CHAPTER 1

Decision Support Systems and Business Intelligence

Learning Objectives

- Understand today's turbulent business environment and describe how organizations survive and even excel in such an environment (solving problems and exploiting opportunities)
- Understand the need for computerized support of managerial decision making
- Understand an early framework for managerial decision making
- Learn the conceptual foundations of the decision support systems (DSS[1]) methodology
- Describe the business intelligence (BI) methodology and concepts and relate them to DSS
- Describe the concept of work systems and its relationship to decision support
- List the major tools of computerized decision support
- Understand the major issues in implementing computerized support systems

The business environment (climate) in which organizations operate today is ever changing, and it is becoming more and more complex. Organizations, both private and public, feel increasing pressures that force them to respond quickly to changing conditions and to be innovative in the way they operate. Such activities require organizations to be agile and make frequent and quick strategic, tactical, and operational decisions, some of which are very complex. Making such decisions may require considerable amounts of relevant data, information, and knowledge. Processing these, in the framework of the needed decisions, must be done quickly, frequently in real-time, and usually requires some computerized support.

This book is about using business intelligence as a computerized support for managerial decision making. It concentrates both on the theoretical and conceptual foundations of decision support, as well as on the commercial tools and techniques that are available. This introductory chapter provides more details of these topics as well as an overview of the book. This chapter has the following sections:

1.1 Opening Vignette: Toyota Uses Business Intelligence to Excel

1.2 Changing Business Environments and Computerized Decision Support

1.3 Managerial Decision Making

[1]The acronym *DSS* is treated as both singular and plural throughout this book. Similarly, other acronyms, such as *MIS* and *GSS*, designate both plural and singular forms.

1.1 OPENING VIGNETTE: TOYOTA USES BUSINESS INTELLIGENCE TO EXCEL

PROBLEM

Toyota Motor Sales USA (**toyota.com**) is the U.S. distributor of cars and trucks built by Toyota (i.e., it is a subsidiary of Toyota). The company buys the cars at the Toyota factories in Japan and elsewhere, takes ownership of the vehicles, and then sells them to Toyota dealers across the United States. An average vehicle costs $8/day to keep while in transit. Because it used to take 9 to 10 days in transit, the financial charge was $72 to $80 per car. For 2 million cars per year, the cost to the company was $144 to $160 million per year. This was too much.

In the late 1990s, the company faced increased problems in its supply chain and its operations, and its car-keeping costs mounted. Also, the inability to deliver cars to the dealers resulted in unhappy customers purchasing cars from competitors, such as Honda. This became extremely important in 2003 and 2004, when hybrid cars were introduced and the competition with Honda intensified.

In the past, managers used computers that generated huge numbers of directionless reports and data. Managers were unable to use such data and reports strategically. Furthermore, internal departments regularly failed to share information, or they did it too slowly. Actionable reports were often produced too late. In addition, overlapping reporting systems provided data that were not always accurate. Managers were unable to make timely decisions because they were not certain what portion of the data was accurate. The situation was especially dire in the Toyota Logistic Services (TLS) division, which manages the transport of vehicles.

The managers of TLS require precision tracking and supply-chain management to ensure that the right cars go to the right dealers in a timely manner. Manual scheduling and other related business processes that were conducted with incorrect information caused additional problems. For example, if one individual made a data entry mistake when a ship docked, the mistake would endure throughout the entire supply chain. (For example, some data indicated to managers that ships never made it to a port weeks after the ships had safely docked.) The information technology (IT) organization was unable to respond to the growing needs of the business. Finally, a new chief information officer (CIO) was hired in 1997 in order to fix the problems.

SOLUTION

Barbara Cooper, the new CIO of TMS started by trying to identify the problems. Cooper realized that a data warehouse was needed. A *data warehouse* is a central repository of historical data, organized in such a way that it is easy to access (using a Web browser) and it can be manipulated for decision support. (See the discussion of data warehousing later in this chapter and in Chapter 5.) Cooper also saw that software tools to process, mine, and manipulate the data were needed. A system was therefore set up to provide real-time, accurate data. Unfortunately, the system did not work properly. To begin with, the historical data input into the system included years of human errors that had gone unnoticed, including inconsistent duplicated data as well as missing data. This resulted in erroneous results and analysis. In addition, the new system lacked capabilities to provide what managers needed. By 1999, it had become clear that the solution did not work. It was the right concept but used the wrong technology from the wrong vendors. In 2000, Toyota switched to a better technology. The new TLS system used Oracle's data warehouse and Hyperion's business intelligence platform. The system also included Hyperion's *dashboard* feature (discussed in Chapters 6 and 9), which allows executives to visually see hot spots in their business units and investigate further to identify problems and their causes.

With the new TLS system, which uses colors meaningfully (e.g., red for danger), a business manager can see in real-time, for example, when delivery times are slowing and can immediately find the sources of the problems and even evaluate potential solutions by using "what-if" analysis.

RESULTS

Within a few days, the new TLS system started to provide eye-popping results. For example, the system helped managers discover that Toyota was getting billed twice for a specific rail shipment (an $800,000 error). Overall, Toyota USA managed to increase the volume of cars it handled by 40 percent between 2001 and 2005, while increasing head count by just 3 percent. In addition, in-transit time was reduced by more than 5 percent. Word of the success of TLS's new BI quickly spread throughout Toyota USA and then all over the company, and many other areas of the company started to adopt BI. For example, the former manager of TLS, who now runs the Toyota Customer Services Division, uses dashboards in his office, as do chief financial officers (CFOs) and other top executives throughout Toyota (e.g., to better manage expenses, purchasing, and so on).

It is clear now that the more people who use data analysis tools, the more money Toyota can earn. The TLS system was upgraded in 2003 and 2005, and tools are continuously added as needed. Thanks to the new TLS system and other BI, the parent company, Toyota Motor Corporation, reached the highest profit margins in the automotive industry in 2003. Also, Toyota's market share has increased consistently. (Incidentally, Toyota, which is an agile company, will start to produce consumer-helping robots—that is, service robots for the elderly—in the year 2010.)

Finally, an independent study by IDC, Inc., about the justification of business performance management (see Chapter 9) and BI systems indicates that Toyota achieved a 506 percent return on its BI investment. The median return on investment [ROI] for the 43 other Fortune 500 companies that participated in the study was 112 percent.

Sources: Compiled from D. Briody, "Toyota's Business Intelligence: Oh! What a Feeling!" *CIO Insight*, October 1, 2004, and Hyperion Solution Corporation, "Toyota Motor Sales—A Customer White Paper" **hyperion.com/customers/stories/us_toyota_motor.cfm**[2] (accessed March 2006); and **toyota.com** (accessed March 2006).

