Chapter 5

IT Infrastructure and Emerging Technologies

LEARNING OBJECTIVES

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

1. What is IT infrastructure and what are its components?
2. What are the stages and technology drivers of IT infrastructure evolution?
3. What are the current trends in computer hardware platforms?
4. What are the current trends in software platforms?
5. What are the challenges of managing IT infrastructure and management solutions?

Interactive Sessions:

New to the Touch

Is Green Computing Good for Business?

CHAPTER OUTLINE

BART SPEEDS UP WITH A NEW IT INFRASTRUCTURE

The Bay Area Rapid Transit (BART) is a heavy-rail public transit system that connects San Francisco to Oakland, California, and other neighboring cities to the east and south. BART has provided fast, reliable transportation for more than 35 years and now carries more than 346,000 passengers each day over 104 miles of track and 43 stations. It provides an alternative to driving on bridges and highways, decreasing travel time and the number of cars on the Bay Area's congested roads. It is the fifth busiest rapid transit system in the United States.

BART recently embarked on an ambitious modernization effort to overhaul stations, deploy new rail cars, and extend routes. This modernization effort also encompassed BART's information technology infrastructure. BART's information systems were no longer state-of-the art, and they were starting to affect its ability to provide good service. Aging homegrown financial and human resources systems could no longer provide information rapidly enough for making timely decisions, and they were too unreliable to support its 24/7 operations.

BART upgraded both its hardware and software. It replaced old legacy mainframe applications with Oracle's PeopleSoft Enterprise applications running on HP Integrity blade servers and the Oracle Enterprise Linux operating system. This configuration provides more flexibility and room to grow because BART is able to run the PeopleSoft software in conjunction with new applications it could not previously run.

BART wanted to create a high-availability IT infrastructure using grid computing where it could match computing and storage capacity more closely to actual demand. BART chose to run its applications on a cluster of servers using a grid architecture. Multiple operating environments share capacity and computing resources that can be provisioned, distributed, and redistributed as needed over the grid.

In most data centers, a distinct server is deployed for each application, and each server typically uses only a fraction of its capacity. BART uses virtualization to run multiple applications on the same server, increasing server capacity utilization to 50 percent or higher. This means fewer servers can be used to accomplish the same amount of work.

With blade servers, if BART needs more capacity, it can add another server to the main system. Energy usage is minimized because BART does not have to purchase computing capacity it doesn't need and the blade servers' stripped down modular design minimizes the use of physical space and energy.

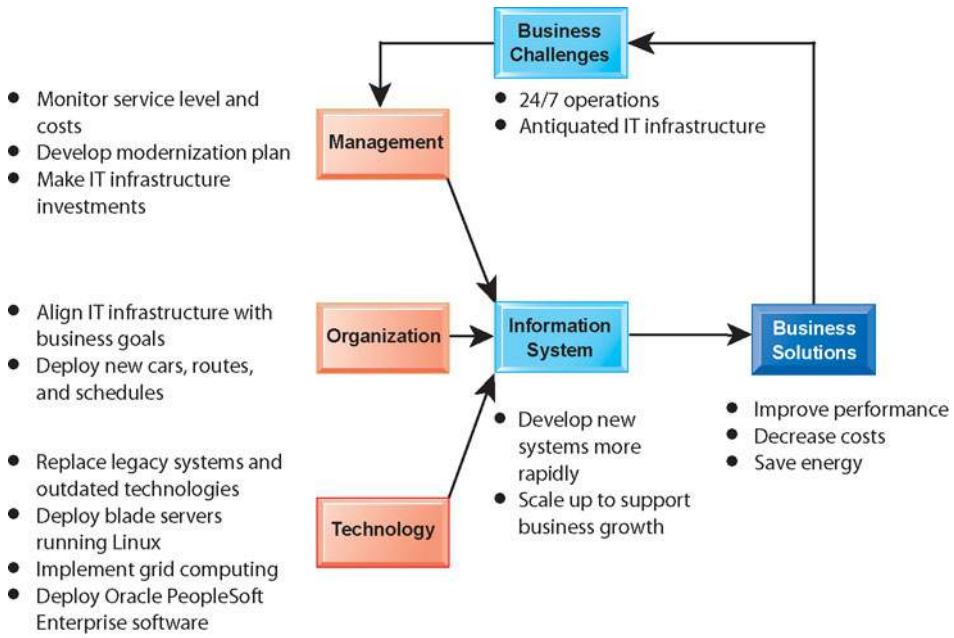
By using less hardware and using existing computing resources more efficiently, BART's grid environment saves power and cooling costs. Consolidating applications onto a shared grid of server capacity is expected to reduce energy usage by about 20 percent.

Sources: David Baum, "Speeding into the Modern Age," *Profit*, February 2010; www.bart.gov, accessed June 5, 2010; and Steve Clouther, "The San Francisco Bay Area Rapid Transit Uses IBM Technology to Improve Safety and Reliability," ARC Advisory Group, October 7, 2009.

BART has been widely praised as a successful modern rapid transit system, but its operations and ability to grow where needed were hampered by an outdated IT infrastructure. BART's management felt the best solution was to invest in new hardware and software technologies that were more cost-effective, efficient, and energy-saving.

The chapter-opening diagram calls attention to important points raised by this case and this chapter. Management realized that in order to keep providing the level of service expected by Bay Area residents, it had to modernize its operations, including the hardware and software used for running the organization. The IT infrastructure investments it made had to support BART's business goals and contribute to improving its performance. Other goals included reducing costs and also "green" goals of reducing power and materials consumption.

By replacing its legacy software and computers with blade servers on a grid and more modern business software, BART was able to reduce wasted computer resources not used for processing, use existing resources more efficiently, and cut costs and power consumption. New software tools make it much easier to develop new applications and services. BART's IT infrastucture is easier to manage and capable of scaling to accommodate growing processing loads and new business opportunities. This case shows that the right hardware and software investments not only improve business performance but can also contribute to important social goals, such as conservation of power and materials.



5.1 IT Infrastructure

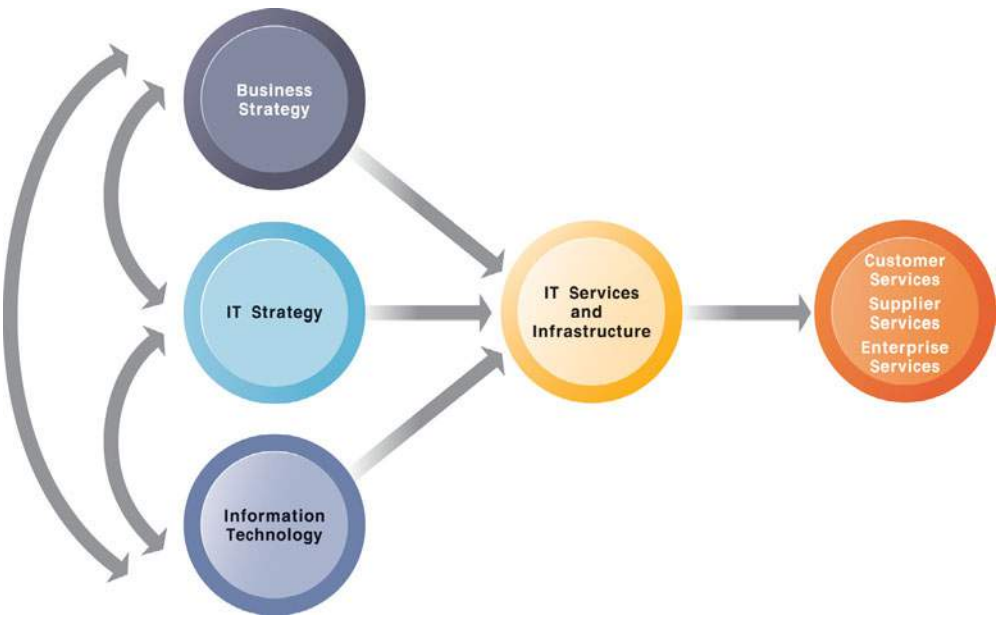
In Chapter 1, we defined *information technology (IT) infrastructure* as the shared technology resources that provide the platform for the firm's specific information system applications. IT infrastructure includes investment in hardware, software, and services—such as consulting, education, and training—that are shared across the entire firm or across entire business units in the firm. A firm's IT infrastructure provides the foundation for serving customers, working with vendors, and managing internal firm business processes (see Figure 5-1).

Supplying U.S. firms with IT infrastructure (hardware and software) in 2010 is estimated to be a $1 trillion industry when telecommunications, networking equipment, and telecommunications services (Internet, telephone, and data transmission) are included. This does not include IT and related business process consulting services, which would add another $800 billion. Investments in infrastructure account for between 25 and 50 percent of information technology expenditures in large firms, led by financial services firms where IT investment is well over half of all capital investment (Weill et al., 2002).

DEFINING IT INFRASTRUCTURE

IT infrastructure consists of a set of physical devices and software applications that are required to operate the entire enterprise. But IT infrastructure is also a set of firmwide services budgeted by management and comprising both human and technical capabilities. These services include the following:

FIGURE 5-1 CONNECTION BETWEEN THE FIRM, IT INFRASTRUCTURE, AND BUSINESS CAPABILITIES



The services a firm is capable of providing to its customers, suppliers, and employees are a direct function of its IT infrastructure. Ideally, this infrastructure should support the firm's business and information systems strategy. New information technologies have a powerful impact on business and IT strategies, as well as the services that can be provided to customers.

- Computing platforms used to provide computing services that connect employees, customers, and suppliers into a coherent digital environment, including large mainframes, midrange computers, desktop and laptop computers, and mobile handheld devices.
- Telecommunications services that provide data, voice, and video connectivity to employees, customers, and suppliers.
- Data management services that store and manage corporate data and provide capabilities for analyzing the data.
- Application software services that provide enterprise-wide capabilities such as enterprise resource planning, customer relationship management, supply chain management, and knowledge management systems that are shared by all business units.
- Physical facilities management services that develop and manage the physical installations required for computing, telecommunications, and data management services.
- IT management services that plan and develop the infrastructure, coordinate with the business units for IT services, manage accounting for the IT expenditure, and provide project management services.
- IT standards services that provide the firm and its business units with policies that determine which information technology will be used, when, and how.
- IT education services that provide training in system use to employees and offer managers training in how to plan for and manage IT investments.
- IT research and development services that provide the firm with research on potential future IT projects and investments that could help the firm differentiate itself in the marketplace.

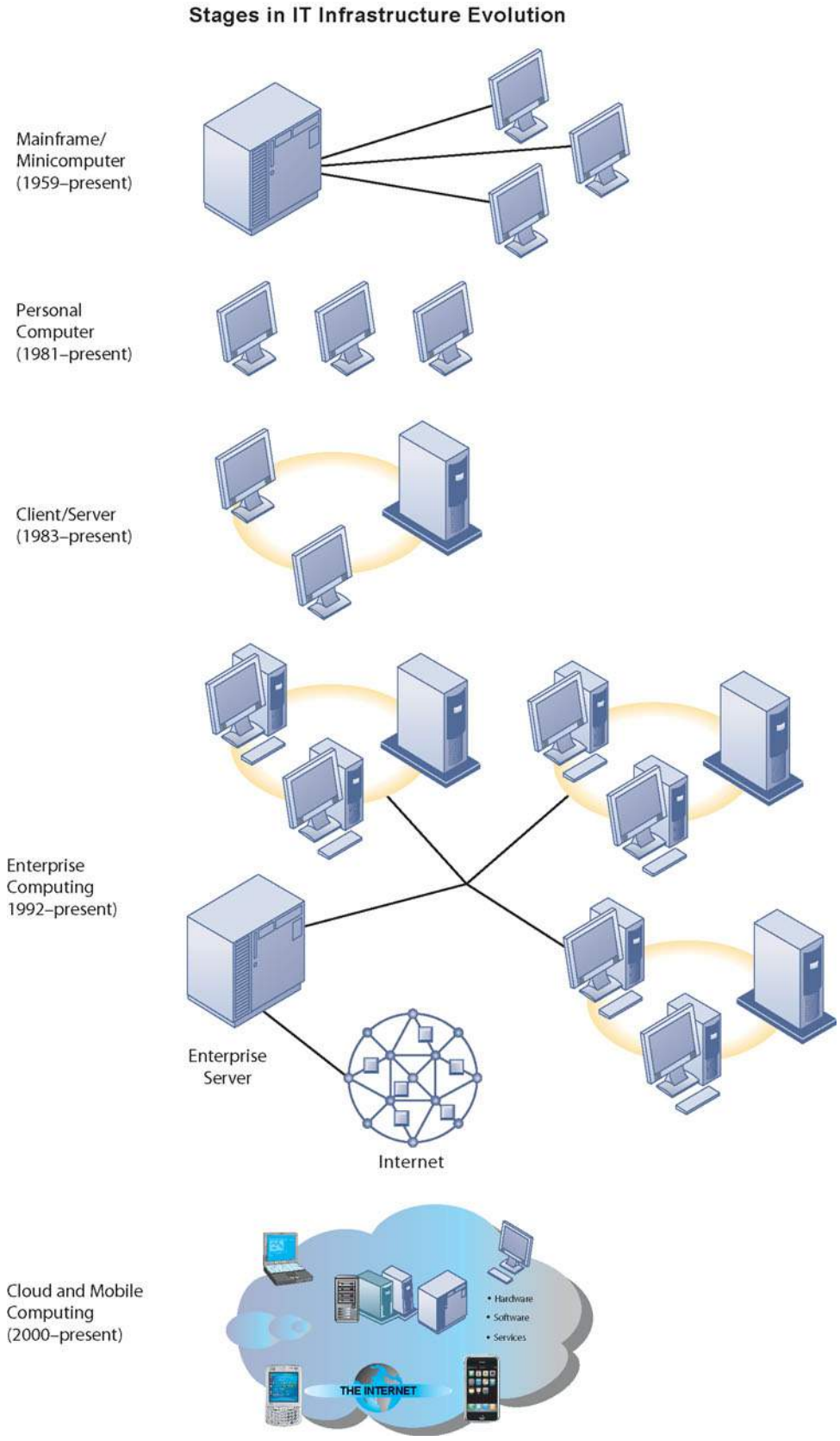
This "service platform" perspective makes it easier to understand the business value provided by infrastructure investments. For instance, the real business value of a fully loaded personal computer operating at 3 gigahertz that costs about $1,000 or a high-speed Internet connection is hard to understand without knowing who will use it and how it will be used. When we look at the services provided by these tools, however, their value becomes more apparent: The new PC makes it possible for a high-cost employee making $100,000 a year to connect to all the company's major systems and the public Internet. The high-speed Internet service saves this employee about one hour per day in reduced wait time for Internet information. Without this PC and Internet connection, the value of this one employee to the firm might be cut in half.

