many restaurant chains

use handheld input devices or computerized terminals that let food servers enter orders efficiently and accurately. These systems have also cut costs by helping to track inventory and market to customers.

Characteristics and Functionality

In general, businesses want input devices that let them rapidly enter data into a computer system, and they want output devices that let them produce timely results. When selecting input and output devices, businesses also need to consider the form of the output they want, the nature of the data required to generate this output, and the speed and accuracy they need for both. Some organizations have very specific needs for output and input, requiring devices that perform specific functions. The more specialized the application, the more specialized the associated system input and output devices.

The speed and functions of input and output devices should be balanced with their cost, control, and complexity. More specialized devices might make it easier to enter data or output information, but they are generally more costly, less flexible, and more susceptible to malfunction.

The Nature of Data

Getting data into the computer—input—often requires transferring human-readable data, such as a sales order, into the computer system. "Human-readable" means data that people can read and understand. A sheet of paper containing inventory adjustments is an example of human-readable data. In contrast, machine-readable data can be understood and read by computer devices (e.g., the universal bar code that grocery scanners read) and is typically stored as bits or bytes. Inventory changes stored on a disk is an example of machine-readable data.

Some data can be read by people and machines, such as magnetic ink on bank checks. Usually, people begin the input process by organizing human-readable data and transforming it into machine-readable data. Every keystroke on a keyboard, for example, turns a letter symbol of a human language into a digital code that the machine can understand.

Data Entry and Input

data entry
Converting human-readable data into a machine-readable form.

data input
Transferring machine-readable data into the system.

Getting data into the computer system is a two-stage process. First, the human-readable data is converted into a machine-readable form through **data entry**. The second stage involves transferring the machine-readable data into the system. This is **data input**.

Today, many companies are using online data entry and input—they communicate and transfer data to computer devices directly connected to the computer system. Online data entry and input places data into the computer system in a matter of seconds. Organizations in many industries require the instantaneous updating offered by this approach. For example, when ticket agents need to enter a request for concert tickets, they can use online data entry and input to record the request as soon as it is made. Ticket agents at other terminals can then access this data to make a seating check before they process another request.

Source Data Automation

source data automation
Capturing and editing data where it is initially created and in a form that can be directly input to a computer, thus ensuring accuracy and timeliness.

Regardless of how data gets into the computer, it should be captured and edited at its source. **Source data automation** involves capturing and editing data where it is originally created and in a form that can be directly input to a computer, thus ensuring accuracy and timeliness. For example, using source data automation, salespeople enter sales orders into the computer at the time and place they take the order. Any errors can be detected and corrected immediately. If an item is temporarily out of stock, the salesperson can discuss options with the customer. Prior to source data automation, orders were written on paper and entered into the computer later (usually by a clerk, not the person who took the order). Often the handwritten information wasn't legible or, worse yet, got lost. If problems occurred during data entry, the clerk had to contact the salesperson or the customer to "recapture" the data needed for order entry, leading to further delays and customer dissatisfaction.

Input Devices

You can use hundreds of devices for data entry and input. They range from special-purpose devices that capture specific types of data to more general-purpose input devices. Some of the special-purpose data entry and input devices are discussed later in this chapter. First, we focus on devices used to enter and input general types of data, including text, audio, images, and video for personal computers.

Personal Computer Input Devices

A keyboard and a computer mouse are the most common devices used for entry and input of data such as characters, text, and basic commands. Some companies are developing keyboards that are more comfortable, more easily adjusted, and faster to use than standard keyboards. These ergonomic keyboards, such as the split keyboard by Microsoft and others, are designed to avoid wrist and hand injuries caused by hours of typing. Other keyboards include touchpads that let you enter sketches on the touchpad and text using the keys. Another innovation is wireless mice and keyboards, which keep a physical desktop free from clutter.

You use a computer mouse to point to and click symbols, icons, menus, and commands on the screen. The computer takes a number of actions in response, such as placing data into the computer system.

A keyboard and mouse are two of the most common devices for computer input. Wireless mice and keyboards are now readily available.

(Source: Courtesy of Hewlett-Packard Company.)

Speech-Recognition Technology

Using **speech-recognition technology**, a computer equipped with a source of speech input such as a microphone can interpret human speech as an alternative means of providing data or instructions to the computer. The most basic systems require you to train the system to recognize your speech patterns or are limited to a small vocabulary of words. More advanced systems can recognize continuous speech without requiring you to break your speech into discrete words. The U.S. Department of Defense awarded $49 million to Johns Hopkins University to set up and run a Human Language Technology Center of Excellence to develop advanced technology and analyze a wide range of speech, text, and document image data in multiple languages. According to Gary Strong, the executive director of the center, "We need a better way to sort, filter, interpret, and call attention to important material that's buried within the enormous amount of multilingual data being produced every day in other nations. The government does not have nearly enough people with the multiple language skills needed to review this material. We need to develop technology to help."[34]

speech-recognition technology
Input devices that recognize human speech.

Companies that must constantly interact with customers are eager to reduce their customer support costs while improving the quality of their service. One company, Dial Directions, offers a free cell phone direction service. Users dial 347-328-4667 and tell the voice-activated service their originating location and desired destination and receive instant text messages with MapQuest driving directions on their cell phone.[35]

digital camera
An input device used with a PC to record and store images and video in digital form.

Digital Cameras

Digital cameras record and store images or video in digital form (see Figure 3.10). When you take pictures, the images are electronically stored in the camera. You can download the images to a computer either directly or by using a flash memory card. After you store the images on the computer's hard disk, you can edit and print them, send them to another location, or paste them into another application. For example, you can download a photo of your project team captured by a digital camera and then post it on a Web site or paste it into a project status report. Digital cameras have eclipsed film cameras used by professional photographers for photo quality and features such as zoom, flash, exposure controls, special effects, and even video-capture capabilities. With the right software, you can add sound and handwriting to the photo.

Figure 3.10
A Digital Camera
Digital cameras save time and money by eliminating the need to buy and process film.
(Source: Courtesy of Casio, Inc.)

More than two dozen camera manufacturers offer at least one digital camera model for under $225 with sufficient resolution to produce high-quality 5 × 7-inch photos. Many manufacturers offer a video camera that records full-motion video.

The primary advantage of digital cameras is saving time and money by eliminating the need to process film. In fact, digital cameras that can easily transfer images to CDs have made the consumer film business of Kodak and Fujitsu nearly obsolete. Until film-camera users switch to digital cameras, Kodak is allowing photographers to have it both ways. When you want to develop print film, Kodak offers the option of placing pictures on a CD in addition to the traditional prints. After the photos are stored on the CD, they can be edited, placed on a Web site, or sent electronically to business associates or friends around the world.

Organizations use digital cameras for research as well as for business purposes. Microsoft chairman Bill Gates and philanthropist Charles Simonyi donated $30 million to build the Large Synoptic Survey Telescope on a mountain in Chile. When operational in 2014, the 8.4 meter telescope will include a 3,200 megapixel digital camera that captures up to 30 TB of image data per night. The images from deep space will be loaded onto the Web and made available to the public.[36]

Terminals

Inexpensive and easy to use, terminals are input and display devices that perform data entry and input at the same time. A terminal is connected to a complete computer system, including a processor, memory, and secondary storage. After you enter general commands, text, and other data via a keyboard or mouse, it is converted into machine-readable form and transferred to the processing portion of the computer system. Terminals, normally connected directly to the computer system by telephone lines or cables, can be placed in offices, in warehouses, and on the factory floor.

Scanning Devices

You can input image and character data using a scanning device. A page scanner is like a copy machine. You typically insert a page you want to input into the scanner or place it face down on the glass plate of the scanner, cover it, and then scan it. With a handheld scanner,

you manually move or roll the scanning device over the image you want to scan. Both page and handheld scanners can convert monochrome or color pictures, forms, text, and other images into machine-readable digits. Considering that U.S. enterprises generate an estimated 1 billion pieces of paper daily, many companies are looking to scanning devices to help them manage their documents and reduce the high cost of using and processing paper.

Optical Data Readers

You can also use a special scanning device called an *optical data reader* to scan documents. The two categories of optical data readers are for optical mark recognition (OMR) and optical character recognition (OCR). You use OMR readers for test scoring and other purposes when test takers use pencils to fill in boxes on OMR paper, which is also called a "mark sense form." OMR systems are used in standardized tests, including the SAT and GMAT tests, and are being considered as a means to capture voters' choices on Election Day. In comparison, most OCR readers use reflected light to recognize and scan various characters. With special software, OCR readers can convert handwritten or typed documents into digital data. After being entered, this data can be shared, modified, and distributed over computer networks to hundreds or thousands of people.

Con-way Inc. is a $4.7 billion company that offers freight transportation and logistics services. Not long ago, the company had an antiquated and expensive payroll system that required its 15,000 drivers to fill out timesheets, which were then manually processed at several document management centers. The centers forwarded the timesheets to Portland, where data-entry clerks keyed the information into the payroll system. The process was awkward, error prone, and expensive—Con-way paid $300,000 per year just to have the forms shipped to Portland. The firm converted to an OCR-based system so that the timesheets can be processed and scanned at any of 38 locations in the United States and Canada, and then forwarded electronically to the payroll office. Initially, the OCR scans were 85 percent accurate, but over time and with a few improvements, the scans are now 99.9 percent accurate. Con-way eliminated the cost of shipping the forms to Portland along with cost of three full-time positions in the payroll department. In addition, the OCR system increased the speed of the entire process and made it more reliable.[37]

Magnetic Ink Character Recognition (MICR) Devices

In the 1950s, the banking industry became swamped with paper checks, loan applications, bank statements, and so on. The result was the development of magnetic ink character recognition (MICR), a system for reading banking data quickly. With MICR, data is placed on the bottom of a check or other form using a special magnetic ink. Using a special character set, data printed with this ink is readable by people and computers (see Figure 3.11).

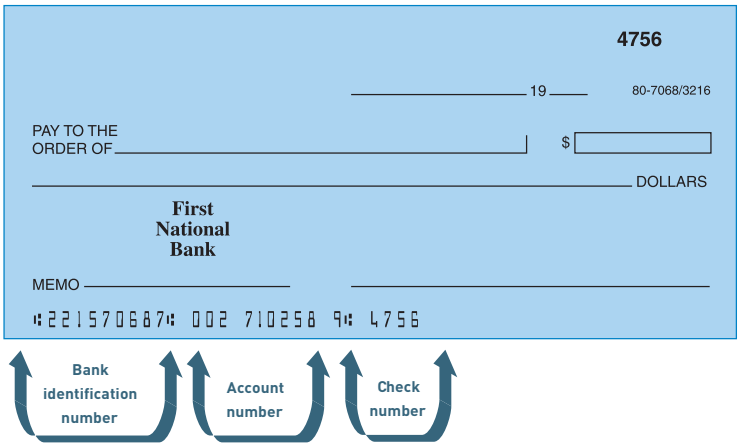


Figure 3.11

MICR Device

Magnetic ink character recognition technology codes data on the bottom of a check or other form using special magnetic ink, which is readable by people and computers. For an example, look at the bottom of a bank check.

(Source: Courtesy of NCR Corporation.)

magnetic stripe card
A type of card that stores limited amounts of data by modifying the magnetism of tiny iron-based particles contained in a band on the card.

Magnetic Stripe Card

A **magnetic stripe card** stores limited amounts of data by modifying the magnetism of tiny iron-based particles contained in a band on the card. The magnetic stripe is read by physically swiping the card past a reading head. Magnetic stripe cards are commonly used in credit cards, transportation tickets, and driver's licenses. The Revolution Card credit card is being touted as more secure than traditional credit cards such as those from Discover, Visa, and MasterCard. The cardholder's name does not appear on the card nor does the card contain any information about the cardholder in the magnetic stripe. Instead, the user must enter a personal ID number to use the card.[38]

point-of-sale (POS) device
A terminal used in retail operations to enter sales information into the computer system.

Point-of-Sale Devices

Point-of-sale (POS) devices are terminals used in retail operations to enter sales information into the computer system. The POS device then computes the total charges, including tax. Many POS devices also use other types of input and output devices, such as keyboards, bar-code readers, printers, and screens. Much of the money that businesses spend on computer technology involves POS devices. First Data, Hewlett-Packard, and Microsoft have collaborated to create a combined hardware and software point-of-sale solution for small retailers called First Data POS Value Exchange. The system can handle all forms of payment including cash, check, credit, debit, and gift cards. The software comes installed on Hewlett-Packard's rp5000 computer, complete with a touch screen interface.[39]

Automated Teller Machine (ATM) Devices

Another type of special-purpose input/output device, the automated teller machine (ATM) is a terminal that bank customers use to perform withdrawals and other transactions with their bank accounts. The ATM, however, is no longer used only for cash and bank receipts. Companies use various ATM devices, sometimes called *kiosks,* to support their business processes. Some can dispense tickets, such as for airlines, concerts, and soccer games. Some colleges use them to produce transcripts. AT&T and Wireless Advocates (a provider of mobile phones and services) sell mobile phones from manufacturers such as Samsung, Nokia, and Motorola plus services at kiosks inside Costco stores.[40]

Pen Input Devices

By touching the screen with a pen input device, you can activate a command or cause the computer to perform a task, enter handwritten notes, and draw objects and figures. Pen input requires special software and hardware. Handwriting recognition software can convert handwriting on the screen into text. The Tablet PC from Microsoft and its hardware partners can transform handwriting into typed text and store the "digital ink" just the way a person writes it. Users can use a pen to write and send e-mail, add comments to Word documents, mark up PowerPoint presentations, and even hand-draw charts in a document. The data can then be moved, highlighted, searched, and converted into text. If perfected, this interface is likely to become widely used. Pen input is especially attractive if you are uncomfortable using a keyboard. The success of pen input depends on how accurately handwriting can be read and translated into digital form and at what cost.

Touch-Sensitive Screens

Advances in screen technology allow display screens to function as input as well as output devices. By touching certain parts of a touch-sensitive screen, you can start a program or trigger other types of action. Touch-sensitive screens are popular input devices for some small computers because they do not require a keyboard, which conserves space and increases portability. Touch screens are frequently used at gas stations for customers to select grades of gas and request a receipt, on photocopy machines to enable users to select various options, at fast-food restaurants for order clerks to enter customer choices, at information centers in hotels to allow guests to request facts about local eating and drinking establishments, and at amusement parks to provide directions to patrons. They also are used in kiosks at airports and department stores. Touch-sensitive screens are also being considered as a technology to use in capturing voter choices.

Bar-Code Scanners

A bar-code scanner employs a laser scanner to read a bar-coded label. This form of input is used widely in grocery store checkouts and warehouse inventory control. Often, bar-code technology is combined with other forms of technology to create innovative ways for capturing data.

Radio Frequency Identification

The purpose of a **Radio Frequency Identification** (**RFID**) system is to transmit data by a mobile device, called a tag (see Figure 3.12), which is read by an RFID reader and processed according to the needs of an IS program. One popular application of RFID is to place a microchip on retail items and install in-store readers that track the inventory on the shelves to determine when shelves should be restocked. Recall that the RFID tag chip includes a special form of EPROM memory that holds data about the item to which the tag is attached. A radio frequency signal can update this memory as the status of the item changes. The data transmitted by the tag might provide identification, location information, or details about the product tagged, such as date manufactured, retail price, color, or date of purchase.

Radio Frequency Identification (RFID)
A technology that employs a microchip with an antenna that broadcasts its unique identifier and location to receivers.

Figure 3.12

RFID Tag

An RFID tag is small compared to current bar-code labels used to identify items.

(Source: Courtesy of Intermec Technologies Corporation.)

Boekhandels Groep Nederland (BGN) is a major book retailer with 40 stores in the Netherlands that sell to roughly 30,000 customers per day. BGN implemented item-level RFID tagging to track the movement of books along with new software to create a tightly integrated warehouse-to-consumer supply chain. With this solution, BGN simplified the inventory process, reduced errors in inventory, and improved the entire supply chain process.[41]

Read the Ethical and Societal Issues special feature to learn about the various approaches being taken to capture votes in an accurate and verifiable manner.

Collecting Accurate and Verifiable Data Where It Counts

Imagine having to design or choose an input device that will satisfy every person's needs: the young, elderly, intelligent, illiterate, sighted, or blind. Then imagine that this device has to provide a 100 percent guarantee that it is easy to use for all and collects accurate data—exactly what the user wants to enter. Sound challenging? That's the struggle that countries around the world are facing as they continue to create the perfect voting machine.

As the technology revolution races ahead, those responsible for voting systems are trying to harness technology to streamline the voting process. Submitting paper ballots now seems prehistoric in this day of movie downloads and cell phone text messaging. It was only natural that the touch screen would make its way into the voting process—with disastrous results. Touch screen machines, also called Direct Recording Electronic (DRE) units, allow the voter to press the name of the person for whom they want to vote. Each vote is either stored in the machine's storage device to be collected later and batch processed, or sent directly to a central database over a private network.

The use of touch screen machines has led to numerous questionable elections and accusations of scandal. The most prominent are the 2000 and 2004 United States presidential elections, where the close results were questioned due to voting irregularities caused by electronic voting machines.

To overcome the problems with touch screen voting machines, many experts feel that a paper backup of a citizen's vote should be generated along with the electronic vote. By providing a "paper trail" of votes, questionable elections can be easily checked. At the time of this writing, 12 U.S. states still have no paper record requirements.

Many voting administrators have given up on touch screen voting systems altogether. In the 2008 primary presidential elections, the state of New Hampshire relied on optical mark recognition (OMR) technology for their voting. Voters fill in the circle next to a candidate's name on a card. The voter's card is scanned to record the votes, and is filed away as a backup in case a recount is needed. Some precincts in New Hampshire provide voters with simple paper ballots that are counted by hand at the polling place. Visually impaired and disabled can use a touch-tone phone to place their votes. In this way, New Hampshire uses several methods to collect votes.

Other states are experimenting with other systems. Oregon holds its votes by mail. Citizens do not have to travel to a precinct center to cast their votes; instead, they simply mark their ballots, stamp them, and put them in the mailbox. The state claims record voting turnouts and little strife.

Some states seem committed to touch screen systems. Despite a report describing several methods of compromising the vote records of its voting machines, the Crawford County, Ohio, county commissioner tells the citizens that there is nothing to worry about. Since only officials from the county are provided with access codes to the inner workings of the machines, the system should be secure.

The voting machine debate extends beyond the United States to every other voting country. In Germany, a group of computer experts collected signatures to request that a court grant an injunction stopping the use of electronic voting machines. They wanted the system switched to a paper ballot system. They argue that the system had security flaws that allowed a hacker to manipulate voting outcomes. The group contended that the government didn't have the technical understanding to ensure an accurate vote count using the electronic system.

As the search for the perfect voting machine continues, one thing is clear: Collecting data into a system that is verifiably accurate, using easy and fast methods, can be a challenge. Security experts put forth three requirements for touch screen machines: They should produce a voter-verifiable paper trail, use software that is open to examination by the public, and provide verifiable ballots to safeguard against machine failure.

Discussion Questions

1. Do you think that one method of collecting data into a voting system can satisfy all the different types of voters? Or are multiple methods required?
2. What would be your concerns about elections by mail, such as the system used in Oregon?

Critical Thinking Questions

1. Of the systems described in this feature, which would you most like to use? In other words, describe your ideal voting method.
2. What are the security risks of your ideal voting method?

SOURCES: Weiss, Todd, "As primary season ramps up, an e-voting snapshot," *Computerworld*, January 8, 2008, *www.computerworld.com/action/article.do?command=viewArticleBasic&articleId=9056098*. Smith, Jane, "Officials confident voting machines pose no problems," The Meadville Tribune, January 12, 2008, *www.meadvilletribune.com/local/local_story_009222956.html*. Kirk, Jeremy, "German activists move to block e-voting," *NetworkWorld*, January 8, 2008, *www.networkworld.com/news/2008/010808-german-activists-move-to-block.html?fsrc=rss-security*. Kim, Myung, "Most clerks pushing for mail ballots," Rocky Mountain News, January 12, 2008, *www.rockymountainnews.com/news/2008/jan/12/most-clerks-pushing-for-mail-ballots*.

Output Devices

Computer systems provide output to decision makers at all levels of an organization so they can solve a business problem or capitalize on a competitive opportunity. In addition, output from one computer system can provide input into another computer system. The desired form of this output might be visual, audio, or even digital. Whatever the output's content or form, output devices are designed to provide the right information to the right person in the right format at the right time.

Display Monitors

The display monitor is a device similar to a TV screen that displays output from the computer. Because early monitors used a cathode-ray tube to display images, they were sometimes called *CRTs*. Such a monitor works much the same way a traditional TV screen does—the cathode-ray tubes generate one or more electron beams. As the beams strike a phosphorescent compound (phosphor) coated on the inside of the screen, a dot on the screen called a **pixel** lights up. A pixel is a dot of color on a photo image or a point of light on a display screen. It appears in one of two modes: on or off. The electron beam sweeps across the screen so that as the phosphor starts to fade, it is struck and lights up again.

pixel
A dot of color on a photo image or a point of light on a display screen.

With today's wide selection of monitors, price and overall quality can vary tremendously. The quality of a screen image is often measured by the number of horizontal and vertical pixels used to create it. The more pixels per square inch, the higher the resolution, or clarity and sharpness, of the image. For example, a screen with a 1,024 × 768 resolution (786,432 pixels) has a higher sharpness than one with a resolution of 800 × 600 (480,000 pixels). Another way to measure image quality is the distance between one pixel on the screen and the next nearest pixel, which is known as *dot pitch*. The common range of dot pitch is from .25 mm to .31 mm. The smaller the dot pitch, the better the picture. A dot pitch of .28 mm or smaller is considered good. Greater pixel densities and smaller dot pitches yield sharper images of higher resolution.

The characteristics of screen color depend on the quality of the monitor, the amount of RAM in the computer system, and the monitor's graphics adapter card. Digital Video Interface (DVI) is a video interface standard designed to maximize the visual quality of digital display devices such as flat-panel LCD computer displays.

Companies are competing on the innovation frontier to create thinner display devices for computers, cell phones, and other mobile devices. In its effort to gain an edge, LG Phillips has developed an extremely thin display that is only .15 mm thick, or roughly as thick as a human hair. The display is also flexible so that it can be bent or rolled up without being damaged. This flexible display opens up some exciting possibilities for manufacturers to make cell phones, PDAs, and laptops with significantly larger displays but without increasing the size of the device itself, as the screen could be rolled up or folded and tucked away into a pocket.[42]

Plasma Displays

A **plasma display** uses thousands of smart cells (pixels) consisting of electrodes and neon and xeon gases that are electrically turned into plasma (electrically charged atoms and negatively charged particles) to emit light. The plasma display lights up the pixels to form an image based on the information in the video signal. Each pixel is made up of three types of light—red, green, and blue. The plasma display varies the intensities of the lights to produce a full range of colors. Plasma displays can produce high resolution and accurate representation of colors to create a high-quality image.

plasma display
A plasma display uses thousands of smart cells (pixels) consisting of electrodes and neon and xeon gases which are electrically turned into plasma (electrically charged atoms and negatively charged particles) to emit light.

Liquid Crystal Displays (LCDs)

LCD displays are flat displays that use liquid crystals—organic, oil-like material placed between two polarizers—to form characters and graphic images on a backlit screen. These displays are easier on your eyes than CRTs because they are flicker-free, brighter, and don't emit the type of radiation that makes some CRT users worry. In addition, LCD monitors take up less space and use less than half of the electricity required to operate a comparably sized CRT monitor. *Thin-film transistor (TFT) LCDs* are a type of liquid crystal display that

LCD display
Flat display that uses liquid crystals—organic, oil-like material placed between two polarizers—to form characters and graphic images on a backlit screen.

assigns a transistor to control each pixel, resulting in higher resolution and quicker response to changes on the screen. TFT LCD monitors have displaced the older CRT technology and are commonly available in sizes from 12 to 30 inches. A number of companies are capable of providing multimonitor solutions that enable users to see a wealth of related information at a single glance, as shown in Figure 3.13.

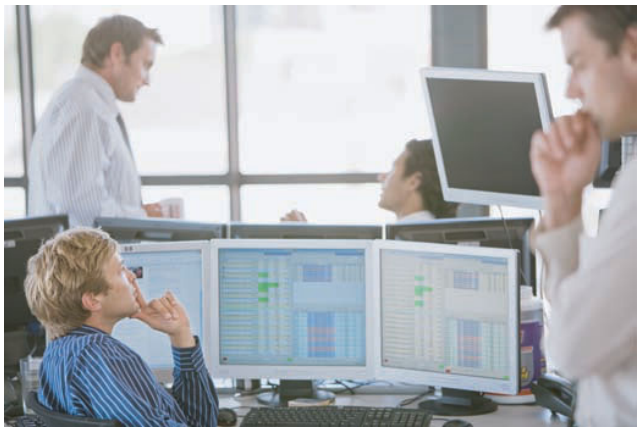


Figure 3.13

A Four-Screen Wide Display

(Source: © Justin Pumfrey/Getty Images.)

