Chapter 11

Managing Knowledge

Interactive Sessions:

Augmented Reality: Reality Gets Better

The Flash Crash: Machines Gone Wild?

CANADIAN TIRE KEEPS THE WHEELS ROLLING WITH KNOWLEDGE MANAGEMENT SYSTEMS

D on't be fooled by its modest name: Canadian Tire sells a lot more than tires. This company is actually five interrelated companies consisting of petroleum outlets, financial services, and retail outlets selling automotive, sports, leisure, home products, and apparel. It is also one of Canada's largest companies and most-shopped retailers, with 57,000 employees, and 1,200 stores and gas stations across Canada. The retail outlets are independently owned and operated and are spread across Canada. Canadian Tire also sells merchandise online.

Obviously, a company this big needs efficient and effective ways of communicating with its workforce and dealers, and arming them with up-to-date information to run the business. The company created two different systems for this purpose, a dealer portal and an employee information intranet.

The dealer portal was based on Microsoft Office SharePoint Portal Server, and provided a central online source for merchandise setup information, alerts, best practices, product ordering, and problem resolution. The money saved from reducing daily and weekly mailings to dealers saved the company $1–2 million annually. Customer service improved because the dealers no longer had to wade through thick paper product binders. Now product manuals are all online, and dealers are able to automatically find accurate up-to-date information.

The employee intranet called TIREnet was initially more problematic. It was based on Lotus Notes Domino software and had been poorly designed. Employees complained that the site was disorganized, brimming with outdated and redundant material, and lacked effective search features. People spent more time than necessary searching for administrative and human resource-related documents.

Canadian Tire upgraded TIREnet with a new interface that was more streamlined and intuitive. The foundation for the new TIREnet was Microsoft SharePoint Server, and the company reorganized the internal Web site so that it was easier to use and find information. SharePoint provides an option to freeze specific content, such as human resources documents, so only staff with appropriate clearance can post changes.

Canadian Tire catalogued more than 30,000 documents from the old system and transferred them to the new system. Employees no longer have to browse through TIREnet to locate a document. SharePoint's Enterprise Search technology lets employees search for documents by typing their queries into a search box, instantly providing more up-to-date information for decision making.

It is also much easier to keep documents current. Employees and managers archived up to 50 percent of old TIREnet content that was irrelevant and outdated. Documents are now automatically updated according to who has reviewed each, and the last date each was accessed. This information helps Canadian Tire management identify and remove outdated and time-sensitive material, further reducing the time required to find information.

Canadian Tire's experience shows how business performance can benefit by making organizational knowledge more easily available. 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.

The chapter-opening diagram calls attention to important points raised by this case and this chapter. Canadian Tire is a very large and far-flung company with multiple lines of business. It has many different business units and retail dealers with which to communicate knowledge about the operation of the business. Delays in accessing product information impaired dealer efficiency and customer service, while cumbersome processes and tools for accessing information used by employees similarly hampered internal operations.

Canadian Tire developed a successful information-sharing platform for its dealers using Microsoft SharePoint Server, improving dealer operations and customer service. But the knowledge it provided internally to employees was disorganized and out of date. Canadian Tire revamped its TIREnet employee intranet based on Lotus Notes Domino software by switching its technology platform to Microsoft SharePoint Server and by streamlining and simplifying the user interface. It improved its business processes for classifying and storing documents to make them easier to locate using SharePoint search technology. SharePoint has tools for automatically tracking the time and authorship of document updates, which also helps Canadian Tire keep its information up to date. Thanks to better knowledge management, Canadian Tire is operating much more efficiently and effectively.
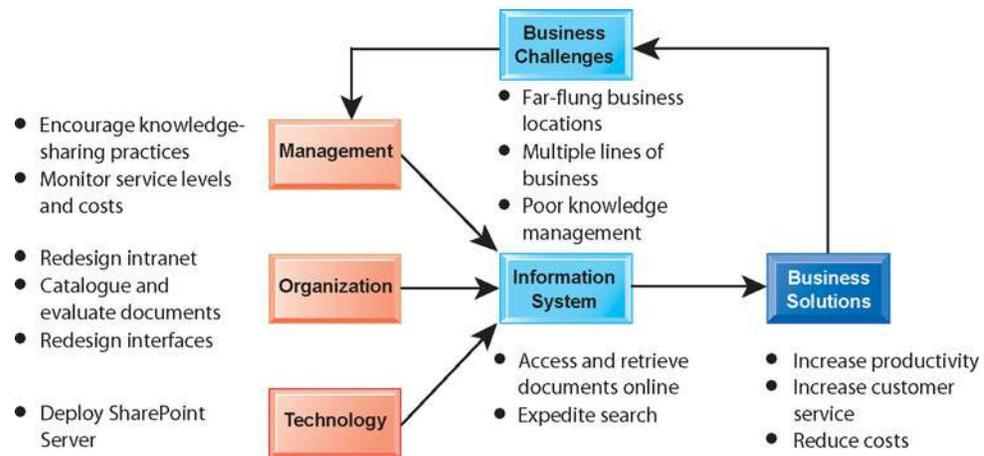
11.1 THE KNOWLEDGE MANAGEMENT LANDSCAPE

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. As we described in Chapter 2, collaboration systems include Internet-based collaboration environments like Google Sites and IBM's Lotus Notes, social networking, e-mail and instant messaging, virtual meeting systems, wikis, and virtual worlds. In this chapter, we will be focusing on knowledge management systems, always mindful of the fact 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. About 55 percent of the U.S. labor force consists of knowledge and information workers, and 60 percent of the gross domestic product of the United States comes from the knowledge and information sectors, such as finance and publishing.

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; Blair and Wallman, 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 peoples' 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.

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

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.

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 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.

FIGURE 11-1   THE KNOWLEDGE MANAGEMENT VALUE CHAIN
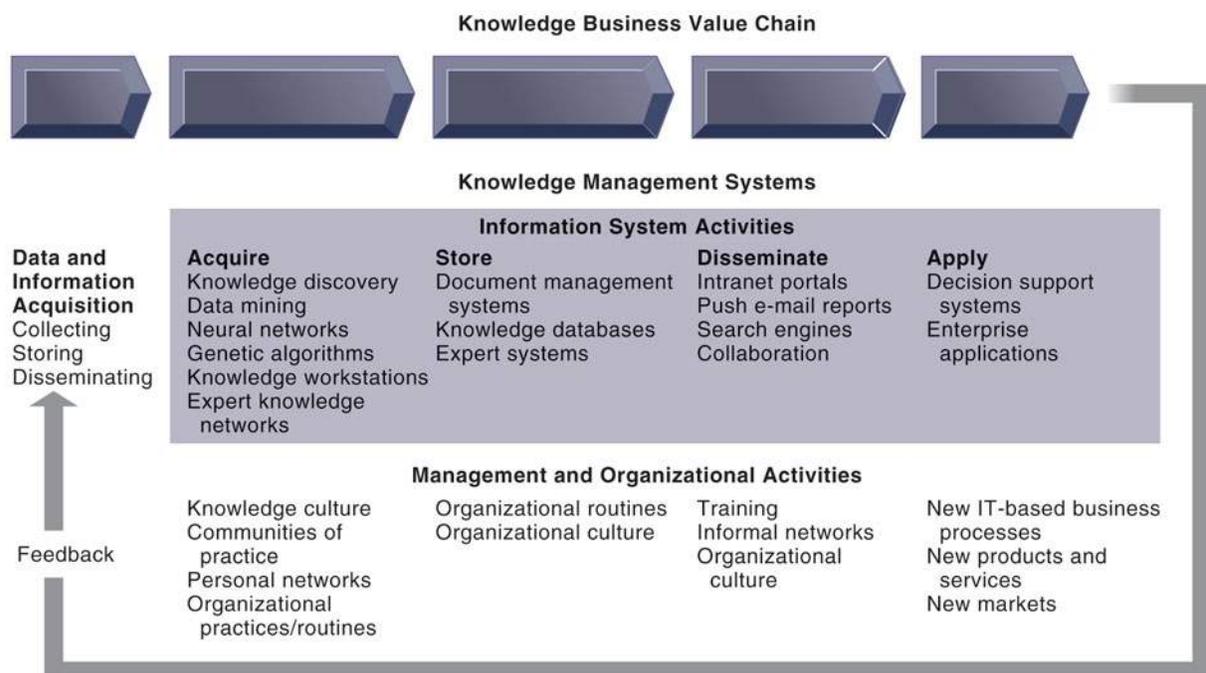
Knowledge management today involves both information systems activities and a host of enabling management and organizational activities.

