Chapter 11

Managing Knowledge

LEARNING OBJECTIVES

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

1. What is the role of knowledge management and knowledge management programs in business?
2. What types of systems are used for enterprise-wide knowledge management and how do they provide value for businesses?
3. What are the major types of knowledge work systems and how do they provide value for firms?
4. What are the business benefits of using intelligent techniques for knowledge management?

CHAPTER OUTLINE

Interactive Sessions:

Firewire Surfboards Lights Up with CAD

Albassami's Job is Not Feasible Without IT

DESIGNING DRUGS VIRTUALLY

Pharmaceutical companies and medical researchers are constantly trying to find new drugs that will provide better treatments for cancer and other serious illnesses. Until recently, this process was largely a matter of trial and error.

Disease-fighting drugs typically work by attacking a disease-causing protein that is harmfully interacting with other molecules in the body. The drug is able to stop these interactions by connecting to the protein, and either restoring healthy interactions or compensating for the unhealthy ones.

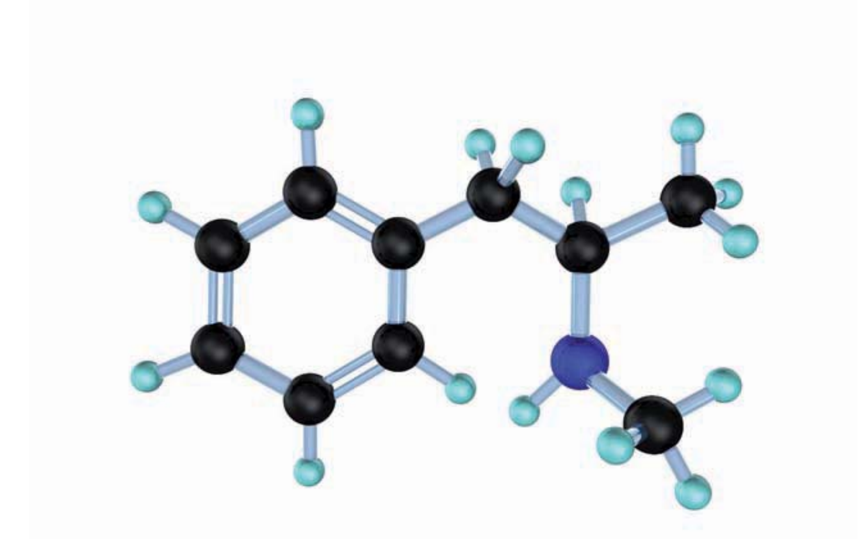
A drug connecting to a protein has been likened to a key fitting into a lock. In the traditional drug discovery process, drug makers would be looking for the "keys" while ignoring the "locks." They sifted through natural substances found in soil, dyes and industrial chemicals, and failed compounds from previous drug research efforts. They would test their samples for their impact on diseased cells. Once in a great while, as in the case of penicillin, one worked, but for the overwhelming majority of efforts, this was not the case.

Drug development companies tried to speed up the process by creating huge libraries of potential compounds and using robots to quickly review hundreds of thousands of samples to see if any worked. Machines would create thousands of chemicals per day by mixing and matching common building blocks. Then robots would drop bits of each chemical into tiny vials containing samples of a bodily substance involved in a disease, such as the protein that triggers cholesterol production. A "hit" occurred when the substance and the chemical produced a desired reaction. Way too much depended on chance. When researchers did come upon a new treatment that worked, they often had no idea for many years why. They did not understand the "key" or the "lock." Very few effective medications were discovered this way.

Joshua Boger, a former Merck & Company scientist, decided to try a different approach called structure-based design. In 1989, he formed a company called Vertex Pharmaceuticals, which would focus on figuring out what a "lock" looked like so it could fashion the right disease-fighting "key."

It would not be easy to determine the shape of a "lock." Proteins escape when X-rays try to capture their images, so scientists must first crystallize the proteins and try to deduce their shape by examining the patterns left by the X-rays deflecting around them. This work requires powerful computers analyzing thousands of interference patterns.

Next, researchers must find a custom molecule to fit that particular "lock." The molecule must be able to bind to the target, be synthesized and manufactured in large quantities, and be metabolized by the body at just the right rate. Powerful computers help evaluate the structures and properties of molecules that are most likely to bind to that target and rapidly search large database libraries of chemical structures in order to identify the most promising candidates.



The discovery of the drug called Xalkori, a treatment for a rare and resistant form of lung cancer, is one example of how structure-based design helped. Reseachers led by Dr. Jean Cui at the biotech firm Sugen were trying to block a protein called c-Met that was found to play an important role in the growth of cancer tumors. The researchers identified a naturally occurring molecule that connected to c-Met, but the molecule at that stage lacked properties, such as avoiding rapid metabolism in the body, that would make it a workable drug. Other researchers using structure-based design crystallized the c-Met protein with one of the potential drug molecules linked to it, subjected this arrangement to X-rays, and used computer analysis to deduce the structure of the protein and how the prototype drug molecule "key" fit into its "lock."

Dr. Cui was able to use this information to develop an entirely new molecule that could both bind to c-Met and that had properties suitable for a drug. Colleagues used Cui's sketch of what she thought the drug design should look like to model compounds virtually on a computer and make them in test tubes for further study. By February 2003, animal tests showed that the molecule could arrest tumor growth. After Sugen and its parent company Pharmacia were acquired by Pfizer, researchers further refined the molecule to make Xalkori ready for testing in humans. Xalkori was approved by the FDA in the summer of 2011.

In addition to treating lung cancer, Xalkori is being used in conjunction with an Alzheimer's disease treatment developed by Eli Lilly & Co., an antibiotic made by GlaxoSmithKline PLC that is in clinical trials, and a Sanofi SA blood thinner that is in the final stages of development. Vertex's hepatitis C therapy, called Incivek, was FDA-approved in May 2011, and its drug for treating cystic fibrosis, called Ivacaftor, was approved in January 2012.

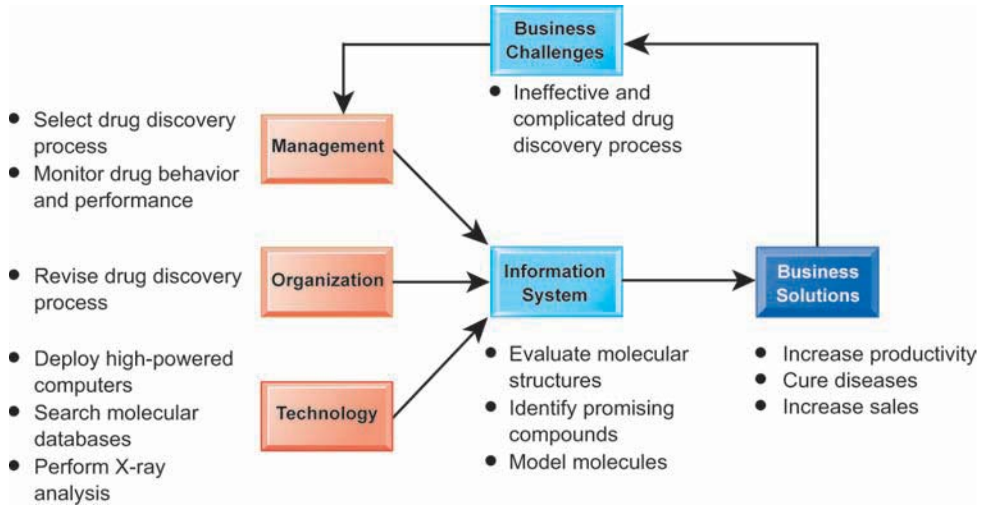
Sources: Jonathan D. Rockoff, "Drug Discovery Gets an Upgrade," *The Wall Street Journal*, April 16, 2012; www.vrtx.com, accessed July 1, 2012; and Matthew Herperi, "Pfizer Wins Approval For Xalkori, Lung Cancer Drug That Heralds Age Of Expensive, Personalized Medicines," *Forbes*, August 26, 2011.

The experience of the medical researchers engaged in drug discovery described in this case shows how business performance can benefit by using technology to facilitate the acquisition and application of knowledge. Facilitating access to knowledge, improving the quality and currency of knowledge, and using that knowledge to improve business processes are vital to success and survival in all areas of business as well as in medical research.

The chapter-opening diagram calls attention to important points raised by this case and this chapter. Phamaceutical companies trying to develop new drugs are very challenged because the drug discovery process is so painstaking and complicated. Earlier methods were not very accurate or effective and depended too much on trial and error. This is beginning to change, thanks to the development of new processes for visualizing and designing new drugs and the use of powerful computers and information technology.

Drug researchers using structure-based design benefit from a new process of visualizing and modeling promising compounds at the molecular level. Powerful computers for analyzing molecular structure, databases organizing data about specific molecules and compounds, and software for visualizing and modeling molecules all play a role in creating new knowledge and making that knowledge available to researchers. Thanks to better systems for capturing and creating knowledge, drug researchers and pharmaceutical companies have a much more accurate and efficient process for developing effective medications and for understanding how these drugs actually work.

Here are some questions to think about: Why are computers so important in drug discovery? What roles are played by computers in the drug discovery process?



11.1 THE KNOWLEDGE MANAGEMENT LANDSCAPE

Knowledge management and collaboration systems are among the fastest growing areas of corporate and government software investment. The past decade has shown an explosive growth in research on knowledge and knowledge management in the economics, management, and information systems fields.

Knowledge management and collaboration are closely related. Knowledge that cannot be communicated and shared with others is nearly useless. Knowledge becomes useful and actionable when shared throughout the firm. We have already described the major tools for collaboration and social business in Chapter 2. In this chapter, we will focus on knowledge management systems, and be mindful that communicating and sharing knowledge are becoming increasingly important.

We live in an information economy in which the major source of wealth and prosperity is the production and distribution of information and knowledge. An estimated 37 percent of the U.S. labor force consists of knowledge and information workers, the largest single segment of the labor force. About 45 percent of the gross domestic product (GDP) of the United States is generated by the knowledge and information sectors (U.S. Department of Commerce, 2012).

Knowledge management has become an important theme at many large business firms as managers realize that much of their firm's value depends on the firm's ability to create and manage knowledge. Studies have found that a substantial part of a firm's stock market value is related to its intangible assets, of which knowledge is one important component, along with brands, reputations, and unique business processes. Well-executed knowledge-based projects have been known to produce extraordinary returns on investment, although the impacts of knowledge-based investments are difficult to measure (Gu and Lev, 2001).

IMPORTANT DIMENSIONS OF KNOWLEDGE

There is an important distinction between data, information, knowledge, and wisdom. Chapter 1 defines **data** as a flow of events or transactions captured by an organization's systems that, by itself, is useful for transacting but little else. To turn data into useful *information*, a firm must expend resources to organize data into categories of understanding, such as monthly, daily, regional, or store-based reports of total sales. To transform information into **knowledge**, a firm must expend additional resources to discover patterns, rules, and contexts where the knowledge works. Finally, **wisdom** is thought to be the collective and individual experience of applying knowledge to the solution of problems. Wisdom involves where, when, and how to apply knowledge.

Knowledge is both an individual attribute and a collective attribute of the firm. Knowledge is a cognitive, even a physiological, event that takes place inside people's heads. It is also stored in libraries and records, shared in lectures, and stored by firms in the form of business processes and employee know-how. Knowledge residing in the minds of employees that has not been documented is called **tacit knowledge**, whereas knowledge that has been documented is called **explicit knowledge**. Knowledge can reside in e-mail, voice mail, graphics, and unstructured documents as well as structured documents. Knowledge is generally believed to have a location, either in the minds of humans or in specific business processes. Knowledge is "sticky" and not universally applicable or easily moved. Finally, knowledge is thought to be situational and contextual. For example, you must know when to perform a procedure as well as how to perform it. Table 11.1 reviews these dimensions of knowledge.

We can see that knowledge is a different kind of firm asset from, say, buildings and financial assets; that knowledge is a complex phenomenon; and that there are many aspects to the process of managing knowledge. We can also recognize that knowledge-based core competencies of firms—the two or three things that an organization does best—are key organizational assets. Knowing how to do things effectively and efficiently in ways that other organizations cannot duplicate is a primary source of profit and competitive advantage that cannot be purchased easily by competitors in the marketplace.

TABLE 11.1 IMPORTANT DIMENSIONS OF KNOWLEDGE

KNOWLEDGE IS A FIRM ASSET
Knowledge is an intangible asset.
The transformation of data into useful information and knowledge requires organizational resources.
Knowledge is not subject to the law of diminishing returns as are physical assets, but instead experiences network effects as its value increases as more people share it.
KNOWLEDGE HAS DIFFERENT FORMS
Knowledge can be either tacit or explicit (codified).
Knowledge involves know-how, craft, and skill.
Knowledge involves knowing how to follow procedures.
Knowledge involves knowing why, not simply when, things happen (causality).
KNOWLEDGE HAS A LOCATION
Knowledge is a cognitive event involving mental models and maps of individuals.
There is both a social and an individual basis of knowledge.
Knowledge is "sticky" (hard to move), situated (enmeshed in a firm's culture), and contextual (works only in certain situations).
KNOWLEDGE IS SITUATIONAL
Knowledge is conditional; knowing when to apply a procedure is just as important as knowing the procedure (conditional).
Knowledge is related to context; you must know how to use a certain tool and under what circumstances.

