1. Describe the problems that modern information technology departments face.
2. Describe the key characteristics and advantages of cloud computing.
3. Identify a use-case-scenario for each of the four types of clouds.
4. Explain the operational model of each of the three types of cloud services.
5. Identify the key benefits of cloud computing.
6. Discuss the concerns and risks associated with cloud computing.
7. Explain the role of Web services in building a firm’s IT applications, providing examples.

**TG 3.1** Introduction
**TG 3.2** What Is Cloud Computing?
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Because the overall goal of this book is for you to be an informed user of information technology, we devote this Technology Guide to a vital and cutting-edge topic: cloud computing. A working knowledge of cloud computing will enhance your appreciation of what technology can and cannot do for a business. In addition, it will enable you to make an immediate contribution by analyzing how your organization manages its information technology assets.

Going further, you will be using these computing resources in your career, and you will have input into decisions about how your department and organization can best utilize them. Additionally, cloud computing can be extremely valuable if you decide to start your own business.

This Technology Guide defines cloud computing as a type of computing that delivers convenient, on-demand, pay-as-you-go access for multiple customers to a shared pool of configurable computing resources (e.g., servers, networks, storage, applications, and services) that can be rapidly and easily accessed over the Internet. Cloud computing allows customers to acquire resources at any time and then delete them the instant they are no longer needed. We present many examples of how the cloud can be used for business purposes. In addition, the cloud provides you with personal applications. Therefore, this guide can help you plan for your own use of the cloud. For a more detailed discussion of how you can utilize the cloud, see the section titled IT’s Personal: “The Cloud.”

Introduction

You were introduced to the concept of IT infrastructure in Chapter 1. Recall that an organization’s IT infrastructure consists of IT components—hardware, software, networks, and databases—and IT services—developing information systems, managing security and risk, and managing data. (It is helpful to review Figure 1.3 here.) The organization’s IT infrastructure is the foundation for all of the information systems that the organization uses.

Modern IT infrastructure has evolved through several stages since the early 1950s, when firms first began to apply information technology to business applications. These stages are as follows:

• Stand-alone mainframes. Organizations initially used mainframe computers in their engineering and accounting departments. The mainframe was typically housed in a secure area and only MIS personnel had access to it.
• **Mainframe and dumb terminals.** Forcing users to go to wherever the mainframe was located was time-consuming and inefficient. As a result, firms began placing so-called dumb terminals—essentially electronic typewriters with little processing power—in user departments. This arrangement enabled users to input computer programs into the mainframe from their departments, a process called *remote job entry*.

• **Stand-alone personal computers.** In the late 1970s, the first personal computers appeared. The IBM PC’s debut in 1981 legitimized the entire personal computer market. Users began bringing personal computers to the workplace to improve their productivity—for example, by using spreadsheet and word processing applications. These computers were not initially supported by the firm’s MIS department. However, as the number of personal computers increased dramatically, organizations decided to support personal computers, and they established policies as to which personal computers and software they would support.

• **Local area networks (client/server computing).** When personal computers are networked, individual productivity is substantially increased. For this reason, organizations began to connect personal computers into local area networks (LANs) and then connect these LANs to the mainframe, a type of processing known as *client/server computing*.

• **Enterprise computing.** In the early 1990s, organizations began to use networking standards to integrate different kinds of networks throughout the firm, thereby creating enterprise computing. As the Internet became widespread after 1995, organizations began using the TCP/IP networking protocol to integrate different types of networks. All types of hardware were networked, from mainframes to personal computers to smartphones. Software applications and data could now flow seamlessly throughout the enterprise and between and among organizations.

• **Cloud computing and mobile computing.** Today, organizations and individuals can use the power of cloud computing. As you will see in this Technology Guide, cloud computing provides access to a shared pool of computing resources, including computers, storage, applications, and services, over a network, typically the Internet.

Keep in mind that the computing resources in each stage can be cumulative. For instance, most large firms still use mainframe computers (in addition to all the other types of computing resources) as large servers to manage operations that involve millions of transactions per day. As you have seen from the evolution of IT infrastructures, the world is experiencing a digital and mobile transformation, with more information becoming available more quickly from more sources than ever before. As a result, businesspeople need IT-enabled services to help them handle this transformation and envision new opportunities.

To appreciate the transformation effects of cloud computing, you first need to understand traditional IT departments in organizations and the problems they face. Today, most companies own IT infrastructure (their software, hardware, networks, and data management) and maintain them “on premise” in their data centers. On-premise software, then, is the traditional model of the IT function in organizations.

Traditional IT departments spend huge amounts on both IT infrastructure and the expert staffs they need to build and maintain complex IT systems. These expenses include software licenses, hardware, and staff training and salaries. Despite all of this spending, however, organizations typically do not use their infrastructure to its full capacity. The majority of these expenses are typically applied to maintaining the existing IT infrastructure, with the remainder being allocated to developing new systems. In addition, companies are being buried under vast amounts of data (which you learned about in Chapter 5). Traditional IT departments are struggling to capture, store, manage, and analyze all of these data. As a result of these problems, traditional IT infrastructures can actually inhibit an organization’s ability to respond quickly and appropriately to today’s rapidly changing business environments.

Large organizations can afford comprehensive enterprise software and top IT talent. These companies can buy or build software and install these systems in their data centers. They can enable their applications to be used on different devices—desktops, laptops, tablets, and smartphones—and make them accessible to employees regardless of their location. These companies can also make their applications available to people outside the organization, such as consultants, contractors,
suppliers, customers, and other business partners. These capabilities, however, come with huge costs. In addition, the companies’ IT departments are often overtaxed and unable to execute all of these functions effectively. This problem is even more acute for smaller organizations, which typically do not have the resources required to execute these functions.

As you will see in the next section, cloud computing can help organizations manage the problems that traditional IT departments face. The next section defines cloud computing and describes its essential characteristics.

What Is Cloud Computing?