Questions for the Opening Vignette

1. In what ways did the old information systems create problems for Toyota?
2. What information needs of managers are satisfied by the new BI system? What decisions are satisfied by the BI support?
3. Relate the TLS problem to the supply chain (from factories, to dealers, to consumers).
4. List the decision support tools cited here.
5. What strategic advantage can Toyota derive from this system?
6. Relate Toyota's decision to make consumer-helping robots to the changing business environment.

WHAT WE CAN LEARN FROM THIS VIGNETTE

This vignette illustrates a typical case in which information flow could not meet the needs of managers. Information was late, sometimes inaccurate, and not shared by all. The old system did not meet the needs to make fast decisions, evaluate large amounts of information that was stored in different locations, and collaborate. The solution is a technology called *business intelligence*, which is based on a data warehouse and provides a strategic advantage. The major objective of this book is to show how it is done. In this chapter, we provide a preview of the book.

1.2 CHANGING BUSINESS ENVIRONMENTS AND COMPUTERIZED DECISION SUPPORT

The opening vignette illustrates how a global company excels in the highly competitive automotive market. Toyota, which is known for pioneering manual management techniques, such as just-in-time (JIT) techniques, has moved aggressively to computerized support of its operations. To understand why Toyota and many other companies are embracing computerized support, including business intelligence, we developed a model called the *Business Pressures–Responses–Support Model*, which is shown in Figure 1.1.

THE BUSINESS PRESSURES–RESPONSES–SUPPORT MODEL

The Business Pressures–Responses–Support model, as its name indicates, has three components: business pressures that result from today's business climate, responses (actions taken) by companies to counter the pressures (or to take advantage of the opportunities available in the environment), and computerized support that facilitates the monitoring of the environment and enhances the response actions taken by organizations.

The Business Environment

The environment in which organizations operate today is becoming more and more complex (Huber, 2003). This complexity creates opportunities on one hand and problems on the other. Take globalization as an example. Today, you can easily find suppliers and customers in many countries, which means you can buy cheaper materials

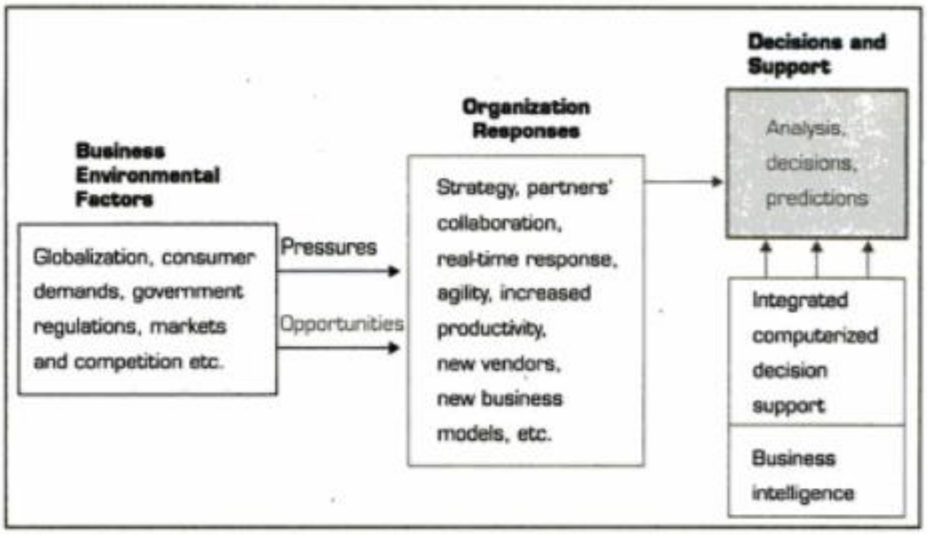


FIGURE 1.1 The Business Pressures–Responses–Support Model

and sell more of your products and services; great opportunities exist. However, globalization also means more and stronger competitors. Business environment factors can be divided into four major categories: *markets*, *consumer demands*, *technology*, and *societal*. These categories are summarized in Table 1.1.

TABLE 1-1 Business Environment Factors That Create Pressures on Organizations

Factor	*Description*
Markets	Strong competition Expanding global markets Blooming electronic markets on the Internet Innovative marketing methods Opportunities for outsourcing with IT support Need for real-time, on-demand transactions
Consumer demands	Desire for customization Desire for quality, diversity of products, and speed of delivery Customers getting powerful and less loyal
Technology	More innovations, new products, and new services Increasing obsolescence rate Increasing information overload
Societal	Growing government regulations and deregulation Work force more diversified, older, and composed of more women Prime concerns of homeland security and terrorist attacks Necessity of Sarbanes-Oxley Act and other reporting-related legislation Increasing social responsibility of companies

Note that the *intensity* of most of these factors increases with time, leading to more pressures, more competition, and so on. In addition, organizations and departments within organizations face decreased budgets and amplified pressures from top managers to increase performance and profit. In this kind of environment, managers must respond quickly, innovate, and be agile. Let's see how they do it.

Organizational Responses: Be Reactive, Anticipative, Adaptive, and Proactive

Both private and public organizations are aware of today's business environment and pressures. They use different actions to counter the pressures. Toyota TLS, for example, turned to BI to improve communication and to support executives in their effort to know exactly what is going on in each area of operation, almost in real-time. TLS also uses its BI system to better collaborate with business partners. By doing so, it can cut expenses and increase customer satisfaction. Managers may take other actions, including the following:

- Employ strategic planning
- Use new and innovative business models
- Restructure business processes
- Participate in business alliances
- Improve corporate information systems
- Improve partnership relationships
- Encourage innovation and creativity
- Improve customer service and relationships
- Move to electronic commerce (e-commerce)
- Move to make-to-order production and on-demand manufacturing and services
- Use new IT to improve communication, data access (discovery of information), and collaboration
- Respond quickly to competitors' actions (e.g., in pricing, promotions, new products and services)
- Automate many tasks of white-collar employees
- Automate certain decision processes, especially those dealing with customers
- Improve decision making

Many, if not all, of these actions require some computerized support.

These and other response actions are frequently facilitated by computerized DSS such as the Toyota TLS BI system.

Closing the Strategy Gap

One of the major objectives of computerized decision support is to facilitate closing the gap between the current performance of an organization and its desired performance, as expressed in its mission, objectives, and goals, and the strategy to achieve them. For details, see Coveney et al. (2003) and the discussion in Chapter 9. In order to understand why computerized support is needed and how it is provided, especially for decision-making support, let's look at managerial decision making.

Section 1.2 Review Questions

1. List the components of and explain the Business Pressures–Responses–Support model.
2. What are the major factors in today's business environment?
3. What are some of the major response activities that organizations take?
4. Define the strategy gap.

