Information Technology Infrastructure

PART II

Part II provides the technical foundation for understanding information systems by examining hardware, software, databases, networking technologies, and tools and techniques for security and control. This part answers questions such as these: What technologies and tools do businesses today need to accomplish their work? What do I need to know about these technologies to make sure they enhance the performance of my firm? How are these technologies likely to change in the future?

IT Infrastructure: Hardware and Software

CHAPTER 4

STUDENT LEARNING OBJECTIVES

After completing this chapter, you will be able to answer the following questions:

1. What are the components of IT infrastructure?
2. What are the major computer hardware, data storage, input, and output technologies used in business?
3. What are the major types of computer software used in business?
4. What are the most important contemporary hardware and software trends?
5. What are the principal issues in managing hardware and software technology?

Chapter Outline

UNIVERSITY OF PITTSBURGH MEDICAL CENTER'S TECHNOLOGY CURE

The University of Pittsburgh Medical Center (UPMC) is a $6 billion integrated health care enterprise and a widely recognized leader in using information technology for health care. UPMC puts great demands on its information systems to operate 19 hospitals, a network of other care sites, and international and commercial ventures. With 43,000 employees, it is the largest employer in western Pennsylvania. It is a national leader in implementing electronic medical records.

UPMC was such a heavy user of information technology that demand for additional servers and storage technology was growing by 20 percent each year. Integrating the systems of a new hospital it acquired or adding new information systems increased the complexity of its infrastructure, making it increasingly difficult to manage. UPMC was setting up a separate server for every application, and its servers and other computers were running a number of different operating systems, including several versions of UNIX and Windows. UPMC had to manage technologies from many different vendors, including Hewlett-Packard (HP), Sun Microsystems, Microsoft, and IBM.

To reduce costs and simplify its IT infrastructure, UPMC turned to IBM. In 2005, UPMC selected IBM as its primary server and storage technology provider with the goal of reducing UPMC's IT infrastructure spending by 20 percent. IBM would also provide help in managing the people, process, and technology issues surrounding the overhaul of UPMC's IT infrastructure. Both organizations agreed to work together on developing applications to jointly market to other hospitals and health care firms.

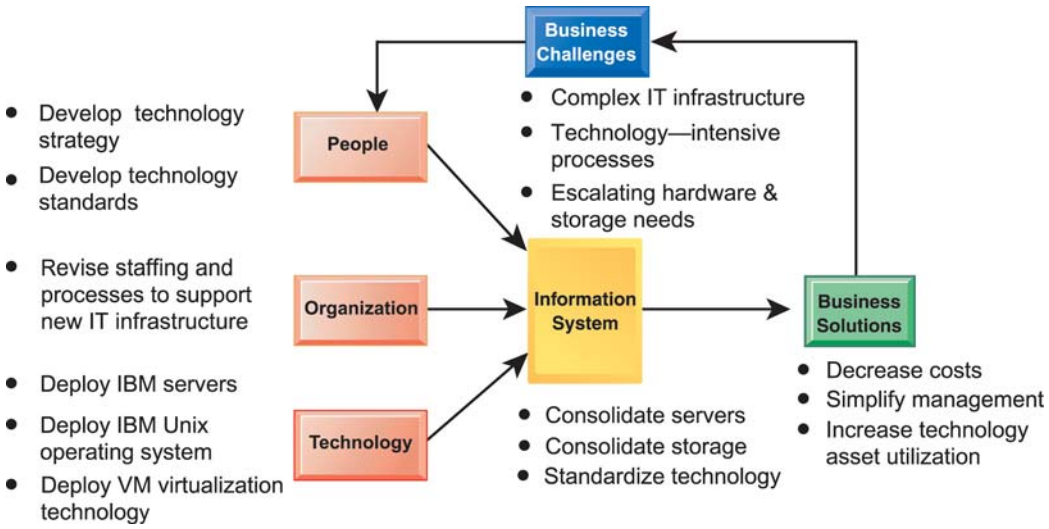
IBM recommended that UPMC use virtualization to reduce the number of servers it needed to run its applications. Virtualization makes it possible to put many applications on a single physical server but give each its own instance of the operating system, so what appear to be many separate applications and operating systems are running on a single machine. It standardized UNIX applications on IBM's AIX version of the UNIX operating system running on IBM System p5 595 servers and used VMware technology to consolidate more than 1,000 physical servers on just 20 IBM System x servers. As a result, server utilization rates have increased from 3 percent per server to nearly 80 percent, the same staff are able to support 150 percent more server capacity, and the space required for servers has been reduced by 40 percent.

UPMC also used IBM technology to consolidate its storage infrastructure to three enterprise-wide storage pools, enhancing utilization, flexibility, and management. International Data Corporation's Health Industry Insights service estimated that UPMC's server virtualization project alone will save $18 million to $22 million over the next three years by reducing costs for new hardware, floor space, and staffing.

Sources: David F. Carr, "Major Surgery," *Baseline Magazine*, July 2007 and IBM, "University of Pittsburgh Medical Center Boosts Efficiency and Cost Savings with IBM Virtualization Technology," April 9, 2007.

The University of Pittsburgh Medical Center is highly dependent on information technology for its daily operations and patient care. But UPMC is a large organization with many local branches, new units to integrate, and a massive amount of data to store and process. Its IT infrastructure used technology from many different vendors. It was so complex and massive that it had become difficult to manage, and its server and storage needs were growing at 20 percent each year.

UPMC could have kept adding more hardware each year, but this would have made its infrastructure even more complex and added to IT costs. But this is an organization with a very large amount of information to manage that would benefit from an enterprise-wide approach to managing computers, storage, and networks. UPMC chose instead to standardize its technology as much as possible on IBM platforms and to use virtualization technology to reduce the number of servers required to run its applications. This solution lowered costs, increased resource utilization rates, and made UPMC's IT infrastructure easier to maintain and manage.



HEADS UP

This chapter describes the kind of software and hardware you will need to operate a business. In your business career, you will inevitably be making decisions about what information technology to buy, from whom to buy it, and how much to spend for it. You will need to know how to select technology that enhances the performance of your business, is cost effective, and is appropriate for the kind of work you will be doing.

4.1 IT Infrastructure: Computer Hardware

If you want to know why American businesses spend about $2 trillion every year on computing and information systems, just consider what it would take for you personally to set up a business or manage a business today. Businesses today require a wide variety of computing equipment, software, and communications capabilities simply to operate and solve basic business problems. Obviously, you need computers, and, as it turns out, a wide variety of computers are available, including desktops, laptops, and handhelds.

Do your employees travel or do some work from home? You will want to equip them with laptop computers (over half the computers sold in the U.S. are laptops). If you are employed by a medium to large business, you will also need larger server computers, perhaps an entire data center or server farm with hundreds or even thousands of servers. Google, for instance, is able to answer 80 million queries a day in the United States, most within one second, by using a massive network of 450,000 PC servers linked together to spread the workload.

You will also need plenty of software. Each computer will require an operating system and a wide range of application software capable of dealing with spreadsheets, documents, and data files. Unless you are a single-person business, you will most likely want to have a network to link all the people in your business together and perhaps your customers and suppliers. As a matter of fact, you will probably want several networks: a local area network connecting employees in your office and remote access capabilities so employees can share e-mail and computer files while they are out of the office. You will also want all your employees to have access to land and cell phone networks and the Internet. Finally, to make all this equipment and software work harmoniously, you will also need the services of trained people to help you run and manage this technology.

All of these elements we have just described combine to make up the firm's *information technology (IT) infrastructure*, which we first defined in Chapter 1. A firm's IT infrastructure provides the foundation, or platform, for supporting all the information systems in the business.

INFRASTRUCTURE COMPONENTS

IT infrastructure today is composed of five major components: computer hardware, computer software, data management technology, networking and telecommunications technology, and technology services (see Figure 4-1). These components must be coordinated with each other.

Computer Hardware

Computer hardware consists of technology for computer processing, data storage, input, and output. This component includes large mainframes, servers, midrange computers, desktop and laptop computers, handheld personal digital assistants (PDAs), and mobile devices for accessing corporate data and the Internet. It also includes equipment for gathering and inputting data, physical media for storing the data, and devices for delivering the processed information as output.

Computer Software

Computer software includes both system software and application software. **System software** manages the resources and activities of the computer. **Application software** applies the computer to a specific task for an end user, such as processing an order or generating a mailing list. Today, most system and application software is no longer custom programmed but rather is purchased from outside vendors. We describe these types of software in detail in Section 4.2.

Data Management Technology

In addition to physical media for storing the firm's data, businesses need specialized software to organize the data and make them available to business users. **Data management software** organizes, manages, and processes business data concerned with inventory, customers, and vendors. Chapter 5 describes data management software in detail.

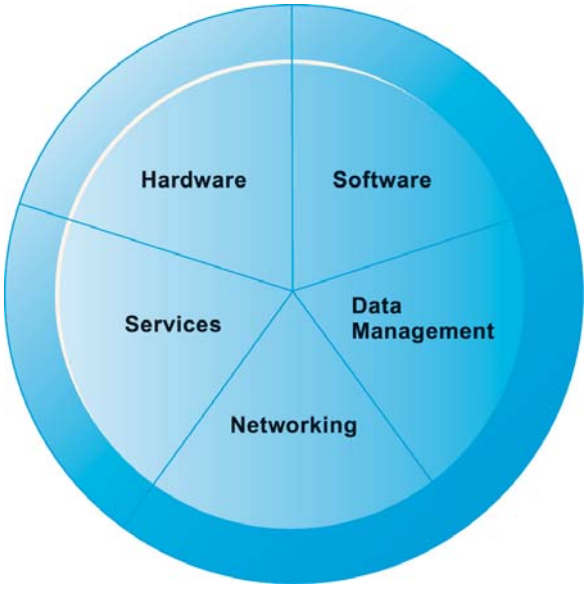


Figure 4-1
IT Infrastructure Components
A firm's IT infrastructure is composed of hardware, software, data management technology, networking technology, and technology services.

Networking and Telecommunications Technology

Networking and telecommunications technology provides data, voice, and video connectivity to employees, customers, and suppliers. It includes technology for running a company's internal networks, services from telecommunications/telephone services companies, and technology for running Web sites and linking to other computer systems through the Internet. Chapter 6 provides an in-depth description of these technologies.

Technology Services

Businesses need people to run and manage the other infrastructure components we have just described and to train employees in how to use these technologies for their work. Chapter 2 described the role of the information systems department, which is the firm's internal business unit set up for this purpose. Today, many businesses supplement their in-house information systems staff with external technology consultants. Even large firms do not have the staff, the skills, the budget, or the necessary experience to implement and run the wide array of technologies that would be required. When businesses need to make major system changes or implement an entirely new IT infrastructure, they typically turn to external consultants to help them with systems integration.

Systems integration means ensuring that the new infrastructure works with the firm's older, so-called legacy systems and that the new elements of the infrastructure work with one another. **Legacy systems** are generally older transaction processing systems created for mainframe computers that continue to be used to avoid the high cost of replacing or redesigning them.

There are many thousands of technology vendors supplying IT infrastructure components and services and an equally large number of ways of putting them together. This chapter is about the hardware and software components of infrastructure you will need to run a business. Chapter 5 describes the data management component, and Chapter 6 is devoted to the networking and telecommunications technology component. Chapter 7 deals with hardware and software for ensuring that information systems are reliable and secure, and Chapter 8 discusses software for enterprise applications.

TYPES OF COMPUTERS

Business firms face many different challenges and problems that can be solved by computers and information systems. In order to be efficient, firms need to match the right computer hardware to the nature of the business challenge, neither overspending nor underspending for the technology.

Computers come in an array of sizes with differing capabilities for processing information, from the smallest handheld devices to the largest mainframes and supercomputers. Table 4.1 illustrates the different broad categories of computers and their relative performance.

Although there are many factors that enter into a computer system's performance, one way to think about the performance of computers is to measure how long it takes them to perform a FLOPS (FLoating point Operations Per Second). A floating point operation is essentially long division. The faster a computer system can calculate long division problems, the higher its overall performance. Computers range in power from about 500 FLOPS (a handheld) to more than a trillion FLOPS for supercomputers.

If you're working alone or with a few other people in a small business, you'll probably be using a desktop or laptop **personal computer (PC)**. You might carry around a mobile device with some computing capability, such as a BlackBerry, iPhone or Palm handheld, or other high-end cell phone. If you're doing advanced design or engineering work requiring powerful graphics or computational capabilities, you might use a **workstation**, which fits on a desktop but has more powerful mathematical and graphics-processing capabilities than a PC.