For instance, having a unique build-to-order production system constitutes a form of knowledge and perhaps a unique asset that other firms cannot copy easily. With knowledge, firms become more efficient and effective in their use of scarce resources. Without knowledge, firms become less efficient and less effective in their use of resources and ultimately fail.

Organizational Learning and Knowledge Management

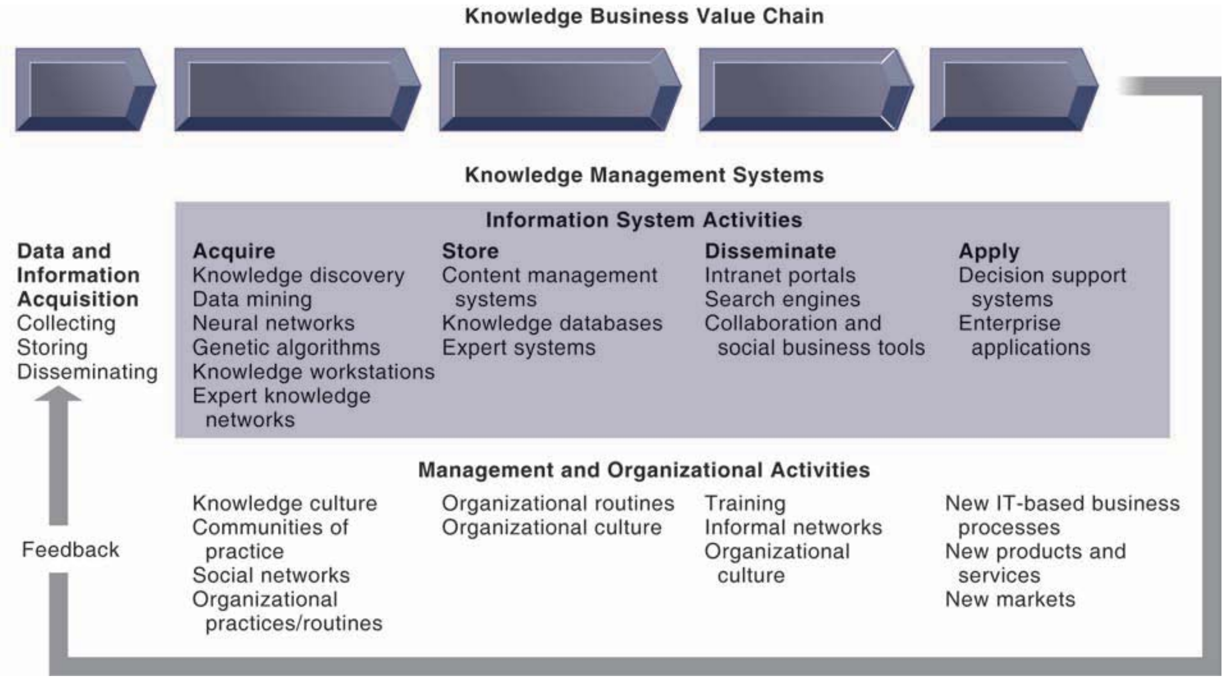
Like humans, organizations create and gather knowledge using a variety of organizational learning mechanisms. Through collection of data, careful measurement of planned activities, trial and error (experiment), and feedback from customers and the environment in general, organizations gain experience. Organizations that learn adjust their behavior to reflect that learning by creating new business processes and by changing patterns of management decision making. This process of change is called **organizational learning**. Arguably, organizations that can sense and respond to their environments rapidly will survive longer than organizations that have poor learning mechanisms.

THE KNOWLEDGE MANAGEMENT VALUE CHAIN

Knowledge management refers to the set of business processes developed in an organization to create, store, transfer, and apply knowledge. Knowledge management increases the ability of the organization to learn from its environment and to incorporate knowledge into its business processes. Figure 11.1 illustrates the five value-adding steps in the knowledge management value chain. Each stage in the value chain adds value to raw data and information as they are transformed into usable knowledge.

In Figure 11.1, information systems activities are separated from related management and organizational activities, with information systems activities on

FIGURE 11.1 THE KNOWLEDGE MANAGEMENT VALUE CHAIN



Knowledge management today involves both information systems activities and a host of enabling management and organizational activities.

the top of the graphic and organizational and management activities below. One apt slogan of the knowledge management field is, "Effective knowledge management is 80 percent managerial and organizational, and 20 percent technology."

In Chapter 1, we define *organizational and management capital* as the set of business processes, culture, and behavior required to obtain value from investments in information systems. In the case of knowledge management, as with other information systems investments, supportive values, structures, and behavior patterns must be built to maximize the return on investment in knowledge management projects. In Figure 11.1, the management and organizational activities in the lower half of the diagram represent the investment in organizational capital required to obtain substantial returns on the information technology (IT) investments and systems shown in the top half of the diagram.

Knowledge Acquisition

Organizations acquire knowledge in a number of ways, depending on the type of knowledge they seek. The first knowledge management systems sought to build corporate repositories of documents, reports, presentations, and best practices. These efforts have been extended to include unstructured documents (such as e-mail). In other cases, organizations acquire knowledge by developing online expert networks so that employees can "find the expert" in the company who is personally knowledgeable.

In still other cases, firms must create new knowledge by discovering patterns in corporate data or by using knowledge workstations where engineers can discover new knowledge. These various efforts are described throughout this chapter. A coherent and organized knowledge system also requires systematic data from the firm's transaction processing systems that track sales, payments, inventory, customers, and other vital data, as well as data from external sources such as news feeds, industry reports, legal opinions, scientific research, and government statistics.

Knowledge Storage

Once they are discovered, documents, patterns, and expert rules must be stored so they can be retrieved and used by employees. Knowledge storage generally involves the creation of a database. Document management systems that digitize, index, and tag documents according to a coherent framework are large databases adept at storing collections of documents. Expert systems also help corporations preserve the knowledge that is acquired by incorporating that knowledge into organizational processes and culture. Each of these is discussed later in this chapter and in the following chapter.

Management must support the development of planned knowledge storage systems, encourage the development of corporate-wide schemas for indexing documents, and reward employees for taking the time to update and store documents properly. For instance, it would reward the sales force for submitting names of prospects to a shared corporate database of prospects where all sales personnel can identify each prospect and review the stored knowledge.

Knowledge Dissemination

Portals, e-mail, instant messaging, wikis, social business tools, and search engines technology have added to an existing array of collaboration tools for sharing calendars, documents, data, and graphics (see Chapter 2). Contemporary technology seems to have created a deluge of information and knowledge. How can managers and employees discover, in a sea of information and knowledge, that which is really important for their decisions and their work? Here, training programs, informal networks, and shared management experience communicated through a supportive culture help managers focus their attention on the important knowledge and information.

Knowledge Application

Regardless of what type of knowledge management system is involved, knowledge that is not shared and applied to the practical problems facing firms and managers does not add business value. To provide a return on investment, organizational knowledge must become a systematic part of management decision making and become situated in systems for decision support (described in Chapter 12). Ultimately, new knowledge must be built into a firm's business processes and key application systems, including enterprise applications for managing key internal business processes and relationships with customers and suppliers. Management supports this process by creating—based on new knowledge—new business practices, new products and services, and new markets for the firm.

Building Organizational and Management Capital: Collaboration, Communities of Practice, and Office Environments

In addition to the activities we have just described, managers can help by developing new organizational roles and responsibilities for the acquisition of knowledge, including the creation of chief knowledge officer executive positions, dedicated staff positions (knowledge managers), and communities of practice. **Communities of practice (COPs)** are informal social networks of professionals and employees within and outside the firm who have similar work-related activities and interests. The activities of these communities include self-education and group education, conferences, online newsletters, and day-to-day sharing of experiences and techniques to solve specific work problems. Many organizations, such as IBM, the U.S. Federal Highway Administration, and the World Bank have encouraged the development of thousands of online communities of practice. These communities of practice depend greatly on software environments that enable collaboration and communication.

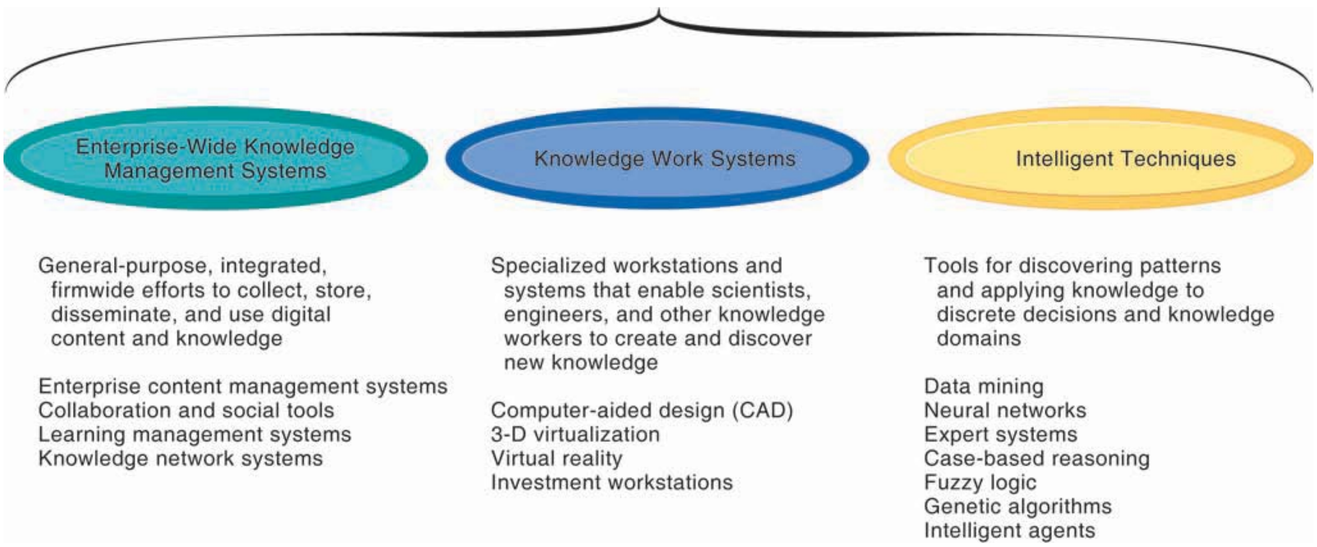
COPs can make it easier for people to reuse knowledge by pointing community members to useful documents, creating document repositories, and filtering information for newcomers. COPs members act as facilitators, encouraging contributions and discussion. COPs can also reduce the learning curve for new employees by providing contacts with subject matter experts and access to a community's established methods and tools. Finally, COPs can act as a spawning ground for new ideas, techniques, and decision-making behavior.

TYPES OF KNOWLEDGE MANAGEMENT SYSTEMS

There are essentially three major types of knowledge management systems: enterprise-wide knowledge management systems, knowledge work systems, and intelligent techniques. Figure 11.2 shows the knowledge management system applications for each of these major categories.

Enterprise-wide knowledge management systems are general-purpose firmwide efforts to collect, store, distribute, and apply digital content and knowledge. These systems include capabilities for searching for information, storing both structured and unstructured data, and locating employee expertise within the firm. They also include supporting technologies such as portals,

FIGURE 11.2 MAJOR TYPES OF KNOWLEDGE MANAGEMENT SYSTEMS



There are three major categories of knowledge management systems, and each can be broken down further into more specialized types of knowledge management systems.

search engines, collaboration and social business tools, and learning management systems.

The development of powerful networked workstations and software for assisting engineers and scientists in the discovery of new knowledge has led to the creation of knowledge work systems such as computer-aided design (CAD), visualization, simulation, and virtual reality systems. **Knowledge work systems (KWS)** are specialized systems built for engineers, scientists, and other knowledge workers charged with discovering and creating new knowledge for a company. We discuss knowledge work applications in detail in Section 11.3.

Knowledge management also includes a diverse group of **intelligent techniques**, such as data mining, expert systems, neural networks, fuzzy logic, genetic algorithms, and intelligent agents. These techniques have different objectives, from a focus on discovering knowledge (data mining and neural networks), to distilling knowledge in the form of rules for a computer program (expert systems and fuzzy logic), to discovering optimal solutions for problems (genetic algorithms). Section 11.4 provides more detail about these intelligent techniques.

11.2 Enterprise-Wide Knowledge Management Systems

Firms must deal with at least three kinds of knowledge. Some knowledge exists within the firm in the form of structured text documents (reports and presentations). Decision makers also need knowledge that is semistructured, such as e-mail, voice mail, chat room exchanges, videos, digital pictures, brochures, or bulletin board postings. In still other cases, there is no formal or digital information of any kind, and the knowledge resides in the heads of employees. Much of this knowledge is tacit knowledge that is rarely written down.

Enterprise-wide knowledge management systems deal with all three types of knowledge.