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 has the knowledge in his or her head.

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 networks, and search engines technology have added to an existing array of collaboration technologies and office systems for sharing calendars, documents, data, and graphics (see Chapter 7). 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 decision-support systems (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- 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, search engines, collaboration tools (e-mail, instant messaging, wikis, blogs, and social bookmarking), 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

FIGURE 11-2   **MAJOR TYPES OF KNOWLEDGE MANAGEMENT SYSTEMS**
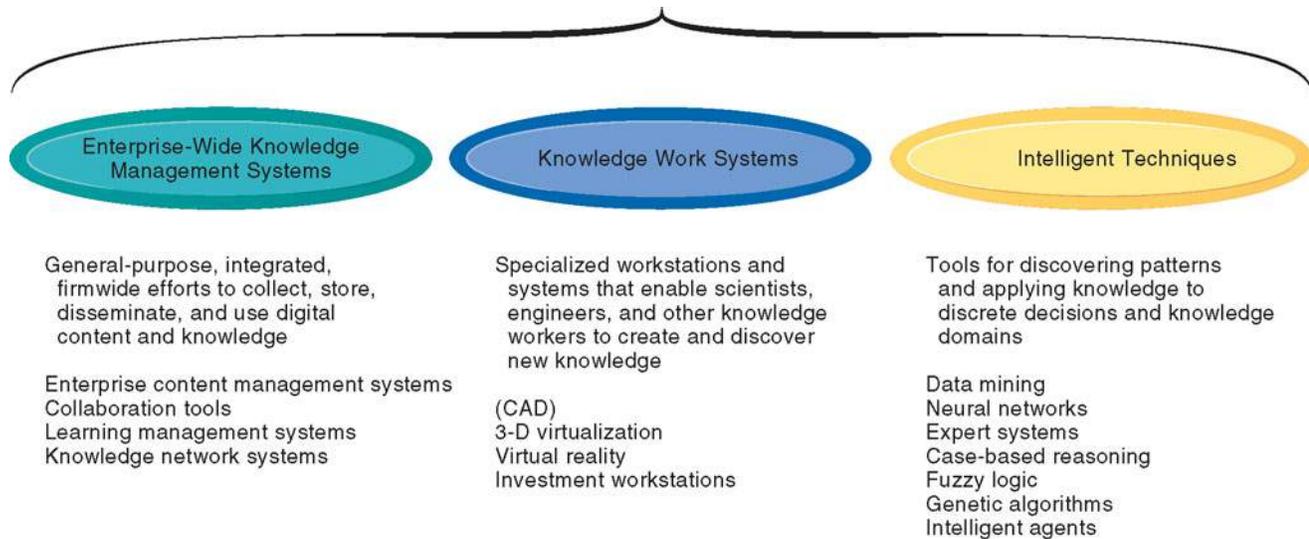
There are three major categories of knowledge management systems, and each can be broken down further into more specialized types of knowledge management systems.

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. Open Text Corporation, EMC (Documentum), IBM, and Oracle Corporation are leading vendors of enterprise content management software.

Barrick Gold, the world's leading gold producer, uses Open Text LiveLink Enterprise Content Management tools to manage the massive amounts of information required for building mines. The system organizes and stores both structured and unstructured content, including CAD drawings, contracts, engineering data, and production reports. If an operational team needs to refer back to the original document, that document is in a single digital repository as opposed to being scattered over multiple systems. Barrick's electronic content management system reduces the amount of time required to search for documents, shortening project schedules, improving the quality of decisions, and minimizing rework (Open Text, 2010).

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 where the documents are stored, and creating an enterprise portal environment for employees to use when searching for corporate knowledge.

FIGURE 11-3   AN ENTERPRISE CONTENT MANAGEMENT SYSTEM
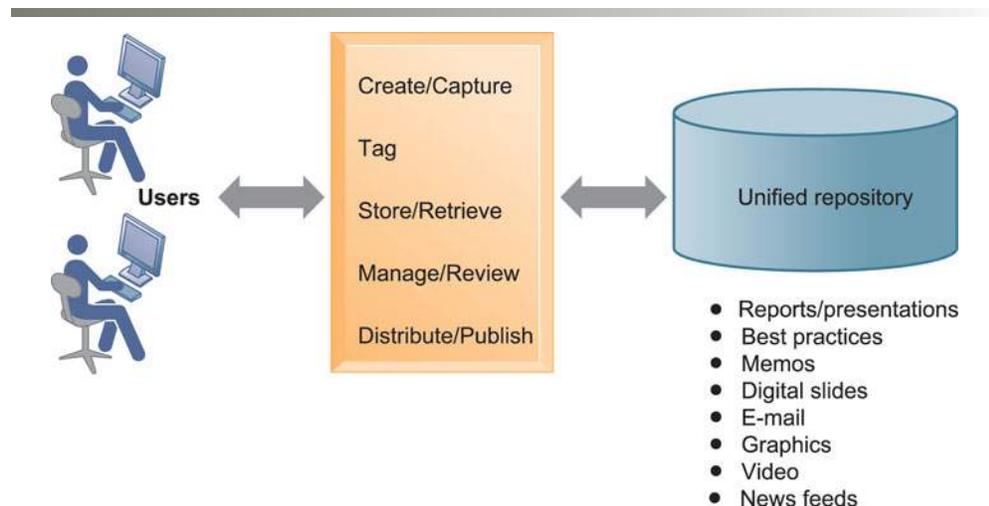
An enterprise content management system has capabilities for classifying, organizing, and managing structured and semistructured knowledge and making it available throughout the enterprise.

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, also known as *expertise location and management 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 expert individuals in the firm. Knowledge network systems provide an online directory of corporate experts in well-defined knowledge domains and use communication technologies to make it easy for employees to find the appropriate expert in a company. Some knowledge network systems go further by systematizing the solutions developed by experts and then storing the solutions in a knowledge database as a best practices or frequently asked questions (FAQ) repository (see Figure 11-4). AskMe provides stand-alone knowledge network software, and some knowledge networking capabilities can be found in the leading collaboration software suites.

## COLLABORATION TOOLS AND LEARNING MANAGEMENT SYSTEMS

The major enterprise content management systems include powerful portal and collaboration technologies. Enterprise knowledge portals can provide access to external sources of information, such as news feeds and research, as well as to internal knowledge resources along with capabilities for e-mail, chat/instant messaging, discussion groups, and videoconferencing.

Companies are starting to use consumer Web technologies such as blogs, wikis, and social bookmarking for internal use to foster collaboration and information exchange between individuals and teams. Blogs and wikis help capture, consolidate, and centralize this knowledge for the firm. Collaboration tools from commercial software vendors, such as Microsoft SharePoint and Lotus Connections, also offer these capabilities along with secure online collaborative workspaces.

Wikis, which we introduced in Chapters 2 and 7, are inexpensive and easy to implement. Wikis provide a central repository for all types of corporate data that can be displayed in a Web browser, including electronic pages of documents, spreadsheets, and electronic slides, and can embed e-mail and instant messages. Although users are able to modify wiki content contributed by others, wikis have capabilities for tracking these changes and tools for reverting to earlier versions. A wiki is most appropriate for information that is revised frequently but must remain available perpetually as it changes.

