SECTION II

Foundation Concepts: The Components of Information Systems

System Concepts: A Foundation

System concepts underlie all business processes, as well as our understanding of information systems and technologies. That's why we need to discuss how generic system concepts apply to business firms and the components and activities of information systems. Understanding system concepts will help you understand many other concepts in the technology, applications, development, and management of information systems that we cover in this text. For example, system concepts help us understand:

- **Technology.** Computer networks are systems of information processing components that use a variety of hardware, software, data management, and telecommunications network technologies.
- **Applications.** E-business and e-commerce applications involve interconnected business information systems.
- **Development.** Developing ways to use information technology in business includes designing the basic components of information systems.
- **Management.** Managing information technology emphasizes the quality, strategic business value, and security of an organization's information systems.

Read the Real World Case about how some companies are turning to IT to help them develop new products and services. We can learn a lot from this case regarding the various ways in which IT can be used to foster innovation. See Figure 1.16.

What Is a System?

We have used the term *system* more than 100 times already and will use it thousands more before we are done. It therefore seems reasonable that we focus our attention on exactly what a **system** is. As we discussed at the beginning of the chapter, a system is defined as *a set of interrelated components, with a clearly defined boundary, working together to achieve a common set of objectives by accepting inputs and producing outputs in an organized transformation process*. Many examples of systems can be found in the physical and biological sciences, in modern technology, and in human society. Thus, we can talk of the physical system of the sun and its planets, the biological system of the human body, the technological system of an oil refinery, and the socioeconomic system of a business organization.

Systems have three basic functions:

- **Input** involves capturing and assembling elements that enter the system to be processed. For example, raw materials, energy, data, and human effort must be secured and organized for processing.
- **Processing** involves transformation processes that convert input into output. Examples are manufacturing processes, the human breathing process, or mathematical calculations.
- **Output** involves transferring elements that have been produced by a transformation process to their ultimate destination. For example, finished products, human services, and management information must be transmitted to their human users.

Example. A manufacturing system accepts raw materials as input and produces finished goods as output. An information system is a system that accepts resources (data) as input and processes them into products (information) as output. A business organization is a system in which human and economic resources are transformed by various business processes into goods and services.

REAL WORLD CASE 2

The New York Times and Boston Scientific: Two Different Ways of Innovating with Information Technology

Almost everybody has a theory about how to save the U.S. newspaper industry. The only consensus, it seems, is that it needs to change fundamentally or it could all but disappear. At *The New York Times*, tough times have elevated IT-enabled innovation to the top of the agenda.

A research and development group, created in 2006, operates as a shared service across nearly two dozen newspapers, a radio station, and more than 50 Web sites.

"Our role is to accelerate our entry onto new platforms by identifying opportunities, conceptualizing, and prototyping ideas," explains Michael Zimbalist, the company's vice president of R&D.

Zimbalist's staff of 12 includes experts in rapid prototyping, specialists in areas like mobile or cloud computing and data miners who probe Web site data for insight into what visitors do. They work within a common framework based on idea generation, development, and diffusion throughout the business. Recent projects included prototypes for new display ad concepts, as well as BlackBerry applications for Boston.com and the expert site About.com. The team's work is intended to supplement and support innovation taking place within the business units. For example, the team is prototyping E-Ink, an emerging display technology; some business units can't spare the resources to investigate it.

At NYTimes.com, the design and product development group of Marc Frons, CTO of Digital Operations, worked with Zimbalist's team and Adobe developers on the Times Reader 2.0 application, the next generation, on-screen reading system it developed on the Adobe AIR platform. Frons further encourages forward thinking among his 120-person team with twice-annual innovation contests. Winners receive cash, recognition and the resources to turn their ideas into reality. Typical projects are measured against criteria like revenue potential or journalistic value. R&D projects aren't. "Since we build software, there's no huge capital investment up front," Frons says, "which allows us to experiment. The emphasis is on rapid development."

FIGURE 1.16

IT can enable innovation initiatives as companies seek to develop new products and services.

Source: © Stockbyte/Getty Images.

Times Widgets, a widget-making platform, was a contest winner, as was the recently launched Times Wire, a near real-time customizable interface for online content. "We're trying to solve specific problems and think about where the business is going," Frons says. Frons is focused on enhancing revenue, cutting costs, and increasing efficiency through process improvements and automation.