Organic Light-Emitting Diodes

Organic light-emitting diode (OLED) technology is based on research by Eastman Kodak Company and is appearing on the market in small electronic devices. OLEDs use the same base technology as LCDs, with one key difference: Whereas LCD screens contain a fluorescent backlight and the LCD acts as a shutter to selectively block that light, OLEDs directly emit light. OLEDs can provide sharper and brighter colors than LCDs and CRTs, and because they don't require a backlight, the displays can be half as thick as LCDs and used in flexible displays. Another big advantage is that OLEDs don't break when dropped. OLED technology can also create three-dimensional (3-D) video displays by taking a traditional LCD monitor and then adding layers of transparent OLED films to create the perception of depth without the need for 3-D glasses or laser optics.[43]

Printers and Plotters

One of the most useful and popular forms of output is called *hard copy*, which is simply paper output from a printer. The two main types of printers are laser printers and inkjet printers, and they are available with different speeds, features, and capabilities. Some can be set up to accommodate paper forms, such as blank check forms and invoice forms. Newer printers allow businesses to create customized printed output for each customer from standard paper and data input using full color. Ticket-receipt printers such as those used in restaurants, ATMs, and point-of-sale systems are in wide-scale use.

The speed of the printer is typically measured by the number of pages printed per minute (ppm). Like a display screen, the quality, or resolution, of a printer's output depends on the number of dots printed per inch (dpi). A 600-dpi printer prints more clearly than a 300-dpi printer. A recurring cost of using a printer is the inkjet or laser cartridge that must be replaced periodically—every few thousand pages for laser printers and every 500 to 900 pages for inkjet printers. Figure 3.14 shows a laser printer.

Laser printers are generally faster than inkjet printers and can handle more volume than inkjet printers. Laser printers print 15 to 50 pages per minute (ppm) for black and white and 4 to 20 ppm for color. Inkjet printers print 10 to 30 ppm for black and white and 2 to 10 ppm for color.

For color printing, inkjet printers print vivid hues and with an initial cost much less than color laser printers. Inkjet printers can produce high-quality banners, graphics, greeting cards, letters, text, and prints of photos. Hewlett-Packard introduced the CM8060 inkjet printers with a stationary print head that uses 60,000 nozzles to spray ink as the paper moves.

Figure 3.14

The Hewlett-Packard CM8060 Inkjet Printer

(Source: Courtesy of Hewlett-Packard Company.)

Traditional inkjet printers rely on a moving print head and many fewer nozzles. The advantage of the new technology is the ability to print pages much faster (50 pages per minute for color and 60 pages per minute for black and white). In addition, the printer uses less ink.[44]

A number of manufacturers offer multiple-function printers that can copy, print (in color or black and white), fax, and scan. Such multifunctional devices are often used when people need to do a relatively low volume of copying, printing, faxing, and scanning. The typical price of multifunction printers ranges from $150 to $500, depending on features and capabilities. Because these devices take the place of more than one piece of equipment, they are less expensive to acquire and maintain than a stand-alone fax, plus a stand-alone printer, plus a stand-alone copier, and so on. Also, eliminating equipment that was once located on a countertop or desktop clears a workspace for other work-related activities. As a result, such devices are popular in homes and small office settings.

3-D printers can be used to turn three-dimensional computer models into three-dimensional objects. See Figure 3.15. One form of 3-D printer uses an inkjet printing system to print an adhesive in the shape of a cross-section of the model. Next, a fine powder is sprayed onto the adhesive to form one layer of the object. This process is repeated thousands of times until the object is completed. 3-D printing is commonly used in aerospace companies, auto manufacturers, and other design-intensive companies. It is especially valuable during the conceptual stage of engineering design, when the exact dimensions and material strength of the prototype are not critical.

Figure 3.15

The Spectrum Z510 3D Printer

(Source: Courtesy of Z Corporation.)

Plotters are a type of hard-copy output device used for general design work. Businesses typically use plotters to generate paper or acetate blueprints, schematics, and drawings of buildings or new products. Standard plot widths are 24 inches and 36 inches, and the length can be whatever meets the need—from a few inches to many feet.

Digital Audio Player

digital audio player
A device that can store, organize, and play digital music files.

MP3
A standard format for compressing a sound sequence into a small file.

A **digital audio player** is a device that can store, organize, and play digital music files. **MP3** (MPEG-1 Audio Layer-3) is a popular format for compressing a sound sequence into a very small file while preserving the original level of sound quality when it is played. By compressing the sound file, it requires less time to download the file and less storage space on a hard drive.

You can use many different music devices about the size of a deck of cards to download music from the Internet and other sources. These devices have no moving parts and can store hours of music. Apple expanded into the digital music market with an MP3 player (the iPod) and the iTunes Music Store, which allows you to find music online, preview it, and download it in a way that is safe, legal, and affordable. Other MP3 manufacturers include Dell, Sony, Samsung, Iomega, and Motorola, whose Rokr product is the first iTunes-compatible phone.

The Apple iPod Touch 3.5-inch widescreen lets the user watch movies and TV shows and view photos and album art. The display automatically adjusts the view when it's rotated from portrait to landscape. An ambient light sensor adjusts brightness to match the current lighting conditions. It also supports wireless networking so that the user can access the Internet, view YouTube videos, and purchase music from the iTunes Wi-Fi Music Store.

The Apple's iPod Touch
(Source: Courtesy of Apple.)

Special-Purpose Input and Output Devices

Many additional input and output devices are used for specialized or unique applications. Two examples of such devices are discussed in the following sections.

E-Books

The digital media equivalent of a conventional printed book is called an e-book (short for electronic book). The Project Gutenberg Online Book Catalog lists over 20,000 free e-books and a total of more than 100,000 e-books available. E-books can be downloaded from this

source or many others onto personal computers or dedicated hardware devices known as e-book readers. A number of e-book hardware devices are available including the Kindle from Amazon.com and the Pepper Pad, Cybook, Franklin eBookMan, Easyread, Personal Digital Reader, and Hanlin Reader, all priced from around $150 to $400. The Sony Reader Digital Book sells for just under $300 and has a 6-inch display that uses e-Ink technology and is almost paper-like, making it easy to read even in bright sunshine. The text can also be magnified for readers with impaired vision. The Reader Digital Book weighs 9 ounces, is only half an inch thin, and can store up to 160 e-Books. It is more compact than most paperbacks so it can be easily held in one hand.[45]

Eyebud Screens

Eyebud screens are portable media devices that display video in front of one eye. They employ optical technology that provides very high resolution and "enlarges" the video or images. With the proximity of the screen to the eye and the magnifying effect of the optical technology, using an eyebud screen is like watching a 105-inch display from 12 feet away. Such devices enable users of portable media devices to capture the big-screen, movie-screen, or home-theater experience, wherever they are.

The eyebud screen displays "enlarged" and high-resolution video.

(Source: Courtesy of eMagin Corp.)

COMPUTER SYSTEM TYPES

In general, computers can be classified as either special purpose or general purpose. *Special-purpose computers* are used for limited applications by military and scientific research groups such as the CIA and NASA. Other applications include specialized processors found in appliances, cars, and other products. For example, automobile repair shops connect special-purpose computers to your car's engine to identify specific performance problems.

General-purpose computers are used for a variety of applications and to execute the business applications discussed in this text. General-purpose computer systems can be divided into two major groups: systems used by one user at a time and systems used by multiple concurrent users. Table 3.4 shows the general ranges of capabilities for various types of computer systems.

	Single-User Systems					Multiuser System			
Factor	**Handheld**	**Ultra Laptop**	**Portable**	**Thin Client**	**Desktop**	**Workstation**	**Server**	**Mainframe**	**Supercomputer**
Cost Range	$90 to $900	$700 to $2250	$500 to $3,000	$300 to $900	$400 to $2,500	$3,000 to $40,000	$500 to $50,000	>$100,000	>$250,000
Weight	<24 oz.	<3 lbs.	<7 lbs.	<15 lbs.	<25 lbs.	<25 lbs.	>25 lbs.	>200 lbs.	>200 lbs.
Typical Size	Palm size	Size of a notebook	Size of a notebook	Fits on desktop	Fits on desktop	Fits on desktop	Three-drawer filing cabinet	Refrigerator	Refrigerator and larger
Typical Use	Organize personal data	Improve productivity of highly mobile worker	Improve worker productivity	Enter data and access the Internet	Improve worker productivity	Perform engineering, CAD, and software development	Perform network and Internet applications	Perform computing tasks for large organizations and provide massive data storage	Run scientific applications; perform intensive number crunching
Example	HP iPAQ Pocket PC	Fujitsu Lifebook Q2010	Dell Inspiron T5450	Wyse V90LE Thin Client	Mac Pro	Sun Ultra 40 M2 workstation	Hewlett-Packard HP ProLiant BL	Unisys Clear Path	IBM RS/6000 SP

Table 3.4
Types of Computer Systems

Computer System Types

Computer systems can range from small handheld computers to massive supercomputers that fill an entire room. We start first with the smallest computers.

Handheld Computers

handheld computer
A single-user computer that provides ease of portability because of its small size.

Handheld computers are single-user computers that provide ease of portability because of their small size—some are as small as a credit card. These systems often include a variety of software and communications capabilities. Most can communicate with desktop computers over wireless networks. Some even add a built-in GPS receiver with software that can integrate location data into the application. For example, if you click an entry in an electronic address book, the device displays a map and directions from your current location. Such a computer can also be mounted in your car and serve as a navigation system. One of the shortcomings of handheld computers is that they require a lot of power relative to their size.

PalmOne is the company that invented the Palm Pilot organizer in 1996. The Palm personal digital assistant (PDA) lets you track appointments, addresses, and tasks. PalmOne has now signed licensing agreements with Handspring, IBM, Sony, and many other manufacturers, permitting them to make what amounts to Palm clones. As a result of the popularity of the Palm PDA, all handheld computers are often referred to as PDAs.

The U.S. Census Bureau awarded a $600 million contract to the Harris Corporation to integrate multiple automated systems to obtain field data for the 2010 census in an efficient and secure manner. It is anticipated that 500,000 PDAs will be used by census takers for address canvassing and nonresponse followup.[46]

smartphone
A phone that combines the functionality of a mobile phone, personal digital assistant, camera, Web browser, e-mail tool, MP3 player, and other devices into a single handheld device.

A **smartphone** combines the functionality of a mobile phone, personal digital assistant, camera, Web browser, e-mail tool, MP3 player, and other devices into a single handheld device. Smartphones will continue to evolve as new applications are defined and installed on the device. The applications might be developed by the manufacturer of the handheld device, by the operator of the communications network on which it operates, or by any other third-party software developer.

Portable Computers

portable computer
A computer small enough to be carried easily.

Many computer manufacturers offer a variety of **portable computers**, those that can be carried easily—from pocket or handheld computers to laptops, to notebooks, to subnotebooks, to tablet computers.

The pocket computer is a device smaller than the smallest laptop that can perform most of the common functions of a PC. The Nokia 770 Internet Tablet is a $360 pocket computer that you can use to surf the Web, send and receive e-mail and instant messages, view images and videos, and play music and simple games. It weighs 8.1 ounces and is 5.5 inches long and 0.7 inches thick. It has a vivid, bright display with a resolution of 800 × 480, which is very good for a handheld digital device.[47]

The Coca-Cola field salesforce uses a Pocket PC (a handheld computer that runs the Microsoft Windows Mobile operating system) to automate the collection of information about sales calls, customers, and prospects. They chose a Pocket PC over a laptop because of the cost savings and because it is easier to point and click using radio buttons and drop-down menus on the Pocket PC than to fumble with a keyboard and mouse on a much heavier laptop.[48]

The Nokia 770 Internet Tablet is designed for wireless Internet browsing and electronic mail, and includes software such as Internet radio, an RSS news reader, and audio and video players.

(Source: Courtesy of Nokia.)

An ultra laptop is a laptop computer weighing less than 3 pounds (1.4 kg) and is usually targeted for use by business travelers. Such laptops typically have a screen that measures 12 inches (30 cm) or less diagonally with a less than full-size keyboard. Many ultra laptops come with extended battery life and energy-efficient CPUs. Popular ultra laptop computers include the Fujitsu Lifebook Q2010, Lenovo ThinkPad X60, Sony VAIO VGN-TXN15P, Samsung Q1 Ultra, and Apple MacBook Air. See Figure 3.16. The Q1 uses tablet PC technology with a built-in keyboard and can accept handwritten notes on its computer screen. These devices cost between $700 and $2,250 as of January 2008.[49]

Figure 3.16

The MacBook Air

The MacBook Air is an ultraportable laptop that measures 0.76 inches deep at the back and tapers down to 0.16 inches at the front. It weighs 3 pounds and includes a 13-inch LED screen and full-size keyboard.

(Source: Courtesy of Apple.)

Tablet PCs (introduced earlier) are portable, lightweight computers that allow you to roam the office, home, or factory floor carrying the device like a clipboard. Recall that you can enter text with a writing stylus directly on the screen thanks to built-in handwriting recognition software. Other input methods might include an on-screen (virtual) keyboard, speech recognition, or a physical keyboard. Tablet PCs that only support input via a writing stylus are called *slates*. The *convertible tablet PC* comes with a swivel screen and can be used as a traditional notebook or as a pen-based tablet PC.

Tablet computers are especially popular and useful in the healthcare, retail, insurance, and manufacturing industries because of their versatility. DT Research provides portable tablet personal computers that come with optional input devices including an integrated bar-code scanner, a card reader, and a camera. The bar-code scanner can capture data from retail, patient, or shipping labels. The card reader can capture data from any card with a magnetic stripe, such as a credit card or driver's license. These devices capture data quickly and accurately and can input the data directly into applications running on the computer.[50] CSX

The Nokia N80 smartphone can function as a phone, camera, FM radio, or e-mail device, and allows you to send text messages with audio and video clips.

(Source: Courtesy of Nokia.)

Transportation, one of the nation's largest railroads, uses DT Research's WebDT 360 to enable train conductors to monitor systems while onboard and communicate with stations for real-time updates. The WebDT 360 has improved operations efficiency and worker productivity.[51]

Low-Cost Laptops The mission of the nonprofit One Laptop per Child (OLPC) association is to provide children around the world with new opportunities to explore, experiment, and express themselves with the help of a low-cost laptop priced at about $100. OLPC was founded by Nicholas Negroponte of the Massachusetts Institute of Technology and includes a wide variety of members from academia, the arts, business, and the information technology industry. Negroponte states: "It's an education project, not a laptop project."[52] The first version of the laptop, the OLPC XO, was made available to third-world countries in 2007. OLPC launched a "give one, get one" campaign in North America, asking consumers to pay $400 for an XO for themselves and a "free" XO to be given to a child in a developing country. The bright green computer is designed to be extremely rugged and durable with child-friendly features including an easy-to-use interface. See Figure 3.17.

Figure 3.17

The OLPC XO Laptop Computer

(Source: Courtesy of fuseproject.)

For-profit computer manufacturers have also recognized the tremendous market for low-cost computers. Taiwan's Asus produces a $300–$400 basic laptop called the Eee. Intel, in collaboration with local manufacturers in the developing world, is producing a $300 laptop for use in schools called the Classmate PC.[53] Mary Lou Jepsen, founder of low-cost laptop company Pixel Xi, says, "The computer industry has been able to keep the price flat by focusing on gazillion-gigahertz machines running really bloated software, and that's worked for years since the IBM PC revolution."[54] Will the development of low-cost, limited-capability laptops drive software manufacturers to develop simpler, less resource-intensive programs? What will happen to the current market for relatively high-priced laptops?

Thin Client

thin client
A low-cost, centrally managed computer with essential but limited capabilities and no extra drives, such as a CD or DVD drive, or expansion slots.

A **thin client** is a low-cost, centrally managed computer with no extra drives, such as a CD or DVD drive, or expansion slots. These computers have limited capabilities and perform only essential applications, so they remain "thin" in terms of the client applications they include. These stripped-down versions of desktop computers do not have the storage capacity or computing power of typical desktop computers, nor do they need it for the role they play. With no hard disk, they never pick up viruses or suffer a hard disk crash. Unlike personal computers, thin clients download software from a network when needed, making support, distribution, and updating of software applications much easier and less expensive. Thin-client manufacturers include Hewlett-Packard, Wyse, BOSaNOVA, and DTR Research.

Amerisure is a mutual insurance company specializing in worker's compensation policies, with 800 employees spread across eight U.S. locations. The firm had 700 personal computers of varying types and manufacturers. The diverse set of computers was so difficult to support that the resulting lack of operational reliability threatened the firm's quality of service. To improve the situation, Amerisure converted every PC into a thin client capable of running the same software, but with processing taking place on centralized servers rather than on users' desktops. This conversion resulted in a much more stable environment that led to savings of nearly $1 million per year from reduced hardware and support costs.[55]

Desktop Computers

desktop computer
A relatively small, inexpensive, single-user computer that is highly versatile.

Desktop computers are relatively small, inexpensive single-user computer systems that are highly versatile. Named for their size—the parts are small enough to fit on or beside an office desk—*desktop computers* can provide sufficient memory and storage for most business computing tasks.

Ultrasmall desktop personal computers are much smaller than traditional desktop computers yet often as powerful in terms of processor speed and hard drive capacity. Although they may have fewer expansion slots for RAM and other devices, they are highly energy efficient. These small computers are available from most personal computer manufacturers. For example, the Mac mini is the smallest desktop computer released from Apple. It measures only 6.5 × 6.5 × 2 inches and weighs 2.9 pounds. You can purchase a Mac mini with a 2-GHz Intel Core 2 Duo chip set, a 120 GB hard drive, and 1 GB of RAM for under $1,000. The Mac mini does not come with a mouse, keyboard, or monitor but it works with surplus equipment from Windows personal computers. The Mac mini comes with software that lets the user enhance, organize, and share photos—on the Mac mini itself or stored on other computers.[56] See Figure 3.18.

Figure 3.18
The Apple Mac mini
(Source: Courtesy of Apple.)

Workstations

workstation
A more powerful personal computer that is used for technical computing, such as engineering, but still fits on a desktop.

Workstations are more powerful than personal computers but still small enough to fit on a desktop. They are used to support engineering and technical users who perform heavy mathematical computing, computer-aided design (CAD), and other applications requiring a high-end processor. Such users need very powerful CPUs, large amounts of main memory, and extremely high-resolution graphic displays.

Servers

server
A computer designed for a specific task, such as network or Internet applications.

A **server** is a computer used by many users to perform a specific task, such as running network or Internet applications. Servers typically have large memory and storage capacities, along with fast and efficient communications abilities. A Web server handles Internet traffic and communications. An Internet caching server stores Web sites that a company uses frequently. An enterprise server stores and provides access to programs that meet the needs of an entire organization. A file server stores and coordinates program and data files. A transaction server processes business transactions. Server systems consist of multiuser computers, including supercomputers, mainframes, and other servers. Often an organization will house a large number of servers in the same room where access to the machines can be controlled and authorized support personnel can more easily manage and maintain them from this single location. Such a facility is called a *server farm*.

scalability
The ability to increase the capability of a computer system to process more transactions in a given period by adding more, or more powerful, processors.

Servers offer great **scalability**, the ability to increase the processing capability of a computer system so that it can handle more users, more data, or more transactions in a given period. Scalability is increased by adding more, or more powerful, processors. *Scaling up* adds more powerful processors, and *scaling out* adds many more equal (or even less powerful) processors to increase the total data-processing capacity.

A virtual server is a method of logically dividing the resources of a single physical server to create multiple logical servers, with each acting as if it is running on its own dedicated machine. Often a single physical Web server is divided into two virtual private servers. One of the virtual servers hosts the live Web site while the other hosts a copy of the Web site. The second private virtual server is used to test and verify updates to software before changes are made to the live Web site. The U.S. Marine Corps has adopted server virtualization to reduce the number of its data centers from 300 to 30 plus 100 mobile platforms. They will do this by setting up virtual servers capable of running half a dozen or so applications, eliminating the need to dedicate one server to one application.[57]

blade server
A server that houses many individual computer motherboards that include one or more processors, computer memory, computer storage, and computer network connections.

A **blade server** houses many computer motherboards that include one or more processors, computer memory, computer storage, and computer network connections. These all share a common power supply and air-cooling source within a single chassis. By placing many blades into a single chassis, and then mounting multiple chassis in a single rack, the blade server is more powerful but less expensive than traditional systems based on mainframes or server farms of individual computers. In addition, the blade server approach requires much less physical space than traditional server farms.

The city of Burbank, California upgraded to IBM blade servers to provide the speed and flexibility it needed in its computer hardware. The servers run an Oracle ERP system and a geographic information system that maps the city's infrastructure of streets, gas and power lines, and sewers. Converting to new blade servers from a collection of different stand-alone computers and regular servers reduced the total cost of ownership by 40 percent and made it easy for the city to add more blades when it needed additional processing power.[58] Read the Information Systems @ Work special feature to learn about another interesting use of blade server technology.

The Dell Power Edge 1855 Chassis can hold up to ten blade servers.

(Source: Courtesy of Dell Inc.)

INFORMATION SYSTEMS @ WORK

Penguins, Animal Logic, and Blades

And the Oscar goes to... *Happy Feet*! Perhaps you saw *Happy Feet*, the motion picture that won the 2007 Oscar for best animated feature. The movie included animated shots of groups of thousands of picture-perfect Emperor penguins, including Mumble, a young penguin with an uncanny ability to dance.

Happy Feet is the brainchild of George Miller with animation by Australia's Animal Logic. *Happy Feet* was Animal Logic's first full-length animated movie, although the company had its hand in many other popular films including the *Harry Potter* series, *Moulin Rouge*, the *Matrix* trilogy, and *The Lord of the Rings*.

If you did see *Happy Feet*, you were sure to be impressed by the detail of the photo-realistic animation. For example, the star of the film, Mumble, had 6 million picture-perfect feathers. Several shots included more than 400,000 realistic-looking penguins. This type of artisanship requires processing power, and lots of it.

Animators at Animal Logic realized that they would require more processing power than the company currently owned. Producing 3-D animated films requires a process called rendering, where defined 3-D objects in a scene, along with the lighting, shadings, shadows, and reflections, are created on a computer based on commands from the artist and the laws of physics. *Happy Feet* required the rendering of 140,000 frames, with each frame taking hours to render. Using a PC, one rendering of the film would take around 17 years. Xavier Desdoigts, director of technical operations at Animal Logic, calculated that nine months of production would require 17 million CPU hours. Animal Logic turned to IBM for help.

IBM installed a rendering server farm built from blade servers, each containing two processors—2,000 of them for a total of 4,000 processors. The installation of the system posed some challenges. The density of the blade centers that housed the servers produced a higher amount of power consumption and heat generation than standard servers. Animal Logic had to work with IBM to create a suitable environment for the system. IBM provided management tools that allowed one technician to handle the day-to-day maintenance of the system. Desdoigts says, "Sometimes we forget that we have 2,000 CPUs doing their job every day. There's one person who looks after all of them....But that's what we were aiming for. It was part of choosing a vendor that could provide that level of service and support so we could focus on creating movies. We didn't want to get bogged down in technology issues; it just had to work every day."

Animal Logic's new system gives it the power of industry leaders like Pixar and Sony Pictures. *Happy Feet* proved to be a great leap into the big league for Animal Logic, grossing more than $41 million on its opening weekend, and beating out the top-tier companies for an Oscar.

Discussion Questions

1. Why did Animal Logic want a system that was easy to maintain? How did this requirement contribute to the company's ability to meet its goals?
2. Purchasing a 4,000-processor blade server required a huge investment from Animal Logic and a leap of faith. How do you think they justified the expense?

Critical Thinking Questions

1. The IBM Case Study on which this article is partly based states that "in specialized areas such as weather forecasting, scientific and financial research, and digital media production, there can never be enough processing power." Why do you think this is?
2. Based on what you have read in this chapter, why do you think IBM recommended blade servers instead of other types of servers for Animal Logic's needs?

SOURCES: Rossi, Sandra, "And the Oscar goes to ... jovial penguins and 2,000 blade servers," *Computerworld*, March 6, 2007, *www.computerworld.com/action/article.do?command=viewArticleBasic&taxonomyName=Servers_and_Data_Center&articleId=9012400&taxonomyId=154&intsrc=kc_li_story*. Staff, "Animal Logic builds rendering farm with IBM eServer BladeCenter," IBM Success Story, October 11, 2005, *www-01.ibm.com/software/success/cssdb.nsf/CS/MCAG-6H2SR2?OpenDocument&Site=corp&cty=en_us*. Animal Logic Web Site, *www.animallogic.com*, accessed January 12, 2008.

Mainframe Computers

mainframe computer
A large, powerful computer often shared by hundreds of concurrent users connected to the machine via terminals.

A **mainframe computer** is a large, powerful computer shared by dozens or even hundreds of concurrent users connected to the machine over a network. The mainframe computer must reside in a data center with special heating, ventilating, and air-conditioning (HVAC) equipment to control temperature, humidity, and dust levels. In addition, most mainframes are kept in a secure data center with limited access to the room. The construction and maintenance of a controlled-access room with HVAC can add hundreds of thousands of dollars to the cost of owning and operating a mainframe computer.