Information technology departments have always been tasked to deliver useful IT applications to business users. For a variety of reasons, today’s IT departments are facing increased challenges in delivering useful applications. As you learn about cloud computing, you will see how it can help organizations manage the problems that occur in traditional IT departments. You will also see why so many organizations are utilizing cloud computing. A 2012 survey conducted by the Open Data Center Alliance—which includes companies such as Lockheed Martin, BMW, Deutsche Bank, China Unicom, and Terremark—found that organizations are utilizing cloud computing at a faster rate than was previously forecast. In fact, more than half of the survey respondents expect to run 40 percent half of their IT operations in private clouds by 2015.

Cloud Computing Characteristics

The cloud computing phenomenon has several important characteristics. We take a closer look at them in this section.

Cloud Computing Provides On-Demand Self-Service. A customer can access needed computing resources automatically.

Cloud Computing Encompasses the Characteristics of Grid Computing. Grid computing pools various hardware and software components to create a single IT environment with shared resources. Grid computing shares the processing resources of many geographically dispersed computers across a network.

• Grid computing enables organizations to utilize their computing resources more efficiently.
• Grid computing provides fault tolerance and redundancy, meaning that there is no single point of failure, so the failure of one computer will not stop an application from executing.
• Grid computing makes it easy to scale up—that is, to access increased computing resources—to meet the processing demands of complex applications.
• Grid computing makes it easy to scale down (remove computers) if extensive processing is not needed.

Consider Dell Computing (www.dell.com). After years of database proliferation, Dell began to run out of physical space in its data center for its databases. The company deployed each new database on its own server. It ended up with roughly 10,000 databases, each of which ran on individual servers and spread across multiple data centers. In addition to occupying physical space, this system resulted in high costs for power, cooling, and management. Further, it was taking Dell as long as two to three months to launch a new database project. The company needed to speed up the process so that it could be more responsive to changes in its business environment.

Dell chose a grid computing solution to its problem. The solution reduced the physical database environment by 30 percent, accelerated new database project launches to less than five days, and saved the company more than $20 million.

Cloud Computing Encompasses the Characteristics of Utility Computing. In utility computing, a service provider makes computing resources and infrastructure management available to a customer as needed. The provider then charges the customer for its specific
usage rather than a flat rate. Utility computing enables companies to efficiently meet fluctuating demands for computing power by lowering the costs of owning the hardware infrastructure.

Cloud Computing Utilizes Broad Network Access. The cloud provider’s computing resources are available over a network, accessed with a Web browser, and they are configured so they can be used with any computing device.

Cloud Computing Pools Computing Resources. The provider’s computing resources are available to serve multiple customers. These resources are dynamically assigned and reassigned according to customer demand.

Cloud Computing Often Occurs on Virtualized Servers. Cloud computing providers have placed hundreds or thousands of networked servers inside massive data centers called server farms (see Figure TG 3.1). Recall that a server is a computer that supports networks, thus enabling users to share files, software, and other network devices. Server farms require massive amounts of electrical power, air-conditioning, backup generators, and security. They also need to be located fairly closely to fiber-optic communications links (see Figure TG 3.2).

Going further, Gartner estimates that typical utilization rates on servers are very low, generally from 5 to 10 percent. That is, most of the time, organizations are using only a small percentage of their total computing capacity. CIOs tolerate this inefficiency to make certain that they can supply sufficient computing resources to users in case demand should spike. To alleviate with this underutilization problem, companies and cloud computing providers are turning to virtualization.

Server virtualization uses software-based partitions to create multiple virtual servers—called virtual machines—on a single physical server. The major benefit of this system is that each server no longer has to be dedicated to a particular task. Instead, multiple applications can run on a single physical server, with each application running within its own software environment. As a result, virtualization enables companies to increase server utilization. In addition, companies realize cost savings in two areas. First, they do not have to buy additional servers to meet peak demand. Second, they reduce their utility costs because they are using less energy. The following example illustrates the benefits of virtualization for MaximumASP.
Example
MaximumASP is a Web-hosting company based in Louisville, Kentucky. Its 35 employees host more than 48,000 domains for customers located in more than 60 countries. MaximumASP prides itself on its innovative offerings and its outstanding customer service. Unfortunately, the company’s rapid expansion resulted in a proliferation of servers that required increasing amounts of resources to manage. This situation adversely affected the company’s bottom line. Furthermore, servers, the company pulled staff away from researching new services, which diminished the company’s agility and innovation.

Web hosting has become extremely competitive and even commoditized in many parts of the world. The company’s CIO noted that there is tremendous market pressure to develop new products. To accomplish this task, MaximumASP had to add new servers, which increased the company’s costs. MaximumASP added hundreds of new servers every year, each of which took roughly 4 hours to deploy. The company spent so much time deploying new servers that it could not respond as quickly to its customers’ needs or its competitors’ moves as it had in the past.
MaximumASP also wanted to reduce the rising costs of physical servers as well as the related real estate and power costs. The company was spending thousands of dollars every year on new hardware, software licenses, and electrical power. Finally, the firm was concerned that if it continued to deploy more servers, it would outgrow its Louisville data center and have to build another one. Having to fund new servers each year was especially frustrating because most of the company’s existing servers operated at a very low capacity, often 5 percent or less.

To resolve these problems, MaximumASP decided to implement Microsoft’s server virtualization technology. Thus far, the results have been outstanding. The company was able to operate between five and ten virtual machines on each physical server, which generated a savings of $350,000 in hardware costs alone. In addition, the technology enabled MaximumASP to utilize its data center floor space much more efficiently, thereby sparing the firm the cost of building a new data center. Furthermore, average server utilization increased dramatically from 5 percent to 65 percent.

And the bottom line? Virtualization allowed MaximumASP to expand its product offerings, enhance its business agility, and improve its customer service, while actually lowering its operating costs.


With cloud computing, setting up and maintaining an IT infrastructure need no longer be a challenge for an organization. Businesses do not have to scramble to meet the evolving needs of developing applications. In addition, cloud computing reduces up-front capital expenses and operational costs, and it enables businesses to better utilize their infrastructure and to share it from one project to the next. In general, then, cloud computing eases the difficult tasks of procuring, configuring, and maintaining hardware and software environments. In addition, it allows enterprises to get their applications up and running faster, with easier manageability and less maintenance. It also enables IT to adjust IT resources (such as servers, storage, and networking) more rapidly to meet fluctuating and unpredictable business demand.