The New York Times has launched a cool interactive map that shows the most popular Netflix rentals across 12 U.S. metropolitan areas: New York, San Francisco/Bay Area, Boston, Chicago, Washington, Los Angeles, Seattle, Minneapolis, Denver, Atlanta, Dallas, and Miami. If you're a Netflix junkie and a closet *Twilight* fan (and you live in a major U.S. city), your rental habits are now on display. To create the map, *The New York Times* partnered with Netflix. The map is a graphical database of the top 100 most-rented Netflix films of 2009 laid on top of maps. With it you can graphically explore top 2009 Netflix movies based on three criteria: films that were hated or loved by critics, an alphabetical list, and most rented. For example, select most rented, and when you place the mouse over a zip code, a window pops up showing you what the top Netflix rentals are for that specific region.

Some trends are not surprising: The most popular Netflix movie of 2009 was *The Curious Case of Benjamin Button*, although *Slumdog Millionaire* and *Twilight* were both in the top 10. *Milk*, the story of San Franciscan activist Harvey Milk, was popular in San Francisco and other city centers, but not so much in the suburbs of southern cities (such as Dallas and Atlanta). *Mad Men*, the 1960s-set drama about advertising execs, was hot in parts of Manhattan and Brooklyn, but not in any other major cities. It barely got mention in Denver and Dallas, and not at all in Miami.

The map does show some interesting trends: Big blockbusters were not as popular in city centers (*Wanted* and *Transformers: Revenge of the Fallen*, barely made a splash in the city centers of Manhattan and San Francisco), although this could be due to the fact that a lot of people see blockbusters in movie theaters. *Last Chance Harvey*, a romantic comedy starring Dustin Hoffman and Emma Thompson, was enjoyed in wealthier suburbs (such as Scarsdale), but not in city centers (such as Manhattan). Tyler Perry's movies (Tyler Perry's *Madea Goes to Jail* and Tyler Perry's *The Family That Preys*) were popular in predominantly black neighborhoods.

Much of what has been innovative thus far at *The New York Times* can be classified as process or product innovation. Typically, a healthy and growing company should be content with focusing 90 to 95 percent of its innovation dollars on such core business innovation and 5 percent or 10 percent on new business models, says Mark Johnson, chairman of strategic innovation consultancy Innosight. However, he adds, "The newspaper industry is in so much trouble that business model innovation is more important than ever."

Now is a good—and bad—time for fostering such innovation. "You've got the leadership's attention you need," says Johnson. "But it's harder in the sense that there's an urgency to fix the financials, and being patient in the way you need to be for a new business model to unfold is a very difficult thing to do."

The New York Times is focused on experimenting with a number of different initiatives, but Boston Scientific faces a much different challenge: how to foster innovation without risking the disclosure and leakage of very valuable intellectual property. And the company has turned to technology to help find the right mix of access and security.

Boston Scientific wants to tear down barriers that prevent product developers from accessing the research that went into its successful medical devices so that they can create new products faster. But making data too easily accessible could open the way to theft of information potentially worth millions or billions of dollars. It's a classic corporate data privacy problem.

"The more info you give knowledge workers, the more effective they can be in creating a lot of value for the company," says Boris Evelson, a principal analyst at Forrester. "This creates disclosure risks—that someone's going to walk away with the data and give it to a competitor."

This tension compels the $8 billion company to seek out software that allows the broader engineering community to share knowledge while managing access to product development data, says Jude Currier, cardiovascular knowledge management and innovation practices lead at Boston Scientific. "Active security is the way to address this problem," Currier says.

That is, regularly monitor who's accessing what, and adjust permissions as business conditions change.

Keeping the pipeline of new stents, pacemakers, and catheters fresh is especially important because heart-related items account for 80 percent of Boston Scientific's sales. Over the past few years, engineers have been focused on quality system improvements, Currier says. Boston Scientific had inherited regulatory problems from acquisitions it made during that time. Now that those situations are addressed, the company is ready to reinvigorate internal innovation.

Boston Scientific is piloting Invention Machine's Goldfire software, which, Currier says, provides the right mix of openness and security for data. Before, Boston Scientific's product developers worked in silos with limited access to research by colleagues on different product lines. Information was so locked down that even if scientists found something useful from a past project, they often didn't have access to it. "We're changing that," Currier says.

Goldfire makes an automated workflow out of such tasks as analyzing markets and milking a company's intellectual property. It combines internal company data with information from public sources, such as federal government databases.