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 the documents. Lists of tags can be shared with other people to help them find information of interest. The user-created taxonomies created for

FIGURE 11-4   AN ENTERPRISE KNOWLEDGE NETWORK SYSTEM
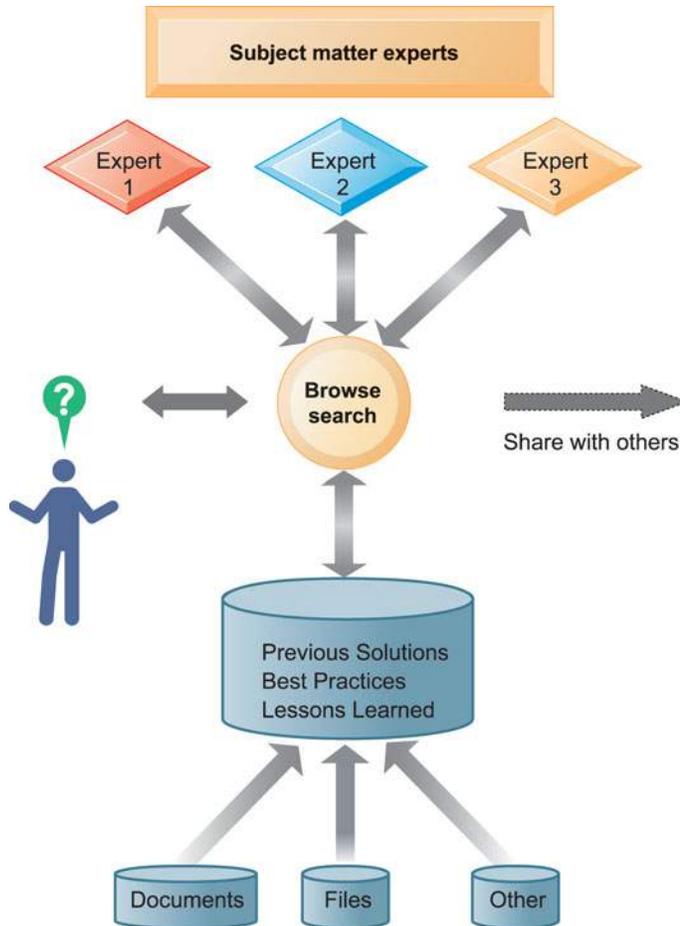
A knowledge network maintains a database of firm experts, as well as accepted solutions to known problems, and then facilitates the communication between employees looking for knowledge and experts who have that knowledge. Solutions created in this communication are then added to a database of solutions in the form of FAQs, best practices, or other documents.

shared bookmarks are called **folksonomies**. Delicious and Digg are two 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.

For example, the Whirlpool Corporation uses CERTPOINT's learning management system to manage the registration, scheduling, reporting, and content for its training programs for 3,500 salespeople. The system helps Whirlpool tailor course content to the right audience, track the people who took courses and their scores, and compile metrics on employee performance.

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 11-5 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.

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.

Troy Lee Designs, which makes sports helmets, recently invested in CAD design software that could create the helmets in 3-D. The technology defined the shapes better than traditional methods, which involved sketching an idea

FIGURE 11-5   **REQUIREMENTS OF KNOWLEDGE WORK SYSTEMS**
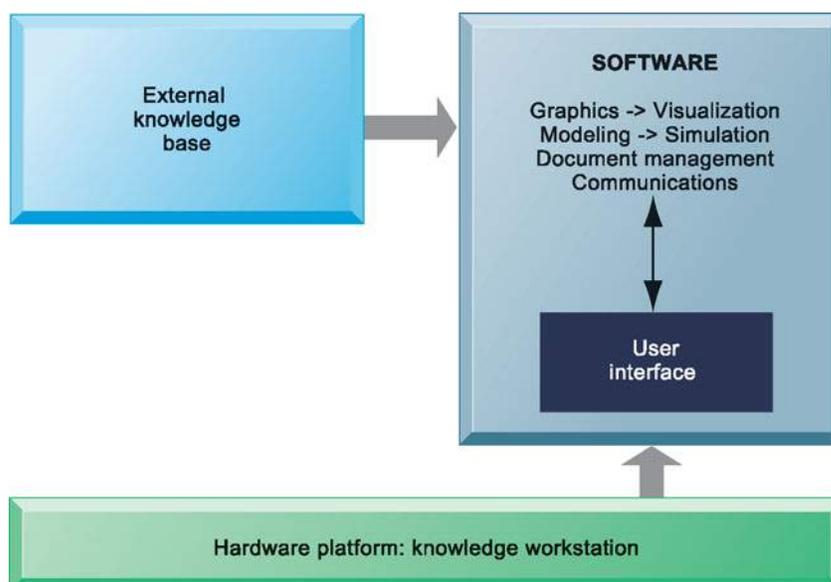
Knowledge work systems require strong links to external knowledge bases in addition to specialized hardware and software.

on paper, hand-molding a clay model, and shipping the model to Asian factories to create a plastic prototype. Production is now about six months faster and about 35 percent cheaper, with Asian factories about to produce an exact replica after receiving the digital design via e-mail (Maltby, 2010).

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 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.

A virtual reality system helps mechanics in Boeing Co.'s 25-day training course for its 787 Dreamliner learn to fix all kinds of problems, from broken lights in the cabin to major glitches with flight controls. Using both laptop and desktop computers inside a classroom with huge wall-mounted diagrams, Boeing airline mechanics train on a system that displays an interactive Boeing 787 cockpit, as well as a 3-D exterior of the plane. The mechanics "walk" around the jet by clicking a mouse, open virtual maintenance access panels, and go inside the plane to repair and replace parts (Sanders, 2010).

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 and

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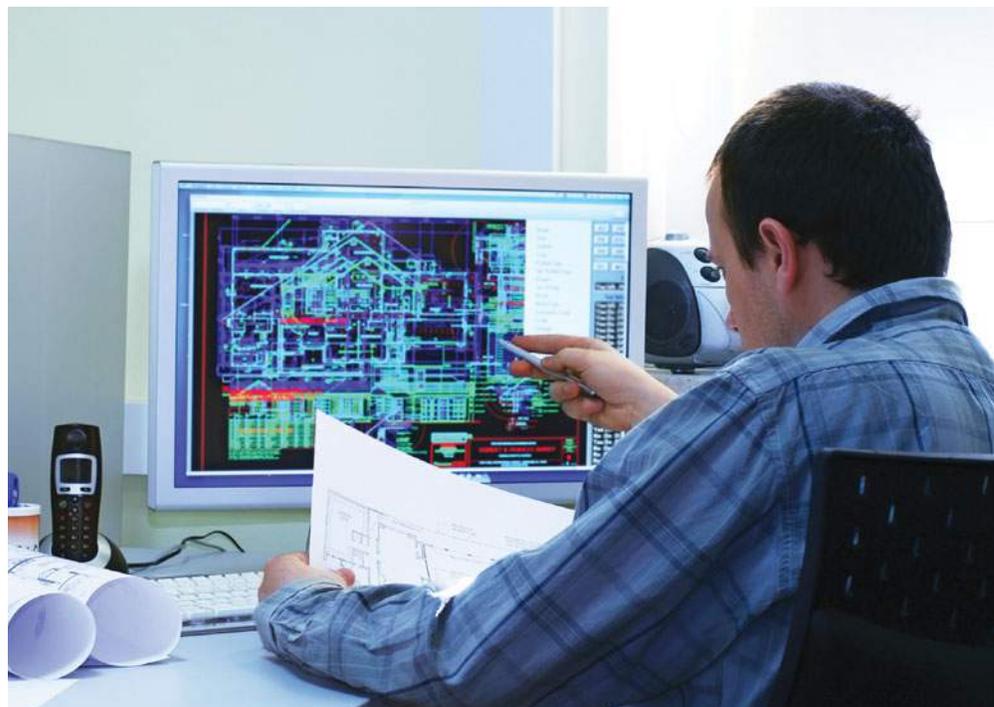
INTERACTIVE SESSION:TECHNOLOGY

AUGMENTED REALITY: REALITY GETS BETTER

Many of us are familiar with the concept of virtual reality, either from films like *Avatar* and *The Matrix*, or from science fiction novels and video games. Virtual reality is a computer-generated, interactive, three-dimensional environment in which people become immersed. But in the past few years, a new spin on virtual reality known as augmented reality has emerged as a major focus of many companies' marketing efforts. More than just science fiction, augmented reality is an exciting new way of creating richer, more interactive experiences with users and future customers.