1.3 MANAGERIAL DECISION MAKING

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 are often measured by the ratio of outputs to inputs. This ratio is an indication of the organization's *productivity*, which is a reflection of the *organizational and managerial performance*.

The level of productivity or the success of management depends on the performance of managerial functions, such as planning, organizing, directing, and controlling. To perform their functions, managers are engaged in a continuous process of making decisions. Making a decision means selecting the best alternative from two or more solutions.

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*, *informational*, and *decisional* (see Table 1.2).

To perform these roles, managers need information that is delivered efficiently and in a timely manner to personal computers (PCs) on their desktops, to mobile computers, to personal digital assistants (PDAs), and to cell phones. This information is delivered by networks, generally via Web technologies.

In addition to obtaining information necessary to better perform their roles, managers use computers directly to support and improve decision making, which is a key task that is part of most of these roles. Many managerial activities in all roles revolve around decision making. *Managers, especially those at high managerial levels, are primarily decision makers* (see Technology Insights 1.1). Organizations are filled with decision makers at various levels (see Ireland and Miller, 2004).

THE PROCESS OF DECISION MAKING

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

Managers usually make decisions by following a four-step process:

1. Define the problem (i.e., a decision situation that may deal with some difficulty or with an opportunity).
2. Construct a model that describes the real-world problem.
3. Identify possible solutions to the modeled problem and evaluate the solutions.
4. Compare, choose, and recommend a potential solution to the problem.

To follow this process, one must make sure that sufficient alternative solutions are being considered, that the consequences of using these alternatives can be reasonably

TABLE 1.2 Mintzberg's 10 Managerial Roles

Role	*Description*
Interpersonal	
Figurehead	Is symbolic head; obliged to perform a number of routine duties of a legal or social nature
Leader	Is 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
Informational	
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 of this information is factual, and some involves interpretation and integration
Spokesperson	Transmits information to outsiders about the organization's plans, policies, actions, results, and so forth; serves as an expert on the organization's industry
Decisional	
Entrepreneur	Searches the organization and its environment for opportunities and initiates improvement projects to bring about change; supervises design of certain projects
Disturbance handler	Is responsible for corrective action when the organization faces important, unexpected disturbances
Resource allocator	Is responsible for the allocation of organizational resources of all kinds; in effect, is responsible for the making or approval of all significant organizational decisions
Negotiator	Is responsible for representing the organization at major negotiations

Sources: Compiled from H.A. Mintzberg, *The Nature of Managerial Work*. Prentice Hall, Englewood Cliffs, NJ, 1980; and H.A. Mintzberg, *The Rise and Fall of Strategic Planning*. The Free Press, New York, 1993.

predicted, and that comparisons are done properly. However, the environmental factors listed in Table 1.1 make such an evaluation process difficult for the following reasons:

- Technology, information systems, advanced search engines, and globalization result in more and more alternatives from which to choose.
- Government regulations and the need for compliance, political instability and terrorism, competition, and changing consumer demands produce more uncertainty, making it more difficult to predict consequences and the future.

TECHNOLOGY INSIGHTS 1.1

Decision-Making Ability Rated First in Survey

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 were also asked how well, in their estimation, managers performed these practices. From a statistical distillation of the answers it received, 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 *Baseline*, *CIO Insight*, *Forbes*, *Fortune*, or *InformationWeek*. For a specific survey see CIO Research Report, "State of the CIO 2006," *CIO.com*, December 30, 2005. **cio.com/research/surveyreport.cfm?id=101** (accessed September 2006).

- Other factors are the need to make rapid decisions, the frequent and unpredictable changes that make trial-and-error learning difficult, and the potential costs of making mistakes.
- These environments are growing more complex every day. Therefore, making decisions today is indeed a complex task (Huber, 2003).

Because of these trends and changes, it is nearly impossible to rely on a trial-and-error approach to management, especially for decisions for which the factors shown in Table 1.1 are strong influences. Managers must be more sophisticated; they must use the new tools and techniques of their fields. Most of those tools and techniques are discussed in this book. Using them to support decision making can be extremely rewarding in making effective decisions.

In the following section, we look now at why we need computer support and how it is provided.

Section 1.3 Review Questions

1. Describe the three major managerial roles, and list some of the specific activities in each.
2. Why have some argued that management is the same as decision making?
3. Describe the four steps managers take in making a decision.
4. Explain why intuition and trial-and-error approaches to managerial decision making may not be effective in today's business environment.

1.4 COMPUTERIZED SUPPORT FOR DECISION MAKING

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 information technologies, especially Web-based ones.

Computer applications have moved from transaction processing and monitoring activities to problem analysis and solution applications, and much of the activity is done with Web-based technologies (see Geoffrion and Krishnan, 2001). BI tools such as data warehousing, data mining, online analytical processing (OLAP), dashboards, and the use of the Web for decision support are the cornerstones of today's modern management. Managers must have high-speed, networked information systems (wireline or wireless) to assist them with their most important task: making decisions (see Huber, 2003). Let's look at why and how computerized systems can help.

WHY WE USE COMPUTERIZED DECISION SUPPORT SYSTEMS

Today's computerized systems possess capabilities that can facilitate decision support in a number of ways, including the following:

- *Speedy computations*. A computer enables the decision maker to perform many computations quickly and at a low cost. Timely decisions are critical in many situations, ranging from a physician in an emergency room to a stock trader on the trading floor. With a computer, thousands of alternatives can be evaluated in seconds. Furthermore, the benefits-to-cost ratio of computers and the speed of executions are constantly increasing.
- *Improved communication and collaboration*. Many decisions are made today by groups whose members may be in different locations. Groups can collaborate and communicate readily by using Web-based tools. Collaboration is especially important along the supply chain, where partners—all the way from vendors to customers—must share information (recall the Toyota TLS case discussed earlier in this chapter; also see Chapters 10 and 17).
- *Increased productivity of group members*. Assembling a group of decision makers, especially experts, in one place can be costly. Computerized support can improve the collaboration process of a group and enable its members to be at different locations (saving travel costs). In addition, computerized support can increase the productivity of staff support (e.g., financial and legal analysts). Decision makers can also increase their productivity by using software optimization tools that help determine the best way to run a business (see Chapter 4).
- *Improved data management*. Many decisions involve complex computations. Data for these can be stored in different databases anywhere in the organization and even possibly at Web sites outside the organization. The data may include text, sound, graphics, and video, and they can be in foreign languages. It may be necessary to transmit data quickly from distant locations. Computers can search, store, and transmit needed data quickly, economically, securely, and transparently.
- *Managing giant data warehouses*. Large data warehouses, like the one operated by Wal-Mart, contain terabytes and even petabytes of data. Computers can provide extremely great storage capability for any type of digital information, and this information can be accessed and searched very rapidly. Special

methods, including parallel computing, are available to organize, search, and mine the data. The costs related to data warehousing are declining.