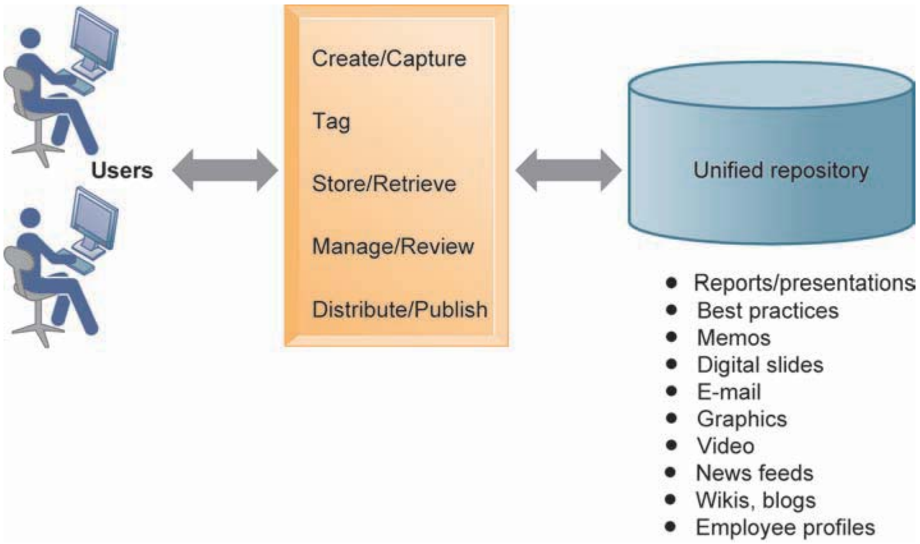
ENTERPRISE CONTENT MANAGEMENT SYSTEMS

Businesses today need to organize and manage both structured and semistructured knowledge assets. **Structured knowledge** is explicit knowledge that exists in formal documents, as well as in formal rules that organizations derive by observing experts and their decision-making behaviors. But, according to experts, at least 80 percent of an organization's business content is semistructured or unstructured—information in folders, messages, memos, proposals, e-mails, graphics, electronic slide presentations, and even videos created in different formats and stored in many locations.

Enterprise content management systems help organizations manage both types of information. They have capabilities for knowledge capture, storage, retrieval, distribution, and preservation to help firms improve their business processes and decisions. Such systems include corporate repositories of documents, reports, presentations, and best practices, as well as capabilities for collecting and organizing semistructured knowledge such as e-mail (see Figure 11.3). Major enterprise content management systems also enable users to access external sources of information, such as news feeds and research, and to communicate via e-mail, chat/instant messaging, discussion groups, and videoconferencing. They are starting to incorporate blogs, wikis, and other enterprise social networking tools. Open Text Corporation, EMC (Documentum), IBM, and Oracle Corporation are leading vendors of enterprise content management software.

Barrick Gold, headquartered in Toronto, is the world's leading gold producer, and it uses Open Text tools for enterprise content management and for supporting communities of practice. The company has 26 operating mines and 20,000 employees worldwide, who were creating and storing information in many different locations. Barrick needed a way to centralize this organizational

FIGURE 11.3 AN ENTERPRISE CONTENT MANAGEMENT SYSTEM



An enterprise content management system has capabilities for classifying, organizing, and managing structured and semistructured knowledge and making it available throughout the enterprise.

expertise, make it easier to access critical company information, and ensure that best practices are documented and shared. Barrick's Knowledge Center is a central repository for documents about policies, procedures, standards, guidelines, new ideas, and best practices, and has capabilities to identify the latest version of each document. Administrators know who is accessing the site and which documents they are using. The content management system includes social networking tools, such as wikis, blogs, and forums, to help communities of practice share their knowledge (Open Text, 2012).

A key problem in managing knowledge is the creation of an appropriate classification scheme, or **taxonomy**, to organize information into meaningful categories so that it can be easily accessed. Once the categories for classifying knowledge have been created, each knowledge object needs to be "tagged," or classified, so that it can be easily retrieved. Enterprise content management systems have capabilities for tagging, interfacing with corporate databases and content repositories, and creating enterprise knowledge portals that provide a single point of access to information resources.

Firms in publishing, advertising, broadcasting, and entertainment have special needs for storing and managing unstructured digital data such as photographs, graphic images, video, and audio content. For example, Coca-Cola must keep track of all the images of the Coca-Cola brand that have been created in the past at all of the company's worldwide offices, to prevent both redundant work and variation from a standard brand image. **Digital asset management systems** help companies classify, store, and distribute these digital objects.

KNOWLEDGE NETWORK SYSTEMS

Knowledge network systems, address the problem that arises when the appropriate knowledge is not in the form of a digital document but instead resides in the memory of individual experts in the firm. Knowledge network systems provide an online directory of corporate experts and their profiles, with details about their job experience, projects, publications, and educational degrees. Search tools make it easy for employees to find the appropriate expert in a company. Knowledge network systems such as Hivemine's AskMe include repositories of expert-generated content. Some knowledge networking capabilities are included in the leading enterprise content management, social networking, and collaboration software products.

COLLABORATION AND SOCIAL TOOLS AND LEARNING MANAGEMENT SYSTEMS

Chapters 2 and 7 have already discussed the importance of collaboration and social tools for information sharing within the firm. For knowledge resources outside the firm, **social bookmarking** makes it easier to search for and share information by allowing users to save their bookmarks to Web pages on a public Web site and tag these bookmarks with keywords. These tags can be used to organize and search for text and images. Lists of tags can be shared with other people to help them find information of interest. The user-created taxonomies created for shared bookmarks are called **folksonomies**. Delicious, Slashdot, and Pinterest are popular social bookmarking sites.

Suppose, for example, that you're on a corporate team researching wind power. If you did a Web search and found relevant Web pages on wind power, you'd click on a bookmarking button on a social bookmarking site and create a tag identifying each Web document you found to link it to wind power. By clicking on the "tags" button at the social networking site, you'd be able to see a list of all the tags you created and select the documents you need.

Companies need ways to keep track of and manage employee learning and to integrate it more fully into their knowledge management and other corporate systems. A **learning management system (LMS)** provides tools for the management, delivery, tracking, and assessment of various types of employee learning and training.

Contemporary LMS support multiple modes of learning, including CD-ROM, downloadable videos, Web-based classes, live instruction in classes or online, and group learning in online forums and chat sessions. The LMS consolidates mixed-media training, automates the selection and administration of courses, assembles and delivers learning content, and measures learning effectiveness.

CVM Solutions, LLC (CVM) uses Digitec's Knowledge Direct learning management system to provide training about how to manage suppliers for clients such as Procter & Gamble, Colgate-Palmolive, and Delta Airlines. Knowledge Direct provides a portal for accessing course content online, along with hands-free administration features such as student registration and assessment tools, built-in Help and Contact Support, automatic e-mail triggers to remind users of courses or deadlines, automatic e-mail acknowledgement of course completions, and Web-based reporting for courses accessed. Knowledge Direct also provides a company-branded login for each client firm and enables CVM to create and assign a company administrator who has access to the student reporting tool for that company.

11.3 Knowledge Work Systems

The enterprise-wide knowledge systems we have just described provide a wide range of capabilities that can be used by many if not all the workers and groups in an organization. Firms also have specialized systems for knowledge workers to help them create new knowledge and to ensure that this knowledge is properly integrated into the business.

KNOWLEDGE WORKERS AND KNOWLEDGE WORK

Knowledge workers, which we introduced in Chapter 1, include researchers, designers, architects, scientists, and engineers who primarily create knowledge and information for the organization. Knowledge workers usually have high levels of education and memberships in professional organizations and are often asked to exercise independent judgment as a routine aspect of their work. For example, knowledge workers create new products or find ways of improving existing ones. Knowledge workers perform three key roles that are critical to the organization and to the managers who work within the organization:

- Keeping the organization current in knowledge as it develops in the external world—in technology, science, social thought, and the arts
- Serving as internal consultants regarding the areas of their knowledge, the changes taking place, and opportunities

- Acting as change agents, evaluating, initiating, and promoting change projects

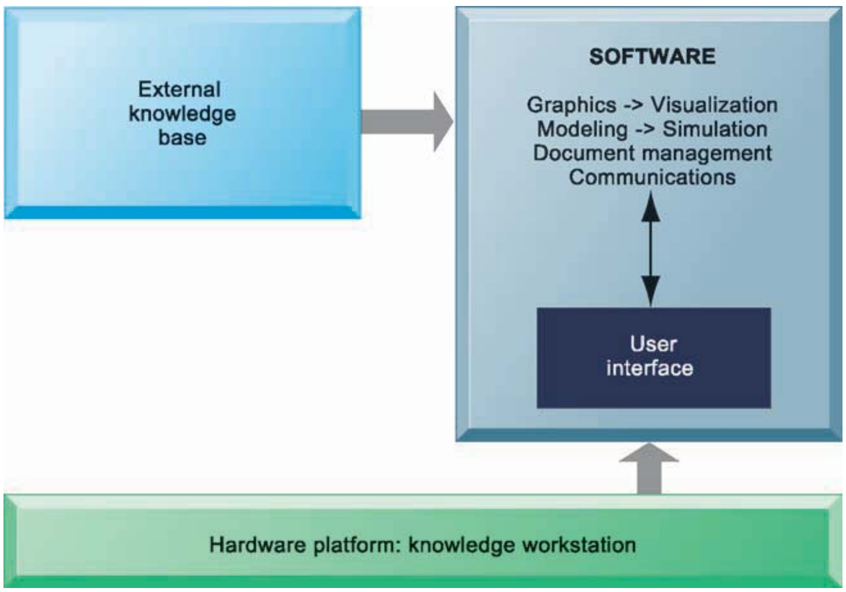
REQUIREMENTS OF KNOWLEDGE WORK SYSTEMS

Most knowledge workers rely on office systems, such as word processors, voice mail, e-mail, videoconferencing, and scheduling systems, which are designed to increase worker productivity in the office. However, knowledge workers also require highly specialized knowledge work systems with powerful graphics, analytical tools, and communications and document management capabilities.

These systems require sufficient computing power to handle the sophisticated graphics or complex calculations necessary for such knowledge workers as scientific researchers, product designers, and financial analysts. Because knowledge workers are so focused on knowledge in the external world, these systems also must give the worker quick and easy access to external databases. They typically feature user-friendly interfaces that enable users to perform needed tasks without having to spend a great deal of time learning how to use the system. Knowledge workers are highly paid—wasting a knowledge worker's time is simply too expensive. Figure 11.4 summarizes the requirements of knowledge work systems.

Knowledge workstations often are designed and optimized for the specific tasks to be performed; so, for example, a design engineer requires a different workstation setup than a financial analyst. Design engineers need graphics with enough power to handle three-dimensional (3-D) CAD systems. However, financial analysts are more interested in access to a myriad number of external databases and large databases for efficiently storing and accessing massive amounts of financial data.

FIGURE 11.4 REQUIREMENTS OF KNOWLEDGE WORK SYSTEMS



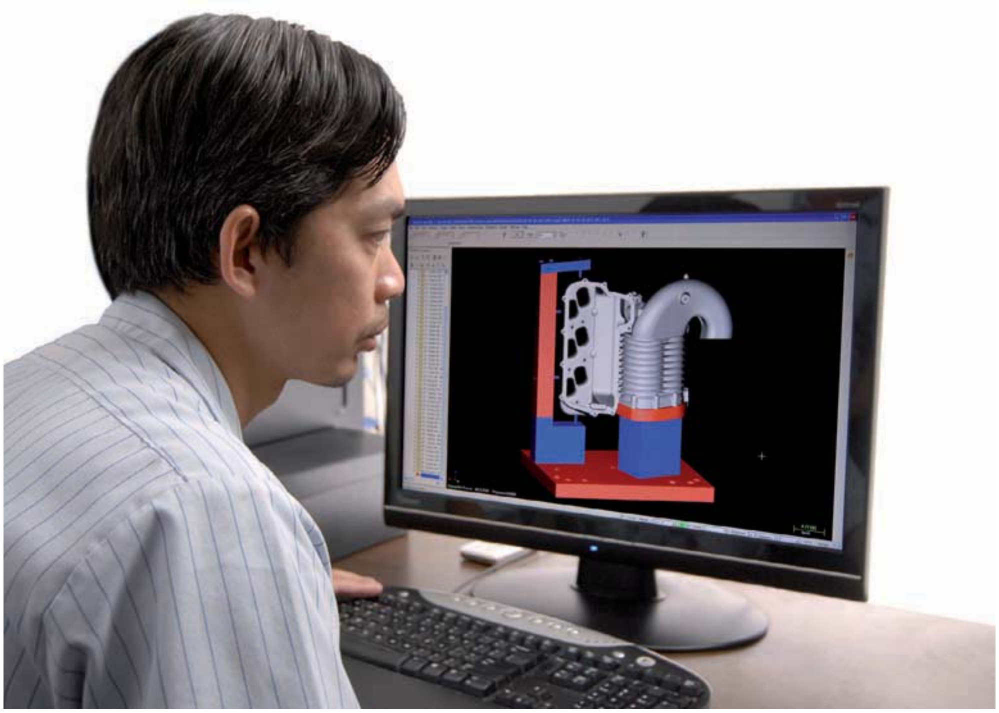
Knowledge work systems require strong links to external knowledge bases in addition to specialized hardware and software.