Augmented reality differs from traditional virtual reality because users of augmented reality (also called AR) tools maintain a presence in the real world. In virtual reality, users are completely immersed in a computer-generated environment, and often use head-mounted displays that facilitate the immersion and eliminate any interference from the real world. Augmented reality mixes real-life images with graphics or other effects and can use any of three major display techniques—head-mounted displays, just as with virtual reality, spatial displays, which display graphical information on physical objects, and handheld displays.

Almost everyone has already encountered some form of AR technology. Sports fans are familiar with the yellow first-down markers shown on televised football games, or the special markings denoting the location and direction of hockey pucks in hockey games. These are examples of augmented reality. Other common usages of AR include 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.

As companies get more comfortable with augmented reality, marketers are developing creative new ways to use the technology. Print media companies see AR as a way to generate excitement about their products in an entirely new way. Esquire magazine used AR extensively in its December 2009 issue, adding several stickers with designs that, when held up to a Web camera, triggered interactive video segments featuring cover subject Robert Downey Jr. Turning the magazine in different directions yielded different images. A fashion spread describing dressing in layers showed actor Jeremy Renner adding more layers as the seasons changed. The orientation of the magazine as held up to a Web camera determined the season.

Lexus placed an advertisement in the magazine that displayed "radar waves" bouncing off of nearby objects on the page. Again, adjusting the angle of the magazine affected the content of the ad. Lexus Vice President of Marketing David Nordstrom stated that AR was attractive to him because "our job as marketers is to be able to communicate to people in interesting ways that are relevant to them and also entertaining." User response to the magazine was positive, suggesting that AR accomplished this goal. Other companies that have pursued AR as a way to attract and entertain their customers include Papa John's, which added AR tags to their pizza boxes. These tags display images of the company's founder driving a car when triggered using a Web camera. That company's president believes AR is "a great way to get customers involved in a promotion in a more interactive way than just reading or seeing an ad."

Mobile phone application developers are also excited about the growing demand for AR technologies. Most mobile phones have camera, global positioning system (GPS), Internet, and compass functionalities, which make smartphones ideal candidates for handheld AR displays. One of the major new markets for AR is in real estate, where applications that help users access real estate listings and information on the go have already taken off. An Amsterdam-based start-up, application developer Layar, has created an app for French real estate agency MeilleursAgents.com where users can point their phones at any building in Paris and within seconds the phone displays the property's value per square meter and a small photo of the property, along with a live image of the building streamed through the phone's camera.

Over 30 similar applications have been developed in other countries, including American real estate company ZipRealty, whose HomeScan application has met with early success. While the technology is still new and will take some time to develop, users can already stand in front of some houses for sale

and point their phones at the property to display details superimposed on their screen. If the house is too far away, users can switch to the phone's interactive map and locate the house and other nearby houses for sale. ZipRealty is so encouraged by the early response to HomeScan that it plans to add data on restaurants, coffee shops, and other neighborhood features to the app. Another well-known application, Wikitude, allows users to view user-contributed Web-based information about their surroundings using their mobile phones.

Skeptics believe that the technology is more of a gimmick than a useful tool, but Layar's application has been downloaded over 1,000 times per week since its launch. Being able to access information on properties is more than just a gimmick—it is a legitimately useful tool to help buyers on the go.

Marketers are finding that users increasingly want their phones to have all of the functionality of desktop computers, and more AR mash-ups have been released that display information on tourist sites, chart subway stops, and restaurants, and allow interior designers to superimpose new furniture schemes onto a room so that potential customers can more easily choose what they like best. Analysts believe that AR is here to stay, predicting that the mobile AR market will grow to $732 million by 2014.

Sources: R. Scott MacIntosh, "Portable Real Estate Listings-with a Difference," *The New York Times*, March 25, 2010; Alex Viega, "Augmented Reality for Real Estate Search," Associated Press, April 16, 2010; "Augmented Reality - 5 More Examples of This 3D Virtual Experience," http://www.nickburcher.com/2009/05/augmented-reality-5-more-examples-of.html, May 30, 2009; Shira Ovide, "Esquire Flirts with Digital Reality," *The Wall Street Journal*, October 29, 2009.

CASE STUDY QUESTIONS

1. What is the difference between virtual reality and augmented reality?
2. Why is augmented reality so appealing to marketers?
3. What makes augmented reality useful for real estate shopping applications?
4. Suggest some other knowledge work applications for augmented reality

MIS IN ACTION

Find example videos of augmented reality in action (use Nick Burcher's blog if you're stuck: http://www.nickburcher.com/2009/05/augmented-reality-5-more-examples-of.html), and use them to answer the following questions:

1. Why is the example shown in the video an instance of AR?
2. Do you think it is an effective marketing tool or application? Why or why not?
3. Can you think of other products or services that would be well suited to AR?

make the surrounding real world of the user more interactive and meaningful. The Interactive Session on Technology provides more detail about AR and its applications.

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** 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.

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.

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

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 11-6).

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 11-7).
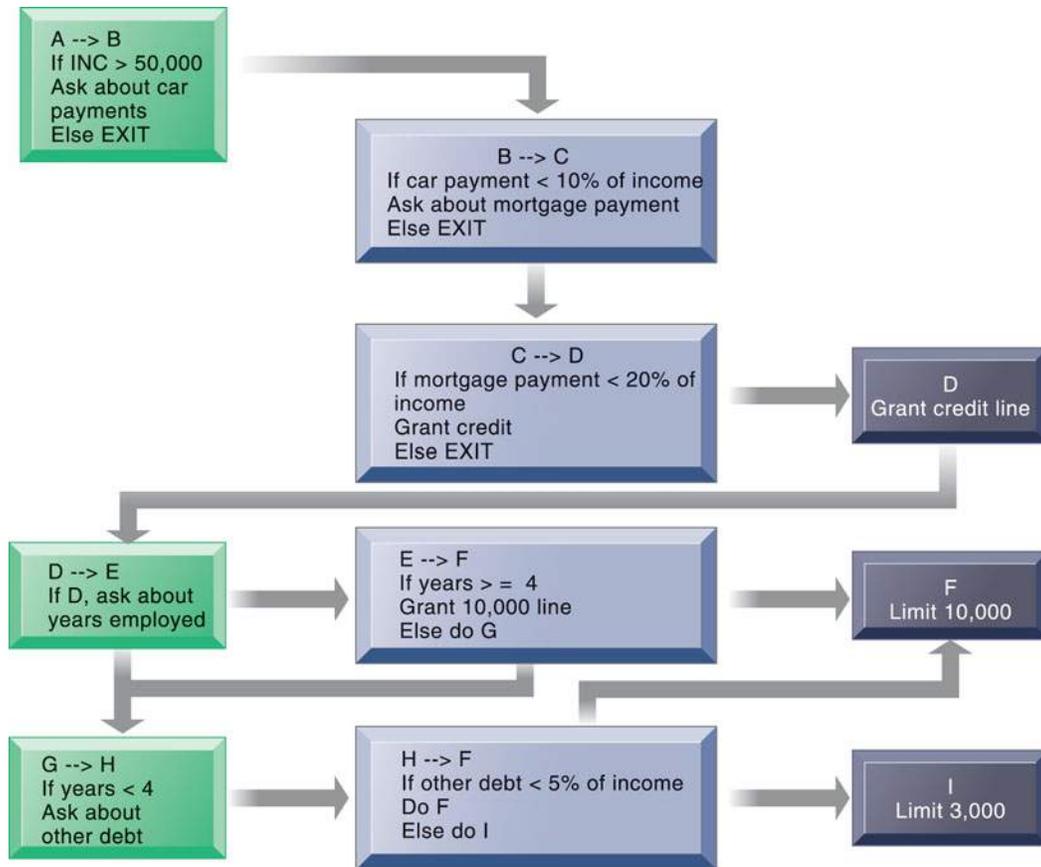
In **forward chaining,** the inference engine begins with the information entered by the user and searches the rule base to arrive at a conclusion. The strategy is to fire, or carry out, the action of the rule when a condition is true. In Figure 11-7, beginning on the left, if the user enters a client's 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 11-7, 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

