

DECISION SUPPORT SYSTEMS AND INTELLIGENT SYSTEMS

SEVENTH EDITION



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by' EfrailTI Turban, Jay E., Aronson, 'and ,Jing-PengLiang with contributions by Richard
V. McCarthy . ,

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*Dedicated to my
wife, Sharon,
and my children, Marla, Michael, and Stephanie,
with love*

*To my wife, Lina,
and my daughters, Daphne and Sharon,
with love*

*To my wife, Jenny,
and my sons, Nigel and David*

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As we begin the 21st century, we observe major changes in how managers use computerized support in making decisions. As more and more decision-makers become computer and Web literate, decision-support systems (DSS) / business intelligence (BI) is evolving from its beginnings as primarily a personal-support tool, and is quickly becoming a *shared commodity* across the organization. Organizations can now easily use intranets and the Internet to deliver high-value performance-analysis applications to decision-makers around the world. Corporations regularly develop distributed systems, *intranets* and *extranets*, that enable easy access to data stored in multiple locations, and collaboration and communication worldwide. Various information systems are integrated with one other and/or with other Web-based automated systems. Some integration even transcends organizational boundaries. Managers can make better decisions because they have more accurate information at their fingertips.

Today's DSS tools utilize the Web for their graphical user interface that allows users to flexibly, efficiently, and easily view and process data and models with familiar Web browsers. The easy-to-use and readily available capabilities of enterprise information, knowledge and other advanced systems have migrated to the PC and personal digital assistants (PDAs). Managers communicate with computers and the Web using a variety of hand-held wireless devices, including the cell telephone. These devices enable managers to access important information and useful tools, communicate, and collaborate. *Data warehouses* and their analytical tools (e.g., *online analytical processing/OLAP* and *data mining*) dramatically enhance information access across organizational boundaries. Decision support for groups continues to improve with major new developments in *group support systems* for enhancing collaborative work, anytime and anywhere. *Artificial intelligence* methods are improving the quality of decision support, and have become embedded in many applications ranging from antilocking automotive brakes to intelligent Web search engines. *Intelligent agents* perform routine tasks, freeing up time that decision-makers can devote to important work. Developments in *organizational learning* and *knowledge management* deliver the entire organization's expertise to bear on problems anytime and anywhere. The Internet and intranet information-delivery systems enhance and enable all of these decision support systems.

The purpose of this book is to introduce the reader to these technologies, which we call, collectively, *management support systems* (MSS). This book presents the fundamentals of the techniques and the manner in which these systems are constructed and used.

The theme of this totally revised edition is "Web-based, enterprise decision support." In addition to traditional DSS applications, this edition expands the reader's understanding of the world of the Web by providing examples, products, services, and exercises, and by discussing Web-related issues throughout the text. We highlight *Web intelligence* and *Web analytics*, which parallel business intelligence/business analytics for electronic commerce and other Web applications. The book is supported by a Web site (prenhall.com/turban) containing additional Web Chapters that supplement the text. Most of the specific improvements made in this seventh edition concentrate on three areas: enterprise decision support, artificial intelligence, and Web DSS. Despite the many changes, we have preserved the comprehensiveness and user friendliness that

have made the text a market leader. We have also reduced the book's size by eliminating generic material and by moving material to the Web site. Finally, we present accurate and updated material not available in any other text.

DSS and ES courses and portions of courses are recommended jointly by the Association for Computing Machinery (ACM), the Association for Information Systems (AIS), and the Association of Information Technology Professionals (AITP, formerly DPMA) (see *Data Base*, Vol. 28, No.1, Winter 1997). This course is designed to cover the decision-support and artificial intelligence components of the IS'97 Model Curriculum for information systems. It actually covers more than what is recommended. The text also covers the decision-support and artificial intelligence components of the Information Systems 2000 Model Curriculum draft (www.is2000.org). Another objective is to provide the practicing manager with the foundations and applications of DSS, GSS, knowledge management, ES, neural computing, intelligent agents, and other intelligent systems.

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THE SEVENTH EDITION

The seventh edition of this book makes a major departure from the previous editions for the purpose of improving the text.

The major improvements include the following:

- Expansion and major updating of data warehousing, online analytical processing, and data-mining materials in Chapter 5.
- Reordering Chapters 4 and 5 on modeling and data to enable intelligent, detailed coverage of data warehousing and its associated business intelligence development and application.
- Expansion and major updating of the materials on enterprise information systems, including portals, supply chain management, enterprise resource planning/enterprise resource management, customer relationship (resource) management, product life-cycle management, business process management, business activity monitoring, and a reduction in the historical materials in Chapter 8.
- A support Web site organized by chapters to enhance the text materials.
- A major updating of the treatment of knowledge management (Chapter 9).
- Condensing the material on artificial neural networks into a single chapter (Chapter 13).
- Combining the several chapters on expert systems into one.
- Creating a single chapter from those on networked decision support and group support systems (Chapter 7).
- Eliminating the chapter on intelligent systems development from the text and moving it to the book's Web site.
- Updating the theoretical material on decision-making in Chapter 2. This includes material on alternative decision-making models and temperament types.
- Updating the real-world case applications in many of the chapters. These include the IMERYS case applications in Chapters 2, 4, and 6.
- Including major discussions on OLAp, data mining, expert systems, and neural network packages.
- The overall number of chapters was reduced.

- The book is supported by a Web site, prenhall.com/turban, that includes supplementary material organized by chapters.
- The Internet Exercises for each chapter have been expanded. A diversity of exercises provides students with extensive, up-to-date information and a better sense of reality.
- Hands-on exercises provide opportunities to build decision support applications.
- Expanded group exercises and term projects. These enhance the learning experience by providing activities for small groups and longer-term activities. Some term projects involve building systems for real organizations (we have used this approach very successfully for over 15 years in our teaching).
- Updated research findings and references.
- More real-world examples.

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IE.A.

E.T.

T.p.L.

PART

I

DECISION-MAKING AND COMPUTERIZED SUPPORT

LEARNING OBJECTIVES FOR PART I

- ❖ Understand how computer technologies can assist managers in their work
- ❖ Recognize the different types of decision support systems used in practice
- ❖ Understand the foundations of decision-making
- ❖ Understand the key issues in decision-making
- ❖ Understand how the World Wide Web/Internet has affected decision support systems
- ❖ Learn why computer technologies are necessary for modern decision-making

Management-support systems (MSS) are collections of computer technologies that support managerial work—essentially decision-making. MSS developments follow those of computer technologies, most recently the Internet and the World Wide Web. These technologies have had a profound impact on MSS in terms of their tools and their use. We highlight their effects throughout this text. In Part I, we cover two topics. Chapter 1 contains an overview of the text, including the rationale for the technologies and a brief description of each. In Chapter 2, we present the fundamentals of decision-making, including terminology and an overview of the decision-making process.

Note: Web site URLs are dynamic. As this book went to press, we verified that all the cited Web sites were active and valid. Web sites to which we refer in the text sometimes change or are discontinued because companies change names, are bought or sold, merge, or fail. Sometimes Web sites are down for maintenance, repair, or redesign. Most organizations have dropped the initial "www" designation for their sites, but some still use it. If you have a problem connecting to a Web site that we mention, please be patient and simply run a Web search to try to identify the possible new site. Most times, the new site can be quickly found. We apologize in advance for this inconvenience.

MANAGEMENT SUPPORT SYSTEMS: AN OVERVIEW

LEARNING OBJECTIVES

- .. Understand how computer technologies can assist managers in their work
- .. Learn the basic concepts of decision-making
- .. Learn the basic concepts of decision support systems
- .. Recognize the different types of decision support systems used in practice
- .. Recognize when a certain decision support system is applicable to a specific type of problem
- .. Understand how the World Wide Web/Internet has affected decision support systems

This book is about emerging and advanced computer technologies for supporting the solution of managerial problems. These technologies continually change how organizations are structured, reengineered, and managed. This introductory chapter provides an overview of the book and covers the following topics:

- 1.1 Opening Vignette: Harrah's Makes a Great Bet 1.2
- Managers and Decision-Making
- 1.3 Managerial Decision-Making and Information Systems 1.4
- Managers and Computer Support
- 1.5 Computerized Decision Support and the Supporting Technologies 1.6
- A Framework for Decision Support
- 1.7 The Concept of Decision Support Systems 1.8
- Group Support Systems
- 1.9 Enterprise Information Systems 1.10
- Knowledge Management Systems 1.11
- Expert Systems
- 1.12 Artificial Neural Networks
- 1.13 Advanced Intelligent Decision Support Systems 1.14
- Hybrid Support Systems
- 1.15 Plan of the Book

4.1 OPENING VIGNETTE: HARRAH'S MAKES A GREAT BET¹

THE PROBLEM

Gaming is highly competitive and profitable. Many people want to gamble, and every casino wants to attract their business. In the early 1990s, gambling on riverboats and Native American reservations was legalized. Major operators moved into these new markets. Between 1990 and 1997, Harrah's tripled its number of casinos. As the new markets grew more competitive, the business reached the point of diminishing returns. Harrah's early arrival was often usurped by newer, grander, more extravagant casinos nearby. Each Harrah's casino operated and marketed itself independently from the others. The managers of each property felt that they owned certain customers, and customers were treated differently at other Harrah's properties.

Customer service had not changed much since the 1970s. Casino managers had long recognized the importance of *building relationships* with their most profitable clientele. They reserved *star* treatment for the high-rollers, but only gave an occasional free drink to the folks playing machines. However, by the end of the 1980s, slot machines surpassed table games as the major casinos' largest source of income. In 1997, executives at Harrah's recognized that devising a means to keep their 25 million slot players loyal to Harrah's was the *key to profitability*.

THE SOLUTION

Harrah's approaches each new customer as a *long-term acquaintance*. The company analyzed gigabytes of customer data collected by player-tracking systems during the previous five years with data mining techniques. Executives found that the 30 percent of their customers who spent between \$100 and \$500 per visit accounted for 80 percent of company revenue and almost 100 percent of profits. These gamblers were typically locals who visited regional Harrah's properties frequently.

Harrah's developed a *Total Rewards Program*. It distributes *Harrah's Total Rewards Cards* to its customers, which they use to pay for slots, food, and rooms operated by the Harrah's, Players, Rio, and Showboat brands. The company uses magnetic strips on the cards to capture gaming information on every customer, and offers comps (free drinks, meals, hotel rooms, etc.) and other incentives based on the amount of money inserted into machines, not the amount won. The card tracks how long customers play, how much they bet, what games they prefer, and whether they win or lose. It creates a "profitability profile" that estimates a customer's value to the company. Harrah's publishes clear criteria for comping players free rooms and upgrades, and makes them accessible and redeemable.

Harrah's electronically linked all of its players clubs so that when gamblers at one location go to another, they can redeem their Reward points for free meals, rooms, or shows. Harrah's can actively market its casino "family" to Total Rewards Customers. The airlines have been doing this for years. Now Harrah's could establish close relationships with its most profitable customers and develop brand loyalty.

Harrah's system works as follows:

¹Adapted from I.A. Nickell, "Welcome to Harrah's," *Business 2.0*, April 2002; and C. Rosen, "Harrah's Bets on Loyalty Program," *InformationWeek*, October 30, 2000.

- *Magnetic card readers* on all its gaming machines read a customer ID number from each card and flash a personalized greeting with the customer's current tally • of Reward points.
- *Electronic gaming machines* are computerized and networked. Each machine captures transaction data and relays it to Harrah's mainframe servers.
- *Onsite transaction systems* at each casino property store all casino, hotel, and dining transaction data.
- *A national data warehouse* links the casinos' computer systems and customer data to a single server that tallies customer history and Reward points.
- *Predictive analysis software* programs produce nearly instantaneous customer profiles. The company can design and track marketing initiatives and their results.
- *A Web site* keeps customers informed, connected, and entertained.