If your business has a number of computers networked together or maintains a Web site, it will need a **server**. Server computers are specifically optimized to support a computer

TABLE 4.1

Computer Performance

Computer	Processor/Speed	Performance	Comment
Personal digital assistant (PDA) Palm handheld	Intel™ XScale/ 312 MHz	~500 FLOPS	PDAs are generally asked to perform one task at a time by the operator. Most of the processing power is used to draw the screen and handle voice messages.
Personal computer Dell XPS 720 H2C	Intel Core 2 Extreme (quad-core) processor/3.67 GHz,	4 Giga FLOPS	High-end game machine. Most PCs used in business are 1–3 GHz, with 2 GFLOPS performance, plenty for word processing, Web surfing, and spreadsheets.
Server computer (midrange computer) SUN Sun Fire E6900 Server	UltraSPARC IV+/1.8 GHz	~48 Giga FLOPS	Up to 24 processors can be used with this powerful server.
Mainframe computer IBM System z9 Enterprise Class	System z9 Integrated Information Processor/Equal to 100 or more distributed processors	~1 Tera FLOPS	Up to 60 logical partitions, each with 64-bit central memory addressability.
SuperComputer IBM Blue Gene/P	4 PowerPC 450 processors per chip/850 MHz	~1 Peta FLOPS	Configured with 294,912 PowerPC processors on 72 racks. A chip of 4 processors capable of 13.6 billion operations per second.
Distributed Computing Grid Folding@home	Various PC processors, whatever is available on the Internet.	~125 Peta FLOPS	A volunteer program with approximately 250,000 CPUs online; the largest and fastest online distributed computing project devoted to study protein folding.

network, enabling users to share files, software, peripheral devices (such as printers), or other network resources. Servers are classified as **midrange computers**.

Servers have become important components of firms' IT infrastructures because they provide the hardware platform for electronic commerce. By adding special software, they can be customized to deliver Web pages, process purchase and sale transactions, or exchange data with systems inside the company. You will sometimes find many servers linked together to provide all the processing needs for large companies. If your company has to process millions of financial transactions or customer records, you will need several midrange computers or a single large mainframe to solve these challenges.

Mainframe computers first appeared in the mid-1960s, and are still used by large banks, insurance companies, stock brokerages, airline reservation systems, and government agencies to keep track of hundreds of thousands, or even millions, of records and transactions. A **mainframe** is a large-capacity, high-performance computer that can process large amounts of data very rapidly. Airlines, for instance, use mainframes to process upwards of 3,000 reservation transactions per second.

IBM, the leading mainframe vendor, has repurposed its mainframe systems so they can be used as giant servers for large-scale enterprise networks and corporate Web sites. A single IBM mainframe can run enough instances of Linux or Windows server software to replace thousands of smaller Windows-based servers.

A **supercomputer** is a specially designed and more sophisticated computer that is used for tasks requiring extremely rapid and complex calculations with thousands of variables, millions of measurements, and thousands of equations. Supercomputers traditionally have been used in engineering analysis of structures, scientific exploration and simulations, and military work, such as classified weapons research and weather forecasting. A few private business firms use supercomputers. For instance, Volvo and most other automobile manufacturers use supercomputers to simulate vehicle crash tests.

If you are a long-term weather forecaster, such as the National Oceanic and Atmospheric Administration (NOAA), or the National Hurricane Center, and your challenge is to predict the movement of weather systems based on hundreds of thousands of measurements, and thousands of equations, you would want access to a supercomputer or a distributed network of computers called a grid.

Grid computing involves connecting geographically remote computers into a single network to create a "virtual supercomputer" by combining the computational power of all computers on the grid. Grid computing takes advantage of the fact that most computers in the United States use their central processing units on average only 25 percent of the time, leaving 75 percent of their capacity available for other tasks. By using the combined power of thousands of PCs and other computers networked together, the grid is able to solve complicated problems at supercomputer speeds at far lower cost.

Private firms are beginning to use computing grids because of their greater reliability than supercomputers, higher capacity, and lower cost. For example, Citigroup is implementing grid computing for analyzing complex financial products, harnessing 7,000 processors in Texas and London (Crosman, 2007).

Computer Networks and Client/Server Computing

Unless you are in a small business with a stand-alone computer, you'll be using networked computers for most processing tasks. The use of multiple computers linked by a communications network for processing is called **distributed processing**. **Centralized processing**, in which all processing is accomplished by one large central computer, is much less common.

One widely used form of distributed processing is **client/server computing**. Client/server computing splits processing between "clients" and "servers." Both are on the network, but each machine is assigned functions it is best suited to perform. The **client** is the user point of entry for the required function and is normally a desktop or laptop computer. The user generally interacts directly only with the client portion of the application. The server provides the client with services. Servers store and process shared data and also perform functions such as managing printers, backup storage, and network activities such as security, remote access, and user authentication. Figure 4-2 illustrates the client/server computing concept. Computing on the Internet uses the client/server model (see Chapter 6).

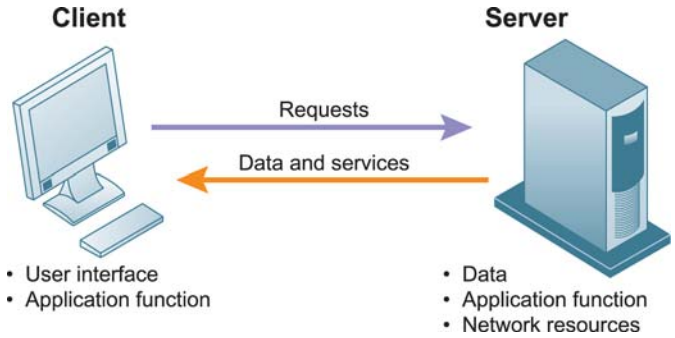


Figure 4-2
Client/Server Computing
In client/server computing, computer processing is split between client machines and server machines linked by a network. Users interface with the client machines.

Figure 4-2 illustrates the simplest client/server network, consisting of a client computer networked to a server computer, with processing split between the two types of machines. This is called a *two-tiered client/server architecture*. Whereas simple client/server networks can be found in small businesses, most corporations have more complex, multitiered (often called **N-tier**) **client/server architectures**, in which the work of the entire network is balanced over several different levels of servers, depending on the kind of service being requested (see Figure 4-3).

For instance, at the first level a **Web server** will serve a Web page to a client in response to a request for service. Web server software is responsible for locating and managing stored Web pages. If the client requests access to a corporate system (a product list or price information, for instance), the request is passed along to an **application server**. Application server software handles all application operations between a user and an organization's back-end business systems. The application server may reside on the same computer as the Web server or on its own dedicated computer. Chapters 5 and 6 provide more detail on other pieces of software that are used in multitiered client/server architectures for e-commerce and e-business.

STORAGE, INPUT, AND OUTPUT TECHNOLOGY

In addition to hardware for processing data, you will need technologies for data storage, and input and output. Storage and input and output devices are called *peripheral devices* because they are outside the main computer system unit.

Secondary Storage Technology

Electronic commerce and electronic business, and regulations such as Sarbanes-Oxley, have made storage a strategic technology. The amount of data that companies now need to store is doubling every 12 to 18 months. The primary storage technologies are magnetic disks, optical disc, magnetic tape, and storage networks.

Magnetic Disks The most widely used secondary storage medium today is the **magnetic disk**. PCs have *hard drives*, and large mainframe or midrange computer systems have multiple hard disk drives because they require immense disk storage capacity in the gigabyte and terabyte range. Some PCs use floppy disks, but they have been largely supplanted by *USB flash drives*, also known as USB drives. A USB flash drive provides portable flash memory storage by plugging into a computer's USB port. It can provide up to 64 gigabytes of portable storage capacity and is small enough to fit into a pocket.

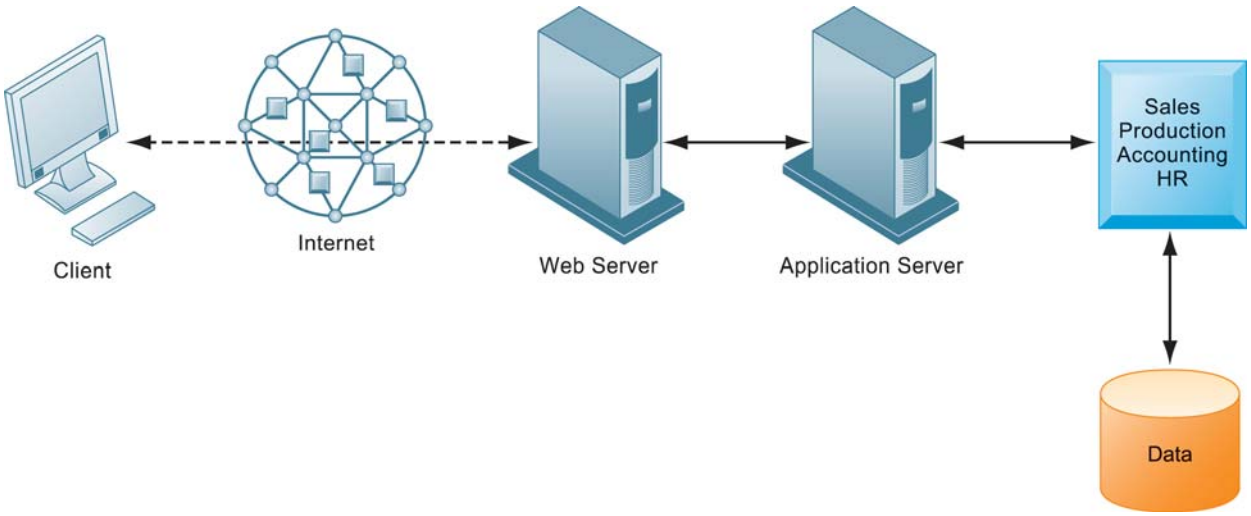


Figure 4-3
A Multitiered Client/Server Network (N-Tier)
In a multitiered client/server network, client requests for service are handled by different levels of servers.

Large computers with massive storage requirements use a disk technology called *RAID (Redundant Array of Inexpensive Disks*). RAID devices package more than 100 disk drives, a controller chip, and specialized software into a single, large unit delivering data over multiple paths simultaneously.

Optical Discs Optical discs use laser technology to store massive quantities of data in a highly compact form. They are available for both PCs and large computers. The most common optical disc system used with PCs is called **CD-ROM** (**compact disc read-only memory**). A 4.75-inch compact disc for PCs can store up to 660 megabytes. Optical discs are most appropriate for applications where enormous quantities of unchanging data must be stored compactly for easy retrieval or for applications combining text, sound, and images.

CD-ROM is read-only storage. No new data can be written to it; it can only be read. *CD-RW (CD-ReWritable)* technology has been developed to allow users to create rewritable optical discs for applications requiring large volumes of storage where the information is only occasionally updated.

Digital video discs (DVDs) are optical discs the same size as CD-ROMs but of even higher capacity. They can hold a minimum of 4.7 gigabytes of data, enough to store a full-length, high-quality motion picture. DVDs are being used to store video and digitized text, graphics, and audio data. Rewritable DVD drives and media are now available.

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

Storage Networking Large firms are turning to network-based storage technologies to deal with the complexity and cost of mushrooming storage requirements. **Storage area networks (SANs)** connect multiple storage devices on a separate high-speed network dedicated to storage. The SAN creates a large central pool of storage that can be rapidly accessed and shared by multiple servers (see Figure 4-4).

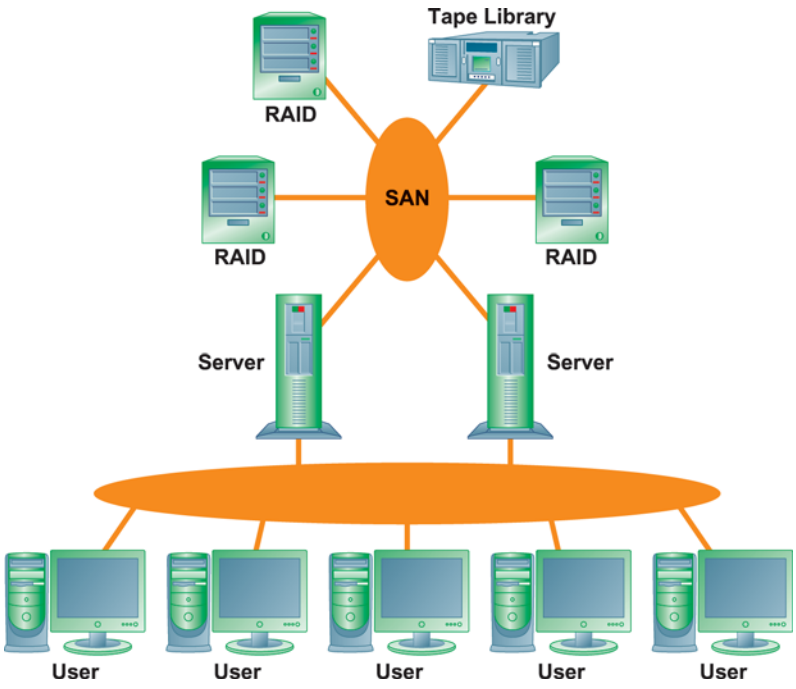


Figure 4-4
A Storage Area Network (SAN)
A typical SAN consists of a server, storage devices, and networking devices, and is used strictly for storage. The SAN stores data on many different types of storage devices, providing data to the enterprise. The SAN supports communication between any server and the storage unit as well as between different storage devices in the network.

Input and Output Devices

Human beings interact with computer systems largely through input and output devices. **Input devices** gather data and convert them into electronic form for use by the computer, whereas **output devices** display data after they have been processed. Table 4.2 describes the principal input and output devices.

TABLE 4.2

Input and Output Devices

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

Batch and Online Input and Processing

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

CONTEMPORARY HARDWARE TRENDS

The exploding power of computer hardware and networking technology has dramatically changed how businesses organize their computing power, putting more of this power on networks. We look at six trends: technology convergence, nanotechnology, edge computing, autonomic computing, virtualization, and multicore processors.

The Integration of Computing and Telecommunications Platforms

Arguably the most dominant theme in hardware platforms today is the convergence of telecommunications and computing platforms to the point where, increasingly, computing takes place over the network. You can see this convergence at several levels.