EVOLUTION OF IT INFRASTRUCTURE

The IT infrastructure in organizations today is an outgrowth of over 50 years of evolution in computing platforms. There have been five stages in this evolution, each representing a different configuration of computing power and infrastructure elements (see Figure 5-2). The five eras are general-purpose mainframe and minicomputer computing, personal computers, client/server networks, enterprise computing, and cloud and mobile computing.

Technologies that characterize one era may also be used in another time period for other purposes. For example, some companies still run traditional mainframe systems or use mainframe computers as massive servers supporting large Web sites and corporate enterprise applications.

FIGURE 5-2 ERAS IN IT INFRASTRUCTURE EVOLUTION



Illustrated here are the typical computing configurations characterizing each of the five eras of IT infrastructure evolution.

General-Purpose Mainframe and Minicomputer Era: (1959 to Present)

The introduction of the IBM 1401 and 7090 transistorized machines in 1959 marked the beginning of widespread commercial use of **mainframe** computers. In 1965, the mainframe computer truly came into its own with the introduction of the IBM 360 series. The 360 was the first commercial computer with a powerful operating system that could provide time sharing, multitasking, and virtual memory in more advanced models. IBM has dominated mainframe computing from this point on. Mainframe computers became powerful enough to support thousands of online remote terminals connected to the centralized mainframe using proprietary communication protocols and proprietary data lines.

The mainframe era was a period of highly centralized computing under the control of professional programmers and systems operators (usually in a corporate data center), with most elements of infrastructure provided by a single vendor, the manufacturer of the hardware and the software.

This pattern began to change with the introduction of **minicomputers** produced by Digital Equipment Corporation (DEC) in 1965. DEC minicomputers (PDP-11 and later the VAX machines) offered powerful machines at far lower prices than IBM mainframes, making possible decentralized computing, customized to the specific needs of individual departments or business units rather than time sharing on a single huge mainframe. In recent years, the minicomputer has evolved into a midrange computer or midrange server and is part of a network.

Personal Computer Era: (1981 to Present)

Although the first truly personal computers (PCs) appeared in the 1970s (the Xerox Alto, the MITS Altair 8800, and the Apple I and II, to name a few), these machines had only limited distribution to computer enthusiasts. The appearance of the IBM PC in 1981 is usually considered the beginning of the PC era because this machine was the first to be widely adopted by American businesses. At first using the DOS operating system, a text-based command language, and later the Microsoft Windows operating system, the **Wintel PC** computer (Windows operating system software on a computer with an Intel microprocessor) became the standard desktop personal computer. Today, 95 percent of the world's estimated 1.5 billion computers use the Wintel standard.

Proliferation of PCs in the 1980s and early 1990s launched a spate of personal desktop productivity software tools—word processors, spreadsheets, electronic presentation software, and small data management programs—that were very valuable to both home and corporate users. These PCs were standalone systems until PC operating system software in the 1990s made it possible to link them into networks.

Client/Server Era (1983 to Present)

In **client/server computing**, desktop or laptop computers called **clients** are networked to powerful **server** computers that provide the client computers with a variety of services and capabilities. Computer processing work is split between these two types of machines. The client is the user point of entry, whereas the server typically processes and stores shared data, serves up Web pages, or manages network activities. The term "server" refers to both the software application and the physical computer on which the network software runs. The server could be a mainframe, but today, server computers typically are more powerful versions of personal computers, based on inexpensive chips and often using multiple processors in a single computer box.

The simplest client/server network consists 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 5-3).

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 6 and 7 provide more detail on other pieces of software that are used in multitiered client/server architectures for e-commerce and e-business.

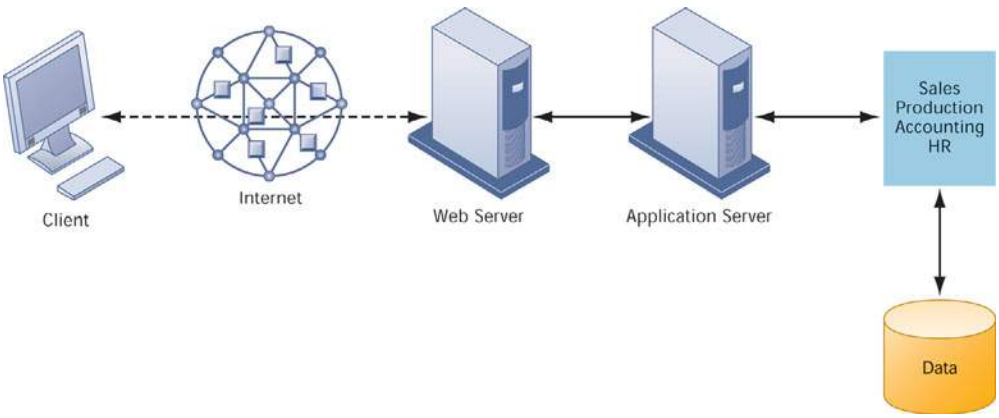
Client/server computing enables businesses to distribute computing work across a series of smaller, inexpensive machines that cost much less than minicomputers or centralized mainframe systems. The result is an explosion in computing power and applications throughout the firm.

Novell NetWare was the leading technology for client/server networking at the beginning of the client/server era. Today, Microsoft is the market leader with its **Windows** operating systems (Windows Server, Windows 7, Windows Vista, and Windows XP).

Enterprise Computing Era (1992 to Present)

In the early 1990s, firms turned to networking standards and software tools that could integrate disparate networks and applications throughout the firm into an enterprise-wide infrastructure. As the Internet developed into a trusted communications environment after 1995, business firms began seriously using the *Transmission Control Protocol/Internet Protocol (TCP/IP)* networking

FIGURE 5-3 A MULTITIERED CLIENT/SERVER NETWORK (N-TIER)



In a multitiered client/server network, client requests for service are handled by different levels of servers.

standard to tie their disparate networks together. We discuss TCP/IP in detail in Chapter 7.

The resulting IT infrastructure links different pieces of computer hardware and smaller networks into an enterprise-wide network so that information can flow freely across the organization and between the firm and other organizations. It can link different types of computer hardware, including mainframes, servers, PCs, mobile phones, and other handheld devices, and it includes public infrastructures such as the telephone system, the Internet, and public network services. The enterprise infrastructure also requires software to link disparate applications and enable data to flow freely among different parts of the business, such as enterprise applications (see Chapters 2 and 9) and Web services (discussed in Section 5.4).

Cloud and Mobile Computing Era (2000 to Present)

The growing bandwidth power of the Internet has pushed the client/server model one step further, towards what is called the "Cloud Computing Model." **Cloud computing** refers to a model of computing that provides access to a shared pool of computing resources (computers, storage, applications, and services), over a network, often the Internet. These "clouds" of computing resources can be accessed on an as-needed basis from any connected device and location. Currently, cloud computing is the fastest growing form of computing, with global revenue expected to reach close to $89 billion in 2011 and nearly $149 billion by 2014 according to Gartner Inc. technology consultants (Cheng and Borzo, 2010; Veverka, 2010).

Thousands or even hundreds of thousands computers are located in cloud data centers, where they can be accessed by desktop computers, laptop computers, netbooks, entertainment centers, mobile devices, and other client machines linked to the Internet, with both personal and corporate computing increasingly moving to mobile platforms. IBM, HP, Dell, and Amazon operate huge, scalable cloud computing centers that provide computing power, data storage, and high-speed Internet connections to firms that want to maintain their IT infrastructures remotely. Software firms such as Google, Microsoft, SAP, Oracle, and Salesforce.com sell software applications as services delivered over the Internet.

We discuss cloud computing in more detail in Section 5.3. The Learning Tracks include a table on Stages in IT Infrastructure Evolution, which compares each era on the infrastructure dimensions introduced.

TECHNOLOGY DRIVERS OF INFRASTRUCTURE EVOLUTION

The changes in IT infrastructure we have just described have resulted from developments in computer processing, memory chips, storage devices, telecommunications and networking hardware and software, and software design that have exponentially increased computing power while exponentially reducing costs. Let's look at the most important developments.

Moore's Law and Microprocessing Power

In 1965, Gordon Moore, the directory of Fairchild Semiconductor's Research and Development Laboratories, an early manufacturer of integrated circuits, wrote in *Electronics* magazine that since the first microprocessor chip was introduced in 1959, the number of components on a chip with the smallest

manufacturing costs per component (generally transistors) had doubled each year. This assertion became the foundation of **Moore's Law**. Moore later reduced the rate of growth to a doubling every two years.

This law would later be interpreted in multiple ways. There are at least three variations of Moore's Law, none of which Moore ever stated: (1) the power of microprocessors doubles every 18 months; (2) computing power doubles every 18 months; and (3) the price of computing falls by half every 18 months.

Figure 5-4 illustrates the relationship between number of transistors on a microprocessor and millions of instructions per second (MIPS), a common measure of processor power. Figure 5-5 shows the exponential decline in the cost of transistors and rise in computing power. In 2010 for instance, and Intel 8-Core Xeon processor contains 2.3 billion transistors.

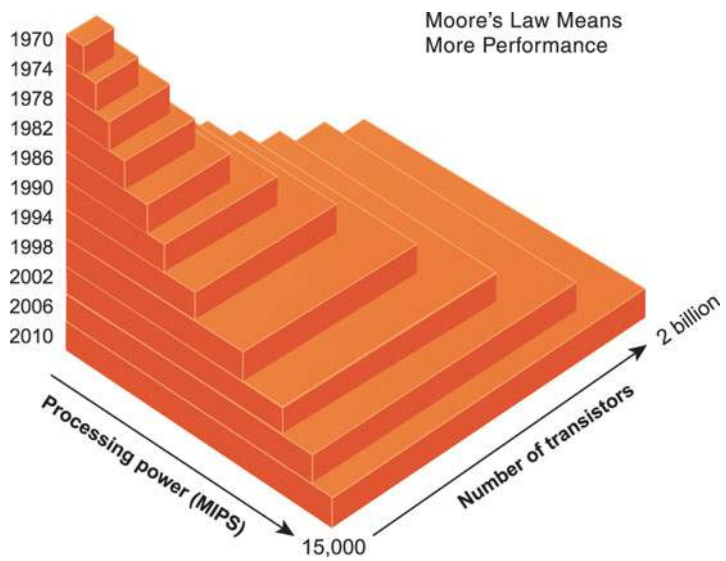
Exponential growth in the number of transistors and the power of processors coupled with an exponential decline in computing costs is likely to continue. Chip manufacturers continue to miniaturize components. Today's transistors should no longer be compared to the size of a human hair but rather to the size of a virus.

By using nanotechnology, chip manufacturers can even 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. Chip manufacturers are trying to develop a manufacturing process that could produce nanotube processors economically (Figure 5-6). IBM has just started making microprocessors in a production setting using this technology.

The Law of Mass Digital Storage

A second technology driver of IT infrastructure change is the Law of Mass Digital Storage. The world produces as much as 5 exabytes of unique information per year (an exabyte is a billion gigabytes, or 10^{18} bytes). The amount of digital information is roughly doubling every year (Lyman and Varian, 2003). Fortunately, the cost of storing digital information is falling at an exponential

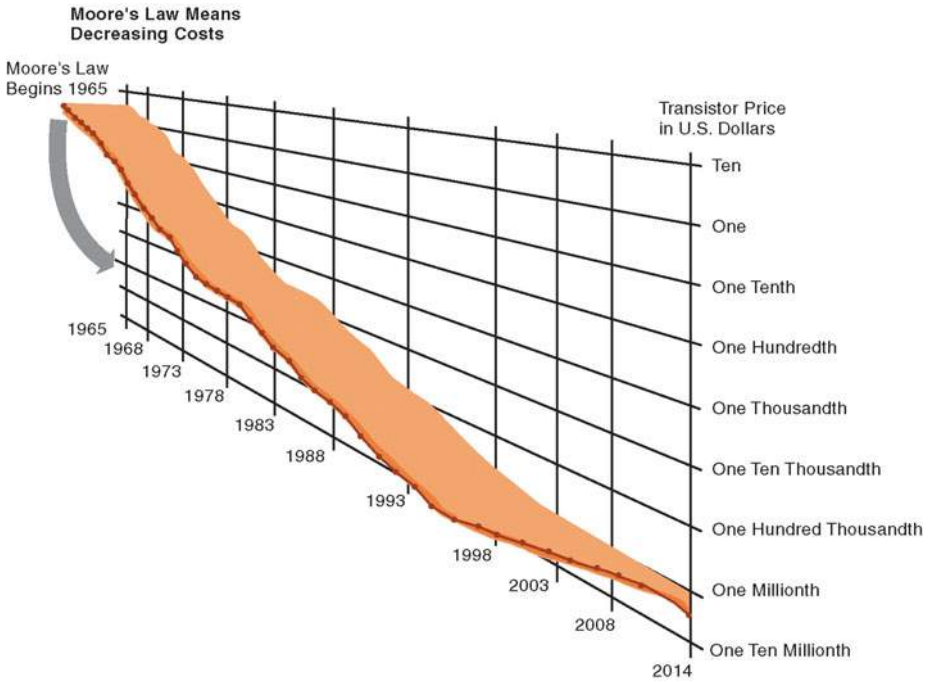
FIGURE 5-4 MOORE'S LAW AND MICROPROCESSOR PERFORMANCE



Packing over 2 billion transistors into a tiny microprocessor has exponentially increased processing power. Processing power has increased to over 500,000 MIPS (millions of instructions per second).