The role of the mainframe is undergoing some remarkable changes as lower-cost, single-user computers become increasingly powerful. Many computer jobs that used to run on mainframe computers have migrated onto these smaller, less-expensive computers. This information-processing migration is called *computer downsizing*.

Mainframe computers have been the workhorses of corporate computing for more than 50 years. They can support hundreds of users simultaneously and handle all of the core functions of a corporation.

(Source: Courtesy of IBM Corporation.)

The new role of the mainframe is as a large information-processing and data-storage utility for a corporation—running jobs too large for other computers, storing files and databases too large to be stored elsewhere, and storing backups of files and databases created elsewhere. The mainframe can handle the millions of daily transactions associated with airline, automobile, and hotel/motel reservation systems. It can process the tens of thousands of daily queries necessary to provide data to decision support systems. Its massive storage and input/output capabilities enable it to play the role of a video computer, providing full-motion video to multiple, concurrent users. IBM mainframe computer customers include the top 25 banks and the top 25 retailers in the world who use the machines for processing large amounts of transactions. For example, the Bank of China houses 350 million accounts with 3 billion transaction histories and processes 30 million transactions in less than an hour using IBM's System z mainframe computer.[59]

Supercomputers

supercomputers
The most powerful computer systems with the fastest processing speeds.

Supercomputers are the most powerful computers with the fastest processing speed and highest performance. They are *special-purpose machines* designed for applications that require extensive and rapid computational capabilities. Originally, supercomputers were used primarily by government agencies to perform the high-speed number crunching needed in weather forecasting and military applications. With recent reductions in the cost of these machines, they are now used more broadly for commercial purposes.

The IBM Blue Gene/L supercomputer was designed and built in collaboration with the Department of Energy and the Lawrence Livermore National Laboratory. This basketball court-size, number-crunching monster supports a wide range of research projects, ranging from detailed simulations of nuclear weapons programs to human biological processes such as protein folding. When comparing the speed of supercomputers, the metric used is floating-point operating instructions per second, or FLOPS. The Blue Gene/L supercomputer has a peak computational speed of 596 TeraFLOPS (1 TeraFLOP = 10^{12} floating-point operations per second) and is currently the fastest single computer in the world.[60] Three additional

Blue Gene computers are in development including the BlueGene/C (sister project to BlueGene L and scheduled to be released in 2007 but delayed), BlueGene/P (designed to run at a speed of 1 to 3 PetaFLOPS), and BlueGene/Q (targeted to achieve 10 PetaFLOPS by 2012). Table 3.5 compares the processing speeds of supercomputers.

Table 3.5

Supercomputer Processing Speeds

Speed	Meaning
GigaFLOPS	1 x 10^9 FLOPS
TeraFLOPS	1 x 10^{12} FLOPS
PetaFLOPS	1 x 10^{15} FLOPS

Scientists say that these supercomputers will enable more realistic computer simulations that will provide new insights into new drug development, geology, climate change, dark matter, and other mysteries of the universe. "They are a tool that really helps stimulate the imagination of scientists and engineers in ways that weren't previously possible," according to David Turek, vice president of supercomputing at IBM. "Nature is the final arbiter of truth," says Mark Seager, a Lawrence Livermore computer scientist, but "rather than doing experiments, a lot of times now we're actually simulating those experiments and getting the data that way."[61]

IBM's Blue Gene/L System at the Lawrence Livermore National Laboratory is the fastest supercomputer in the world and can perform 596 trillion floating-point operations per second.

(Source: Courtesy of IBM Corporation.)

In an effort to keep the United States in the forefront of supercomputing, the Defense Advanced Research Projects Agency (DARPA) awarded $250 million to both Cray and IBM to develop so-called Petascale computers by 2010 capable of achieving 2 PetaFLOPS of sustained performance. According to Dr. William Harrod, DARPA program manager, "High-productivity computing is a key technology enabler for meeting our national security and economic competitiveness requirements. High-productivity computing contributes substantially to the design and development of advanced vehicles and weapons, planning and execution of operational military scenarios, the intelligence problems of cryptanalysis and image processing, the maintenance of our nuclear stockpile, and is a key enabler for science and discovery in security-related fields."[62]

SUMMARY

Principle

Computer hardware must be carefully selected to meet the evolving needs of the organization and its supporting information systems.

Computer hardware should be selected to meet specific user and business requirements. These requirements can evolve and change over time.

The central processing unit (CPU) and memory cooperate to execute data processing. The CPU has three main components: the arithmetic/logic unit (ALU), the control unit, and the register areas. Instructions are executed in a two-phase process called a machine cycle that includes the instruction phase and the execution phase.

Computer system processing speed is affected by clock speed, which is measured in gigahertz (GHz). As the clock speed of the CPU increases, heat is generated that can corrupt the data and instructions the computer is trying to process. Bigger heat sinks, fans, and other components are required to eliminate the excess heat. This excess heat can also raise safety issues.

Primary storage, or memory, provides working storage for program instructions and data to be processed and provides them to the CPU. Storage capacity is measured in bytes.

A common form of memory is random access memory (RAM). RAM is volatile; loss of power to the computer erases its contents. RAM comes in many different varieties including dynamic RAM (DRAM), synchronous DRAM (SDRAM), Double Data Rate SDRAM, and DDR2 SDRAM.

Read-only memory (ROM) is nonvolatile and contains permanent program instructions for execution by the CPU. Other nonvolatile memory types include programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable PROM, and flash memory.

Cache memory is a type of high-speed memory that CPUs can access more rapidly than RAM.

A multicore microprocessor is one that combines two or more independent processors into a single computer so they can share the workload. Intel and AMD have introduced quad-core processors that are effective in working on problems involving large databases and multimedia.

Parallel computing is the simultaneous execution of the same task on multiple processors to obtain results faster. Massively parallel processing involves linking many processors to work together to solve complex problems.

Grid computing is the use of a collection of computers, often owned by multiple individuals or organizations, to work in a coordinated manner to solve a common problem.

Computer systems can store larger amounts of data and instructions in secondary storage, which is less volatile and has greater capacity than memory. The primary characteristics of secondary storage media and devices include access method, capacity, portability, and cost. Storage media can implement either sequential access or direct access. Common forms of secondary storage include magnetic tape, magnetic disk, virtual tape, optical disc, digital video disc (DVD), and holographic versatile disc (HVD).

Redundant array of independent/inexpensive disks (RAID) is a method of storing data that generates extra bits of data from existing data, allowing the system to more easily recover data in the event of a hardware failure.

Network-attached storage (NAS) and storage area networks (SAN) are alternative forms of data storage that enable an organization to share data resources among a much larger number of computers and users for improved storage efficiency and greater cost-effectiveness.

The overall trend in secondary storage is toward direct-access methods, higher capacity, increased portability, and automated storage management. Interest in renting space on massive storage devices is increasing.

Input and output devices allow users to provide data and instructions to the computer for processing and allow subsequent storage and output. These devices are part of a user interface through which human beings interact with computer systems.

Data is placed in a computer system in a two-stage process: Data entry converts human-readable data into machine-readable form; data input then transfers it to the computer. Common input devices include a keyboard, a mouse, speech recognition, digital cameras, terminals, scanning devices, optical data readers, magnetic ink character recognition devices, magnetic stripe cards, point-of-sale devices, automated teller machines, pen input devices, touch-sensitive screens, bar-code scanners, and Radio Frequency Identification tags.

Display monitor quality is determined by size, color, and resolution. Liquid crystal display and organic light-emitting diode technology is enabling improvements in the resolution and size of computer monitors. Other output devices include printers, plotters, and digital audio players. E-books and multiple-function printers are common forms of special-purpose input/output devices.

Computer systems are generally divided into two categories: single user and multiple users. Single-user systems include handheld, ultra laptop, portable, thin client, desktop, and workstation computers.

Multiuser systems include servers, blade servers, mainframes, and supercomputers.

Principle

The computer hardware industry is rapidly changing and highly competitive, creating an environment ripe for technological breakthroughs.

CPU processing speed is limited by physical constraints such as the distance between circuitry points and circuitry materials. Moore's Law is a hypothesis stating that the number of transistors on a single chip will double every two years. This hypothesis has been accurate since it was introduced in 1970 and has led to smaller, faster, less expensive computer hardware.

Advances in tri-gate transistors, carbon nanotubes, and extreme miniaturization will result in faster CPUs.

Cell Broadband Engine Architecture is a microprocessor architecture developed by IBM, Sony, and Toshiba to provide more power-efficient, cost-effective, and higher-performance processing. This technology has numerous applications.

Manufacturers are competing to develop a nonvolatile memory chip that requires minimal power, offers extremely fast write speed, and can store data accurately even after it has been stored and written over many times. Such a chip could eliminate the need for RAM forms of memory. PCM, FeRAM, and MRAM are three potential solutions.

Cloud computing involves the use of a giant cluster of computers that serves as a host to run applications that require high-performance computing. Some organizations are exploring the use of cloud computing to replace major components of their infrastructure.

CHAPTER 3: SELF-ASSESSMENT TEST

Computer hardware must be carefully selected to meet the evolving needs of the organization and its supporting information systems.

1. Organizations typically make a one-time investment in the computer hardware necessary to meet their needs with little need for future changes and upgrades. True or False?
2. The computer hardware that most nonprofit organizations choose is virtually identical. True or False?
3. The overriding consideration for a business making hardware decisions should be how the hardware meets specific _____ and _____ requirements.
4. Which represents a larger amount of data—a terabyte or a gigabyte?
5. Which of the following components performs mathematical calculations and makes logical comparisons?
   a. control unit
   b. register
   c. ALU
   d. main memory
6. Executing an instruction by the CPU involves two phases: the instruction phase and the _____ phase.
7. _____ involves capturing and editing data when it is originally created and in a form that can be directly input to a computer, thus ensuring accuracy and timeliness.

The computer hardware industry is rapidly changing and highly competitive, creating an environment ripe for technological breakthroughs.

8. Some organizations are exploring the use of _____ to replace major components of their infrastructure.
9. There are few examples of companies in the computer industry collaborating to create a new product or service. True or False?

CHAPTER 3: SELF-ASSESSMENT TEST ANSWERS

(1) False (2) False (3) user and business requirements (4) terabyte (5) c (6) execution (7) Source data automation (8) cloud computing (9) False

REVIEW QUESTIONS

1. When determining the appropriate hardware components of a new information system, what role must the end user of the system play?
2. What is a blade server? What advantages does it offer over an ordinary server?
3. Identify three basic characteristics of RAM and ROM.
4. What is RFID technology? Identify three practical uses for this technology.
5. What issues can arise when the CPU runs at a very fast rate?

6. What advantages do fuel cells offer over batteries for use in portable electronic devices? Do they have any disadvantages?
7. What is the difference between data entry and data input?
8. What is RAID storage technology?
9. Explain the two-phase process for executing instructions.
10. Why are the components of all information systems described as interdependent?
11. Identify the three components of the CPU and explain the role of each.
12. What is the difference between sequential and direct access of data?
13. Identify several types of secondary storage media in terms of access method, capacity, portability, and cost per GB of storage.
14. Identify and briefly describe the various classes of personal computers.
15. What is the difference between cloud computing and grid computing?
16. What is source data automation?
17. What is the overall trend in secondary storage devices?

DISCUSSION QUESTIONS

1. Briefly describe how RFID technology works. Why is RFID technology being used to track product inventory in retail stores?
2. What would be the advantages for a university computer lab to install thin clients rather than standard desktop personal computers? Can you identify any disadvantages?
3. What is a quad-core processor? What advantages does it offer users?
4. Describe a practical business problem that could be solved through the use of a multiple-monitor solution.
5. Briefly describe Moore's Law. What are the implications of this law? Are there any practical limitations to Moore's Law?
6. Identify and briefly describe the three fundamental approaches to data storage.
7. Discuss the potential impact of converting to cloud computing on an individual organization's IS infrastructure.
8. Briefly discuss several data-storage issues that face the modern organization.
9. If cost was not an issue, describe the characteristics of your ideal computer. What would you use it for? Would you choose a handheld, portable, desktop, or workstation computer? Why?
10. How should organizations allocate grid computing resources so they address only important research projects?

PROBLEM-SOLVING EXERCISES

1. Use word processing software to document what your needs are as a computer user and your justification for selecting either a desktop or laptop computer. Find a Web site that allows you to order and customize a computer, and select those options that best meet your needs in a cost-effective manner. Assume that you have a budget of $1,250. Enter the computer specifications and associated costs into an Excel spreadsheet that you cut and paste into the document defining your needs. E-mail the document to your instructor.
2. Develop a spreadsheet that compares the features, initial purchase price, and ongoing operating costs for three laser printers. Now do the same for three inkjet printers. Write a brief memo on which printer you would choose and why. Cut and paste the spreadsheet into a document.
3. Enter data from Figure 3.3 (Moore's Law) into a spreadsheet program. Use the forecasting capabilities of the program to estimate the number of transistors on a chip for the next six years, and draw a chart depicting this. Are there basic limitations that can keep this forecast from being met? If so, what are they?

TEAM ACTIVITIES

1. With one or two of your classmates, visit a retail store that employs Radio Frequency Identification chips to track inventory. Interview an employee involved in inventory control, and document the advantages and disadvantages they see in this technology.
2. With two or three of your classmates, visit a computer retail store and identify the most popular ultra laptop computers. Interview members of the sales staff to find out why they think this particular laptop is popular.

WEB EXERCISES

1. Do research on the Web to document the current state of computer hardware disposal. What are some of the issues? What solutions are there to this problem? Write a brief report summarizing your findings.
2. Do research on the Web to identify the current status of the use of cloud computing. What companies are offering this service? What companies are exploring use of the service? Write a brief report summarizing your findings.

CAREER EXERCISES

1. Imagine that you are going to buy a single handheld device to improve your communication and organizational abilities. What tasks do you need it to perform? What features would you look for in this device? Visit a computer store or a consumer electronics store and see whether you can purchase such a device for under $400.
2. Your company's finance department plans to acquire 25 new computers and monitors, plus several new printers. The finance vice president has asked you to lead a project team assigned to define users' computer hardware needs. Who else (role, department) and how many people would you select to be a member of the team? How would you go about defining users' needs? Do you think that one hardware configuration (computer, monitor, and printer) will meet everyone's needs? Should you define multiple configurations based on the needs of various classes of end user? What business justification can you define to substantiate this expenditure of roughly $50,000?

CASE STUDIES

Case One

Advance America Implements Grid Computing

Chances are you have seen places that offer payday loans in your town. Payday loans are short-term loans designed for people that run out of money before payday, but can repay the loan when their paycheck arrives. Advance America is the leading payday loan company in the United States. It includes 3,000 centers in 37 states, and employs nearly 7,000 people, according to its Web site. Advance America is big, and growing bigger every day. Its growth in recent years is straining the capabilities of its client-server information system infrastructure and holding the company back from further growth.

Advance America used a system in which each center was equipped with an independent hardware and software environment. Installation and maintenance costs were high, and compiling data for all centers was time consuming and difficult. Each night the thousands of centers would upload their data to the main server for consolidation. With the growing number of centers, there wasn't enough time in the night to process all of the incoming data. Advance America's system had run up against a wall. It was time for a change.

Advance America decided to invest in a new system based on a grid computing architecture. They installed thin client machines to run in each center, connecting via the Web to a fault-tolerant server cluster running Oracle database software. The server cluster consists of a four-node cluster of

IBM P5 series servers, which include four processors per node for a total of 16 processors. The servers in the cluster work as a grid by sharing the work load of the entire organization equally among them. A pair of Cisco load balancers make sure that processing is distributed evenly among the servers for maximum performance. The new system includes a 2 TB storage area network (SAN) that uses an IBM disk array controlled by the Oracle Automatic Storage Management (ASM) software.

System IT managers at headquarters use a central grid-management console to oversee the entire nationwide network. Problems are easily identified and fixed through the centrally managed system. So far, the system has provided 100 percent uptime at the cash-advance centers.

Advance America took a chance with its $3.8 million investment in this new technology, but it has paid off. Center managers can now tap into "a continuously updated central database and generate reports in near real time." The new system has decreased the time it takes to open a new Advance America center. Managers are getting information much more quickly, making it easier for them to analyze business performance and customer trends. The new system is also easy to expand as the business grows. It is estimated that the new system will provide total net benefits of almost $3 million over five years for an ROI of 131 percent.

Discussion Questions

1. How does grid computing provide Advance America managers with faster access to data?
2. How did grid computing assist Advance America in breaking through the wall that held it back from growth?

Critical Thinking Questions

1. Why is the new grid computing system at Advance America much easier to install, manage, and maintain than its old system?
2. How might Advance America expand its system as the company outgrows it?

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Case Two

Mayo Clinic Turns to Game Processor to Save Lives

The Mayo Clinic and IBM have partnered in a venture to improve medical imaging technology. The clinic's current technologies aren't keeping up with the intense processing demands required to analyze digital medical images such as x-rays, CT scans, and MRIs.

You've learned in this chapter that transistor densities on a chip double roughly every two years, a rule of thumb referred to as Moore's Law. Bradley Erickson, chairman of radiology at the Rochester-based Mayo Clinic, was quoted in Computerworld as saying, "We are facing significant problems in medical imaging because the number of images produced in CT scanners basically tracks Moore's Law. My eyes and brain can't keep up. I see more and more images I have to interpret. ... The innovation here is to take computer chips and extract the information in these increasing number of images and help present it usefully to the radiologist."

This is a case of technology outpacing the human ability to manage the information it produces. In such cases, we turn to technology for solutions. For doctors and radiologists at the Mayo Clinic, standard computer processors cannot keep up with their need to analyze digital images. So they are turning to the Cell processor from IBM in hopes that it will provide a solution. The Cell processor is the chip that makes Sony's PlayStation video-game console the most powerful console in the industry, according to many game enthusiasts. The Cell processor was created in a joint effort by IBM, Sony, and Toshiba, with an architecture that is specially designed to accelerate graphics processing. Researchers at IBM and Mayo believe that it could turn a 10-minute CT image analysis into a four-second job.

One of the tasks in which the Cell processor could be useful is in comparing scan images of a patient over time. For example, to track the progression or regression of cancer in a patient, physicians compare CT scans of the tumor over time to look for change. Changes are often too subtle for the human eye to notice, so software that implements a complex algorithm is used to analyze the photos. Using a standard PC processor, the algorithm may take several minutes to complete. While this may not sound like much, typically a physician needs to run several analyses in sequence, consuming significant amounts of time. The process of transforming 2-D images into 3-D—something the Cell processor was designed for—also requires significant time using traditional processors. With the Cell processor, these tasks might be completed in a matter of a seconds.

Mayo Clinic and its effort to speed up the analysis of image scanning illustrate the importance of time when it comes to processing. Whether it's working to save a life, to finish design specifications for a new product, or to analyze stock market trends, the difference between a minute and a second can mean success or failure. For professionals in most industries, having the best processor for the task at hand, and matching it with the best hardware and software, provides them with a winning solution.

Discussion Questions

1. Why is the Cell processor the best processor for the Mayo Clinic's tasks? How might it empower physicians to save more lives?
2. If the Cell processor is so much faster than typical PC processors, why isn't it being used in PCs?

Critical Thinking Questions

1. In what other industry and scenario might time play an important role when it comes to processing? Explain how reducing minutes to seconds has an impact in that scenario.
2. What other processing technologies presented in this chapter might assist the Mayo Clinic in speeding up its computations?

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Questions for Web Case

See the Web site for this book to read about the Whitmann Price Consulting case for this chapter. Following are questions concerning this Web case.

Whitmann Price Consulting: Choosing Hardware

Discussion Questions

1. What considerations led Josh and Sandra to lean towards a Blackberry as the handheld device on which to run the AMCIS?
2. How did Josh and Sandra organize their hardware considerations for the new system?

Critical Thinking Questions

1. What role does system compatibility play in Josh and Sandra's decision?
2. What device(s) might have been chosen if the system requirements called for a 12-inch display and the ability to take handwritten notes and communicate through voice, text, and video?

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CHAPTER

• 4 •

Software: Systems and Application Software

PRINCIPLES	LEARNING OBJECTIVES
▪ Systems and application software are critical in helping individuals and organizations achieve their goals.	▪ Identify and briefly describe the functions of the two basic kinds of software. ▪ Outline the role of the operating system and identify the features of several popular operating systems.
▪ Organizations should not develop proprietary application software unless doing so will meet a compelling business need that can provide a competitive advantage.	▪ Discuss how application software can support personal, workgroup, and enterprise business objectives. ▪ Identify three basic approaches to developing application software and discuss the pros and cons of each.
▪ Organizations should choose a programming language whose functional characteristics are appropriate for the task at hand, considering the skills and experience of the programming staff.	▪ Outline the overall evolution and importance of programming languages and clearly differentiate among the generations of programming languages.
▪ The software industry continues to undergo constant change; users need to be aware of recent trends and issues to be effective in their business and personal life.	▪ Identify several key software issues and trends that have an impact on organizations and individuals.

Information Systems in the Global Economy
General Motors, United States

GM Changes Focus from Gears and Mechanics to Software and Electronic Systems

The automotive industry is experiencing perhaps the most significant evolutionary transition since Henry Ford designed the first production line. Faced with formidable pressures that include international competition, environmental concerns, increasing traffic, and driving-related fatalities, automotive companies are rethinking the way they design and build cars. For General Motors (GM), this means changing its focus from gears and pistons to electronic systems and software.

Addressing an audience of technology innovators, GM researcher Robert Baillargeon explained that GM is embracing what it calls "a new automotive DNA." Although the automotive industry historically focused on mechanical innovation, GM is now turning its attention to electronic propulsion, steering systems, and the software that controls them. Baillargeon suggested that an increasing number of GM researchers will have backgrounds in software engineering. Overseas competitors such as Toyota have relied on technology to streamline production processes and offer lower prices to consumers. Now GM is countering with its own technological innovations.

The new automotive DNA that Baillargeon described uses dozens of software systems to control some vehicle operations and work together by communicating over a network. Not only will various systems within a car communicate with each other, but each car on the road will communicate with other cars. For example, cars a mile ahead of your car could warn you of icy conditions, a pothole, or heavy traffic, allowing you to prepare by slowing down or choosing an alternate route. Software in the car will also provide information about the cost of travel routes based on fuel consumption and tolls. Software will empower cars with new levels of intelligence, creating smart cars that provide the driver with helpful travel information. Eventually, cars will be able to drive themselves using vehicle-to-vehicle communications, GPS, 360-degree sensing, and swarm intelligence (the ability to solve traffic problems as a group) to deliver passengers to their destination safely, quickly, and with minimum impact on the environment.

Companies such as GM are taking the first steps to realize this automotive vision. GM engineers are selecting software platforms on which to base these systems and determining how to distribute the software systems throughout the car's components. They are relying on state-of-the-art software development techniques such as object-oriented design and programming to define how software systems interact within the car, and using the Unified Modeling Language (UML) to map the entire automotive system. The new electronics paradigm of the automotive industry will dramatically change the way we think of cars and transportation.

As you read this chapter, consider the following:

- What types of activities can we entrust to software? In systems where life is at stake, how can we ensure safety when software fails?
- What should companies consider when designing software systems that need to interact with similar systems designed by competitors?

Why Learn About Software?

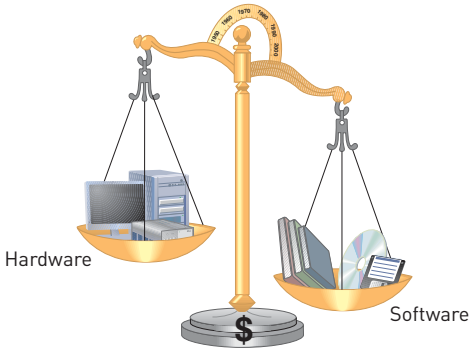
Software is indispensable for any computer system and the people using it. In this chapter, you will learn about systems and application software. Without systems software, computers would not be able to input data from a keyboard, make calculations, or print results. Application software is the key to helping you achieve your career goals. Sales representatives use software to enter sales orders and help their customers get what they want. Stock and bond traders use software to make split-second decisions involving millions of dollars. Scientists use software to analyze the threat of global warming. Regardless of your job, you most likely will use software to help you advance in your career and earn higher wages. Today, most organizations could not function without accounting software to print payroll checks, enter sales orders, and send out bills. You can also use software to help you prepare your personal income taxes, keep a budget, and play entertaining games. Software can truly advance your career and enrich your life. We begin with an overview of software.

Software has a profound impact on individuals and organizations. It can make the difference between profits and losses, and between financial health and bankruptcy. As Figure 4.1 shows, companies recognize this impact and spend more on software than on computer hardware.

Figure 4.1

The Importance of Software in Business

Since the 1950s, businesses have greatly increased their expenditures on software compared with hardware.



AN OVERVIEW OF SOFTWARE

computer programs
Sequences of instructions for the computer.

documentation
The text that describes the program functions to help the user operate the computer system.

As you learned in Chapter 1, software consists of computer programs that control the workings of computer hardware. **Computer programs** are sequences of instructions for the computer. **Documentation** describes the program functions to help the user operate the computer system. The program displays some documentation on screen, while other forms appear in external resources, such as printed manuals. People using commercially available software are usually asked to read and agree to End-User License Agreements (EULAs). After reading the EULA, you normally have to click an "I agree" button before you can use the software, which can be one of two basic types: systems software and application software.