- *Quality support.* Computers can improve the quality of decisions made. For example, more data can be accessed, more alternatives can be evaluated, forecasts can be improved, 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 reduced cost. Expertise can even be derived directly from a computer system using artificial intelligence methods (discussed in Chapter 12). With computers, decision makers can perform complex simulations, check many possible scenarios, and assess diverse impacts quickly and economically.
- *Agility support.* Competition today is based not just on price but also on quality, timeliness, customization of products, and customer support. In addition, organizations must be able to frequently and rapidly change their mode of operation, reengineer processes and structures, empower employees, and innovate in order to adapt to their changing environments. Decision support technologies such as intelligent systems can empower people by allowing them to make good decisions quickly, even if they lack some knowledge.
- *Overcoming cognitive limits in processing and storing information.* According to Simon (1977), the human mind has only a limited ability to process and store information. People sometimes find it difficult to recall and use information in an error-free fashion due to their 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. Computerized systems enable people to overcome their cognitive limits by quickly accessing and processing vast amounts of stored information (see Chapter 2).

- *Using the Web.* Since the development of the Internet and Web servers and tools, there have been dramatic changes in how decision makers are supported. Most important, the Web provides (1) access to a vast body of data, information, and knowledge available around the world; (2) a common, user-friendly graphical user interface (GUI) that is easy to learn to use and readily available; (3) the ability to effectively collaborate with remote partners; and (4) the availability of intelligent search tools that enable managers to find the information they need quickly and inexpensively.
- *Anywhere, anytime support.* Using wireless technology, managers can access information anytime and from anyplace, analyze and interpret it, and communicate with those involved.

These and other capabilities have been driving the use of computerized decision support since the late 1960s, but especially since the mid-1990s. Next, we present an early framework for decision support.

Section 1.4 Review Questions

1. How have the capabilities of computing evolved over time?
2. List some capabilities of computing that can facilitate managerial decision making.
3. How can a computer help overcome the cognitive limits of humans?
4. Why is the Web considered so important for decision support?

1.5 AN EARLY FRAMEWORK FOR COMPUTERIZED DECISION SUPPORT

An early framework for computerized decision support includes several major concepts that are used in forthcoming sections and chapters of this book. Gorry and Scott-Morton created and used this framework in the early 1970s, and the framework then evolved into a new technology called DSS.

THE GORRY AND SCOTT-MORTON CLASSICAL FRAMEWORK

Gorry and Scott-Morton (1971) proposed a framework that is a 3-by-3 matrix, as shown in Figure 1.2. Its two dimensions are the degree of structuredness and the types of control.

Degree of Structuredness

The left side of Figure 1.2 is based on Simon's (1977) idea that decision-making processes fall along a continuum that ranges from highly structured (sometimes called *programmed*) to highly unstructured (i.e., *nonprogrammed*) decisions. Structured processes are routine and typically repetitive problems for which standard solution methods exist. *Unstructured processes* are fuzzy, complex problems for

FIGURE 1.2 Decision Support Frameworks

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

which there are no cut-and-dried solution methods. Simon also described the decision-making process with a three-phase process of *intelligence*, *design*, and *choice*. Later, a fourth phase was added: *implementation* (see Chapter 2). The four phases are defined as follows:

1. *Intelligence.* This phase involves searching for conditions that call for decisions.
2. *Design.* This phase involves inventing, developing, and analyzing possible alternative courses of action (solutions).
3. *Choice.* This phase involves selecting a course of action from among those available.
4. *Implementation.* This phase involves adapting the selected course of action to the decision situation (i.e., problem solving or opportunity exploiting).

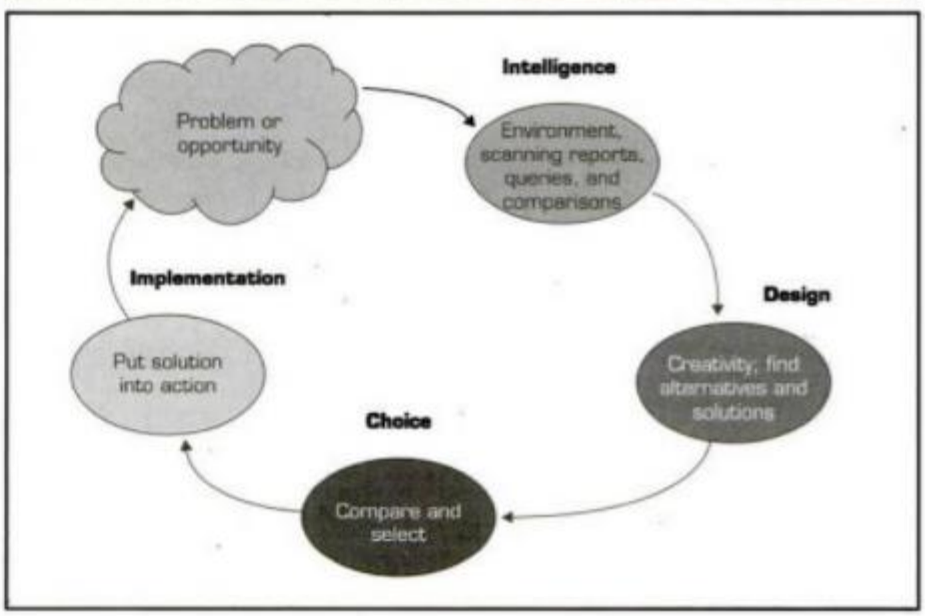
The relationships among the four phases are shown in Figure 1.3.

An *unstructured problem* is one in which none of the four phases described in Figure 1.3 is structured.

In a *structured problem*, all phases are structured. 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.

Semistructured problems fall between structured and unstructured problems, having some structured elements and some unstructured elements. Keen and Scott-Morton (1978) mentioned trading bonds, setting marketing budgets for consumer products, and performing capital acquisition analysis as semistructured problems.

FIGURE 1.3 The Steps of Decision Support



Types of Control

The second half of the Gorry and Scott-Morton framework (refer to Figure 1.2) is based on Anthony's (1965) taxonomy, which defines three broad categories that encompass all managerial activities: *strategic planning*, which involves 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.

The Decision Support Matrix

Anthony's and Simon's taxonomies are combined in the nine-cell decision support matrix shown in Figure 1.2. The initial purpose of this matrix was to suggest different types of computerized support to different cells in the matrix. Gorry and Scott-Morton suggested, for example, that for *semistructured decisions* and *unstructured decisions*, conventional management information systems (MIS) and management science (MS) tools 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 DSS.