Businesses are increasingly employing cloud computing for important and innovative work. The next example illustrates how Amazon has successfully “moved music into the cloud.”

Example
Amazon, whose online music store competes with Apple’s (www.apple.com/icloud), has “moved music into its cloud” to solve two problems. The first problem is that music libraries have typically been scattered. For example, when you bought a new song at home, you could not listen to it at work, at least not without copying it manually. You could buy a song on your phone, but you had to perform a sync in order to download it onto your computer. Moreover, if your music library was large, then you could fit only a portion of it onto your phone. The second problem is that Amazon wants more people to buy music from its proprietary store instead of from iTunes.

In March 2011, Amazon released a package of software and services that solved both of these problems. The fundamental idea behind the new package is that your music collection will reside in the cloud. That way, you can conveniently listen to it from any computer—at home, at work, at a friend’s home—by logging into a special Web page called the Amazon Cloud Player (www.amazon.com/clouddrive).

You can also listen to any of the songs in your music collection on an Android phone without having to copy or sync the music. All your songs are always available everywhere, and they do not take up any storage space on your phone itself.

In addition to being accessible from anywhere, the Cloud Player has some other notable perks. It contains a list of your songs, which you can sort and search. You can also drag songs into playlists and play back a song, an album, or a playlist. Plus, you can download songs to your computer. Amazon also provides a free Uploader app that lets you send your existing music files to your online library so your music is available anywhere.

The Cloud Player is almost free. To attract new customers, Amazon offers everyone 5 gigabytes of free space online—enough room for about 1,200 MP3 songs. You can buy additional storage for the price of $1 per gigabyte per year. Although this price might seem insignificant,
the service can become expensive if you have a huge music collection—enough to make sites like Rhapsody that offer “pay $15 per month for unlimited music” look appealing.

In addition to these special deals, Amazon is also offering incentives. For example, if you buy an album from Amazon’s music store, your Cloud Player storage is increased to 20 gigabytes for the year at no charge. In addition, any songs you buy from Amazon do not count against your storage limit.

Despite these aggressive marketing efforts, Amazon’s Cloud Player faces tough competition. Many other companies offer similar systems. Apple (www.apple.com/icloud) and Google (http://music.google.com) offer similar services. Also, Rdio (www.rdio.com), Audio Galaxy (www.audiogalaxy.com), Spotify (www.spotify.com), and GrooveShark (www.grooveshark.com) all offer some elements of the Amazon concept for less money.


In the next section, you learn about the various ways in which customers (individuals and organizations) can implement cloud computing. Specifically, you will read about public clouds, private clouds, hybrid clouds, and vertical clouds.

**Different Types of Clouds**

There are three major types of cloud computing that companies provide to customers or groups of customers: public clouds, private clouds, and hybrid clouds. A fourth type of cloud computing is called vertical clouds (see Figure TG 3.3).

**Public Cloud**

Public clouds are shared, easily accessible, multicustomer IT infrastructures that are available nonexclusively to any entity in the general public (individuals, groups, and/or organizations). Public cloud vendors provide applications, storage, and other computing resources as services over the Internet. These services may be free or offered on a pay-per-usage model.

Movirtu, a private technology company, is an example of a public cloud. Significantly, it is playing a major role in addressing a widespread global problem. In the developing world, people commonly share their mobile phones. They frequently use their own SIM card, which they switch in and out when they borrow a mobile device. This practice can compromise privacy, however. In addition, SIM cards are easy to lose.

**FIGURE TG 3.3**

![Diagram of cloud types](image-url)
Now, millions of impoverished citizens in Africa and Asia will receive mobile phone numbers under a plan developed by the United Nations. Movirtu (www.movirtu.com) is a cloud-based phone service that allows people to manage their own mobile network accounts—phone number, voice mail, texting, etc.—without ever owning a phone or a SIM card. Movirtu prices its service with lower-income users in mind, and it shares its profits with the mobile network carriers.

Under the UN plan, Movirtu will supply low-cost mobile phone numbers to participants, who can use any mobile device to log in with their own number to make and receive calls and to access information and services. The primary beneficiaries will be women in rural communities in South Asia and sub-Saharan Africa, because they are far less likely than men to own their own phones.

Movirtu will bring this technology to 12 or more markets in the selected regions by early 2013, thereby improving the lives and expanding the earning potential of at least 50 million people. The company selected Madagascar, an island nation off Africa’s east coast, as a starting point. The country has an extensive network, but many of its citizens cannot afford their own phone. The service became available throughout the island via a local carrier in August 2011.

Private Cloud

Private clouds (also known as internal clouds or corporate clouds) are IT infrastructures that can be accessed only by a single entity or by an exclusive group of related entities that share the same purpose and requirements, such as all of the business units within a single organization. Private clouds provide IT activities and applications as a service over an intranet within an enterprise. Enterprises adopt private clouds to ensure system and data security. For this reason these systems are implemented behind the corporate firewall.

Hybrid Cloud

Hybrid clouds are composed of public and private clouds that remain unique entities but are nevertheless bound together, thereby offering users the benefits of multiple deployment models. Hybrid clouds deliver services based on security requirements, the mission-critical nature of applications, and other company-established policies. For example, customers may need to keep some of their data in a private cloud for security and privacy reasons while storing other, less-sensitive data in a public cloud because it is less expensive.

Vertical Clouds

It is now possible to build cloud infrastructure and applications for different businesses—the construction, finance, or insurance businesses, for example—thus building vertical clouds (see www.vertical-cloud.com).

TG 3.4 Cloud Computing Services

Cloud computing services are based on three models: infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS), and software-as-a-service (SaaS). These models represent the three types of computing generally required by consumers: infrastructure to run software and store data (IaaS), platforms to develop applications (PaaS), and software applications to process their data (SaaS). Figure TG 3.4 illustrates the differences between the three models.

As you examine the figure from left to right, note that the customer manages the service less and less, and the vendor manages it more and more.