Sources: Intel, 2010; authors' estimate.

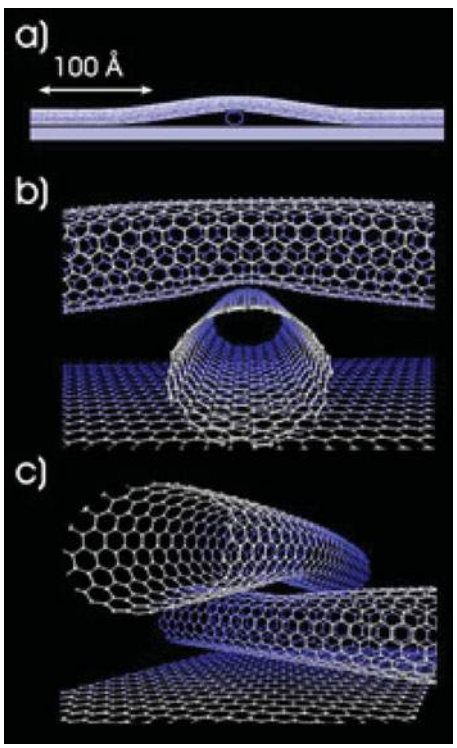
FIGURE 5-5 FALLING COST OF CHIPS



Packing more transistors into less space has driven down transistor cost dramatically as well as the cost of the products in which they are used.

Source: Intel, 2010; authors' estimates.

FIGURE 5-6 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 and have the potential uses as minuscule wires or in ultrasmall electronic devices and are very powerful conductors of electrical current.

rate of 100 percent a year. Figure 5-7 shows that the number of kilobytes that can be stored on magnetic media for $1 from 1950 to the present roughly doubled every 15 months.

Metcalfe's Law and Network Economics

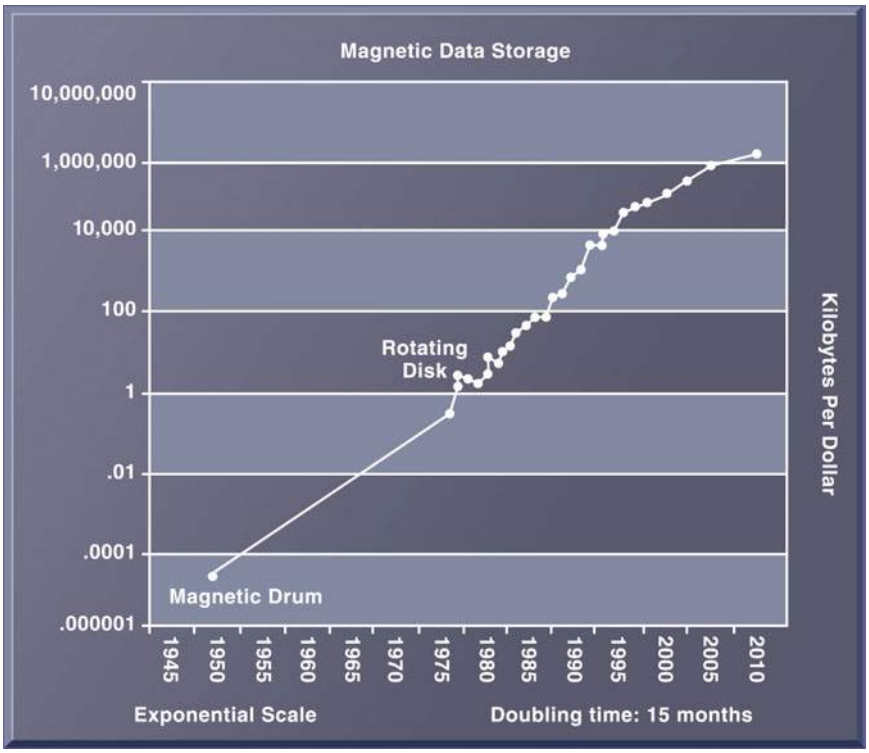
Moore's Law and the Law of Mass Storage help us understand why computing resources are now so readily available. But why do people want more computing and storage power? The economics of networks and the growth of the Internet provide some answers.

Robert Metcalfe—inventor of Ethernet local area network technology—claimed in 1970 that the value or power of a network grows exponentially as a function of the number of network members. Metcalfe and others point to the *increasing returns to scale* that network members receive as more and more people join the network. As the number of members in a network grows linearly, the value of the entire system grows exponentially and continues to grow forever as members increase. Demand for information technology has been driven by the social and business value of digital networks, which rapidly multiply the number of actual and potential links among network members.

Declining Communications Costs and the Internet

A fourth technology driver transforming IT infrastructure is the rapid decline in the costs of communication and the exponential growth in the size of the

FIGURE 5-7 THE COST OF STORING DATA DECLINES EXPONENTIALLY 1950–2010



Since the first magnetic storage device was used in 1955, the cost of storing a kilobyte of data has fallen exponentially, doubling the amount of digital storage for each dollar expended every 15 months on average.

Sources: Kurzweil 2003; authors' estimates.

Internet. An estimated 1.8 billion people worldwide now have Internet access (Internet World Stats, 2010). Figure 5-8 illustrates the exponentially declining cost of communication both over the Internet and over telephone networks (which increasingly are based on the Internet). As communication costs fall toward a very small number and approach 0, utilization of communication and computing facilities explodes.

To take advantage of the business value associated with the Internet, firms must greatly expand their Internet connections, including wireless connectivity, and greatly expand the power of their client/server networks, desktop clients, and mobile computing devices. There is every reason to believe these trends will continue.

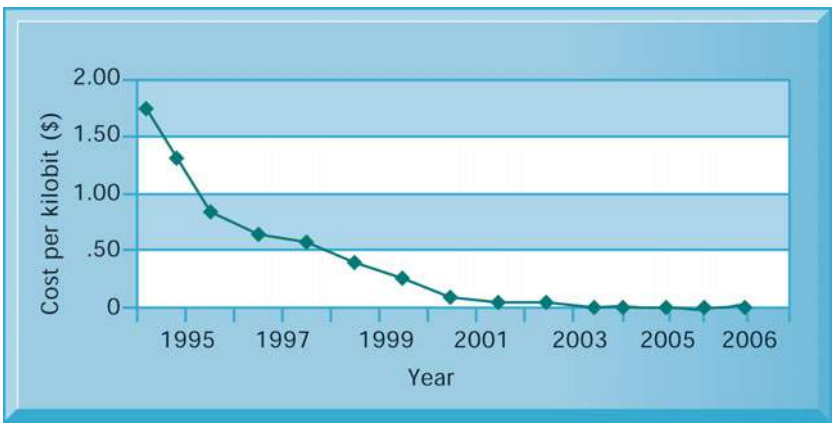
Standards and Network Effects

Today's enterprise infrastructure and Internet computing would be impossible—both now and in the future—without agreements among manufacturers and widespread consumer acceptance of **technology standards**. Technology standards are specifications that establish the compatibility of products and the ability to communicate in a network (Stango, 2004).

Technology standards unleash powerful economies of scale and result in price declines as manufacturers focus on the products built to a single standard. Without these economies of scale, computing of any sort would be far more expensive than is currently the case. Table 5-1 describes important standards that have shaped IT infrastructure.

Beginning in the 1990s, corporations started moving toward standard computing and communications platforms. The Wintel PC with the Windows operating system and Microsoft Office desktop productivity applications became the standard desktop and mobile client computing platform. Widespread adoption of Unix as the enterprise server operating system of choice made possible the replacement of proprietary and expensive mainframe infrastructures. In telecommunications, the Ethernet standard enabled PCs to connect together in small local area networks (LANs; see Chapter 7), and the TCP/IP standard enabled these LANs to be connected into firm-wide networks, and ultimately, to the Internet.

FIGURE 5-8 EXPONENTIAL DECLINES IN INTERNET COMMUNICATIONS COSTS



One reason for the growth in the Internet population is the rapid decline in Internet connection and overall communication costs. The cost per kilobit of Internet access has fallen exponentially since 1995. Digital subscriber line (DSL) and cable modems now deliver a kilobit of communication for a retail price of around 2 cents.

Source: Authors.

TABLE 5-1 SOME IMPORTANT STANDARDS IN COMPUTING

STANDARD	SIGNIFICANCE
American Standard Code for Information Interchange (ASCII) (1958)	Made it possible for computer machines from different manufacturers to exchange data; later used as the universal language linking input and output devices such as keyboards and mice to computers. Adopted by the American National Standards Institute in 1963.
Common Business Oriented Language (COBOL) (1959)	An easy-to-use software language that greatly expanded the ability of programmers to write business-related programs and reduced the cost of software. Sponsored by the Defense Department in 1959.
Unix (1969–1975)	A powerful multitasking, multiuser, portable operating system initially developed at Bell Labs (1969) and later released for use by others (1975). It operates on a wide variety of computers from different manufacturers. Adopted by Sun, IBM, HP, and others in the 1980s, it became the most widely used enterprise-level operating system.
Transmission Control Protocol/Internet Protocol (TCP/IP) (1974)	Suite of communications protocols and a common addressing scheme that enables millions of computers to connect together in one giant global network (the Internet). Later, it was used as the default networking protocol suite for local area networks and intranets. Developed in the early 1970s for the U.S. Department of Defense.
Ethernet (1973)	A network standard for connecting desktop computers into local area networks that enabled the widespread adoption of client/server computing and local area networks, and further stimulated the adoption of personal computers.
IBM/Microsoft/Intel Personal Computer (1981)	The standard Wintel design for personal desktop computing based on standard Intel processors and other standard devices, Microsoft DOS, and later Windows software. The emergence of this standard, low-cost product laid the foundation for a 25-year period of explosive growth in computing throughout all organizations around the globe. Today, more than 1 billion PCs power business and government activities every day.
World Wide Web (1989–1993)	Standards for storing, retrieving, formatting, and displaying information as a worldwide web of electronic pages incorporating text, graphics, audio, and video enables creation of a global repository of billions of Web pages.

5.2 Infrastructure Components

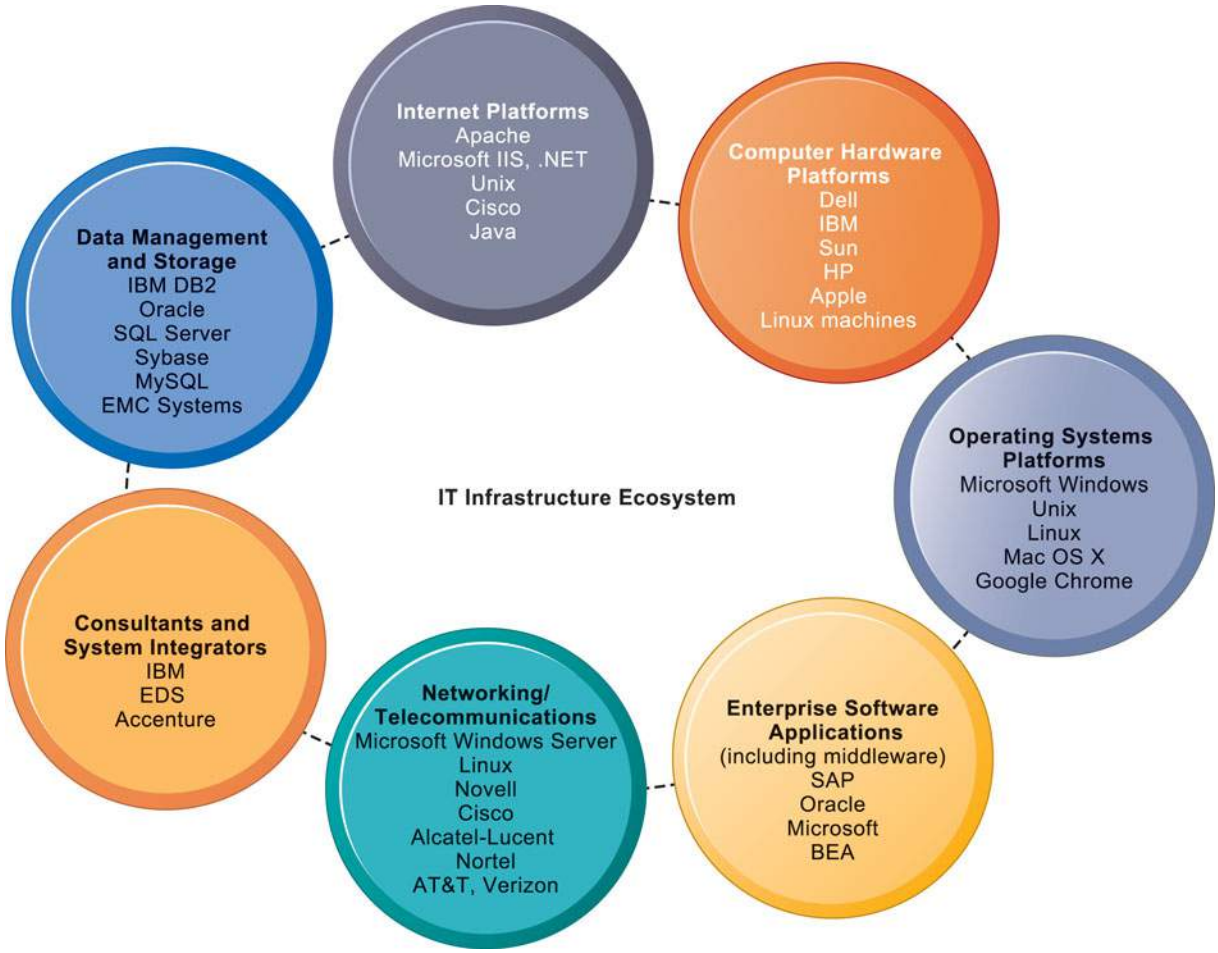
IT infrastructure today is composed of seven major components. Figure 5-9 illustrates these infrastructure components and the major vendors within each component category. These components constitute investments that must be coordinated with one another to provide the firm with a coherent infrastructure.