The data warehouse, a large, specialized database, maintains demographic and spending-pattern data on all customers. Data mining techniques, also called business intelligence (business analytics, or analytical methods), are used to analyze the data and identify classes of profitable customers to target for future business at all properties. Together, these methods are combined into a customer relationship management (CRM) system, a decision support system (DSS) that helps managers make sales and marketing decisions- The Harrah's Web site links customer information, the brandloyalty program, the properties, specials, and other relevant data.

Data are collected at each property by transaction processing systems (TPS) and moved to a centralized data warehouse, where they are analyzed. Age and distance from the casino are critical predictors of frequency, coupled with the kind of game played and how many coins are played per game. For example, the *perfect player* is a 62-year-old woman who lives within 30 minutes of Kansas City, Missouri, and plays dollar video poker. Such customers typically have substantial disposable cash, plenty of time on their hands, and easy access to a Harrah's riverboat casino.

The system identifies high-value customers and places them in corresponding demographic segments (all told there are 90). Customers who live far away typically receive direct-mail discounts or comps on hotel rooms or transportation, while drive-in customers get food, entertainment, or cash incentives. Most offers have tight expiration dates to encourage visitors to either return sooner or switch from a competitor. For each direct-marketing pitch, the company tracks response rates and returns on investment, and adjusts its future campaigns according to the results.

THE RESULTS

Slots and other electronic gaming machines account for most of Harrah's \$3.7 billion in revenue and more than 80 percent of its operating profit. Largely on the strength of its new tracking and data mining system for slot players, Harrah's has recently emerged as the second-largest operator in the United States, with the highest threeyear investment return in the industry. The Total Rewards program has generated \$20 million in annual cost reductions by identifying unprofitable customers and treating them as such. In 2001, the Harrah's network linked more than 40,000 gaming machines

²The acronym *DSS* is treated as both singular and plural throughout this book. Similarly, other acronyms, such as *MIS* and *EIS*, designate both plural and singular forms.

in twelve states and created brand loyalty. In just the first two years of the Total Rewards program, revenue increased by \$100 million from customers who gambled at more than one Harrah's casino. Since 1998, each percentage-point increase in Harrah's share of its customers' overall gambling budgets has coincided with an additional \$125 million in shareholder value. The company's record earnings of \$3.7 billion in 2001 were up 11 percent from 2000. More than half of the revenue at Harrah's three Las Vegas casinos now comes from players the company already knows from its casinos outside of Nevada .

•. QUESTIONS FOR THE OPENING VIGNETTE

1. How did Harrah's end up with a major problem on its hands?
2. Why was it important to collect data on customers?
3. How do DSS technologies (data mining, data warehouse, customer resource management, etc.) help managers identify customer profiles and their profitability?
4. What was the impact of the Harrah's customer-loyalty program?
5. *Open-ended:* How could a retail store effectively develop methods and systems like those used by Harrah's to boost profitability and market share?

1.2 MANAGERS AND DECISION MAKING

The opening vignette illustrates how Harrah's developed and uses a computerized decision support system to maintain customer loyalty, expand its market, and crossmarket its properties. Harrah's was an underperformer in the market until the DSS was deployed. It is now an industry leader, operating successfully in an extremely competitive market. Some of the points demonstrated by this vignette are:

- The nature of the competition in the gaming industry makes it necessary to use computerized decision support tools to succeed and to survive.
- The company uses the World Wide Web extensively for its interface. Analysts, marketing specialists, and even customers can access the system directly through the World Wide Web.
- The system is based on data organized in a special data warehouse to allow easy processing and analysis.
- The major technologies used are data mining (business intelligence/business analytics) systems to identify profitable customer classes (analysis) and a customer-relationship management (CRM) system to market promotions, monitor sales, and identify problems and new opportunities. The data-mining methods may include regression analysis, neural networks, cluster analysis, and optimization approaches.
- The DSS is used in making a variety of marketing decisions, ranging from determining which customers are most profitable to how to promote the properties to all customers. Promotions can be made on a day-to-day basis.
- Decision support is based on a vast amount of internal and external data.
- The DSS analysis software applications are separate from the transaction processing system (TPS), yet they use much of the TPS data.
- Statistical and other quantitative models are used in the CRM.
- The managers are ultimately responsible for all decisions ..

Airlines, retail organizations, banks, service companies, and others have successfully used many of Harrah's methods. The vignette demonstrates that to run an effective business today in a competitive environment, real-time, targeted, computerized decision support is essential. This is the major theme of the book.

THE NATURE OF MANAGERS' WORK

To better understand the support information systems can give managers, it is useful to look at the nature of managers' work. Mintzberg's (1980) classic study of top managers and several replicated studies suggest that managers perform 10 major roles that can be classified into three major categories: interpersonal, information, and decisional (see Table 1.1).

To perform these roles, managers need information that is delivered, efficiently and in a timely manner, to personal computers on their desktops, to mobile computers, and even to computers embedded in PDAs (personal digital assistants) and cell telephones. This information is delivered by computers that function as servers, generally via Web technologies (Shim et al., 2002; see also Gregg, 2002; Hall, 2002; Hoch and Kunreuther, 2001; and Langseth and Vivatrat, 2002). In addition to obtaining information necessary to better perform their roles, managers use computers directly

TABLE 1.1 Mintzberg's 10 Management Roles

<i>Role</i>	<i>Description</i>
<i>Interpersonal</i>	
Figurehead	Symbolic head; obliged to perform a number of routine duties of a legal or social nature
Leader	Responsible for the motivation and activation of subordinates; responsible for staffing, training, and associated duties
Liaison	Maintains self-developed network of outside contacts and informers who provide favors and information
<i>Informational</i>	
Monitor	Seeks and receives a wide variety of special information (much of it current) to develop a thorough understanding of the organization and environment; emerges as the nerve center of the organization's internal and external information
Disseminator	Transmits information received from outsiders or from subordinates to members of the organization; some information factual, some involving interpretation and integration
Spokesperson	Transmits information to outsiders on the organization's plans, policies, actions, results, and so forth; serves as an expert on the organization's industry
<i>Decisional</i>	
Entrepreneur	Seeks out opportunities for the organization and its environment for opportunities and initiates improvement projects to bring about change; supervises design of certain projects
Disturbance handler	Responsible for corrective action when the organization faces important, unexpected disturbances
Resource allocator	Responsible for the allocation of organizational resources of all kinds-in effect the making or approving of all significant organizational decisions
Negotiator	Responsible for representing the organization at major negotiations

Source: Adapted from Mintzberg (1980) and Mintzberg (1993).

to support and improve decision-making, a key task that is part of most of these roles.

1.3 MANAGERIAL DECISION-MAKING AND INFORMATION SYSTEMS

We begin by examining the two important topics of managerial decision-making and information systems.

Management is a process by which organizational goals are achieved using resources. The resources are considered inputs, and attainment of goals is viewed as the output of the process. The degree of success of the organization and the manager's job is often measured by the ratio of outputs to inputs. This ratio is an indication of the organization's **productivity**.

Productivity is a major concern for any organization because it determines the well-being of the organization and its members. Productivity is also a very important issue at the national level. National productivity is the aggregate of the productivity of all the people and organizations in the country, and it determines the country's standard of living, employment level, and economic health. The level of productivity, or the success of management, depends on the performance of managerial functions, such as planning, organizing, directing, and controlling. In addition, the Web improves productivity by providing, among other things, data, environmental scanning, and portals that lead to better decisions, and thus, increased productivity. To perform their functions, managers are engaged in a continuous process of making decisions.

All managerial activities revolve around decision-making. *The manager is primarily a decision-maker* (see DSS in Focus 1.1). Organizations are filled with decisionmakers at various levels.

For years, managers considered decision-making purely an art—a talent acquired over a long period through experience (learning by trial and error). Management was

DSS IN FOCUS 1.1

DECISION-MAKING ABILITY RATED FIRST IN SURVEY **U-4**

In almost any survey of what constitutes good management, the ability to make clear-cut decisions when needed is prominently mentioned. It is not surprising, therefore, to learn that the ability to make crisp decisions was rated first in importance in a study of 6,500 managers in more than 100 companies, many of them large blue-chip corporations.

Managers starting a training course at Harbridge House, a Boston-based firm, were asked how important it was for managers to follow certain managerial practices. They also were asked how well, in their estimation, managers performed these practices.

From a statistical distillation of these answers, Harbridge ranked making clear-cut decisions when needed as the most important of 10 managerial practices. Unfortunately, the respondents concluded that only 20 percent of the managers performed well on this.

Ranked second in managerial importance was getting to the heart of problems rather than dealing with less important issues, a finding that shows up in similar studies. Most of the remaining eight management practices were related directly or indirectly to decision-making.

This situation is timeless. See any recent survey in *CIO*, *Datamation*, or *Information Week*.

considered an art because a variety of individual styles could be used in approaching and successfully solving the same types of managerial problems. These styles were often based on creativity, judgment, intuition, and experience rather than on systematic quantitative methods grounded in a scientific approach.

However, the environment in which management operates changes rapidly. Business and its environment are growing more complex every day. Figure 1.1 shows the changes in major factors that affect managerial decision-making. As a result, decision-making today is more complicated. It is more difficult to make decisions for several reasons. First, the number of available alternatives is much larger than ever before because of improved technology and communication systems, especially the Web/Internet and its search engines. As more data and information become available, more alternatives can be identified and explored. Despite the speed at which data and information can be accessed, the decision-making alternatives must be analyzed. This takes (human-scale = slow). time and thought. Despite having more and better information than ever before, time pressure prevents decision-makers from gathering all that they need and from sharing it (Hoch et al., 2001; Tobia, 2000). Second, the cost of making errors can be large because of the complexity and magnitude of operations, automation, and the chain reaction that an error can cause in many parts of the organization. Third, there are continuous changes in the fluctuating environment and more uncertainty in several impacting elements. Finally, decisions must be made quickly to respond to the market. Advances in technology, notably the Web, have dramatically increased the speed at which we obtain information and the expected speed at which we make our decisions. There is an expectation that we can respond instantly to changes in the environment.

Because of these trends and changes, it is nearly impossible to rely on a trial-and-error approach to management, especially for decisions involving the factors shown in Figure 1.1. Managers must be more sophisticated: They must use the new tools and techniques of their fields. Some of these tools and techniques are the subject of this book. Using them to support decision-making can be extremely rewarding in making effective decisions (Vitt et al., 2002). For an example of Web-based technology creating effective decision-making by Imperial Sugar's customers and vendors, see DSS in Action 1.2.

FIGURE 1.1 FACTORS AFFECTING DECISION MAKING

Factor	Trend	Results
Technology	Increasing	More alternatives to choose from
Information/computers	Increasing	
Structural complexity	Increasing	Larger cost of making errors
Competition	Increasing	
International markets	Increasing	More uncertainty regarding the future
Political stability	Decreasing	
Consumerism	Increasing	
Government intervention	Increasing	Need for quick decisions
Changes, fluctuations	Increasing	

DSS IN ACTION 1.2

IMPERIAL SUGAR SWEETENS THE
DEAL WITH WEB SERVICES

Imperial Sugar (based in Sugarland, Texas) is the largest sugar refiner in the United States (\$1.6 billion in sales in 2001). Nevertheless, the company was in the red in 2000 and 2001, with losses totaling more than \$372 million. At the start of 2001, sugar prices collapsed, leading Imperial Sugar to file for bankruptcy protection. As a major part of Imperial's recovery program, CEO George Muller decided to use technology to improve the company's situation. His first effort involved integrating Imperial directly into its customers' supply chains by giving them direct access to order-status information on their orders via the Web. This would result in lower selling costs, and in consequence Imperial hoped to obtain a bigger share of its customers' business. The system would change the mostly personal relationships between Imperial's 20 customer service representatives and 40 large customers and brokers, representing more than 800 different customer offices. Decision-making at the company and for its customers would never be the same. In a commodity-based business, adding value is the only thing that differentiates one firm from another. This system added value!