EXAMPLES OF KNOWLEDGE WORK SYSTEMS

Major knowledge work applications include CAD systems, virtual reality systems for simulation and modeling, and financial workstations. **Computer-aided design (CAD)** automates the creation and revision of designs, using computers and sophisticated graphics software. Using a more traditional physical design methodology, each design modification requires a mold to be made and a prototype to be tested physically. That process must be repeated many times, which is a very expensive and time-consuming process. Using a CAD workstation, the designer need only make a physical prototype toward the end of the design process because the design can be easily tested and changed on the computer. The ability of CAD software to provide design specifications for the tooling and manufacturing processes also saves a great deal of time and money while producing a manufacturing process with far fewer problems. The Interactive Session on Technology illustrates some of these benefits, and shows how they can be a source of competitive advantage.

CAD systems are able to supply data for **3-D printing**, also know known as additive manufacturing, which uses machines to make solid objects, layer by layer, from specifications in a digital file. 3-D printing is currently being used for producing prototypes and small items, such as jewelry and hip implants, as well as aircraft parts. In the future, it may be used for custom-fabricating parts for autos and military equipment.

Virtual reality systems have visualization, rendering, and simulation capabilities that go far beyond those of conventional CAD systems. They use interactive graphics software to create computer-generated simulations that are so close to reality that users almost believe they are participating in a real-world situation. In many virtual reality systems, the user dons special clothing, headgear, and equipment, depending on the application. The clothing contains sensors that record the user's movements and immediately transmit



CAD systems improve the quality and precision of product design by performing much of the design and testing work on the computer.

INTERACTIVE SESSION: TECHNOLOGY

FIREWIRE SURFBOARDS LIGHTS UP WITH CAD

Nev Hyman had been building surfboards in Australia for 35 years. In 2005, he teamed up with Mark Price and a group of longtime surfing friends in Carlsbad, California, to form Firewire Surfboards. This company thrives on innovation and was responsible for the first major change in surfboard composition and assembly methods in 40 years. Rather than polyurethane resin and polyurethane foam, Firewire's boards were composed of expanded polystyrene (EPS) foam and epoxy resins. Hyman and Price believed that this composition for the surfboard core, along with aerospace composites for the deck skin and balsa wood rails (the outside edge),created a more flexible and maneuverable product that would attract top surfers and set Firewire apart from its competitors.

Firewire is competing in a crowded field that includes Isle Surfboards, Surftech, Aviso Surf, Board works Surf, Channel Island, and Lost Enterprises. Firewire is alone in the reintroduction of balsa wood to the board rails for added flex response time and the ability to maintain speed during precarious maneuvers. Firewire believes it can compete successfully because its surfboards are far lighter, stronger, and more flexible than those of its competitors. An additional selling point is the reduced environmental impact: Firewire's materials emit only 2 percent of the harmful compounds of traditional boards and recycling excess expanded polystyrene (EPS) foam has earned Firewire international awards and acclaim.

But that isn't enough. To make sure it stays ahead of the competition, Firewire decided to start making custom surfboards instead of just the usual off-the-rack sizes. For the everyday surfer, the durability and flexibility of Firewire's materials was a key selling point. However, custom boards made to surfer specifications are critical in the elite surfboard market, and the ability to claim top-level competitive surfers as customers drives the broader surfboard market as well.

Traditionally, skilled craftsman, called shapers, designed and built surfboards by hand, but Firewire started doing some of this work using computer-aided designs (CAD) sent to cutting facilities. The company's computer-aided manufacturing process returned to the shaper a board that was 85 to 90 percent complete, leaving the artisan to complete the customization and the lamination process.

According to Price, who became Firewire's CEO, there are 29 time-consuming and labor-intensive steps in the surfboard manufacturing process. Initially, the multifaceted manufacturing process made it impossible to offer personalized CAD to the average consumer. Customized boards could only be produced for elite competitive customers. There was no way to offer customization to a wider market without overburdening Firewire's CAD system. Moreover, most custom boards had to be ordered by filling out a piece of paper with various dimensions for the requested changes. There was no way to see a visual representation of these adjustments or assess their impact on the board's volume, which directly affects buoyancy, paddling ability, and performance.

Firewire needed a system that would allow customers to experiment with established designs, feed the CAD process, and integrate it with its computer numerical control (CNC) manufacturing process. Enter ShapeLogic Design-to-Order Live! For NX, which provides an online customization system with a Web-based user interface and advanced 3-D CAD tools.

Firewire started working with the ShapeLogic NX software in 2009 to develop its own Firewire Surfboards' Custom Board Design (CBD) system, which allows users to easily manipulate board dimensions of established models within design parameters. Any registered customer can choose a standard Firewire model and use drag-and-drop tools to adjust the board's length, midpoint width, nose width, tail width, and thickness, as long as these changes don't degrade the board's design integrity. CBD generates a precise three-dimensional model of the stock model used as the base design along with a 3-D portable document format (PDF) file of the customized board. The PDF file documents the board's dimensions and volume. A customer can manipulate the model from all angles and compare the customized board to the standard board to fully understand the design before placing an order. When the customer uses the system to order a custom board, CBD generates a precise solid CAD model of the board that is transmitted directly to the Firewire factory for driving the CNC machines that manufacture the board.

This combination of technologies results in a board that is 97 percent complete, minimizing the manufacturing time, finishing process, and thus, costs to the consumer. In contrast to the earlier CAD assisted, 10 to 15 percent hand-finished boards, once a surfer has designed the board of his or her dreams, it can be remade to those exact specifications time and again. Neither the ideal handmade board nor a shaper-finished board can be replicated with this degree of precision.

An additional benefit of Firewire's online design system is the social networking engendered by the sharing of customers' unique design files. Before placing an order, customers can show their modifications to fellow surfers and ask for opinions and advice. After placing an order and using the product, they can report their experiences and (hopefully) tout their design or suggest improvements to other customers. Interactive communication such as this drives customers to the Firewire site, creating a marketing buzz that boosts sales.

Sources: "Case Study: NX CAD technology drives custom surfboard design," http://www.plm.automation.siemens.com/en_us, accessed June 14, 2012; "Firewire Surfboards by Nev Hyman," www.allaboutsurfboards.com, accessed June 14, 2012; "Firewire Partners with NanoTune 'Board Tuning Technology,'" www.surfnewsdaily.com, February 22, 2012; William Atkinson, "How Firewire Surfboards Refined Its 3D Order Customization," www.cioinsight.com, November 21, 2011; "Firewire Surfboards Custom Board Design Blends Replicability of Machine Made Boards With Uniqueness of Custom Boards," http://surfingnewsdaily.com, October 12, 2011; and "Firewire Surfboards Garner Recognition for Technological Advances," www.surfermag.com, July 22, 2010.

CASE STUDY QUESTIONS

1. Analyze Firewire using the value chain and competitive forces models.
2. What strategies is Firewire using to differentiate its product, reach its customers, and persuade them to buy its products?
3. What is the role of CAD in Firewire's business model?
4. How did the integration of online custom board design software (CBD), CAD, and computer numerical control (CNC) improve Firewire's operations?

that information back to the computer. For instance, to walk through a virtual reality simulation of a house, you would need garb that monitors the movement of your feet, hands, and head. You also would need goggles containing video screens and sometimes audio attachments and feeling gloves so that you can be immersed in the computer feedback.

At NYU Langone Medical Center in New York City, students wearing 3-D glasses are able to "dissect" a virtual cadaver projected on a screen. With the help of a computer, they can move through the virtual body, scrutinizing layers of muscles or watching a close-up of a pumping heart along with bright red arteries and deep blue veins. The virtual human body was created by BioDigital Systems, a New York City medical visualization firm. The virtual cadaver being used at Langone is a beta version that BioDigital plans to develop into a searchable, customizable map of the human body for medical educators and physicians. NYU medical school has no current plans to phase out dissection, but the 3-D virtual cadaver is a valuable complementary teaching tool (Singer, 2012).

Ford Motor Company has been using virtual reality to help design its vehicles. In one example of Ford's Immersive Virtual Environment, a designer was presented with a car seat, steering wheel, and blank dashboard. Wearing virtual reality glasses and gloves with sensors, the designer was able to "sit" in the seat surrounded by the vehicle's 3-D design to experience how a proposed interior would look and feel. The designer would be able to identify blind spots or see if knobs were in an awkward place. Ford's designers could also use this technology to see the impact of a design on manufacturing. For example, is a bolt that assembly line workers need to tighten too hard to reach (Murphy, 2012)?

Augmented reality (AR) is a related technology for enhancing visualization. AR provides a live direct or indirect view of a physical real-world environment whose elements are augmented by virtual computer-generated imagery. The user is grounded in the real physical world, and the virtual images are merged with the real view to create the augmented display. The digital technology provides additional information to enhance the perception of reality, making the surrounding real world of the user more interactive and meaningful. The yellow first-down markers shown on televised football games are examples of augmented reality as are medical procedures like image-guided surgery, where data acquired from computerized tomography (CT) and magnetic resonance imaging (MRI) scans or from ultrasound imaging are superimposed on the patient in the operating room. Other industries where AR has caught on include military training, engineering design, robotics, and consumer design.

Virtual reality applications developed for the Web use a standard called **Virtual Reality Modeling Language (VRML)**. VRML is a set of specifications for interactive, 3-D modeling on the World Wide Web that can organize multiple media types, including animation, images, and audio to put users in a simulated real-world environment. VRML is platform independent, operates over a desktop computer, and requires little bandwidth.

DuPont, the Wilmington, Delaware, chemical company, created a VRML application called HyperPlant, which enables users to access 3-D data over the Internet using Web browser software. Engineers can go through 3-D models as if they were physically walking through a plant, viewing objects at eye level. This level of detail reduces the number of mistakes they make during construction of oil rigs, oil plants, and other structures.

The financial industry is using specialized **investment workstations** such as Bloomberg Terminals to leverage the knowledge and time of its brokers, traders, and portfolio managers. Firms such as Merrill Lynch and UBS Financial Services have installed investment workstations that integrate a wide range of data from both internal and external sources, including contact management data, real-time and historical market data, and research reports. Previously, financial professionals had to spend considerable time accessing data from separate systems and piecing together the information they needed. By providing one-stop information faster and with fewer errors, the workstations streamline the entire investment process from stock selection to updating client records. Table 11.2 summarizes the major types of knowledge work systems.

TABLE 11.2 EXAMPLES OF KNOWLEDGE WORK SYSTEMS

KNOWLEDGE WORK SYSTEM	FUNCTION IN ORGANIZATION
CAD/CAM (computer-aided manufacturing)	Provides engineers, designers, and factory managers with precise control over industrial design and manufacturing
Virtual reality systems	Provide drug designers, architects, engineers, and medical workers with precise, photorealistic simulations of objects
Investment workstations	High-end PCs used in the financial sector to analyze trading situations instantaneously and facilitate portfolio management

11.4 Intelligent Techniques

Artificial intelligence and database technology provide a number of intelligent techniques that organizations can use to capture individual and collective knowledge and to extend their knowledge base. Expert systems, case-based reasoning, and fuzzy logic are used for capturing tacit knowledge. Neural networks and data mining are used for **knowledge discovery**. They can discover underlying patterns, categories, and behaviors in large data sets that could not be discovered by managers alone or simply through experience. Genetic algorithms are used for generating solutions to problems that are too large and complex for human beings to analyze on their own. Intelligent agents can automate routine tasks to help firms search for and filter information for use in electronic commerce, supply chain management, and other activities.

Data mining, which we introduced in Chapter 6, helps organizations capture undiscovered knowledge residing in large databases, providing managers with new insight for improving business performance. It has become an important tool for management decision making, and we provide a detailed discussion of data mining for management decision support in Chapter 12.

The other intelligent techniques discussed in this section are based on **artificial intelligence (AI)** technology, which consists of computer-based systems (both hardware and software) that attempt to emulate human behavior. Such systems would be able to learn languages, accomplish physical tasks, use a perceptual apparatus, and emulate human expertise and decision making. Although AI applications do not exhibit the breadth, complexity, originality, and generality of human intelligence, they play an important role in contemporary knowledge management.