Note that the more structured and operational control-oriented tasks (such as those in 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.

COMPUTER SUPPORT FOR STRUCTURED DECISIONS

Computers have supported structured and some semistructured decisions, especially those that involve operational and managerial control, since the 1960s. Operational and managerial control decisions are made in all functional areas, especially in finance and production (i.e., operations) management.

Structured problems, which are encountered repeatedly, have a high level of structure. It is therefore possible to abstract, analyze, and classify them into specific categories. For example, a make-or-buy decision is one category. Other examples of categories are capital budgeting, allocation of resources, distribution, procurement, planning, and inventory control decisions. For each category of decision, an easy-to-apply prescribed model and solution approach have been developed, generally as quantitative formulas. This approach is called *management science*.

Management Science

The **management science (MS)** approach (also called the **operations research [OR]** approach) says that in solving problems, managers should follow the four-step systematic process described in Section 1.3. Therefore, it is possible to use a *scientific approach* to automating portions of managerial decision making.

The MS process adds a new step 2 to the process described in Section 1.3 so that the steps are as follows:

1. Define the problem (i.e., a decision situation that may deal with some difficulty or with an opportunity).
2. Classify the problem into a standard category.
3. Construct a model that describes the real-world problem.
4. Identify possible solutions to the modeled problem and evaluate the solutions.
5. Compare, choose, and recommend a potential solution to the problem.

MS is based on mathematical modeling (i.e., algebraic expressions that describe problems). Modeling involves transforming a real-world problem into an appropriate prototype structure (model). Computerized methodologies can find solutions to the standard category models quickly and efficiently (see Chapter 4). Some of these, such as linear programming, are deployed directly over the Web.

Automated Decision Making

A relatively new approach to supporting decision making is called **automated decision systems (ADS)**, also known as *decision automation systems* (DAS; see Davenport and Harris, 2005). An ADS is a rule-based system that provides a solution, usually in one functional area (e.g., finance, manufacturing), to a specific repetitive managerial problem, usually in one industry (e.g., to approve or not to approve a request for a loan, to determine the price of an item in a store). Application Case 1.2 shows an example of applying ADS.

Application Case 1.2

Intelligent Price Setting Using an ADS

The pricing of several thousand items at Longs Drug Stores (a U.S. chain of about 400 drug stores; **longs.com**) is a decentralized process. Each store is empowered to price each of the items it carries in the store in order to better compete locally. Pricing was traditionally done manually by modifying the manufacturer's suggested retail price. Similar practices existed in most other retail chains, including supermarkets. Furthermore, when a price war occurred, or when a seasonal sales time arrived, prices were slashed across the board, without regard to demand forecast, profitability, pricing strategy, or price consistency across stores.

Today, price setting is undergoing a radical change, largely as a result of improved IT support systems. Following what airlines and automobile leasing companies have done for years, the retail industry, including Longs Drug Stores and about half of all other U.S. retailers, is introducing *price-optimization* programs. These programs—such as those offered by SAS, Inc. (**sas.com**), and others—combine business rules with some calculating algorithms to form a system that automatically recommends a price for each item in each store. The input data used for these programs are seasonal sales figures, actual sales at each store (in real-time), each product's price-demand curve, competitors' prices, profitability metrics, and more. By using an ADS program, a retailer can identify the most price-sensitive products and can test within seconds what impact a price change would probably have on profit margin (or another desired goal, such as sales volume). Each store can use its own priorities, policies, and constraints to develop and test strategies.

Results of using an ADS at Longs Drugs and at other retail stores that have used similar programs show volume, revenue, and profit increases of between 2 and 10 percent. The software is still fairly expensive, so as of 2006, only large retailers could afford to use it. As more competitors produce similar software, however, it will become less expensive, and more stores will use it. Consumers will be the ultimate beneficiaries because they will pay less for items.

Sources: Compiled from A. Cortese, "The Power of Optimal Pricing," *Business 2.0*, September 2002; and **sas.com** (accessed March 2006).

ADS appeared initially in the airline industry, where they were called *revenue* (or *yield*) *management* (or revenue optimization) systems. Airlines attempted to use these systems to dynamically price their tickets depending on actual demand. Today, many service industries use similar pricing models. In contrast with MS, which provides a model-based solution to generic structured problems (e.g., resource allocation, inventory level determination), ADS provide rule-based solutions. The following are examples of business rules: "If only 70 percent of the seats on a flight from Los Angeles to New York are sold three days prior to departure, offer a discount of x percent to nonbusiness travelers," "If an applicant owns a house and makes over $100,000 a year, offer a \$10,000 credit line," and "If an item costs more than \$2,000, and if your company buys it only once a year, the purchasing agent does not need special approval." Such rules, which are based on experience or derived through statistical analysis (see Chapter 13), can be combined with mathematical models to form solutions that can be automatically and instantly applied to problems (e.g., "Based on the information provided and subject to verification, you will be admitted to our university"), or they can be provided to a human, who will make the final decision (see Figure 1.4). ADS attempt to automate highly repetitive decisions (in order to justify the computerization cost), based on business rules. ADS are mostly suitable for frontline employees who can see the customer information online and frequently must make quick decisions. For further information on ADS, see Chapters 6 and 16, and also see Davenport and Harris (2005).

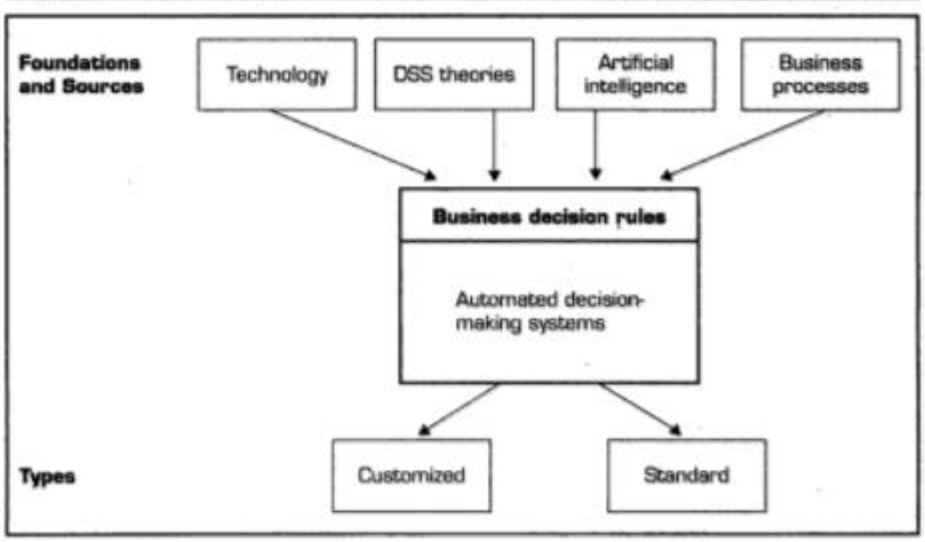
COMPUTER SUPPORT FOR UNSTRUCTURED DECISIONS

Unstructured problems can be only partially supported by standard computerized quantitative methods. It is usually necessary to develop customized solutions. However, such solutions may require certain expertise that can sometimes be provided by intelligent systems (see Chapters 12-14). Intuition and judgment may play a large role in this type of decisions, as may computerized communication and collaboration technologies (see Chapter 10), as well as knowledge management (see Chapter 11).