The cost of the XML-based project was well less than \$500,000. Just as Imperial emerged from bank-

ruptcy in August, the self-service application was rolled out. Before the self-service system, a customer service representative might spend as many as five hours per day on the phone handling customer inquiries. Now, the time spent on status inquiries dropped to two hours or less. By halving the phone workload, Imperial nearly doubled its effective salesforce (in person-hours)-and its customer service representatives were able to take a more consultative approach to sales. Online order tracking gives customers 24-hour access to information about coming shipments, helping them to plan their production better.

Following system deployment, the company generated its first operating profit in six quarters: \$669,000 on net sales of \$322.3 million. In the long term, Imperial plans to do *collaborative forecasting of demand* with its customers to lower its inventory costs. By making the purchasing process easier, Imperial also plans to *analyze its customers' needs* to boost overall revenue, thus creating an effective revenue-management system. Finally, customers can order directly over the Web.

Source: Adapted from S. Gallagher, "Imperial Sugar Rebuilds on Web Services," *Baseline*, March 18, 2002.

1.4 MANAGERS AND COMPUTER SUPPORT

The impact of computer technology on organizations and society is increasing as new technologies evolve and current technologies expand. More and more aspects of organizational activities are characterized by interaction and cooperation between people and machines. From traditional uses in payroll and bookkeeping functions, computerized systems are now penetrating complex managerial areas ranging from the design and management of automated factories to the application of artificial intelligence methods to the evaluation of proposed mergers and acquisitions. Nearly all executives know that information technology is vital to their business and extensively use technologies, especially Web-based technologies.

Computer applications have moved from transaction processing and monitoring activities to problem analysis and solution applications, where much of the activity is handled over the Web (see Geoffrion and Krishnan, 2001). Topics such as data warehousing, data mining, online analytical processing, and the use of the Web via the Internet, intranets and extranets for decision support are the cornerstones of high-tech modern management at the start of the twenty-first century. Managers must have highspeed, networked information systems to assist them directly with their most important task: making decisions (see Hoch, 2001).

1.5 COMPUTERIZED DECISION SUPPORT AND THE SUPPORTING TECHNOLOGIES

A computerized decision support system may be needed for various reasons. For example:

- *Speedy computations.* A computer lets the decision-maker perform many computations quickly and at a low cost. Timely decisions are critical for many situations, ranging from a physician in an emergency room to a stock trader on the trading floor.
- *Improved communication.* Groups can collaborate and communicate readily with Web-based tools. Collaboration is especially important along the supply chain, where customers all the way through to vendors must share information.
- *Increased productivity.* Assembling a group of decision-makers, especially experts, may be costly. Computerized support can reduce the size of the group and enable its members to be at different locations (saving travel costs). In addition, the productivity of staff support (such as financial and legal analysts) may be increased. Productivity may also be increased by using optimization tools that determine the best way to run a business. See the! Chapter 4 Case Applications; Sodhi, 2001; Keskinocak and Tayur, 2001, Geoffrion and Krishnan, 2001; Warren et al., 2002.
- *Technical support.* Many decisions involve complex computations. Data can be stored in different databases and at Web sites anywhere in the organization and even possibly outside the organization. The data may include text, sound, graphics, and video. It may be necessary to transmit them quickly from distant locations. Computers can search, store, and transmit needed data quickly, economically, and transparently.
- *Data warehouse access.* Large data warehouses, like the one operated by WalMart, contain petabytes of data. Special methods, and sometimes parallel computing, are needed to organize and search the data.
- *Quality support.* Computers can improve the *quality* of the decisions made. For example, more data can be accessed, more alternatives can be evaluated, risk analysis can be performed quickly, and the views of experts (some of whom are in remote locations) can be collected quickly and at a lower cost. Expertise can even be derived directly from a computer system through artificial intelligence methods. With computers, decision-makers can perform complex simulations, check many possible scenarios, and assess diverse impacts quickly and economically (see Saltzman and Mehrotra, 2001). All these capabilities lead to better decisions.
- *Competitive edge: enterprise resource management and empowerment.* Competitive pressures make the job of decision-making difficult. Competition is based not just on price but on quality, timeliness, customization of products, and customer support. Organizations must be able to frequently and rapidly change their mode of operation, reengineer processes and structures, empower employees, and innovate. Decision-support technologies such as expert systems can create meaningful empowerment by allowing people to make good decisions quickly, even if they lack some knowledge. **Enterprise resource management (ERM)** systems are a type of decision support system that describes an entire organization, and help manage it. Finally, optimizing the supply chain requires special tools (see Keskinocak and Tayur, 2001; and Sodhi, 2001).
- *Overcoming cognitive limits in processing and storage.* According to Simon (1977), the human mind has only a limited ability to process and store information.

People may sometimes find it difficult to recall and use information in an errorfree fashion.

Most decision-support methods provide for quick data queries and use models to convert the data into usable information for consideration by a decision-maker. For example, data can be fed into a forecasting model where they are converted into a forecast. The resulting forecast may be used as information for decision-making. It may be further converted by another model, thereby providing additional information for decision-making.

COGNITIVE LIMITS

The term **cognitive limits** indicates that an individual's problem-solving capability is limited when a wide range of diverse information and knowledge is required. Pooling several individuals may help, but problems of coordination and communication may arise in workgroups. Computerized systems enable people to quickly access and process vast amounts of stored information. Computers can also improve coordination and communication for group work, as is done in **group support systems (GSS)**, **knowledge management systems (KMS)**, and several types of **enterprise information systems (EIS)**. The Web has contributed both to this problem and to its solution. For example, many of us are hit daily with a barrage of e-mail. Intelligent agents (a type of artificial intelligence) as part of an e-mail client system can effectively filter out the undesired e-mail messages.

DECISION SUPPORT TECHNOLOGIES

Decision support can be provided by one or more decision support-technologies. The major decision support technologies are listed in DSS in Focus 1.3 together with the relevant chapter in this book. They are described briefly in this chapter. Related decision support technologies are described on the book's Web site (prenhall.com/turban) in Web Chapters. Which of these technologies should be used depends on the nature of the problem and the specific decision support configuration.

In this text, the term **management support system (MSS)** refers to the application of any technology, either as an independent tool or in combination with other information technologies, to support management tasks in general and decision-making in particular. This term may be used interchangeably with decision support system (DSS) and business intelligence (BI) system.



Before describing specific management support technologies, we present a classic framework for decision support. This framework provides several major concepts that will be used in forthcoming definitions. It also helps to cover several additional issues, such as the relationship between the technologies and the evolution of computerized systems. Gerry and Scott Morton (1971), who combined the work of Simon (1977) and Anthony (1965), proposed this framework, shown as Figure 1.2.

1.6 A FRAMEWORK FOR DECISION SUPPORT

DSS IN FOCUS 1.3**MANAGEMENT SUPPORT
SYSTEM TECHNOLOGIES (TOOLS)**

- Decision support systems (DSS) (Chapter 3)
- Management science (MS)/operations research (OR) models and techniques (Chapter 4)
- Business analytics (Chapter 4)
- Data mining (Chapter 5)
- Data warehousing (Chapter 5)
- Business intelligence (Chapter 5)
- Online analytical processing (OLAP) (Chapter 5)
- Computer-assisted systems engineering (CASE) tools (Chapter 6)
- Group support systems (GSS)/collaborative computing (Chapter 7)
- Enterprise information systems (EIS) and enterprise information portals (EIP) (Chapter 8)
- Enterprise resource management (ERM)/enterprise resource planning (ERP) systems (Chapter 8)
- Customer resource management (CRM) systems (Chapter 8)
- Supply-chain management (SCM) (Chapter 8)
- Knowledge management systems (KMS) and knowledge management portals (KMP) (Chapter 9)
- Expert systems (ES) (Chapters 10 and 11)
- Artificial neural networks (ANN), genetic algorithms, fuzzy logic, and hybrid intelligent support systems (Chapter 12)
- Intelligent systems over the Internet (intelligent agents) (Chapter 13)
- Electronic Commerce DSS (Chapter 14)

The left side of Figure 1.2 is based on Simon's idea that decision-making processes fall along a continuum that ranges from highly structured (sometimes called *programmed*) to highly unstructured (*nonprogrammed*) decisions. Structured processes are routine, and typically repetitive problems for which standard solution methods exist. Unstructured processes are fuzzy, complex problems for which there are no cut-and-dried solution methods. Simon also describes the decision-making process with a three-phase process of intelligence, design, and choice (see Chapter 2).

***Intelligence:* searching for conditions that call for decisions**

***Design:* inventing, developing, and analyzing possible courses of action**

***Choice:* selecting a course of action from those available**

An *unstructured problem* is one in which none of these three phases is structured. Decisions in which some but not all of the phases are structured are called semistructured by Gorry and Scott Morton.

In a *structured problem*, the procedures for obtaining the best (or at least a good enough) solution are known. Whether the problem involves finding an appropriate inventory level or choosing an optimal investment strategy, the objectives are clearly defined. Common objectives are cost minimization and profit maximization. The manager can use the support of clerical, data processing, or management science models. Management support systems such as DSS and expert systems can be useful at times. In an *unstructured problem*, human intuition is often the basis for decision-making. Typical unstructured problems include planning new services, hiring an executive, and choosing a set of research and development projects for the next year. Only part of an unstructured problem can be supported by advanced decision support tools, such as expert systems (ES), group support systems (GSS), and knowledge management systems (KMS). Gathering information via the Web is helpful in solving unstructured problems. *Semistructured problems* fall between structured and unstructured prob-

Type of Decision	Type of Control			Technology Support Needed
	Operational Control	Managerial Control	Strategic Planning	
Structured	Accounts receivable, account payable, order entry	1 Budget analysis, short-term forecasting, personnel reports, make-or-buy	2 Financial management (investment), warehouse location, distribution systems	3 Management information system, management science models, transaction processing
Semistructured	Production scheduling, inventory control	4 Credit evaluation, budget preparation, plant layout, project scheduling, reward system design, inventory categorization	5 Building new plant, mergers and acquisitions, new product planning, compensation planning, quality assurance planning, HR policies, inventory planning	6 DSS, KMS, GSS, CRM, SCM
Unstructured	7 Selecting a cover for a magazine, buying software, approving loans, help desk	8 Negotiating, recruiting an executive, buying hardware, lobbying	R&D planning, new technology development, social responsibility planning	9 GSS, KMS, ES, neural networks
Technology Support Needed	Management information system, management science	Management science, DSS, ES, EIS, SCM, CRM, GSS, SCM	GSS, CRM, EIS, ES, neural networks, KMS	

FIGURE 1.2 DECISION SUPPORT FRAMEWORKS

blems, having some structured elements and some unstructured elements. Solving them involves a combination of both standard solution procedures and human judgment. Keen and Scott Morton (1978) mention trading bonds, setting marketing budgets for consumer products, and performing capital acquisition analysis as semistructured problems. DSS provides models for the portion of the decision-making problem that is structured. For these, a DSS can improve the quality of the information on which the decision is based by providing not only a single solution but also a range of alternative solutions along with their potential impacts. These capabilities help managers to better understand the nature of problems and thus to make better decisions.