In the past, technology vendors supplying these components were often in competition with one another, offering purchasing firms a mixture of incompatible, proprietary, partial solutions. But increasingly the vendor firms have been forced by large customers to cooperate in strategic partnerships with one another. For instance, a hardware and services provider such as IBM cooperates with all the major enterprise software providers, has strategic relationships with system integrators, and promises to work with whichever database products its client firms wish to use (even though it sells its own database management software called DB2).

COMPUTER HARDWARE PLATFORMS

U.S. firms will spend about $109 billion in 2010 on computer hardware. This component includes client machines (desktop PCs, mobile computing devices such as netbooks and laptops but not including iPhones or BlackBerrys) and

FIGURE 5-9 THE IT INFRASTRUCTURE ECOSYSTEM



There are seven major components that must be coordinated to provide the firm with a coherent IT infrastructure. Listed here are major technologies and suppliers for each component.

server machines. The client machines use primarily Intel or AMD microprocessors. In 2010, there will be about 90 million PCs sold to U.S. customers (400 million worldwide) (Gartner, 2010).

The server market uses mostly Intel or AMD processors in the form of blade servers in racks, but also includes Sun SPARC microprocessors and IBM POWER chips specially designed for server use. **Blade servers**, which we discussed in the chapter-opening case, are ultrathin computers consisting of a circuit board with processors, memory, and network connections that are stored in racks. They take up less space than traditional box-based servers. Secondary storage may be provided by a hard drive in each blade server or by external mass-storage drives.

The marketplace for computer hardware has increasingly become concentrated in top firms such as IBM, HP, Dell, and Sun Microsystems (acquired by Oracle), and three chip producers: Intel, AMD, and IBM. The industry has collectively settled on Intel as the standard processor, with major exceptions in the server market for Unix and Linux machines, which might use Sun or IBM Unix processors.

Mainframes have not disappeared. The mainframe market has actually grown steadily over the last decade, although the number of providers has dwindled to one: IBM. IBM has also repurposed its mainframe systems so they can be used as giant servers for massive enterprise networks and corporate Web sites. A single IBM mainframe can run up to 17,000 instances of Linux or Windows server software and is capable of replacing thousands of smaller blade servers (see the discussion of virtualization in Section 5.3).

OPERATING SYSTEM PLATFORMS

In 2010, Microsoft Windows comprises about 75 percent of the server operating system market, with 25 percent of corporate servers using some form of the **Unix** operating system or **Linux**, an inexpensive and robust open source relative of Unix. Microsoft Windows Server is capable of providing enterprise-wide operating system and network services, and appeals to organizations seeking Windows-based IT infrastructures (IDC, 2010).

Unix and Linux are scalable, reliable, and much less expensive than mainframe operating systems. They can also run on many different types of processors. The major providers of Unix operating systems are IBM, HP, and Sun, each with slightly different and partially incompatible versions.

At the client level, 90 percent of PCs use some form of Microsoft Windows **operating system** (such as Windows 7, Windows Vista, or Windows XP) to manage the resources and activities of the computer. However, there is now a much greater variety of operating systems than in the past, with new operating systems for computing on handheld mobile digital devices or cloud-connected computers.

Google's **Chrome OS** provides a lightweight operating system for cloud computing using netbooks. Programs are not stored on the user's PC but are used over the Internet and accessed through the Chrome Web browser. User data resides on servers across the Internet. Microsoft has introduced the *Windows Azure* operating system for its cloud services and platform. **Android** is a mobile operating system developed by Android, Inc. (purchased by Google) and later the Open Handset Alliance as a flexible, upgradeable mobile device platform.

Conventional client operating system software is designed around the mouse and keyboard, but increasingly becoming more natural and intuitive by using touch technology. *IPhone OS*, the operating system for the phenomenally popular Apple iPad, iPhone, and iPod Touch, features a **multitouch** interface, where users use their fingers to manipulate objects on the screen. The Interactive Session on Technology explores the implications of using multitouch to interact with the computer.

ENTERPRISE SOFTWARE APPLICATIONS

In addition to software for applications used by specific groups or business units, U.S. firms will spend about $165 billion in 2010 on software for enterprise applications that are treated as components of IT infrastructure. We introduced the various types of enterprise applications in Chapter 2, and Chapter 9 provides a more detailed discussion of each.

The largest providers of enterprise application software are SAP and Oracle (which acquired PeopleSoft). Also included in this category is middleware software supplied by vendors such as BEA for achieving firmwide integration by linking the firm's existing application systems. Microsoft is attempting to move into the lower ends of this market by focusing on small and medium-sized businesses that have not yet implemented enterprise applications.

INTERACTIVE SESSION: TECHNOLOGY

NEW TO THE TOUCH

When Steve Jobs first demonstrated "the pinch"—the two-finger gesture for zooming in and out of photos and Web pages on the iPhone, he not only shook up the mobile phone industry—the entire digital world took notice. The Apple iPhone's multitouch features dramatized new ways of using touch to interact with software and devices.

Touch interfaces are not new. People use them every day to get money from ATMs or to check into flights at airport kiosks. Academic and commercial researchers have been working on multitouch technology for years. What Apple did was to make multitouch more exciting and relevant, popularizing it just as it did in the 1980s with the mouse and the graphical user interface. (These had also been invented elsewhere.)

Multitouch interfaces are potentially more versatile than single-touch interfaces. They allow you to use one or more fingers to perform special gestures that manipulate lists or objects on a screen without moving a mouse, pressing buttons, turning scroll wheels, or striking keys. They take different actions depending on how many fingers they detect and which gestures a user performs. Multitouch gestures are easier to remember than commands because they are based on ingrained human movements that do not have to be learned, scientists say.

The iPhone's Multi-Touch display and software lets you control everything using only your fingers. A panel underneath the display's glass cover senses your touch using electrical fields. It then transmits that information to a LCD screen below it. Special software recognizes multiple simultaneous touch points, (as opposed to the single-touch screen, which recognizes only one touch point.) You can quickly move back and forth through a series of Web pages or photos by "swiping," or placing three fingers on the screen and moving them rapidly sideways. By pinching the image, you can shrink or expand a photo.

Apple has made a concerted effort to provide multitouch features in all of its product categories, but many other consumer technology companies have adopted multitouch for some of their products. Synaptics, a leading supplier of touchpads for laptop makers who compete with Apple, has announced that it is incorporating several multitouch features into its touchpads.

Microsoft's Windows 7 operating system sports multitouch features: When you pair Windows 7 with a touch-screen PC, you can browse online newspapers, flick through photo albums, and shuffle files and folders using nothing but your fingers. To zoom in on something on the screen of a multitouch-compatible PC, you would place two fingers on the screen and spread them apart. To right-click a file, touch it with one finger and tap the screen with a second.

A number of Microsoft Windows PCs have touch screens, with a few Windows laptops emulating some of the multitouch features of Apple computers and handhelds. Microsoft's Surface computer runs on Windows 7 and lets its business customers use multitouch in a table-top display. Customers of hotels, casinos, and retail stores will be able to use multitouch finger gestures to move around digital objects such as photos, to play games, and to browse through product options. The Dell Latitude XT tablet PC uses multitouch, which is helpful to people who can't grasp a mouse and want the functionality of a traditional PC. They can use a finger or a stylus instead. The Android operating system for smartphones has native support for multi-touch, and handsets such as the HTC Desire, Nexus One, and the Motorola Droid have this capability.

Hewlett-Packard (HP) now has laptops and desktops that use touch technology. Its TouchSmart computer lets you use two fingers at once to manipulate images on the screen or to make on-screen gestures designating specific commands without using cursors or scroll bars. To move an object, you touch it with a finger and drag it to its new location. Sliding your finger up and down or sideways smoothly scrolls the display.

The TouchSmart makes it possible for home users to engage in a new type of casual computing—putting on music while preparing dinner, quickly searching for directions before leaving the house, or leaving written, video, or audio memos for family members. Both consumers and businesses have found other uses as well. According to Alan Reed, HP's vice president and general manager for Business Desktops, "There is untapped potential for touch technology in the business marketplace to engage users in a way that has never been done before."

Chicago's O'Hare Airport integrated a group of TouchSmart PCs into "Explore Chicago" tourist kiosks, allowing visitors to check out a virtual Visitor's Center. TouchSmart computing helped an autistic student to speak to and communicate with others for the first time in the 14 years of his life. Without using the TouchSmart PC's wireless keyboard and mouse, users can hold video chats with remote workers through a built-in Webcam and microphone, access e-mail and the Internet, and manage contacts, calendar items, and photos.

Touch-enabled PCs could also appeal to elementary schools seeking an easy-to-use computer for students in early grades, or a wall-mountable information kiosk-type device for parents and visitors. Customers might use touch to place orders with a retailer, conduct virtual video service calls, or to teach or utilize social networking for business.

It's too early to know if the new multitouch interface will ever be as popular as the mouse-driven graphical user interface. Although putting ones fingers on the screen is the ultimate measure of "cool" in the cell phone market, a "killer application" for touch on the PC has not yet emerged. But it's already evident that touch has real advantages on devices where a mouse isn't possible or convenient to use, or the decades-old interface of menus and folders is too cumbersome.

Sources: Claire Cain Miller, "To Win Over Today's Users, Gadgets Have to be Touchable," *The New York Times*, September 1, 2010; Katherine Boehret, "Apple Adds Touches to Its Mac Desktops," *The Wall Street Journal*, August 4, 2010; Ashlee Vance, " Tech Industry Catches Its Breath," *The New York Times*, February 17, 2010; Kathy Sandler, "The Future of Touch," *The Wall Street Journal*, June 2, 2009; Suzanne Robitaille, "Multitouch to the Rescue?" Suite101.com, January 22, 2009; and Eric Lai, "HP Aims TouchSmart Desktop PC at Businesses," *Computerworld*, August 1, 2009.

CASE STUDY QUESTIONS

1. What problems does multitouch technology solve?
2. What are the advantages and disadvantages of a multitouch interface? How useful is it? Explain.
3. Describe three business applications that would benefit from a multitouch interface.
4. What management, organization, and technology issues must be addressed if you or your business was considering systems and computers with multitouch interfaces?

MIS IN ACTION

1. Describe what you would do differently on your PC if it had multitouch capabilities. How much difference would multitouch make in the way you use your computer?

DATA MANAGEMENT AND STORAGE

Enterprise database management software is responsible for organizing and managing the firm's data so that they can be efficiently accessed and used. Chapter 6 describes this software in detail. The leading database software providers are IBM (DB2), Oracle, Microsoft (SQL Server), and Sybase (Adaptive Server Enterprise), which supply more than 90 percent of the U.S. database software marketplace. MySQL is a Linux open source relational database product now owned by Oracle Corporation.

The physical data storage market is dominated by EMC Corporation for large-scale systems, and a small number of PC hard disk manufacturers led by Seagate, Maxtor, and Western Digital.

Digital information is estimated to be growing at 1.2 zettabytes a year. All the tweets, blogs, videos, e-mails, and Facebook postings as well as traditional corporate data add up in 2010 to several thousand Libraries of Congress (EMC Corporation, 2010).

With the amount of new digital information in the world growing so rapidly, the market for digital data storage devices has been growing at more than 15 percent annually over the last five years. In addition to traditional

disk arrays and tape libraries, large firms are turning to network-based storage technologies. **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.

NETWORKING/TELECOMMUNICATIONS PLATFORMS

U.S. firms spend $100 billon a year on networking and telecommunications hardware and a huge $700 billion on networking services (consisting mainly of telecommunications and telephone company charges for voice lines and Internet access; these are not included in this discussion). Chapter 7 is devoted to an in-depth description of the enterprise networking environment, including the Internet. Windows Server is predominantly used as a local area network operating system, followed by Linux and Unix. Large enterprise wide area networks primarily use some variant of Unix. Most local area networks, as well as wide area enterprise networks, use the TCP/IP protocol suite as a standard (see Chapter 7).

The leading networking hardware providers are Cisco, Alcatel-Lucent, Nortel, and Juniper Networks. Telecommunications platforms are typically provided by telecommunications/telephone services companies that offer voice and data connectivity, wide area networking, wireless services, and Internet access. Leading telecommunications service vendors include AT&T and Verizon (see the Chapter 3 opening case). This market is exploding with new providers of cellular wireless, high-speed Internet, and Internet telephone services.

INTERNET PLATFORMS

Internet platforms overlap with, and must relate to, the firm's general networking infrastructure and hardware and software platforms. U.S. firms spent an estimated $40 billion annually on Internet-related infrastructure. These expenditures were for hardware, software, and management services to support a firm's Web site, including Web hosting services, routers, and cabling or wireless equipment. A **Web hosting service** maintains a large Web server, or series of servers, and provides fee-paying subscribers with space to maintain their Web sites.

The Internet revolution created a veritable explosion in server computers, with many firms collecting thousands of small servers to run their Internet operations. Since then there has been a steady push toward server consolidation, reducing the number of server computers by increasing the size and power of each. The Internet hardware server market has become increasingly concentrated in the hands of IBM, Dell, and HP/Compaq, as prices have fallen dramatically.

The major Web software application development tools and suites are supplied by Microsoft (Microsoft Expression Web, SharePoint Designer, and the Microsoft .NET family of development tools); Oracle-Sun (Sun's Java is the most widely used tool for developing interactive Web applications on both the server and client sides); and a host of independent software developers, including Adobe (Flash and text tools like Acrobat), and Real Media (media software). Chapter 7 describes the components of the firm's Internet platform in greater detail.