Researchers can use the software to find connections among different sources, for instance by highlighting similar ideas. Engineers can use such analysis to get ideas for new products and begin to study their feasibility. The goal is to have any engineer be able to access any other engineer's research.

"The people in the trenches can't wait for that day to arrive," he says.

Although the goal is more openness, not all data stay open forever. For example, as a project gets closer to the patent application stage, access to the data about it is clipped to fewer people, Currier says.

He adds that since installing Goldfire, patent applications are up compared to similar engineering groups that do not use the Goldfire tool. "We have had to educate people that we aren't throwing security out the window but making valuable knowledge available to the organization," he says.

Source: Adapted from Stephanie Overby, "Rapid Prototyping Provides Innovation that Fits at the New York Times," *CIO.com*, June 24, 2009; Sarah Jacobson, "Netflix Map Shows What's Hot in Your Neighborhood," *PCWorld.com*, January 11, 2010; and Kim S. Nash, "Innovation: How Boston Scientific Shares Data Securely to Foster Product Development," *CIO.com*, November 23, 2009.

CASE STUDY QUESTIONS

1. As stated in the case, *The New York Times* chose to deploy their innovation support group as a shared service across business units. What do you think this means? What are the advantages of choosing this approach? Are there any disadvantages?
2. Boston Scientific faced the challenge of balancing openness and sharing with security and the need for restricting access to information. How did the use of technology allow the company to achieve both objectives at the same time? What kind of cultural changes were required for this to be possible? Are these more important than the technology-related issues? Develop a few examples to justify your answer.
3. The video rental map developed by *The New York Times* and Netflix graphically displays movie popularity across neighborhoods from major U.S. cities. How would Netflix use this information to improve their business? Could other companies also take advantage of these data? How? Provide some examples.

REAL WORLD ACTIVITIES

1. The newspaper industry has been facing serious challenges to its viability ever since the Internet made news available online. In addition to those initiatives described in the case, how are *The New York Times* and other leading newspapers coping with these challenges? What do you think the industry will look like 5 or 10 years from now? Go online to research these issues and prepare a report to share your findings.
2. Go online and search the Internet for other examples of companies using technology to help them innovate and develop new products or services. Break into small groups with your classmates to share your findings and discuss any trends or patterns you see in current uses of technology in this regard.

Feedback and Control

The system concept becomes even more useful by including two additional elements: feedback and control. A system with feedback and control functions is sometimes called a *cybernetic* system, that is, a self-monitoring, self-regulating system.

- **Feedback** is data about the performance of a system. For example, data about sales performance are feedback to a sales manager. Data about the speed, altitude, attitude, and direction of an aircraft are feedback to the aircraft's pilot or autopilot.
- **Control** involves monitoring and evaluating feedback to determine whether a system is moving toward the achievement of its goal. The control function then makes the necessary adjustments to a system's input and processing components to ensure that it produces proper output. For example, a sales manager exercises control when reassigning salespersons to new sales territories after evaluating feedback about their sales performance. An airline pilot, or the aircraft's autopilot, makes minute adjustments after evaluating the feedback from the instruments to ensure that the plane is exactly where the pilot wants it to be.

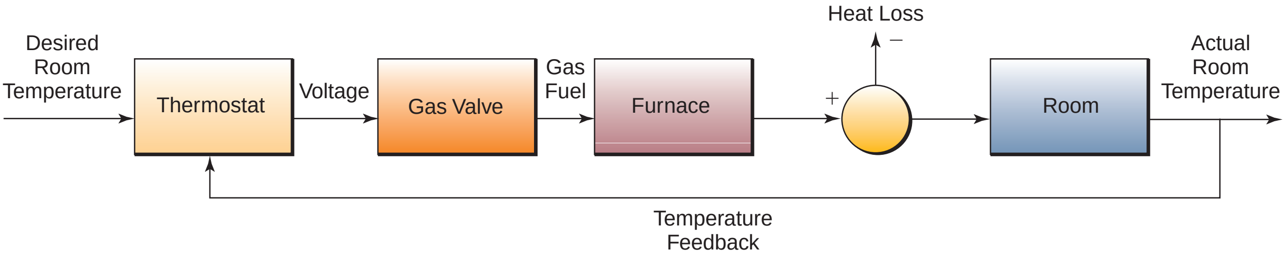
Example. Figure 1.17 illustrates a familiar example of a self-monitoring, self-regulating, thermostat-controlled heating system found in many homes; it automatically monitors and regulates itself to maintain a desired temperature. Another example is the human body, which can be regarded as a cybernetic system that automatically monitors and adjusts many of its functions, such as temperature, heartbeat, and breathing. A business also has many control activities. For example, computers may monitor and control manufacturing processes, accounting procedures help control financial systems, data entry displays provide control of data entry activities, and sales quotas and sales bonuses attempt to control sales performance.