Although each model has its distinctive features, all three share certain characteristics. First, customers rent them instead of buying them. This arrangement shifts IT from a capital expense to an operating expense. Second, vendors are responsible for maintenance, administration, capacity planning, troubleshooting, and backups. Finally, obtaining additional computing resources (i.e., scale from the cloud—for example, more storage from an IaaS vendor, the ability to handle more PaaS projects, or more users of a SaaS application) is usually fast and easy.
**Infrastructure as a Service (IaaS)**

With the **infrastructure-as-a-service** (IaaS) model, cloud computing providers offer remotely accessible servers, networks, and storage capacity. They supply these resources on demand from their large pools of such resources, which are located in their data centers.

IaaS customers are often technology companies with IT expertise. They want access to computing power, but they do not want to be responsible for installing or maintaining it. Companies use the infrastructure to run software or simply to store data.

To deploy their applications, IaaS users install their operating system and their application software on the cloud computing provider's computers. They can deploy any software on this infrastructure, including different operating systems, applications, and development platforms. Each user is responsible for maintaining their operating system and application software. Cloud providers typically bill IaaS services on a utility computing basis—that is, the cost reflects the amount of resources the user consumes.

Amazon is a well-known IaaS provider. The company sells the spare capacity of its vast IT infrastructure to its customers in a cloud environment. These services include its Simple Storage Service (S3) for storing customers' data and its Elastic Compute Cloud (EC2) service for operating their customers' applications. Customers pay only for the amount of storage and computing they use.

**Platform as a Service (PaaS)**

In the **platform-as-a-service** (PaaS) model, customers rent servers, operating systems, storage, a database, software development technologies such as Java and .NET, and network capacity over the Internet. The PaaS model allows the customer both to run existing applications and to develop and test new applications.

PaaS offers customers several advantages, which include the following:

- Application developers can develop and run their software solutions on a cloud platform without the cost and complexity of buying and managing the underlying hardware and software layers.
- Underlying computing and storage resources automatically scale to match application demand.
- Operating system features can be upgraded frequently.
• Geographically distributed development teams can work together on software development projects.
• PaaS services can be provided by diverse sources located throughout the world.
• Initial and ongoing costs can be reduced by the use of infrastructure services from a single vendor rather than maintaining multiple hardware facilities that often perform duplicate functions or suffer from incompatibility problems.

As an example of an entity that employed PaaS to improve its performance, consider the city of Miami (www.miamigov.com). Miami has created a service that monitors nonemergency 311 requests. City officials and local residents can access a Web site that pulls up a map of the city with pins in every spot that is tied to a 311 complaint. Before cloud computing became available, the city would have needed three months to develop the concept, buy new hardware (including backups in case of a hurricane), hire a team to install the necessary software, and then build the application. In contrast, by utilizing cloud computing, Miami created a working prototype within 8 days, and it deployed the application shortly thereafter.

**Software as a Service (SaaS)**

With the software-as-a-service (SaaS) delivery model, cloud computing vendors provide software that is specific to their customers’ requirements. SaaS is the most widely utilized service model, and it provides a broad range of software applications. SaaS providers typically charge their customers a monthly or yearly subscription fee.

SaaS applications reside in the cloud instead of on a user’s hard drive or in a data center. The host manages the software and the infrastructure that runs this software and stores data. The customers do not control either the software, beyond the usual configuration settings, or the infrastructure, beyond changing the resources they use, such as the amount of disk space required for their data. This process eliminates the need to install and run the application on the user’s computers, thereby simplifying maintenance and support.

What differentiates SaaS applications from other applications is its ability to scale. As a result, applications can run on as many servers as is necessary to meet changing demands. This process is transparent to the user.

To reduce the risk of an infrastructure outage, SaaS providers regularly back up all of their customers’ data. In addition, customers can back up their data on their storage hardware.

To understand how SaaS operates, consider the case of Flextronics (www.flextronics.com), the Singapore-based manufacturer of such devices as Research in Motion’s BlackBerry handsets and Microsoft’s motion-sensing Kinect add-on for the Xbox 360 gaming console. Flextronics utilizes SaaS from Workday (www.workday.com), an outside provider, for some of its human resources management function. Workday handles Flextronics’s human resources processes from tracking employee compensation and benefits to hiring for open positions. By outsourcing to Workday rather than handling HR computing in-house with on-premise IT infrastructure, Flextronics was able to save $100 million in 3 years. These expense reductions were extremely important because Flextronics has an operating margin of only 2.9 percent.

As we previously discussed, a major concern related to cloud computing is security. In the case of Flextronics, the company’s CIO realized he was taking risks as he handed over the human resources computing tasks for his 200,000-employee company to Workday. What would happen, for example, if Workday lost sensitive employee data? Fortunately for Flextronics, the company’s employee information remained secure.

A subset of SaaS is the Desktop-as-a-Service (DaaS) model, also known as a cloud desktop or desktop in the cloud. In this model, a SaaS provider hosts a software environment for a desktop personal computer, including productivity and collaboration software—spreadsheets, word processing programs, and so on—such as Google Apps, Microsoft 365, and other products. Significantly, in DaaS only a thin client (discussed in Technology Guide 1) can access all the required software. The DaaS model can be financially advantageous for the consumer because they do have to necessarily buy a fully-configured personal computer, or fat client (discussed in Technology Guide 1). In addition, it makes the PC environment simpler to deploy and administer.
The Benefits of Cloud Computing

Cloud computing offers benefits for both individuals and groups. It allows companies to increase the scale and power of their IT and the speed at which it can be deployed and accessed. It eliminates administrative headaches, and it works across locations, devices, and organizational boundaries.

Cloud computing has transformed both business and everyday life—from consumers who use it to access their favorite music to companies that harness its powerful resources. When cloud computing capabilities are utilized effectively, they offer numerous opportunities to businesses to drive innovation. Organizations are exploiting cloud computing to transform both product and service development as well as to strengthen customer relationships.

Organizations of all sizes, across geographies, and in virtually every industry are using cloud computing to reduce the complexity and costs associated with traditional IT approaches. Nearly half of the respondents in a recent CIO Economic Impact survey indicated that they evaluate cloud computing options first—over traditional IT approaches—before making any new IT investments.
Organizations are relying on cloud computing not only to enhance internal efficiencies, but also to target more strategic business capabilities. IBM predicts that the global cloud computing market will grow 22 percent annually to $241 billion by 2020. Below we examine seven major benefits that cloud computing provides to individuals and organizations.