Systems Software

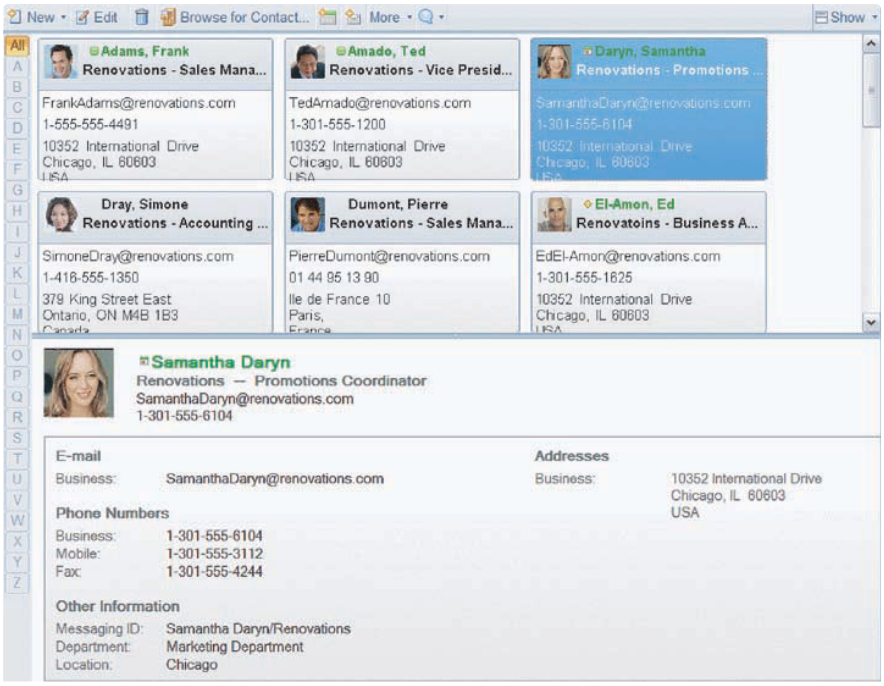
Systems software is the set of programs that coordinates the activities and functions of the hardware and other programs throughout the computer system. Each type of systems software is designed for a specific CPU and class of hardware. The combination of a hardware configuration and systems software is known as a computer system platform.

Application software has the greatest potential to affect processes that add value to a business because it is designed for specific organizational activities and functions.

(Source: © Jim West / Alamy.)

Application Software

Application software consists of programs that help users solve particular computing problems. In most cases, application software resides on the computer's hard disk before it is brought into the computer's memory and run. Application software can also be stored on CDs, DVDs, and even flash or keychain storage devices that plug into a USB port. Before a person, group, or enterprise decides on the best approach for acquiring application software, they should analyze their goals and needs carefully.



Lotus Notes is an application that enables a workgroup to schedule meetings and coordinate activities.

(Source: Courtesy of IBM Corporation.)

Supporting Individual, Group, and Organizational Goals

Every organization relies on the contributions of people, groups, and the entire enterprise to achieve its business objectives. Conversely, the organization also supports people, groups, and the enterprise with application software and information systems. One useful way of

classifying the many potential uses of information systems is to identify the scope of the problems and opportunities that an organization addresses. This scope is called the sphere of influence. For most companies, the spheres of influence are personal, workgroup, and enterprise. Table 4.1 shows how software can support these three spheres.

Table 4.1
Software Supporting Individuals, Workgroups, and Enterprises

Software	Personal	Workgroup	Enterprise
Systems software	Personal computer and workstation operating systems	Network operating systems	Midrange computer and mainframe operating systems
Application software	Word processing, spreadsheet, database, graphics	Electronic mail, group scheduling, shared work, collaboration	General ledger, order entry, payroll, human resources

personal sphere of influence
The sphere of influence that serves the needs of an individual user.

personal productivity software
The software that enables users to improve their personal effectiveness, increasing the amount of work they can perform and enhancing its quality.

workgroup
Two or more people who work together to achieve a common goal.

workgroup sphere of influence
The sphere of influence that serves the needs of a workgroup.

Information systems that operate within the **personal sphere of influence** serve the needs of an individual user. These information systems help users improve their personal effectiveness, increasing the amount and quality of work they can do. Such software is often called **personal productivity software**. When two or more people work together to achieve a common goal, they form a **workgroup**. A workgroup might be a large, formal, permanent organizational entity, such as a section or department, or a temporary group formed to complete a specific project. An information system in the **workgroup sphere of influence** helps a workgroup attain its common goals. Users of such applications must be able to communicate, interact, and collaborate to be successful.

Information systems that operate within the **enterprise sphere of influence** support the firm in its interaction with its environment. The surrounding environment includes customers, suppliers, shareholders, competitors, special-interest groups, the financial community, and government agencies. This means the enterprise sphere of influence includes business partners such as suppliers that provide raw materials, retail companies that store and sell a company's products, and shipping companies that transport raw materials to the plant and finished goods to retail outlets.

SYSTEMS SOFTWARE

enterprise sphere of influence
The sphere of influence that serves the needs of the firm in its interaction with its environment.

Controlling the operations of computer hardware is one of the most critical functions of systems software. Systems software also supports the application programs' problem-solving capabilities. Types of systems software include operating systems, utility programs, and middleware.

Operating Systems

operating system (OS)
A set of computer programs that controls the computer hardware and acts as an interface with application programs.

An **operating system (OS)** is a set of programs that controls the computer hardware and acts as an interface with applications (see Figure 4.2). Operating systems can control one or more computers, or they can allow multiple users to interact with one computer. The various combinations of OSs, computers, and users include the following:

- **Single computer with a single user.** This system is commonly used in a personal computer or a handheld computer that allows one user at a time.
- **Single computer with multiple users.** This system is typical of larger, mainframe computers that can accommodate hundreds or thousands of people, all using the computer at the same time.
- **Multiple computers.** This system is typical of a network of computers, such as a home network with several computers attached or a large computer network with hundreds of computers attached around the world.

- **Special-purpose computers.** This system is typical of a number of computers with specialized functions, such as those that control sophisticated military aircraft, the space shuttle, and some home appliances.

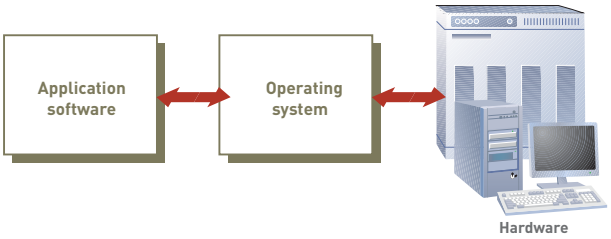


Figure 4.2
The Role of Operating Systems
The role of the operating system is to act as an interface or buffer between application software and hardware.

The OS, which plays a central role in the functioning of the complete computer system, is usually stored on disk. After you start, or "boot up," a computer system, portions of the OS are transferred to memory as they are needed. You can also boot a computer from a CD, DVD, or even a thumb drive that plugs into a USB port. A storage device that contains some or all of the OS is often called a "rescue disk" because you can use it to start the computer if you have problems with the primary hard disk.

Some OSs for handheld computers and notebooks that use solid-state hard drives have an "Instant On" feature that significantly reduces the time needed to boot a computer. The set of programs that make up the OS performs a variety of activities, including the following:

- Performing common computer hardware functions
- Providing a user interface and input/output management
- Providing a degree of hardware independence
- Managing system memory
- Managing processing tasks
- Providing networking capability
- Controlling access to system resources
- Managing files

The **kernel**, as its name suggests, is the heart of the OS and controls the most critical processes. The kernel ties all of the OS components together and regulates other programs.

kernel
The heart of the operating system, which controls the most critical processes.

Common Hardware Functions

All applications must perform certain hardware-related tasks, such as the following:

- Get input from the keyboard or another input device
- Retrieve data from disks
- Store data on disks
- Display information on a monitor or printer

Each of these tasks requires a detailed set of instructions. The OS converts a basic request into the instructions that the hardware requires. In effect, the OS acts as an intermediary between the application and the hardware. The typical OS performs hundreds of such tasks, translating each task into one or more instructions for the hardware. The OS notifies the user if input or output devices need attention, if an error has occurred, and if anything abnormal happens in the system.

User Interface and Input/Output Management

One of the most important functions of any OS is providing a **user interface**. A user interface allows people to access and command the computer system. The first user interfaces for mainframe and personal computer systems were command based. A **command-based user interface** requires you to give text commands to the computer to perform basic activities (see Figure 4.3). For example, the command ERASE 00TAXRTN would cause the computer to erase a file called 00TAXRTN. RENAME and COPY are other examples of commands used to rename files and copy files from one location to another. Many operating systems that use a graphical user interface, discussed next, also have powerful command-based features.

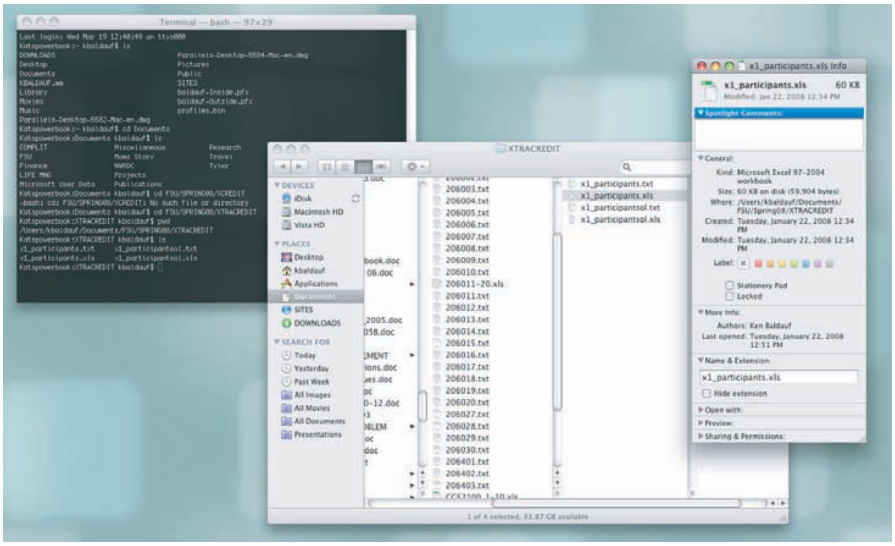
user interface
The element of the operating system that allows you to access and command the computer system.

command-based user interface
A user interface that requires you to give text commands to the computer to perform basic activities.

Figure 4.3

Command-Based and Graphical User Interfaces

While a command-based user interface provides only a prompt for text commands, a GUI provides icons, menus, and dialog boxes to support many forms of input.



graphical user interface (GUI)
An interface that uses icons and menus displayed on screen to send commands to the computer system.

Figure 4.3 also shows a **graphical user interface (GUI)**, which uses pictures (called icons) and menus displayed on screen to send commands to the computer system. Many people find that GUIs are easier to use because they intuitively grasp the functions. Today, the most widely used graphical user interface is Microsoft Windows. Alan Kay and others at Xerox PARC (Palo Alto Research Center, located in California) were pioneers in investigating the use of overlapping windows and icons as an interface. As the name suggests, Windows is based on the use of a window, or a portion of the display screen dedicated to a specific application. The screen can display several windows at once. GUIs have contributed greatly to the increased use of computers because users no longer need to know command-line syntax to accomplish tasks.

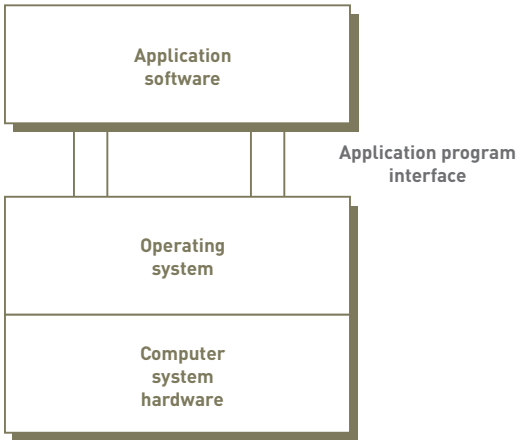
Hardware Independence

application program interface (API)
An interface that allows applications to make use of the operating system.

To run, applications request services from the OS through a defined **application program interface (API)**, as shown in Figure 4.4. Programmers can use APIs to create application software without having to understand the inner workings of the OS.

Figure 4.4

Application Program Interface Links Application Software to the Operating System



Suppose that a computer manufacturer designs new hardware that can operate much faster than before. If the same OS for which an application was developed can run on the new hardware, the application will require minimal (or no) changes to enable it to run on the new hardware. If APIs did not exist, the application developers might have to completely rewrite the application to take advantage of the new, faster hardware.

Memory Management

The OS also controls how memory is accessed and maximizes available memory and storage. Newer OSs typically manage memory better than older OSs. The memory-management feature of many OSs allows the computer to execute program instructions effectively and to speed processing. One way to increase the performance of an old computer is to upgrade to a newer OS and increase the amount of memory.

Most OSs support virtual memory, which allocates space on the hard disk to supplement the immediate, functional memory capacity of RAM. Virtual memory works by swapping programs or parts of programs between memory and one or more disk devices—a concept called paging. This reduces CPU idle time and increases the number of jobs that can run in a given time span.

Processing Tasks

The task-management features of today's OSs manage all processing activities. Task management allocates computer resources to make the best use of each system's assets. Task-management software can permit one user to run several programs or tasks at the same time (multitasking) and allow several users to use the same computer at the same time (time-sharing).

An OS with multitasking capabilities allows a user to run more than one application at the same time. Without having to exit a program, you can work in one application, easily pop into another, and then jump back to the first program, picking up where you left off. Better still, while you're working in the *foreground* in one program, one or more other applications can be churning away, unseen, in the *background*, sorting a database, printing a document, or performing other lengthy operations that otherwise would monopolize your computer and leave you staring at the screen unable to perform other work. Multitasking can save users a considerable amount of time and effort.

Time-sharing allows more than one person to use a computer system at the same time. For example, 15 customer service representatives might be entering sales data into a computer system for a mail-order company at the same time. In another case, thousands of people might be simultaneously using an online computer service to get stock quotes and valuable business news.

The ability of the computer to handle an increasing number of concurrent users smoothly is called *scalability*. This feature is critical for systems expected to handle a large number of users, such as a mainframe computer or a Web server. Because personal computer OSs usually are oriented toward single users, they do not need to manage multiple-user tasks often.

Networking Capability

Most operating systems include networking capabilities so that computers can join together in a network to send and receive data and share computing resources. PCs running Mac, Windows, or Linux operating systems allow users to easily set up home or business networks for sharing Internet connections, printers, storage, and data. Operating systems for larger server computers are designed specifically for computer networking environments.

Access to System Resources and Security

Because computers often handle sensitive data that can be accessed over networks, the OS needs to provide a high level of security against unauthorized access to the users' data and programs. Typically, the OS establishes a logon procedure that requires users to enter an identification code, such as a user name, and a matching password. If the identification code is invalid or if the password does not match the identification code, the user cannot gain access to the computer. Some OSs require that user passwords change frequently—such as every 20 to 40 days. If the user successfully logs on to the system, the OS restricts access to only portions of the system for which the user has been cleared. The OS records who is using the system and for how long, and reports any attempted breaches of security.

File Management

The OS manages files to ensure that files in secondary storage are available when needed and that they are protected from access by unauthorized users. Many computers support multiple users who store files on centrally located disks or tape drives. The OS keeps track of where each file is stored and who can access it. The OS must determine what to do if more than one user requests access to the same file at the same time. Even on stand-alone personal computers with only one user, file management is needed to track where files are located, what size they are, when they were created, and who created them.

Current Operating Systems

Early OSs were very basic. Recently, however, more advanced OSs have been developed, incorporating sophisticated features and impressive graphics effects. Table 4.2 classifies a few current OSs by sphere of influence.

Table 4.2

Popular Operating Systems Cross All Three Spheres of Influence

Personal	Workgroup	Enterprise
Microsoft Windows Vista, Windows XP, Windows Mobile, Windows Automotive, and Windows Embedded	Microsoft Windows Server 2003 and Server 2008	Microsoft Windows Server 2003 and Server 2008
Mac OS X	Mac OS X Server	
UNIX	UNIX	UNIX
Solaris	Solaris	Solaris
Linux	Linux	Linux
Red Hat Linux	Red Hat Linux	Red Hat Linux
Palm OS	Netware	
	IBM i5/OS and z/OS	IBM i5/OS and z/OS
	HP-UX 11i	HP-UX 11i

Microsoft PC Operating Systems

Since a small company called Microsoft developed PC-DOS and MS-DOS to support the IBM personal computer introduced in the 1980s, personal computer OSs have steadily evolved. *PC-DOS* and *MS-DOS* had command-driven interfaces that were difficult to learn and use. Each new version of OS has improved the ease of use, processing capability, reliability, and ability to support new computer hardware devices.

Windows XP (XP reportedly stands for the positive experience that you will have with your personal computer) was released in fall 2001. Previous consumer versions of Windows were notably unstable and crashed frequently, requiring frustrating and time-consuming reboots. With XP, Microsoft sought to bring reliability to the consumer.

In 2007, Microsoft released Windows Vista to the public, introducing it as the most secure version of Windows ever. Windows Vista includes design improvements that make it attractive and easy to use. The most advanced editions of Windows Vista include a 3-D graphics interface called Aero. However, the system requirements for Windows Vista with Aero require many users to purchase new, more powerful PCs. Windows Vista also suffered some negative press when early adopters found that some software and hardware designed for Windows XP did not run on Vista.

Windows Vista is available in five editions. Windows Vista Home Basic provides improved security, but otherwise has features similar to those included in Windows XP. Windows Vista Home Premium includes enhanced security, the Aero interface, and other improvements such as home media, but lacks business features. Windows Vista Business includes all of the above except the home media features plus business features such as a backup and restore tool, a scan and fax tool, and easy access to business networks from home.

Windows Vista Ultimate includes all of these features (see Figure 4.5). A fifth version of Windows Vista, Vista Enterprise, is designed for use on business networks. It includes encryption technology to keep stored data secure, and the ability to deliver a Windows desktop environment from an enterprise server. Today, Microsoft has over 90 percent of the PC OS market. Apple holds 7.3 percent of the market, and Linux publishers and other companies account for the rest of the PC OS market.[1]

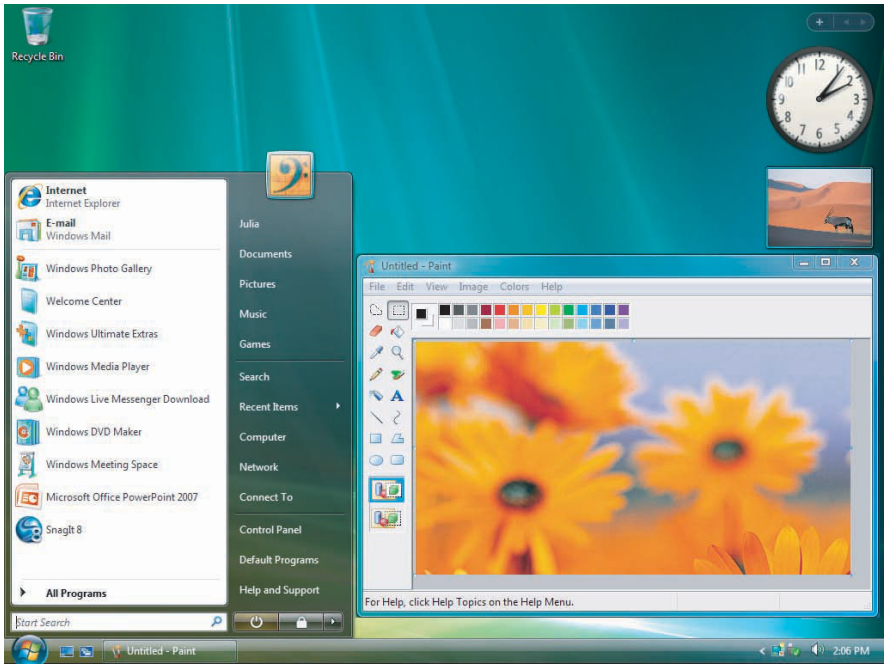


Figure 4.5
Microsoft Windows Vista

The National Aquarium in Baltimore decided to upgrade to Microsoft Vista Home Premium to improve data security and staff productivity.[2] The staff that manages the 16,000 aquatic specimens has little time for computer work. Staff members share PC workstations placed strategically around the 250,000 square foot facility. Before upgrading to Windows Vista, various versions of operating systems were installed around the aquarium, and staff members found the logon time a test of their patience. It was not uncommon for users to forget to log out and leave secure data open to others. The aquarium chose Windows Vista for two important features: Fast User Switching, which automatically logs users out after a period of inactivity, but allows them to return to their work in seconds, and Windows built-in desktop search, which saves time when looking for data. The staff estimates that it has doubled its computing productivity since switching to Windows Vista.

Apple Computer Operating Systems

Although IBM system platforms traditionally use one of the Windows OSs and Intel microprocessors (often called *Wintel* for this reason), Apple computers have used non-Intel microprocessors designed by Apple, IBM, and Motorola which run a proprietary Apple OS—the Mac OS. Newer Apple computers, however, use Intel chips. Although Wintel computers hold the largest share of the business PC market, Apple computers are also popular, especially in the fields of publishing, education, graphic arts, music, movies, and media. Software developed for the Macintosh often provides cutting-edge options for creative people. GarageBand, for example, is Macintosh software that allows you to create your own music the way a professional does, and it can sound like a small orchestra. Pro Tools is another software program used to edit digital music.

The Apple OSs have also evolved over a number of years and often provide features not available from Microsoft. Starting in July 2001, the Mac OS X was installed on all new Macs. It includes an entirely new user interface, which provides a new visual appearance for

users—including luminous and semitransparent elements, such as buttons, scroll bars, windows, and fluid animation to enhance the user's experience.

Since its first release, Apple has upgraded OS X several times. Leopard is the most recent version of OS X, released in 2007 to compete with Windows Vista (see Figure 4.6). OS X Leopard includes an attractive 3-D graphical user interface that Apple claims is more intuitive than Windows. Leopard includes Time Machine, a powerful backup tool that allows users to view their system as it looked in the past and resurrect deleted files. Leopard also includes multiple desktops, a video chat program that allows users to pose in front of imaginary landscapes, a powerful system search utility, and other updated software. Because Mac OS X runs on Intel processors, Mac users can set up their PC to run both Windows Vista and Mac OS X and select which platform they want to work with when they boot their PC. Macs are also considered very secure, with no widespread virus or spyware infections to date.

Figure 4.6

Mac OS X Leopard

(Source: Courtesy of Apple Computer, Inc.)

When attorney Renee Mancino decided to leave her Las Vegas law firm and start her own home-based practice, she chose an Apple MacBook Pro with the Mac OS as her mobile office.[3] She appreciates the Mac's organizational features that help her to manage and sift through the thousands of documents associated with her cases.

Linux

Linux is an OS developed by Linus Torvalds in 1991 as a student in Finland. The OS is distributed under the GNU General Public License, and its source code is freely available to everyone. It is, therefore, called an open-source operating system. This doesn't mean, however, that Linux and its assorted distributions are necessarily free—companies and developers can charge money for a distribution as long as the source code remains available. Linux is actually only the kernel of an OS, the part that controls hardware, manages files, separates processes, and so forth. Several combinations of Linux are available, with various sets of capabilities and applications to form a complete OS. Each of these combinations is called a *distribution* of Linux. Many distributions are available as free downloads.

Linux is available on the Internet and from other sources, including Red Hat Linux and Caldera OpenLinux. Many people and organizations use Linux.

In addition, several large computer vendors, including IBM, Hewlett-Packard, and Intel, support the Linux operating system. For example, IBM has more than 500 programmers working with Linux, primarily because of its security features. Many CIOs are considering switching to Linux and open-source software because of security concerns with Microsoft software.

Linux is making inroads to the consumer PC market with their GUI distributions. Both Dell and Lenovo sell notebook computers running Ubuntu and SuSE Linux.[4] Ubuntu is a user-friendly Linux distribution that is free to download and includes dozens of free software packages (see Figure 4.7). Wal-Mart and Sears are selling Linux PCs for $200, making them a popular alternative to other types of computers.[5] (Wal-Mart is selling the PCs only online.) New ultra-compact notebooks such as the ASUS Eee PC are preinstalled with Linux to make the most of their limited system resources.