Communication devices, such as cell phones, are taking on functions of handheld computers or morphing into wireless handhelds. For instance, the Apple iPhone integrates a phone, digital camera, digital music player, and handheld computer capable of surfing the Web in a single device. Television, radio, and video are moving toward all-digital production and distribution.

The growing success of Internet telephone systems (now the fastest-growing type of telephone service) demonstrates how historically separate telecommunications and computing platforms are converging toward a single network—the Internet. Chapter 6 describes the convergence of computing and telecommunications in greater depth.

Nanotechnology

Over the years, microprocessor manufacturers have been able to exponentially increase processing power while shrinking chip size by finding ways to pack more transistors into less space. They are now turning to nanotechnology to shrink the size of transistors down to the width of several atoms. **Nanotechnology** uses individual atoms and molecules to create computer chips and other devices that are thousands of times smaller than current technologies permit. IBM and other research labs have created transistors from nanotubes and other electrical devices and have developed a manufacturing process for producing nanotube processors economically (Figure 4-5).

Edge Computing

Edge computing is a multitier, load-balancing scheme for Web-based applications in which significant parts of Web site content, logic, and processing are performed by smaller, less expensive servers located nearby the user in order to increase response time and resilience while lowering technology costs. In this sense, edge computing is another technique like grid computing and on-demand computing for using the Internet to share the workload experienced by a firm across many computers located remotely on the network.

Figure 4-6 illustrates the components of edge computing. There are three tiers in edge computing: the local client; the nearby edge computing platform, which consists of servers positioned at any of the 5,000-plus Internet service providers in the United States; and enterprise computers located at the firm's main data center. The edge computing platform is owned by a service firm, such as Akamai, which employs about 15,000 edge servers around the United States.

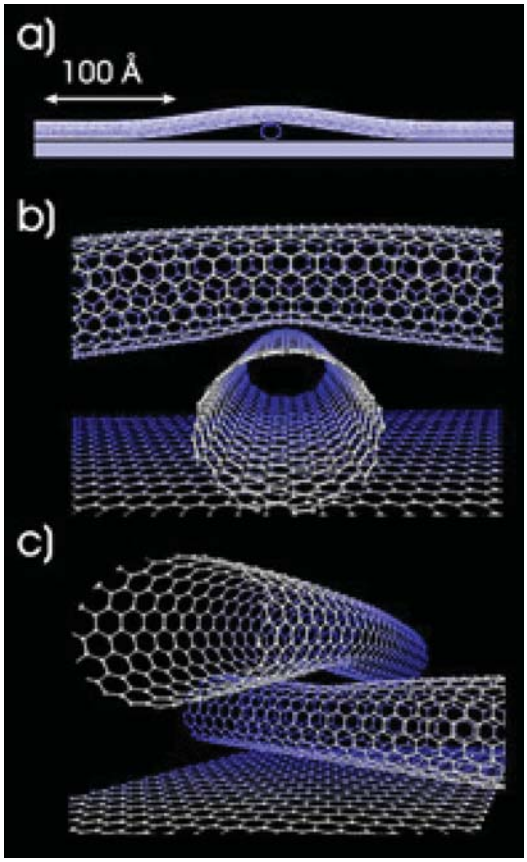


Figure 4-5
Examples of Nanotubes
Nanotubes are tiny tubes about 10,000 times thinner than a human hair. They consist of rolled up sheets of carbon hexagons, have potential uses as minuscule wires or in ultrasmall electronic devices, and are very powerful conductors of electrical current.

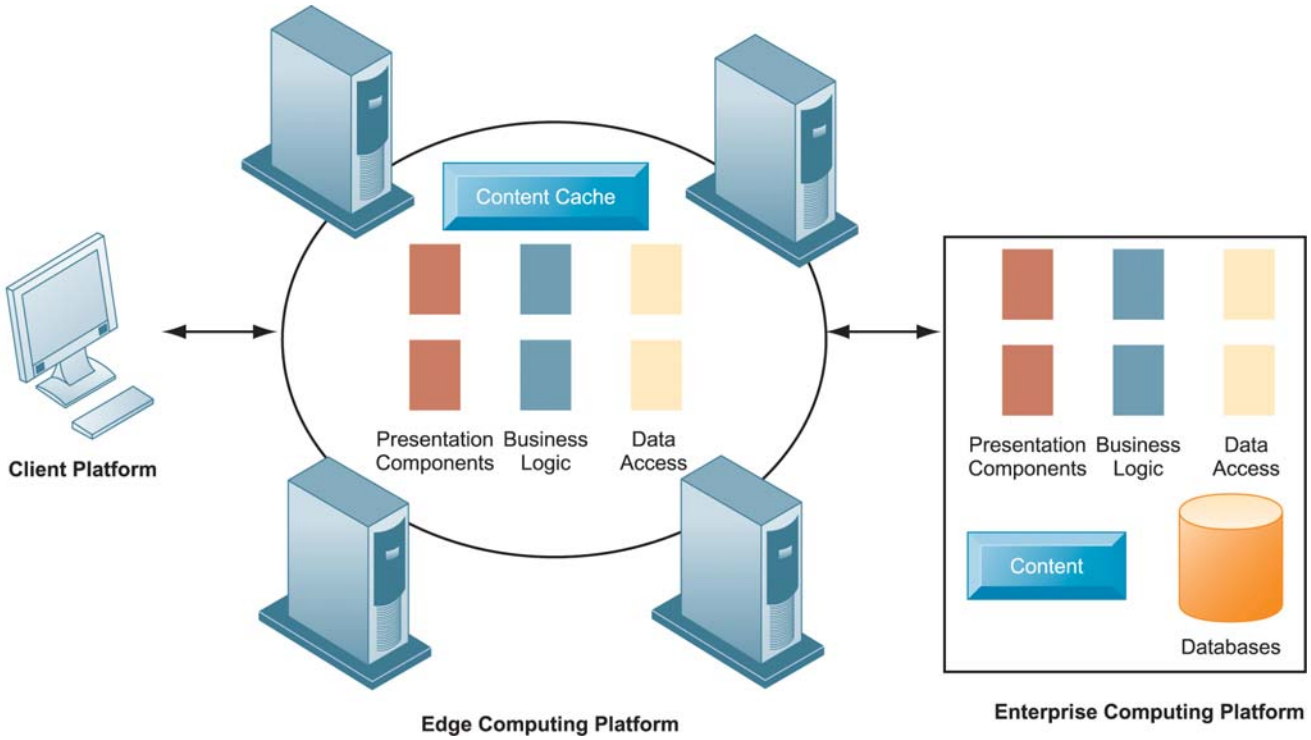


Figure 4-6
Edge Computing Platform
Edge computing involves the use of the Internet to balance the processing load of enterprise platforms across the client and edge computing platform.

In an edge platform application, the edge servers initially process requests from the user client computer. Presentation components, such as static Web page content, reusable code fragments, and interactive elements gathered on forms, are delivered by the edge server to the client. Database and business logic elements are delivered by the enterprise computing platform.

Autonomic Computing

With large systems encompassing many thousands of networked devices, computer systems have become so complex today that some experts believe they may not be manageable in the future. One approach to dealing with this problem from a computer hardware perspective is to employ autonomic computing. **Autonomic computing** is an industry-wide effort to develop systems that can configure themselves, optimize and tune themselves, heal themselves when broken, and protect themselves from outside intruders and self-destruction. Imagine, for instance, a desktop PC that could know it was invaded by a computer virus. Instead of blindly allowing the virus to invade, the PC would identify and eradicate the virus or, alternatively, turn its workload over to another processor and shut itself down before the virus destroyed any files.

You can glimpse some of these capabilities in your desktop system. For instance, virus and firewall protection software can detect viruses on PCs, automatically defeat the viruses, and alert operators. These programs can be updated automatically as the need arises by connecting to an online virus protection service such as McAfee. You can see autonomic computing occur nearly every day on your computer as Microsoft, Apple, and Sun automatically update their users' computers when they are connected to the Internet.

Virtualization and Multicore Processors

As companies deploy hundreds or thousands of servers, many have discovered that they are spending almost as much on electricity to power and cool their systems as they did on purchasing the hardware. Energy consumed by data centers doubled between 2000 and 2005. Cutting power consumption in data centers is now a major business challenge. The Interactive Session on Technology examines this problem. As you read this case, try to identify the alternative solutions for this problem and the advantages and disadvantages of each.

This Interactive Session and the chapter-opening case describe organizations curbing hardware proliferation and power consumption by using virtualization to reduce the number of computers required for processing. **Virtualization** is the process of presenting a set of computing resources (such as computing power or data storage) so that they can all be accessed in ways that are not restricted by physical configuration or geographic location. Server virtualization enables companies to run more than one operating system at the same time on a single machine. Most servers run at just 10 to 15 percent of capacity, and virtualization can boost server utilization rates to 70 percent or higher. Higher utilization rates translate into fewer computers required to process the same amount of work.

For example, the Denver Health and Hospital Authority servers mushroomed from 10 in 1996 to 220 in 2005, with server utilization rates averaging below 20 percent and 90 percent of the servers running a single application. The health care organization used virtualization to consolidate the work of 15 physical servers onto two machines running 15 virtual servers.

Server virtualization software runs between the operating system and the hardware, masking server resources, including the number and identity of physical servers, processors, and operating systems, from server users. VMware is the leading server virtualization software vendor for Windows and Linux systems. Microsoft offers its own Virtual Server product and has built virtualization capabilities into the newest version of Windows Server.

In addition to reducing hardware and power expenditures, virtualization allows businesses to run their legacy applications on older versions of an operating system on the same server as newer applications. Virtualization also facilitates centralization of hardware administration.

INTERACTIVE SESSION: TECHNOLOGY — Computing Goes Green

Computer rooms are becoming too hot to handle. Data-hungry tasks such as video on demand, music downloads, exchanging photos, and maintaining Web sites require more and more power-hungry machines. Between 2000 and 2007, the number of servers in corporate data center servers increased from 5.6 million to an estimated 12 million in the United States, and 29 million worldwide. During the same period, the total annual cost of electricity for data center servers jumped from $1.3 billion to $2.7 billion in the United States and from $3.2 billion to $7.2 billion across the world.

What's more, the heat generated from all of these severs is causing equipment to fail. Firms are forced to spend even more on cooling their data centers or to find other solutions. Some organizations spend more money to keep their data centers cool than they spend to lease the property itself. Cooling costs have helped raise the average annual utility bill of a 100,000-square-foot data center to $5.9 million. It is a vicious cycle, as companies must pay to power their servers, and then pay again to keep them cool and operational. Cooling a server requires roughly the same number of kilowatts of energy as running one. All this additional power consumption has a negative impact on the environment and as well as corporate operating costs.

At Pomona Valley Hospital Medical Center in Pomona, California, a 6,000-square-foot data center housed so many servers that the room temperature skyrocketed to nearly 100 degrees. IT managers aim to keep such rooms in the 60s. The elevated temperature caused server malfunctions and one case of outright failure. The hospital resolved the issue by investing $500,000 in a network of overhead air conditioners. Temperatures now hover at 64 degrees.

Emerson Network Power of St. Louis offers a cooling solution called Liebert XD that sits directly on top of server racks and conditions the air with pipes containing waterless refrigerant. US Internet Corp., a regional ISP in Minneapolis, installed the Liebert XD product to combat the 90-degree temperatures in one of its data centers. Without the system, US Internet was suffering from daily breakdowns of servers and storage drives.

Another cooling solution comes from Degree Controls Inc., based in Milford, New Hampshire. Degree Controls installs floor tiles equipped with powerful fans that blow cool air directly onto servers. The tiles cost $1,800 each. HP now offers an energy management system named Dynamic Smart Cooling that directs cool air to the hot spots in a data center.

Some of the world's most prominent firms are tackling their power consumption issues with one eye toward saving the environment and the other toward saving dollars. Google, Microsoft, and HSBC are all building data centers that will take advantage of hydroelectric power. Salesforce.com plans to offset its carbon footprint by investing in renewable energy projects and alternative energy sources. Sun Microsystems permits over 14,000 employees to telecommute at least twice a week. None of these companies claim that their efforts will save the world, but they do demonstrate recognition of a growing problem and the commencement of the green computing era.

IT managers also have hardware and software options that conserve power. Some organizations are choosing to use thin client computers, which are very basic terminal machines that connect directly to servers and consume significantly less power than normal desktop clients. A call center operated by Verizon Wireless in Chandler, Arizona, replaced 1,700 PCs with thin clients from Sun Microsystems and saw its power consumption go down by one-third. Sun states that, on average, its thin clients use less than half of the electricity that PCs require.

Two years ago, City University of New York adopted software called Surveyor made by Verdiem Corp. for its 20,000 PCs. The software enables IT managers to have the computers turn themselves off when they are inactive at night. Surveyor has trimmed 10 percent from CUNY's power bills, creating an annual savings of around $320,000. Quad Graphics Inc., of Sussex, Wisconsin, also deployed Surveyor after tests indicated savings on power of 35 to 50 percent, or up to $70,000 annually, were possible.

Microsoft's latest desktop PC operating system, Windows Vista, has enhanced sleep features that reduce power consumption by much greater margins than the standby modes in previous versions of Windows. In sleep mode, computers may draw as little as 3 to 4 watts of power versus 100 watts for an idle computer that is not asleep.