Other System Characteristics

Figure 1.18 uses a business organization to illustrate the fundamental components of a system, as well as several other system characteristics. Note that a system does not exist in a vacuum; rather, it exists and functions in an *environment* containing other systems. If a system is one of the components of a larger system, it is a *subsystem*, and the larger system is its environment.

Several systems may share the same environment. Some of these systems may be connected to one another by means of a shared boundary, or *interface*. Figure 1.18 also illustrates the concept of an *open system*, that is, a system that interacts with other systems in its environment. In this diagram, the system exchanges inputs and outputs with its environment. Thus, we could say that it is connected to its environment by input and output interfaces. Finally, a system that has the ability to change itself or its environment to survive is an *adaptive system*.

FIGURE 1.17 A common cybernetic system is a home temperature control system. The thermostat accepts the desired room temperature as input and sends voltage to open the gas valve, which fires the furnace. The resulting hot air goes into the room, and the thermometer in the thermostat provides feedback to shut the system down when the desired temperature is reached.



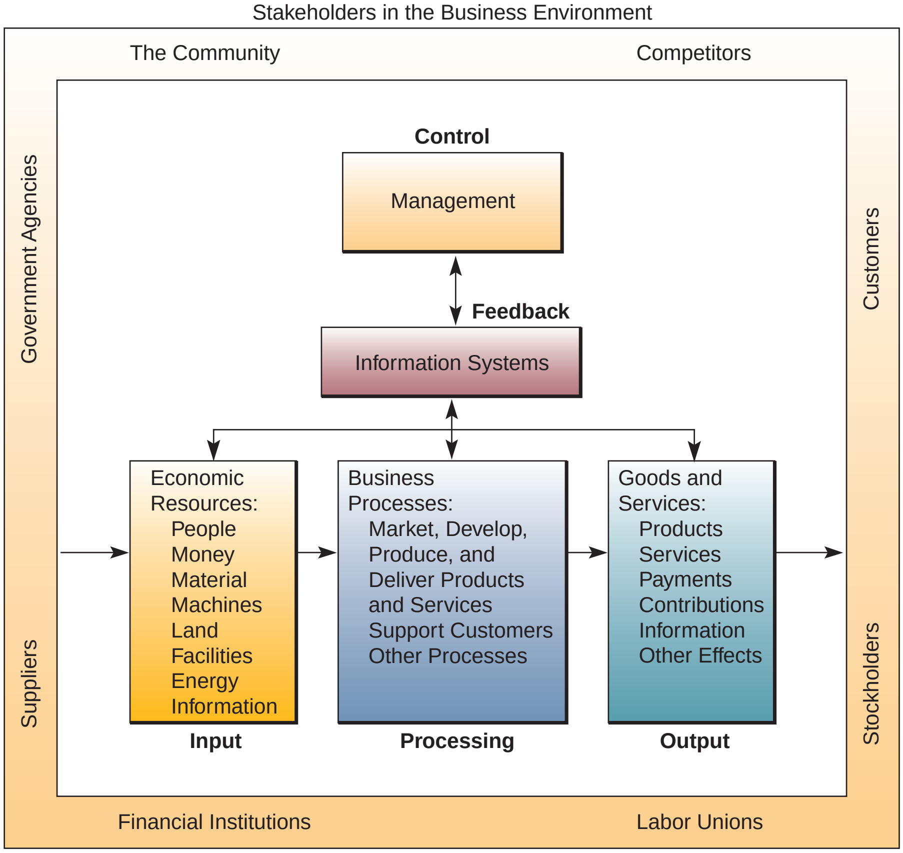


FIGURE 1.18
A business is an example of an organizational system in which economic resources (input) are transformed by various business processes (processing) into goods and services (output). Information systems provide information (feedback) about the operations of the system to management for the direction and maintenance of the system (control) as it exchanges inputs and outputs with its environment.