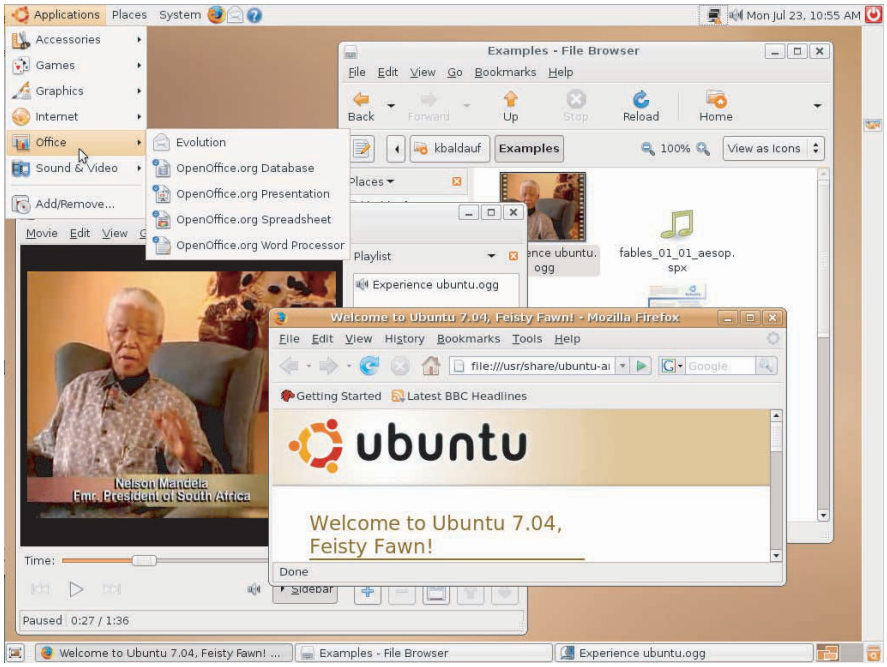


Figure 4.7

Ubuntu Linux Operating System

(Source: Courtesy of Ubuntu.)

Radio station KRUU, "the Voice of Fairfield" in Iowa, is a nonprofit, community-based radio station. It broadcasts locally every day, 24 hours a day, and online to 30 countries (*www.kruufm.com*). The station supports about 100 hosts and 75 programs, broadcasting programs ranging from bedtime stories to death-metal music. When shopping for an operating system to use in the studio, KRUU selected Linux Ubuntu.[6] "Our requirements were quite complex and our decision to go with Ubuntu was based on three factors and Ubuntu won hands down," stated Sundar Raman, a presenter at the station. The three factors were: (1) Ubuntu looks good and is simple for both Windows and Mac users to use, (2) Ubuntu is reliable and easy to manage both locally and remotely, and (3) Ubuntu software supports professional audio editing and mixing software and hardware. One benefit of using Linux Ubuntu is the user community support. KRUU found all the answers it needed regarding running a professional studio on Linux from the "Ubuntu-Studio" community. Communicating with other Linux professionals helped the station use Linux computers for all of their computing tasks, including recording and mixing consoles.

Workgroup Operating Systems

To keep pace with user demands, the technology of the future must support a world in which network usage, data-storage requirements, and data-processing speeds increase at a dramatic rate. This rapid increase in communications and data-processing capabilities pushes the boundaries of computer science and physics. Powerful and sophisticated OSs are needed to run the servers that meet these business needs for workgroups. Small businesses, for example, often use workgroup OSs to run networks and perform critical business tasks.

Windows Server

Microsoft designed *Windows Server* to perform a host of tasks that are vital for Web sites and corporate Web applications. For example, Microsoft Windows Server can be used to coordinate large data centers. The OS also works with other Microsoft products. It can be used to prevent unauthorized disclosure of information by blocking text and e-mails from being copied, printed, or forwarded to other people. Microsoft *Windows Server 2008* is the most recent version of Windows Server and delivers benefits such as a powerful Web server management system, virtualization tools that allow various operating systems to run on a single server, advanced security features, and robust administrative support.

UNIX

UNIX is a powerful OS originally developed by AT&T for minicomputers. UNIX can be used on many computer system types and platforms, from personal computers to mainframe systems. UNIX also makes it much easier to move programs and data among computers or to connect mainframes and personal computers to share resources. There are many variants of UNIX—including HP/UX from Hewlett-Packard, AIX from IBM, UNIX SystemV from UNIX Systems Lab, Solaris from Sun Microsystems, and SCO from Santa Cruz Operations. Sun Microsystems hopes that its open-source Solaris will attract developers to make the software even better.

The online marketplace eBay uses Sun Microsystems servers, software, storage, and services to run its operations.[7] Sun's Solaris operating system manages eBay's systems, including database servers, Web servers, tape libraries, and identity management systems. The online auction company found that when they switched to Sun and Solaris, system performance increased by 20 percent. The Idaho National Laboratory also uses Solaris to conduct research in their work to design more efficient and safe nuclear reactors.[8]

NetWare

NetWare is a network OS sold by Novell that can support users on Windows, Macintosh, and UNIX platforms. NetWare provides directory software to track computers, programs, and people on a network, helping large companies to manage complex networks. NetWare users can log on from any computer on the network and use their own familiar desktop with all their applications, data, and preferences.

Red Hat Linux

Red Hat Software offers a Linux network OS that taps into the talents of tens of thousands of volunteer programmers who generate a steady stream of improvements for the Linux OS. The *Red Hat Linux* network OS is very efficient at serving Web pages and can manage a cluster of up to eight servers. Linux environments typically have fewer virus and security problems than other OSs. Distributions such as SuSE and Red Hat have proven Linux to be a very stable and efficient OS.

Mac OS X Server

The *Mac OS X Server* is the first modern server OS from Apple Computer and is based on the UNIX OS. The most recent version is OS X Server 10.5 Leopard. It includes features that allow the easy management of network and Internet services such as e-mail, Web site hosting, calendar management and sharing, wikis, and podcasting.

Enterprise Operating Systems

New mainframe computers provide the computing and storage capacity to meet massive data-processing requirements and offer many users high performance and excellent system availability, strong security, and scalability. In addition, a wide range of application software has been developed to run in the mainframe environment, making it possible to purchase software to address almost any business problem. As a result, mainframe computers remain the computing platform of choice for mission-critical business applications for many companies. Examples of mainframe OSs include z/OS from IBM, HP-UX from Hewlett-Packard, and Linux.

z/OS

The *z/OS* is IBM's first 64-bit enterprise OS. It supports IBM's z900 and z800 lines of mainframes that can come with up to sixteen 64-bit processors. (The z stands for zero downtime.) The OS provides several new capabilities to make it easier and less expensive for users to run large mainframe computers. The OS has improved workload management and advanced e-commerce security. The IBM zSeries mainframe, like previous generations of IBM mainframes, lets users subdivide a single computer into multiple smaller servers, each of which can run a different application. In recognition of the widespread popularity of a competing OS, z/OS allows partitions to run a version of the Linux OS. This means that a company can upgrade to a mainframe that runs the Linux OS.

HP-UX and Linux

The *HP-UX* is a robust UNIX-based OS from Hewlett-Packard designed to handle a variety of business tasks, including online transaction processing and Web applications. It supports Internet, database, and business applications on server and mainframe enterprise systems. It can work with Java programs and Linux applications. The OS comes in five versions: foundation, enterprise, mission critical, minimal technical, and technical. HP-UX supports Hewlett-Packard's computers and those designed to run Intel's Itanium processors. *Red Hat Enterprise Linux* for IBM mainframe computers is another example of an enterprise operating system.

Operating Systems for Small Computers, Embedded Computers, and Special-Purpose Devices

New OSs and other software are changing the way we interact with personal digital assistants (PDAs), smartphones, cell phones, digital cameras, TVs, and other appliances. These OSs are also called *embedded operating systems* because they are typically embedded within a device, such as an automobile or TV recorder. Embedded software is a multibillion dollar industry. Some of these OSs allow you to synchronize handheld devices with PCs using cradles, cables, and wireless connections. Cell phones also use embedded OSs (see Figure 4.8). In addition, some OSs have been developed for special-purpose devices, such as TV set-top boxes, computers on the space shuttle, computers in military weapons, and computers in some home appliances. Some of the more popular OSs for devices are described in the following section.

Figure 4.8

Mobile Phones Have Embedded Operating Systems

Many cell phones and smartphones, such as this BlackBerry, have an embedded OS that can support access to communications, media, and information.

(Source: Courtesy of PRNewsFoto/ Verizon Wireless.)

An IT group within the United States Department of Agriculture recently deployed BlackBerries to their IT staff.[9] The high-speed network connection between BlackBerry and the organization's private network allowed system support staff to troubleshoot problems on Linux, UNIX, and Microsoft servers located in the home office from any location.

Palm OS

ACCESS Systems makes the Palm operating system, which is used in over 30 million handheld computers and smartphones manufactured by Palm, Inc. and other companies. Palm also develops and supports applications, including business, multimedia, games, productivity, reference and education, hobbies and entertainment, travel, sports, utilities, and wireless applications. Today, the smartphone market is overtaking the PDA market, as mobile users prefer to combine phone and information services in one device. OSs for this market are also provided by Research in Motion, Microsoft, Symbian, Apple (for the iPhone), and others.

Windows Embedded

Windows Embedded is a family of Microsoft OSs included with or embedded into small computer devices. Windows Embedded includes several versions that provide computing power for TV set-top boxes, automated industrial machines, media players, medical devices, digital cameras, PDAs, GPS receivers, ATMs, gaming devices, and business devices such as cash registers. Microsoft Auto provides a computing platform for automotive software such as Ford Sync. The Ford Sync system uses an in-dashboard display and wireless networking technologies to link automotive systems with cell phones and portable media players (see Figure 4.9).

Figure 4.9

Microsoft Auto and Ford Sync

The Ford Sync system, developed on the Microsoft Auto operating system, allows drivers to wirelessly connect cell phones and media devices to automotive systems.

(Source: Courtesy of Microsoft Corporation and Ford Motor Company.)

Windows Mobile

Windows Mobile is an operating system designed for smartphones and PDAs. Different versions of Windows Mobile support either a touch screen interface or a menu-driven interface. In addition to supporting typical cellular services, Windows Mobile provides handwriting recognition, instant messaging technology, support for more secure Internet connections, and the ability to beam information to other devices. The OS also has advanced telecommunications capabilities, discussed in more detail in Chapter 6. Dozens of phones provided by all of the major carriers run Windows Mobile.

Utility Programs

Utility programs help to perform maintenance or correct problems with a computer system. For example, some utility programs merge and sort sets of data, keep track of computer jobs being run, compress files of data before they are stored or transmitted over a network (thus saving space and time), and perform other important tasks. Some utility programs can help computer systems run better and longer without problems.

utility programs
Programs that help to perform maintenance or correct problems with a computer system.

Another type of utility program allows people and organizations to take advantage of unused computer power over a network. Often called *grid computing*, the approach can be very efficient and less expensive than purchasing additional hardware or computer equipment. Financial services firm Wachovia Corporation uses grid computing to combine the power of 10,000 CPUs located on computers around the world for processing transactions. [10] In the future, grid computing could become a common feature of OSs and provide inexpensive, on-demand access to computer power and resources.

Utility programs can also help to secure and safeguard data. For example, the recording and motion picture industry uses digital rights management (DRM) technologies to prevent copyright-protected movies and music from being unlawfully copied. Music and media files are encoded so that software running on players recognizes and plays only legally obtained copies. DRM has been criticized for infringing on the freedom and rights of customers. Record companies are experimenting with DRM-free music to see if it increases sales.

Although many PC utility programs come installed on computers (see Figure 4.10), you can also purchase utility programs separately. The following sections examine some common types of utilities.

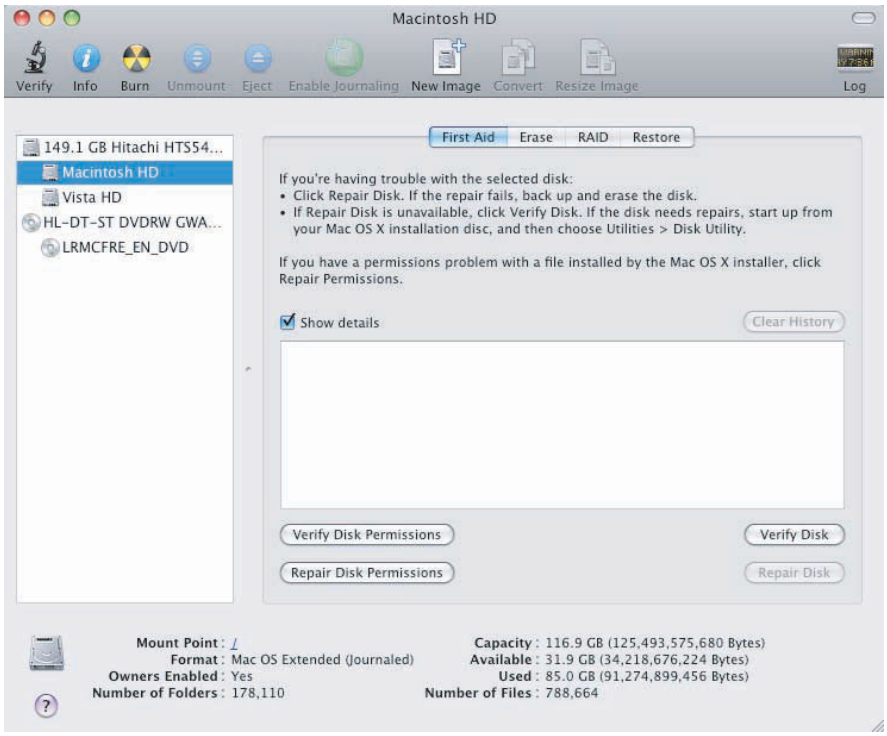


Figure 4.10

Mac Disk Utility

The Apple Mac Disk Utility is packaged with OS X and provides tools for repairing disks, backing up disks, creating disk images, and burning CDs and DVDs.

Hardware Utilities

Some hardware utilities are available from companies such as Symantec, which produces Norton Utilities. Hardware utilities can check the status of all parts of the PC, including hard disks, memory, modems, speakers, and printers. Disk utilities check the hard disk's boot sector, file allocation tables, and directories, and analyze them to ensure that the hard disk is not damaged. Disk utilities can also optimize the placement of files on a crowded disk.

Security Utilities

Computer viruses and spyware from the Internet and other sources can be a nuisance—and sometimes can completely disable a computer. Antivirus and antispyware software can be installed to constantly monitor and protect the computer. If a virus or spyware is found, often times it can be removed. This software runs continuously in the background to keep new viruses and spyware from entering the system. To keep current and make sure that the software checks for the latest threats, it can be easily updated over the Internet. It is also a good idea to protect computer systems with firewall software. Firewall software filters incoming and outgoing packets making sure that hackers or their tools are not attacking the system. Some software assists in keeping private data from being accessed from a computer system, in order to protect you from scams and fraud. Symantec, McAfee, and Microsoft are the most popular providers of security software.

File-Compression Utilities

File-compression programs can reduce the amount of disk space required to store a file or reduce the time it takes to transfer a file over the Internet. A popular program on Windows PCs is WinZip (*www.winzip.com*), which generates zip files, which are collections of one or more compressed files. A zip file has a .zip extension, and its contents can be easily unzipped to their original size. Windows Vista includes utilities for compressing and uncompressing files. *MP3 (Motion Pictures Experts Group-Layer 3)* is a popular file-compression format used to store, transfer, and play music and audio files, such as podcasts—audio programs that can be downloaded from the Internet. MP3 can compress files ten times smaller than the original file with near-CD-quality sound. Software, such as iTunes from Apple, can be used to store, organize, and play MP3 music files.

Spam and Pop-Up Blocker Utilities

Getting unwanted e-mail (spam) and having annoying and unwanted ads pop up on your screen while you are on the Web can be a frustrating waste of time. You can install a number of utility programs to help block unwanted e-mail spam and pop-up ads. Most Internet service providers and Web-based e-mail systems provide a spam-blocking service, and Web browsers such as Internet Explorer and Firefox include pop-up blocking utilities.

Network and Internet Utilities

A broad range of network- and systems-management utility software is available to monitor hardware and network performance and trigger an alert when a Web server is crashing or a network problem occurs. Although these general management features are helpful, what is needed is a way to pinpoint the cause of the problem. Topaz from Mercury Interactive is an example of software called an *advanced Web-performance monitoring utility*. It is designed to sound an alarm when it detects problems and let network administrators isolate the most likely causes of the problems. Its Auto RCA (root-cause analysis) module uses statistical analysis with built-in rules to measure system and Web performance. Actual performance data is compared with the rules, and the results can help pinpoint where trouble originated—in the application software, database, server, network, or the security features.

Server and Mainframe Utilities

Some utilities enhance the performance of servers and mainframe computers. IBM has created systems-management software that allows a support person to monitor the growing number of desktop computers in a business attached to a server or mainframe computer. With this software, the support people can sit at their personal computers and check or diagnose problems, such as a hard disk failure on a network computer. The support people can even repair individual systems anywhere on the organization's network, often without having to leave their desks. The direct benefit is to the system manager, but the business also gains from having a smoothly functioning information system. Utility programs can meet the needs of a single user, workgroup, or enterprise, as listed in Table 4.3. These programs perform useful tasks—from tracking jobs to monitoring system integrity.

Personal	Workgroup	Enterprise
Software to compress data so that it takes less hard disk space	Software to provide detailed reports of work-group computer activity and status of user accounts	Software to archive contents of a database by copying data from disk to tape
Screen saver	Software that manages an uninterruptible power supply to do a controlled shutdown of the workgroup computer in the event of a loss of power	Software that compares the content of one file with another and identifies any differences
Antivirus and antispyware software	Software that reports unsuccessful user logon attempts	Software that reports the status of a particular computer job

Table 4.3
Examples of Utility Programs

Virtualization software can make computers simulate other computers. The result is often called a *virtual machine*. Using virtualization software, servers and mainframe computers can run software applications written for different operating systems. For example, you can use a server or mainframe to test and run a number of PC applications simultaneously, such as spreadsheets, word processors, and databases. Virtualization software such as VMWare is being used by businesses to safeguard private data. For example, Kindred Healthcare uses VMWare on its server to run hundreds of virtual Windows PC desktops that are accessed by mobile computers throughout the organization.[11] Because the patient data and the software tools used to access that data are running on the server, security measures are easy to implement.

Other Utilities

Utility programs are available for almost every conceivable task or function. For example, you can use Microsoft Windows Rights Management Services with Microsoft Office programs to manage and protect important corporate documents. ValueIT is a utility that can help a company verify the value of investments in information systems and technology. Widgit Software has developed an important software utility that helps people with visual disabilities use the Internet. The software converts icons and symbols into plain text that can be easily seen. Another software utility allows a manager to see every keystroke a worker makes on a computer system. Monitoring software can catalog the Internet sites that employees visit and the time that employees are working at their computer.

In addition, you can use many search tools to find important files and documents. Most of these desktop search tools are free and available from a number of popular Internet sites. Yahoo! Desktop Search, Google Desktop, Mac Spotlight, and Windows Search are examples (see Figure 4.11).

Middleware

Middleware is software that allows different systems to communicate and exchange data. Middleware can also be used as an interface between the Internet and older legacy systems. (Legacy software is a previous, major version that continues to be used.) For example, middleware can be used to transfer a request for information from a corporate customer on the corporate Web site to a traditional database on a mainframe computer and return the results to the customer on the Internet.

middleware
Software that allows different systems to communicate and exchange data.

The use of middleware to connect disparate systems has evolved into an approach for developing software and systems called SOA. A **service-oriented architecture**, or SOA, uses modular application services to allow users to interact with systems, and systems to interact with each other. Systems developed with SOA are flexible and ideal for businesses that need a system to expand and evolve over time. SOA modules can be reused for a variety of purposes, which reduces development time. Because SOA modules are designed using programming standards so they can interact with other modules, rigid custom-designed middleware software is not needed to connect systems. However, Southside Electric Cooperative, Inc. in Virginia found SOA to be the perfect solution to eliminating time-consuming paperwork, reducing response time to customer needs, and doubling the rate that it is able to collect delinquent payments.[12] The system uses Qualcomm OmniTRACS wireless communications and IBM's SOA-based WebSphere software.

service-oriented architecture (SOA)
A modular method of developing software and systems that allows users to interact with systems, and systems to interact with each other.

Figure 4.11

Desktop Search Tool

With a desktop search tool, you can search through files on your computer to instantly find files of all types that have something to do with the specified keyword.

APPLICATION SOFTWARE

As discussed earlier in this chapter, the primary function of application software is to apply the power of the computer to give people, workgroups, and the entire enterprise the ability to solve problems and perform specific tasks. When you need the computer to do something, you use one or more application programs. The application programs interact with systems software, and the systems software then directs the computer hardware to perform the necessary tasks. Applications help you perform common tasks, such as creating and formatting text documents, performing calculations, or managing information, though some applications are more specialized. A pharmaceutical company, for example, has developed application software to detect the early signs of Parkinson's disease. The new software detects slight trembling in speech patterns not detectable by the human ear that predicts the disease. Application software is used throughout the medical profession to save and prolong lives. For example, Oregon Health & Science University uses iRecruitment software from Oracle to match employees to job openings.[13]

The functions performed by application software are diverse, and range from personal productivity to business analysis. For example, application software can help sales managers track sales of a new item in a test market. Software from IntelliVid monitors video feeds from store security cameras and notifies security when a shopper is behaving suspiciously.[14] Most of the computerized business jobs and activities discussed in this book involve application software. We begin by investigating the types and functions of application software.

INFORMATION SYSTEMS @ WORK

Software Helps Target Radiation Treatment for Cancer

Doctors have been using radiation therapy as a treatment for cancer since the 1940s. The treatment has saved countless lives, yet has been somewhat imprecise until recently. The original method of treating a tumor with radiation used a linear accelerator that delivered radiation in rectangular beams. Doctors used lead blocks to prevent the beams from harming healthy tissue. The process was cumbersome and only partially effective. Surrounding tissue was often destroyed along with the tumor.

In the 1980s, a machine called an MLC, for multileaf collimator, was invented. The MLC had motorized leaves to disrupt the beam of radiation and focus it more closely on where it was needed. Still, the treatment was imprecise, lacking real-time control of the radiation intensity and direction.

Until the mid-1990s, most of the development of radiation treatment technologies focused on hardware. Varian Medical Systems decided that devising a more effective system would require a heavy investment in software development. Computing processors and hardware were advanced enough to precisely control beams of radiation, but the software to empower the hardware had yet to be developed. Varian transformed itself from a hardware company to a software company to get the job done.

Varian hired experts in programming embedded controls, user interfaces, treatment planning, and databases. It proceeded incrementally over many years to develop a trustworthy and powerful system called the SmartBeam IMRT (for Intensity Modulated Radiation Therapy), which is now in use at thousands of medical facilities around the world.

The SmartBeam IMRT combines an x-ray and radiation technology into one device that rotates around the patient delivering radiation at precise intensities from any angle. The machine is the first that allows physicians to examine and treat a tumor at the same time. The on-board imager produces "high-resolution images of tumors and tracks changes in a tumor's shape, size, and position... that when coupled with SmartBeam IMRT, allows clinicians to be even more precise when targeting tumors," according to *Computerworld*. The magazine awarded Varian the top prize for information systems in manufacturing in its 2007 Computerworld Honors Program.

Discussion Questions

1. What role does software play in the SmartBeam IMRT medical system?
2. Why couldn't Varian produce the SmartBeam IMRT before it did?

Critical Thinking Questions

1. What additional safeguards must be programmed into the software that runs the SmartBeam IMRT that aren't necessary in typical PC software?
2. How do you think the development of the SmartBeam IMRT launched Varian to the top of the market in cancer treatment systems?

SOURCES: Pratt, Mary K., "Software Helps Target Radiation Treatment for Cancer," *Computerworld*, December 3, 2007, *www.computerworld.com/action/article.do?command=viewArticleBasic&articleId=30486 5&pageNumber=1*. Varian Medical Systems Web site, *www.varian.com*, accessed February 3, 2007.

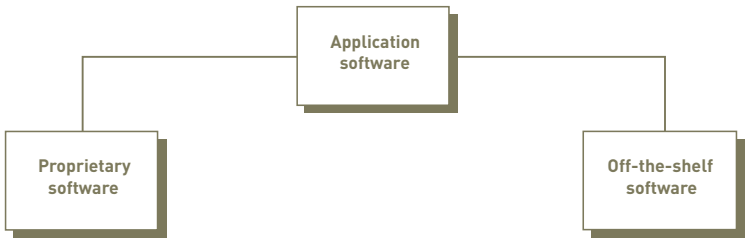
Overview of Application Software

Proprietary software and off-the-shelf software are important types of application software (see Figure 4.12). A company can develop a one-of-a-kind program for a specific application (called **proprietary software**). Proprietary software is not in the public domain. A company can also purchase or acquire an existing software program (sometimes called **off-the-shelf software** because it can literally be purchased or acquired "off the shelf" in a store). The relative advantages and disadvantages of proprietary software and off-the-shelf software are summarized in Table 4.4.

Figure 4.12

Types of Application Software

Some off-the-shelf software can be customized to suit user needs.



Proprietary Software		Off-the-Shelf Software	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
You can get exactly what you need in terms of features, reports, and so on.	It can take a long time and significant resources to develop required features.	The initial cost is lower because the software firm can spread the development costs over many customers.	An organization might have to pay for features that are not required and never used.
Being involved in the development offers control over the results.	In-house system development staff may become hard pressed to provide the required level of ongoing support and maintenance because of pressure to move on to other new projects.	The software is likely to meet the basic business needs—you can analyze existing features and the performance of the package before purchasing.	The software might lack important features, thus requiring future modification or customization. This can be very expensive because users must adopt future releases of the software as well.
You can modify features that you might need to counteract an initiative by competitors or to meet new supplier or customer demands. A merger with or acquisition of another firm also requires software changes to meet new business needs.	The features and performance of software that has yet to be developed presents more potential risk.	The package is likely to be of high quality because many customer firms have tested the software and helped identify its bugs.	The software might not match current work processes and data standards.