HP launched a three-year initiative to reduce its power costs by 20 to 25 percent through a consolidation of servers and data centers. The company uses the program as a selling point when it pitches its services to clients. Businesses also have the options of using more efficient chips in their servers. In 2006, Intel introduced new Dual-Core Intel Xeon 7100 microprocessors that achieve "nearly three times better performance per watt" than their predecessors.

Virtualization is a highly effective tool for more cost-effective greener computing because it reduces the number of servers required to run a firm's applications. The University of Pittsburgh Medical Center, described in the chapter-opening case, and Swinerton Construction in San Francisco are among many firms that have benefited from this technology. Swinerton saved $140,000 in one year alone by using virtualization, which included a $50,000 savings in power and cooling costs as well as reductions in its server purchases.

Sources: Jim Carlton, "IT Managers Make a Power Play," *The Wall Street Journal*, March 27, 2007, and "IT Managers Find Novel Ways to Cool Powerful Servers," *The Wall Street Journal*, April 10, 2007; and Marianne Kolbasuk McGee, "Data Center Electricity Bills Double," *Information Week*, February 17, 2007, and "What Every Tech Pro Should Know About 'Green Computing,'" *Information Week*, March 10, 2007.

CASE STUDY QUESTIONS

1. What business and social problems does data center power consumption cause?
2. What solutions are available for these problems? Which are the most environment-friendly?
3. What are the business benefits and costs of these solutions?
4. Should all firms move toward green computing? Why or why not?

MIS IN ACTION

Perform an Internet search on the phrase "green computing" and then answer the following questions:

1. How would you define green computing?
2. Who are some of the leaders of the green computing movement? Which corporations are leading the way? Which environmental organizations are playing an important role?
3. What are the latest trends in green computing? What kind of impact are they having?
4. What can individuals do to contribute to the green computing movement? Is the movement worthwhile?

Multicore Processors Another way to reduce power requirements and hardware sprawl is to use multicore processors. A **multicore processor** is an integrated circuit to which two or more processors have been attached for enhanced performance, reduced power consumption and more efficient simultaneous processing of multiple tasks. This technology enables two processing engines with reduced power requirements and heat dissipation to perform tasks faster than a resource-hungry chip with a single processing core. Today you will find dual-core processors in PCs and quad-core processors in servers. Sun Microsystems's UltraSparc TI chip for managing Web applications has 8 processors, and Intel is working on an 80-processor chip.

4.2 IT Infrastructure: Computer Software

In order to use computer hardware, you will need software, which provides the detailed instructions that direct the computer's work. System software and application software are interrelated and can be thought of as a set of nested boxes, each of which must interact closely with the other boxes surrounding it. Figure 4-7 illustrates this relationship. The system software surrounds and controls access to the hardware. Application software must work through the system software in order to operate. End users work primarily with application software. Each type of software must be specially designed for a specific machine to ensure its compatibility.

OPERATING SYSTEM SOFTWARE

The system software that manages and controls the computer's activities is called the **operating system**. Other system software consists of computer language translation

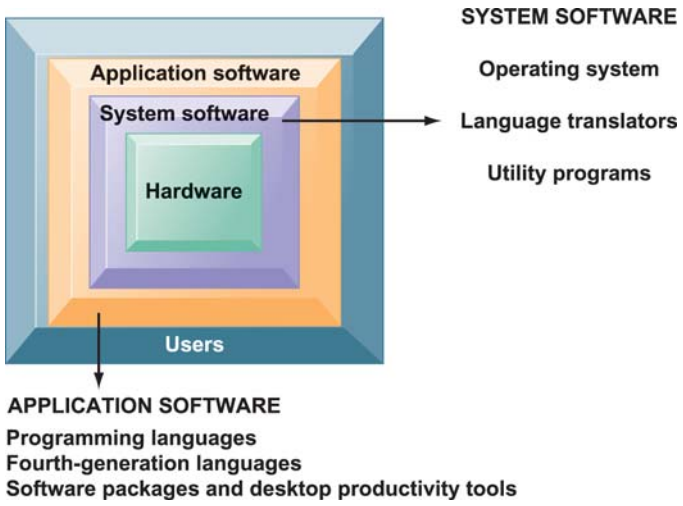


Figure 4-7
The Major Types of Software
The relationship between the system software, application software, and users can be illustrated by a series of nested boxes. System software—consisting of operating systems, language translators, and utility programs—controls access to the hardware. Application software, including programming languages and "fourth-generation" languages, must work through the system software to operate. The user interacts primarily with the application software.

programs that convert programming languages into machine language that can be understood by the computer and utility programs that perform common processing tasks, such as copying, sorting, or computing a square root.

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

PC and Server Operating Systems

Like any other software, the software you use on your PC or corporate server is based on specific operating systems and computer hardware. Software written for one operating system generally cannot run on another. Table 4.3 compares leading PC and server operating systems. These include the Windows family of operating systems (Windows Vista, Windows XP, Windows Server 2003), UNIX, Linux, and the Macintosh operating system.

The operating system controls the way users interact with the computer. Contemporary PC operating systems and many types of contemporary application software use a **graphical user interface**, often called a **GUI**, which makes extensive use of icons, buttons, bars, and boxes to perform tasks.

Microsoft's Windows family of operating systems has both client and server versions and a streamlined GUI. Windows systems can perform multiple programming tasks simultaneously and have powerful networking capabilities, including the ability to access information from the Internet. **Windows Vista** features improved security, diagnostics, and networking; desktop searching; and support for multimedia. It has versions for home, small business, and enterprise users.

Windows operating systems for network servers provide network management functions, including tools for creating and operating Web sites and other Internet services. They include Windows Server 2003, which has multiple versions for small, medium, and large businesses, and businesses that have massive computer centers and processing requirements.

UNIX is an interactive, multiuser, multitasking operating system developed by Bell Laboratories in 1969 to connect various machines together and is highly supportive of

TABLE 4.3

Leading PC and Server Operating Systems

Operating System	Features
Windows Vista	Most recent Windows operating system. Includes improved security; desktop searching; and synchronization with mobile devices, cameras, and Internet services, as well as better support for video and TV.
Windows XP	Reliable, robust operating system for powerful PCs with versions for both home and corporate users. Features support of Internet access; multimedia; and group collaboration; along with powerful networking, security, and corporate management capabilities.
Windows Server 2003	Most recent Windows operating system for servers.
UNIX	Used for powerful PCs, workstations, and network servers. Supports multitasking, multiuser processing, and networking. Is portable to different models of computer hardware.
Linux	Open source, reliable alternative to UNIX and Windows operating systems that runs on many different types of computer hardware and can be modified by software developers.
Mac OS X	Operating system for the Macintosh computer. Is stable and reliable, with powerful search capabilities, support for video and image processing, and an elegant user interface. Most recent version is Leopard.

communications and networking. UNIX is often used on workstations and servers, and provides the reliability and scalability for running large systems on high-end servers. UNIX can run on many different kinds of computers and can be easily customized. Application programs that run under UNIX can be ported from one computer to run on a different computer with little modification. Graphical user interfaces have been developed for UNIX. UNIX poses some security problems because multiple jobs and users can access the same files simultaneously. Vendors have developed different versions of UNIX that are incompatible, thereby limiting software portability.

Linux is a UNIX-like operating system that can be downloaded from the Internet free of charge or purchased for a small fee from companies that provide additional tools for the software. It is free, reliable, compactly designed, and capable of running on many different hardware platforms, including servers, handheld computers, and consumer electronics.

Linux has become popular as a robust low-cost alternative to UNIX and the Windows operating systems. For example, E-Trade Financial saves $13 million annually with improved computer performance by running Linux on a series of small inexpensive IBM servers instead of large expensive Sun Microsystems servers running Sun's proprietary version of UNIX.

Linux plays a major role in the back office, running Web servers and local area networks in about 25 percent of the U.S. server market. Its use in desktop computers is growing steadily. IBM, HP, Intel, Dell, and Sun have made Linux a central part of their offerings to corporations, and major software vendors are starting to provide versions of their products that can run on Linux. Both IBM and Sun offer Linux-based office tools for free or a minimal charge of $50.

Linux is an example of **open source software**, which provides all computer users with free access to its program code, so they can modify the code to fix errors or to make improvements. Open source software, such as Linux, is not owned by any company or individual. A global network of programmers and users manages and modifies the software, usually without being paid to do so. Open source software is by definition not restricted to any specific operating system or hardware technology, although most open source software is currently based on a Linux or UNIX.

APPLICATION SOFTWARE AND DESKTOP PRODUCTIVITY TOOLS

Today, businesses have access to an array of tools for developing their application software. These include traditional programming languages, fourth-generation languages, application software packages and desktop productivity tools, software for developing Internet applications, and software for enterprise integration. It is important to know which software tools and programming languages are appropriate for the work your business wants to accomplish.

Application Programming Languages for Business

For business applications, the most important programming languages have been COBOL, C, C++, and Visual Basic. **COBOL** (**Common Business Oriented Language**) was developed in the early 1960s for processing large data files with alphanumeric characters (mixed alphabetic and numeric data) and for business reporting. **C** is a powerful and efficient language developed in the early 1970s that combines machine portability with tight control and efficient use of computer resources. C is used primarily by professional programmers to create operating systems and application software, especially for PCs. C++ is a newer version of C that has all the capabilities of C plus additional features for working with software objects. Unlike traditional programs, which separate data from the actions to be taken on the data, a software **object** combines data and procedures. Chapter 11 describes object-oriented software development in detail. Visual Basic is a widely used visual programming tool and environment for creating applications that run on Microsoft Windows operating systems. A **visual programming language** allows users to manipulate graphic or iconic elements to create programs.

Fourth-Generation Languages

Fourth-generation languages consist of a variety of software tools that enable end users to develop software applications with minimal or no technical assistance or that enhance professional programmers' productivity. Fourth-generation languages tend to be nonprocedural, or less procedural, than conventional programming languages. Procedural languages require specification of the sequence of steps, or procedures, that tell the computer what to do and how to do it. Nonprocedural languages need only specify what has to be accomplished rather than provide details about how to carry out the task. Some of these nonprocedural languages are *natural languages* that enable users to communicate with the computer using conversational commands resembling human speech.

Table 4.4 shows that there are seven categories of fourth-generation languages: PC software tools, query languages, report generators, graphics languages, application generators, application software packages, and very high-level programming languages. The table lists the tools in order of ease of use by nonprogramming end users. End users are most likely to work with PC software tools and query languages. **Query languages** are software tools that provide immediate online answers to requests for information that are not predefined, such as "Who are the highest-performing sales representatives?" Query languages are often tied to data management software (described later in this section) and to database management systems (see Chapter 5).

Table 4.4

Categories of Fourth-Generation Languages

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

Software Packages and Desktop Productivity Tools

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

Software packages that run on mainframes and larger computers usually require professional programmers for their installation and support. Desktop productivity software packages for word processing, spreadsheets, data management, presentation graphics, and Web browsers are the most widely used software tools among business and consumer users.

Word Processing Software If you work in an office or attend school, you probably use word processing software every day. **Word processing software** stores text data electronically as a computer file rather than on paper. The word processing software allows the user to make changes in the document electronically, with formatting options to make changes in line spacing, margins, character size, and column width. Microsoft Word and WordPerfect are popular word processing packages.

Most word processing software has advanced features that automate other writing tasks: spelling checkers; style checkers (to analyze grammar and punctuation); thesaurus programs; mail merge programs, which link letters or other text documents with names and addresses in a mailing list; and capabilities for creating and accessing Web pages.

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

Spreadsheet Software Spreadsheets are valuable for applications in which numerous calculations with pieces of data must be related to each other. It organizes data into a grid of columns and rows. When you change a value or values, all other related values on the spreadsheet will be automatically recomputed.

You will often see spreadsheets in applications that require modeling and "what-if" analysis. After the user has constructed a set of mathematical relationships, the spreadsheet can be recalculated instantaneously using a different set of assumptions. Spreadsheet packages include graphics functions to present data in the form of line graphs, bar graphs, or pie charts, and the ability to read and create Web files. The most popular spreadsheet package is Microsoft Excel. Figure 4-8 illustrates the output from a spreadsheet for a break-even analysis and its accompanying graph.

Data Management Software Although spreadsheet programs are powerful tools for manipulating quantitative data, data management software, which we defined earlier in this chapter, is more suitable for creating and manipulating lists and for combining information from different files. PC database management packages have programming features and easy-to-learn menus that enable nonspecialists to build small information systems.

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

Custom Neckties Pro Forma Income Statement

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

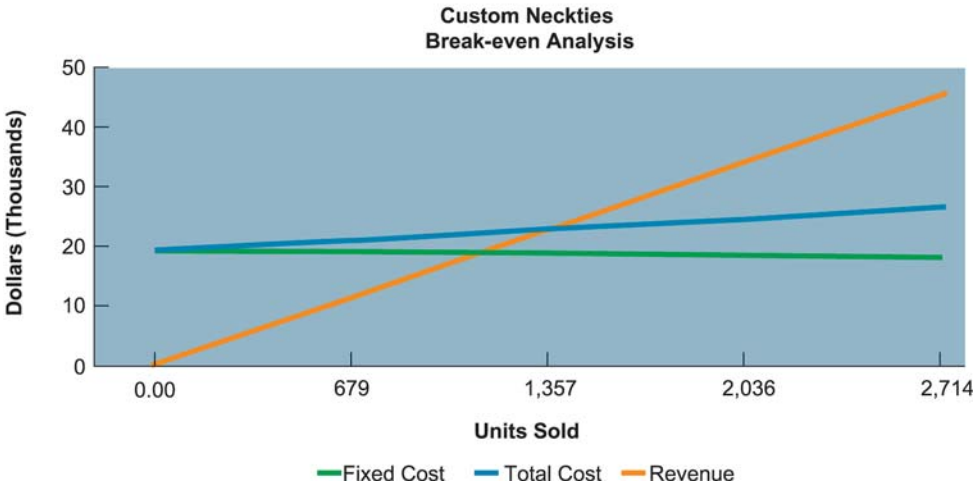


Figure 4-8 Spreadsheet Software
Spreadsheet software organizes data into columns and rows for analysis and manipulation. Contemporary spreadsheet software provides graphing abilities for a clear, visual representation of the data in the spreadsheets. This sample break-even analysis is represented as numbers in a spreadsheet as well as a line graph for easy interpretation.