CAPTURING KNOWLEDGE: EXPERT SYSTEMS

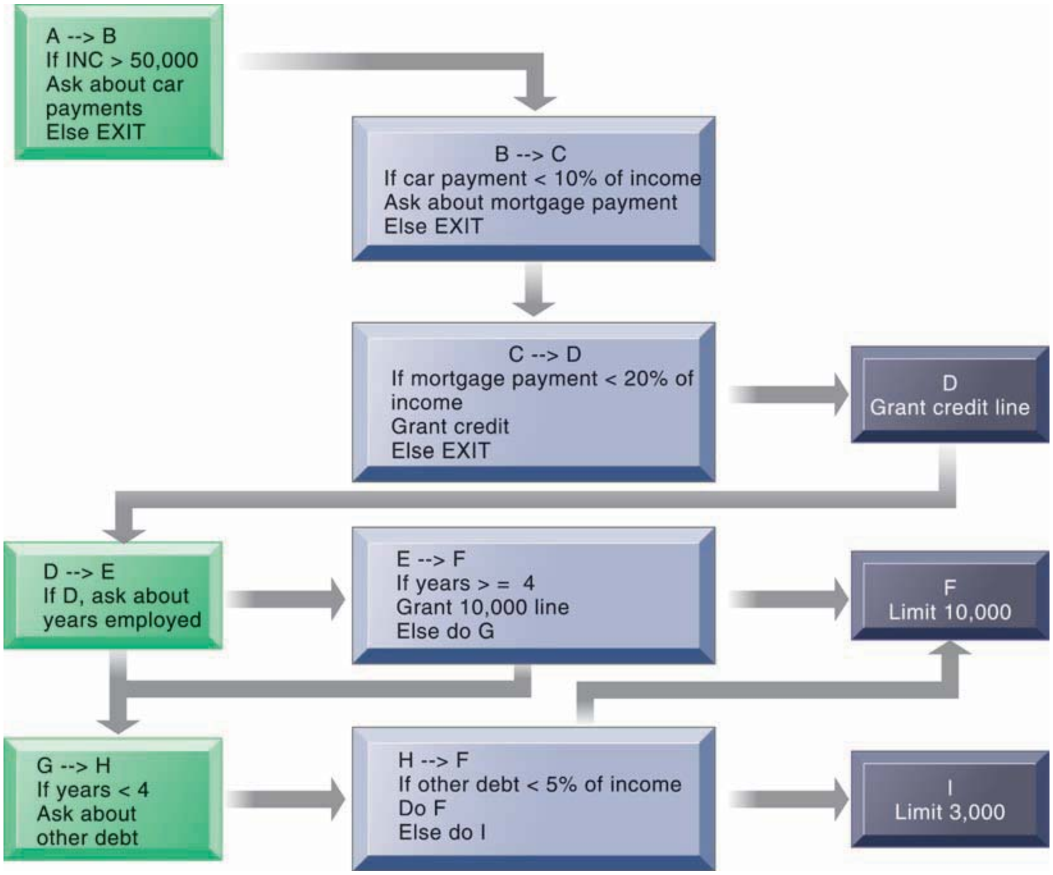
Expert systems are an intelligent technique for capturing tacit knowledge in a very specific and limited domain of human expertise. These systems capture the knowledge of skilled employees in the form of a set of rules in a software system that can be used by others in the organization. The set of rules in the expert system adds to the memory, or stored learning, of the firm.

Expert systems lack the breadth of knowledge and the understanding of fundamental principles of a human expert. They typically perform very limited tasks that can be performed by professionals in a few minutes or hours, such as diagnosing a malfunctioning machine or determining whether to grant credit for a loan. Problems that cannot be solved by human experts in the same short period of time are far too difficult for an expert system. However, by capturing human expertise in limited areas, expert systems can provide benefits, helping organizations make high-quality decisions with fewer people. Today, expert systems are widely used in business in discrete, highly structured decision-making situations.

How Expert Systems Work

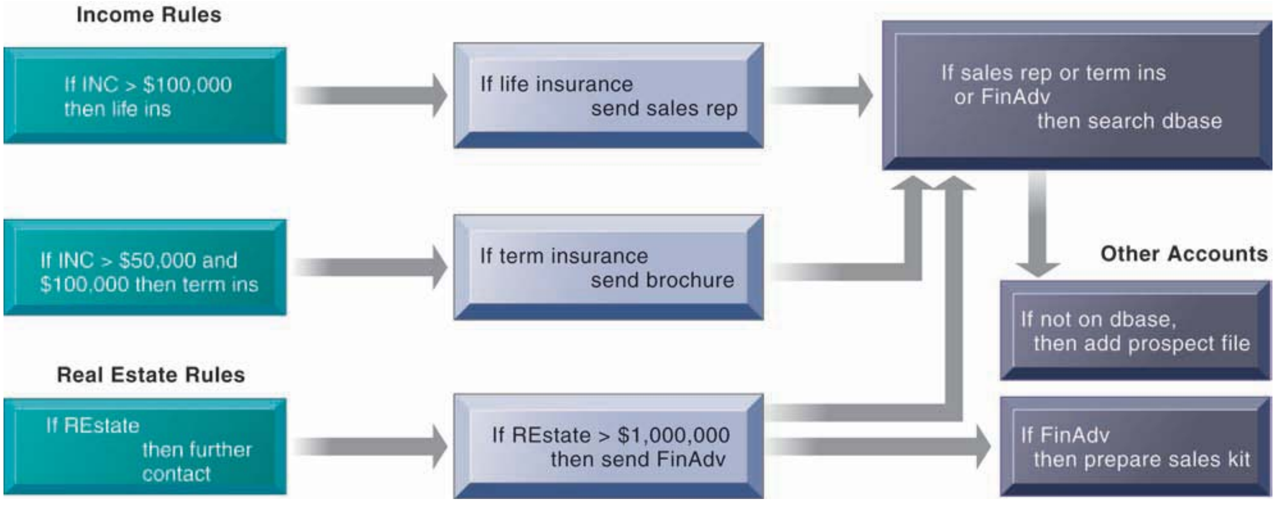
Human knowledge must be modeled or represented in a way that a computer can process. Expert systems model human knowledge as a set of rules that collectively are called the **knowledge base**. Expert systems have from 200 to many thousands of these rules, depending on the complexity of the problem. These rules are much more interconnected and nested than in a traditional software program (see Figure 11.5).

FIGURE 11.5 RULES IN AN EXPERT SYSTEM



An expert system contains a number of rules to be followed. The rules are interconnected; the number of outcomes is known in advance and is limited; there are multiple paths to the same outcome; and the system can consider multiple rules at a single time. The rules illustrated are for simple credit-granting expert systems.

FIGURE 11.6 INFERENCE ENGINES IN EXPERT SYSTEMS



An inference engine works by searching through the rules and "firing" those rules that are triggered by facts gathered and entered by the user. Basically, a collection of rules is similar to a series of nested IF statements in a traditional software program; however, the magnitude of the statements and degree of nesting are much greater in an expert system.

The strategy used to search through the knowledge base is called the **inference engine**. Two strategies are commonly used: forward chaining and backward chaining (see Figure 11.6).

In **forward chaining,** the inference engine begins with the information entered by the user and searches the rule base to arrive at a conclusion. The strategy is to fire, or carry out, the action of the rule when a condition is true. In Figure 11.6, beginning on the left, if the user enters a client's name with income greater than $100,000, the engine will fire all rules in sequence from left to right. If the user then enters information indicating that the same client owns real estate, another pass of the rule base will occur and more rules will fire. Processing continues until no more rules can be fired.

In **backward chaining,** the strategy for searching the rule base starts with a hypothesis and proceeds by asking the user questions about selected facts until the hypothesis is either confirmed or disproved. In our example, in Figure 11.6, ask the question, "Should we add this person to the prospect database?" Begin on the right of the diagram and work toward the left. You can see that the person should be added to the database if a sales representative is sent, term insurance is granted, or a financial adviser visits the client.

Examples of Successful Expert Systems

Expert systems provide businesses with an array of benefits including improved decisions, reduced errors, reduced costs, reduced training time, and higher levels of quality and service. Con-Way Transportation built an expert system called Line-haul to automate and optimize planning of overnight shipment routes for its nationwide freight-trucking business. The expert system captures the business rules that dispatchers follow when assigning drivers, trucks, and trailers to transport 50,000 shipments of heavy freight each night across 25 states and Canada and when plotting their routes. Line-haul runs on a Sun computer platform and uses data on daily customer shipment requests, available drivers, trucks, trailer space, and weight stored in an Oracle database. The expert system uses thousands of rules and 100,000 lines of program code written in C++ to crunch the numbers and create optimum routing plans for 95 percent of daily freight shipments. Con-Way dispatchers tweak the routing plan provided by the expert system and relay final routing specifications to field personnel responsible for packing the trailers for their nighttime runs. Con-Way recouped its $3 million investment in the system within two years by reducing the number of drivers, packing more freight per trailer, and reducing damage from rehandling. The system also reduces dispatchers' arduous nightly tasks.

Although expert systems lack the robust and general intelligence of human beings, they can provide benefits to organizations if their limitations are well understood. Only certain classes of problems can be solved using expert systems. Virtually all successful expert systems deal with problems of classification in limited domains of knowledge where there are relatively few alternative outcomes and these possible outcomes are all known in advance. Expert systems are much less useful for dealing with unstructured problems typically encountered by managers.

Many expert systems require large, lengthy, and expensive development efforts. Hiring or training more experts may be less expensive than building an expert system. Typically, the environment in which an expert system operates is continually changing so that the expert system must also continually change.

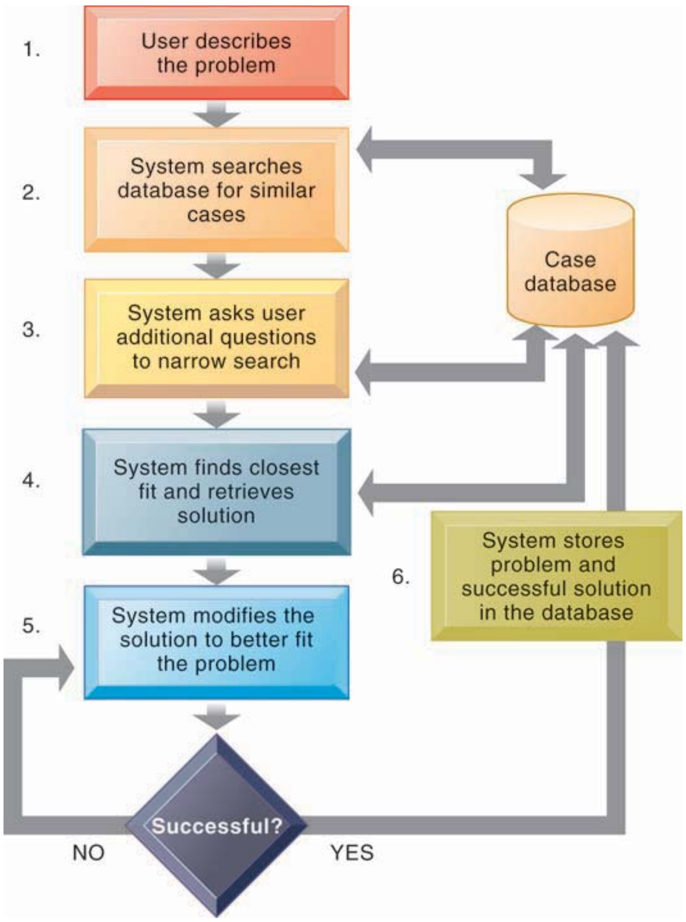
Some expert systems, especially large ones, are so complex that in a few years the maintenance costs equal the development costs.

ORGANIZATIONAL INTELLIGENCE: CASE-BASED REASONING

Expert systems primarily capture the tacit knowledge of individual experts, but organizations also have collective knowledge and expertise that they have built up over the years. This organizational knowledge can be captured and stored using case-based reasoning. In **case-based reasoning (CBR)**, descriptions of past experiences of human specialists, represented as cases, are stored in a database for later retrieval when the user encounters a new case with similar parameters. The system searches for stored cases with problem characteristics similar to the new one, finds the closest fit, and applies the solutions of the old case to the new case. Successful solutions are tagged to the new case and both are stored together with the other cases in the knowledge base. Unsuccessful solutions also are appended to the case database along with explanations as to why the solutions did not work (see Figure 11.7).

Expert systems work by applying a set of IF-THEN-ELSE rules extracted from human experts. Case-based reasoning, in contrast, represents knowledge as a

FIGURE 11.7 HOW CASE-BASED REASONING WORKS



Case-based reasoning represents knowledge as a database of past cases and their solutions. The system uses a six-step process to generate solutions to new problems encountered by the user.

series of cases, and this knowledge base is continuously expanded and refined by users. You'll find case-based reasoning in diagnostic systems in medicine or customer support where users can retrieve past cases whose characteristics are similar to the new case. The system suggests a solution or diagnosis based on the best-matching retrieved case.

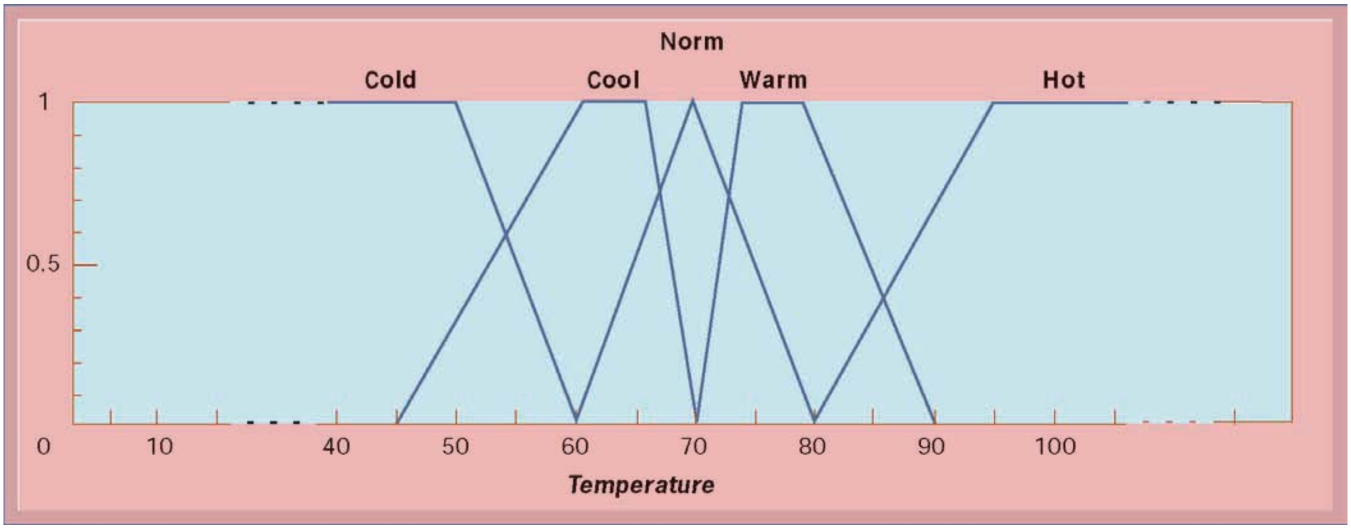
FUZZY LOGIC SYSTEMS

Most people do not think in terms of traditional IF-THEN rules or precise numbers. Humans tend to categorize things imprecisely using rules for making decisions that may have many shades of meaning. For example, a man or a woman can be *strong* or *intelligent*. A company can be *large*, *medium*, or *small* in size. Temperature can be *hot*, *cold*, *cool*, or *warm*. These categories represent a range of values.