FIGURE 11-6   RULES IN AN EXPERT SYSTEM

```
A --> B
If INC > 50,000
Ask about car
payments
Else EXIT

B --> C
If car payment < 10% of income
Ask about mortgage payment
Else EXIT

C --> D
If mortgage payment < 20% of
income
Grant credit
Else EXIT

D
Grant credit line

D --> E
If D, ask about
years employed

E --> F
If years > = 4
Grant 10,000 line
Else do G

F
Limit 10,000

G --> H
If years < 4
Ask about
other debt

H --> F
If other debt < 5% of income
Do F
Else do I

I
Limit 3,000
```

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 11-7   INFERENCE ENGINES IN EXPERT SYSTEMS

```
Income Rules

If INC > $100,000
then life ins

If life insurance
           send sales rep

If sales rep or term ins
    or FinAdv
           then search dbase

If INC > $50,000 and
$100,000 then term ins

If term insurance
           send brochure

Other Accounts

If not on dbase,
    then add prospect file

Real Estate Rules

If REstate
           then further
           contact

If REstate > $1,000,000
           then send FinAdv

If FinAdv
    then prepare sales kit
```

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.

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 11-8).

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 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

**FIGURE 11-8   HOW CASE-BASED REASONING WORKS**
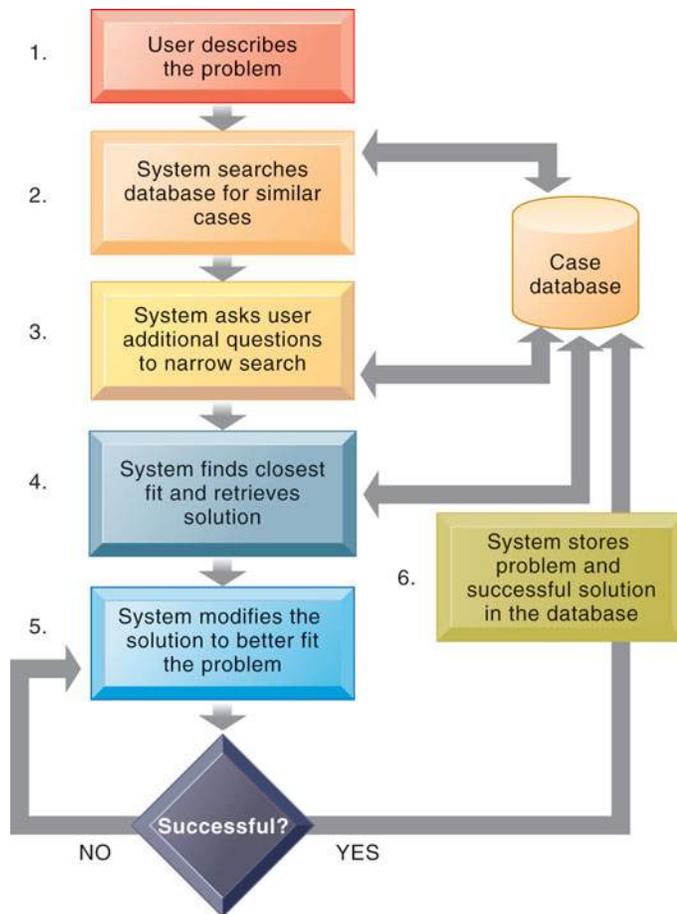
Case-based reasoning represents knowledge as a database of past cases and their solutions.
The system uses a six-step process to generate solutions to new problems encountered by the user.

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 11-9, 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

FIGURE 11-9   FUZZY LOGIC FOR TEMPERATURE CONTROL
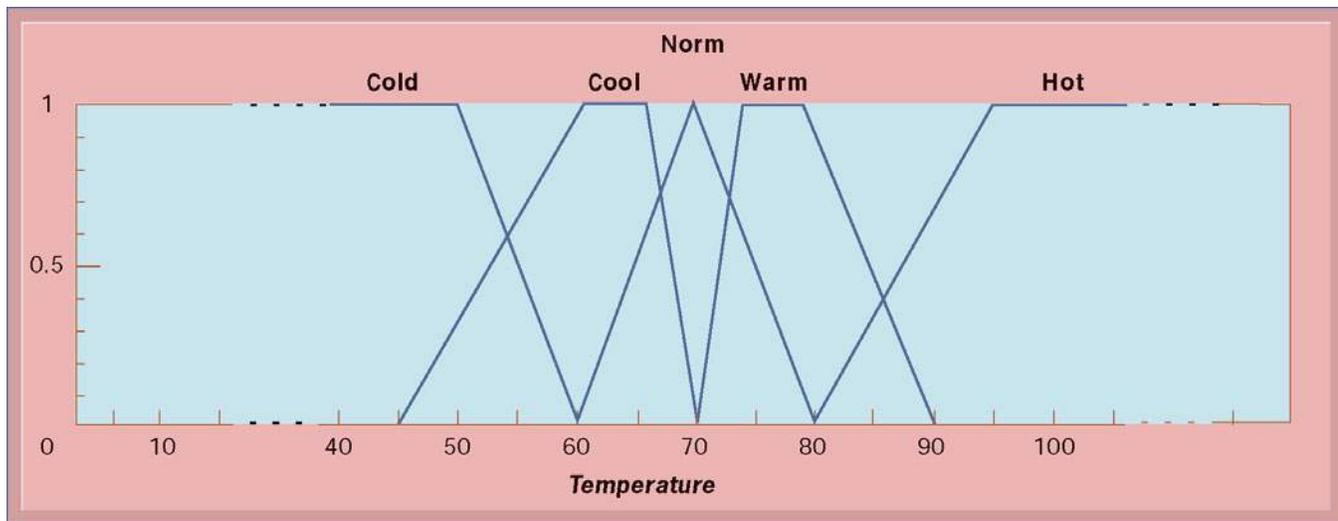
The membership functions for the input called temperature are in the logic of the thermostat to control the room temperature. Membership functions help translate linguistic expressions such as *warm* into numbers that the computer can manipulate.

outdoor temperature is low, raise the heat and humidity in the room." 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.

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 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 11-10 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 11-10 has learned how to identify a fraudulent credit card 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.

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

FIGURE 11-10 HOW A NEURAL NETWORK WORKS
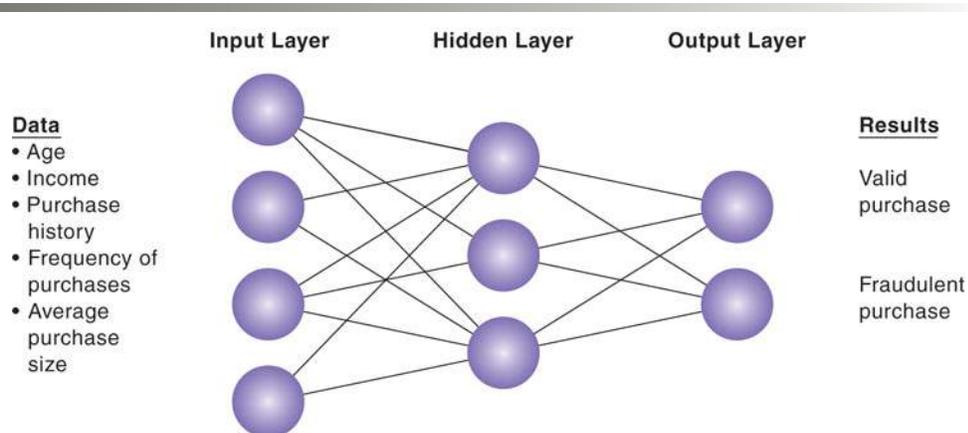
A neural network uses rules it "learns" from patterns in data to construct a hidden layer of logic. The hidden layer then processes inputs, classifying them based on the experience of the model. In this example, the neural network has been trained to distinguish between valid and fraudulent credit card purchases.