CONSULTING AND SYSTEM INTEGRATION SERVICES

Today, even a large firm does not have the staff, the skills, the budget, or the necessary experience to deploy and maintain its entire IT infrastructure. Implementing a new infrastructure requires (as noted in Chapters 3 and 14) significant changes in business processes and procedures, training and education, and software integration. Leading consulting firms providing this expertise include Accenture, IBM Global Services, HP Enterprise Services, Infosys, and Wipro Technologies.

Software integration means ensuring the new infrastructure works with the firm's older, so-called legacy systems and ensuring 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. Replacing these systems is cost prohibitive and generally not necessary if these older systems can be integrated into a contemporary infrastructure.

5.3 Contemporary Hardware Platform 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 and mobile handheld devices. We look at seven hardware trends: the emerging mobile digital platform, grid computing, virtualization, cloud computing, green computing, high-performance/power-saving processors, and autonomic computing.

THE EMERGING MOBILE DIGITAL PLATFORM

Chapter 1 pointed out that new mobile digital computing platforms have emerged as alternatives to PCs and larger computers. Cell phones and smartphones such as the BlackBerry and iPhone have taken on many functions of handheld computers, including transmission of data, surfing the Web, transmitting e-mail and instant messages, displaying digital content, and exchanging data with internal corporate systems. The new mobile platform also includes small low-cost lightweight subnotebooks called **netbooks** optimized for wireless communication and Internet access, with core computing functions such as word processing; tablet computers such as the iPad; and digital e-book readers such as Amazon's Kindle with some Web access capabilities.

In a few years, smartphones, netbooks, and tablet computers will be the primary means of accessing the Internet, with business computing moving increasingly from PCs and desktop machines to these mobile devices. For example, senior executives at General Motors are using smartphone applications that drill down into vehicle sales information, financial performance, manufacturing metrics, and project management status. At medical device maker Astra Tech, sales reps use their smartphones to access Salesforce.com customer relationship management (CRM) applications and sales data, checking data on sold and returned products and overall revenue trends before meeting with customers.

GRID COMPUTING

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 use their central processing units on average only 25 percent of the time for the work they have been assigned, leaving these idle resources available for other processing tasks. Grid computing was impossible until high-speed Internet connections enabled firms to connect remote machines economically and move enormous quantities of data.

Grid computing requires software programs to control and allocate resources on the grid. Client software communicates with a server software application. The server software breaks data and application code into chunks that are then parceled out to the grid's machines. The client machines perform their traditional tasks while running grid applications in the background.

The business case for using grid computing involves cost savings, speed of computation, and agility, as noted in the chapter-opening case. The chapter-opening case shows that by running its applications on clustered servers on a grid, BART eliminated unused computer resources, used existing resources more efficiently, and reduced costs and power consumption.

VIRTUALIZATION

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. Virtualization enables a single physical resource (such as a server or a storage device) to appear to the user as multiple logical resources. For example, a server or mainframe can be configured to run many instances of an operating system so that it acts like many different machines. Virtualization also enables multiple physical resources (such as storage devices or servers) to appear as a single logical resource, as would be the case with storage area networks or grid computing. Virtualization makes it possible for a company to handle its computer processing and storage using computing resources housed in remote locations. VMware is the leading virtualization software vendor for Windows and Linux servers. Microsoft offers its own Virtual Server product and has built virtualization capabilities into the newest version of Windows Server.

Business Benefits of Virtualization

By providing the ability to host multiple systems on a single physical machine, virtualization helps organizations increase equipment utilization rates, conserving data center space and energy usage. Most servers run at just 15-20 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, as illustrated by BART's experience with virtualization in the chapter-opening case.

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 and consolidation of hardware administration. It is now possible for companies and individuals to perform all of their computing work using a virtualized IT infrastructure, as is the case with cloud computing. We now turn to this topic.

CLOUD COMPUTING

Earlier in this chapter, we introduced cloud computing, in which firms and individuals obtain computer processing, storage, software, and other services as a pool of virtualized resources over a network, primarily the Internet. These resources are made available to users, based on their needs, irrespective of their physical location or the location of the users themselves. The U.S. National Institute of Standards and Technology (NIST) defines cloud computing as having the following essential characteristics (Mell and Grance, 2009):

- **On-demand self-service:** Individuals can obtain computing capabilities such as server time or network storage on their own.
- **Ubiquitous network access:** Individuals can use standard network and Internet devices, including mobile platforms, to access cloud resources.
- **Location independent resource pooling:** Computing resources are pooled to serve multiple users, with different virtual resources dynamically assigned according to user demand. The user generally does not know where the computing resources are located.
- **Rapid elasticity:** Computing resources can be rapidly provisioned, increased, or decreased to meet changing user demand.
- **Measured service:** Charges for cloud resources are based on amount of resources actually used.

Cloud computing consists of three different types of services:

- **Cloud infrastructure as a service:** Customers use processing, storage, networking, and other computing resources from cloud service providers to run their information systems. For example, Amazon uses the spare capacity of its IT infrastructure to provide a broadly based cloud environment selling IT infrastructure services. These include its Simple Storage Service (S3) for storing customers' data and its Elastic Compute Cloud (EC2) service for running their applications. Users pay only for the amount of computing and storage capacity they actually use.
- **Cloud platform as a service:** Customers use infrastructure and programming tools hosted by the service provider to develop their own applications. For example, IBM offers a Smart Business Application Development & Test service for software development and testing on the IBM Cloud. Another example is Salesforce.com's Force.com, described in the chapter-ending case study, which allows developers to build applications that are hosted on its servers as a service.
- **Cloud software as a service:** Customers use software hosted by the vendor on the vendor's hardware and delivered over a network. Leading examples are Google Apps, which provides common business applications online and Salesforce.com, which also leases CRM and related software services over the Internet. Both charge users an annual subscription fee, although Google Apps also has a pared-down free version. Users access these applications from a Web browser, and the data and software are maintained on the providers' remote servers.

A cloud can be private or public. A **public cloud** is maintained by an external service provider, such as Amazon Web Services, accessed through the Internet, and available to the general public. A **private cloud** is a proprietary network or a data center that ties together servers, storage, networks, data, and applications as a set of virtualized services that are shared by users inside a company. Like public clouds, private clouds are able to allocate storage, computing power, or other resources seamlessly to provide computing resources on an as-needed basis. Financial institutions and health care

providers are likely to gravitate toward private clouds because these organizations handle so much sensitive financial and personal data. We discuss cloud security issues in Chapter 8.

Since organizations using cloud computing generally do not own the infrastructure, they do not have to make large investments in their own hardware and software. Instead, they purchase their computing services from remote providers and pay only for the amount of computing power they actually use (**utility computing**) or are billed on a monthly or annual subscription basis. The term **on-demand computing** has also been used to describe such services.

For example, Envoy Media Group, a direct-marketing firm that offers highly-targeted media campaigns across multiple channels, including TV, radio, and Internet, hosts its entire Web presence on Azimuth Web Services. The "pay as you go" pricing structure allows the company to quickly and painlessly add servers where they are needed without large investments in hardware. Cloud computing reduced costs about 20 percent because Envoy no longer had to maintain its own hardware or IT personnel.

Cloud computing has some drawbacks. Unless users make provisions for storing their data locally, the responsibility for data storage and control is in the hands of the provider. Some companies worry about the security risks related to entrusting their critical data and systems to an outside vendor that also works with other companies. There are also questions of system reliability. Companies expect their systems to be available 24/7 and do not want to suffer any loss of business capability if their IT infrastructures malfunction. When Amazon's cloud went down in December 2009, subscribers on the U.S. east coast were unable to use their systems for several hours. Another limitation of cloud computing is the possibility of making users dependent on the cloud computing provider.

There are some who believe that cloud computing represents a sea change in the way computing will be performed by corporations as business computing shifts out of private data centers into cloud services (Carr, 2008). This remains a matter of debate. Cloud computing is more immediately appealing to small and medium-sized businesses that lack resources to purchase and own their own hardware and software. However, large corporations have huge investments in complex proprietary systems supporting unique business processes, some of which give them strategic advantages. For them, the most likely scenario is a hybrid computing model where firms use their own infrastructure for their most essential core activities and adopt public cloud computing for less-critical systems or for additional processing capacity during peak business periods. Cloud computing will gradually shift firms from having a fixed infrastructure capacity toward a more flexible infrastructure, some of it owned by the firm, and some of it rented from giant computer centers owned by computer hardware vendors.

GREEN COMPUTING

By curbing hardware proliferation and power consumption, virtualization has become one of the principal technologies for promoting green computing. **Green computing** or **green IT**, refers to practices and technologies for designing, manufacturing, using, and disposing of computers, servers, and associated devices such as monitors, printers, storage devices,

and networking and communications systems to minimize impact on the environment.

Reducing computer power consumption has been a very high "green" priority. As companies deploy hundreds or thousands of servers, many are spending almost as much on electricity to power and cool their systems as they did on purchasing the hardware. The U.S. Environmental Protection Agency estimates that data centers will use more than 2 percent of all U.S. electrical power by 2011. Information technology is believed to contribute about 2 percent of the world's greenhouse gases. Cutting power consumption in data centers has become both a serious business and environmental challenge. The Interactive Session on Organizations examines this problem.

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 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.

You can glimpse a few of these capabilities in desktop systems. For instance, virus and firewall protection software are able to 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. IBM and other vendors are starting to build autonomic features into products for large systems.

HIGH-PERFORMANCE AND POWER-SAVING PROCESSORS

Another way to reduce power requirements and hardware sprawl is to use more efficient and power-saving processors. Contemporary microprocessors now feature multiple processor cores (which perform the reading and execution of computer instructions) on a single chip. A **multicore processor** is an integrated circuit to which two or more processor cores have been attached for enhanced performance, reduced power consumption, and more efficient simultaneous processing of multiple tasks. This technology enables two or more 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'll find dual-core and quad-core processors in PCs and servers with 8-, 10-, 12-, and 16-core processors.

Intel and other chip manufacturers have also developed microprocessors that minimize power consumption. Low power consumption is essential for prolonging battery life in smartphones, netbooks, and other mobile digital devices. You will now find highly power-efficient microprocessors, such as ARM, Apple's A4 processor, and Intel's Atom in netbooks, digital media players, and smartphones. The A4 processor used in the latest version of the iPhone and the iPad consumes approximately 500–800 milliwatts of power, about 1/50 to 1/30 the power consumption of a laptop dual-core processor.

INTERACTIVE SESSION: ORGANIZATIONS

IS GREEN COMPUTING GOOD FOR BUSINESS?

Computer rooms are becoming too hot to handle. Data-hungry tasks such as video on demand, downloading music, exchanging photos, and maintaining Web sites require more and more power-hungry machines. Power and cooling costs for data centers have skyrocketed by more than 800 percent since 1996, with U.S. enterprise data centers predicted to spend twice as much on energy costs as on hardware over the next five years.

The heat generated from rooms full of servers is causing equipment to fail. Some organizations spend more money to keep their data centers cool than they spend to lease the property itself. It's 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.

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 and Microsoft are building data centers that take advantage of hydroelectric power. Hewlett-Packard is working on a series of technologies to reduce the carbon footprint of data centers by 75 percent and, with new software and services, to measure energy use and carbon emissions. It reduced its power costs by 20 to 25 percent through consolidation of servers and data centers.

Microsoft's San Antonio data center deploys sensors that measure nearly all power consumption, recycles water used in cooling, and uses internally-developed power management software. Microsoft is also trying to encourage energy-saving software practices by charging business units by the amount of power they consume in the data enter rather than the space they take up on the floor.

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. And since these companies' technology and processes are more efficient than most other companies, using their online software services in place of in-house software may also count as a green investment.

PCs typically stay on more than twice the amount of time they are actually being used each day. According to a report by the Alliance to Save Energy, a company with 10,000 personal computer desktops will spend more than $165,000 per year in electricity bills if these machines are left on all night. The group estimates that this practice is wasting around $1.7 billion each year in the United States alone.

Although many companies establish default PC power management settings, about 70 percent of employees turn these settings off. PC power management software from BigFix, 1E NightWatchman, and Verdiem locks PC power settings and automatically powers PCs up right before employees arrive for work in the morning.

Miami-Dade County public schools cut the time its PCs were on from 21 hours to 10.3 hours daily by using BigFix to centrally control PC power settings. City University of New York adopted Verdiem's Surveyor software to turn off its 20,000 PCs when they are inactive at night. Surveyor has trimmed 10 percent from CUNY's power bills, creating an annual savings of around $320,000.

Virtualization is a highly effective tool for cost-effective green computing because it reduces the number of servers and storage resources in the firm's IT infrastructure. Fulton County, Georgia, which provides services for 988,000 citizens, scrutinizes energy usage when purchasing new information technology. It used VMWare virtualization software and a new Fujitsu blade server platform to consolidate underutilized legacy servers so that one machine performs the work that was formerly performed by eight, saving $44,000 per year in power costs. These efforts also created a more up-to-date IT infrastructure.

Experts note that it's important for companies to measure their energy use and inventory and track their information technology assets both before and after they start their green initiatives. Commonly used metrics used by Microsoft and other companies include Power Usage Effectiveness, Data Center Infrastructure Efficiency, and Average Data Efficiency.

It isn't always necessary to purchase new technologies to achieve "green" goals. Organizations can achieve sizable efficiencies by better managing the computing resources they already have.

Health insurer Highmark initially wanted to increase its CPU utilization by 10 percent while reducing power use by 5 percent and eventually by 10 percent. When the company inventoried all of its information technology assets, it found that its information systems staff was hanging onto "dead" servers that served no function but continued to consume power. Unfortunately, many information systems departments still aren't deploying their existing technology resources efficiently or using green measurement tools.