The second half of this framework (Figure 1.2, top) is based on Anthony's (1965) taxonomy, which defines three broad categories that encompass all managerial activities: *strategic planning*, defining long-range goals and policies for resource allocation; *management control*, the acquisition and efficient use of resources in the accomplishment of organizational goals; and *operational control*, the efficient and effective execution of specific tasks.

Anthony and Simon's taxonomies are combined in the nine-cell decision support framework shown in Figure 1.2. The right-hand column and the bottom row indicate

the technologies needed to support the various decisions. Gorry and Scott Morton suggested, for example, that for semistructured decisions and unstructured decisions, conventional management information systems (MIS) and management science (MS) approaches are insufficient. Human intellect and a different approach to computer technologies are necessary. They proposed the use of a supportive information system, which they called a decision support system (DSS).

The more structured and operational control-oriented tasks (cells 1,2, and 4) are performed by low-level managers, whereas the tasks in cells 6,8, and 9 are the responsibility of top executives or highly trained specialists. This means that KMS, neural computing, and ES are more often applicable for people tackling specialized, complex problems.

The Gorry and Scott Morton framework classifies problems and helps us select appropriate tools. However, there are times when a structured approach may help in solving unstructured tasks, and vice versa. In addition, combinations of tools may be used.

COMPUTER SUPPORT FOR STRUCTURED DECISIONS

Structured and some semistructured decisions, especially of the operational and managerial control type, have been supported by computers since the 1960s. Decisions of this type are made in all functional areas, especially in finance and production (operations management).

Such problems, which are encountered often, have a high level of structure. It is therefore possible to abstract and analyze them and classify them into specific classical problem types. For example, a make-or-buy decision belongs in this category. Other examples are capital budgeting, allocation of resources, distribution problems, procurement, planning, and inventory control. For each type of problem, an easy-to-apply prescribed model and solution approach have been developed, generally as quantitative formulas. This approach is called management science (MS) or operations research (OR).

MANAGEMENT SCIENCE

The management science approach adopts the view that managers follow a systematic process in solving problems. Therefore, it is possible to use a scientific approach to automate portions of managerial decision-making. The systematic process involves the following steps:

1. Defining the problem (a decision situation that may deal with some difficulty or with an opportunity).
2. Classifying the problem into a standard category.
3. Constructing a mathematical model that describes the real-world problem.
4. Finding possible solutions to the modeled problem and evaluating them.
5. Choosing and recommending a solution to the problem.

The management science process is based on mathematical modeling (algebraic expressions that describe the problem). Modeling involves transforming the real-world problem into an appropriate prototype structure (model). There are computerized methodologies that find solutions to this model quickly and efficiently. Some of these are deployed directly over the Web (e.g., Fourer and Goux, 2001). Less structured problems can be handled only by a DSS that includes customized modeling capabilities. For example, in a bookstore, the given annual demand for a particular kind of book implies that a standard inventory management model could be used to determine the number of books to order, but human judgment is necessary to predict demand and order quantities that vary over time for blockbuster authors, such as John Grisham and Stephen King.

Since the development of the Internet and World Wide Web servers and tools, there have been dramatic changes in how decision-makers are supported. Most importantly, the Web provides (1) access to a vast body of data available around the world, and (2) a common, user-friendly graphical user interface (GUI), which is easy to learn and use and readily available. At the structured operational level (1), these are the most critical Web impacts. As enhanced collaboration becomes more important, we find the inclusion of enterprise systems that include **supply chain management**, customer relationship management, and knowledge management systems.

1.7 THE CONCEPT OF DECISION SUPPORT SYSTEMS

In the early 1970s, Scott Morton first articulated the major concepts of DSS. He defined DSS as "interactive computer-based systems, which help decision-makers utilize data and models to solve unstructured problems" (Gorry and Scott Morton, 1971). Another classic DSS definition, provided by Keen and Scott Morton (1978), is:

Decision support systems couple the intellectual resources of individuals with the capabilities of the computer to improve the quality of decisions. It is a computer-based support system for management decision makers who deal with semistructured problems.

Note that the term decision support system, like management information system and other terms in the field of Management support systems (MSS), is a content-free expression; that is, it means different things to different people. Therefore, *there is no universally accepted definition of DSS*. We present the major definitions in Chapter 3.

DSS AS AN UMBRELLA TERM

DSS is used by some as a specific tool. The term DSS is also sometimes used as an umbrella term to describe any computerized system that supports decision-making in an organization. An organization may have a knowledge management system to guide all its personnel in their problem-solving, it may have separate DSS for marketing, finance, and accounting, a supply chain management (SCM) system for production, and several expert systems for product repair diagnostics and help desks. DSS encompasses them all. In contrast, a narrow definition refers to a specific technology (see Chapter 3).

DSS in Action 1.4 demonstrates some of the major characteristics of a decision support system. The initial risk analysis was based on the decision-maker's definition of the situation using a management science approach. Then the executive vice president, using his experience, judgment, and intuition, felt that the model should be scrutinized. The initial model, although mathematically correct, was incomplete. With a regular simulation system, a modification would have taken a long time, but the DSS provided a quick analysis. Furthermore, the DSS was flexible and responsive enough to allow managerial intuition and judgment to be incorporated into the analysis. A similar incident occurred at American Airlines in the 1980s. Through a detailed and complex analysis, analysts determined that the airline could save hundreds of millions of dollars

DSS IN ACTION 1.4**THE HOUSTON MINERALS CASE**

Houston Minerals Corporation was interested in a proposed joint venture with a petrochemical company to develop a chemical plant. Houston's executive vice president responsible for the decision wanted an analysis of the risks involved in the areas of supplies, demands, and prices. Bob Sampson, manager of planning and administration, and his staff built a DSS in a few days by means of a specialized planning language. The results strongly suggested that the project should be accepted.

Then came the real test. Although the executive vice president accepted the validity and value of the results, he was worried about the project's downside risk: the chance of a catastrophic outcome. As Sampson tells it, he

said something like this: "I know how much work you have already done, and I am ninety-nine percent confident with it. However, I would like to see this in a different light. I know we are short of time, and we have to get back to our partners with our yes or no decision."

Sampson replied that the executive could have the risk analysis he needed in less than an hour. He continued. "Within twenty minutes, there in the executive boardroom, we were reviewing the results of his what-if? questions. The results led to the eventual dismissal of the project, which we otherwise would probably have accepted."

Source: Based on information provided by Comshare, Inc.

annually in fuel costs by using altitude profiles. An airplane could ascend optimally to its cruising altitude as a function of meteorological conditions, its route, and other traffic. A second analysis requested by the CEO confirmed that the initial analysis was indeed correct. The CEO felt more comfortable about the solution to this fuzzy problem. However, in this case the delay in implementing the decision cost the airline several million dollars.

How can a thorough risk analysis like the one in DSS in Action 1.4 be performed so quickly? How can the judgment factors be elicited, quantified, and worked into a model? How can the results be presented meaningfully and convincingly to the executive? What are "what-if" questions? How can the Web be used to access appropriate data and models, and integrate them? We provide answers to these questions throughout this book.

WHY USE A DSS?

Surveys have identified the many reasons why major corporations have developed large-scale decision support systems. These include:

Companies work in an unstable or rapidly changing economy. There are difficulties in tracking the numerous business operations. Competition has increased.

Electronic commerce.

Existing systems do not support decision-making.

The Information systems department is too busy and cannot address all management inquiries.

Special analysis of profitability and efficiency is needed.

Accurate information is needed.

DSS is viewed as an organizational winner.

New information is needed.

Management mandates a DSS.
Higher decision quality.
Improved communication.
Improved customer and employee satisfaction.
Timely information is provided.
Cost reduction is achieved (cost and timesaving, increased productivity).

Another reason for DSS development is the high level of computer and Web literacy among managers. Most end-users are not programmers, so they need easy-to-use development tools and procedures. They need access to data in an understandable format and the ability to manipulate them in meaningful ways. These are provided by Web-based DSS.

In the early days of DSS, managers did not depend on numbers. Many managers preferred to manage by intuition. As time went by, managers did indeed use MIS-generated reports, but the gut feel of what was right was what was important in solving a problem. As PC technology advanced, a new generation of managers evolved—one that was comfortable with computing and knew that the technology helped them make intelligent business decisions faster. During the 1990s, the business intelligence technologies industry grew steadily, with revenues reaching into the low billions, according to an IDC report from the period. Now, new tools like online analytical processing, data warehousing, data mining, enterprise information systems, and knowledge management systems, delivered via Web technology, promise managers easy access to tools, models, and data for decision-making. These tools are also described under the names

DSS IN ACTION 1.5

HELPING ATLANTIC ELECTRIC COMPANY SURVIVE IN THE FREE MARKETPLACE



Atlantic Electric Company of New Jersey was losing the monopoly it once held. Some of its old clients were already buying electricity from a new, unregulated type of competitor: an independent co-generator that generated its own electricity and sold its additional capacity to other companies at low prices. The competitor found easy-to-serve commercial accounts. Atlantic Electric Company was even in danger of losing its residential customer base because the local regulatory commission was about to rule that these customers would be better served by another utility.

To survive, the company had to become the least expensive provider in its territory. One way to do this was to provide employees with the information they needed to make more up-to-date and accurate business decisions. The old information technology included a mainframe and a corporate network for mainframe access. However, this system was unable to meet the new challenge. It was necessary to develop user appli-

cations, in a familiar format, and to do it rapidly with minimum cost. This required a PC-based decision support system that currently runs on the corporate intranet.

Some of the applications developed include

- A DSS for fuel-purchasing decisions
- A DSS for customized rates, based on a database for customers and their electricity usage pattern
- A DSS for substation design and transmission
- A cash-management DSS for the finance department

The implementation of these and other DSS applications helped the company to survive and successfully compete in its field. By 2000, the company had deployed the DSS applications on its intranet, an internal Internet-based system that includes Web servers and uses Web browsers for access (see atlanticelectric.com).

of business intelligence and business analytics. See Hapgood (2001) for details. See also . Cohen et al. (2001), Hoch et al. (2001), Powers (2002), and Vitt et al. (2002).

The overall results of using a DSS can be impressive, as indicated by the Atlantic Electric Company case (see DSS in Action 1.5).

We next describe some of the most important DSS technologies. In Table 1.2, we describe how the World Wide Web has affected important DSS technologies, and vice versa. In most cases, the communications capabilities of the Internet/Web have affected managers' practices in terms of accessing data and files, and of communicating with one other. The Web readily permits collaboration through communication. Data (including text, graphics, video clips, etc.) are stored on Web servers or legacy (older mainframe) systems that deliver data to the Web server and then to the client Web browser. The Web browser and its associated technologies and scripting languages have raised the bar in terms of processing on the client side, and presenting information to the user. High-resolution graphics through a powerful GUI is the norm for how we interact with computer systems.



1.8 GROUP SUPPORT SYSTEMS

Groups make many major decisions in organizations. Getting a group together in one place and at one time can be difficult and expensive. Furthermore, traditional meetings can last a long time, and any resulting decisions may be mediocre.