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.

The Interactive Session on Organizations describes computerized stock trading applications based on a related AI technology called **machine learning.** Machine learning focuses on algorithms and statistical methods that allow computers to "learn" by extracting rules and patterns from massive data sets and make predictions about the future. Both neural networks and machine learning techniques are used in data mining. As the Interactive Session points out, the use of machine learning in the financial industry for securities trading decisions has had mixed results.
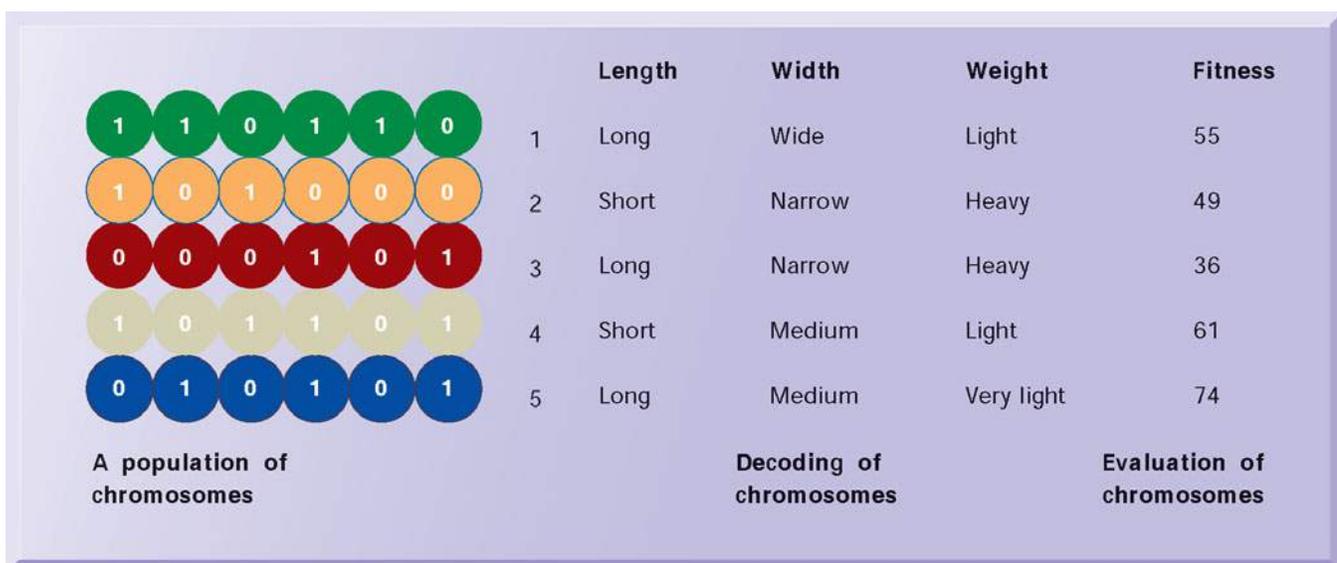
GENETIC ALGORITHMS

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 11-11, each string corresponds to one of the variables in the problem. One applies a test for fitness, ranking the strings in the population

FIGURE 11-11   THE COMPONENTS OF A GENETIC ALGORITHM

	Length	Width	Weight	Fitness
1	Long	Wide	Light	55
2	Short	Narrow	Heavy	49
3	Long	Narrow	Heavy	36
4	Short	Medium	Light	61
5	Long	Medium	Very light	74

A population of chromosomes   Decoding of chromosomes   Evaluation of chromosomes

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.

INTERACTIVE SESSION: ORGANIZATIONS

THE FLASH CRASH: MACHINES GONE WILD?

On May 6, 2010, the U.S. stock markets were already down and trending even lower. Concerns about European debt, primarily the possibility of Greece defaulting, added to existing investor uncertainties about the markets and the economy at that time. But at 2:42 PM, in a flash, the equity market took a plunge so fast and so deep that it could not have been motivated by investor uncertainty alone.

Before the plunge, the market was already down 300 points on the day. In less than five minutes after 2:42, the Dow Jones Industrial Average plummeted more than 600 points, representing a loss of $1 trillion in market value. At its lowest point, the Dow was down a whopping 998.50 points to 9869.62, a 9.2 percent drop from the day's opening. This represented the biggest intraday decline in Dow history. Fortunately, this loss was temporary, vanishing nearly as quickly as it appeared. By 3:07 PM, the market had already regained nearly all of the points it had lost, and eventually closed down just 347.80 points that day at 10,520.32. The hefty loss was still its worst Dow percentage decline in over a year, but it certainly could have been worse.

How could this "flash crash" have happened? It now appears that the abrupt selling activities of a single mutual fund company touched off a chain reaction. A confluence of forces was unleashed by the structural and organizational features of the electronic trading systems that execute the majority of trades on the Dow and the rest of the world's major stock exchanges. Electronic trading systems offer considerable advantages over human brokers, including speed, reduced cost, and more liquid markets. High-frequency traders (HFTs) have taken over many of the responsibilities once filled by stock exchange specialists and market makers whose job was to match buyers and sellers efficiently.

Many trading systems today, such as those used by HFTs, are automated, using algorithms to place their nearly instant trades. A number of the HFT trading firms and hedge funds now use machine learning to help their computer systems trade in and out of stocks efficiently. Machine learning programs are able to crunch vast amounts of data in short periods, "learn" what works, and adjust their stock trading strategies on the fly, based on shifting dynamics in the market and broader economy. This method is far beyond human capability: As Michael Kearns, computer science professor at University of Pennsylvania and expert in AI investing, stated, "No human could do this. Your head would blow off." It would appear, however, in situations like the flash crash, where a computer algorithm is insufficient to handle the complexity of the event in progress, electronic trading systems have the potential to make a bad situation much worse.

At 2:32 P.M. on May 6, Waddell & Reed Financial of Overland Park, Kansas started to sell $4.1 billion of futures contracts using a computer selling algorithm that dumped 75,000 contracts onto the market over the next 20 minutes. Normally, a sale of that size would take as much as five hours, but on that day, it was executed in 20 minutes. The algorithm instructed computers to execute the trade without regard to price or time, and thus continued to sell as prices sharply dropped.

After Waddell & Reed started to sell, many of the futures contracts were bought by HFTs. As the HFTs realized prices were continuing to fall, they began to sell what they had just bought very aggressively, which caused the mutual fund's algorithm in turn to accelerate its selling. The HFT computers traded contracts back and forth, creating a "hot potato" effect. The selling pressure was then transferred from the futures market to the stock market. Frightened buyers pulled to the sidelines. The markets were overwhelmed by sell orders with no legitimate buyers available to meet those orders.

The only buy orders available at all originated from automated systems, which were submitting orders known as "stub quotes." Stub quotes are offers to buy stocks at prices so low that they are unlikely to ever be the sole buyers of that stock available; during the unique conditions of the flash crash, they were. When the only offer to buy available is a penny-priced stub quote, a market order, by its terms, will execute against the stub quote. In this respect, automated trading systems will follow their coded logic regardless of outcome, while human involvement would likely have prevented these orders from executing at absurd prices.