Programs to educate employees in energy conservation may also be necessary. In addition to using energy-monitoring tools, Honda Motor Corporation trains its data center administrators how to be more energy efficient. For example, it taught them to decommission unused equipment quickly and to use management tools to ensure servers are being optimized.

Sources: Kathleen Lao, "The Green Issue," *Computerworld Canada*, April 2010; Matthew Sarrell, "Greening Your Data Center: The Real Deal," *eWeek*, January 15, 2010; Robert L. Mitchell, "Data Center Density Hits the Wall," *Computerworld*, January 21, 2010; Jim Carlton, "The PC Goes on an Energy Diet," *The Wall Street Journal*, September 8, 2009; and Ronan Kavanagh, "IT Virtualization Helps to Go Green," *Information Management Magazine*, March 2009.

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 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. 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?
2. What are the latest trends in green computing? What kind of impact are they having?
3. What can individuals do to contribute to the green computing movement? Is the movement worthwhile?

5.4 Contemporary Software Platform Trends

There are four major themes in contemporary software platform evolution:

- Linux and open source software
- Java and Ajax
- Web services and service-oriented architecture
- Software outsourcing and cloud services

LINUX AND OPEN SOURCE SOFTWARE

Open source software is software produced by a community of several hundred thousand programmers around the world. According to the leading open source professional association, OpenSource.org, open source software is free and can be modified by users. Works derived from the original code must also be free, and the software can be redistributed by the user without additional licensing. 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 operating system.

The open source movement has been evolving for more than 30 years and has demonstrated that it can produce commercially acceptable, high-quality software. Popular open source software tools include the Linux operating system, the Apache HTTP Web server, the Mozilla Firefox Web browser, and the Oracle Open Office desktop productivity suite. Open source tools are being used on netbooks as inexpensive alternatives to Microsoft Office. Major hardware and software vendors, including IBM, HP, Dell, Oracle, and SAP, now offer Linux-compatible versions of their products. You can find out more out more about the Open Source Definition from the Open Source Initiative and the history of open source software at the Learning Tracks for this chapter.

Linux

Perhaps the most well known open source software is Linux, an operating system related to Unix. Linux was created by the Finnish programmer Linus Torvalds and first posted on the Internet in August 1991. Linux applications are embedded in cell phones, smartphones, netbooks, and consumer electronics. Linux is available in free versions downloadable from the Internet or in low-cost commercial versions that include tools and support from vendors such as Red Hat.

Although Linux is not used in many desktop systems, it is a major force in local area networks, Web servers, and high-performance computing work, with over 20 percent of the server operating system market. IBM, HP, Intel, Dell, and Oracle-Sun have made Linux a central part of their offerings to corporations.

The rise of open source software, particularly Linux and the applications it supports, has profound implications for corporate software platforms: cost reduction, reliability and resilience, and integration, because Linux works on all the major hardware platforms from mainframes to servers to clients.

SOFTWARE FOR THE WEB: JAVA AND AJAX

Java is an operating system-independent, processor-independent, object-oriented programming language that has become the leading interactive environment for the Web. Java was created by James Gosling and the Green Team at Sun Microsystems in 1992. In November 13, 2006, Sun released much of Java as open source software under the terms of the GNU General Public License (GPL), completing the process on May 8, 2007.

The Java platform has migrated into cellular phones, smartphones, automobiles, music players, game machines, and finally, into set-top cable television systems serving interactive content and pay-per-view services. Java software is designed to run on any computer or computing device, regardless of the specific microprocessor or operating system the device uses. For each of the computing environments in which Java is used, Sun created a Java Virtual Machine that interprets Java programming code for that machine. In this manner, the code is written once and can be used on any machine for which there exists a Java Virtual Machine.

Java developers can create small applet programs that can be embedded in Web pages and downloaded to run on a Web browser. A **Web browser** is an easy-to-use software tool with a graphical user interface for displaying Web pages and for accessing the Web and other Internet resources. Microsoft's Internet Explorer, Mozilla Firefox, and Google Chrome browser are examples. At the enterprise level, Java is being used for more complex e-commerce and

e-business applications that require communication with an organization's back-end transaction processing systems.

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.

WEB SERVICES AND SERVICE-ORIENTED ARCHITECTURE

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 hypertext markup language (HTML) for Web pages. **Hypertext Markup Language (HTML)** is a page description language for specifying how text, graphics, video, and sound are placed on a Web page document. 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 5-2 illustrates some sample XML statements.

TABLE 5-2 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.

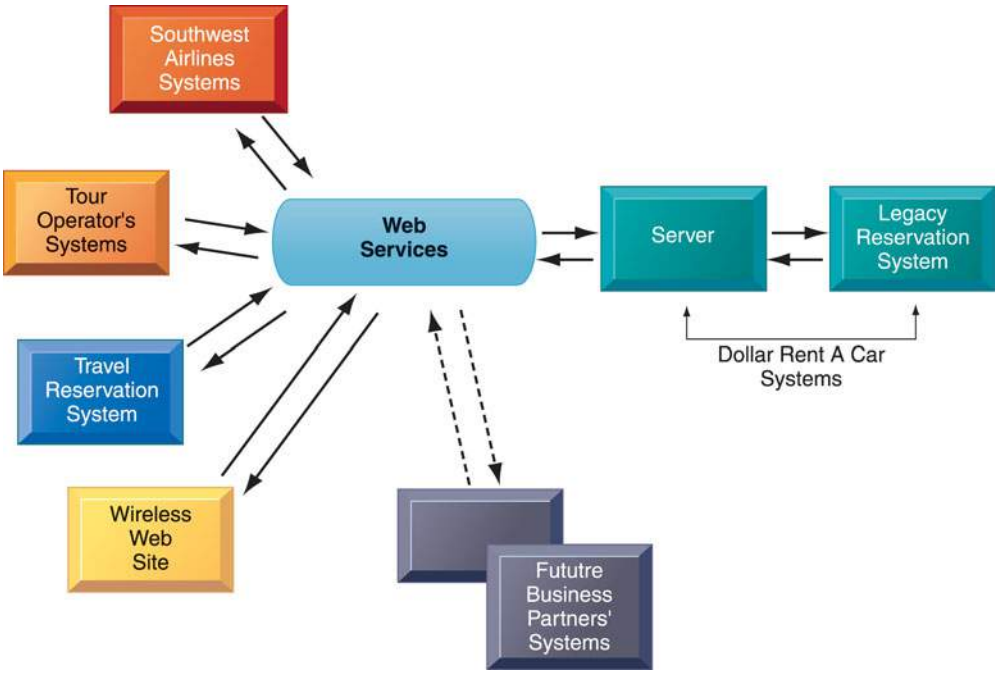
The collection of Web services that are used to build a firm's software systems constitutes what is known as a service-oriented architecture. A **service-oriented architecture (SOA)** is set of self-contained services that communicate with each other to create a working software application. Business 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 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 for its online booking system with Southwest Airlines' 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 cell phones and smartphones. It does not have to write new software code for each new partner's information systems or each new wireless device (see Figure 5-10).

FIGURE 5-10 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 OUTSOURCING AND CLOUD SERVICES

Today many business firms continue to operate legacy systems that continue to meet a business need and that would be extremely costly to replace. But they will purchase or rent most of their new software applications from external sources. Figure 5-11 illustrates the rapid growth in external sources of software for U.S. firms.

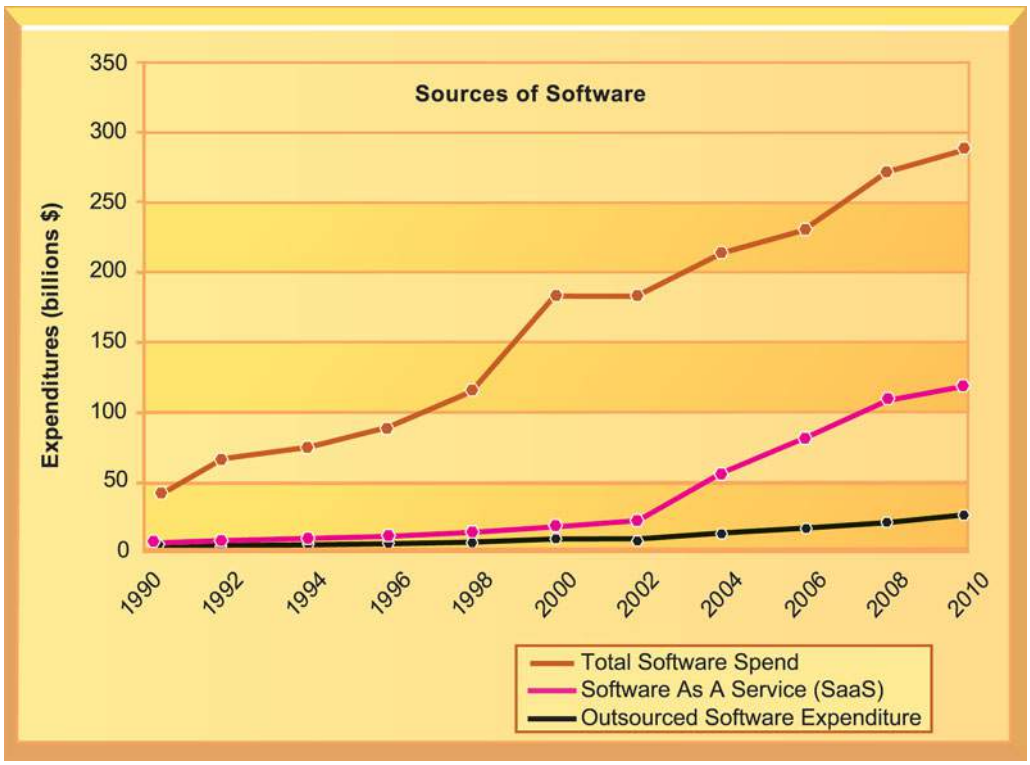
There are three external sources for software: software packages from a commercial software vendor, outsourcing custom application development to an external vendor, and cloud-based software services and tools.

Software Packages and Enterprise Software

We have already described software packages for enterprise applications as one of the major types of software components in contemporary IT infrastructures. A **software package** is a prewritten commercially available set of software programs that eliminates the need for a firm to write its own software programs for certain functions, such as payroll processing or order handling.

Enterprise application software vendors such as SAP and Oracle-PeopleSoft have developed powerful software packages that can support the primary business processes of a firm worldwide from warehousing, customer relationship management, supply chain management, and finance to human resources. These large-scale enterprise software systems provide a single, integrated, worldwide software system for firms at a cost much less than they would pay if they developed it themselves. Chapter 9 discusses enterprise systems in detail.

FIGURE 5-11 CHANGING SOURCES OF FIRM SOFTWARE



In 2010, U.S. firms will spend over $291 billion on software. About 40 percent of that ($116 billion) will originate outside the firm, either from enterprise software vendors selling firmwide applications or individual application service providers leasing or selling software modules. Another 10 percent ($29 billion) will be provided by SaaS vendors as an online cloud-based service.

Sources: BEA National Income and Product Accounts, 2010; Gartner Group, 2010; author estimates.

Software Outsourcing

Software **outsourcing** enables a firm to contract custom software development or maintenance of existing legacy programs to outside firms, which often operate offshore in low-wage areas of the world. According to the industry analysts, 2010 offshore outsourcing revenues in the United States will be approximately $50 billion, and domestic outsourcing revenues will be $106 billion (Lohr, 2009). The largest expenditure here is paid to domestic U.S. firms providing middleware, integration services, and other software support that are often required to operate larger enterprise systems.

For example, in March 2008, Royal Dutch Shell PLC, the world's third largest oil producer, signed a five-year, $4 billion outsourcing deal with T-Systems International GmbH, AT&T, and Electronic Data Systems (EDS). The agreement assigned AT&T responsibility for networking and telecommunications, T-Systems for hosting and storage, and EDS for end-user computing services and for integration of the infrastructure services. Outsourcing this work has helped Shell cut costs and focus on systems that improve its competitive position in the oil and gas market.

Offshore outsourcing firms have primarily provided lower-level maintenance, data entry, and call center operations. However, with the growing sophistication and experience of offshore firms, particularly in India, more and more new-program development is taking place offshore. Chapter 13 discusses offshore software outsourcing in greater detail.

Cloud-Based Software Services and Tools

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're more likely to download the software from the vendor's Web site, or to use the software as a cloud service delivered over the Internet.

Cloud-based software and the data it uses are hosted on powerful servers in massive data centers, and can be accessed with an Internet connection and standard Web browser. 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, described in the chapter-ending case study, which provides on-demand software services for customer relationship management.

In order to manage their relationship with an outsourcer or technology service provider, firms 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. We provide a Learning Track on this topic.

Mashups and Apps

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. 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. You have performed a mashup if you've ever personalized your Facebook profile or your blog with a capability to display videos or slide shows.

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. For instance, EveryBlock Chicago 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 Map. Amazon uses mashup technologies to aggregate product descriptions with partner sites and user profiles.

Apps are small pieces of software that run on the Internet, on your computer, or on your cell phone and are generally delivered over the Internet. Google refers to its online services as apps, including the Google Apps suite of desktop productivity tools. But when we talk about apps today, most of the attention goes to the apps that have been developed for the mobile digital platform. It is these apps that turn smartphones and other mobile handheld devices into general-purpose computing tools.

Most of these apps are for the iPhone, Android, and BlackBerry operating system platforms. Many are free or purchased for a small charge, much less

than conventional software. There are already over 250,000 apps for the Apple iPhone and iPad platform and over 80,000 that run on smartphones using Google's Android operating system. The success of these mobile platforms depends in large part on the quantity and the quality of the apps they provide. Apps tie the customer to a specific hardware platform: As the user adds more and more apps to his or her mobile phone, the cost of switching to a competing mobile platform rises.