Fuzzy logic is a rule-based technology that can represent such imprecision by creating rules that use approximate or subjective values. It can describe a particular phenomenon or process linguistically and then represent that description in a small number of flexible rules. Organizations can use fuzzy logic to create software systems that capture tacit knowledge where there is linguistic ambiguity.

Let's look at the way fuzzy logic would represent various temperatures in a computer application to control room temperature automatically. The terms (known as *membership functions*) are imprecisely defined so that, for example, in Figure 11.8, cool is between 45 degrees and 70 degrees, although the temperature is most clearly cool between about 60 degrees and 67 degrees. Note that *cool* is overlapped by *cold* or *norm*. To control the room environment using this logic, the programmer would develop similarly imprecise definitions for humidity and other factors, such as outdoor wind and temperature. The rules might include one that says: "If the temperature is *cool* or *cold* and the humidity is low while the outdoor wind is high and the outdoor temperature is low, raise the heat and humidity in the room."

FIGURE 11.8 FUZZY LOGIC FOR TEMPERATURE CONTROL



The membership functions for the input called temperature are in the logic of the thermostat to control the room temperature. Membership functions help translate linguistic expressions such as *warm* into numbers that the computer can manipulate.

The computer would combine the membership function readings in a weighted manner and, using all the rules, raise and lower the temperature and humidity.

Fuzzy logic provides solutions to problems requiring expertise that is difficult to represent in the form of crisp IF-THEN rules. In Japan, Sendai's subway system uses fuzzy logic controls to accelerate so smoothly that standing passengers need not hold on. Mitsubishi Heavy Industries in Tokyo has been able to reduce the power consumption of its air conditioners by 20 percent by implementing control programs in fuzzy logic. The autofocus device in cameras is only possible because of fuzzy logic. In these instances, fuzzy logic allows incremental changes in inputs to produce smooth changes in outputs instead of discontinuous ones, making it useful for consumer electronics and engineering applications.

Management also has found fuzzy logic useful for decision making and organizational control. A Wall Street firm created a system that selects companies for potential acquisition, using the language stock traders understand. A fuzzy logic system has been developed to detect possible fraud in medical claims submitted by health care providers anywhere in the United States.

MACHINE LEARNING

Machine learning is the study of how computer programs can improve their performance without explicit programming. Why does this constitute learning? A machine that learns is a machine that, like a human being, can recognize patterns in data, and change its behavior based on its recognition of patterns, experience, or prior learnings (a database). For instance, a car-driving robot should be able to recognize the presence of other cars and objects (people), and change its behavior accordingly (stop, go, slow down, speed up, or turn). The idea of a self-taught, self-correcting, computer program is not new, and has been a part of the artificial intelligence field at least since the 1970s. Up until the 1990s, however, machine learning was not very capable of producing useful devices or solving interesting, business problems.

Machine learning has expanded greatly in the last ten years because of the growth in computing power available to scientists and firms and its falling cost, along with advances in the design of algorithms, databases, and robots. The Internet and the big data (see Chapter 6) made available on the Internet have proved to be very useful testing and proving grounds for machine learning.

We use machine learning everyday but don't recognize it. Every Google search is resolved using algorithms that rank the billions of Web pages based on your query, and change the results based on any changes you make in your search, all in a few milliseconds. Search results also vary according to your prior searches and the items you clicked on. Every time you buy something on Amazon, its recommender engine will suggest other items you might be interested in based on patterns in your prior consumption, behavior on other Web sites, and the purchases of others who are "similar" to you. Every time you visit Netflix, a recommender system will come up with movies you might be interested in based on a similar set of factors.

Neural Networks

Neural networks are used for solving complex, poorly understood problems for which large amounts of data have been collected. They find patterns and relationships in massive amounts of data that would be too complicated and difficult for a human being to analyze. Neural networks discover this knowledge by using hardware and software that parallel the processing patterns of

INTERACTIVE SESSION: ORGANIZATIONS

ALBASSAMI'S JOB IS NOT FEASIBLE WITHOUT IT

If you live in a country with a diverse geography and a climate characterized as being harsh, with a dry desert and great temperature extremes like the Kingdom of Saudi Arabia (area: 2.1 million square kilometers), and you need to move from one city to another, where the distance could be some thousand kilometers, you have two choices: to drive, or to fly and ship your car via a car transport carrier. Many people in the Kingdom prefer the second option. This has created a market for car transportation in the Kingdom that is the largest in the Middle East. Albassami was established to respond to these market needs. The Albassami International Group is considered one of the leading land transporters in the Middle East.

The estimated size of the car transportation market, both inside the Kingdom and with neighboring countries, is about 2 billion Saudi riyals and is increasing considerably annually. There are more than a million cars transported inside and outside the Kingdom. Albassami International Group owns the largest fleet of carriers in the Middle East.

At present, the group is operating all over the Kingdom and extends throughout the Gulf Cooperation Council (GCC) countries, Syria, Lebanon, and Jordan. Throughout these years the company has focused on how to maintain business leadership in order to achieve safe and fast transportation.

Every day there are more than 1,000 shipping contracts, including 2,000 to 2,500 bills of lading daily between the main branches. With the introduction of its new division of Express transportation in 2003, the group owns and allocates 170 heavy duty, medium, and light vehicles of various types for its door-to-door courier services, which operate all over the Kingdom, covering more than 45 locations. It was therefore impossible to properly handle and control the endless number of daily work options and orders related to these operations at a perfect level of service without a robust computerized system. The system needed the facility to serve specific sectors in the organization, in addition to providing information throughout the group.

The system is based on clustered Dell servers running Windows 2003 and connected to over 270 Windows XP clients. The database management system, used as the backbone of the system, is Sybase Adaptive server, whereas clients use SQL Anywhere. There is replication between the server at headquarters and the client's branches. Throughout the replication, branches' data is sent to the server and aggregated to create the most updated database version, and then sent back to the branches. This means every branch has the most recent version of the client list, trucks' availability, and new shipping contracts so that any customer is able to deal with any branch at any time.

The business process starts when the customer goes to a branch to ship his car to a destination within shipping areas, and the branch then creates a shipping agreement. As the database is sent from the branch to HQ every 30 minutes, an aggregated version of the database of all branches is available at HQ and thereafter sent back to all branches. The recipient branch will create a receipt entry on the system upon arrival of the truck and then an SMS message is created and sent to the customer, who will then go to the destination branch to receive the car.

The shipping information system used at Albassami maintains all the sender information such as the sent car, the truck number, the sender and receiving branches, and it also sends an SMS message to the client acknowledging the arrival of the car. The system also records the client's data, and holds maintenance information. Linking the data of vehicle maintenance centers with the transportation service helps to enhance company performance and achieve better customer service. The system also enables standard reports to be provided to top management and head sectors about the productivity of each branch, resulting in accurate identification of needs for different regions and thus proper budget allocation. In addition, the system allowed a better audit on all drivers' behavior by using the output of the vehicles' tracking information. Proper performance monitoring resulted in adequate employees' appraisals and consequently loyal staff!

All business processes are facilitated by the shipping system, and the knowledge extracted from the central database has enabled the management team to make sound investment and operational decisions and therefore helped the business maintain its success and leadership in the Kingdom.

Sources: Michael Fitzgerald, "Predicting Where You'll Go and What You'll Like," The New York Times, June 22, 2008; Erick Schonfeld, "Location-Tracking Startup Sense Networks Emerges from Stealth to Answer the Question: Where Is Everybody?" TechCrunch.com, June 9, 2008; "Macrosense," sensenetworks.com, accessed July 2008; Caroline McCarthy, "Meet Sense Networks, the Latest Player in the Hot 'Geo' Market," news.cnet.com, June 9, 2008.

Case contributed by Dr Ahmed Elragal, German University in Cairo

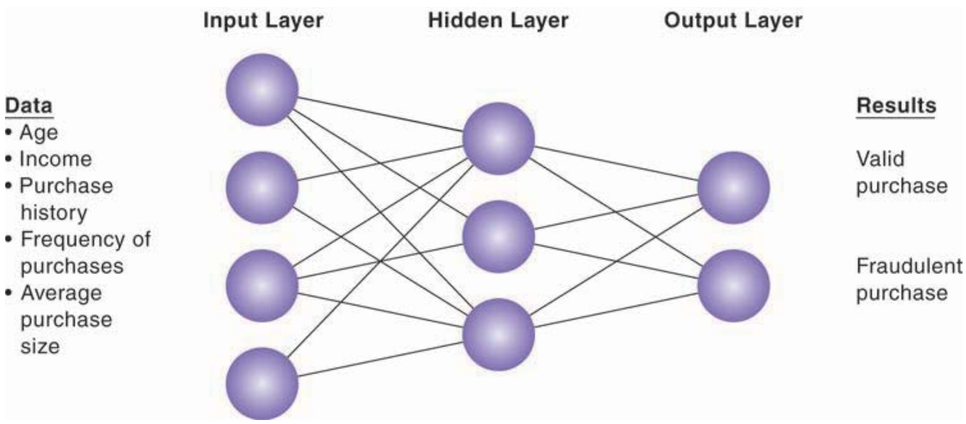
CASE STUDY QUESTIONS

1. What systems are described here? What valuable information do they provide?
2. What value did the IT/IS investments add to Albassami?
3. How did implementing the Shipping Information System address the business needs and information requirements of Albassami?

the biological or human brain. Neural networks "learn" patterns from large quantities of data by sifting through data, searching for relationships, building models, and correcting over and over again the model's own mistakes.

A neural network has a large number of sensing and processing nodes that continuously interact with each other. Figure 11.9 represents one type of neural network comprising an input layer, an output layer, and a hidden processing layer. Humans "train" the network by feeding it a set of training data for which the inputs produce a known set of outputs or conclusions. This helps the computer learn the correct solution by example. As the computer is fed more data, each case is compared with the known outcome. If it differs, a correction is calculated and applied to the nodes in the hidden processing layer. These steps are repeated until a condition, such as corrections being less than a certain amount, is reached. The neural network in Figure 11.9 has learned how to identify a fraudulent credit card

FIGURE 11.9 HOW A NEURAL NETWORK WORKS



A neural network uses rules it "learns" from patterns in data to construct a hidden layer of logic. The hidden layer then processes inputs, classifying them based on the experience of the model. In this example, the neural network has been trained to distinguish between valid and fraudulent credit card purchases.

purchase. Also, self-organizing neural networks can be trained by exposing them to large amounts of data and allowing them to discover the patterns and relationships in the data.

A Google research team headed by Stanford University computer scientist Andrew Y. Ng and Google fellow Jeff Dean recently created a neural network with more than one billion connections that could identify cats. The network used an array of 16,000 processors and was fed random thumbnails of images, each extracted from a collection of 10 million YouTube videos. The neural network taught itself to recognize cats, without human help in identifying specific features during the learning process. Google believes this neural network has promising applications in image search, speech recognition, and machine language translation (Markoff, 2012).

Whereas expert systems seek to emulate or model a human expert's way of solving problems, neural network builders claim that they do not program solutions and do not aim to solve specific problems. Instead, neural network designers seek to put intelligence into the hardware in the form of a generalized capability to learn. In contrast, the expert system is highly specific to a given problem and cannot be retrained easily.

Neural network applications in medicine, science, and business address problems in pattern classification, prediction, financial analysis, and control and optimization. In medicine, neural network applications are used for screening patients for coronary artery disease, for diagnosing patients with epilepsy and Alzheimer's disease, and for performing pattern recognition of pathology images. The financial industry uses neural networks to discern patterns in vast pools of data that might help predict the performance of equities, corporate bond ratings, or corporate bankruptcies. Visa International uses a neural network to help detect credit card fraud by monitoring all Visa transactions for sudden changes in the buying patterns of cardholders.

There are many puzzling aspects of neural networks. Unlike expert systems, which typically provide explanations for their solutions, neural networks cannot always explain why they arrived at a particular solution. Moreover, they cannot always guarantee a completely certain solution, arrive at the same solution again with the same input data, or always guarantee the best solution. They are very sensitive and may not perform well if their training covers too little or too much data. In most current applications, neural networks are best used as aids to human decision makers instead of substitutes for them.