Attempts to improve the work of groups with the aid of information technology have been described as collaborative computing systems, groupware, electronic meeting systems, and GSS (see DSS in Action 1.6). Most groupware currently runs over the Web and provides both videoconferencing and audio conferencing, in addition to meeting-tools like electronic brainstorming, voting, and document sharirig. Groupware includes Groupsystems, Groove, PlaceWare, WebEx. NetMeeting, and even distance learning courseware tools, such as Blackboard.



1.9 ENTERPRISE INFORMATION SYSTEMS

Enterprise information systems (EIS) evolved from executive information systems combined with Web technologies. Enterprise information *portals* are now utilized to view information that spans the entire organization. Enterprise information systems give access to relevant enterprise-wide information that individuals need to perform their tasks.

- Provide an organizational view of operations
- Provide an extremely user-friendly interface through portals, sometimes compatible with individual decision styles
- Provide timely and effective corporate level tracking and control
- Provide quick access to detailed information behind text, numbers, or graphics through *drill-down*
- Filter, compress, and track critical data and information
- Identify problems (opportunities).

TABLE 1.2 MSS Technologies and the Web

<i>MSS Technology</i>	<i>Web Impact</i>	<i>Improved, Universal</i>	<i>Effect on the Web</i>
Database Management Systems (DBMS) and Management Information Systems (MIS)	Graphical User Interfaces (GUI) Quick Access to Data Anywhere, Anytime, In Many Formats Improved Communication of Data and Results Access and interface		Database Web servers provide information directly rather than accessing data stored on legacy systems Database organization helps in Web database design and development
Model-base management systems (MBMS) and models (business analytics)	Models and solution methods easily distributed Java applets of optimization and simulation code Access to information about models and solution methods Improved data access and interface		Better network design through optimization and simulation Improved network infrastructure design Optimal message routing Improved integrated circuit and circuit board design
Revenue management	Improved data gathering More accurate, advanced economic and forecasting models and data Improved data access and interface		Accurate, dynamic pricing of Web services and software
Online analytical processing (OLAP)/ Business intelligence (BI)	Better access to solution and visualization tools Better communication-can utilize parallel processing Improved data access and interface		Analysis of network design and loads on Web sites-more effective Web sites
Data mining (BI) (includes models)	Better access to solution tools Better communication-can utilize parallel processing Improved data access and interface		Identify relationships among customers and other factors that indicate loads on Web sites-more effective Web sites
Data warehousing	Improved data access and interface		Need to handle large amounts of data, graphs, charts, etc.
Geographic information systems (GIS)	Improved data access and interface Improved communication Improved visualization Improved data access and interface and data		Accurate geographic data leads to more effective network design and efficient message passing
Systems development tools and methods: Computer-aided systems engineering (CASE)			Design of Web applications follows a defined path Diagrams and methodologies are applied to network, database and server design and development
Group support systems (GSS)	Provides access to data, information, and models Enables communication and collaboration		Older systems via telephone and LANs indicated how the Web could provide these capabilities Collaborative network and e-commerce site design Access to experts on e-commerce
Enterprise information systems (EIS)/ Enterprise information portals	Access to relevant information in many formats Web browsers provide GUIs that appeal to executives with drill-down capability Communication capabilities with others in the organization		Intranet structuring Financial decisions regarding the Web's design, equipment, and use Identification of strategic Web use

(continued)

TABLE 1.2 MSS Technologies and the Web (continued)

<i>MSS Technology</i>	<i>Web Impact</i>	<i>Effect on the Web Used</i>
Enterprise resource planning (ERP)/ Enterprise resource management (ERM)	Access to data and the interface enabled their expansion	bye-commerce firms for operations
Customer relationship (resource) management (CRM)	Access to data and the interface Enabled their development and expansion	Increased load due to customer reach Provides new products and technologies that customers want
Supply chain management (SCM)	Improved communication and collaboration along the supply chain Web tools have become embedded in SCM	Improved production of Web hardware and software Improved communication of problems from customers to vendors helps in identifying problems with the Web
Knowledge management systems (KMS)	Access to optimization tools Provides the communication, collaboration, and storage technologies-anytime, anywhere Access to legacy systems Provides collaboration needed for knowledge gathering Provides improved access to a	Designers and developers can access and share knowledge and information about Web infrastructure for improvements
Executive information systems (EIS)	information in a variety of formats Improved, standardized G UI Drill-down into legacy systems and Web database servers	In the late 1970s, EIS already incorporated user-seductive GUI interfaces, and access to information in a variety of formats EIS also incorporated a client/server architecture-adopted by Web systems Showed what computers were capable of , These capabilities were eventually incorporated into all Web-based systems
Expert systems (ES)	Improved interface and access to knowledge Access to experts Deployable applets for system development and deployment Deployable applets for system development and deployment	Provides expertise in network and circuit design and troubleshooting
Artificial neural networks (ANN)	Deployable applets for system development and deployment	Detects credit card and other fraud in e-commerce
Genetic algorithms (GA)	Deployable applets for system development and deployment	Identifies Web use patterns
Fuzzy logic (FL)	Deployable applets for system development and deployment	Solves dynamic message routing and design problems
Intelligent agents (IA)	Enables them to travel and run on different sites, especially enabling automatic negotiations	Solves dynamic message routing and design problems
Electronic commerce (<u>e-commerce</u>)	Enabled by the Web	Enables intelligent Web search engines, efficient message passing Web products and services

Notes: Some technologies listed are not strictly MSS technologies, but they are used by decision-makers. All technologies have improved user interfaces and transparent or at least easier access to data.

This table contains a sample of impacts.

DSS IN ACTION 1.6

GROUPSYSTEMS ENHANCE TRAINING OF THE
HONG KONG POLICE FORCE (HKPF)

THE PROBLEM

The HKPF runs management skills training courses for its police officers. These involve deliberation of topics central to police work, with officers expected to reach a decision and develop an action plan. The police have traditionally used face-to-face discussion and "butcher paper" for these sessions but found that discussions lacked depth and that a minority of "loud" officers dominated many sessions.

THE SOLUTION

The course director (a senior officer), turned to GroupSystems software (Groupsystems.com, Tucson, Arizona) to enhance the quality of the training provided. Officers, in groups of five to eight, brainstormed issues online before voting on key solution components and developing action plans. Topics include the repatriation of Vietnamese migrants and combating CD-ROM piracy. The course director used GroupSystems to inject his own contributions into the discussions as they were in progress, modifying the problem context and increas-

ing the realism of the material. Officers were expected to incorporate these new challenges on the fly.

THE RESULTS

The officers, despite their lack of familiarity with GroupSystems, expressed general approval of the software, believing that their learning experience had been significantly enhanced and that their skills in eliciting and discussing critical issues had been developed remarkably. The course director was similarly satisfied, acknowledging that more had been accomplished than would normally be possible given session constraints. No officer rated the sessions negatively, even though some admitted their computer phobia and inability to type effectively. All used the system to contribute valuable ideas, and the dominance of individual officers was much reduced. These positive impacts occur routinely, as is evident from success stories on groupware vendor Web sites.

Source: Contributed by Robert Davison, City University of Hong Kong (Jan. 2000). Used with permission.

In DSS in Action 1.7, we describe how Cisco's sales department uses its enterprise information system, which hooks into its supply chain management system, to alert managers about possible problems as they occur in real time.

There are several important specialized enterprise information systems. These include **enterprise resource management (ERM)** systems/enterprise **resource planning (ERP)** systems, customer relationship management (CRM) systems, and supply chain management (SCM) systems.

Strong global competition drives companies to find ways to reduce costs, improve customer service, and increase productivity. One area where substantial savings are realized is the streamlining of the various activities conducted along the supply chain, both inside a company and throughout the extended supply chain that includes its suppliers, business partners, and customers (e.g., Sodhi, 2001; Sodhi and Aichlmayr, 2001). Using various information technologies and decision support methodologies, companies attempt to integrate as many information support systems as possible. Two major concepts are involved. First, **enterprise resource planning (ERP)** (also called enterprise resource management) tries to integrate, within one organization, repetitive transaction processing systems, such as ordering, producing, packaging, costing, delivery, and billing. Such integration involves many decisions that can be facilitated by DSS or provide a fertile ground for DSS applications. Second, supply chain management (SCM) attempts to improve tasks within the various segments of the supply chain, such as manufacturing and human resource management, as well as along the entire extended chain. The previously described decision support tools can enhance SCM, especially management science

DSS IN ACTION 1.7**CISCO'S ENTERPRISE INFORMATION SYSTEM /
PORTAL: A DIGITAL DASHBOARD DRIVES THE COMPANY'**

Ideally, everyone in an organization should have access to the real-time information that is needed for decision-making. At Cisco, "The whole corporation is moving to real time," says Mike Zill, director of sales and finance information technology. "It's difficult to have the applications stay in batch when the architecture is message-based."

Sales department managers use a Web-based "dashboard," or enterprise information portal (a graphical user-interface-based view), from One Channel Inc. (Mountain View, California). The dashboard gives them real-time views of their accounts' activities. Just as a red light appears on a car's dashboard when there is a problem, the software triggers an alert when a business condition hits a predetermined threshold, sending a message or warning to the user's dashboard. For example, if

Cisco's sales department has a top-ten list of new products it wants sold, the application will let the Cisco manager know the instant the distributor's sales fall outside target levels.

Cisco had to build deep hooks into its supply chain. Once it receives the data, Cisco couples them with realtime Web-based inventory information and processes them using analytics software from Hyperion Solutions Corp. in Sunnyvale, California. Channel managers can then query the Hyperion software in detail through the OneChannel dashboard to find the underlying causes of any problem.

Source: Adapted from M. Hall, "Web Analytics: Get Real," Computer World, Vol. 36, No. 14, April, 2002, pp. 42-43.

methods that can be used to optimize the supply chain (see Keskinocak and Tayur, 2001), and group support systems that enhance collaboration from vendors through to customers. SCM involves many nonroutine decisions. These topics are related to enterprise systems, such as organizational decision support systems, EIS, and intranet applications. They are also related to interorganizational systems and concepts, such as customer relationship management (CRM) (Swift, 2001), extranets, and virtual organizations. Related to these are revenue management systems, which utilize demand and pricing forecasts to establish the right product at the right price at the right time at the right location in the right format for the right customer (see Cross, 1997; Smith et al., 2001; and e-optimization.com, 2002).

Web technologies are critical for the success of EIS, SCM, CRM, and now revenue management. The Web provides access to terabytes of data in data warehouses and business intelligence / business analytics tools like those in **online analytical processing (OLAP)** and data mining, which are used to establish relationships that lead to higher profitability (Callaghan, 2002). Data access, communication, and collaboration are critical in making MSS technologies work.

Closely interrelated to these is electronic commerce (e-commerce), which includes not only electronic markets, but also interorganizational electronic systems, Web-based customer services, intra organizational applications, and business-processes reengineering. Of course, the Web and its associated technologies are critical for all aspects of e-commerce and its success. See DSS in Action 1.2.

1.10 KNOWLEDGE MANAGEMENT SYSTEMS

Past knowledge and expertise can often be used to expedite decision-making. It does not make sense to reinvent the wheel each time a decision-making situation is encountered. The knowledge accumulated in organizations over time can be used to solve

identical or similar problems. There are several important issues to address: where to find knowledge, how to classify it, how to ensure its quality, how to store it, how to maintain it, and how to use it. Furthermore, it is important to motivate people to contribute their knowledge, because much knowledge is usually not documented. Moreover, when people leave an organization, they take their knowledge with them. Knowledge management systems (KMS) and their associated technologies deal with these issues. Knowledge is organized and stored in a **knowledge repository**, a kind of textual database. When a problem has to be solved, or an opportunity to be assessed, the relevant knowledge can be found and extracted from the knowledge repository. **Knowledge management** systems have the potential to dramatically leverage knowledge use in an organization. Documented cases indicate that *returns on investment are as high as a factor of 25 within one to two years* (see Housel and Bell, 2001). Web technologies feature prominently in almost all KMS. Web technologies provide the communication, collaboration, and storage capabilities so needed by KMS.