Data management software typically has facilities for creating files and databases and for storing, modifying, and manipulating data for reports and queries. Popular database management software for the personal computer includes Microsoft Access, which has been enhanced to publish data on the Web. We discuss data management software in greater detail in Chapter 5.

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

Software Suites You will often see the major desktop productivity tools bundled together as a software suite. Microsoft Office is an example. There are a number of different versions of Office for home and business users, but the core desktop tools include Word word processing software; Excel spreadsheet software; Access database software; PowerPoint presentation graphics software; and Outlook, a set of tools for e-mail, scheduling, and contact management. Microsoft **Office 2007** features a new icon-driven Ribbon interface and enhanced capabilities to support collaborative work on the Web, publish Web documents, and update documents with information from the Web.

Low-cost alternatives to Microsoft Office are Sun Microsystems's *StarOffice* and *OpenOffice* (which can be downloaded over the Internet). Google recently launched a suite of Web-based desktop productivity tools that run over the Internet called Google Apps.The Interactive Session on Organizations discusses the capabilities of Google's tools in greater detail and whether they pose a challenge to Microsoft Office. As you read this case, try to determine what problems Google Apps are designed to solve and whether this online software suite is a viable alternative to productivity software on the desktop.

Web Browsers Web browsers are easy-to-use software tools for displaying Web pages and for accessing the Web and other Internet resources. Web browser software features a point-and-click GUI that can be employed throughout the Internet to access and display information stored on computers at other Internet sites. Browsers can display or present graphics, audio, and video information, as well as traditional text, and they allow you to click on-screen buttons or highlighted words to link to related Web sites. Web browsers have become the primary interface for accessing the Internet or for using networked systems based on Internet technology. The leading Web browsers today are Microsoft's Internet Explorer, Mozilla Firefox, and Netscape Navigator.

SOFTWARE FOR THE WEB: JAVA, AJAX, AND HTML

Special software tools help businesses build Web sites and applications that run on the Web. Java and Ajax are used for building applications that run on the Web and HTML is used for creating Web pages.

Java

Java is an operating system-independent, processor-independent, object-oriented programming language that has become a leading interactive programming environment for the Web. Java enables users to work with data on networked systems using Web browsers, reducing the need to write specialized software. At the enterprise level, Java is used for more complex e-commerce and e-business applications that require communication with an organization's back-end transaction processing systems.

Nearly all Web browser software has a Java platform built in. The Java platform has migrated into cell phones, automobiles, music players, game machines, and, finally, into set-top cable television systems serving interactive content.

INTERACTIVE SESSION: ORGANIZATIONS Will Google Take Over the Desktop?

The competition between Google and Microsoft is heating up another notch. Google has dominated Web search and ad placement technologies, while Microsoft has a near-monopoly on desktop office productivity and operating system software. Now Google is challenging Microsoft on the desktop as well.

In August 2006, Google launched Google Apps for Your Domain, a suite of Web-based applications targeted at small and midsize businesses. Google Apps bundled the company's e-mail, calendar, instant messaging, and Web site creation applications. The package was made available free of charge. Google designed the suite to be hosted in its own data center, but enabled customers to brand the components using their own domain names. The package also included management tools for those companies that had experienced IT professionals.

In February 2007, Google released Google Apps Premier Edition, which added its Docs word processing and Spreadsheets applications with the other tools in Google Apps for Your Domain. The Premier Edition also included APIs (application programming interfaces) to facilitate integration with a company's existing applications and the ability to build a customized home page with a single sign-on for all of a company's applications. An Apps user can save his or her files on Google's servers and access them anywhere that connects to the Internet using a standard Web browser. Multiple users are able to share files and work on them simultaneously online.

The charge for all of this: only $50 per year per employee—one-tenth the cost of Microsoft Office Professional Edition, which runs $499 for a single copy. The $50 license came with 10 gigabytes of storage for Gmail (e-mail) with no ads, a guaranteed performance level of 99.9-percent uptime, and tech support by phone 24 hours a day, seven days a week. Companies using the Web-based Google Apps save support costs because they do not have to hire their own IT workers to maintain the software.

Google Apps provides only basic functionality in its word processing and spreadsheet programs and lacks database and electronic presentation software to compete with Microsoft Access and PowerPoint. Microsoft's spreadsheet and word processing programs are far more powerful and rich in features than those offered by Google. However most Office users don't even use half of these features, so Google's value proposition is compelling.

Google positioned its productivity applications as "collaboration components" to Microsoft Office, especially in the context of larger businesses. Google did hope that its Gmail users who typically attached Office documents to their e-mail messages would instead move them to Google Apps for editing and sharing. Part of the company's overall business strategy was to encourage users to store both personal and business data on Google's servers where Google could appropriately match up documents with targeted ads.

Microsoft tried to counter Google by enhancing its Office 2007 suite with more capabilities for integrating with common business applications and additional collaboration tools. It introduced a new Office Live suite comprising Web design tools, a Web hosting service, and e-mail, calendar, contact manager, and online collaboration tools. At $39.95 per month, Office Live could not compete with Google Apps Premier Edition on price, and was not as integrated with the other productivity tools as Google Apps.

Google does, however, have major obstacles to overcome. Users must be connected to the Internet to use Google Apps. Microsoft Office users can work offline, which is a big advantage to mobile workers. Office, particularly Excel, is also entrenched in the business world. Although Google's document and spreadsheet files are interoperable with Microsoft's, companies may be hesitant to switch to Google's products, regardless of the savings.

Google must also face security issues. SF Bay Pediatrics, a medical clinic in San Francisco, implemented Google Apps in December 2006. The doctors at the clinic are enthusiastically collaborating on treatments and techniques using Google Docs. However, the clinic cannot use the services for sensitive information, such as patient records, because the hosted setup does not comply with HIPAA regulations for safeguarding privacy and security of medical records. According to Forrester Research, some large companies are wary of Google Apps because the data are not encrypted in Google's systems. Rajen Sheth, project manager for enterprise at Google, responds, "We put the security around [the data]. We provide a variety of security mechanisms to prevent penetration into the data center [with] strong perimeter security." Google practices what it preaches by storing its own data and intellectual property on the same system.

Google is probably more capable of backing up and protecting data than most small companies. However, Google's terms of service do contain language about the company not being responsible for lost data.

Small companies appear to be highly enthusiastic about the Google tools. According to Jason Winship, managing principal at Sea Change Management, "They are simple to use, they enable previously known levels of realtime collaboration." General Electric and Procter & Gamble are testing the tools, but only a few large organizations have been known to adopt Google Apps so far.

One of the largest Google Apps adopters to date is Arizona State University, where 40,000 students and faculty members are already using Google Gmail. ASU is using the free version of Apps, and will continue to reap the benefits of a no-cost solution as the university expands from 65,000 students to 90,000 over the next four years. ASU technology officer Adrian Sannier is also looking forward to the school's e-mail system and other applications being upgraded with the speed and innovation of Google's development team, rather than at the pace of a university IT department.

Sources: Paul McDougall, "Google Business Apps Shows the Changing Battle for Workers' Desktops," *InformationWeek*, February 24, 2007; Richard Martin, "Computer Science 101: A Case Study in Google Applications," *InformationWeek*, March 24, 2007; Harry McCracken, "PC World's Techlog: Google Apps vs. Microsoft Office," www.pcworld.com, February 22, 2007; and Chloe Albanesius, "Google Slyly Pushing Google Apps into Businesses," *PC Magazine*, accessed via Yahoo! News, April 26, 2007.

CASE STUDY QUESTIONS

1. What are the benefits of using Google Apps? What kinds of businesses are most likely to benefit? What kinds are least likely to benefit?
2. What reasons might a business have to continue using Microsoft Office for desktop productivity?
3. Search the Web for an article titled *Microsoft Office Live Vs. Google Apps For Your Domain* by Preston Gralla from September 2006. Do you agree with the author's conclusion?

MIS IN ACTION

Explore the Google Apps Web site. View the quick tour and comprehensive overview of the product, noting all the features and capabilities. Then answer the following question:

1. How could Google Apps be used by a small but growing events planning business to run the company? The business consists of an owner and three employees, who work with both individuals and companies to plan parties and large meetings. Two live in New York City, ones lives in Washington, D.C., and one lives in Boston. They all have laptops connected to the Internet. Their work involves soliciting clients; communicating with clients and vendors such as photographers, printers, musicians, caterers, and florists; and preparing budgets and bills for services.

Java software is designed to run on any computer or computing device, regardless of the specific microprocessor or operating system the device uses. Java achieves this neat trick by using a Java virtual machine built for each type of computer and operating system. The virtual machine enables it to run Java applications. A Macintosh PC, an IBM PC running Windows, a Sun server running UNIX, and even a smart cell phone or PDA can share the same Java application, reducing the costs of software development and creating the same user experience regardless of what kind of computer the user is working with.

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

TABLE 4.5
Examples of HTML

Plain English	HTML
Subcompact	<TITLE>Automobile</TITLE>
4 passenger	<LI>4 passenger
$16,800	<LI>$16,800

Ajax

Have you ever filled out a Web order form, made a mistake, and then had to start all over gain after a long wait for a new order form page to appear on your computer screen? Or visited a map site, clicked the North arrow once, and waited some time for an entire new page to load? **Ajax** (Asynchronous JavaScript and XML) is another Web development technique for creating interactive Web applications that prevents all of this inconvenience.

Ajax allows a client and server to exchange small pieces of data behind the scene so that an entire Web page does not have to be reloaded each time the user requests a change. So if you click North on a map site, such as Google Maps, the server downloads just that part of the application that changes with no wait for an entirely new map. You can also grab maps in map applications and move the map in any direction without forcing a reload of the entire page. Ajax uses JavaScript programs downloaded to your client to maintain a near-continuous conversation with the server you are using, making the user experience more seamless.

Hypertext Markup Language (HTML)

Hypertext markup language (HTML) is a page description language for specifying how text, graphics, video, and sound are placed on a Web page and for creating dynamic links to other Web pages and objects. Using these links, a user need only point at a highlighted keyword or graphic, click on it, and immediately be transported to another document. Table 4.5 illustrates some sample HTML statements.

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

WEB SERVICES

Web services refer to a set of loosely coupled software components that exchange information with each other using universal Web communication standards and languages. They can exchange information between two different systems regardless of the operating systems or programming languages on which the systems are based. They can be used to build open-standard, Web-based applications linking systems of two different organizations, and they can also be used to create applications that link disparate systems within a single company. Web services are not tied to any one operating system or programming language, and different applications can use them to communicate with each other in a standard way without time-consuming custom coding.

The foundation technology for Web services is **XML**, which stands for **extensible markup language**. This language was developed in 1996 by the World Wide Web Consortium (W3C, the international body that oversees the development of the Web) as a more powerful and flexible markup language than HTML for Web pages. Whereas HTML is limited to describing how data should be presented in the form of Web pages, XML can perform presentation, communication, and storage of data. In XML, a number is not simply a number; the XML tag specifies whether the number represents a price, a date, or a ZIP code. Table 4.6 illustrates some sample XML statements.

TABLE 4.6
Examples of XML

Plain English	XML
Subcompact	<AUTOMOBILETYPE="Subcompact">
4 passenger	<PASSENGERUNIT="PASS">4</PASSENGER>
$16,800	<PRICE CURRENCY="USD">$16,800</PRICE>

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

Web services communicate through XML messages over standard Web protocols. *SOAP*, which stands for *Simple Object Access Protocol*, is a set of rules for structuring messages that enables applications to pass data and instructions to one another. *WSDL* stands for *Web services description language*; it is a common framework for describing the tasks performed by a Web service and the commands and data it will accept so that it can be used by other applications. *UDDI* , which stands for *Universal Description, Discovery, and Integration*, enables a Web service to be listed in a directory of Web services so that it can be easily located. Companies discover and locate Web services through this directory much as they would locate services in the Yellow Pages of a telephone book. Using these protocols, a software application can connect freely to other applications without custom programming for each different application with which it wants to communicate. Everyone shares the same standards.

The collection of Web services that are used to build a firm's software systems constitutes what is known as a service-oriented architecture. A **service-oriented architecture (SOA)** is set of self-contained services that communicate with each other to create a working software application. Business tasks are accomplished by executing a series of these services. Software developers reuse these services in other combinations to assemble other applications as needed.

Virtually all major software vendors, such as IBM, Microsoft, Sun, and HP, provide tools and entire platforms for building and integrating software applications using Web services. IBM includes Web service tools in its WebSphere e-business software platform, and Microsoft has incorporated Web services tools in its Microsoft .NET platform.