Genetic Algorithms

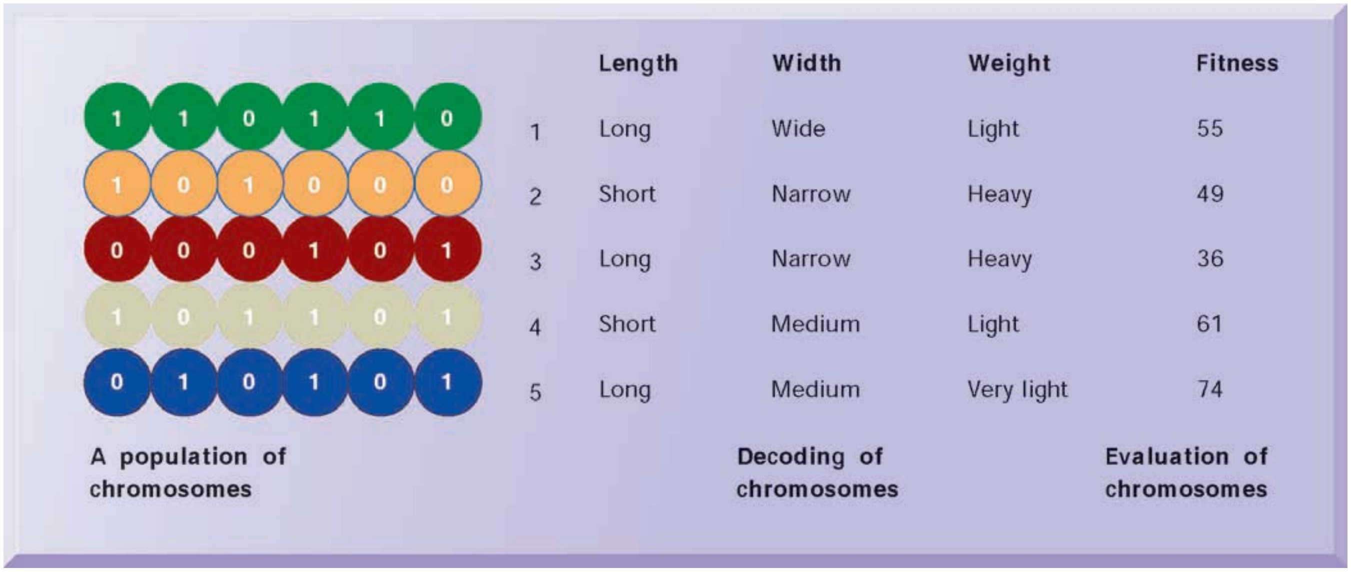
Genetic algorithms are useful for finding the optimal solution for a specific problem by examining a very large number of possible solutions for that problem. They are based on techniques inspired by evolutionary biology, such as inheritance, mutation, selection, and crossover (recombination).

A genetic algorithm works by representing information as a string of 0s and 1s. The genetic algorithm searches a population of randomly generated strings of binary digits to identify the right string representing the best possible solution for the problem. As solutions alter and combine, the worst ones are discarded and the better ones survive to go on to produce even better solutions.

In Figure 11.10, each string corresponds to one of the variables in the problem. One applies a test for fitness, ranking the strings in the population according to their level of desirability as possible solutions. After the initial population is evaluated for fitness, the algorithm then produces the next generation of strings, consisting of strings that survived the fitness test plus offspring strings produced from mating pairs of strings, and tests their fitness. The process continues until a solution is reached.

Genetic algorithms are used to solve problems that are very dynamic and complex, involving hundreds or thousands of variables or formulas. The problem must be one where the range of possible solutions can be represented genetically and criteria can be established for evaluating fitness. Genetic algorithms expedite the solution because they are able to evaluate many solution alternatives quickly to find the best one. For example, General

FIGURE 11.10 THE COMPONENTS OF A GENETIC ALGORITHM



This example illustrates an initial population of "chromosomes," each representing a different solution. The genetic algorithm uses an iterative process to refine the initial solutions so that the better ones, those with the higher fitness, are more likely to emerge as the best solution.

Electric engineers used genetic algorithms to help optimize the design for jet turbine aircraft engines, where each design change required changes in up to 100 variables. The supply chain management software from i2 Technologies uses genetic algorithms to optimize production-scheduling models incorporating hundreds of thousands of details about customer orders, material and resource availability, manufacturing and distribution capability, and delivery dates.

INTELLIGENT AGENTS

Intelligent agent technology helps businesses navigate through large amounts of data to locate and act on information that is considered important. **Intelligent agents** are software programs that work without direct human intervention to carry out specific tasks for an individual user, business process, or software application. The agent uses a built-in or learned knowledge base to accomplish tasks or make decisions on the user's behalf, such as deleting junk e-mail, scheduling appointments, or traveling over interconnected networks to find the cheapest airfare to California.

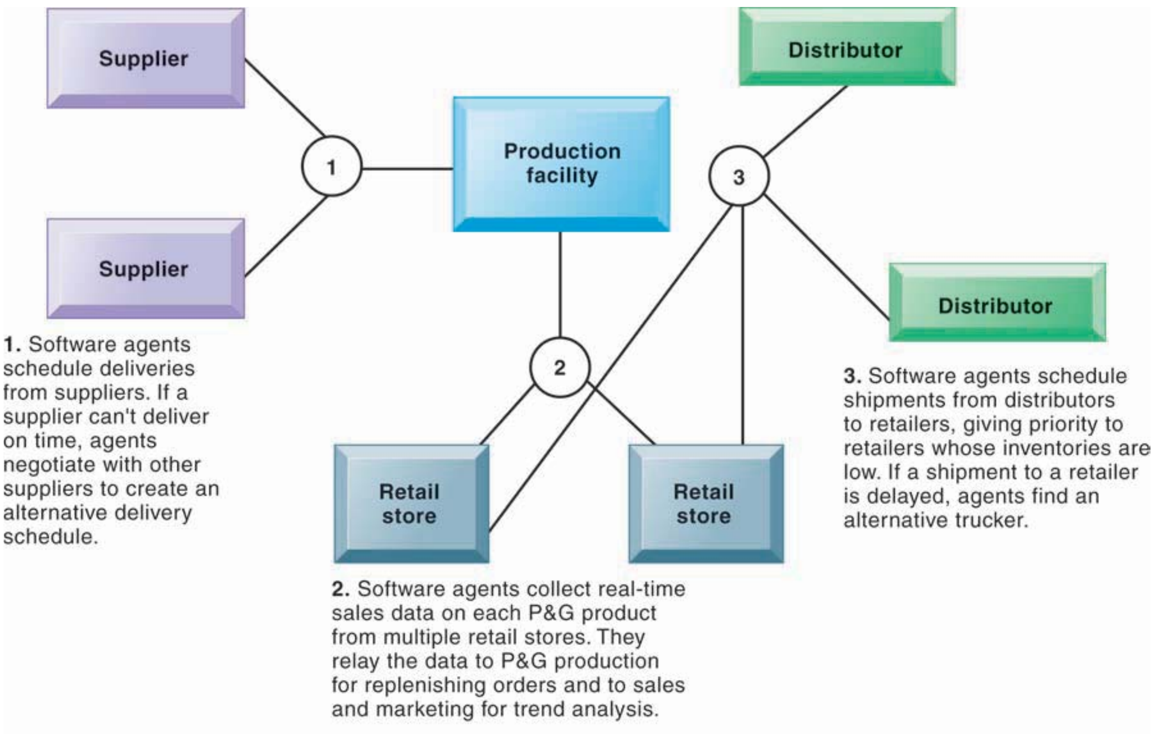
There are many intelligent agent applications today in operating systems, application software, e-mail systems, mobile computing software, and network tools. For example, the wizards found in Microsoft Office software tools have built-in capabilities to show users how to accomplish various tasks, such as formatting documents or creating graphs, and to anticipate when users need assistance. Chapter 10 describes how intelligent agent shopping bots can help consumers find products they want and assist them in comparing prices and other features.

Although some intelligent agents are programmed to follow a simple set of rules, others are capable of learning from experience and adjusting their behavior. Siri, an application on Apple's iOS operating system for the iPhone and iPad, is an example. Siri is an intelligent personal assistant that uses voice recognition technology to answer questions, make recommendations, and perform actions. The software adapts to the user's individual preferences over time and personalizes results, performing tasks such as finding nearby restaurants, purchasing movie tickets, getting directions, scheduling appointments, and sending messages. Siri understands natural speech, and it asks the user questions if it needs more information to complete a task. Siri does not process speech input locally on the users's device. Instead, it sends commands through a remote server, so users have to be connected to Wi-Fi or a 3G signal.

Many complex phenomena can be modeled as systems of autonomous agents that follow relatively simple rules for interaction. **Agent-based modeling** applications have been developed to model the behavior of consumers, stock markets, and supply chains and to predict the spread of epidemics.

Procter & Gamble (P&G) used agent-based modeling to improve coordination among different members of its supply chain in response to changing business conditions (see Figure 11.11). It modeled a complex supply chain as a group of semiautonomous "agents" representing individual supply chain components, such as trucks, production facilities, distributors, and retail stores. The behavior of each agent is programmed to follow rules that mimic actual behavior, such as "order an item when it is out of stock." Simulations using the agents enable the company to perform what-if analyses on inventory levels, in-store stockouts, and transportation costs.

FIGURE 11.11 INTELLIGENT AGENTS IN P&G'S SUPPLY CHAIN NETWORK



Intelligent agents are helping P&G shorten the replenishment cycles for products such as a box of Tide.

Using intelligent agent models, P&G discovered that trucks should often be dispatched before being fully loaded. Although transportation costs would be higher using partially loaded trucks, the simulation showed that retail store stockouts would occur less often, thus reducing the amount of lost sales, which would more than make up for the higher distribution costs. Agent-based modeling has saved P&G $300 million annually on an investment of less than 1 percent of that amount.

HYBRID AI SYSTEMS

Genetic algorithms, fuzzy logic, neural networks, and expert systems can be integrated into a single application to take advantage of the best features of these technologies. Such systems are called **hybrid AI systems**. Hybrid applications in business are growing. In Japan, Hitachi, Mitsubishi, Ricoh, Sanyo, and others are starting to incorporate hybrid AI in products such as home appliances, factory machinery, and office equipment. Matsushita has developed a "neurofuzzy" washing machine that combines fuzzy logic with neural networks. Nikko Securities has been working on a neurofuzzy system to forecast convertible-bond ratings.

Learning Track Module

The following Learning Track provides content relevant to topics covered in this chapter:

1. Challenges of Knowledge Management Systems

Review Summary

1. ***What is the role of knowledge management and knowledge management programs in business?***

Knowledge management is a set of processes to create, store, transfer, and apply knowledge in the organization. Much of a firm's value depends on its ability to create and manage knowledge. Knowledge management promotes organizational learning by increasing the ability of the organization to learn from its environment and to incorporate knowledge into its business processes. There are three major types of knowledge management systems: enterprise-wide knowledge management systems, knowledge work systems, and intelligent techniques.

2. ***What types of systems are used for enterprise-wide knowledge management and how do they provide value for businesses?***

Enterprise-wide knowledge management systems are firmwide efforts to collect, store, distribute, and apply digital content and knowledge. Enterprise content management systems provide databases and tools for organizing and storing structured documents and tools for organizing and storing semistructured knowledge, such as e-mail or rich media. Knowledge network systems provide directories and tools for locating firm employees with special expertise who are important sources of tacit knowledge. Often these systems include group collaboration tools (including wikis and social bookmarking), portals to simplify information access, search tools, and tools for classifying information based on a taxonomy that is appropriate for the organization. Enterprise-wide knowledge management systems can provide considerable value if they are well designed and enable employees to locate, share, and use knowledge more efficiently.

3. ***What are the major types of knowledge work systems and how do they provide value for firms?***

Knowledge work systems (KWS) support the creation of new knowledge and its integration into the organization. KWS require easy access to an external knowledge base; powerful computer hardware that can support software with intensive graphics, analysis, document management, and communications capabilities; and a user-friendly interface. Computer-aided design (CAD) systems, augmented reality applications, and virtual reality systems, which create interactive simulations that behave like the real world, require graphics and powerful modeling capabilities. KWS for financial professionals provide access to external databases and the ability to analyze massive amounts of financial data very quickly.

4. ***What are the business benefits of using intelligent techniques for knowledge management?***

Artificial intelligence lacks the flexibility, breadth, and generality of human intelligence, but it can be used to capture, codify, and extend organizational knowledge. Expert systems capture tacit knowledge from a limited domain of human expertise and express that knowledge in the form of rules. Expert systems are most useful for problems of classification or diagnosis. Case-based reasoning represents organizational knowledge as a database of cases that can be continually expanded and refined.

Fuzzy logic is a software technology for expressing knowledge in the form of rules that use approximate or subjective values. Fuzzy logic has been used for controlling physical devices and is starting to be used for limited decision-making applications.

Machine learning refers to the ability of computer programs to automatically learn and improve with experience. Neural networks consist of hardware and software that attempt to mimic the thought processes of the human brain. Neural networks are notable for their ability to learn without programming and to recognize patterns that cannot be easily described by humans. They are being used in science, medicine, and business to discriminate patterns in massive amounts of data.

Genetic algorithms develop solutions to particular problems using genetically based processes such as fitness, crossover, and mutation. Genetic algorithms are beginning to be applied to problems involving optimization, product design, and monitoring industrial systems where many alternatives or variables must be evaluated to generate an optimal solution.