There are many kinds of knowledge management systems, and they can be used to support decision-making in several ways, including allowing employees direct access to usable knowledge and to people who have the knowledge. One important application is described in DSS in Action 1.8.

1.11 EXPERT SYSTEMS

When an organization has a complex decision to make or a problem to solve, it often turns to experts for advice. The experts it selects have specific knowledge about and experience in the problem area. They are aware of the alternatives, the chances of success, and the benefits and costs the business may incur. Companies engage experts for

DSS IN ACTION 1.8

XEROX CORPORATION'S KNOWLEDGE BASE HELPS THE COMPANY SURVIVE



With decreasing demand for copying, Xerox Corporation has been struggling to survive the digital revolution. Championed by Cindy Cassman, the company pioneered an intranet-based knowledge repository in 1996, with the objective of delivering information and knowledge to the company's employees. A second objective was to create a sharing virtual community. Known as the first knowledge base (FKB), the system was designed initially to support salespeople so that they could quickly answer customers' queries. Before FKB, it frequently took hours of investigation to collect information to answer one query. Since each salesperson had to deal with several queries simultaneously, clients sometimes had to wait days for a reply. Now a salesperson can log on to the KMS and in a few minutes provide answers to the client. Customers tend to have similar questions, and when a solution to an inquiry is

found, it is indexed so that it can be quickly found when needed by another salesperson. An average saving of two days per inquiry was realized. In addition to improved customer service, the accumulated knowledge is analyzed to learn about products' strengths and weaknesses, customer demand trends, and so on. Employees now share their knowledge and help each other. Xerox had a major problem when it introduced the FKB; it had to persuade people to share and contribute knowledge as well as to go on the intranet and use the knowledge base. This required an *organizational culture change* that took several years to implement. The FKB continues to evolve and expand rapidly (which is not unusual in KMS implementations). People in almost every area of the company, worldwide, are now making much faster and frequently better decisions.

advice on such matters as what equipment to buy, mergers and acquisitions, major problem diagnostics in the field, and advertising strategy. The more unstructured the situation, the more specialized (and expensive) the advice is. Expert systems attempt to mimic human experts' problem-solving abilities.

Typically, an expert system (ES) is a decision-making or problem-solving software package that can reach a level of performance comparable to--or even exceeding--that of a human expert in some specialized and usually narrow problem area. The basic idea behind an ES, an applied artificial intelligence technology, is simple. Expertise is transferred from the expert to a computer. This knowledge is then stored in the computer, and users run the computer for specific advice as needed. The ES asks for facts and can make inferences and arrive at a specific conclusion. Then, like a human consultant, it advises nonexperts and explains, if necessary, the logic behind the advice. Expert systems are used today in thousands of organizations, and they support many tasks. For example, see AIS (Artificial Intelligence Systems) in Action 1.9. Expert systems are often integrated with or even embedded in other information technologies. Most new ES software is implemented in Web tools (e.g., Java applets), installed on Web servers, and use Web-browsers for their interfaces. For example, Corvid Exsys is written in Java and runs as an applet.

1.12 ARTIFICIAL NEURAL NETWORKS

The application of the technologies mentioned above was based on the use of explicit data, information, or knowledge stored in a computer and manipulated as needed. However, in the complex real world we may not have explicit data, information, or knowledge. People often must make decisions based on partial, incomplete, or inexact information. Such conditions are created in rapidly changing environments. Decisionmakers use their experiences to handle these situations; that is, they recall similar experiences and learn from them what to do with similar new situations for which exact replicas are unavailable. When this approach to problem-solving is computerized, we call it machine learning, and its primary tools are artificial neural networks (ANN) and case-based reasoning.

Neural computing, or an artificial neural network (ANN), uses a pattern-recognition approach to problem-solving, and they have been employed successfully in many business applications (Fadlalla and Lin, 2001; Haykin, 1999; Ainscough et al., 1997). An ANN *learns* patterns in data presented during training and can apply what it has learned to new cases. One important application is that of bank loan approval. An ANN can learn to identify potential loan defaulters from patterns. One of the most successful applications of an ANN is in detecting unusual credit card spending patterns, thus identifying fraudulent charges. This is especially important for the many Web-based transactions of e-commerce (see AIS in Action 1.10).

1.13 ADVANCED INTELLIGENT DECISION SUPPORT SYSTEMS

At the cutting edge of applied artificial intelligence are several exciting technologies that assist decision-makers. These include genetic algorithms, fuzzy logic, and intelligent agents (IA).

Genetic algorithms solve problems in an evolutionary way. They mimic the process of evolution and search for an extremely good solution. Survival of the fittest guides this method. Genetic algorithms have been used to maximize advertising profit at tele-

AIS IN ACTION 1.9

EXPERT SYSTEMS PROVIDE USEFUL ADVICE



Suppose you manage an *engineering firm* that bids on many projects. Each project is, in a sense, unique. You can calculate your expected cost, but that is not sufficient to determine your bid. You have background information on your likely competitors and their bidding strategies. Something is known about the risks: possible technical problems, political delays, material shortages, or other sources of trouble. An experienced proposal manager can generally put all this together and arrive at a sound judgment concerning terms and bidding price. However, you do not have that many experienced proposal managers. This is where expert systems become useful. An expert system can capture the lines of thinking the experienced proposal managers can follow. It can also catalog information gained on competitors, local risks, and so on, and can incorporate your policies and strategies concerning risk, pricing, and terms; It can help your inexperienced proposal managers develop an informed bid consistent with your policy.

A *bank loan officer* must make many decisions daily about who is a good credit risk and who is not. Once information is gathered about a client, an expert can readily estimate the likelihood that he or she will pay back a loan or default on it. Sometimes a loan officer is busy, unavailable, or even new to the job. A Web-based expert system can help. All the needed data are captured and placed into a database. An expert system can then determine the likelihood of a good risk. Furthermore, it can determine what the potential borrower can do to improve his or her likelihood of obtaining a loan (e.g., payoff some credit cards, ask for a smaller loan or higher interest rate). A final benefit is

that an expert system can indicate when it does not know, and the loan officer can focus only on these difficult cases rather than the easy yes/no decisions.

Suppose you are a *life insurance agent*, and you are a good one; however, your market has changed. You are no longer competing only with other insurance agents. You are also competing with banks, brokers, money market fund managers, and the like. Your company now carries a whole array of products, from universal life insurance to venture capital funds. Your clients have the same problems as ever, but they are more inquisitive, more sophisticated, and more conscious of tax avoidance and similar considerations. How can you give them advice and put together a sensible package for them when you are more confused than they are? How can you provide service to your customers and market new services to existing and new customers over the Web? Try an expert system for support.

Financial planning systems and estate planning guides have been part of the insurance industry's marketing kit for a long time. However, sensible financial planning takes more skill than the average insurance agent has or can afford to acquire. This is one reason why the fees of professional planners are as high as they are. A number of insurance companies have been investing heavily in artificial intelligence techniques in the hope that these techniques can be used to build sophisticated, competitive, knowledge-based financial planning support systems to assist their agents in helping their clients.

Source: Part is condensed from a publicly disclosed project description of Arthur D. Little, Inc.

vision stations, and facilities layout among other applications. Genetic algorithms have been implemented directly in Java applets (and other Web technology), and in spreadsheets (e.g., *evolver* from Palisade Software).

Fuzzy logic approaches problems the way people do. It can handle the imprecise nature of how humans communicate information. For example, you might say, "The weather is really hot!" on a hot day. Consider how *hot* is *hot*? Would one degree cooler still be *really hot*, or simply *hot*? This imprecision can be handled mathematically in a precise way to assist decision-makers in solving problems with imprecise statements of their parameters. Usually fuzzy logic methods are combined with other artificial intelligence methods, such as expert systems and artificial neural networks, to boost their accuracy in their decision-making.

Intelligent agents (intelligent software agents, *softbots*) help in automating various tasks, increasing productivity and quality. Most intelligent systems include expert sys-

AIS IN ACTION 1.10

SUMITOMO CREDIT SERVICE: AN EXPANDING WORLD MARKET



With close to 18 million cardholders and 1.8 million merchants nationwide, the Sumitomo Credit Service Co., Ltd., was the leading credit card issuer in Japan in 2000. Sumitomo Credit Service is recognized as an innovator in the Japanese consumer credit industry, both for its international business strategy and its early adoption of technical advances in card processing.

When credit card fraud became a critical issue in the Japanese market in 1996, Sumitomo Credit Service decided to implement Falcon, a neural network-based system from HNC Software. The system excelled in identifying fraud patterns that had gone undetected before. HNC had never before implemented a Japanese version of Falcon, complete with features specific to the

Japanese market, such as the double-byte architecture necessary for Japanese characters.

Sumitomo Credit Service was the first issuer in Japan to implement predictive software solutions, and the enhanced power to predict fraud has become Sumitomo Credit Service's competitive advantage in the security and risk-management area. A neural network, as we will see in Chapters 12, uses historical data to predict the future behavior of systems, people, and markets to meet the growing demand for predictive analysis to provide effective consumer business strategies.

Source: Compiled from HNC Software Web Site: hnc.com, San Diego, CA, 2000.

terms or another intelligent component. Intelligent agents play an increasingly important role in electronic commerce (Turban and King, 2003). Like a good human agent (travel agent, real estate agent, etc.), these systems learn what you want to do, and eventually take over and can perform many of your mundane tasks .

The objective of a **computer-based information system (CBIS)**, regardless of its name or nature, is to assist management in solving managerial or organizational problems faster and better than is possible without computers. To attain this objective, the system may use one or more information technologies. Every type of CBIS has certain advantages and disadvantages. By integrating technologies, we can improve decision-making, because one technology can provide advantages where another is weak.

1.14 HYBRID SUPPORT SYSTEMS

Machine repair provides a useful analogy. The repair technician diagnoses the problem and identifies the best tools to make the repair. Although only one tool may be sufficient, it is often necessary to use several tools to improve results. Sometimes there may be no standard tools. Then special tools must be developed, like a ratchet tip at the end of a screwdriver handle, or a screwdriver blade at the end of a ratchet wrench to reach into those hard to get places. The managerial decision-making process described in DSS in Action 1.11 illustrates the combined use of several MSS technologies in solving a single enterprise-wide problem. United Sugars is a competitor of Imperial Sugar (DSS in Action 1.2).

Many complex problems require several MSS technologies, as illustrated in the opening vignette and throughout this book. A problem-solver can employ several tools in different ways, such as:

- Use each tool independently to solve different aspects of the problem.
- Use several loosely integrated tools. This mainly involves transferring data from one tool to another (e.g., from an ES to a DSS) for further processing.

DSS IN ACTION 1.11.**UNITED SUGARS CORPORATION OPTIMIZES
PRODUCTION, DISTRIBUTION, AND INVENTORY
CAPACITY**

United Sugars Corporation (Bloomington, Minnesota) is a grower-owned cooperative that sells and distributes sugar products for its member companies. United has a 25 percent U.S. market share and sales of more than \$1 billion annually. When the United States Sugar Corporation in southern Florida joined the cooperative, United Sugars decided to revise its marketing and distribution plans to gain access to new markets and serve existing ones more efficiently. Improvements in managing the supply chain and in the supply chain's design were in order.