**Benefit 1: Making Individuals More Productive**

Cloud computing can enable companies to provide their employees with access to all the information they need no matter where they are, what device they are using, or whom they are working with.

Cloud computing provides a mechanism for organizations to “hide” some of the complexity of their operations from end users, which can help attract a broader range of consumers. By hiding complexity from the end user, a company can expand its product and service sophistication without requiring its users to substantially increase their knowledge in order to utilize or maintain the product or service.

For example, Chicago-based law firm Segal McCambridge Singer & Mahoney (www.smsm.com) operates offices in seven states. Its attorneys need to access documents and data on a constant, year-round basis. Since 2000, the firm’s data had expanded dramatically from 30 gigabytes to more than 40 terabytes. All of these data must be stored and accessed securely. To manage and protect this vast amount of data, the firm needed more flexibility and scalability than it was able to obtain from its existing IT infrastructure.

To address this problem, the firm turned to cloud computing for data storage, offsite disaster recovery, and global multisite access within a highly secure public cloud. Rather than maintaining a massive inventory of extra storage as required by its old IT infrastructure, the firm can now increase storage capacity on demand. The cloud provides perpetual access via encrypted communications channels for attorneys. Further, the cloud helps distributed teams of attorneys collaborate, thereby increasing their overall productivity.

In the past, to place huge amounts of case-relevant information on the computers, attorneys often had to manually copy data onto external hard drives and USB devices. Alternatively, the firm had to physically ship hard drives to them. These processes were inherently non-secure. At times, attorneys had to submit a request for information to the firm’s Chicago headquarters and wait for someone there to process it and send them the necessary information. Today, an attorney can conduct database queries over the company’s cloud network, and offices and attorneys can share documents in near real time.

The firm’s cloud environment has made its attorneys much more efficient. As a result, the firm’s IT expenses have declined by 60 percent.

**Benefit 2: Facilitating Collaboration**

Cloud computing enables groups and communities to work together in ways that were previously not possible. For example, it enhances a company’s ability to collaborate with its partners and customers, a process that can lead to greater productivity and increased innovation. Cloud-based platforms can bring together disparate groups of people who can collaborate and share resources, information, and processes.

For example, to improve knowledge capture and sharing among its 90,000 employees, Computer Systems Corporation (CSC; www.csc.com) is using Jive’s cloud-based collaboration software. CSC’s first step was an experiment to determine whether people would be receptive to working with the software. The company made Jive available to all of its employees, an approach that would have been prohibitively expensive if it had to buy all the hardware and software licenses itself. Employees could use Jive to perform a number of diverse tasks such as posing a question to the entire company, visiting and contributing to digital forums like “Where Have We Done This Before?” and “Excel Power Tips,” and setting up new communities as needed.

During the initial 20-week experiment, more than 25,000 employees voluntarily registered for the new cloud-based resource, called C3. They created more than 2,100 groups and logged as many as 150,000 activities per month. Those results persuaded CSC to make C3 permanent.
The company’s CIO characterized the results as “stunning.” C3 is now the standard for how CSC collaborates.

**Benefit 3: Mining Insights from Data**

Analytics is one of the most popular cloud computing applications. Companies today gather massive amounts of data, and cloud providers are providing hardware and software algorithms to help businesses perform sophisticated analyses of these data.

For example, restaurant owners can utilize a cloud-based service from Radiant Systems to reduce shrinkage. Shrinkage, a polite term for employee theft, is a serious problem in the food service industry. It is also a difficult problem to solve, because there is no easy way for restaurant owners to closely monitor servers and bartenders in their busy work environments.

Enter Radiant Systems (www.radiantsystems.com), a company that supplies the Aloha point-of-sale system to thousands of restaurants and also maintains their data. Radiant possesses the capability to analyze the huge amounts of transaction data that it keeps for each customer for suspicious patterns, such as a significantly greater-than-average volume of large tips for bartenders on a Friday night. This pattern often indicates that the bartender is not charging people for drinks in hopes of getting a big tip.

Using data from all of its customers, Radiant developed a set of algorithms to detect many types of shrinkage. It then bundled them into a product called Aloha Restaurant Guard (ARG). ARG generates a weekly set of reports on suspicious activity by site and by employee. It sends these reports to restaurant owners and managers, who use them to take corrective action. The results can be surprising and dramatic. According to Radiant, one casual dining restaurant experienced a profit increase of $20,000 to $40,000 per year after using ARG to detect employee theft. Significantly, the restaurant owner did not have to buy or install any new software, hire IT people, or alter his IT infrastructure in any way.

**Benefit 4: Reduce Costs**

Cloud computing can help an organization reduce fixed IT costs by enabling them to shift from capital expenses to operational expenses—or from fixed to variable. IT capital expenses—which typically include enterprise software licenses, servers and networking equipment, and other costs—tend to be more expensive than routine IT operating expenses. Cloud computing applications eliminate the need to purchase hardware, build and install software, and pay software licensing fees. The organization pays only for the computing resources it needs, and then only when it needs them. This pay-for-use model provides greater flexibility, and it eliminates the need for significant capital expenditures.

Consider State Street Bank (www.statestreet.com) in Boston. The bank writes its own highly customized software to manage its assets. In fact, 20 to 25 percent of the bank’s annual IT budget has gone to software development. As is true of many other large companies, the State Street data center contains a broad array of best-of-breed systems. Integrating these systems, a job that State Street traditionally has performed done in-house, is quite expensive.

Consequently, State Street is moving to a private cloud to achieve cost savings from more-efficient software development and increased efficiency in its data center. The bank expects to realize $600 million in savings by the end of 2014. The savings in software development are due to the fact that the developers are writing software for the same cloud-based development platform, making code sharing much easier. Therefore, the bank will have to write dramatically less code.

The cloud environment simplifies and standardizes State Street’s data center systems. This process reduces the company’s expenses by making it easier to maintain the system and to modify it when necessary.

Over time, the economics of building and operating an IT infrastructure will favor cloud computing. Cloud providers purchase massive amounts of technology infrastructure (e.g., hardware and bandwidth) because they can obtain better prices by buying in bulk. They also buy technology on a continuous basis. As a result, they can take advantage of the declines in computing cost predicted by Moore’s law (discussed in Technology Guide 1). For example,
the Amazon cloud, known as Amazon Web Services, reduced its prices a dozen times between 2008 and 2012.