Example. Organizations such as businesses and government agencies are good examples of the systems in society, which is their environment. Society contains a multitude of such systems, including individuals and their social, political, and economic institutions. Organizations themselves consist of many subsystems, such as departments, divisions, process teams, and other workgroups. Organizations are examples of open systems because they interface and interact with other systems in their environment. Finally, organizations are examples of adaptive systems because they can modify themselves to meet the demands of a changing environment.

If we apply our understanding of general system concepts to information systems, it should be easy to see the parallels.

Information systems are made up of interrelated components:

- People, hardware, software, peripherals, and networks.

They have clearly defined boundaries:

- Functions, modules, type of application, department, or end-user group.

All the interrelated components work together to achieve a common goal by accepting inputs and producing outputs in an organized transformation process:

- Using raw materials, hiring new people, manufacturing products for sale, and disseminating information to others.

Information systems make extensive use of feedback and control to improve their effectiveness:

- Error messages, dialog boxes, passwords, and user rights management.

Many information systems are designed to change in relation to their environments and are adaptive:

- Intelligent software agents, expert systems, and highly specialized decision support systems.

Information systems are systems just like any other system. Their value to the modern organization, however, is unlike any other system ever created.

Components of Information Systems

We have noted that an information system is a system that accepts data resources as input and processes them into information products as output. How does an information system accomplish this task? What system components and activities are involved?

Figure 1.19 illustrates an **information system model** that expresses a fundamental conceptual framework for the major components and activities of information systems. An information system depends on the resources of people (end users and IS specialists), hardware (machines and media), software (programs and procedures), data (data and knowledge bases), and networks (communications media and network support) to perform input, processing, output, storage, and control activities that transform data resources into information products.

This information system model highlights the relationships among the components and activities of information systems. It also provides a framework that emphasizes four major concepts that can be applied to all types of information systems:

- People, hardware, software, data, and networks are the five basic resources of information systems.
- People resources include end users and IS specialists, hardware resources consist of machines and media, software resources include both programs and procedures, data resources include data and knowledge bases, and network resources include communications media and networks.

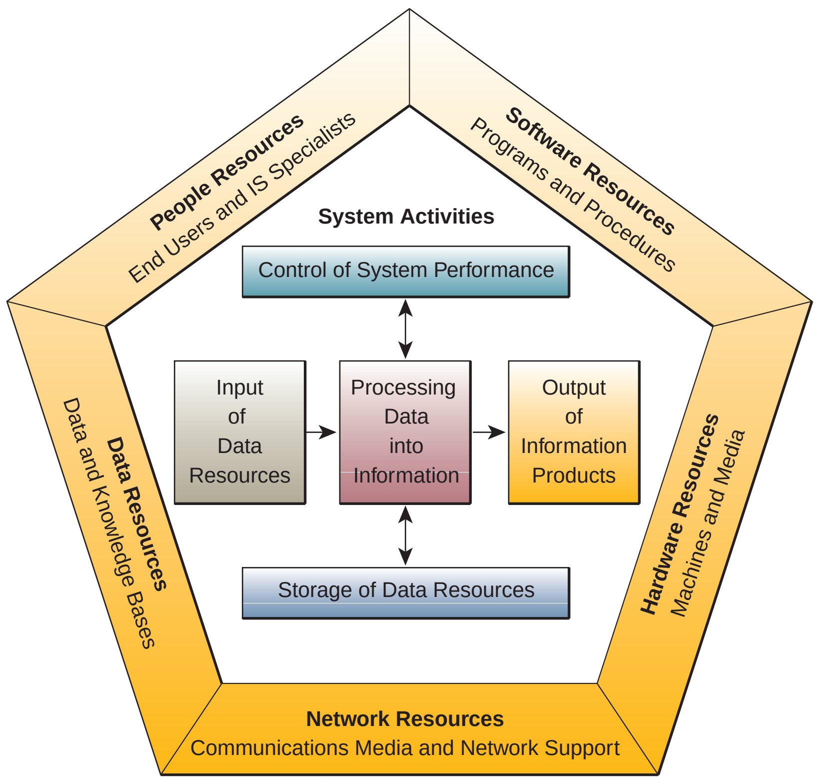


FIGURE 1.19
The components of an information system. All information systems use people, hardware, software, data, and network resources to perform input, processing, output, storage, and control activities that transform data resources into information products.

- Data resources are transformed by information processing activities into a variety of information products for end users.
- Information processing consists of the system activities of input, processing, output, storage, and control.