A strategic model was developed to identify the minimum-cost solution for packaging, inventory, and distribution. The company's ERP system (SAP) and a legacy database system provided data for the mathematical model. This first model contains about a million decision variables and more than 250,000 relationships.

A Web-based GIS graphically displays reports optimal solutions. A map of the United States indicates the location of plants, warehouses, and customers. Each one is a hotspot that links to additional information about the solution.

This model is used to schedule production and distribution. Results are uploaded into the ERP to support operational decisions. The results of the strategic model drive the generation of subsequent models for inventory analysis. These models simulate a variety of inventory situations, through what-if analyses, and help analysts reduce overall inventory. All results are displayed in a variety of formats in a Web browser.

The hybrid DSS consisting of several optimization and simulation models, an ERP, and Web interfaces optimizes the supply chain at United Sugars.

Source: Adapted from Cohen et al. (2001).

- Use several tightly integrated tools (e.g., a fuzzy neural network). From the user's standpoint, the tool appears as one hybrid system.

The goal of using **hybrid computer** systems is the *successful solution* of managerial problems as is illustrated in DSS in Action 1.11.

In addition to performing different tasks in the problem-solving process, tools can support each other. For example, an expert system can enhance the modeling and data management of a DSS. A neural computing system or a GSS can support the knowledge acquisition process in building an expert system. Expert systems and artificial neural networks play an increasingly important role in enhancing other MSS technologies by making them *smarter*. The components of such systems include not only MSS, but also management science, statistics, and a variety of computer-based tools.

EMERGING TECHNOLOGIES AND TECHNOLOGY TRENDS

A number of emerging technologies directly and indirectly influence decision support systems. The World Wide Web has influenced many aspects of computer use, and therefore of DSS.

As technology advances, the speed of computation increases, leading to greater computational capability, while the physical size of the computer decreases. Every few years there is a several-factor change in these parameters. Purchasing a personal computer may seem expensive to a student, but its capabilities far exceed those of many legacy mainframes only a few years old. Many important *new* technologies have been around for decades. However, owing to the interconnectivity available through the Web, successful commercial implementation has now become feasible. Some specific

technologies to watch (Vaughan, 20(2) include grid computing, rich client interfaces, model-driven architecture, wireless computing, and agents, algorithms, and heuristics.

- *Grid computing.* Although a hot area, this has been around for decades. The basic idea is to cluster computing power in an organization and utilize unused cycles for problem-solving and other data-processing needs. This lets an organization get full use of its in-house number-crunching power. Some firms utilize unused cycles on employee desktops, whereas other firms simply replace their supercomputers with PC clusters. For example, CGG, an oil firm, replaced its supercomputers with a cluster of more than 6,000 PCs that is expected to grow to 10,000. These cost less than a supercomputer, but special software is needed to manage it (see Nash, 2002).
- *Rich client interfaces.* Customers and employees expect data and tool access to be pleasant to use and correct. In time, expectations have risen. As servers increase in capability, browser technology improves. GUIs, especially for Web access, improve continuously.
- *Model-driven architecture.* Software reuse and machine-generated software via computer-aided software engineering (CASE) tools are becoming more prevalent. The standardization of model vocabularies around UML has led developers to believe that code generation is feasible. However, even if code is 90 percent correct, the extra human effort required to fix the 10 percent to make it work may eliminate any benefits.
- *Wireless computing (also mobile computing).* The move to e-commerce is evolving because cellular telephones and wireless PC cards are so inexpensive. Mobile devices are being developed along with useful software to make this new approach work. A number of firms, such as FedEx, have been using mobile computing to gather data on packages to track shipping and analyze patterns.
- *Agents, algorithms, and heuristics.* Intelligent agents, though embedded in Web search engines for years, are being developed to function within devices and other software. They help users and assist in e-commerce negotiations. Algorithms and heuristics for improving system performance are being distributed as part of Java middleware and other platforms. For example, how to route a message over the Web may be computed by an algorithm embedded in an instant messenger system.

Gartner Inc. (Anonymous, 2002) recommends that enterprises in an economic slowdown select technologies that support their core business initiatives. This is generally good advice for any economic situation. In good times, money can be spent on exploring new technology impacts. All the items on Gartner's emerging-technologies list involve the Web. Here are Gartner's four emerging-technology trends to watch:

- *Customer self-service.* By 2005, it is expected that more than 70 percent of customer-service interaction for information and remote transactions will be automated. Web sites will have to provide the services that customers need and move the "products" that firms want to sell. There is an expectation of high returns on investment, better customer reach, and improved service quality. This will lead to increased competitiveness and savings that can be passed on to customers. DSS in Action 1.12 describes an example of how Palm Inc. deployed a portal that provides excellent customer service.
- *Web services.* The world has moved to the Web. Firms want a Web presence. Regardless of your industry, there is some aspect of what you do that can and should be put onto an e-commerce Web site. At a bare minimum, customers

DSS IN ACTION 1.12**PALM PROVIDES IMPROVED CUSTOMER SERVICE
WITH A WEB PORTAL**

Palm Inc. faced a problem with its Web site. Customers would access it, look over the various models of PDAs (personal digital assistants), get thoroughly confused, and order nothing. Something had to be done. In March 2002, Palm launched Active Sales Assistant, created by Active Decisions, to assist customers in comparing and deciding among Palm products. Customers identify the important features. The Assistant drills down and asks for more information from the customer if specific features were not identified (e.g., a color or monochrome screen display may not be important initially, but price may make it more significant when choosing between a pair of PDAs). When

the Assistant was pilot tested for a month, Palm discovered that customers preferred it to navigating on their own. Customers generally purchased all item, usually a higher-priced one than they initially intended. Aspects of fuzzy logic and economic utility functions are used in an internal model that helps the customers. The system learns what the user wants and attempts to identify the best fit. After implementing Active Decisions, revenues were up 20 percent.

Source: Adapted from Marvin Pyles, "A Fistful of Dollars: How Palm Increased Revenues 20 Percent," *Customer Relationship Management*, November 2002, pp. 54-55.

expect contact information and advertising. They want to be able to find you and see what you sell.

- *Wearable computers.* By 2007, more than 60 percent of the U.S. population between ages 15 and 50 will carry or wear a wireless computing and communications device at least six hours a day. The prevalence of these devices will definitely lead to significant commerce and service opportunities.
- *Tagging the world.* By 2008, more than \$90 billion of business-to-consumer (B2C) purchase decisions and \$350 billion of business-to-business (B2B) purchase decisions will be based on *tags*. Tags contain information and opinions about purchasable items. The flood of information, products, and services is spurring a focus on organizing and labeling choices to help buyers find, prioritize, and select items. The growing tagging industry will modify buying behavior and help create new industries in advisory and market research services.

1.15 PLAN OF THE BOOK

The 15 chapters of the book are organized in six parts (Figure 1.3). **PART I: BUSINESS INTELLIGENCE: DECISION-MAKING AND COMPUTERIZED SUPPORT**

In Chapter 1 we provide an introduction, definitions, and an overview of decision support systems. In Chapter 2, we describe the process of managerial decision-making and DSS impacts.

PART II: DECISION SUPPORT SYSTEMS

Chapter 3 provides an overview of DSS and its major components. Chapter 4 describes the difficult topic of (mathematical) modeling and analysis. We describe both structured models and modeling tools. We also describe how unstructured problems can be modeled. In Chapter 5, we build on the modeling and analysis concepts, combine them

**PART I DECISION-MAKING AND
COMPUTERIZED SUPPORT**

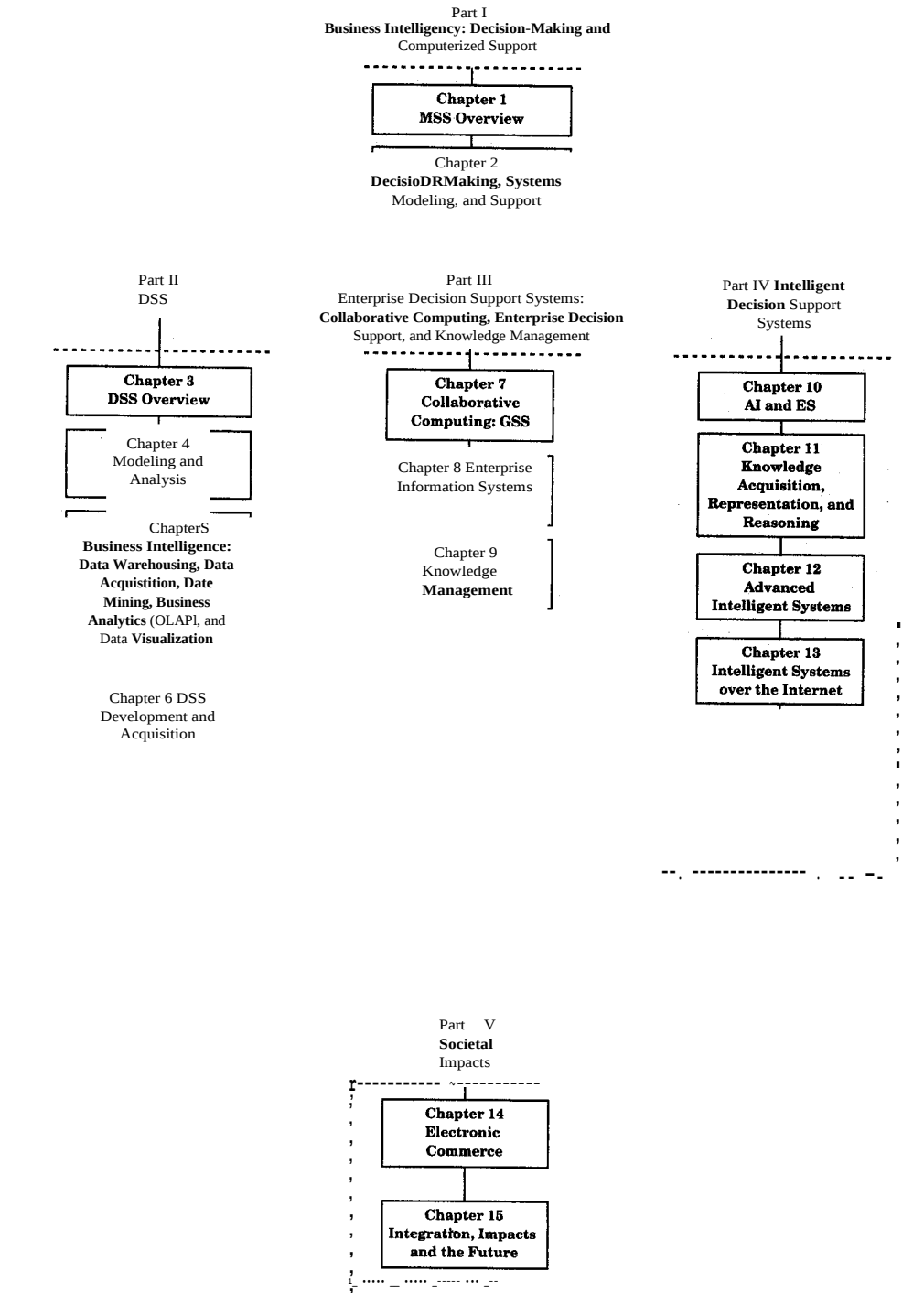


FIGURE 1.3 PLAN OF THE BOOK

with database concepts, resulting in modern business intelligence technologies and tools. These include **data warehousing**, **data acquisition**, **data mining**, online analytical processing (OLAP), and visualization. In Chapter 6, we describe DSS development and acquisition processes, and technologies.