COMPUTER SUPPORT FOR SEMISTRUCTURED PROBLEMS

Solving semistructured problems may involve a combination of standard solution procedures and human judgment. MS can provide models for the portion of a decision-making problem that is structured. For the unstructured portion, a DSS can improve the quality of the information on which the decision is based by providing, for example, 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.

FIGURE 1.4 Automated Decision-Making Framework



In Chapter 2, we provide a detailed description of how decisions are supported during the major phases of decision making: intelligence, design, choice, and implementation.

THE BENEFITS OF COMPUTERIZED DECISION SUPPORT

The following are some of the main reasons major corporations have developed large-scale computerized decision support:

- Companies work in an unstable or rapidly changing economy.
- The company has difficulty tracking its numerous business operations.
- Competition—especially global competition—has increased.
- E-commerce is changing the ways business is done.
- Existing information systems do not fully support decision making.
- The company's information systems department is too busy to address all of management's inquiries.
- The company needs a special analysis of profitability and efficiency.
- Accurate information is needed.
- Computerized support is viewed as an organizational winner.
- New information is needed.
- Management mandates computerized decision support.
- Higher decision quality is needed.
- The company desires improved communication.
- The company wants improved customer and employee satisfaction.
- Timely information is needed.
- The company wants to reduce costs.
- The company wants to see improved employee productivity.

For an example of how Hallmark Cards is supporting several strategic and operational decisions, see Application Case 1.3.

Application Case 1.3

Decision Support at Hallmark for Better Strategy and Performance

Hallmark Cards exceeds $4 billion a year in sales in more than 42,000 retail outlets across the United States. The company's challenge is to maintain its lead in the competitive greeting card and gift industry. To accomplish this, the company needs to make decisions such as the following:

- Which of more than 40,000 different items to display in each store, when, and how many of each item.
- How to improve item inventory along the supply chain.
- How to reduce production cost.
- How to decide on major new initiatives, such as the launching of the Expressions from Hallmark brand.
- How to design new cards and which design promotes the highest number of sales.
- How to decide on advertising and promotions.
- How to conduct strategic planning.

To make such decisions, Hallmark managers need to have a clear picture of what is going on in the marketplace. They need to analyze sales data by store, by customer segment, by holiday, and so on. The company must be able to understand sales trends and to predict relationships between stores' displays and sales at given locations and times.

To support the decisions, some of which are made by 40,000 store managers, Hallmark Cards is using a computerized decision-making system from MicroStrategy, Inc. (**microstrategy.com**). The system involves BI software, a data warehouse, data mining, and a diversified collection of business analytics tools. In addition to the BI system, some decisions, especially one-time strategic decisions, are supported by MicroStrategy's DSS software.

The Hallmark system allows managers to make more than 1,000 ad hoc queries per week, and it provides faster turnaround of reports on actionable business trends. In addition, product testing time has been reduced through faster analysis of point-of-sale (POS) terminals, helping to eliminate items that are unprofitable or that are less profitable than others. A promotional analysis has been improved, thanks to faster response time (and the resultant improvement recommendations). All this enables more strategically targeted promotion activities.

Sources: Compiled from MicroStrategy, "Success Story: Hallmark Cards, Inc.," **microstrategy.com/Customers/Successes/Hallmark.asp** (accessed March 2006); and TDWI.org, "From Small Pieces to the Big Picture: Hallmark Cards Creates a Flexible IT Infrastructure," *What Works*, Vol. 5, May 1998, **tdwi.org/research/display.aspx?ID=5552** (accessed March 2006).

Another reason for developing managerial computerized decision support is that many managers have low levels of computer and Web literacy. Most managers are not programmers, but they need access to data in an understandable format, and they need to be able to easily manipulate data in meaningful ways. In the following sections, we explore how this is done.

Section 1.5 Review Questions

1. What are structured, unstructured, and semistructured decisions? Provide two examples of each.
2. Define *operational control*, *managerial control*, and *strategic planning*. Provide two examples of each.
3. What are the nine cells of the decision framework? Explain what each is for.
4. How can computers provide support for making structured decisions?
5. Define *automated decision systems (ADS)*.
6. How can computers provide support to semistructured and unstructured decisions?
7. What are some of the drivers and benefits of computerized decision support?

1.6 THE CONCEPT OF DECISION SUPPORT SYSTEMS (DSS)

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

> 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* (MIS) and other terms in the field of IT, is a content-free expression (i.e., it means different things to different people). Therefore, there is no universally accepted definition of DSS. (We present additional definitions in Chapter 3.) Actually, DSS can be viewed as a *conceptual methodology*—that is, a broad, umbrella term. However, some view DSS as a narrower, specific decision support application.

DSS AS AN UMBRELLA TERM

The term *DSS* can be 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. I may have separate support systems 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.

Application Case 1.4 demonstrates some of the major characteristics of the DSS framework. The problem to be solved was unstructured, but the initial analysis was based on the decision maker's structured definition of the situation, using an MS 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. The DSS provided a quick what-if analysis (see Chapter 4). Furthermore, the DSS was flexible and responsive enough to allow managerial intuition and judgment to be incorporated into the analysis.

Application Case 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. The Houston executive vice president who was 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, using a specialized planning language. The results strongly suggested that the project should be accepted.

Then came the real test of the DSS. 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, but we have to get back to our partners with our yes or no decision quickly."

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 executives' '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. (now part of Geac Computer Corporation, Ltd., a Golden Gate Capital Company).

How can a thorough risk analysis, like the one in Application Case 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 and integrate appropriate data and models? We provide answers to these questions in Chapters 3 and 4. The DSS concepts introduced in Chapter 3 provide considerable insights to software vendors that develop decision support tools, to builders that construct specific decision support applications, and to users.