Information System Resources

Our basic IS model shows that an information system consists of five major resources: people, hardware, software, data, and networks. Let's briefly discuss several basic concepts and examples of the roles these resources play as the fundamental components of information systems. You should be able to recognize these five components at work in any type of information system you encounter in the real world. Figure 1.20 outlines several examples of typical information system resources and products.

People Resources

People are the essential ingredient for the successful operation of all information systems. These **people resources** include end users and IS specialists.

- **End users** (also called users or clients) are people who use an information system or the information it produces. They can be customers, salespersons, engineers, clerks, accountants, or managers and are found at all levels of an organization. In fact, most of us are information system end users. Most end users in business are **knowledge workers**, that is, people who spend most of their time communicating and collaborating in teams and workgroups and creating, using, and distributing information.
- **IS specialists** are people who develop and operate information systems. They include systems analysts, software developers, system operators, and other managerial, technical, and clerical IS personnel. Briefly, systems analysts design information systems based on the information requirements of end users, software developers create computer programs based on the specifications of systems analysts, and system operators help monitor and operate large computer systems and networks.

Hardware Resources

The concept of **hardware resources** includes all physical devices and materials used in information processing. Specifically, it includes not only **machines**, such as computers

FIGURE 1.20
Examples of information system resources and products.

Information System Resources and Products
People Resources Specialists—systems analysts, software developers, systems operators. End Users—anyone else who uses information systems.
Hardware Resources Machines—computers, video monitors, magnetic disk drives, printers, optical scanners. Media—floppy disks, magnetic tape, optical disks, plastic cards, paper forms.
Software Resources Programs—operating system programs, spreadsheet programs, word processing programs, payroll programs. Procedures—data entry procedures, error correction procedures, paycheck distribution procedures.
Data Resources Product descriptions, customer records, employee files, inventory databases.
Network Resources Communications media, communications processors, network access, control software.
Information Products Management reports and business documents using text and graphics displays, audio responses, and paper forms.

and other equipment, but also all data **media**, that is, tangible objects on which data are recorded, from sheets of paper to magnetic or optical disks. Examples of hardware in computer-based information systems are:

- **Computer systems,** which consist of central processing units containing microprocessors and a variety of interconnected peripheral devices such as printers, scanners, monitors, and so on. Examples are handheld, laptop, tablet, or desktop microcomputer systems, midrange computer systems, and large mainframe computer systems.
- **Computer peripherals,** which are devices such as a keyboard, electronic mouse, trackball, or stylus for the input of data and commands, a video screen or printer for the output of information, and magnetic or optical disk drives for the storage of data resources.

Software Resources

The concept of **software resources** includes all sets of information processing instructions. This generic concept of software includes not only the sets of operating instructions called **programs**, which direct and control computer hardware, but also the sets of information processing instructions called **procedures** that people need.

It is important to understand that even information systems that do not use computers have a software resource component. This claim is true even for the information systems of ancient times or the manual and machine-supported information systems still used in the world today. They all require software resources in the form of information processing instructions and procedures to properly capture, process, and disseminate information to their users.

The following are examples of software resources:

- **System software,** such as an operating system program, which controls and supports the operations of a computer system. Microsoft Windows and Unix are two examples of popular computer operating systems.
- **Application software,** which are programs that direct processing for a particular use of computers by end users. Examples are sales analysis, payroll, and word processing programs.
- **Procedures,** which are operating instructions for the people who will use an information system. Examples are instructions for filling out a paper form or using a software package.

Data Resources

Data are more than the raw material of information systems. The concept of **data resources** has been broadened by managers and information systems professionals. They realize that data constitute valuable organizational resources. Thus, you should view data just as you would any organizational resource that must be managed effectively to benefit all stakeholders in an organization.

The concept of data as an organizational resource has resulted in a variety of changes in the modern organization. Data that previously were captured as a result of a common transaction are now stored, processed, and analyzed using sophisticated software applications that can reveal complex relationships among sales, customers, competitors, and markets. In today's wired world, the data to create a simple list of an organization's customers are protected with the same energy as the cash in a bank vault. Data are the lifeblood of today's organizations, and the effective and efficient management of data is considered an integral part of organizational strategy.

Data can take many forms, including traditional alphanumeric data, composed of numbers, letters, and other characters that describe business transactions and other events and entities; text data, consisting of sentences and paragraphs used in written communications; image data, such as graphic shapes and figures or photographic and video images; and audio data, including the human voice and other sounds.