**Benefit 5: Expand the Scope of Business Operations**

Cloud computing allows organizations to use the amount of computing resources they need. Therefore, companies utilizing cloud computing are able to increase the scope of their business operations.

Consider College Hunks Hauling Junk (CHHJ; www.collegehunks.com), a moving and junk removal company with 43 franchises around the country. CHHJ was experiencing numerous issues with the proprietary software system it was using to run its scheduling and franchising operations. When CHHJ first deployed this system, it was exclusively a junk removal company. Over time, however, it had added new and more complex businesses, such as moving customers’ goods. The original system did not easily support these new lines of business. In addition, CHHJ needed a system that could collect different types of data and produce necessary reports based on an analysis of those data. Essentially, CHHJ needed a system for all of its service lines and to provide flexibility for continued growth, both in new areas of business and in new franchises.

CHHJ turned to Waterstreet Technology Group (www.waterstreet.net) to develop an entirely new system from the ground up. Waterstreet developed the software and housed it on its own servers. CHHJ uses the software as a software-as-a-service product. The software supports CHHJ’s junk removal and moving businesses as well as its franchise operations and call center.

The new software provides vastly improved reporting on data gathered from customers and franchisees. This capability enables CHHJ to provide better customer service and to support its growing franchise business more effectively. In addition, the software enables CHHJ to expand its lines of business and its franchises.

**Benefit 6: Respond Quickly to Market Changes**

The ability to quickly respond to rapidly changing customer needs is a critical strategic goal for organizations. Therefore, companies are continuously seeking ways to improve their agility in adjusting to market demands. Cloud computing enables businesses to rapidly adjust their processes, products, and services to meet the changing needs of the market. Furthermore, cloud computing facilitates rapid prototyping and innovation, and it speeds time to market for new products.

For example, ActiveVideo (www.activevideo.com) recognized cloud computing’s potential to enhance their market adaptability when they created CloudTV, a cloud-based platform that unifies all forms of content—Web, television, mobile, social, video-on-demand, etc.—onto any video screen. Content and applications from Web content creators, television networks, advertisers, and other media entities can be quickly developed for CloudTV using standard Web tools. CloudTV leverages content stored and processed in the cloud to significantly expand the reach and availability of Web-based user experiences. It also enables operators to quickly deploy a consistent user interface across diverse set top boxes and connected devices. A set top box is a device that enables a TV set to become a user interface to the Internet and also enables a TV set to receive and decode digital television broadcasts. The CloudTV approach of placing the intelligence in the network, rather than in the device, enables content creators, service providers, and consumer electronics manufacturers to create new television experiences for their viewers.

**Benefit 7: Customize Products and Services**

Because of its expanded computing power and capacity, cloud computing can store massive amounts of information about user preferences. Companies can then utilize this information to customize their products and services. This context-driven variability allows businesses to offer personal experiences to users by adapting the service or product to subtle changes in the user-defined context. Customers are more likely to enjoy their personally customized experience and are therefore more likely to become return customers.
A good example of a product that has effectively made use of cloud computing’s user preference storage is Siri, the Apple iPhone 4S cloud-based natural language “intelligent assistant.” Siri allows users to send messages, schedule meetings, place phone calls, locate restaurants, and much more. Whereas other phones have some voice recognition features, Siri effectively “learns your voice.” It uses artificial intelligence and a growing base of knowledge about the user, including his or her location and frequent contacts, to understand not only what users say, but what they actually mean. Siri leverages cloud computing to enable individualized, context-relevant customer experiences.

Concerns and Risks with Cloud Computing

Gartner predicts that cloud computing will grow at an annual rate of 19 percent through the year 2015. Even if this prediction is accurate, however, cloud computing will still account for less than 5 percent of total worldwide IT spending that year. Why is this percentage so low? The reason is that there are serious concerns with cloud computing. These concerns fall into five categories: legacy IT systems, reliability, privacy, security, and regulations.

Concern 1: Legacy IT Systems

Historically, organizational IT systems have accumulated a diversity of hardware, operating systems, and applications. When bundled together, these systems are called “legacy spaghetti.” These systems cannot easily be transferred to the cloud because they must first be untangled and simplified. Furthermore, many IT professionals have vested interests in various legacy systems, and they resist efforts to exchange these systems for cloud computing.

Concern 2: Reliability

Many skeptics contend that cloud computing is not as reliable as a well-managed, on-premise IT infrastructure. The cloud’s reliability was called into question in April 2011 when large parts of Amazon’s Web Services infrastructure went down for as long as three days (see the example below). This outage created serious problems for many companies that used the service. Although the outage was serious, however, it affected only one of Amazon’s U.S. data centers. Amazon had also explicitly advised its customers to design their IT architectures to withstand a service interruption. Other cloud companies have learned from Amazon’s experience, and they are improving the redundancy and reliability of their offerings.

Example

Amazon Web Services (AWS; http://aws.amazon.com) is designed with backups to the back-ups’ backups to prevent its hosted Web sites and applications from failing. Despite all of these safety measures, however, in April 2011 Amazon’s cloud crashed, taking with it Reddit (www.reddit.com), Quora (www.quora.com), FourSquare (www.foursquare.com), ProPublica (www.propublica.org), parts of the New York Times (www.nytimes.com), and about 70 other Web sites. The massive outage raised questions about the reliability of Amazon Web Services and about the cloud itself.

Thousands of companies use Amazon Web Services (AWS) to run their Web sites through a service called Elastic Compute Cloud (EC2). Rather than hosting their sites on their own servers, these customers essentially rent some of Amazon’s unused server capacity. EC2 is hosted in five regions: Virginia, California, Ireland, Tokyo, and Singapore. Within each region are multiple “availability zones,” and within each availability zone are multiple “locations” or data centers.

Amazon assured its customers that its method of linking together many different data centers would protect its customers from isolated failures. It promised to keep customers’ sites up and running 99.95 percent of the year, or it would reduce their monthly bills by 10 percent. Based on these claims, customers could be down a maximum of just 4.4 hours in a year. In fact, during the outage, some customers’ Web sites were down for days.