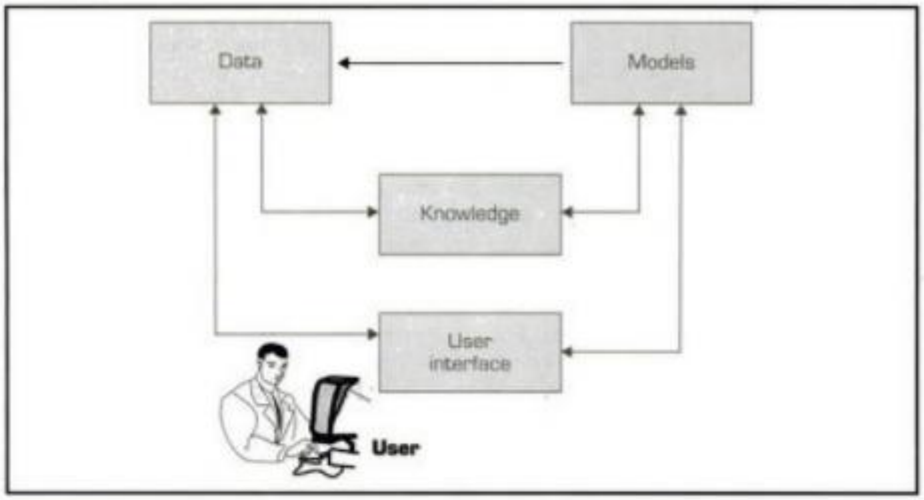


FIGURE 1.5 High-Level Architecture of a DSS

DSS As A Specific Application

While *DSS* usually refers to the umbrella term, some use it in a narrower scope, referring to a process for building customized applications for unstructured or semistructured problems, using the umbrella methodology and concepts. Others use the term *DSS* to refer to the DSS application itself.

The Architecture of DSS

The DSS methodology recognizes the need for data to solve problems. These data can come from many sources, including the Web (see Chapter 5). Every problem that has to be solved and every opportunity or strategy to be analyzed requires some data. Data are the first component of the DSS architecture (see Figure 1.5). Data related to a specific situation are manipulated by using models (see Chapter 2). These models, which are the second component of the DSS architecture, can be standard (e.g., an Excel function) or customized. Some systems have a knowledge (or intelligence) component. This is the third component of the DSS architecture. Users are the vital fourth component of the architecture. Interfacing with the system via a user interface is the fifth component of the DSS architecture.

When creating a DSS, it is important to plan the system and then purchase (or build) the components and "glue" them together. In many DSS, the components are standards and can be purchased. But in other situations, especially unstructured ones, it is necessary to custom build some or all of the components (see Chapter 15). The details of the major components are provided in Chapter 3.

Types Of DSS

There are many types of DSS, with different objectives. The two major types are the *model-oriented DSS*, in which quantitative models are used to generate a recommended solution to a problem, and *data-oriented DSS*, which support ad hoc reporting and queries. For details and other types, see Chapter 3 and the Special Interest Group on Decision Support, Knowledge and Data Management Systems (SIGDSS) Web site, at **sigs.aisnet.org/sigdss**.

CONCLUDING REMARKS

In the early days of DSS, managers let their staff do some supportive analysis by using DSS tools. As PC technology advanced, a new generation of managers evolved—one that was comfortable with computing and knew that technology can directly help them make intelligent business decisions faster. During the 1990s, purchases of commercialized decision support tools grew steadily, with revenues reaching into the low billions of dollars, according to an IDC report from that period (reported in DSStar, 1998). New tools such as OLAP, data warehousing, data mining, and intelligent systems, delivered via Web technology, added promised capabilities and easy access to tools, models, and data for computer-aided decision making. These tools started to appear under the names BI and *business analytics* in the mid-1990s (see Section 1.7). The overall results of using a DSS application can be impressive, as indicated by the Atlantic Electric Company case described in Application Case 1.5.

Application Case 1.5

Helping Atlantic Electric Company Survive in the Deregulated Marketplace

Atlantic Electric Company of New Jersey was losing the monopoly it had 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 surplus capacity to electricity-using companies at low prices. The competitor picked up especially the 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 those customers would be better served by another utility.

To survive, Atlantic Electric 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 applications, in a familiar format, and to do so rapidly and with minimum cost. This required a PC-based DSS, run on the corporate intranet.

The following are some of the DSS applications Atlantic Electric developed:

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

The implementation of these and other decision support applications helped the company survive and successfully compete in its field.

Sources: Compiled from 2000–2003 press releases from the Atlantic Electric Company.

Today, the term *DSS* serves mainly as an umbrella for convening groups of researchers interested in studies related to computer support for decision making (e.g., SIGDSS; **sigs.aisnet.org/sigdss**). It is also used as the name of the leading journal in the field, as well as in the title of academic courses. On the other hand, the term *DSS* is not used much today by vendors who develop managerial decision support tools. Vendors seem to prefer buzzwords or new terms that describe the products more precisely than the term *DSS*. The most popular term used in the industry today in *business intelligence*, the topic we present next.

Section 1.6 Review Questions

1. Provide two definitions of *DSS*.
2. Describe *DSS* as an umbrella term.
3. Describe the architecture of DSS.
4. How is the term *DSS* used in the academic world?

1.7 A FRAMEWORK FOR BUSINESS INTELLIGENCE (BI)

The decision support concepts presented in Sections 1.5 and 1.6 have been implemented incrementally, under different names, by many vendors that have created tools and methodologies for decision support. By 2006, the major *commercial* products and services appeared under the umbrella term *BI*, as used in the Toyota TLS opening vignette.

CHARACTERISTICS OF TOYOTA'S SYSTEM

As you may recall from the opening vignette, Toyota TLS's BI system was driven by the following:

- Too much directionless data, full of errors
- Strong competition in the automotive industry, mostly from Honda
- Problems of communication and coordination along the supply chain
- Departments' inability to share data in a timely manner
- Managers' inability to get information they needed for decision making

Toyota's systems included the following:

- A data warehouse with historical data
- Tools for conducting analysis and data manipulation
- A graphical user interface (i.e., a dashboard), mainly for top managers

As the TLS case indicates, the use of BI solved the company's problems and was an overwhelming success. Let's explore BI and see why it is such a successful technology.

DEFINITIONS OF BI

Business intelligence (BI) is an umbrella term that combines architectures, tools, databases, analytical tools, applications, and methodologies (see Raisinghani, 2004). It is, like DSS, a content-free expression, so it means different things to different people. Part of the confusion about BI lies in the flurry of acronyms and buzzwords that are associated with BI (e.g., business performance management [BPM]). BI's major objective is to enable interactive access (sometimes in real-time) to data, to enable manipulation of data, and to give business managers and analysts the ability to conduct appropriate analysis. By analyzing historical and current data, situations, and performances, decision makers get valuable insights that enable them to make more informed and better decisions (see Zaman, 2005). The process of BI is based on the *transformation* of data to information, then to decisions, and finally to actions. (Details are provided in Chapters 5–7.)