At the moment, the most commonly downloaded apps are games (65%), followed by news and weather (56%), maps/navigation (55%), social networking (54%), music (46%), and video/movies (25%). But there are also serious apps for business users that make it possible to create and edit documents, connect to corporate systems, schedule and participate in meetings, track shipments, and dictate voice messages (see the Chapter 1 Interactive Session on Management). There are also a huge number of e-commerce apps for researching and buying goods and services online.

5.5 Management Issues

Creating and managing a coherent IT infrastructure raises multiple challenges: dealing with platform and technology change (including cloud and mobile computing), management and governance, and making wise infrastructure investments.

DEALING WITH PLATFORM AND INFRASTRUCTURE CHANGE

As firms grow, they often quickly outgrow their infrastructure. As firms shrink, they can get stuck with excessive infrastructure purchased in better times. How can a firm remain flexible when most of the investments in IT infrastructure are fixed-cost purchases and licenses? How well does the infrastructure scale? **Scalability** refers to the ability of a computer, product, or system to expand to serve a large number of users without breaking down. New applications, mergers and acquisitions, and changes in business volume all impact computer workload and must be considered when planning hardware capacity.

Firms using mobile computing and cloud computing platforms will require new policies and procedures for managing these platforms. They will need to inventory all of their mobile devices in business use and develop policies and tools for tracking, updating, and securing them and for controlling the data and applications that run on them. Firms using cloud computing and SaaS will need to fashion new contractual arrangements with remote vendors to make sure that the hardware and software for critical applications are always available when needed and that they meet corporate standards for information security. It is up to business management 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.

MANAGEMENT AND GOVERNANCE

A long-standing issue among information system managers and CEOs has been the question of who will control and manage the firm's IT infrastructure. Chapter 2 introduced the concept of IT governance and described some issues

it addresses. Other important questions about IT governance are: Should departments and divisions have the responsibility of making their own information technology decisions or should IT infrastructure be centrally controlled and managed? What is the relationship between central information systems management and business unit information systems management? How will infrastructure costs be allocated among business units? Each organization will need to arrive at answers based on its own needs.

MAKING WISE INFRASTRUCTURE INVESTMENTS

IT infrastructure is a major investment for the firm. If too much is spent on infrastructure, it lies idle and constitutes a drag on firm financial performance. If too little is spent, important business services cannot be delivered and the firm's competitors (who spent just the right amount) will outperform the underinvesting firm. How much should the firm spend on infrastructure? This question is not easy to answer.

A related question is whether a firm should purchase and maintain its own IT infrastructure components or rent them from external suppliers, including those offering cloud services. The decision either to purchase your own IT assets or rent them from external providers is typically called the *rent-versus-buy* decision.

Cloud computing may be a low-cost way to increase scalability and flexibility, but firms should evaluate this option carefully in light of security requirements and impact on business processes and work flows. In some instances, the cost of renting software adds up to more than purchasing and maintaining an application in-house. Yet there may be benefits to using SaaS if it allows the company to focus on core business issues instead of technology challenges.

Total Cost of Ownership of Technology Assets

The actual cost of owning technology resources includes the original cost of acquiring and installing hardware and software, as well as ongoing administration costs for hardware and software upgrades, maintenance, technical support, training, and even utility and real estate costs for running and housing the technology. The **total cost of ownership (TCO)** model can be used to analyze these direct and indirect costs to help firms determine the actual cost of specific technology implementations. Table 5-3 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. Although the purchase price of a wireless handheld for a corporate employee may run several hundred dollars, the TCO for each device is much higher, ranging from $1,000 to $3,000, according to various consultant estimates. Gains in productivity and efficiency from equipping employees with mobile computing devices must be balanced against increased costs from integrating these devices into the firm's IT infrastructure and from providing technical support. Other cost components include fees for wireless airtime, end-user training, help desk support, and software for special applications. Costs are higher if the mobile devices run many different applications or need to be integrated into back-end systems such as enterprise applications.

Hardware and software acquisition costs account for only about 20 percent of TCO, so managers must pay close attention to administration costs to understand the full cost of the firm's hardware and software. It is possible to reduce some of these administration costs through better management. Many large firms are

TABLE 5-3 TOTAL COST OF OWNERSHIP (TCO) COST COMPONENTS

INFRASTRUCTURE COMPONENT	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 for 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	Cost of 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

saddled with redundant, incompatible hardware and software because their departments and divisions have been allowed to make their own technology purchases.

In addition to switching to cloud services, 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 minimizes the number of different computer models and pieces of software that employees are allowed to use. In a centralized infrastructure, systems can be administered from a central location and troubleshooting can be performed from that location.

Competitive Forces Model for IT Infrastructure Investment

Figure 5-12 illustrates a competitive forces model you can use to address the question of how much your firm should spend on IT infrastructure.

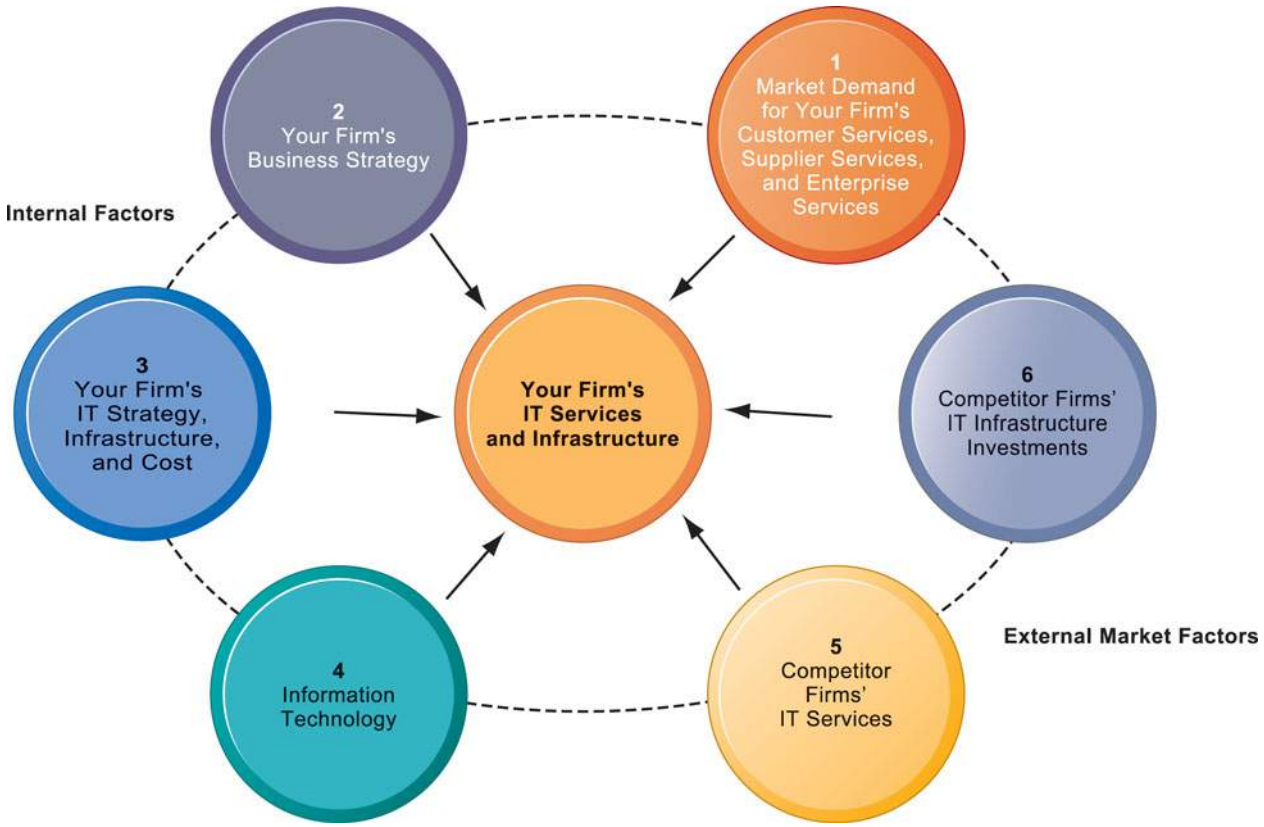
Market demand for your firm's services. Make an inventory of the services you currently provide to customers, suppliers, and employees. Survey each group, or hold focus groups to find out if the services you currently offer are meeting the needs of each group. For example, are customers complaining of slow responses to their queries about price and availability? Are employees complaining about the difficulty of finding the right information for their jobs? Are suppliers complaining about the difficulties of discovering your production requirements?

Your firm's business strategy. Analyze your firm's five-year business strategy and try to assess what new services and capabilities will be required to achieve strategic goals.

Your firm's IT strategy, infrastructure, and cost. Examine your firm's information technology plans for the next five years and assess its alignment with the firm's business plans. Determine the total IT infrastructure costs. You will want to perform a TCO analysis. If your firm has no IT strategy, you will need to devise one that takes into account the firm's five-year strategic plan.

Information technology assessment. Is your firm behind the technology curve or at the bleeding edge of information technology? Both situations are to be avoided. It is usually not desirable to spend resources on advanced technolo-

FIGURE 5-12 COMPETITIVE FORCES MODEL FOR IT INFRASTRUCTURE



There are six factors you can use to answer the question, "How much should our firm spend on IT infrastructure?"

gies that are still experimental, often expensive, and sometimes unreliable. You want to spend on technologies for which standards have been established and IT vendors are competing on cost, not design, and where there are multiple suppliers. However, you do not want to put off investment in new technologies or allow competitors to develop new business models and capabilities based on the new technologies.

Competitor firm services. Try to assess what technology services competitors offer to customers, suppliers, and employees. Establish quantitative and qualitative measures to compare them to those of your firm. If your firm's service levels fall short, your company is at a competitive disadvantage. Look for ways your firm can excel at service levels.

Competitor firm IT infrastructure investments. Benchmark your expenditures for IT infrastructure against your competitors. Many companies are quite public about their innovative expenditures on IT. If competing firms try to keep IT expenditures secret, you may be able to find IT investment information in public companies' SEC Form 10-K annual reports to the federal government when those expenditures impact a firm's financial results.

Your firm does not necessarily need to spend as much as, or more than, your competitors. Perhaps it has discovered much less-expensive ways of providing services, and this can lead to a cost advantage. Alternatively, your firm may be spending far less than competitors and experiencing commensurate poor performance and losing market share.

5.6 Hands-on MIS Projects

The projects in this section give you hands-on experience in developing solutions for managing IT infrastructures and IT outsourcing, using spreadsheet software to evaluate alternative desktop systems, and using Web research to budget for a sales conference.

Management Decision Problems

1. The University of Pittsburgh Medical Center (UPMC) relies on information systems to operate 19 hospitals, a network of other care sites, and international and commercial ventures. Demand for additional servers and storage technology was growing by 20 percent each year. 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 HP, Sun Microsystems, Microsoft, and IBM. Assess the impact of this situation on business performance. What factors and management decisions must be considered when developing a solution to this problem?
2. Qantas Airways, Australia's leading airline, faces cost pressures from high fuel prices and lower levels of global airline traffic. To remain competitive, the airline must find ways to keep costs low while providing a high level of customer service. Qantas had a 30-year-old data center. Management had to decide whether to replace its IT infrastructure with newer technology or outsource it. Should Qantas outsource to a cloud computing vendor? What factors should be considered by Qantas management when deciding whether to outsource? If Qantas decides to outsource, list and describe points that should be addressed in a service level agreement.

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 desktop systems, printers, and software.

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 desktop printers manufactured by HP, Canon, and Dell. Each desktop system must satisfy the minimum specifications shown in the following table:

Minimum Desktop Specifications	
Processor speed	3 GHz
Hard drive	350 GB
RAM	3 GB
DVD-ROM drive	16 x
Monitor (diagonal measurement)	18 inches

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

Minimum Monochrome Printer Specifications	
Print speed (black and white)	20 pages per minute
Print resolution	600 × 600
Network ready?	Yes
Maximum price/unit	$700

After pricing the desktop systems and printers, obtain pricing on 30 copies of the most recent versions of Microsoft Office, Lotus SmartSuite, and Oracle Open Office desktop productivity packages, and on 30 copies of Microsoft Windows 7 Professional. The application software suite packages come in various versions, so be sure that each package contains programs for word processing, spreadsheets, database, and presentations.

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

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 15–16, starting with a reception on the evening of October 14. The conference consists of all-day meetings that the entire sales force, numbering 125 sales representatives and their 16 managers, must attend. Each sales representative requires his or her own room, and the company needs two common meeting rooms, one large enough to hold the entire sales force plus visitors (200 total) and the other able to hold half the force. Management has set a budget of $120,000 for the representatives' room rentals. The hotel must also have such services as overhead and computer projectors as well as business center and banquet facilities. It also should have facilities for the company reps to be able to 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.

Visit the two sites' homepages, 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 Track Modules

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

1. How Computer Hardware and Software Work
2. Service Level Agreements
3. The Open Source Software Initiative
4. Comparing Stages in IT Infrastructure Evolution
5. Cloud Computing

Review Summary

1. *What is IT infrastructure and what are its components?*

   IT infrastructure is the shared technology resources that provide the platform for the firm's specific information system applications. IT infrastructure includes hardware, software, and services that are shared across the entire firm. Major IT infrastructure components include computer hardware platforms, operating system platforms, enterprise software platforms, networking and telecommunications platforms, database management software, Internet platforms, and consulting services and systems integrators.

2. *What are the stages and technology drivers of IT infrastructure evolution?*

   The five stages of IT infrastructure evolution are: the mainframe era, the personal computer era, the client/server era, the enterprise computing era, and the cloud and mobile computing era. Moore's Law deals with the exponential increase in processing power and decline in the cost of computer technology, stating that every 18 months the power of microprocessors doubles and the price of computing falls in half. The Law of Mass Digital Storage deals with the exponential decrease in the cost of storing data, stating that the number of kilobytes of data that can be stored on magnetic media for $1 roughly doubles every 15 months. Metcalfe's Law helps shows that a network's value to participants grows exponentially as the network takes on more members. Also driving exploding computer use is the rapid decline in costs of communication and growing agreement in the technology industry to use computing and communications standards.