PART III: ENTERPRISE DECISION SUPPORT SYSTEMS:

COLLABORATIVE COMPUTING, ENTERPRISE DECISION SUPPORT, AND KNOWLEDGE MANAGEMENT

Chapter 7 deals with the support provided to groups working either in the same room or at different locations, especially via the Web. Chapter 8 covers the topic of enterprise decision support systems, including EIS, ERP/ERM, CRM, SCM, BPM, BAM, and PLM. Many decision-making problems require access to enterprise-wide data, policies, rules, and models; the decisions can then affect employees throughout the organization. The last chapter in this part is an in-depth discussion on knowledge management systems (KM), an exciting, enterprise-level DSS that can leverage large gains in productivity. Again, the Web plays a key role.

PART IV: INTELLIGENT SYSTEMS

The fundamentals of artificial intelligence and expert systems are the subject of Chapter 10. Methods of knowledge acquisition, representation, and reasoning are covered in Chapter 11. Advanced intelligent systems including artificial neural networks, genetic algorithms, fuzzy logic, and hybrids are the subjects of Chapter 12. Chapter 13 covers how intelligent systems work over the Internet, including intelligent agents.

PART V: SOCIETAL IMPACTS

Chapter 14 is an introduction to electronic commerce, the role of the Web, and the role that DSS technologies play. Finally, MSS integration, societal impacts, and its future are covered in Chapter 15.

❖ WEB SITE

This book's Web site, prenhall.com/turban, contains supplemental textual material organized as Web Chapters. The topics of these chapters are listed on the Web site in its *Web Table of Contents*. There is at least one chapter

describing "New Developments in Decision Support Systems and Artificial Intelligence." The Web site also contains the book's PowerPoint presentations.

∴ CHAPTER HIGHLIGHTS

- The rate of computerization is increasing rapidly, and so is its use for managerial decision support.
- Managerial decision-making has become complex. Intuition and trial-and-error method may not be sufficient.
- The time frame for making decisions is shrinking, whereas its global nature is expanding, necessitating the development and use of computerized decision support systems.
- Management support systems are technologies designed to support managerial work. They can be used independently or in combination.
- Computerized support for managers is often essential for the survival of organizations.
- A decision support framework divides decision situations into nine categories, depending on the degree of structuredness and managerial activities. Each category is supported differently.
- Structured decisions are supported by standard quantitative analysis methods, such as management science, and by MIS.
- Decision support systems (DSS) use data, models, and possibly knowledge for the solution of semistructured and unstructured problems.

- Business intelligence methods utilize both analytical tools and database systems that include data warehouses, data mining, online analytical processing, and data visualization.
- Group support systems (GSS) support group work processes.
- Enterprise information systems (EIS) give access to the specific enterprise-wide information that individuals need to perform their tasks.
- Enterprise resource planning (ERP)/enterprise resource management (ERM), customer relationship management (CRM) systems, and supply chain management (SCM) systems are all types of enterprise information systems.
- Enterprise resource planning and supply chain management are correlated with decision support systems, electronic commerce, and customer relationship management.
- Knowledge management systems (KMS) capture, store, and disseminate important expertise throughout an organization.
- Knowledge repositories contain knowledge that can be reused to support complex decisions.
- Expert systems are advisory systems that attempt to mimic experts; they apply knowledge directly to problem-solving.
- Neural computing is an applied artificial intelligence technology that attempts to exhibit pattern recognition by learning from experience.
- Advanced intelligent decision support systems, such as genetic algorithms, fuzzy logic, and intelligent (software) agents, enhance productivity and quality.
- All MSS technologies are interactive and can be integrated among themselves and with other CBIS into hybrid computer systems.
- Web technology and the Internet, intranets, and extra nets play a key role in the development, dissemination, and use of MSS.

• .: KEY WORDS

- | | | |
|--|--|---------------------------------------|
| • artificial neural networks (ANN) | • enterprise resource planning (ERP) | • management information system (MIS) |
| • business analytics | • expert system (ES) | • management science (MS) |
| • business intelligence | • expertise | • management support system (MSS) |
| • cognitive limits | • fuzzy logic | • operations research (OR) |
| • computer-based information system (CBIS) | • genetic algorithms | • organizational knowledge repository |
| • customer relationship management (CRM) | • group support systems (GSS) | • productivity |
| • data mining | • intelligent agent (IA) | • semistructured decisions |
| • decision support systems (DSS) | • hybrid (integrated) computer systems | • structured decisions |
| • electronic commerce (e-commerce) | • knowledge management systems (KM) | • supply chain management (SCM) |
| • enterprise information system (EIS) | • knowledge repository | • transaction processing system (TPS) |
| • enterprise resource management (ERM) | • machine learning | • unstructured decisions |

..: QUESTIONS FOR REVIEW

1. What caused the latest revolution in management use of computers? List at least two causes.
2. List and define the three phases of the decision-making process (according to Simon).
3. Define DSS.
4. Discuss the major characteristics of DSS.
5. List five major benefits of DSS.
6. Why is management often equated with decision-making?
7. Discuss the major trends that affect managerial decision-making.
8. Define management science.
9. Define structured, semistructured, and unstructured decisions.
10. Categorize managerial activities (according to Anthony).
11. Define group support systems.
12. Relate DSS to EIS, ERP/ERM, SCM, and the Web.
13. Define knowledge management.
14. Define expert system.
15. List the major benefits of ES.
16. Define neural computing.
17. Define intelligent agents.
18. What is a hybrid support system?

.. QUESTIONS FOR DISCUSSION

1. Give additional examples for the contents of each cell in Figure 1.2.
2. Design a computerized system for a brokerage house that trades in securities, conducts research on companies, and provides information and advice to customers (such as "buy," "sell," and "hold"). In your design, clearly distinguish seven parts: TPS, MIS, DSS, EIS, GSS, KMS, CRM, ES, and ANN. Be sure to discuss input and output information. Assume that the brokerage company is a small one with only 20 branches in four different cities.
3. Survey the literature of the last six months to find one application of each MSS technology discussed. Summarize the applications on one page and submit it with a copy of the articles.
4. Observe an organization with which you are familiar. List three decisions it makes in each of the following categories: strategic planning, management control (tactical planning), and operational planning and control.
5. What capabilities are provided by ANN and not by any other MSS?
6. Describe how hybrid systems might help a manager in decision-making.
7. Indicate which MSS can be used to assist a manager in fulfilling Mintzberg's 10 management roles. How and why can they help? Be specific.
8. Discuss the relationships among EIS, ERP/ERM, SCM, and CRM.
9. Why is e-commerce related to EIS and decision support?
10. Why is the role of knowledge management so important for decision support? Discuss an example of how the two can be integrated.
11. Describe how the World Wide Web affects MSS, and vice versa.

• .. EXERCISE

1. Write a report (5-10 pages) describing how your company, or a company you are familiar with, currently uses computers and information systems, including Web technologies and the Web itself, in decision-making. In light of the material in this chapter, describe how you could use such support systems if they were readily available (which ones are available to you and which ones are not?).

.. GROUP ASSIGNMENTS AND ROLE-PLAYING

1. Find information on the proactive use of computers to support ad hoc decisions versus transaction processing systems (TPS). Each member of the group should choose an application in a different industry (retail, banking, insurance, food, etc.). Be sure to include the impacts of the Web/Internet. Summarize the findings and point out the similarities and differences of the applications. Use as sources companies where students are employed, trade magazines, Internet newsgroups, and vendor Web sites. Finally, prepare a class presentation on the findings.

.. INTERNET EXERCISES

1. Search the Internet for material regarding the work of managers, the need for computerized support, and the role decision support systems play in providing such support. What kind of references to consulting firms, academic departments, and programs do you find? What major areas are represented? Select five sites that cover one area and report your findings.
2. Explore the *public areas* of dssresources.com. Prepare a list of its major available resources. You may want to refer to this site as you work through the book.
3. Look at the Web Chapters on the book's Web site (prenhall.com/turban). Describe in a one-page summary report how they relate to the chapters in the text.
4. Access sap.com and peoplesoft.com and find information on how enterprise resource planning (ERP) software helps decision-makers. In addition, examine how these software products utilize Web technology, and the Web itself.
5. Access intelligententerprise.com. For each topic cited in this chapter, find some interesting development reported on the site and prepare a report.
6. Search the Web for DSS, business intelligence, business analytics, OLAP, data mining, and data warehousing. Identify similarities and differences among these items based on what you find.

ABB AUTOMATION MAKES FASTER AND BETTER DECISIONS WITH DSS

INTRODUCTION

ABB is a global leader in power and automation technologies that enable utility and industry customers to improve performance while lowering environmental impact. ABB has approximately 152,000 employees in more than 100 countries. It is constantly developing new *automation technology* solutions to help its customers to optimize their productivity. These solutions include simulation, control and optimization strategies, the interaction between people and machines, embedded software, mechatronics, monitoring, and diagnosis. The intent is to develop a common industrial IT architecture for real-time solutions across the business enterprise.

THE DECISION SUPPORT SYSTEM SOLUTION

ABB has expertise in developing such systems, and it developed one for its own use in a textile division. ABB Automation's decision support system captures and manages information from ABB's Range MES package for managers to use in their analysis and decision-making. The primary purpose of the DSS is to provide managers with technology and tools for data warehousing, data mining, and decision support, ideally leading to better and faster decision-making.

The system provides

- Storage of production data from a distributed control system (DCS) in a data warehouse .
- Data capture without burdening the control system hardware
- Site-wide access to data for decision support through data visualization tools (a Web-based interface) that are easily used by nontechnical site staff
- Pre-configured windows to the data (for structured queries)
- Capability to access data for ad hoc reports and data analysis
- Access to real-time operating data (for analysis).

DETAILS OF THE DSS AND ITS USE

The DSS provides a method for flexible-term storage (warehousing) and analysis of important data. It is part of the Managerial Supervisory Control System (MSS) and summarizes data for each process area in a plant. In addition to DSS, MSS includes lot-tracking, history, and process data. The DSS has a flexible, accessible architecture facilitating generation of reports, information searches and flexible term data storage that is easily accessible.

A Web-based dashboard (an enterprise information portal) is used for views in the datawarehouse. The production system status (overall efficiency and of each lot and summary data) can be monitored graphically in near real-time. Equipment failures, off-quality production, and their causes are quickly identified and rectified. Process improvements through time are tracked. Analysis is performed by through data mining and online analytical processing (OLAP) technologies by accessing production data from the data warehouse. Resource consumption, energy consumption and other production factors are also monitored.

RESULTS

The DSS enables the user to make decisions for more consistent and efficient operation and to monitor and manage costs of producing high-quality goods. It provides a near real-time display of operating data, detailing range stops and associated downtime, to eliminate major causes of downtime.

The ultimate challenge is to improve management of the manufacturing process by *leveraging* the large quantities of production data available. The DSS gives managers plant-wide access to relevant plant-floor production data leading to *more informed decisions and increased profits*.

Sources: Based on Anonymous, "ABB: Decision Support System," *Textile World*, Vol. 150, No.4, 52-54, April 2000; and the ABB Web site, abb.com.

CASE QUESTIONS

1. Identify the model, data, and user interface components of the ABB DSS.
2. What DSS technologies does ABB Automation use to improve productivity?
3. How does ABB Automation use DSS to make faster and better decisions?
4. Why are the decisions faster and better?
5. How could artificial intelligence systems, such as expert systems or artificial neural networks, be integrated into ABB's DSS?
6. Consider the DSS material in the chapter: What is meant by leveraging production data to improve the management of the manufacturing process?