Table 4.4

A Comparison of Proprietary and Off-the-Shelf Software

Many companies use off-the-shelf software to support business processes. For example, the lawyers at Ferwick & West LLP use a combination of several off-the-shelf software packages to help "cull data" from millions of legal documents.[15] One case required sorting through over 100 million legal files. The system they developed is called FIND, for File Identification Narrowed by Definition, and it combines the power of 75 software tools, most of them off-the-shelf applications. Key questions for selecting off-the-shelf software include the following: (1) Will the software run on the OS and hardware you have selected? (2) Does the software meet the essential business requirements that have been defined? (3) Is the software manufacturer financially solvent and reliable? and (4) Does the total cost of purchasing, installing, and maintaining the software compare favorably to the expected business benefits?

Some off-the-shelf programs can be modified, in effect blending the off-the-shelf and customized approaches. For example, police officers and dispatchers in Dover, N.H., use a

customized off-the-shelf software package that provides a map view of the jurisdiction. Dispatchers can easily identify the location of patrol cars and crime scenes on the map, and quickly route the nearest car to the desired location.[16] In another example of the blended approach, Blue Cross and Blue Shield worked with Sun Microsystems to customize a claims management system for its customers to access over the Web.[17]

Another approach to obtaining a customized software package is to use an application service provider. An **application service provider (ASP)** is a company that can provide the software, support, and computer hardware on which to run the software from the user's facilities over a network. Some vendors refer to the service as *on-demand software*. An ASP can also simplify a complex corporate software package so that it is easier for the users to set up and manage. ASPs provide contract customization of off-the-shelf software, and they speed deployment of new applications while helping IS managers avoid implementation headaches, reducing the need for many skilled IS staff members and decreasing project start-up expenses. Such an approach allows companies to devote more time and resources to more important tasks. For example, Avanax, a Silicon Valley company that develops intelligent photonic solutions for optical networks, uses a Product Lifecycle Management system provided by SAP. The system runs on SAP servers, which has helped Avanax reduce costs and provide much higher levels of service.[18]

application service provider (ASP)
A company that provides software, support, and the computer hardware on which to run the software from the user's facilities over a network.

Using an ASP makes the most sense for relatively small, fast-growing companies with limited IS resources. It is also a good strategy for companies that want to deploy a single, functionally focused application quickly, such as setting up an e-commerce Web site or supporting expense reporting. Contracting with an ASP might make less sense, however, for larger companies that have major systems and their technical infrastructure already in place.

Using an ASP involves some risks—sensitive information could be compromised in a number of ways, including unauthorized access by employees or computer hackers; the ASP might not be able to keep its computers and network up and running as consistently as necessary; or a disaster could disable the ASP's data center, temporarily putting an organization out of business. These are legitimate concerns that an ASP must address.

The high overhead of an ASP designing, running, managing, and supporting many customized applications for many businesses has led to a new form of software distribution known as software as a service. **Software as a service (SaaS)** allows businesses to subscribe to Web-delivered business application software by paying a monthly service charge or a per-use fee. Like ASP, SaaS providers maintain software on their own servers and provide access to it over the Internet. SaaS usually uses a Web browser-based user interface. SaaS can reduce expenses by sharing its running applications among many businesses. For example, Sears, JCPenney, and Wal-Mart might use customer relationship management software provided by a common SaaS provider. Providing one high-quality SaaS application to thousands of businesses is much more cost-effective than custom designing software for each business.

software as a service (SaaS)
A service that allows businesses to subscribe to Web-delivered business application software by paying a monthly service charge or a per-use fee.

Customer relationship management (CRM) and other general business systems are good candidates for SaaS. For example, The Improv, "America's Original Comedy Showcase," turned to a SaaS CRM system from salesforce.com to manage marketing and sales of event space to businesses wanting to use its theaters.[19] SaaS is becoming popular for information security as well, as described in the Ethical and Societal Issues sidebar.

ETHICAL AND SOCIETAL ISSUES

Imperial Chemical Turns to SaaS Security Tools

Imperial Chemical Industries is a very large paint and chemicals manufacturer based in London. The company was recently purchased by Akzo Nobel for $16 billion. With a research budget of around $60 million annually, and research data spread geographically over many computer systems at a variety of locations, Imperial Chemical works hard to keep its valuable data protected and secure.

Securing data over large distributed systems can be a costly, time-consuming affair. It becomes more complex when one company's systems are merged with another company's systems over a network. In today's global information economy, it is not unusual for a corporation to join its network with several partners and suppliers. To secure such networks would require a large suite of security software continuously running on all computers and a team of security experts working around the clock.

Rather than incur these costs, Imperial Chemical decided to outsource much of its information security to online companies offering security SaaS. SaaS makes sense for many security applications because the scanning of systems can take place from any network-connected system.

Imperial uses three SaaS security providers:

- Qualys provides a vulnerability management service that includes network discovery and mapping, asset prioritization, vulnerability assessment reporting, and remediation tracking according to business risk.
- Veracode provides a service that scans all binary executable files on the system, looking for bugs and viruses.
- Message Labs protects Imperial's e-mail systems from spam and viruses. It can also be used to filter out unauthorized and inappropriate content.

As securing corporate and customer data becomes increasingly regulated, many companies are turning to security SaaS vendors to make sure that they are in compliance with the law. For example, the three companies above insure that their customers are in compliance with the PCI DSS, the Payment Card Industry Data Security Standard. This standard is required by certain companies and banks that wish to insure their customers' privacy.

SaaS security systems are ideal for large organizations that have thousands of computers to secure. However, it is also easy to imagine how such services could provide a security solution for individual personal computers as well. Currently hundreds or thousands of home PCs are infected by spyware and serving as bots being controlled by hackers to send spam and attack other systems. Internet service providers do what they can to keep their users safe, but they can't stop a user from running an infected file or wandering to an infected Web site. Incorporating SaaS security systems through Internet service providers to personal PCs would clear up most of the infections that plague the Internet. As with most security practices, there would probably be some tradeoff in convenience and privacy.

Discussion Questions

1. Why does it make sense for a large corporation to outsource information security to a SaaS provider?
2. What are the dangers of trusting corporate information systems to an outside security firm?

Critical Thinking Questions

1. Would you be willing to allow a security company to guard your PC remotely while you are connected to the Internet? Why or why not?
2. Currently, PC users must run about four different security applications to keep their computers safe: a firewall, virus protection, spyware protection, and Windows Update. The user is responsible for making sure these systems are operational and up to date. Whose responsibility should it be to secure a PC? How might this system be simplified for users?

SOURCES: Hines, Matt, "Security SaaS offerings growing up fast," *Computerworld*, August 23, 2007, *www.computerworld.com/action/article.do?command=viewArticleBasic&taxonomyName =saas&articleId=9032321&taxonomyId=170&intsrc=kc_feat*. Qualys Web site, *www.qualys.com*, accessed February 2, 2008. MessageLabs Web site, *www.messagelabs.com*, accessed February 2, 2008. PCI (Payment Card Industry) Security Standards Council Web site, *https://www.pcisecuritystandards.org*, accessed February 2, 2008.

Personal Application Software

Hundreds of computer applications can help people at school, home, and work. New computer software under development and existing GPS technology, for example, will allow people to see 3-D views of where they are, along with directions and 3-D maps to where they would like to go. The features of personal application software are summarized in Table 4.5. In addition to these general-purpose programs, thousands of other personal computer applications perform specialized tasks: to help you do your taxes, get in shape, lose weight, get medical advice, write wills and other legal documents, repair your computer, fix your car, write music, and edit your pictures and videos. This type of software, often called *user software* or *personal productivity software*, includes the general-purpose tools and programs that support individual needs.

Table 4.5

Examples of Personal Productivity Software

Type of Software	Explanation	Example	Vendor
Word processing	Create, edit, and print text documents	Word WordPerfect Google Docs Pages Writer	Microsoft Corel Google Apple Sun
Spreadsheet	Provide a wide range of built-in functions for statistical, financial, logical, database, graphics, and date and time calculations	Excel Lotus 1-2-3 Spreadsheet Numbers Calc	Microsoft Lotus/IBM Google Apple Sun
Database	Store, manipulate, and retrieve data	Access Approach dBASE Base	Microsoft Lotus/IBM Borland Sun
Graphics	Develop graphs, illustrations, and drawings	Illustrator FreeHand	Adobe Macromedia
Project management	Plan, schedule, allocate, and control people and resources (money, time, and technology) needed to complete a project according to schedule	Project for Windows On Target Project Schedule Time Line	Microsoft Symantec Scitor Symantec
Financial management	Provide income and expense tracking and reporting to monitor and plan budgets (some programs have investment portfolio management features)	Quicken Money	Intuit Microsoft
Desktop publishing (DTP)	Use with personal computers and high-resolution printers to create high-quality printed output, including text and graphics; various styles of pages can be laid out; art and text files from other programs can also be integrated into "published" pages	QuarkXPress Publisher PageMaker Ventura Publisher Pages	Quark Microsoft Adobe Corel Apple
Creativity	Generate innovative and creative ideas and problem solutions. The software does not propose solutions, but provides a framework conducive to creative thought. The software takes users through a routine, first naming a problem, then organizing ideas and "wishes," and offering new information to suggest different ideas or solutions	Organizer Notes	Macromedia Lotus

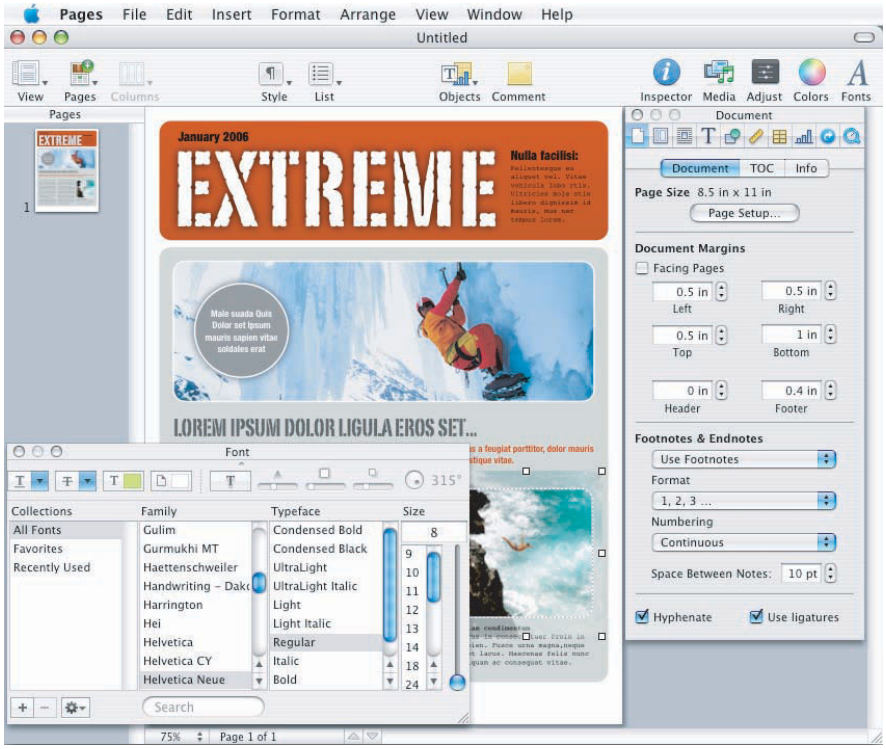
Word Processing

Word processing applications are installed on most PCs today. These applications come with a vast array of features, including those for checking spelling, creating tables, inserting formulas, creating graphics, and much more (see Figure 4.13). This book (and most like it) was entered into a word processing application using a personal computer.

Figure 4.13

Word Processing Program

Word processing applications can be used to write letters, professional documents, work reports, and term papers.



A team of people can use a word processing program to collaborate on a project. The authors and editors who developed this book, for example, used the Track Changes and Reviewing features of Microsoft Word to track and make changes to chapter files. You can add comments or make revisions to a document that a coworker can review and either accept or reject.

Professional chef JoAnna Minneci runs her own catering and in-home cooking services in Los Angeles, California. She believes in treating all of her customers as though they were celebrities. Minneci uses Word for Mac to design colorful and artistic menus and gift certificates.[20] The cross-platform compatibility of Microsoft Office for Mac allows her to deliver materials such as menus, contracts, and budgets to clients working on Macintosh or Windows-based PCs.

Spreadsheet Analysis

Spreadsheets are powerful tools for individuals and organizations. Features of spreadsheets include graphics, limited database capabilities, statistical analysis, built-in business functions, and much more (see Figure 4.14). The business functions include calculation of depreciation, present value, internal rate of return, and the monthly payment on a loan, to name a few. Optimization is another powerful feature of many spreadsheet programs. *Optimization* allows the spreadsheet to maximize or minimize a quantity subject to certain constraints. For example, a small furniture manufacturer that produces chairs and tables might want to maximize its profits. The constraints could be a limited supply of lumber, a limited number of workers who can assemble the chairs and tables, or a limited amount of various hardware fasteners that might be required. Using an optimization feature, such as Solver in Microsoft

Excel, the spreadsheet can determine what number of chairs and tables to produce with labor and material constraints to maximize profits.

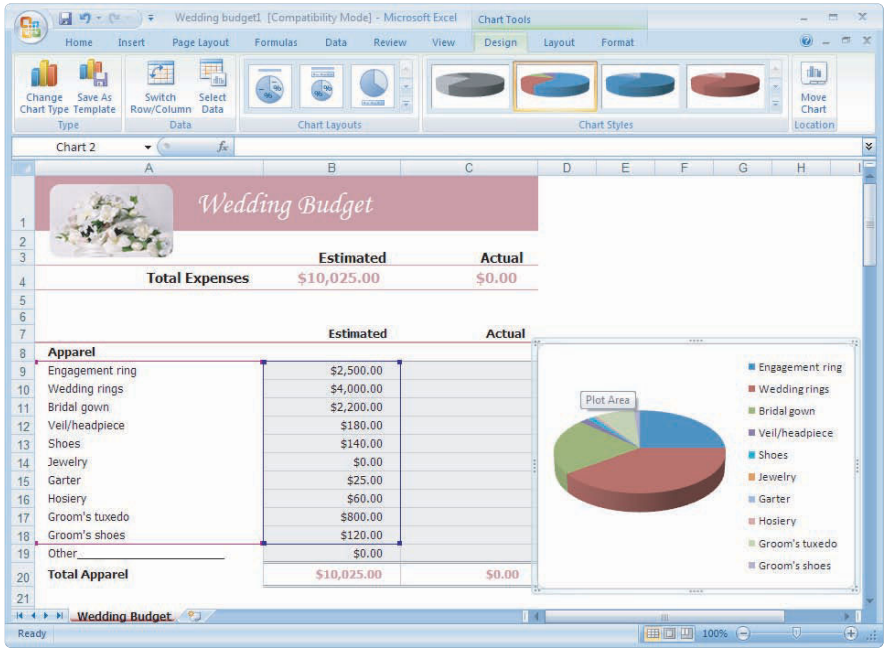


Figure 4.14

Spreadsheet Program

Spreadsheet programs should be considered when calculations are required.

Database Applications

Database applications are ideal for storing, manipulating, and retrieving data. These applications are particularly useful when you need to manipulate a large amount of data and produce reports and documents. Database manipulations include merging, editing, and sorting data. The uses of a database application are varied. You can keep track of a CD collection, the items in your apartment, tax records, and expenses. A student club can use a database to store names, addresses, phone numbers, and dues paid. In business, a database application can help process sales orders, control inventory, order new supplies, send letters to customers, and pay employees. Database management systems can be used to track orders, products, and customers; analyze weather data to make forecasts for the next several days; and summarize medical research results. A database can also be a front end to another application. For example, you can use a database application to enter and store income tax information, then export the stored results to other applications, such as a spreadsheet or tax-preparation application (see Figure 4.15).

Graphics Program

It is often said that a picture is worth a thousand words. With today's graphics programs, it is easy to develop attractive graphs, illustrations, and drawings (see Figure 4.16). Graphics programs can be used to develop advertising brochures, announcements, and full-color presentations, and to organize and edit photographic images. If you need to make a presentation at school or work, you can use a special type of graphics program called a presentation application to develop slides and then display them while you are speaking. Because of their popularity, many colleges and departments require students to become proficient at using presentation graphics programs.

Many graphics programs, such as Microsoft Office PowerPoint, consist of a series of slides. Each slide can be displayed on a computer screen, printed as a handout, or (more commonly) projected onto a large viewing screen for audiences. Powerful built-in features allow you to develop attractive slides and complete presentations. You can select a template for a type of presentation, such as recommending a strategy for managers, communicating news to a sales force, giving a training presentation, or facilitating a brainstorming session.

Figure 4.15

Database Program

After being entered into a database application, information can be manipulated and used to produce reports and documents.

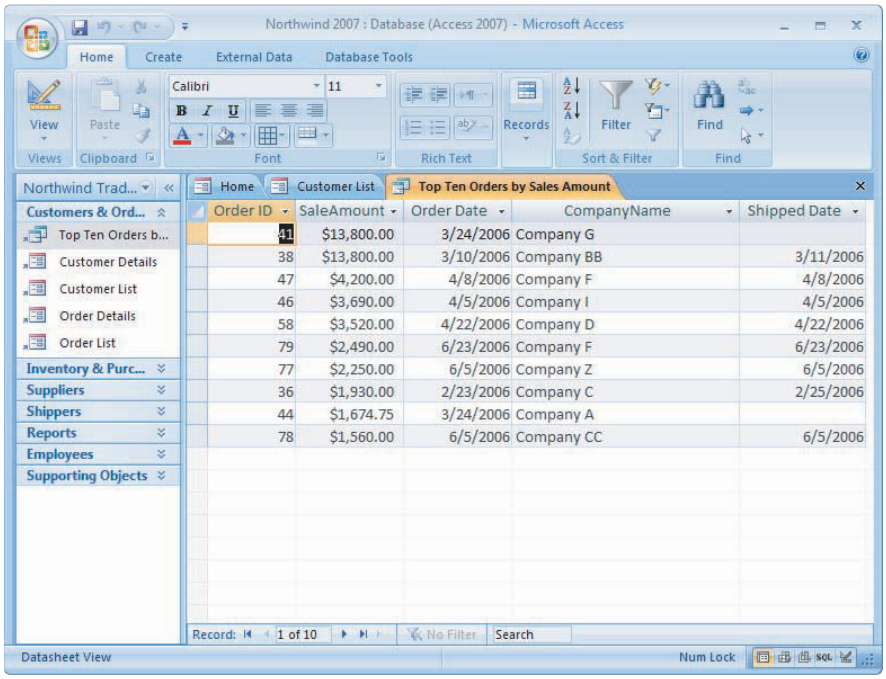
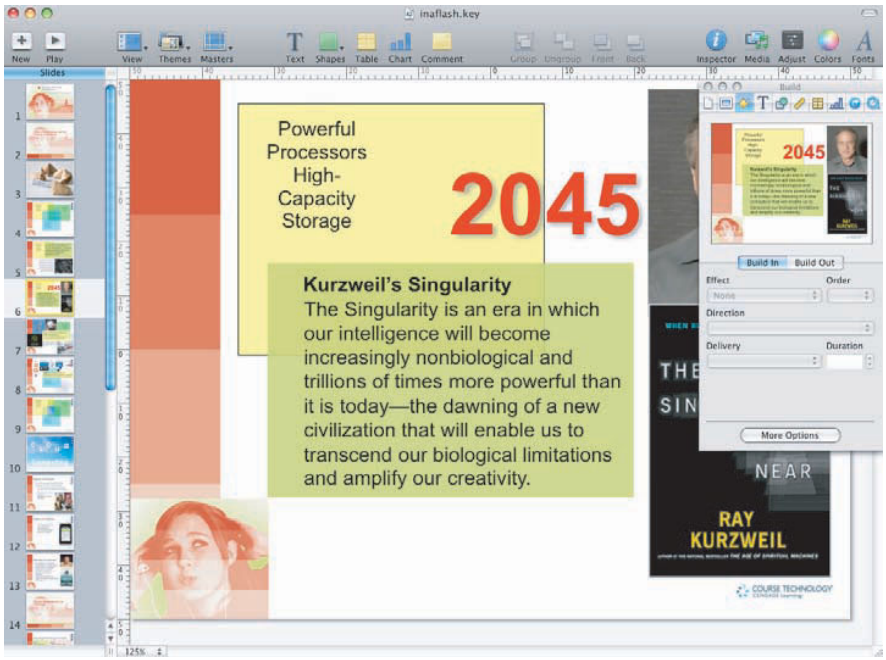


Figure 4.16

Presentation Graphics Program

Graphics programs can help you make a presentation at school or work.



The presentation graphics program takes you through the presentation step by step, including applying color and attractive formatting. You can also design a custom presentation using the many types of charts, drawings, and formatting available. Most presentation graphics programs come with many pieces of *clip art*, such as drawings and photos of people meeting, medical equipment, telecommunications equipment, entertainment, and much more.

Personal Information Managers

Personal information managers (PIMs) help people, groups, and organizations store useful information, such as a list of tasks to complete or a set of names and addresses. PIMs usually provide an appointment calendar and a place to take notes. In addition, information in a

PIM can be linked. For example, you can link an appointment with a sales manager in the calendar to information on the sales manager in the address book. When you click the appointment in the calendar, a window opens displaying information on the sales manager from the address book. Google provides PIM software to integrate e-mail, appointment, and address book tasks.

Figure 4.17

Personal Information Manager

PIM software assists individuals, groups, and organizations with organizing appointments, schedules, contacts, and to-do lists.

Some PIMs allow you to schedule and coordinate group meetings. If a computer or handheld device is connected to a network, you can upload the PIM data and coordinate it with the calendar and schedule of others using the same PIM software on the network. You can also use some PIMs to coordinate e-mails sent and received over the Internet.

Consider Greenfield Online as an example of one collaborative PIM system. Greenfield Online is a Web survey solution provider that has about 500 employees in 12 countries and 30 cities. Employees were having a difficult time scheduling and preparing for meetings. Using Microsoft Live Meeting and Outlook, the company reduced meeting time by 60 percent.[21] Now employees schedule Web conferences directly using Microsoft Office Outlook. Documents are distributed to meeting participants who receive meeting requests through Outlook to attend the Web conferences. When it is time for a meeting, all participants click a URL in the meeting request and the link takes them to the Web-conferencing area.

Software Suites and Integrated Software Packages

software suite
A collection of single application programs packaged in a bundle.

A **software suite** is a collection of single application programs packaged in a bundle. Software suites can include word processors, spreadsheets, database management systems, graphics programs, communications tools, organizers, and more. Some suites support the development of Web pages, note taking, and speech recognition, where applications in the suite can accept voice commands and record dictation. Software suites offer many advantages. The software programs have been designed to work similarly, so after you learn the basics for one application, the other applications are easy to learn and use. Buying software in a bundled suite is cost-effective; the programs usually sell for a fraction of what they would cost individually.

Microsoft Office, Corel's WordPerfect Office, Lotus SmartSuite, and Sun Microsystems's StarOffice are examples of popular general-purpose software suites for personal computer users. Microsoft Office has the largest market share. The Free Software Foundation offers software similar to Sun Microsystems's StarOffice that includes word processing, spreadsheet, database, presentation graphics, and e-mail applications for the Linux OS. OpenOffice is another Office suite for Linux. Wine, software designed for Linux and Unix, can run any Windows application, including those in Microsoft Office, on Linux, although some features might not work as well as a Microsoft OS. Each of these software suites includes a spreadsheet program, word processor, database program, and graphics package with the ability to move documents, data, and diagrams among them (see Table 4.6). Thus, a user can create a spreadsheet and then cut and paste that spreadsheet into a document created using the word processing application.

Table 4.6

Major Components of Leading Software Suites

Personal Productivity Function	Microsoft Office	Lotus Symphony	Corel WordPerfect Office	Sun StarOffice	Apple iWork	Google
Word Processing	Word	Documents	WordPerfect	Writer	Pages	Docs
Spreadsheet	Excel	Spreadsheets	Quattro Pro	Calc	Numbers	Spreadsheet
Presentation Graphics	PowerPoint	Presentations	Presentations	Impress	Keynote	Presentation
Database	Access		Paradox	Base		

More than a hundred million people worldwide use the Microsoft Office software suite, with Office 2007 representing the latest version of the productivity software. Office 2007 uses new file formats that are more compatible with Web standards. It also provides a revolutionary new interface, moving from menus and toolbars to a Ribbon with tabs. Office 2007 is available in seven editions: Professional, Standard, Home and Student, Small Business, Ultimate, Professional Plus, and Enterprise. Each edition includes a subset of 15 applications

In addition to suites, some companies produce *integrated application packages* that contain several programs. For example, *Microsoft Works* is one program that contains basic word processing, spreadsheet, database, address book, calendar, and other applications. Although not as powerful as stand-alone software included in software suites, integrated software packages offer a range of capabilities for less money. Some integrated packages cost about $100.