Intelligent agents are software programs with built-in or learned knowledge bases that carry out specific tasks for an individual user, business process, or software application. Intelligent agents can be programmed to navigate through large amounts of data to locate useful information and in some cases act on that information on behalf of the user.

Key Terms

3-D printing, 459
Agent-based modeling, 473
Artificial intelligence (AI), 463
Augmented reality (AR), 462
Backward chaining, 465
Case-based reasoning (CBR), 466
Communities of practice (COPs), 453
Computer-aided design (CAD), 459
Data, 449
Digital asset management systems, 456
Enterprise content management systems, 455
Enterprise-wide knowledge management systems, 453
Expert systems, 463
Explicit knowledge, 450
Folksonomies, 456
Forward chaining, 465
Fuzzy logic, 467
Genetic algorithms, 472
Hybrid AI systems, 474
Inference engine, 465
Intelligent agents, 473
Intelligent techniques, 454
Investment workstations, 462
Knowledge, 450
Knowledge base, 463
Knowledge discovery, 463
Knowledge management, 451
Knowledge network systems, 456
Knowledge work systems (KWS), 454
Learning management system (LMS), 457
Machine learning, 468
Neural networks, 468
Organizational learning, 451
Social bookmarking, 456
Structured knowledge, 455
Tacit knowledge, 450
Taxonomy, 456
Virtual Reality Modeling Language (VRML), 462
Virtual reality systems, 459
Wisdom, 450

Review Questions

1. What is the role of knowledge management and knowledge management programs in business?
- Define knowledge management and explain its value to businesses.
- Describe the important dimensions of knowledge.
- Distinguish between data, knowledge, and wisdom and between tacit knowledge and explicit knowledge.
- Describe the stages in the knowledge management value chain.

2. What types of systems are used for enterprise-wide knowledge management and how do they provide value for businesses?
- Define and describe the various types of enterprise-wide knowledge management systems and explain how they provide value for businesses.
- Describe the role of the following in facilitating knowledge management: portals, wikis, social bookmarking, and learning management systems.

3. What are the major types of knowledge work systems and how do they provide value for firms?
- Define knowledge work systems and describe the generic requirements of knowledge work systems.
- Describe how the following systems support knowledge work: CAD, virtual reality, augmented reality, and investment workstations.

4. What are the business benefits of using intelligent techniques for knowledge management?
- Define an expert system, describe how it works, and explain its value to business.
- Define case-based reasoning and explain how it differs from an expert system.
- Define machine learning and give some examples.
- Define a neural network, and describe how it works and how it benefits businesses.
- Define and describe fuzzy logic, genetic algorithms, and intelligent agents. Explain how each works and the kinds of problems for which each is suited.

Discussion Questions

1. Knowledge management is a business process, not a technology. Discuss.
2. Describe various ways that knowledge management systems could help firms with sales and marketing or with manufacturing and production.
3. Your company wants to do more with knowledge management. Describe the steps it should take to develop a knowledge management program and select knowledge management applications.

Hands-On MIS Projects

The projects in this section give you hands-on experience designing a knowledge portal, identifying opportunities for knowledge management, creating a simple expert system, and using intelligent agents to research products for sale on the Web.

Management Decision Problems

1. U.S. Pharma Corporation is headquartered in New Jersey but has research sites in Germany, France, the United Kingdom, Switzerland, and Australia. Research and development of new pharmaceuticals is key to ongoing profits, and U.S. Pharma researches and tests thousands of possible drugs. The company's researchers need to share information with others within and outside the company, including the U.S. Food and Drug Administration, the World Health Organization, and the International Federation of Pharmaceutical Manufacturers & Associations. Also critical is access to health information sites, such as the U.S. National Library of Medicine and to industry conferences and professional journals. Design a knowledge portal for U.S. Pharma's researchers. Include in your design specifications relevant internal systems and databases, external sources of information, and internal and external communication and collaboration tools. Design a home page for your portal.

2. Canadian Tire is one of Canada's largest companies, with 57,000 employees and 1,200 stores and gas bars (gas stations) across Canada selling sports, leisure, home products, apparel; and financial services as well as automotive and petroleum products. The retail outlets are independently owned and operated. Canadian Tire was using daily mailings and thick product catalogs to inform its dealers about new products, merchandise setups, best practices, product ordering, and problem resolution and it is looking for a better way to provide employees with human resources and administrative documents. Describe the problems created by this way of doing business and how knowledge management systems might help.

Improving Decision Making: Building a Simple Expert System for Retirement Planning

Software skills: Spreadsheet formulas and IF function or expert system tool
Business skills: Benefits eligibility determination

Expert systems typically use a large number of rules. This project has been simplified to reduce the number of rules, but it will give you experience working with a series of rules to develop an application.

When employees at your company retire, they are given cash bonuses. These cash bonuses are based on the length of employment and the retiree's age. To receive a bonus, an employee must be at least 50 years of age and have worked for the company for more than five years. The following table summarizes the criteria for determining bonuses.

LENGTH OF EMPLOYMENT	BONUS
<5 years	No bonus
5–10 years	20 percent of current annual salary
11–15 years	30 percent of current annual salary
16–20 years	40 percent of current annual salary
20–25 years	50 percent of current annual salary
26 or more years	100 percent of current annual salary

Using the information provided, build a simple expert system. Find a demonstration copy of an expert system software tool on the Web that you can download. Alternatively, use your spreadsheet software to build the expert system. (If you are using spreadsheet software, we suggest using the IF function so you can see how rules are created.)

Improving Decision Making: Using Intelligent Agents for Comparison Shopping

Software skills: Web browser and shopping bot software
Business skills: Product evaluation and selection

This project will give you experience using shopping bots to search online for products, find product information, and find the best prices and vendors. Select a digital camera you might want to purchase, such as the Canon PowerShot S100 or the Olympus Tough TG-820.Visit MySimon (www.mysimon.com), BizRate.com (www.bizrate.com), and Google Product Search to do price comparisons for you. Evaluate these shopping sites in terms of their ease of use, number of offerings, speed in obtaining information, thoroughness of information offered about the product and seller, and price selection. Which site or sites would you use and why? Which camera would you select and why? How helpful were these sites for making your decision?

Video Cases

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

Collaboration and Teamwork Project

In MyMISLab, you will find a Collaboration and Teamwork Project dealing with the concepts in this chapter. You will be able to use Google Sites, Google Docs, and other open source collaboration tools to complete the assignment.

Knowledge Management and Collaboration at Tata Consulting Services

CASE STUDY

Tata Consultancy Services (TCS) is an IT-services, business-solutions and outsourcing organization that offers a portfolio of IT and IT-enabled services to clients all over the globe in horizontal, vertical, and geographical domains. A part of the Tata Group, India's largest industrial conglomerate, TCS has over 108,000 IT consultants in 47 countries.

The concept of knowledge management (KM) was introduced in TCS in 1995 and a dedicated KM team called "Corporate Groupware" was formed in 1998. This group launched the KM-pilot in mid-1999, which was implemented subsequently by a team comprising the steering committee, corporate GroupWare implanters, branch champions, application owners and the infrastructure group.

At that time, KM in TCS covered nearly every function, from quality assurance to HR management. While its 50 offices in India were linked through dedicated communication lines, overseas offices were connected through the Net and the Lotus Notes Domino Servers. The employees could access the knowledge repository that resided on the corporate and branch servers through the intranet, with a browser front-end or a Notes client. The knowledge repository, also called KBases contained a wide range of information about processes, line of business, line of technology, and projects.

Though the formal KM efforts started in TCS in the late 1990s, the informal, closely knit communities of practices (CoPs) had existed at TCS since the 1980s, when it had around a thousand employees. The earliest "group" was based on the migration of technologies. Later, teams were formed for mainframe, Unix, and databases. The groups, consisting of one or two experts in their respective fields, began formal documentation practices with the members writing down the best practices. Recollecting the group practices in the initial days, K. Ananth Krishnan, a technology consultant at that time, recounted that in the mid-eighties, problems and solutions were documented and there were over 1,500 case studies for mainframe. Similarly, for quality area, 40 case studies were reviewed as early as 1993.

The next step was to create Process Asset Libraries (PALs) which contained information related to technology, processes, and case studies for project leaders, which were made available to all development centers through the intranet.

Then Ultimatix, a web-based electronic knowledge management (EKM) portal, which made the knowledge globally available, was developed. The PAL library and KBases, which were hosted on the intranet, were merged with Ultimatix, which had sub-portals for a quality management system, software productivity improvement, training materials, and tools information. There were EKM administrators for each practice and subject group with defined responsibilities, such as editing the documents and approving them for publication. Commenting on the success of CoP, Krishnan maintained that between January 2003 and June 2003, CoP members had exchanged around 10,000 document transactions relating to the industry practices and 21,000 service practices via Ultimatix. The telecom CoP alone had 6,000 transactions, excluding the intranet-based community activities.

To encourage employee conversations, TCS took considerable care in the architecture of its development centers, located across the country. Reflecting on the new design of one of its development centers in Sholinganallur, Chennai, CFO S. Mahalingam commented that the center is made up of modules, each dedicated to one particular technology or a client or an industry practice. These structures lead to garden terraces, where employees gather during their break for informal conversations and brainstorm the solutions to many problems.

TCS also launched a number of training programs such as the Initial Learning Program, targeted at new employees, the Continuous Learning Program for experienced employees, and the Leadership Development Program for employees with more than five years' experience. The integrated competency and learning management systems (iCALMS) that was deployed globally across all TCS offices promoted a culture of learning and growth in the organization. Equipped with data about competency definitions, role definitions, and online/classroom learning objectives it helped the consultants to enhance their skills in a customized manner. To gain cross-industry experience, TCS regularly rotated people across various functions and within other Tata Group companies. Employees were also encouraged to join outside bodies like the IEEE, and go in for certifications.

Knowmax, a knowledge management system, developed using Microsoft sharepoint portal server in 2007, gave TCS consultants access to nearly 40 years of experience and best practices, arranged by type of engagement, the technology in use, and customer requirements. It supported more than 60 knowledge assets and was accessible via Ultimatix to all TCS associates. Any associate could contribute to the K-Bank and Knowledge Officers were made responsible for maintaining the quality of content.

To maintain the work-life balance of its employees, TCS initiated Propel sessions which brought together employees with similar interests to conduct various activities such as reading books. Later, held every quarter through conferences and camps, this initiative also spurred knowledge transfer among the employees. The knowledge sharing at the project level was done through LiveMeeting application, where all the project meetings were recorded and stored in the project repository. Team members who missed the meeting, or any new members in the team, could listen to the recorded sessions and this enabled them to catch up with the rest of the team. Furthermore, Knowledge Transition sessions conducted weekly by the "Subject Matter Expert" helped the team to learn from the experience of the experts. "Tip of the Day" mail, comprising either technical, or conceptual, or human skills tips were also shared within the organization, almost daily.

Though Ultimatix, launched in 2002, digitized the entire organization from end to end and improved the business processes' efficiency, it still couldn't tap the knowledge of employees effectively. To improve collaboration among employees, Project Infinity was launched in 2007; this involved a number of technologies including IBM's Sametime, QuickPlace, Lotus Domino Collaboration tools, Avaya VOIP telephony, and Polycom IP videoconferencing.

As a result of adopting Infinity, collaboration of overseas and local offices improved as instant messaging (IM) got rid of cultural and pronunciation differences that could occur on the phone. Furthermore, corporate communications were able to run a 24-hour internal news broadcast to all TCS offices in the world. In addition, travel and telecommunications costs were reduced by 40 percent and 6 percent respectively.

Other than these channels, the company also used the JustAsk system (embedded into the KM), Blog platform, IdeaStorm, TIP, and My Site. Blogging had caught on rapidly since 2006 when it was first introduced. Almost 40,000-50,000 TCS staff blogged on the intranet. While the JustAsk system allowed employees to post questions that others could answer, Idea Storm was a once-a-year event, where two to three topics were posted by the corporate team on which ideas were invited by everyone. TIP, an open portal for product innovation and potential new ideas was launched to promote the sharing of ideas. MySite, embedded into the KM portal, allowed each associate to have a personal page like Facebook or Orkut.

Sources: Sankaranarayanan G., "Building Communities, the TCS way," expressitpeople.com, September 2003; Kavita Kaur, "Give and Take," india-today.com, January 2000; Sunil Shah, "Network Wonder: Collaborative Tools Help TCS Grow," cio.com, July 2007; Shivani Shinde, "TCS Sees Synergy in Gen X Tools," rediff.com, July 2008.

CASE STUDY QUESTIONS

1. Analyze the knowledge management efforts at TCS using the knowledge management value chain model. Which tools or activities were used for managing tacit knowledge and which ones are used for explicit knowledge?
2. Describe the growth of knowledge management systems at TCS. How have these systems helped TCS in its business?
3. Describe the collaboration tools used at TCS? What benefits did TCS reap from these tools?
4. How did Web 2.0 tools help TCS to manage knowledge and collaboration among its employees?
5. How do you think KM tools have changed some key operational processes at TCS, such as bidding for new projects, project development and implementation, customer service, and so on?

Case contributed by Neerja Sethi and Vijay Sethi, Nanyang Technological University