Example
The crash occurred at Amazon’s Virginia data center, located in one of the company’s East Coast availability zones. Amazon claimed that a “networking event” caused a domino effect across other availability zones in that region, which in turn caused many of its storage volumes to create backups of themselves. That process filled up Amazon’s available storage capacity, and it prevented some Web sites from accessing their data. Amazon did not reveal what the “networking event” was.

Web sites like Quora and Reddit were able to come back online in “read-only” mode, but users were not able to post new content for many hours. Many experts blamed Amazon’s customers themselves, asserting that their Web sites should have spread out their processing among multiple geographical regions to take full advantage of Amazon’s backup systems. In fact, sites like Reddit were simply following the instructions that Amazon provided in its service agreement. The agreement states that hosting in a single region should be sufficient. Furthermore, some smaller companies could not afford the resources needed to duplicate their infrastructure in data centers all over the world.

One company that experienced an Amazon outage was able to put a dollar figure on the resulting damage. Amazon outages completely took down the online date site WhatsYourPrice (www.whatsyourprice.com). Men and women create profiles on the site, featuring the basic information one would find on most dating sites. However, women also include the amount of money they would accept from someone to go on a date with him. Men browse the profiles and make offers to women who “catch their eye.” Once an offer is made, the woman checks the man’s profile and can choose to accept the offer, reject it, or come up with a different price.

During a two-hour outage, staff at the Web site fielded nearly 1,000 complaints from users who were trying to make a date. The outage did more than simply tarnish the reputation of WhatsYourPrice.com and leave its customers without dates. The company claims that in the two hours it was unable to operate it lost almost $8,000 from lost commissions.


**Concern 3: Privacy**

Privacy advocates have criticized cloud computing for posing a major threat to privacy because the providers control, and thus lawfully or unlawfully monitor, the data and communication stored between the user and the host company. For example, AT&T and Verizon collaborated with NSA to use cloud computing to record more than 10 million phone calls between American citizens. In addition, providers could accidently or deliberately alter or even delete some information.

Using a cloud computing provider also complicates data privacy because of the extent to which cloud processing and cloud storage are used to implement cloud services. The point is that customer data may not remain on the same system or in the same data center. This situation can lead to legal concerns over jurisdiction.

There have been efforts to address this problem by integrating the legal environment. One example is the US–EU Safe Harbor, a streamlined process for U.S. companies to comply with the European Union directive on the protection of personal data.

**Concern 4: Security**

Critics also question how secure cloud computing really is. Because the characteristics of cloud computing can differ widely from those of traditional IT architectures, providers need to reconsider the effectiveness and efficiency of traditional security mechanisms. Security issues include access to sensitive data, data segregation (among customers), privacy, error exploitation, recovery, accountability, malicious insiders, and account control.

The security of cloud computing services is a contentious issue that may be delaying the adoption of this technology. Security issues arise primarily from the unease of both the private and public sectors with the external management of security-based services. The fact that
providers manage these services provides great incentive for them to prioritize building and maintaining strong security services.

Another security issue involves the control over who is able to access and utilize the information stored in the cloud. (Recall our discussion of least privilege in Chapter 4.) Many organizations exercise least privilege controls effectively with their on-premise IT infrastructures. Some cloud computing environments, in contrast, cannot exercise least privilege controls effectively. This problem occurs because cloud computing environments were originally designed for individuals or groups, not for hierarchical organizations in which some people have both the right and the responsibility to exercise control over other people’s private information. To address this problem, cloud computing vendors are working to incorporate administrative, least-privilege functionality into their products. In fact, many have already done so.

Security experts note that the best strategies to achieve excellent security are to constantly monitor the threat landscape, to buy or build the best technologies to protect devices and networks, and to hire and retain top digital security specialists. Cloud computing vendors are better able to do these things than all but the very largest and most security-conscious organizations.

**Concern 5: The Regulatory and Legal Environment**

There are numerous legal and regulatory barriers to cloud computing, many of which involve data access and transport. For example, the European Union prohibits consumers’ data from being transferred to nonmember countries without the consumers’ prior consent and approval. Companies located outside the EU can overcome this restriction by demonstrating that they provide a “safe harbor” for the data. Some countries, such as Germany, have enacted even more restrictive data export laws. It is not clear (as of mid-2013) if the safe harbor process will satisfy them. Cloud computing vendors are aware of these regulations and laws, and they are working to modify their offerings so that they can assure customers and regulators that data entrusted to them are secure enough to meet all of them.

In order to obtain compliance with regulations such as the Federal Information Security Management Act (FISMA), the Health Insurance Portability and Accountability Act (HIPAA), and the Sarbanes-Oxley Act (SOX) in the United States, the Data Protection Directive in the European Union, and the credit card industry’s Payment Card Industry’s Data Security Standard (PCI DSS), cloud computing customers may have to adopt hybrid deployment modes that are typically more expensive and may offer restricted benefits. This process is how, for example, Google is able to “manage and meet additional government policy requirements beyond FISMA,” and Rackspace (www.rackspace.com) is able to claim PCI compliance. FISMA requires each federal agency to develop, document, and implement a program to provide information security for the information and information systems that support the operations of the agency, including those provided by contractors. PCI DSS is a set of requirements designed to ensure that all companies that process, store, or transmit credit card information maintain a secure environment.

**For All Business Majors**

As with hardware (Technology Guide 1), the design of enterprise IT architectures has profound impacts for businesspeople. Personal and organizational success can depend on an understanding of cloud computing and a commitment to knowing the opportunities and challenges they will bring.

At the organizational level, cloud computing has the potential to make the organization function more efficiently and effectively, while saving the organization money. Web services and SOA make the organization more flexible when deploying new IT applications.

At the individual level, you might utilize cloud computing yourself if you start your own business. Remember that cloud computing provides start-up companies with world-class IT capabilities at a very low cost.
1. Describe the problems that modern information technology departments face.

Traditional IT departments face many problems:

- They spend huge amounts on IT infrastructure and expert staffs to build and maintain complex IT systems. These expenses include software licenses, hardware, and staff training and salaries.
- They must manage an infrastructure that often is not used to its full capacity.
- They spend the majority of their budgets on maintaining existing IT infrastructure, with the remainder being spent on developing new systems.
- They have difficulty capturing, storing, managing, and analyzing all this data.
- They can actually inhibit an organization’s ability to respond quickly and appropriately to rapidly changing dynamic environments.
- They are expensive.