Some companies are offering Web-based productivity software suites that require no installation, only a Web browser. Zoho, Google, and Thinkfree offer free online word processing, spreadsheet, presentation, and other software that require no installation on the PC. Documents created with the software can be stored on the Web server. Currently these online applications are not as powerful and robust as installed software such as Microsoft Office. However, it is likely that as the technology becomes more powerful, and network connection speeds increase, users will need to install less software on their own PCs and turn instead to using software online.

Microsoft has observed the trend towards Web-based software and is migrating its software towards the Web as well. Microsoft Windows Live provides several Web-based services such as a Live Search for searching the Web, Windows Live Messenger for instant messaging, Windows Live Hotmail for e-mail, and Windows Live OneCare for PC security. Windows Live Spaces provides Windows users with online storage for sharing files with others on the Web. Microsoft Office Live provides tools for sharing Office documents on the Web. The difference between Office Live and Google's applications is that Microsoft requires users to have its software installed on their PCs. Microsoft also provides Xbox Live for online multiplayer gaming.

Other Personal Application Software

In addition to the software already discussed, people can use many other interesting and powerful application software tools. In some cases, the features and capabilities of these applications can more than justify the cost of an entire computer system. TurboTax, for example, is a popular tax-preparation program. Other exciting software packages have been developed for training and distance learning. University professors often believe that colleges and universities must invest in distance learning for their students. Using this type of software, some universities offer complete degree programs over the Internet. Engineers, architects, and designers often use computer-aided design (CAD) software to design and develop buildings, electrical systems, plumbing systems, and more. Autosketch, CorelCAD, and AutoCad are examples of CAD software. Other programs perform a wide array of statistical tests. Colleges and universities often have a number of courses in statistics that use this type of application software. Two popular applications in the social sciences are SPSS and SAS.

Workgroup Application Software

Workgroup application software is designed to support teamwork, whether people are in the same location or dispersed around the world. This support can be accomplished with software known as *groupware* that helps groups of people work together effectively. Microsoft Exchange Server, for example, has groupware and e-mail features. Also called *collaborative software*, the approach allows a team of managers to work on the same production problem, letting them share their ideas and work via connected computer systems. The "Three Cs" rule for successful implementation of groupware is summarized in Table 4.7.

workgroup application software
Software that supports teamwork, whether in one location or around the world.

Table 4.7

Ernst & Young's "Three Cs" Rule for Groupware

Quality	Description
Convenient	If it's too hard to use, it's not used; it should be as easy to use as the telephone.
Content	It must provide a constant stream of rich, relevant, and personalized content.
Coverage	If it isn't easy to access, it might never be used.

Examples of workgroup software include group scheduling software, electronic mail, and other software that enables people to share ideas. Lotus Notes from IBM, for example, lets companies use one software package and one user interface to integrate many business processes. Lotus Notes can allow a global team to work together from a common set of documents, have electronic discussions using threads of discussion, and schedule team meetings. As the program matured, Lotus added services to it and renamed it Domino (Lotus Notes is now the name of the e-mail package), and now an entire third-party market has emerged to build collaborative software based on Domino.

The Web-based software described in the previous section is ideal for group use. Because documents are stored on an Internet server, anyone with an Internet connection can access them easily. Google provides options in its online applications that allow users to share documents, spreadsheets, presentations, calendars, and notes with other specified users or everyone on the Web (see Figure 4.18). This makes it convenient for several people to contribute to a document without concern for software compatibility or storage.

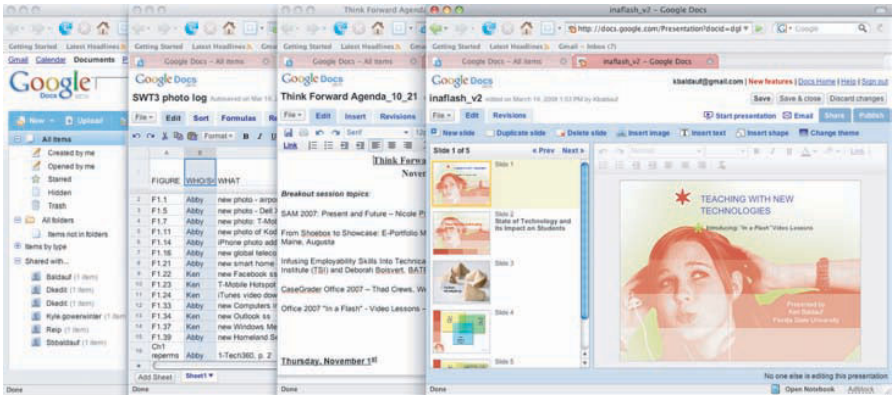


Figure 4.18

Google's Online Applications

Google applications are designed to share documents, presentations, spreadsheets, calendars, and notes with specific users or everyone on the Web.

An increasing number of software applications are moving online to support group document and information sharing. Google applications let users share notes, calendars, documents, spreadsheets, and presentations. At *tadalists.com*, users can share to-do lists with others in a group. Microsoft offers Office Live Workspace for sharing documents, spreadsheets, and other Office files with Office users online. If you have digital information you wish to share, it is likely that some online service has been set up to allow you to put it online and control who can access it.

Enterprise Application Software

Software that benefits an entire organization can also be developed or purchased. Some software vendors, such as SAP, specialize in developing software for enterprises. A fast-food chain, for example, might develop a materials ordering and distribution program to make sure that each of its franchises gets the necessary raw materials and supplies during the week. This program can be developed internally using staff and resources in the IS department or purchased from an external software company. Boeing and DaimlerChrysler use enterprise software to design new airplanes and automotive products. The software simulates the effectiveness and safety of designs, allowing the companies to save time and money compared to developing physical prototypes of airplanes and vehicles. Dunkin Brands, owner of Dunkin' Donuts, Baskin-Robbins, and Togo's, uses enterprise software to help it locate new stores. iSite from geoVue (*www.geovue.com*) is site-selection software that lets companies analyze factors to help determine the location of new stores.

One of the first enterprise applications was a payroll program for Lyons Bakeries in England, developed in 1954 on the Leo 1 computer. Table 4.8 lists some applications that can be addressed with enterprise software. Many organizations are moving to integrated enterprise software that supports supply chain management (movement of raw materials from suppliers through shipment of finished goods to customers), as shown in Figure 4.19.

Table 4.8

Examples of Enterprise Application Software

Type of Software	Description
Accounts receivable	Sales ordering
Accounts payable	Order entry
Airline industry operations	Payroll
Automatic teller systems	Human resource management
Cash-flow analysis	Check processing
Credit and charge card administration	Tax planning and preparation
Manufacturing control	Receiving
Distribution control	Restaurant management
General ledger	Retail operations
Stock and bond management	Invoicing
Savings and time deposits	Shipping
Inventory control	Fixed asset accounting

Enterprise Resource Planning (ERP) Software
A set of integrated programs that manage a company's vital business operations for an entire multisite, global organization.

Organizations can no longer respond to market changes using nonintegrated information systems based on overnight processing of yesterday's business transactions, conflicting data models, and obsolete technology. Wal-Mart and many other companies have sophisticated information systems to speed processing and coordinate communications between stores and their main offices. Many corporations are turning to **enterprise resource planning (ERP)** software, a set of integrated programs that manage a company's vital business operations for an entire multisite, global organization. Thus, an ERP system must be able to support many legal entities, languages, and currencies. Although the scope can vary from vendor to vendor, most ERP systems provide integrated software to support manufacturing and finance. In addition to these core business processes, some ERP systems might support business functions such as human resources, sales, and distribution. The primary benefits of implementing ERP include eliminating inefficient systems, easing adoption of improved work processes, improving access to data for operational decision making, standardizing technology vendors

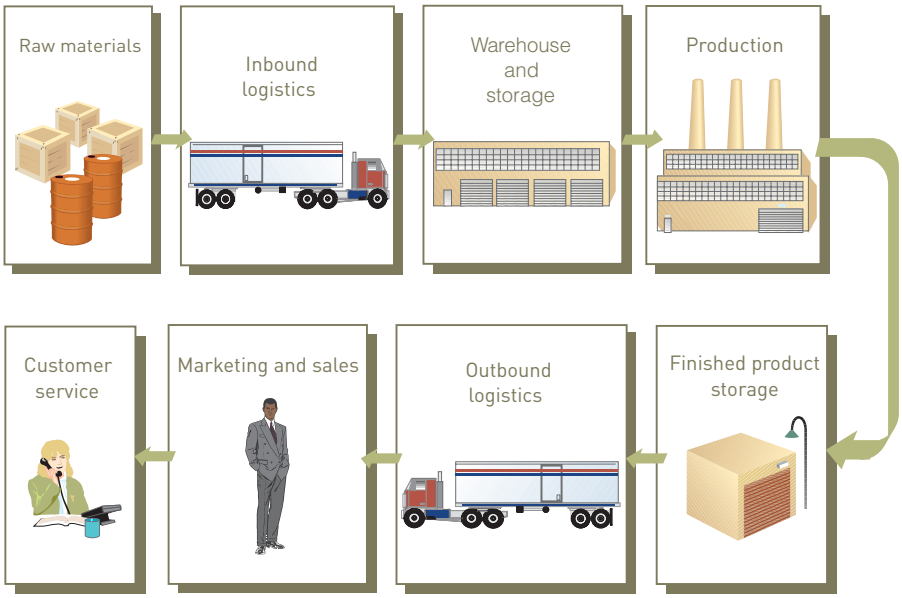


Figure 4.19
Use of Integrated Supply Chain Management Software

Integrated enterprise software to support supply chain management

and equipment, and enabling supply chain management. Even small businesses can benefit from enterprise application software. Intuit's QuickBooks and Microsoft's Office Small Business Accounting are accounting and recording-keeping programs for small businesses and organizations.

Application Software for Information, Decision Support, and Specialized Purposes

Specialized application software for information, decision support, and other purposes is available in every industry. Genetic researchers, for example, are using software to visualize and analyze the human genome. Music executives use decision support software to help pick the next hit song. Sophisticated decision support software is also being used to increase the cure rate for cancer by analyzing about 100 scans of a cancerous tumor to create a 3-D view of the tumor. Software can then consider thousands of angles and doses of radiation to determine the best program of radiation therapy. The software analysis takes only minutes, but the results can save years or decades of life for the patient. As you will see in future chapters, information, decision support, and specialized systems are used in businesses of all sizes and types to increase profits or reduce costs. But how are all these systems actually developed or built? The answer is through the use of programming languages, discussed next.

PROGRAMMING LANGUAGES

Both OSs and application software are written in coding schemes called *programming languages*. The primary function of a programming language is to provide instructions to the computer system so that it can perform a processing activity. IS professionals work with **programming languages**, which are sets of keywords, symbols, and rules for constructing statements by which people can communicate instructions to be executed by a computer. Programming involves translating what a user wants to accomplish into a code that the computer can understand and execute. *Program code* is the set of instructions that signal the CPU to perform circuit-switching operations. In the simplest coding schemes, a line of code typically contains a single instruction such as, "Retrieve the data in memory address X." As discussed in Chapter 3, the instruction is then decoded during the instruction phase of the

programming languages
Sets of keywords, symbols, and a system of rules for constructing statements by which humans can communicate instructions to be executed by a computer.

machine cycle. Like writing a report or a paper in English, writing a computer program in a programming language requires the programmer to follow a set of rules. Each programming language uses symbols that have special meaning. Each language also has its own set of rules, called the **syntax** of the language. The language syntax dictates how the symbols should be combined into statements capable of conveying meaningful instructions to the CPU. A rule that "Variable names must start with a letter" is an example. A variable is a quantity that can take on different values. Program variable names such as SALES, PAYRATE, and TOTAL follow the rule because they start with a letter, whereas variables such as %INTEREST, $TOTAL, and #POUNDS do not.

syntax
A set of rules associated with a programming language.

The Evolution of Programming Languages

The desire to use the power of information processing efficiently in problem solving has pushed the development of newer programming languages. The evolution of programming languages is typically discussed in terms of generations of languages (see Table 4.9).

Table 4.9
The Evolution of Programming Languages

Generation	Language	Approximate Development Date	Sample Statement or Action
First	Machine language	1940s	00010101
Second	Assembly language	1950s	MVC
Third	High-level language	1960s	READ SALES
Fourth	Query and database languages	1970s	PRINT EMPLOYEE NUMBER IF GROSS PAY>1000
Beyond Fourth	Natural and intelligent languages	1980s	IF gross pay is greater than 40, THEN pay the employee overtime pay

Visual, Object-Oriented, and Artificial Intelligence Languages

Today, programmers often use visual and object-oriented languages. In the future, they will likely be using artificial intelligence languages to a greater extent. In general, these languages are easier for nonprogrammers to use compared with older generation languages.

Visual languages use a graphical or visual interface for program development. Unlike earlier languages that depended on writing detailed programming statements, visual languages allow programmers to "drag and drop" programming elements and icons onto the computer screen. Many of these languages are used to develop Web applications. *Visual Basic* was one of the first visual programming languages. Microsoft Visual Studio is a set of object-oriented programming languages and tools to develop Windows and Web-based applications. You can develop applications that can range from a simple Web-based program for displaying your résumé to complex business applications that process customer orders, control inventory, and send out bills—using languages such as Visual Basic .NET, Visual C++ .NET, Visual C#, and Visual J#. *C++* is a powerful and flexible programming language used mostly by computer systems professionals to develop applications. *Java* is an object-oriented programming language developed by Sun Microsystems that can run on any OS and on the Internet. Java can be used to develop complete applications or smaller applications, called *Java applets*. Many of these languages are also examples of object-oriented languages, which are discussed next.

The preceding programming languages separate data elements from the procedures or actions that will be performed on them, but another type of programming language ties them together into units called *objects*. An object consists of data and the actions that can be performed on the data. For example, an object could be data about an employee and all the operations (such as payroll calculations) that might be performed on the data. Programming languages that are based on objects are called *object-oriented programming languages*.

Building programs and applications using object-oriented programming languages is like constructing a building using prefabricated modules or parts. The object containing the data, instructions, and procedures is a programming building block. The same objects (modules or parts) can be used repeatedly. One of the primary advantages of an object is that it contains reusable code. In other words, the instruction code within that object can be reused in different programs for a variety of applications, just as the same basic prefabricated door can be used in two different houses. An object can relate to data on a product, an input routine, or an order-processing routine. An object can even direct a computer to execute other programs or to retrieve and manipulate data. So, a sorting routine developed for a payroll application could be used in both a billing program and an inventory control program. By reusing program code, programmers can write programs for specific application problems more quickly (see Figure 4.20). By combining existing program objects with new ones, programmers can easily and efficiently develop new object-oriented programs to accomplish organizational goals.

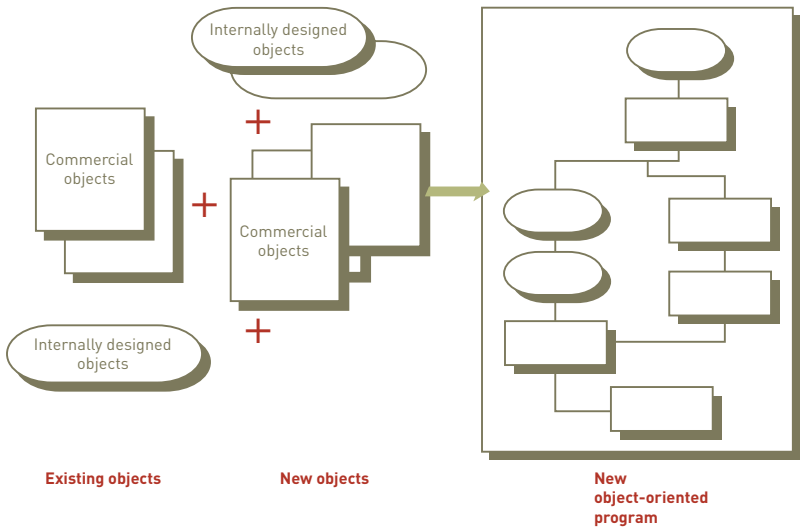


Figure 4.20

Reusable Code in Object-Oriented Programming

By combining existing program objects with new ones, programmers can easily and efficiently develop new object-oriented programs to accomplish organizational goals. Note that these objects can be either commercially available or designed internally.

Programmers often start writing object-oriented programs by developing one or more user interfaces, usually in a Windows or Web environment. You can create programs to run in a Windows or Web environment by using forms to design and develop the type of interface you want. You can select and drag text boxes to add descriptions, buttons that can be clicked and executed, a list box that contains several choices that can be selected, and other input/output features. After creating the Windows interface, you can write programming code to convert tasks a user selects in the interface into actions the computer performs.

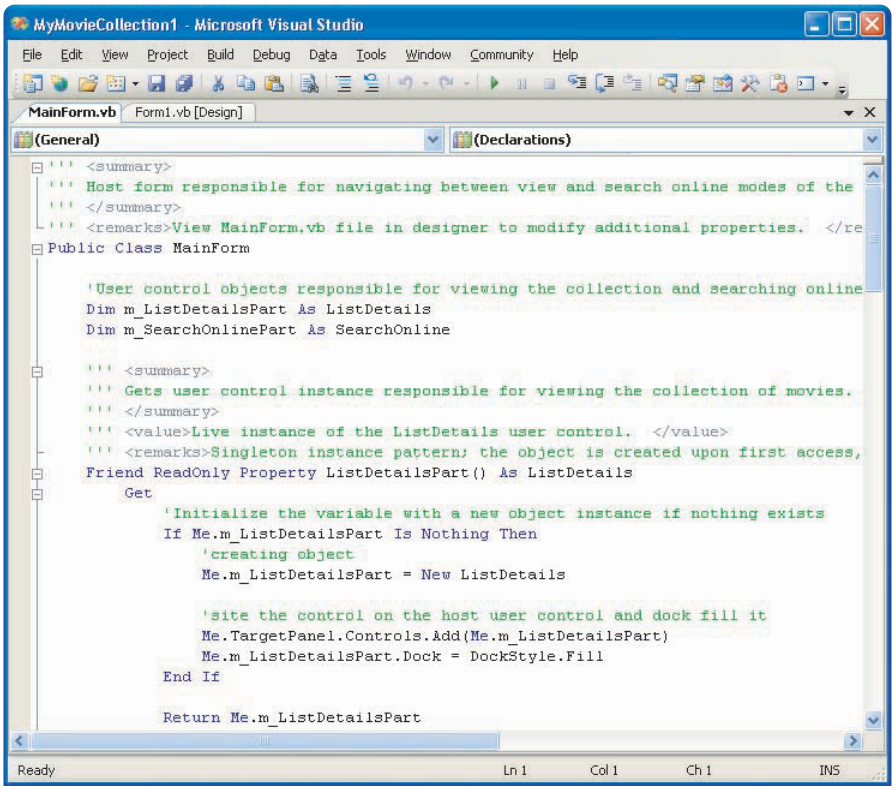
Some of the most popular object-oriented programming languages include Smalltalk, Visual Basic .NET, C++, and Java (see Figure 4.21). Some old languages, such as COBOL, have been modified to support the object-oriented approach. As mentioned earlier, Java is an Internet programming language from Sun Microsystems that can run on a variety of computers and OSs, including UNIX, Windows, and Macintosh OSs.

Object-oriented programs often use *methods*, which are instructions to perform a specific task in the program. The following instructions in C++ use a method named ComputeArea to compute the area of a rectangle, given the width and length.

```
// Method to Compute the Area of a Rectangle Given the Width and
Length
double Rectangle::ComputeArea()
{
   return width * length;
}
// End of the ComputeArea Method
```

Figure 4.21

Microsoft Visual Basic



After they are developed as part of a C++ program, the instructions or method can be used in other programs to compute the area of a picture frame, a living room, a front lawn, or any other application that requires the area of a rectangle. Following are a few instructions in another C++ program that show how to use the ComputeArea method to compute the area of a picture frame.

```
//Assign Data and Compute Area
frameObject -> SetDimensions (frameWidth, frameLength);
frameArea = frameObject -> ComputeArea();
```

Programming languages used to create artificial intelligence or expert systems applications are often called *fifth-generation languages (5GLs)*. FLEXPERT, for example, is an expert system used to perform plant layout and helps companies determine the best placement for equipment and manufacturing facilities. Fifth-generation languages are sometimes called *natural languages* because they use even more English-like syntax than 4GLs. They allow programmers to communicate with the computer by using normal sentences. For example, computers programmed in fifth-generation languages can understand queries such as, "How many athletic shoes did our company sell last month?"

With third-generation and higher-level programming languages, each statement in the language translates into several instructions in machine language. A special software program called a **compiler** converts the programmer's source code into the machine-language instructions consisting of binary digits, as shown in Figure 4.22. A compiler creates a two-stage process for program execution. First, the compiler translates the program into a machine language; second, the CPU executes that program. Another approach is to use an *interpreter*, which is a language translator that carries out the operations called for by the source code. An interpreter does not produce a complete machine-language program. After the statement executes, the machine-language statement is discarded, the process continues for the next statement, and so on.

compiler
A special software program that converts the programmer's source code into the machine-language instructions consisting of binary digits.

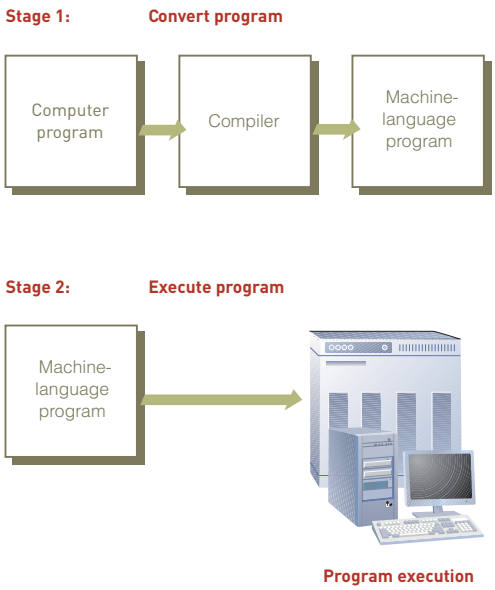


Figure 4.22

How a Compiler Works

A compiler translates a complete program into a complete set of binary instructions (Stage 1). After this is done, the CPU can execute the converted program in its entirety (Stage 2).

SOFTWARE ISSUES AND TRENDS

Because software is such an important part of today's computer systems, issues such as software bugs, licensing, upgrades, and global software support have received increased attention. We highlight several major software issues and trends in this section: software bugs, copyright, software licensing, open-source software, shareware and public domain software, multiorganizational software development, software upgrades, and global software support.

Software Bugs

A software bug is a defect in a computer program that keeps it from performing as it is designed to perform. Some software bugs are obvious and cause the program to terminate unexpectedly. Other bugs are subtler and allow errors to creep into your work. For example, a bug discovered in Microsoft Office Excel 2007 caused the equation 850 x 77.1 to display 100,000 rather than the correct result of 65,535.[22] Computer and software vendors say that as long as people design and program hardware and software, bugs are inevitable. In fact, according to the Pentagon and the Software Engineering Institute at Carnegie Mellon University, there are typically 5 to 15 bugs in every 1,000 lines of code. The following list summarizes tips for reducing the impact of software bugs.

- Register all software so that you receive bug alerts, fixes, and patches.
- Check the manual or read-me files for solutions to known problems.
- Access the support area of the manufacturer's Web site for patches.
- Install the latest software updates.
- Before reporting a bug, make sure that you can re-create the circumstances under which it occurs.
- After you can re-create the bug, call the manufacturer's tech support line.
- Avoid buying the latest release of software for several months or a year until the software bugs have been discovered and removed.

Copyrights and Licenses

Most software products are protected by law using copyright or licensing provisions. Those provisions can vary, however. In some cases, you are given unlimited use of software on one or two computers. This is typical with many applications developed for personal computers.

In other cases, you pay for your usage—if you use the software more, you pay more. This approach is becoming popular with software placed on networks or larger computers. Most of these protections prevent you from copying software and giving it to others without restrictions. Some software now requires that you *register* or *activate* it before it can be fully used. Registration and activation sometimes put software on your hard disk that monitors activities and changes your computer system.

When people purchase software, they don't actually own the software, but rather are licensed to use the software on a computer. This is called a single-user license. A **single-user license** permits you to install the software on one computer, or sometimes two computers, used by one person. A single-user license does not allow you to copy and share the software with others. Table 4.10 describes different types of software licenses. Licenses that accommodate multiple users are usually provided at a discounted price.

single-user license
A software license that permits only one person to use the software, typically on only one computer.

Table 4.10
Software Licenses

License	Description
Single-user license	Permits you to install the software on one computer, or sometimes two computers, used by one person.
Multiuser license	Specifies the number of users allowed to use the software, and can be installed on each user's computer. For example, a 20-user license can be installed on 20 computers for 20 users.
Concurrent-user license	Designed for network-distributed software, this license allows any number of users to use the software, but only a specific number of users to use it at the same time.
Site license	Permits the software to be used anywhere on a particular site, such as a college campus, by everyone on the site.

Open-Source Software

open-source software
Software that is freely available to anyone in a form that can be easily modified.