Dollar Rent-A-Car's systems use Web services to link its online booking system with Southwest Airlines's Web site. Although both companies' systems are based on different technology platforms, a person booking a flight on Southwest.com can reserve a car from Dollar without leaving the airline's Web site. Instead of struggling to get Dollar's reservation system to share data with Southwest's information systems, Dollar used Microsoft .NET Web services technology as an intermediary. Reservations from Southwest are translated into Web services protocols, which are then translated into formats that can be understood by Dollar's computers.

Other car rental companies have linked their information systems to airline companies' Web sites before. But without Web services, these connections had to be built one at a time. Web services provide a standard way for Dollar's computers to "talk" to other companies' information systems without having to build special links to each one. Dollar is now expanding its use of Web services to link directly to the systems of a small tour operator and a large travel reservation system as well as a wireless Web site for mobile phones and PDAs. It does not have to write new software code for each new partner's information systems or each new wireless device (see Figure 4-9).

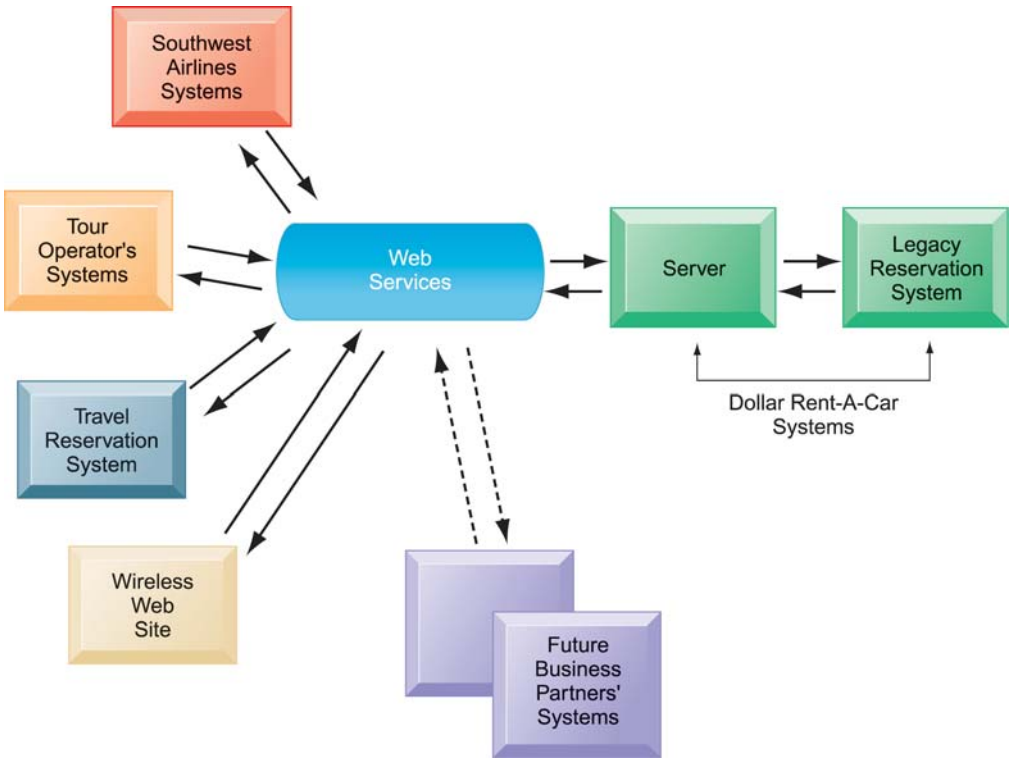


Figure 4-9
How Dollar Rent-A-Car Uses Web Services
Dollar Rent-A-Car uses Web services to provide a standard intermediate layer of software to "talk" to other companies' information systems. Dollar Rent-A-Car can use this set of Web services to link to other companies' information systems without having to build a separate link to each firm's systems.

SOFTWARE TRENDS

Today there are many more sources for obtaining software and many more capabilities for users to create their own customized software applications. Expanding use of open source software, cloud computing, mashups, and widgets exemplify this trend.

Open Source Software

Arguably the most influential software trend is the movement towards open source software. As noted earlier, open source software is developed by a community of programmers around the world, who make their programs available to users under one of several different licensing schemes. Essentially, users of the software can use the software as is, modify it at will, and even include it in for-profit software applications.

The open source movement started out small in 1983 (when it was called "hippie software"), but it has since grown to be a major part of corporate computing infrastructure, as the foundation for programs such as Linux, and Apache, the most widely used Web server software. Today you can find thousands of open source computer programs to accomplish everything from e-commerce shopping carts and funds clearance to salesforce management.

Ubuntu is becoming increasingly popular as a low-cost open source alternative to Microsoft desktop products. It features a Linux-based operating system that is community-developed, updated regularly for free, and designed to be user-friendly. The software comes bundled with open source tools for desktop productivity (OpenOffice), Web browsing (Firefox), instant messaging, and graphics editing.

Cloud Computing, Mashups, and Widgets

In the past, software such as Microsoft Word or Adobe Illustrator came in a box and was designed to operate on a single machine. Today, you are more likely to download the software from the vendor's Web site to your machine or, increasingly, to use the software as a service delivered over the Internet. The term **cloud computing** is becoming popular for describing Web-based applications that are stored and accessed via the "cloud" of the

Internet. The software and the data they use are hosted on powerful servers in massive data centers, and can be accessed by anyone with an Internet connection and standard Web browser.

Google has teamed up with IBM to promote cloud computing, and it offers numerous Web-based applications, including the Google Apps desktop productivity tools described in this chapter's Interactive Session on Organizations. Microsoft is also starting to offer more software as services delivered on the Internet, including its Windows Live and Office Live suites. Windows Live includes updated e-mail and messaging programs, a photo-sharing application, and a writing tool for blogs. Office Live includes tools for building and hosting a Web site, e-mail support, and sharing projects, all of which are stored on Microsoft servers and accessed over the Internet.

The software you use for both personal and business tasks may consist of large, self-contained programs, or it may be composed of interchangeable components that integrate freely with other applications on the Internet. Individual users and entire companies mix and match these software components to create their own customized applications and to share information with others and the resulting software applications are called **mashups**.

The idea is to take different sources and produce a new work that is "greater than" the sum of its parts. Part of the movement called Web 2.0, and in the spirit of musical mashups, Web mashups combine the capabilities of two or more online applications to create a kind of hybrid that provides more customer value than the original sources alone. One area of great innovation is the mashup of mapping and satellite image software with local content. For instance, ChicagoCrime.org combines Google Maps with crime data for the city of Chicago. Users can search by location, police beat, or type of crime, and the results are displayed as color-coded map points on a Google Maps map. Google, Yahoo!, and Microsoft now offer tools to allow other applications to pull in information from their map and satellite images with relatively little programming.

You have performed a mashup if you have ever personalized your Facebook profile or your blog with a capability to display videos or slide shows. The small pieces of software code which enable users to embed content from one site into a Web page or another Web site are called widgets. **Widgets** are small software programs that can be added to Web pages or placed on the desktop to provide additional functionality. For example, the Flixter widget on Facebook profiles transports users to a place where they can list the films they have seen along with their ratings and reviews, view their friends' ratings and reviews, and find out what's playing in theaters.

Web widgets run inside a Web page or blog. Desktop widgets integrate content from an external source into the user's desktop to provide services such as a calculator, dictionary, or display of current weather conditions. The Apple Dashboard, Microsoft Windows Sidebar (in Vista), and Google Desktop Gadgets provide desktop widgets.

Widgets can also provide storefront windows for advertising and selling products and services. Random House Inc. has a widget that enables visitors to its Web site to click through to purchase new book releases from its online store. Amazon.com and Wal-Mart have toolbar widgets that enable surfers to search their Web stores while staying on their social network or another personal page. Widgets have become so powerful and useful that Facebook and Google launched programs to attract developers of widgets for their Web sites.

4.3 Managing Hardware and Software Technology

Selection and use of computer hardware and software technology has a profound impact on business performance. We now describe the most important issues you will face when managing hardware and software technology: capacity planning and scalability; determining the total cost of technology assets; determining whether to own and maintain your own hardware, software and other infrastructure components or lease them from an external technology service provider; and managing software localization.

CAPACITY PLANNING AND SCALABILITY

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

Managers and information systems specialists now need to pay more attention to hardware capacity planning and scalability than before. **Capacity planning** is the process of predicting when a computer hardware system becomes saturated. It considers factors such as the maximum number of users that the system can accommodate at one time; the impact of existing and future software applications; and performance measures, such as minimum response time for processing business transactions. Capacity planning ensures that the firm has enough computing power for its current and future needs. For example, the Nasdaq Stock Market performs ongoing capacity planning to identify peaks in the volume of stock trading transactions and to ensure it has enough computing capacity to handle large surges in volume when trading is very heavy.

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

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

TOTAL COST OF OWNERSHIP (TCO) OF TECHNOLOGY ASSETS

When you calculate how much your hardware and software cost, their purchase price is only the beginning. You must also consider ongoing administration costs for hardware and software upgrades, maintenance, technical support, training, and even utility and real estate costs for running and housing the technology. The **total cost of ownership (TCO)** model can be used to analyze these direct and indirect costs to help determine the actual cost of owning a specific technology. Table 4.7 describes the most important TCO components to consider in a TCO analysis.

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

Many large firms are saddled with redundant, incompatible hardware and software because their departments and divisions have been allowed to make their own technology purchases. These firms could reduce their TCO through greater centralization and standardization of their hardware and software resources. Companies could reduce the size of the information systems staff required to support their infrastructure if the firm minimized the number of different computer models and pieces of software that employees are allowed to use.

USING TECHNOLOGY SERVICE PROVIDERS

Some of the most important questions facing managers are "How should we acquire and maintain our technology assets? Should we build software applications ourselves or

TABLE 4.7

Total Cost of Ownership (TCO) Cost Components

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

outsource them to an external contractor? Should we purchase and run them ourselves or rent them from external service providers?" In the past, most companies ran their own computer facilities and developed their own software. Today, more and more companies are obtaining their hardware and software technology from external service vendors.

Outsourcing

A number of firms are **outsourcing** the maintenance of their IT infrastructures and the development of new systems to external vendors. They may contract with an external service provider to run their computer center and networks, to develop new software, or to manage all of the components of their IT infrastructures, as did Procter & Gamble (P&G). P&G agreed to pay HP $3 billion to manage its IT infrastructure, computer center operations, desktop and end-user support, network management, and applications development and maintenance for global operations in 160 countries.

Specialized Web hosting services are available for companies that lack the financial or technical resources to operate their own Web sites. A **Web hosting service** maintains a large Web server, or a series of servers, and provides fee-paying subscribers with space to maintain their Web sites. The subscribing companies may create their own Web pages or have the hosting service, or a Web design firm, create them. Some services offer *co-location*, in which the firm actually purchases and owns the server computer housing its Web site but locates the server in the physical facility of the hosting service.

Firms often retain control over their hardware resources but outsource custom software development or maintenance to outside firms, frequently firms that operate offshore in low-wage areas of the world. When firms outsource software work outside their national borders, the practice is called **offshore software outsourcing**. Offshore firms provided about $10 billion in software services to the United States in 2006, which is about 2 percent of the combined U.S. software plus software services budget (about $500 billion). Until recently, this type of software development involved lower-level maintenance, data entry, and call center operations, but with the growing sophistication and experience of offshore firms, particularly in India, more and more new program development is taking place offshore. Chapter 11 discusses offshore software outsourcing in greater detail.

In order to manage their relationship with an outsourcer or technology service provider, firms will need a contract that includes a **service level agreement (SLA)**. The SLA is a formal contract between customers and their service providers that defines the specific responsibilities of the service provider and the level of service expected by the customer.

SLAs typically specify the nature and level of services provided, criteria for performance measurement, support options, provisions for security and disaster recovery, hardware and software ownership and upgrades, customer support, billing, and conditions for terminating the agreement.

On-Demand Computing

Even if firms continue to run their own IT infrastructures, they now have the option to rent additional infrastructure capacity on an as-needed basis.**On-demand computing** refers to firms off-loading peak demand for computing power to remote, large-scale data processing centers. In this manner, firms can reduce their technology expenditures by investing just enough to handle average processing loads and paying for only as much additional computing power as the market demands. Another term for on-demand computing is *utility computing*, which suggests that firms purchase computing power from central computing utilities and pay only for the amount of computing power they use, much as they would pay for electricity. Amazon.com, described in the chapter-ending case study, is expanding its business to offer on-demand computing services. IBM, HP, and Sun Microsystems also offer on-demand services.

In addition to lowering the cost of owning hardware resources, on-demand computing gives firms greater agility to use technology. On-demand computing shifts firms from having a fixed infrastructure capacity toward a highly flexible infrastructure, some of it owned by the firm, and some of it rented from giant computer centers run by technology specialists. This arrangement frees firms to launch entirely new business processes that they would never attempt with a fixed infrastructure.

Software as a Service (SaaS)

It is clear that software will be increasingly be delivered and used over networks as a service. Earlier in this chapter, we described cloud computing, in which software is delivered as a service over the Internet. In addition to free or low-cost tools for individuals and small businesses provided by Google or Yahoo!, enterprise software and other complex business functions are available as services from the major commercial software vendors. Instead of buying and installing software programs, subscribing companies rent the same functions from these services, with users paying either on a subscription or per-transaction basis. Services for delivering and providing access to software remotely as a Web-based service are now referred to as **Software as a Service (SaaS)**.