In the midst of the crisis, the New York Stock Exchange activated circuit breakers, measures

intended to slow trading on stocks that have lost a tenth or more of their value in a short time, and routed all of their trading traffic to human brokers in an effort to stop the downward spiral. (NYSE is the only major exchange with the ability to execute trades both via computers and via human brokers.) But because of the enormous volume of orders, and because other fully electronic exchanges lacked similar circuit breakers, it may have had the reverse effect in the short term. While computerized systems simply continued to push the market lower, humans were unable to react fast enough to the situation.

Regulators are considering several different approaches to preventing future flash crashes, but it may be that there is no satisfactory solution. The Securities and Exchange Commission (SEC) may attempt to standardize circuit breakers across all financial markets, limit high-frequency trading, overhaul the stub quoting system, or stipulate that all buy and sell orders be limit orders, which places upper and lower limits on the prices at which stocks can be bought and sold. But it may be that events like the flash crash are what author and hedge fund adviser Nassim Taleb called "Black Swans" in his book

of the same name—unpredictable and uncontrollable events under which we only have "the illusion of control."

After 'Black Monday' in 1987, the last crash of similar size, it was thought that computer trading prevented sudden drops in the market, but the flash crash indicates that electronic trading simply allows them to occur over a shorter time period, and may even magnify these sudden market moves in either direction because they can happen faster with less chance of intervention. But, as the flash crash has proven, if we rely solely on these automated methods of electronic trading, we'll still need to worry about machines gone wild.

Sources: Graham Bowley, "Lone $4.1 Billion Sale Led to 'Flash Crash' in May," *The New York Times*, October 1, 2010; Aaron Lucchetti, "Exchanges Point Fingers Over Human Hands," *The Wall Street Journal*, May 9, 2010; Scott Patterson, "Letting the Machines Decide," *The Wall Street Journal*, July 13, 2010; Scott Patterson and Tom Lauricella, "Did a Big Bet Help Trigger 'Black Swan' Stock Swoon?" *The Wall Street Journal*, May 10, 2010; Edward Wyatt, "Regulators Vow to Find Way to Stop Rapid Dives," *The New York Times*, May 10, 2010; Kara Scannell and Fawn Johnson, "Schapiro: Web of Rules Aided Fall," *The Wall Street Journal*, May 12, 2010; Larry Harris, "How to Prevent Another Trading Panic," *The Wall Street Journal*, May 12, 2010; Scott Patterson, "How the 'Flash Crash' Echoed Black Monday," *The Wall Street Journal*, May 17, 2010.

CASE STUDY QUESTIONS

1. Describe the conditions that preceded the flash crash.
2. What are some of the benefits of electronic trading?
3. What features of electronic trading and automated trading programs contributed to the crash?
4. Could this crash have been prevented? Why or why not?

MIS IN ACTION

Use the Web to search for information on the Black Monday crash of 1987. Then answer the following questions:

1. What features of the Black Monday crash are different from the 2010 flash crash?
2. How are the two crashes similar?
3. What measures did regulators take to ensure that no future crashes would happen again?
4. How has the advent of electronic trading affected those regulatory measures?

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 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.

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.
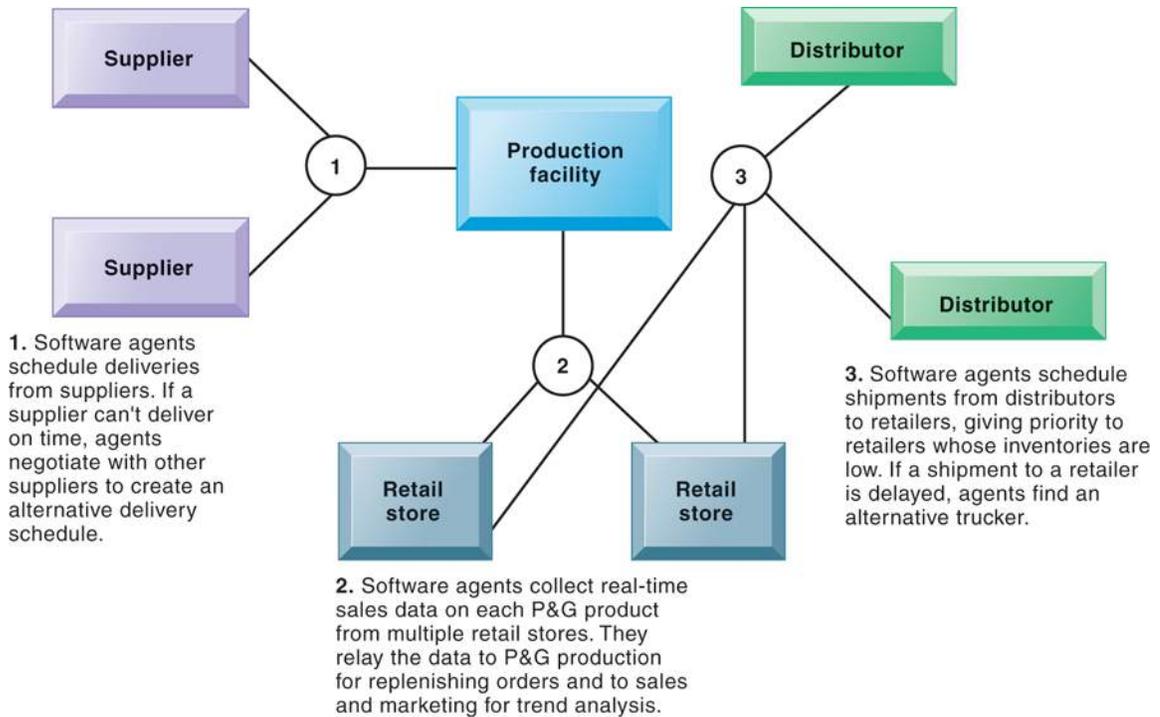
INTELLIGENT AGENTS

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 in the background without direct human intervention to carry out specific, repetitive, and predictable tasks for an individual user, business process, or software application. The agent uses a limited 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.

Of special interest to business are intelligent agents for cruising networks, including the Internet, in search of information. Chapter 7 describes how shopping bots can help consumers find products they want and assist them in comparing prices and other features.

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 (Samuelson and Macal, 2006).

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 11-12). 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

FIGURE 11-12 **INTELLIGENT AGENTS IN P&G'S SUPPLY CHAIN NETWORK**

1. Software agents schedule deliveries from suppliers. If a supplier can't deliver on time, agents negotiate with other suppliers to create an alternative delivery schedule.

2. Software agents collect real-time sales data on each P&G product from multiple retail stores. They relay the data to P&G production for replenishing orders and to sales and marketing for trend analysis.

3. Software agents schedule shipments from distributors to retailers, giving priority to retailers whose inventories are low. If a shipment to a retailer is delayed, agents find an alternative trucker.

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

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.

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.

11.5   HANDS-ON MIS PROJECTS

The projects in this section give you hands-on experience designing a knowledge portal, applying collaboration tools to solve a customer retention problem, using an expert system or spreadsheet tools to create 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 the 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. Sprint Nextel has the highest rate of customer churn (the number of customers who discontinue a service) in the cell phone industry, amounting to 2.45 percent. Over the past two years, Sprint has lost 7 million subscribers. Management wants to know why so many customers are leaving Sprint and what can be done to woo them back. Are customers deserting because of poor customer service, uneven network coverage, or the cost of Sprint cell phone plans? How can the company use tools for online collaboration and communication to help find the answer? What management decisions could be made using information from these sources?

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 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.

You have decided to purchase a new digital camera. Select a digital camera you might want to purchase, such as the Canon PowerShot S95 or the Olympus Stylus 7040. To purchase the camera as inexpensively as possible, try several of the shopping bot sites, which do the price comparisons for you. Visit My Simon (www.mysimon.com), BizRate.com (www.bizrate.com), and Google Product Search. Compare 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?

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.