Open-source software is freely available to anyone in a form that can be easily modified. The Open Source Initiative (OSI) is a nonprofit corporation dedicated to the development and promotion of open-source software (see the OSI Web site at *www.opensource.org* for more information on the group's efforts). Users can download the source code and build the software themselves, or the software developers can make executable versions available along with the source. Open-source software development is a collaborative process—developers around the world use the Internet to keep in close contact via e-mail and to download and submit new software. Major software changes can occur in days rather than weeks or months. Many open-source software packages are widely used, including the Linux OS; Free BSD, another OS; Apache, a popular Web server; Sendmail, a program that delivers e-mail for most systems on the Internet; and Perl, a programming language used to develop Internet application software. See Table 4.11 for some examples of open-source software.

Why would an organization run its business using software that's free? Can something that's given away over the Internet be stable or reliable or sufficiently supported to place at the core of a company's day-to-day operations? The answer is surprising—many believe that open-source software is often *more* reliable and secure than commercial software. How can this be? First, by making a program's source code readily available, users can fix any problems they discover. A fix is often available within hours of the problem's discovery. Second, with the source code for a program accessible to thousands of people, the chances of a bug being discovered and fixed before it does any damage are much greater than with traditional software packages. Of course, open-source software is usually much less expensive than traditional software that is purchased from a software vendor. The auditor of one state estimated that the cost savings using open-source software could be as high as $10 million compared to developing software internally, when legal and project delays are included. Some companies are also starting to reveal their source code, including IBM, Microsoft, and others.

Table 4.11
Examples of Open-Source Software

Software Type	Example
Operating system	Linux
Application software	Open Office
Database software	MySQL
Internet browser	Firefox
Photo editing	Gimp
Project management	OpenProj
Personal accounting	Grisbi
E-mail	Thunderbird

However, using open-source software does have some disadvantages. Although open-source systems can be obtained for next to nothing, the up-front costs are only a small piece of the total cost of ownership that accrues over the years that the system is in place. Some claim that open-source systems contain many hidden costs, particularly for user support or solving problems with the software. Licensed software comes with guarantees and support services that open-source software does not. Still, many businesses appreciate the additional freedom that open-source software provides. The question of software support is the biggest stumbling block to the acceptance of open-source software at the corporate level. Getting support for traditional software packages is easy—you call a company's toll-free support number or access its Web site. But how do you get help if an open-source package doesn't work as expected? Because the open-source community lives on the Internet, you look there for help. Through use of Internet discussion areas, you can communicate with others who use the same software, and you might even reach someone who helped develop it. Users of popular open-source packages can get correct answers to their technical questions within a few hours of asking for help on the appropriate Internet forum. Another approach is to contact one of the many companies emerging to support and service such software—for example, Red Hat for Linux, C2Net for Apache, and Sendmail, Inc., for Sendmail. These companies offer high-quality, for-pay technical assistance.

Shareware, Freeware, and Public Domain Software

Many software users are doing what they can to minimize software costs. Some are turning to **shareware** and **freeware**—software that is very inexpensive or free, usually for use in personal computers, but whose source code cannot be modified. Freeware can be used to perform a variety of tasks. StarOffice is a freeware office suite that contains word processor, spreadsheet, database, drawing, and presentation programs. PhotoPlus 6 is a photo-editing program, and Picasa is a photo-editing and management program. The Web site *www.SourceForge.net* is a resource for programmers to freely exchange programs and program code. It allows programmers to create, collaborate on, and evaluate program code. Over 80,000 programs are at various stages of completion.

shareware and freeware
Software that is very inexpensive or free, but whose source code cannot be modified.

Shareware might not be as powerful as commercial software, but it provides what some people need at a good price. In some cases, you can try the software before sending a nominal fee to the software developer. Some shareware and freeware is in the public domain, often called *public domain software*. This software is not protected by copyright laws and can be freely copied and used. Although shareware and freeware can be free or inexpensive to acquire, it can be more expensive to use and maintain over time compared with software that is purchased. If the software is hard to use and doesn't perform all the required functions, the cost of wasted time and lost productivity can be far greater than the cost of purchasing better software. Shareware, freeware, and public domain software is often not open source—that is, the source code is not available and cannot be modified.

Software Upgrades

Software companies revise their programs and sell new versions periodically. In some cases, the revised software offers new and valuable enhancements. In other cases, the software uses complex program code that offers little in terms of additional capabilities. In addition, revised software can contain bugs or errors. When software companies stop supporting older software versions or releases, some customers feel forced to upgrade to the newer software. Deciding whether to purchase the newest software can be a problem for corporations and people with a large investment in software. Should the newest version be purchased when it is released? Some users do not always get the most current software upgrades or versions, unless it includes significant improvements or capabilities. Instead, they might upgrade to newer software only when it offers vital new features. Software upgrades usually cost much less than the original purchase price.

Global Software Support

Large global companies have little trouble persuading vendors to sell them software licenses for even the most far-flung outposts of their company. But can those same vendors provide adequate support for their software customers in all locations? Supporting local operations is one of the biggest challenges IS teams face when putting together standardized, company-wide systems. Slower technology growth markets, such as Eastern Europe and Latin America, might not have any official vendor presence. Instead, large vendors such as Sybase, IBM, and Hewlett-Packard typically contract with local providers to provide support for their software.

One approach that has been gaining acceptance in North America is to outsource global support to one or more third-party distributors. The user company can still negotiate its license with the software vendor directly, but it then hands the global support contract to a third-party supplier. The supplier acts as a middleman between software vendor and user, often providing distribution, support, and invoicing. American Home Products Corporation handles global support for both Novell NetWare and Microsoft Office applications this way throughout the 145 countries in which it operates. American Home Products, a pharmaceutical and agricultural products company, negotiated the agreements directly with the vendors for both purchasing and maintenance, but fulfillment of the agreement is handled exclusively by Philadelphia-based Softsmart, an international supplier of software and services.

In today's computer systems, software is an increasingly critical component. Whatever approach people and organizations take to acquire software, everyone must be aware of the current trends in the industry. Informed users are wiser consumers, and they can make better decisions.

SUMMARY

Principle

Systems and application software are critical in helping individuals and organizations achieve their goals.

Software consists of programs that control the workings of the computer hardware. The two main categories of software are systems software and application software. Systems software is a collection of programs that interacts between hardware and application software, and includes operating systems, utility programs, and middleware. Application software can be proprietary or off the shelf, and enables people to solve problems and perform specific tasks.

An operating system (OS) is a set of computer programs that controls the computer hardware to support users' computing needs. An OS converts an instruction from an application into a set of instructions needed by the hardware. This intermediary role allows hardware independence. An OS also manages memory, which involves controlling storage access and use by converting logical requests into physical locations and by placing data in the best storage space, including virtual memory.

An OS manages tasks to allocate computer resources through multitasking and time-sharing. With multitasking, users can run more than one application at a time. Time-sharing allows more than one person to use a computer system at the same time.

The ability of a computer to handle an increasing number of concurrent users smoothly is called *scalability*, a feature critical for systems expected to handle a large number of users.

An OS also provides a user interface, which allows users to access and command the computer. A command-based user interface requires text commands to send instructions; a graphical user interface (GUI), such as Windows, uses icons and menus.

Software applications use the OS by requesting services through a defined application program interface (API). Programmers can use APIs to create application software without having to understand the inner workings of the OS. APIs also provide a degree of hardware independence so that the underlying hardware can change without necessarily requiring a rewrite of the software applications.

Over the years, several popular OSs have been developed. These include several proprietary OSs used primarily on mainframes. MS-DOS is an early OS for IBM-compatibles. Older Windows OSs are GUIs used with DOS. Newer versions, such as Windows Vista and XP, are fully functional OSs that do not need DOS. Apple computers use proprietary OSs such as the Mac OS and Mac OS X. UNIX is a powerful OS that can be used on many computer system types and platforms, from personal computers to mainframe systems. UNIX makes it easy to move programs and data among computers or to connect mainframes and personal computers to share resources. Linux is the kernel of an OS whose source code is freely available to everyone. Several variations of Linux are available, with sets of capabilities and applications to form a complete OS, for example, Red Hat Linux. z/OS and HP-UX are OSs for mainframe computers. Some OSs, such as Palm OS, Windows Mobile, Windows Embedded, Pocket PC, and variations of Linux, have been developed to support mobile communications and consumer appliances.

Utility programs can perform many useful tasks and often come installed on computers along with the OS. This software is used to merge and sort sets of data, keep track of computer jobs being run, compress files of data, protect against harmful computer viruses, and monitor hardware and network performance. Middleware is software that allows different systems to communicate and transfer data back and forth. A service-oriented architecture (SOA) uses modular application services to allow users to interact with systems, and systems to interact with each other.

Principle

Organizations should not develop proprietary application software unless doing so will meet a compelling business need that can provide a competitive advantage.

Application software applies the power of the computer to solve problems and perform specific tasks. One useful way of classifying the many potential uses of information systems is to identify the scope of problems and opportunities addressed by a particular organization or its sphere of influence. For most companies, the spheres of influence are personal, workgroup, and enterprise.

User software, or personal productivity software, includes general-purpose programs that enable users to improve their personal effectiveness, increasing the quality and amount of work that can be done. Software that helps groups work together is often called workgroup application software, and includes group scheduling software, electronic mail, and other software that enables people to share ideas. Enterprise software that benefits the entire organization can also be developed or purchased. Many organizations are turning to enterprise resource planning software, a set of integrated programs that manage a company's vital business operations for an entire multisite, global organization.

Three approaches to developing application software are to build proprietary application software, buy existing programs off the shelf, or use a combination of customized and off-the-shelf application software. Building proprietary software (in-house or on contract) has the following advantages: The organization will get software that more closely matches

its needs; by being involved with the development, the organization has further control over the results; and the organization has more flexibility in making changes. The disadvantages include the following: It is likely to take longer and cost more to develop, the in-house staff will be hard pressed to provide ongoing support and maintenance, and there is a greater risk that the software features will not work as expected or that other performance problems will occur.

Purchasing off-the-shelf software has many advantages. The initial cost is lower, there is a lower risk that the software will fail to work as expected, and the software is likely to be of higher quality than proprietary software. Some disadvantages are that the organization might pay for features it does not need, the software might lack important features requiring expensive customization, and the system might require process reengineering.

Some organizations have taken a third approach—customizing software packages. This approach usually involves a mixture of the preceding advantages and disadvantages and must be carefully managed.

An application service provider (ASP) is a company that can provide the software, support, and computer hardware on which to run the software from the user's facilities over a network. ASPs customize off-the-shelf software on contract and speed deployment of new applications while helping IS managers avoid implementation headaches. Use of ASPs reduces the need for many skilled IS staff members and also lowers a project's start-up expenses. Software as a service (SaaS) allows businesses to subscribe to Web-delivered business application software by paying a monthly service charge or a per-use fee.

Although hundreds of computer applications can help people at school, home, and work, the primary applications are word processing, spreadsheet analysis, database, graphics, and online services. A software suite, such as SmartSuite, WordPerfect, StarOffice, or Office, offers a collection of powerful programs.

Principle

Organizations should choose a programming language whose functional characteristics are appropriate for the task at hand, considering the skills and experience of the programming staff.

All software programs are written in coding schemes called *programming languages*, which provide instructions to a computer to perform some processing activity. The several classes of programming languages include machine, assembly, high-level, query and database, object-oriented, and visual programming languages.

Programming languages have changed since their initial development in the early 1950s. In the first generation, computers were programmed in machine language, and the second generation of languages used assembly languages. The third generation consists of many high-level programming languages that use English-like statements and commands. They also must be converted to machine language by special software called a compiler, and include BASIC, COBOL, FORTRAN, and others. Fourth-generation languages include database and query languages such as SQL.

Fifth-generation programming languages combine rules-based code generation, component management, visual programming techniques, reuse management, and other advances. Visual and object-oriented programming languages—such as Smalltalk, C++, and Java—use groups of related data, instructions, and procedures called *objects*, which serve as reusable modules in various programs. These languages can reduce program development and testing time. Java can be used to develop applications on the Internet.

Principle

The software industry continues to undergo constant change; users need to be aware of recent trends and issues to be effective in their business and personal life.

Software bugs, software licensing and copyrighting, open-source software, shareware and freeware, multiorganizational software development, software upgrades, and global software support are all important software issues and trends.

A software bug is a defect in a computer program that keeps it from performing in the manner intended. Software bugs are common, even in key pieces of business software.

Open-source software is software that is freely available to anyone in a form that can be easily modified. Open-source software development and maintenance is a collaborative process, with developers around the world using the Internet to keep in close contact via e-mail and to download and submit new software. Shareware and freeware can reduce the cost of software, but sometimes they might not be as powerful as commercial software. Also, their source code usually cannot be modified.

Multiorganizational software development is the process of extending software development beyond a single organization by finding others who share the same business problem and involving them in a common development effort.

Software upgrades are an important source of increased revenue for software manufacturers and can provide useful new functionality and improved quality for software users.

Global software support is an important consideration for large, global companies putting together standardized, company-wide systems. A common solution is outsourcing global support to one or more third-party software distributors.

CHAPTER 4: SELF-ASSESSMENT TEST

Systems and application software are critical in helping individuals and organizations achieve their goals.

1. Which of the following is an example of a command-driven operating system?
   a. Windows XP
   b. Leopard
   c. MS-DOS
   d. Windows Vista
2. Application software such as Microsoft Office Excel manipulates the computer hardware directly. True or False?
3. Today's operating systems support _____, the ability to run multiple processes seemingly simultaneously.
4. The file manager component of the OS controls how memory is accessed and maximizes available memory and storage. True or False?

Organizations should not develop proprietary application software unless doing so will meet a compelling business need that can provide a competitive advantage.

5. The primary function of system software is to apply the power of the computer to give people, workgroups, and the entire enterprise the ability to solve problems and perform specific tasks. True or False?
6. Software that enables users to improve their personal effectiveness, increasing the amount of work they can do and its quality, is called _____.
   a. personal productivity software
   b. operating system software
   c. utility software
   d. graphics software
7. Optimization can be found in which type of application software?
   a. spreadsheets
   b. word processing programs
   c. database programs
   d. presentation graphics programs
8. Software used to solve a unique or specific problem that is usually built in-house but can also be purchased from an outside company is called _____.
9. A program to detect and eliminate viruses is an example of what type of software?
   a. personal productivity software
   b. operating system software
   c. utility software
   d. applications software

Organizations should choose a programming language whose functional characteristics are appropriate for the task at hand, considering the skills and experience of the programming staff.

10. Most software purchased to run on a personal computer uses a _____ license.
    a. site
    b. concurrent-user
    c. multiuser
    d. single-user
11. A class of application software that helps groups work together and collaborate is called _____.
12. Each programming language has its own set of rules, called the _____ of the language.
13. A special software program called an *interpreter* performs the conversion from the programmer's source code into the machine-language instructions consisting of binary digits, and results in a machine-language program. True or False?

CHAPTER 4: SELF-ASSESSMENT TEST ANSWERS

(1) c (2) False (3) multitasking (4) False (5) False (6) a (7) a (8) proprietary software (9) c (10) d (11) workgroup application software (12) syntax (13) False

REVIEW QUESTIONS

1. What is the difference between systems and application software? Give four examples of personal productivity software.
2. What steps can a user take to correct software bugs?
3. Identify and briefly discuss two types of user interfaces provided by an operating system.
4. What is a software suite? Give several examples.
5. Name four operating systems that support the personal, workgroup, and enterprise spheres of influence.
6. What is a service-oriented architecture (SOA)?
7. What is multitasking?
8. Define the term *utility* software and give two examples.

9. Identify the two primary sources for acquiring application software.
10. What is an application service provider? What issues arise in considering the use of an ASP?
11. What is open-source software? What is the biggest stumbling block with the use of open-source software?
12. What does the acronym API stand for? What is the role of an API?
13. Briefly discuss the advantages and disadvantages of frequent software upgrades.
14. Describe the term *enterprise resource planning (ERP) system*. What functions does such a system perform?
15. What is freeware? Give two examples.

DISCUSSION QUESTIONS

1. Assume that you must take a computer-programming course next semester. What language do you think would be best for you to study? Why? Do you think that a professional programmer needs to know more than one programming language? Why or why not?
2. You are going to buy a personal computer. What operating system features are important to you? What operating system would you select?
3. Identify the fundamental types of application software. Discuss the advantages and disadvantages of each type.
4. You are using a new release of an application software package. You think that you have discovered a bug. Outline the approach that you would take to confirm that it is indeed a bug. What actions would you take if it truly was a bug?
5. How can application software improve the effectiveness of a large enterprise? What are some of the benefits associated with implementation of an enterprise resource planning system? What are some of the issues that could keep the use of enterprise resource planning software from being successful?
6. Define the term *software as a service (SaaS)*. What are some of the advantages and disadvantages of employing a SaaS? What precautions might you take to minimize the risk of using one?
7. Describe three personal productivity software packages you are likely to use the most. What personal productivity software packages would you select for your use?
8. Contrast and compare three popular OSs for personal computers.
9. If you were the IT manager for a large manufacturing company, what issues might you have with the use of open-source software? What advantages might there be for use of such software?
10. Identify four types of software licenses frequently used. Which approach does the best job of ensuring a steady, predictable stream of revenue from customers? Which approach is most fair for the small company that makes infrequent use of the software?

PROBLEM-SOLVING EXERCISES

1. Choose an application software package that might be useful for a career that interests you and develop a six-slide presentation of its history, current level of usage, typical applications, ease of use, and so on.
2. Use a spreadsheet package to prepare a simple monthly budget and forecast your cash flow—both income and expenses for the next six months (make up numbers rather than using actual ones). Now use a graphics package to plot the total monthly income and monthly expenses for six months. Cut and paste both the spreadsheet and the graph into a word processing document that summarizes your financial condition.
3. Use a database program to enter five software products you are likely to use at work. List the name, vendor or manufacturer, cost, and features in the columns of a database table. Use a word processor to write a report on the software. Copy the database table into the word processing program.

TEAM ACTIVITIES

1. Form a group of three or four classmates. Find articles from business periodicals, search the Internet, or interview people on the topic of software bugs. How frequently do they occur, and how serious are they? What can software users do to encourage defect-free software? Compile your results for an in-class presentation or a written report.
2. Form a group of three or four classmates. Identify and contact an employee of a local firm. Interview the individual and describe the application software the company uses and the importance of the software to the organization. Write a brief report summarizing your findings.
3. Divide your team into two groups. The first group should prepare a report using a word processing program. Make sure to include a large number of spelling, grammatical, and similar errors in the document. The second group should use the word processing program's features to locate and eliminate the errors. The entire team should write a report on the advantages and limitations of the spelling and grammar checking features of the word processing program you used. What additional features would you like to see in future word processing programs?

WEB EXERCISES

1. Use the Web to research four productivity software suites from various vendors (see *http://en.wikipedia.org/wiki/Office_Suite*). Create a table in a word processing document to show what applications are provided by the competing suites. Write a few paragraphs on which suite you think best matches your needs and why.
2. Use the Internet to search for three popular freeware utilities that you would find useful. Write a report that describes the features of these three utility programs.
3. Do research on the Web and develop a two-page report summarizing the latest consumer appliance OSs. Which one seems to be gaining the most widespread usage? Why do you think this is the case?
4. Do research on the Web about application software that is used in an industry and is of interest to you. Write a brief report describing how the application software can be used to increase profits or reduce costs.

CAREER EXERCISES

1. What personal computer OS would help you the most in the first job you would like to have after you graduate? Why? What features are the most important to you?
2. Think of your ideal job. Describe five application software packages that could help you advance in your career. If the software package doesn't exist, describe the kinds of software packages that could help you in your career.

CASE STUDIES

Case One

Systems Management Software Helps Fight Crime

The York regional police protect 1,800 square kilometers north of Toronto, Canada. Until recently, the force has been challenged trying to keep the rugged Panasonic laptops in its 200 cruisers, boats, and helicopters up-to-date, secure, and synchronized. Although the notebooks were wirelessly networked, the data, software, and systems were not necessarily well synchronized.

To apply system updates and patches every few months, officers were required to check in at the main station where they had to wait for a few hours while the notebook was updated. With over 200 laptops on the force, this cost the department hundreds of working hours every few months.

Not only were human resources wasted, but the internal IT department was pushed past its limit. Staff members sometimes unknowingly worked to solve the same problems. They spent too much time coordinating applications, running backups, and trying to keep up with new law enforcement applications.

Recently the York police installed system management software from Microsoft called System Center Configuration Manager 2007. The software allows system administrators at the main station to access notebooks remotely over the network for system upgrades, patch management, software distribution, and hardware and software inventory. No longer do officers need to spend hours waiting on their PC updates. PCs are updated as needed over the wireless network. New software and system changes are pushed out to all notebooks simultaneously so all officers have the same information and services at all times.

The new system software allows the department to come close to its paperless ideal. An e-ticketing system allows officers to swipe a driver's license, run a background check, and issue a ticket in minutes. Officers receive daily briefings online and submit reports directly from their notebooks, which allows them to stay on the road rather than at a desk. The new system has freed up the IT staff to concentrate on delivering new and useful services rather than just maintaining the old services.

The York regional police are looking forward to the next edition of System Center Configuration Manager, which promises to support streaming media. They would like to use it to stream video from the helicopter to cruisers on the road.

Discussion Questions

1. What unique challenges did the York regional police IT staff have to overcome?
2. How did Microsoft System Center Configuration Manager resolve the issues for the York regional police?

Critical Thinking Questions

1. What other types of industries would benefit from products like Microsoft System Center Configuration Manager? Why?
2. What general lesson regarding information system administration can you take from this case?

SOURCES: Smith, Briony, "Cops roll out remote patch updates, e-ticketing," *ITWorld Canada*, November 29, 2007, *www.itworldcanada.com/a/Enterprise-Business-Applications/50132083-0699-401d-b7ce-d6f1c16193b5.html*. Microsoft System Center Configuration Manager Web site, *www.microsoft.com/smserver*, accessed February 3, 2008. York Regional Police Web site, *www.yrp.on.ca*, accessed February 3, 2008.

Case Two

Energy Giant Valero Turns to SOA Software

Valero Energy is North America's largest refiner. When they recently acquired some competing refineries, Valero tripled its annual revenue to $90 billion. While Valero's rapid growth has been good for its shareholders, it has been a nightmare for the company's information systems management professionals.

By acquiring several companies that were themselves products of multiple acquisitions, Valero found itself with dozens of incompatible software systems that somehow had to find a way to communicate and share data. Although one traditional solution would have been to design or purchase middleware to bridge the gap, Valero chose a cutting edge software development technique called a service-oriented architecture (SOA).

Valero software engineers began designing software services to provide users with an interface to its disparate systems. They developed the services based on industry standards and designed them to be flexibly reused and recombined. By using the SOA approach, Valero planned to pull together the various information systems, conduct business more efficiently, and reduce operating costs. Over time, the company has introduced over 100 services built on SAP's NetWeaver Application Server Development Environment. Many are composite services built by combining several smaller services. Roughly 22,000 employees and 5,000 customers now use Valero's SOA services.

When approaching a new service request, rather than programming from scratch, Valero's software engineers consider the services that have already been developed to find one that can be reused or refashioned. Organizing and cataloging services for reuse helps Valero save time, effort, and money. Developing services with the NetWeaver platform lets Valero engineers develop 300 services quickly and easily. Nayaki Nayyar, Valero's director of enterprise architecture and technology services, stepped in to reduce the number of services to 50, isolating the best core services before moving forward with new development. "Unless you can catalog, find, and use these services," she said in a *CIO Insight* interview, "you just end up with a virtual junk drawer of services."

The result of their SOA approach has saved Valero millions of dollars. One system designed to provide visibility into tanker transportation schedules saved the company a half-million dollars in penalties for ships that sit idle at the dock. Other savings are incurred from management being able to view corporate data from across the enterprise in real time.

Valero is working on tools that will allow managers to design their own SOA services. If managers can access the information they need without the usual system request process, the business becomes more streamlined, and the information system staff is freed to focus on bigger projects.

Discussion Questions

1. Why did Valero choose an SOA to integrate its systems rather than creating middleware?
2. What benefits does the SOA provide to businesses such as Valero?

Critical Thinking Questions

1. Why is it important to maintain a reasonably sized catalog of services rather than a large amount of services?
2. Is it wise for Valero to empower their managers to create their own services? How might this system benefit the company? Are there any dangers?

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Questions for Web Case

See the Web site for this book to read about the Whitmann Price Consulting case for this chapter. The following questions concern this Web case.

Whitmann Price Consulting: Software Considerations

Discussion Questions

1. What three types of software made the BlackBerry ideal for meeting the needs of Whitmann Price?
2. How did the choice of hardware affect options for software solutions? If Sandra and Josh picked a newly developed handheld device unknown in industry, how would that change the solutions?

Critical Thinking Questions

1. For software other than the BlackBerry software, should Sandra and Josh look to BlackBerry Alliance Program members or should they plan to have their own software engineers develop the software? What are the benefits and drawbacks of either option?
2. What process would you use to evaluate software for the Advanced Mobile Communications and Information System?

NOTES

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