A leading example is Salesforce.com, which provides on-demand software services for customer relationship management, including salesforce automation, partner relationship management, marketing, and customer service. It includes tools for customization, integrating its software with other corporate applications, and creating new applications.

If you are running a business, especially a small business, you might find it much easier to "rent" software from another firm and avoid the expense and difficulty of installing, operating, and maintaining the hardware and software on your own. Such reasons convinced the Patriots Trail Girl Scouts, described in Chapter 11, to use a service providing QuickBase software to run their order management system.

Companies considering the SaaS model need to carefully assess the costs and benefits of the service, weighing all people, organizational, and technology issues, including the ability to integrate with existing systems and deliver a level of service and performance that is acceptable for the business. In some cases, the cost of renting software can add up to more than purchasing and maintaining the application in-house. Yet there may be benefits to paying more for software as a service if this decision allows the company to focus on core business issues instead of technology challenges.

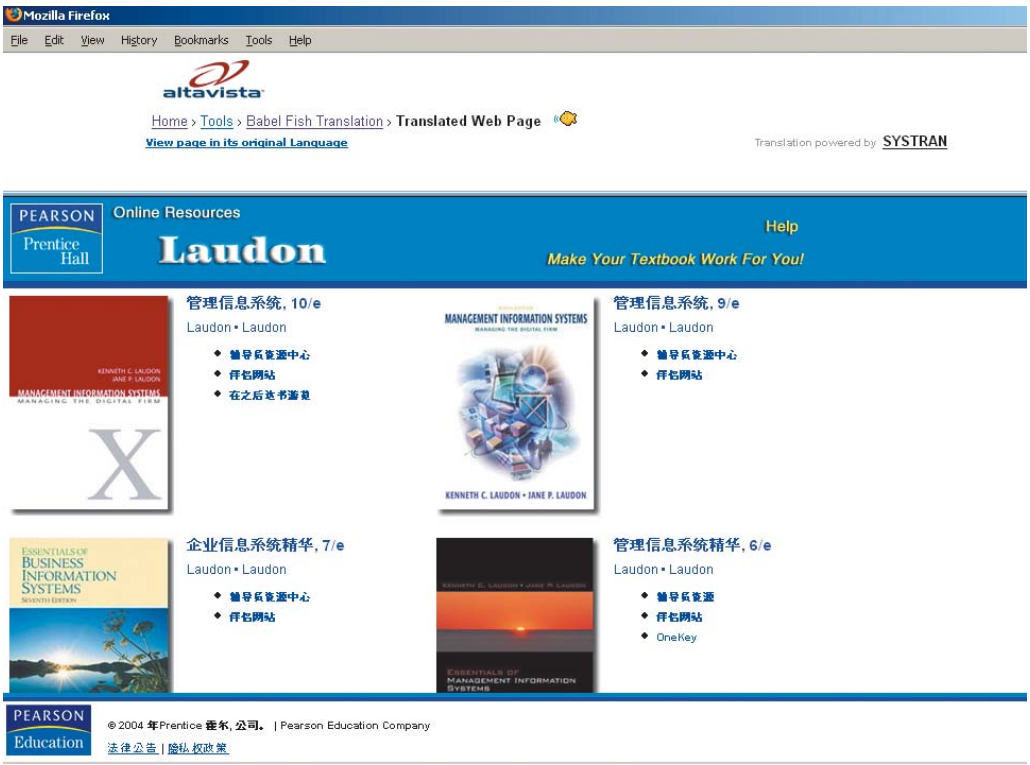
MANAGING SOFTWARE LOCALIZATION FOR GLOBAL BUSINESS

If you are operating a global company, all of the management issues we have just described will be affected by the need to create systems that can be realistically used by multiple business units in different countries. Although English has become a kind of standard business language, this is truer at higher levels of companies and not throughout the middle and lower ranks. Software may have to be built with local language interfaces before a new information system can be successfully implemented worldwide.

These interfaces can be costly and messy to build. Menu bars, commands, error messages, reports, queries, online data entry forms, and system documentation may need to be translated into all the languages of the countries where the system will be used. To be truly useful for enhancing productivity of a global workforce, the software interfaces must be easily understood and mastered quickly. The entire process of converting software to operate in a second language is called *software localization.*

Global systems must also consider differences in local cultures and business processes. Cross-functional systems such as enterprise and supply chain management systems are not always compatible with differences in languages, cultural heritages, and business processes in other countries.

In a global systems environment, all of these factors add to the TCO and will influence decisions about whether to outsource or use technology service providers.



This page from the Pearson Prentice Hall Web site for Laudon text books was translated into Chinese using AltaVista Babel Fish translation tools. Web sites and software interfaces for global systems may have to be translated into multiple languages to accomodate users in other parts of the world.

4.4 Hands-On MIS

The projects in this section give you hands-on experience in using spreadsheet software to help a real-world company make a rent versus buy decision about new manufacturing software, using spreadsheet software to evaluate alternative desktop systems, and using Web research to budget for a sales conference.

IMPROVING DECISION MAKING: MAKING THE RENT VERSUS BUY DECISION FOR HARDWARE AND SOFTWARE

Software skills: Spreadsheet formulas, electronic presentation software (optional)
Business skills: Technology rent vs. buy decision, TCO analysis

This project provides an opportunity for you help a real-world company make a decision about whether to rent or buy new technology. You will use spreadsheet software to compare the total three-year cost of licensing and maintaining new manufacturing software or renting the software from a SaaS provider.

Dirt Bikes would like to implement new production planning, quality control, and scheduling software for use by 25 members of its manufacturing staff. Management is trying to determine whether to purchase the software from a commercial vendor along with any hardware required to run the software or to use a hosted software solution from a SaaS provider. (The hosted software runs on the service provider's computer.) You have been asked to help management with this rent versus buy decision by calculating the total cost of each option over a three-year period.

The costs of purchasing the software (actually for purchasing a license from the vendor to use its software package) include the initial purchase price of the software (licensing fee of $100,000 paid in the first year), the cost of implementing and customizing the software in the first year ($20,000), one new server to run the software (a first-year purchase of $4,000), one information systems specialist devoting half of his or her time to supporting the software ($55,000 in full-time annual salary and benefits with a 3-percent annual salary increase each year after the first year), user training in the first year ($10,000), and the cost of annual software upgrades ($5,000).

The costs of renting hosted software are the rental fees ($2,500 annually per user), implementation and customization costs ($12,000 in the first year), and training ($10,000 in the first year).

- Use your spreadsheet software to calculate the total cost of renting or purchasing this software over a three-year period. Identify the lowest-price alternative that meets Dirt Bikes's requirements.
- What other factors should Dirt Bikes consider besides cost in determining whether to rent or buy the hardware and software?
- (Optional) If possible, use electronic presentation software to summarize your findings for management.

IMPROVING DECISION MAKING: USING A SPREADSHEET TO EVALUATE HARDWARE AND SOFTWARE OPTIONS

Software skills: Spreadsheet formulas
Business skills: Technology pricing

In this exercise, you will use spreadsheet software to calculate the cost of alternative desktop systems.

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

Minimum Desktop Specifications	
Processor speed	3 GHz
Hard drive	250 GB
RAM	1 GB
CD-RW/DVD-ROM speed	48 speed
Monitor (diagonal measurement)	17 inches

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

Minimum Monochrome Printer Specifications	
Print speed	12 pages per minute
Print resolution	600 × 600
Network ready?	Yes
Maximum price/unit	$1,000

After pricing the desktop systems and printers, obtain pricing on 30 copies of the most recent versions of Microsoft Office and Sun StarOffice desktop productivity packages, and on 30 copies of Microsoft Windows Vista Business. The application software suite packages come in various versions, so be sure that each package contains programs for word processing, spreadsheet analysis, database analysis, graphics preparation, and e-mail.

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

IMPROVING DECISION MAKING: USING WEB RESEARCH TO BUDGET FOR A SALES CONFERENCE

In this exercise, you will use software at various online travel sites to arrange transportation and lodging for a large sales force to attend a sales conference at two alternative locations. You will use that information to calculate total travel and lodging costs and decide where to hold the conference.

Software skills: Internet-based software
Business skills: Researching transportation and lodging costs

The Foremost Composite Materials Company is planning a two-day sales conference for October 19–20, starting with a reception on the evening of October 18. The conference

consists of all-day meetings that the entire sales force, numbering 125 sales representatives and their 16 managers, must attend. Each sales representative requires his or her own room, and the company needs two common meeting rooms, one large enough to hold the entire sales force plus a few visitors (200) and the other able to hold half the force. Management has set a budget of $95,000 for the representatives' room rentals. The hotel must also have such services as overhead and computer projectors, as well as a business center and banquet facilities. It also should have facilities for the company reps to be able to work in their rooms and to enjoy themselves in a swimming pool or gym facility. The company would like to hold the conference in either Miami or Marco Island, Florida.

Foremost usually likes to hold such meetings in Hilton- or Marriott-owned hotels. Use the Hilton and Marriott Web sites to select a hotel in whichever of these cities that would enable the company to hold its sales conference within its budget.

Link to the two sites' home pages, and search them to find a hotel that meets Foremost's sales conference requirements. Once you have selected the hotel, locate flights arriving the afternoon prior to the conference because the attendees will need to check in the day before and attend your reception the evening prior to the conference. Your attendees will be coming from Los Angeles (54), San Francisco (32), Seattle (22), Chicago (19), and Pittsburgh (14). Determine costs of each airline ticket from these cities. When you are finished, create a budget for the conference. The budget will include the cost of each airline ticket, the room cost, and $60 per attendee per day for food.

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

LEARNING TRACKS

The following Learning Tracks provide content relevant to topics covered in this chapter:

1. How Computer Hardware and Software Work
2. Evolution of IT Infrastructure
3. Technology Drivers of IT Infrastructure Evolution
4. IT Infrastructure: Management Opportunities, Challenges, and Solutions
5. Service Level Agreements

Review Summary

1 **What are the components of IT infrastructure?** IT infrastructure consists of the shared technology resources that provide the platform for the firm's specific information system applications. Major IT infrastructure components include computer hardware, software, data management technology, networking and telecommunications technology, and technology services.

2 **What are the major computer hardware, data storage, input, and output technologies used in business?** Computers are categorized as mainframes, midrange computers, PCs, workstations, or supercomputers. Mainframes are the largest computers; midrange computers can be servers; PCs are desktop or laptop machines; workstations are desktop machines with powerful mathematical and graphic capabilities; and supercomputers are sophisticated, powerful computers that can perform massive and complex computations

rapidly. Computing power can be further increased by creating a computational grid that combines the computing power of all the computers on a network. In the client/server model of computing, computer processing is split between "clients" and "servers" connected via a network. The exact division of tasks between client and server depends on the application.

The principal secondary storage technologies are magnetic disk, optical disc, and magnetic tape. Optical CD-ROM and DVD discs can store vast amounts of data compactly and some types are rewritable. Storage area networks (SANs) connect multiple storage devices on a separate high-speed network dedicated to storage. The principal input devices are keyboards, computer mice, touch screens, magnetic ink and optical character recognition devices, pen-based instruments, digital scanners, sensors, audio input devices, and radio-frequency identification devices. The principal output devices are cathode ray tube terminals, printers, and audio output devices.

3 **What are the major types of computer software used in business?** The two major types of software are system software and application software. System software coordinates the various parts of the computer system and mediates between application software and computer hardware. Application software is used to develop specific business applications.

The system software that manages and controls the activities of the computer is called the operating system. Leading PC and server operating systems include Windows Vista, Windows XP, Windows Server 2003, UNIX, Linux, and the Macintosh operating system. Linux is a powerful, resilient open source operating system that can run on multiple hardware platforms and is used widely to run Web servers.

The principal programming languages used in business application software include COBOL, C, C++, and Visual Basic. Fourth-generation languages are less procedural than conventional programming languages and enable end users to perform many software tasks that previously required technical specialists. They include popular PC desktop productivity tools, such as word processing, spreadsheet, data management, presentation graphics, and Web browser software. Java is an operating-system- and hardware-independent programming language that is the leading interactive programming environment for the Web. HTML is a page description language for creating Web pages.

Web services are loosely coupled software components based on XML and open Web standards that can work with any application software and operating system. They can be used as components of Web-based applications linking the systems of two different organizations or to link disparate systems of a single company.

4 **What are the most important contemporary hardware and software trends?** Increasingly, computing is taking place over a network with computing and telecommunications platforms increasingly integrated. Edge computing balances the processing load for Web-based applications by distributing parts of the Web content, logic, and processing among multiple servers. In autonomic computing, computer systems have capabilities for automatically configuring and repairing themselves. Open source software is proliferating because it allows users to modify the software at will and use it as a platform for new derivative applications. Mashups and widgets are the building blocks of new software applications and services using the cloud computing model.

5 **What are the principal issues in managing hardware and software technology?** Managers and information systems specialists need to pay special attention to hardware capacity planning and scalability to ensure that the firm has enough computing power for its current and future needs. Businesses also need to balance the costs and benefits of building and maintaining their own hardware and software versus outsourcing or using an on-demand computing model. The total cost of ownership (TCO) of the organization's tech-

nology assets includes not only the original cost of computer hardware and software but also costs for hardware and software upgrades, maintenance, technical support, and training. Companies with global operations need to manage software localization.