3. *What are the current trends in computer hardware platforms?*

   Increasingly, computing is taking place on a mobile digital platform. Grid computing involves connecting geographically remote computers into a single network to create a computational grid that combines the computing power of all the computers on the network. Virtualization organizes computing resources so that their use is not restricted by physical configuration or geographic location. In cloud computing, firms and individuals obtain computing power and software as services over a network, including the Internet, rather than purchasing and installing the hardware and software on their own computers. A multicore processor is a microprocessor to which two or more processing cores have been attached for enhanced performance. Green computing includes practices and technologies for producing, using, and disposing of information technology hardware to minimize negative impact on the environment. In autonomic computing, computer systems have capabilities for automatically configuring and repairing themselves. Power-saving processors dramatically reduce power consumption in mobile digital devices.

4. *What are the current trends in software platforms?*

   Open source software is produced and maintained by a global community of programmers and is often downloadable for free. Linux is a powerful, resilient open source operating system that can run on multiple hardware platforms and is used widely to run Web servers. Java is an operating-system– and hardware-independent programming language that is the leading interactive programming environment for the Web. Web services are loosely coupled software components based on open Web

standards that 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. Companies are purchasing their new software applications from outside sources, including software packages, by outsourcing custom application development to an external vendor (that may be offshore), or by renting online software services (SaaS). Mashups combine two different software services to create new software applications and services. Apps are small pieces of software that run on the Internet, on a computer, or on a mobile phone and are generally delivered over the Internet.

5. *What are the challenges of managing IT infrastructure and management solutions?*

   Major challenges include dealing with platform and infrastructure change, infrastructure management and governance, and making wise infrastructure investments. Solution guidelines include using a competitive forces model to determine how much to spend on IT infrastructure and where to make strategic infrastructure investments, and establishing the total cost of ownership (TCO) of information technology assets. The total cost of owning technology resources includes not only the original cost of computer hardware and software but also costs for hardware and software upgrades, maintenance, technical support, and training.

Key Terms

Ajax, 189
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Review Questions

1. What is IT infrastructure and what are its components?
   - Define IT infrastructure from both a technology and a services perspective.
   - List and describe the components of IT infrastructure that firms need to manage.
2. What are the stages and technology drivers of IT infrastructure evolution?
   - List each of the eras in IT infrastructure evolution and describe its distinguishing characteristics.
   - Define and describe the following: Web server, application server, multitiered client/server architecture.
   - Describe Moore's Law and the Law of Mass Digital Storage.
   - Describe how network economics, declining communications costs, and technology standards affect IT infrastructure.
3. What are the current trends in computer hardware platforms?
   - Describe the evolving mobile platform, grid computing, and cloud computing.
   - Explain how businesses can benefit from autonomic computing, virtualization, green computing, and multicore processors.
4. What are the current trends in software platforms?
   - Define and describe open source software and Linux and explain their business benefits.
   - Define Java and Ajax and explain why they are important.
   - Define and describe Web services and the role played by XML.
   - Name and describe the three external sources for software.
   - Define and describe software mashups and apps.
5. What are the challenges of managing IT infrastructure and management solutions?
   - Name and describe the management challenges posed by IT infrastructure.
   - Explain how using a competitive forces model and calculating the TCO of technology assets help firms make good infrastructure investments.

Discussion Questions

1. Why is selecting computer hardware and software for the organization an important management decision? What management, organization, and technology issues should be considered when selecting computer hardware and software?
2. Should organizations use software service providers for all their software needs? Why or why not? What management, organization, and technology factors should be considered when making this decision?
3. What are the advantages and disadvantages of cloud computing?

Video Cases

Video Cases and Instructional Videos illustrating some of the concepts in this chapter are available. Contact your instructor to access these videos.

Collaboration and Teamwork: Evaluating Server and Mobile Operating Systems

Form a group with three or four of your classmates. Choose server or mobile operating systems to evaluate. You might research and compare the capabilities and costs of Linux versus the most recent version of the Windows operating system or Unix. Alternatively, you could compare the capabilities of the Android mobile operating system with the most recent version of the iPhone operating system (iOS). If possible, use Google Sites to post links to Web pages, team communication announcements, and work assignments; to brainstorm; and to work collaboratively on project documents. Try to use Google Docs to develop a presentation of your findings for the class.

Salesforce.Com: Cloud Services Go Mainstream

CASE STUDY

Salesforce.com, one of the most disruptive technology companies of the past few years, has single-handedly shaken up the software industry with its innovative business model and resounding success. Salesforce provides customer relationship management (CRM) and other application software solutions in the form of software as a service leased over the Internet, as opposed to software bought and installed on machines locally.

The company was founded in 1999 by former Oracle executive Marc Benioff, and has since grown to over 3,900 employees, 82,400 corporate customers, and 2.1 million subscribers. It earned $1.3 billion in revenue in 2009, making it one of the top 50 software companies in the world. Salesforce attributes its success to the many benefits of its on-demand model of software distribution.

The on-demand model eliminates the need for large up-front hardware and software investments in systems and lengthy implementations on corporate computers. Subscriptions start as low as $9 per user per month for the pared-down Group version for small sales and marketing teams, with monthly subscriptions for more advanced versions for large enterprises starting around $65 per user.

For example, the Minneapolis-based Haagen-Dazs Shoppe owned by Nestle USA calculated it would have had to spend $65,000 for a custom-designed database to help management stay in contact with the company's retail franchises. The company only had to pay $20,000 to establish service with Salesforce, plus a monthly charge of $125 per month for 20 users to use wireless handhelds or the Web to remotely monitor all the Haagen-Dazs franchises across the United States.

Salesforce.com implementations take three months at the longest, and usually less than a month. There is no hardware for subscribers to purchase, scale, and maintain. There are no operating systems, database servers, or application servers to install, no consultants and staff, and no expensive licensing and maintenance fees. The system is accessible via a standard Web browser, with some functions accessible by mobile handheld devices. Salesforce.com continually updates its software behind the scenes. There are tools for customizing some features of the software to support a company's unique business processes. Subscribers can leave if business turns sour or a better system comes along. If they lay people off, they can cut down on the number of Salesforce subscriptions they buy.

Salesforce faces significant challenges as it continues to grow and refine its business. The first challenge comes from increased competition, both from traditional industry leaders and new challengers hoping to replicate Salesforce's success. Microsoft, SAP, and Oracle have rolled out subscription-based versions of their CRM products in response to Salesforce. Smaller competitors like NetSuite, Salesboom.com, and RightNow also have made some inroads against Salesforce's market share.

Salesforce still has plenty of catching up to do to reach the size and market share of its larger competitors. As recently as 2007, SAP's market share was nearly four times as large as Salesforce's, and IBM's customer base includes 9,000 software companies that run their applications on their software and that are likelier to choose a solution offered by IBM over Salesforce.

Salesforce needs to continually prove to customers that it is reliable and secure enough to remotely handle their corporate data and applications. The company has experienced a number of service outages. For example, on January 6, 2009, a core network device failed and prevented data in Europe, Japan, and North America from being processed for 38 minutes. Over 177 million transactions were affected. While most of Salesforce's customers accept that IT services provided through the cloud are going to be available slightly less than full time, some customers and critics used the outage as an opportunity to question the soundness of the entire concept of cloud computing. In February 2009, a similar outage occurred, affecting Europe and as well as North America a few hours later.

Thus far, Salesforce has experienced only one security breach. In November 2007, a Salesforce employee was tricked into divulging his corporate password to scammers, exposing Salesforce's customer list. Salesforce clients were subjected to a barrage of highly targeted scams and hacking attempts that appeared authentic. Although this incident raised a red flag, many customers reported that Salesforce's handling of the situation was satisfactory. All of Salesforce's major customers

regularly send auditors to Salesforce to check security.

Another challenge for Salesforce is to expand its business model into other areas. Salesforce is currently used mostly by sales staff needing to keep track of leads and customer lists. One way the company is trying to provide additional functionality is through a partnership with Google and more specifically Google Apps. Salesforce is combining its services with Gmail, Google Docs, Google Talk, and Google Calendar to allow its customers to accomplish more tasks via the Web. Salesforce and Google both hope that their Salesforce.com for Google Apps initiative will galvanize further growth in on-demand software.

Salesforce has also partnered with Apple to distribute its applications for use on the iPhone. The company hopes that it can tap into the large market of iPhone users, pitching the ability to use Salesforce applications any time, anywhere. And Salesforce introduced a development tool for integrating with Facebook's social network to enable customers to build applications that call functions at the Facebook site. (In early 2010, Salesforce introduced its own social networking application called Chatter, which enables employees to create profiles and make status updates that appear in colleagues' news feeds, similar to Facebook and Twitter.)

In order to grow its revenues to the levels that industry observers and Wall Street eventually expects Salesforce is changing its focus from selling a suite of software applications to providing a broader cloud computing "platform" on which many software companies deliver applications. As CEO Marc Benioff put it, over the past decade, "we focused on software as a service…In the next decade, Salesforce.com will really be focused on the platform as a service."

The company has intensified its efforts to provide cloud computing offerings to its customers. The new Salesforce.com Web site places much more emphasis on cloud computing, grouping products into three types of clouds: the Sales Cloud, the Service Cloud, and the Custom Cloud. The Sales and Service clouds consist of applications meant to improve sales and customer service, respectively, but the Custom Cloud is another name for the Force.com application development platform, where customers can develop their own applications for use within the broader Salesforce network.

Force.com provides a set of development tools and IT services that enable users to customize their Salesforce customer relationship management applications or to build entirely new applications and run them "in the cloud" on Salesforce's data center infrastructure. Salesforce opened up Force.com to other independent software developers and listed their programs on its AppExchange.

Using AppExchange, small businesses can go online and easily download over 950 software applications, some add-ons to Salesforce.com and others that are unrelated, even in non-customer-facing functions such as human resources. Force.com Sites, based on the Force.com development environment, enables users to develop Web pages and register domain names. Pricing is based on site traffic.

Salesforce's cloud infrastructure includes two data centers in the United States and a third in Singapore, with others in Europe and Japan planned for the future. Salesforce has additionally partnered with Amazon to enable Force.com customers to tap into Amazon's cloud computing services (Elastic Compute Cloud and Simple Storage Service.) Amazon's services would handle the "cloudburst computing" tasks of Force.com applications that require extra processing power or storage capacity.

An International Data Center (IDC) report estimated that the Force.com platform enables users to build and run business applications and Web sites five times faster and at half the cost of non-cloud alternatives. For instance, RehabCare, a national provider of medical rehabilitation services, used Force.com to build a mobile iPhone patient admission application for clinicians. RehabCare's information systems team built a prototype application within four days that runs on the Force.com platform. It would have taken six months to build a similar mobile application using Microsoft development tools. About 400 clinicians now use the app.

Author Solutions, a self-publishing company based in Bloomington, Minnesota, uses the Force.com platform to host the applications driving its operations. It reports saving up to 75 percent from not having to maintain and manage its own data center, e-commerce, and workflow applications, and the ability to scale as it business mushroomed. Workflow modifications that once took 30 to 120 hours are accomplished in one-fourth the time. The time and cost for adding a new product, which used to take 120 to 240 hours (and cost $6,000 to $12,000) has been reduced by 75 percent. The new platform is able to handle 30 percent more work volume than the old systems with the same number of employees.

The question is whether the audience for Salesforce's AppExchange and Force.com platforms will prove large enough to deliver the level of growth Salesforce wants. It still isn't clear whether the

company will generate the revenue it needs to provide cloud computing services on the same scale as Google or Amazon and also make its cloud computing investments pay off.

Some analysts believe the platform may not be attractive to larger companies for their application needs. Yet another challenge is providing constant availability. Salesforce.com subscribers depend on the service being available 24/7. But thanks to the previously described outages, many companies have rethought their dependency on software as a service. Salesforce.com provides tools to assure customers about its system reliability and also offers PC applications that tie into their services so users can work offline.

Still, a number of companies are reluctant to jump on the SaaS and cloud computing bandwagon. Moreover, it is still not clear whether software delivered over the Web will cost less in the long run. According to Gartner consultants analyst Rob DiSisto, it may be cheaper to subscribe to Salesforce.com's software services for the first few years, but what happens after that? Will the expense of upgrading and managing on-demand software become higher than the fees companies are paying to own and host their own software?

Sources: "How Salesforce.com Brings Success to the Cloud," *IT BusinessEdge.com*, accessed June 10, 2010; Lauren McKay, "Salesforce.com Extends Chatter Across the Cloud," *CRM Magazine*, April 14, 2010; Jeff Cogswell, "Salesforce.com Assembles an Array of Development Tools for Force.com," *eWeek*, February 15, 2010; Mary Hayes Weier, "Why Force.com Is Important to Cloud Computing," *Information Week*, November 23, 2009; Jessi Hempel, "Salesforce Hits Stride," CNN Money.com, March 2, 2009; Clint Boulton, "Salesforce.com Network Device Failure Shuts Thousands Out of SaaS Apps," *eWeek*, January 7, 2009; J. Nicholas Hoover, "Service Outages Force Cloud Adopters to Rethink Tactics," *Information Week*, August 18/25, 2008; and Charles Babcock, "Salesforce Ascends Beyond Software As Service," *Information Week,* November 10, 2008.

CASE STUDY QUESTIONS

1. How does Salesforce.com use cloud computing?
2. What are some of the challenges facing Salesforce as it continues its growth? How well will it be able to meet those challenges?
3. What kinds of businesses could benefit from switching to Salesforce and why?
4. What factors would you take into account in deciding whether to use Saleforce.com for your business?
5. Could a company run its entire business using Salesforce.com, Force.com, and App Exchange? Explain your answer.