2. Describe the key characteristics and advantages of cloud computing.

Cloud computing is a type of computing that delivers convenient, on-demand, pay-as-you-go access for multiple customers to a shared pool of configurable computing resources (e.g., servers, networks, storage, applications, and services) that can be rapidly and easily accessed over the Internet. The essential characteristics of cloud computing include the following:

- Cloud computing provides on-demand self-service.
- Cloud computing includes the characteristics of grid computing.
- Cloud computing includes the characteristics of utility computing.
- Cloud computing utilizes broad network access.
- Cloud computing pools computing resources.
- Cloud computing typically occurs on virtualized servers.

3. Identify a use-case-scenario for each of the four types of clouds.

Public clouds are shared, easily accessible, multi-customer IT infrastructures that are available non-exclusively to any entity in the public (individuals, groups, and/or organizations). Private clouds (also known as internal clouds or corporate clouds) are IT infrastructures that are accessible only by a single entity, or by an exclusive group of related entities that share the same purpose and requirements, such as all the business units within a single organization. Hybrid clouds are composed of public and private clouds that remain unique entities but are bound together, offering the benefits of multiple deployment models. Vertical clouds serve specific industries.

4. Explain the operational model of each of the three types of cloud services.

With the Infrastructure-as-a-Service (IaaS) model, cloud computing providers offer remotely accessible servers, networks, and storage capacity. In the Platform-as-a-Service (PaaS) model, customers rent servers, operating systems, storage, a database, software development technologies such as Java and .NET, and network capacity over the Internet. With the software-as-a-service (SaaS) delivery model, cloud computing vendors provide software that is specific to their customers’ requirements.

5. Identify the key benefits of cloud computing.

The benefits of cloud computing include making individuals more productive; facilitating collaboration; mining insights from data; developing and hosting applications; cost flexibility; business scalability; improved utilization of hardware; market adaptability; and product and service customization.

6. Discuss the concerns and risks associated with cloud computing.

Cloud computing does raise concerns and have risks, which include legacy spaghetti, cost, reliability, privacy, security, and the regulatory and legal environment.
7. Explain the role of Web services in building a firm's IT applications, providing examples.

Web services are applications delivered over the Internet that MIS professionals can select and combine through almost any device, from personal computers to mobile phones. A service-oriented architecture makes it possible for MIS professionals to construct business applications using Web services.

[Chapter Glossary]

cloud computing A technology in which tasks are performed by computers physically removed from the user and accessed over a network, in particular the Internet.

Extensible markup language (XML) A computer language that makes it easier to exchange data among a variety of applications and to validate and interpret these data.

gird computing A technology that applies the unused processing resources of many geographically dispersed computers in a network to form a virtual supercomputer.

Hybrid clouds Clouds composed of public and private clouds that remain unique entities but are bound together, offering the benefits of multiple deployment models.

HTML5 A page-description language that makes it possible to embed images, audio, and video directly into a document without add-ons. Also makes it easier for Web pages to function across different display devices, including mobile devices as well as desktops. Supports the storage of data offline.

hypertext markup language (HTML) A page-description language for specifying how text, graphics, video, and sound are placed on a Web page document.

infrastructure-as-a-service (IaaS) model Cloud computing providers offer remotely accessible servers, networks, and storage capacity.

platform-as-a-service (PaaS) model Customers rent servers, operating systems, storage, a database, software development technologies such as Java and .NET, and network capacity over the Internet.

Private clouds (also known as internal clouds or corporate clouds) IT infrastructures that are accessible only by a single entity or by an exclusive group of related entities that share the same purpose and requirements, such as all the business units within a single organization.

Public clouds Shared, easily accessible, multycustomer IT infrastructures that are available onexclusively to any entity in the general public (individuals, groups, and/or organizations).

server farms Massive data centers, which may contain hundreds of thousands of networked computer servers.

server virtualization A technology that uses software-based partitions to create multiple virtual servers (called virtual machines) on a single physical server.

service-oriented architecture An IT architecture that makes it possible to construct business applications using Web services.

software-as-a-service (SaaS) delivery model Cloud computing vendors provide software that is specific to their customers’ requirements.

utility computing A technology whereby a service provider makes computing resources and infrastructure management available to a customer as needed.

Web services Applications delivered over the Internet that IT developers can select and combine through almost any device, from personal computers to mobile phones.

[Discussion Questions]

1. What is the value of server farms and virtualization to any large organization?

2. If you were the chief information officer (CIO) of a firm, how would you explain the workings, benefits, and limitations of cloud computing?

3. What is the value of cloud computing to a small organization?

4. What is the value of cloud computing to an entrepreneur who is starting a business?

[Problem-Solving Activities]

1. Investigate the status of cloud computing by researching the offerings of the following leading vendors. Note any inhibitors to cloud computing.

   - Dell (see, e.g., http://www.wiley.com/go/rainer/problem solving)
   - Oracle (see, e.g., http://www.wiley.com/go/rainer/problem solving)
   - IBM (see, e.g., http://www.wiley.com/go/rainer/problem solving)
   - Amazon (see, e.g., http://www.wiley.com/go/rainer/problem solving)
   - Microsoft (see, e.g., http://www.wiley.com/go/rainer/problem solving)
   - Google (see, e.g., http://www.wiley.com/go/rainer/problem solving)
[ Internship Activity ]

Industry: Healthcare

In an earlier activity (Chapter 6) you helped Chad Prince and Anniston Orthopaedics determine criteria for measuring latency in the cloud. Again, related to the cloud, they have a need to determine how they can print from the cloud. When printing is done on a local network there is a print server and it is physically connected to each of the computers and printers available. Software then is programmed to manage the printing in the office.

But what if your data is all in the cloud? How will the cloud-based print servers interact with the local print servers? While this may sound trivial, in a health-care related industry, the ability to print records quickly and easily is vital!

Please visit the Book Companion Site to receive the full set of instructions on how you will help Chad research the interaction between cloud and local print servers.