    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, repetitive, and predictable 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

Agent-based modeling, 441
Augmented reality (AR), 428
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Virtual reality systems, 428
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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 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 witih knowledge management. Describe the steps it should take to develop a knowledge management program and select knowledge management applications.

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: Rating Enterprise Content Management Systems

With a group of classmates, select two enterprise content management products, such as those from Open Text, IBM, EMC, or Oracle. Compare their features and capabilities. To prepare your analysis, use articles from computer magazines and the Web sites for the enterprise content management software vendors. If possible, use Google Sites to post links to Web pages, team communication announcements, and work assignments; to brainstorm; and to work collaboratively on project documents. Try to use Google Docs to develop a presentation of your findings for the class.

San Francisco Public Utilities Commission Preserves Expertise with Better Knowledge Management
CASE STUDY

A major challenge facing many companies and organizations is the imminent retirement of baby boomers. For certain organizations, this challenge is more daunting than usual, not only because of a larger spike in employee retirements, but also because of the business process change that must accompany significant shifts in any workforce. The San Francisco Public Utilities Commission (SFPUC) was one such organization.

SFPUC is a department of the city and county of San Francisco that provides water, wastewater, and municipal power services to the city. SFPUC has four major divisions: Regional Water, Local Water, Power, and Wastewater (collection, treatment, and disposal of water). The organization has over 2,000 employees and serves 2.4 million customers in San Francisco and the Bay Area. It is the third largest municipal utility in California.

SFPUC's Power division provides electricity to the city and county of San Francisco, including power used to operate electric streetcars and buses; the Regional and Local Water departments supply some of the purest drinking water in the world to San Francisco and neighboring Santa Clara and San Mateo counties; and the Wastewater division handles flushed and drained water to significantly reduce pollution in the San Francisco Bay and Pacific Ocean. The mission of this organization is to provide San Francisco and its Bay Area customers with reliable, high-quality, affordable water and wastewater treatment while efficiently and responsibly managing human, physical, and natural resources.

SFPUC expected that a significant portion of its employees—about 20 percent—would retire in 2009. To make matters worse, the majority of these positions were technical, which meant that the training of new employees would be more complicated, and maintaining knowledge of the retiring workers would be critical to all areas of SFPUC's business processes.

To deal with this trend, companies and organizations like SFPUC must rearrange their operations so that the generational swap doesn't adversely affect their operational capability in the upcoming decades. In particular, the organization needed a way to capture the knowledge of its retiring employees of "baby boom" age in an efficient and cost-effective manner, and then communicate this knowledge successfully to the next generation of employees. The two major challenges SFPUC faced were successfully capturing, managing, and transferring this knowledge, and maintaining reliability and accountability despite a large influx of new workers.

SFPUC met these challenges by implementing a business process management (BPM) and workflow solution from Interfacing Technologies Corporation to drive change efforts across the organization. The system, called Enterprise Process Center, or EPC, manages knowledge retention and establishes new ways of collaborating, sharing information, and defining roles and responsibilities. SFPUC saw the retirement of its baby boomers as an opportunity to implement a structure that would alleviate similar problems in the future. With EPC, SFPUC would be able to maintain continuity from older to newer employees more easily. SFPUC was impressed that the system would span all four of its major divisions, helping to standardize common processes across multiple departments, and that it would be easy to use and train employees.

EPC sought to identify common processes, called "work crossovers," by mapping business processes across each department. EPC is unique among BPM software providers in its visual representation of these processes. Using flow charts accessible via a Web portal to clearly depict the functions performed by each department, SFPUC was able to identify redundant and inefficient tasks performed by multiple departments. This visually oriented solution for optimizing business processes catered to both technology-savvy new employees and older baby boomers.

Prior to the BPM overhaul, SFPUC employees had little incentive to share business process information. New environmental regulations were difficult to communicate. Certain inspection processes were conducted on an irregular basis, sometimes as infrequently as every 5 to 15 years. The knowledge required to execute these processes was especially valuable, because newer employees would have no

way of completing these tasks without proper documentation and process knowledge. SFPUC needed ways to easily find knowledge about processes that were performed daily, as well as every 15 years, and what's more, that knowledge had to be up to date so that employees didn't stumble across obsolete information.

EPC solved that problem by creating work order flows for all tasks performed within the organization, defining the employee roles and responsibilities for each. For example, the work order flow for SFPUC's wastewater enterprise displayed each step in the process visually, with links to manuals describing how to complete the task and the documents required to complete it. EPC also identified obsolete processes that were well suited to automation or totally superfluous. Automating and eliminating outdated tasks alleviated some of SFPUC's budget and workload concerns, allowing the organization to divert extra resources to training and human resources.

SFPUC management had anticipated that eliminating outdated tasks would have the added effect of keeping employees happy, which would help SFPUC's performance by delaying retirement of older employees and increasing the likelihood that newer hires stayed at the company. EPC allowed employees to provide feedback on various tasks, helping to identify tasks that were most widely disliked. For example, the process for reimbursement of travel expenses was described as lengthy, highly labor-intensive, and valueless to the citizens of San Francisco. To be reimbursed for travel expenses, employees had to print a form, complete it by hand, attach travel receipts, and walk the documents over to their supervisors, who then had to manually review and approve each item and remit expenses for three additional levels of approval. Only then could the division controller issue the reimbursement.

To address this need for sharing information and making documents available across the organization, SFPUC started by using a wiki, but the documents lacked different levels of relevance. Critical information pertaining to everyday tasks took the same amount of time to find as information pertaining to an inspection performed every 15 years. EPC allowed users to assign levels of relevance to tasks and identify critical information so that critical information displays when employees search for certain items. For example, SFPUC employees must comply with various regulatory permits for water and air quality standards. Lack

of awareness of these standards often leads to unintentional violations. The BPM tool helped users assign risks to various tasks so that when employees queried information, the relevant regulations displayed along with the requested documents.

Identifying the experts on particular subjects for mission-critical processes is often challenging when compiling information on business processes across the enterprise. SFPUC anticipated this, using EPC to break down large-scale process knowledge into more manageable pieces, which allowed more users to contribute information. Users were reluctant to buy in to the BPM implementation at first, but management characterized the upgrade in a way that invited employees to share their thoughts about their least favorite processes and contribute their knowledge.

The final product of the knowledge management overhaul took the form of a "centralized electronic knowledge base," which graphically displays critical steps of each task and uses videos to gather information and show work being done. New employees quickly became confident that they could perform certain tasks because of these videos. The overall results of the project were overwhelmingly positive. EPC helped SFPUC take its baby boomers' individual data and knowledge and turn them into usable and actionable information that was easily shared throughout the firm. SFPUC stayed much further under budget than other comparable governmental organizations.

SFPUC's new knowledge processes made many activities more paperless, reducing printing costs, time to distribute documents, and space required for document retention. Going paperless also supported the organization's mission to become more environmentally responsible. The addition of video technology to the process maps helped employees see how they could reduce energy consumption practices and electrical costs. By automating and redesigning the unwieldy travel reimbursement process described earlier, SFPUC reduced the time to process employee reimbursement requests by as much as 50 percent.

Sources: "San Francisco Tackles Baby Boom Retirement Effect and is Selected as a Finalist for the Global Awards for Excellence in BPM-Workflow," *International Business Times*, January 12, 2010; Interfacing Technologies, Canada, "San Francisco Public Utilities Commission USA;" Catherine Curtis, "SFPUC Delivers Workforce Development Presentation at WEFTEC Conference," *Wastewater Enterprise*, October 2009; "SFPUC Water Enterprise Environmental Stewardship Policy," San Francisco Public Utilities Commission, June 27, 2006.

CASE STUDY QUESTIONS

1. What are the business goals of SFPUC? How is knowledge management related to those goals?

2. What were some of the challenges faced by SFPUC? What management, organization, and technology factors were responsible for those challenges?

3. Describe how implementing EPC improved knowledge management and operational effectiveness at SFPUC.

4. How effective was EPC as a solution for SFPUC?

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