Key Terms

Ajax, 138
Application server, 122
Application software, 118
Autonomic computing, 127
Batch processing, 125
C, 132
Capacity planning, 142
CD-ROM (compact disc read-only memory), 123
Centralized processing, 121
Client, 121
Client/server computing, 121
Cloud computing, 140
COBOL (COmmon Business Oriented Language), 132
Data management software, 118
Digital video disc (DVD), 123
Distributed processing, 121
Edge computing, 125
Extensible markup language (XML), 138
Fourth-generation languages, 132
Graphical user interface (GUI), 130
Grid computing, 121
Hypertext markup language (HTML), 138
Input devices, 124
Java, 135
Legacy systems, 119
Linux, 00
Magnetic disk, 122
Magnetic tape, 123
Mainframe, 120
Mashups, 141
Midrange computers, 120
Multicore processor, 129
Nanotechnology, 125
N-tier client/server architectures, 122
Object, 132
Office 2007, 135
Offshore software outsourcing, 143
On-demand computing, 144
Online processing, 125
Open-source software, 132
Operating system, 129
Output devices, 124
Outsourcing, 143
Personal computer (PC), 119
Presentation graphics, 135
Query languages, 132
SaaS (Software as a Service), 144
Scalability, 142
Server, 119
Service level agreement (SLA), 143
Service-oriented architecture (SOA), 139
Software package, 133
Spreadsheet, 134
Storage area networks (SANs), 123
Supercomputer, 121
System software, 118
Total cost of ownership (TCO), 142
UNIX, 130
Virtualization, 127
Visual programming language, 132
Web browsers, 135
Web hosting service, 143
Web server, 122
Web services, 138
Widget, 141
Windows Vista, 130
Word processing software, 133
Workstation, 119

Review Questions

1. What are the components of IT infrastructure?

- Define information technology (IT) infrastructure and describe each of its components.

2. What are the major computer hardware, data storage, input, and output technologies used in business?

- List and describes the various type of computers available to businesses today.
- Define the client/server model of computing and describe the difference between a two-tiered and n-tier client/server architecture.
- List the most important secondary storage media and the strengths and limitations of each.
- List and describe the major computer input and output devices.
- Distinguish between batch and online processing.

3. What are the major types of computer software used in business?

- Distinguish between application software and system software and explain the role played by the operating system of a computer.
- List and describe the major PC and server operating systems.

- Name and describe each category of fourth-generation software tool and explain how fourth-generation languages differ from conventional programming languages.
- Name and describe the major desktop productivity software tools.
- Explain how Java and HTML are used in building applications for the Web.
- Define Web services, describe the technologies they use, and explain how Web services benefit businesses.

4. What are the most important contemporary hardware and software trends?

- Define and describe grid computing, edge computing, autonomic computing, virtualization, and multicore processing.
- Explain why open source software is so important today and its benefits for business.
- Define cloud computing, mashups, and widgets and explain how they benefit individuals and businesses.

5. What are the principal issues in managing hardware and software technology?

- Explain why managers need to pay attention to capacity planning and scalability of technology resources.
- List and describe the cost components used to calculate the TCO of technology assets.
- Describe the benefits of outsourcing, on-demand computing, and SaaS for businesses.
- Explain why software localization has become an important management issue for global companies.

Discussion Questions

1. Why is selecting computer hardware and software for the organization an important business decision? What people, organization, and technology issues should be considered when selecting computer hardware and software?

2. Should organizations use software service providers for all their software needs? Why or why not? What people, organization, and technology factors should be considered when making this decision?

Video Case

You will find a video case illustrating some of the concepts in this chapter on the Laudon Web site along with questions to help you analyze the case.

Teamwork

Evaluating Server Operating Systems

Form a group with three or four of your classmates. One group should research and compare the capabilities and costs of Linux versus the most recent version of the Windows operating system for servers. Another group should research and compare the capabilities and costs of Linux versus UNIX. Each group should present its findings to the class, using electronic presentation software, if possible.

BUSINESS PROBLEM-SOLVING CASE

Amazon's New Store: Utility Computing

Looking for a good deal on that DVD box set of "The West Wing" or the last Harry Potter book? Since opening as an online bookstore in 1995, Amazon.com has morphed into a virtual superstore with product offerings to 36 categories, including furniture, jewelry, clothing, and groceries. But what if what you really need is a place to store several terabytes of data? Or the computing power of 100 Linux servers? Now you can get those from Amazon too.

Over its first 12 years, Amazon.com committed $2 billion to refine the information technology infrastructure that was largely responsible for making it the top online retailer in the world. Following the burst of the dot com bubble in 2001, Amazon focused heavily on modernizing its data centers and software so that it could add new features to its product pages such as discussion forums and software for audio and video.

In March 2006, Amazon introduced the first of several new services that founder Jeff Bezos hoped would transform its future business. With Simple Storage Service (S3) and, later, Elastic Compute Cloud (EC2), Amazon entered the utility computing market. The company had realized that the benefits of its $2 billion investment in technology could also be valuable to other companies.

Amazon had tremendous computing capacity, but like most companies, only used a small portion of it at any one time. Moreover, the Amazon infrastructure was considered by many to be among the most robust in the world. So, the one-time bookseller exposed the guts of its entire system over the Internet to any developer who could make use of them. Amazon began to sell its computing power on a per-usage basis, just like a power company sells electricity.

S3 is a data storage service that is designed to make Web-scale computing easier and more affordable for developers. Customers pay 15 cents per gigabyte of data stored per month on Amazon's network of disk drives. There is also a charge of 20 cents per gigabyte of data transferred. The service has neither a minimum fee nor a start-up charge. Customers pay for exactly what they use and no more. Data may be stored as objects ranging in size from 1 byte to 5 gigabytes, with an unlimited number of objects permitted. Using S3 does not require any client software, nor does it require the user to set up any hardware. Amazon designed S3 to provide a fast, simple, and inexpensive method for businesses to store data on a system that is scalable and reliable. S3 promises 99.99-percent availability through a mechanism of fault tolerance that fixes failures without any downtime.

Working in conjunction with S3, EC2 enables businesses to utilize Amazon's servers for computing tasks, such as testing software. Using EC2 incurs charges of 10 cents per instance-hour consumed. An instance supplies the user with the equivalent of a 1.7 GHz x86 processor with 1.75 GB of RAM, a 160 GB hard drive, and 250 Mbps of bandwidth on the network. The service also includes 20 cents per GB of data traffic inbound and outbound per month, as well as the standard S3 pricing for storing an Amazon Machine Image (AMI), which contains the applications, libraries, data, and configuration settings that a business uses to run its processes.

What does Amazon specifically bring to utility computing? Business writer Nicholas Carr states "Amazon is coming to it fresh, without any baggage. As a result, it's been able to target the current sweet spot for utility computing—startups and smaller companies that have Web-based businesses and need highly scalable systems." Amazon distinguishes itself from traditional utility computing vendors in that it views its Web services as a standalone business, as opposed to as an appendage to a large corporation.

According to Adam Selipsky, vice president of product management and developer relations for Amazon Web Services (AWS), Amazon is really a technology company that can bring a wealth of engineering prowess and experience to independent developers and corporations by allowing them to run their processes on Amazon's computer systems. Selipsky also emphasizes that AWS is not simply about providing great amounts of storage capacity and server time. AWS creates the opportunity for others to work at Web scale without making the mistakes that Amazon has already made and learned from. Simplicity and ease-of-use are not generally terms that go along with building a Web-scale application, but they are major selling points for AWS. Users build on the services through APIs made available by Amazon.

From the very beginning, customers have responded strongly to S3 and EC2. Competition to secure test slots for EC2 was intense, and the slots were all taken within five hours of the program's launch. Bezos targeted micro-sized businesses and Web startups as customers for AWS, but the services have also attracted some midsize businesses and potential big players in e-business.

Webmail.us provides e-mail management services for thousands of companies around the world from its Blacksburg, Virginia, headquarters. When the company

needed to increase its short-term storage capacity and the redundancy of its primary data backups, it selected S3 as its storage provider. Webmail.us sends more than a terabyte of data to Amazon to store with S3 every week. Bill Boebel, cofounder and chief technology officer of Webmail.us, was very pleased that his company was able to create a simple interface with which Amazon can accept the abundant small files that his company manages. Other backup systems have had difficulty handling the typical Webmail.us backup load, and most hosting companies would require a custom application to handle such data. Webmail.us even used EC2 to develop its storage interface. According to CEO Pat Matthews, Amazon immediately reduced his company's data backup costs by 75 percent.

Powerset is an up-and-coming search engine company based in San Francisco that wants to focus its time, and the $12.5 million it has raised, on its core business, natural language search technology. By using S3 and EC2, Powerset saves upfront cash expenditure, and eliminates the risk that building an infrastructure will take longer than expected. Many of the traditional utility computing suppliers charge around one dollar per CPU hour, or 10 times what Amazon charges.

Powerset's CEO Barney Pell says that the pay-as-you go model is very important because his company does not know how fast it will grow. What he does know is that the demand for Powerset's service will come in bursts, and trying to predict hardware needs is a dangerous game. If Powerset overestimates its peak usage capacity, the company will waste money on unnecessary hardware. If the company underestimates peak usage, it could fail to meet its users' expectations and damage its business. With AWS in place, Powerset never has to worry about being unable to add computing power when a spike in usage occurs.

As Powerset prepares to launch its search engine to the public in 2007, it is using EC2 for the rigorous and crucial background work of reading and indexing Web pages. The company is looking into whether EC2 will meet the needs of the run-time application that processes the search queries users will submit when the search engine goes live.

SmugMug Inc., an online photo-sharing startup, was immediately drawn to the ease with which it could back up photos on Amazon's S3. Storing its users' photos on Amazon's devices prevents SmugMug from having to purchase its own additional storage and saves the company $500,000 per year. CEO Don MacAskill anticipates that future annual savings could reach $1 million.

As with any large business initiative, there are issues for Amazon to confront before anyone can declare AWS to be a successful venture. Larger businesses may be more inclined to use a more established company, especially one with more experience hosting core applications and data. Currently, Amazon's flexible, pay-as-you-go model gives the company a competitive advantage over companies that require service contracts.

However, according to Daniel Golding, vice president of Tier 1 Research, the established companies, such as IBM, HP, and Sun Microsystems, may follow Amazon's lead and offer utility computing without service-level agreements (SLAs). Complicating the matter is that some companies are wary of using a supplier that does not offer SLAs, which guarantee the availability of services in terms of time. Golding suggests that Amazon may have launched a major shift in the industry, but others will reap the rewards while Amazon may suffer for it.

One more challenge for Amazon is the viability of AWS itself. Will the services actually function as planned? The company's track record with new technology projects is mixed. Amazon launched its A9.com search site with much fanfare, but the site never really caught on with users. Moreover, the growth of AWS could be harmful to Amazon's Web services line as well as to its retail line if Amazon does not position itself to handle a dramatic increase in demand on its infrastructure. AWS customers could drop the service, and Amazon.com could falter. January 2007 saw the first significant outage of S3 servers. Customers voiced their frustrations of receiving slow service and error messages. Faulty hardware installed during an upgrade caused the problem, which was resolved quickly. However, a quick explanation and resolution did not stop some users from questioning whether Amazon is capable of being their solution for hosted storage going forward.

AWS has charmed some high-profile clients. Microsoft uses S3 to increase software download speeds for its users. Linden Lab, creator of the online virtual world Second Life, uses the service to alleviate the pounding its servers take when the company releases its frequent software upgrades.

For now, the potential of AWS is being converted into performance mostly by tech savvy developers with financial backing. As more developers contribute and the services evolve, Amazon hopes one day to make it possible for anyone with an idea and an Internet connection to begin to put together the next Amazon.com.

Sources: Edward Cone, "Amazon at Your Service," *CIO Insight*, January 7, 2007; Robert D. Hof, "So You Wanna Be a Web Tycoon? Amazon Can Help," www.webworkerdaily.com, January 24, 2007; "Amazon's Hosted Storage Hits Bump," ZDNet.com, January 8, 2007; Thomas Claburn, "Open Source Developers Build on Amazon Web Services," TechWeb.com, January 12, 2007; "Useful Technology™ Leverages Amazon Web Services," Business Wire, accessed via Forbes.com, January 25, 2007; and Mamoon Yunus, Rizwan Mallal, and Dave Shaffer, "Amazon EC2 and Oracle SOA Suite a Strong Combo," *Dr. Dobb's Journal*, January 14, 2007.

Case Study Questions

1. What technology services does Amazon provide? What are the business advantages to Amazon and to subscribers of these services? What are the disadvantages to each? What kinds of businesses are likely to benefit from these services?
2. How do the concepts of capacity planning, scalability, and TCO apply to this case? Apply these concepts both to Amazon and to subscribers of its services.
3. Search the Internet for companies that supply utility computing. Select two or three such companies and compare them to Amazon. What services do these companies provide? What promises do they make about availability? What is their payment model? Who is their target client? If you were launching a Web startup business, would you choose one of these companies over Amazon for technology services? Why or why not? Would your answer change if you were working for a larger company and had to make a recommendation to the CIO?
4. Name three examples each of IT infrastructure hardware components and software components that are relevant to this case. Describe how these components fit into or are used by Amazon's Web services and/or the customers that subscribe to these services.
5. Think of an idea for a Web-based startup business. Explain how this business could utilize Amazon's S3 and EC2 services.