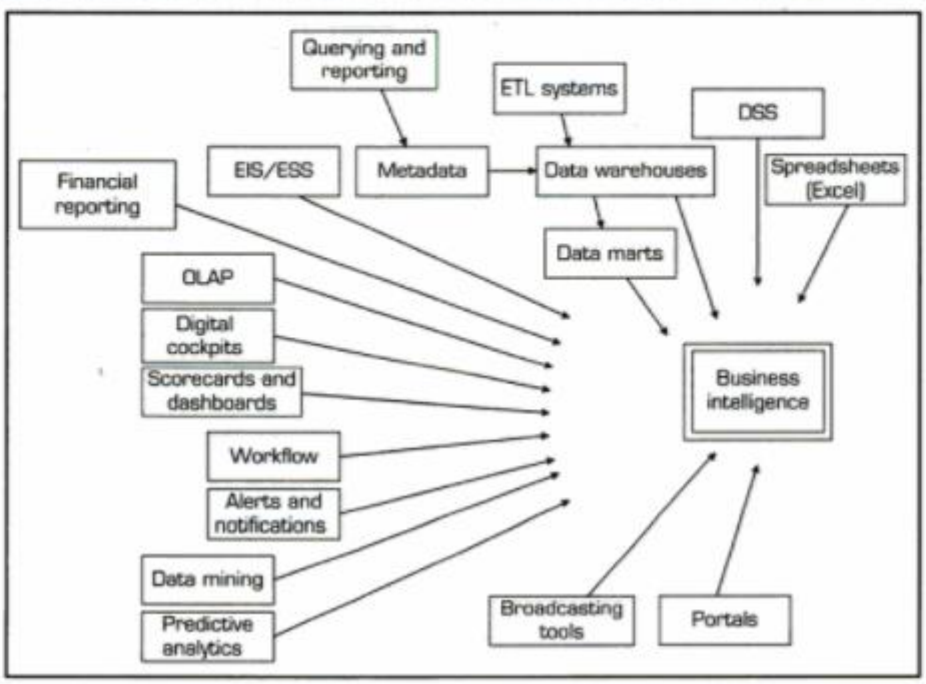
A BRIEF HISTORY OF BI

The term *BI* was coined by the Gartner Group in the mid-1990s. However, the concept is much older; it has its roots in the MIS reporting systems of the 1970s. During that period, reporting systems were static, two dimensional, and had no analytical capabilities. In the early 1980s, the concept of *executive information systems (EIS)* emerged. This concept expanded the computerized support to top-level managers and executives. Some of the capabilities introduced were dynamic multidimensional (ad hoc or on-demand) reporting, forecasting and prediction, trend analysis, drill-down to details, status access, and critical success factors (see Chapter 6). These features appeared in dozens of commercial products until the mid-1990s. Then the same capabilities and some new ones appeared under the name BI. Today, a good BI-based enterprise information system contains all the information executives need. So, the original concept of EIS was transformed into BI. By 2005, BI systems started to include *artificial intelligence* capabilities as well as powerful analytical capabilities. Figure 1.6 illustrates the various tools and techniques that may be included in a BI system. It illustrates the evolution of BI as well. The tools shown in Figure 1.6 provide the capabilities of BI. The most sophisticated BI products include most of these capabilities; others specialize in only some of them. For further details, see Zaman (2005) and Raisinghani (2004).

THE ARCHITECTURE OF BI

As discussed in the opening vignette, a BI system has four major components: a *data warehouse*, with its source data; *business analytics*, a collection of tools for manipulating, mining, and analyzing the data in the data warehouse; *business performance management (BPM)* for monitoring and analyzing performance; and a *user interface* (e.g., a dashboard). The relationship among these components is illustrated in Figure 1.7. For details see Chapter 5–8.

FIGURE 1.6 Evolution of BI



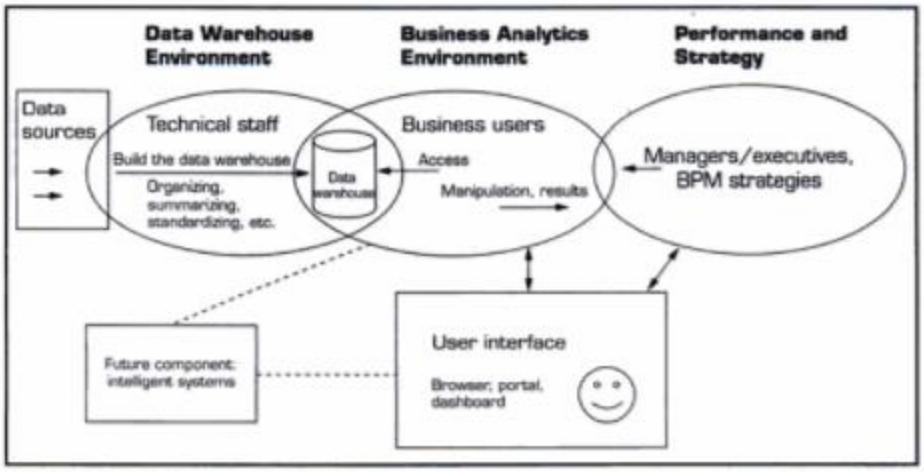


FIGURE 1.7 A High-Level Architecture of BI

Source: Based on W. Eckerson, *Smart Companies in the 21st Century: The Secrets of Creating Successful Business Intelligent Solutions*. The Data Warehousing Institute, Seattle, WA, 2003, p. 32, Illustration 5.

Notice that the data warehousing environment is mainly the responsibility of technical staff, while the analytical environment (also known as *business analytics*) is the realm of business users. Any user can connect to the system via the user interface, such as a browser, and top managers may use the BPM component and also a dashboard.

Some business analytics and user interface tools are introduced briefly in Section 1.9 and in Chapter 6. However, one set of tools, *intelligent systems* (see Chapters 12–14), can be viewed as a futuristic component of BI. According to Zaman (2005), intelligent systems may cause the field's name to be changed to *artificial business intelligence*.

Data Warehousing

The data warehouse and its variants are the cornerstone of any medium-to-large BI system. Originally, the data warehouse included only historical data that were organized and summarized, so end users could easily view or manipulate data and information. Today, some data warehouses include current data as well, so they can provide real-time decision support (see Chapter 5).

Business Analytics

End users can work with the data and information in a data warehouse by using a variety of tools and techniques. These tools and techniques fit into three categories:

1. *Reports and queries.* Business analytics include both static and dynamic reporting, all types of queries, discovery of information, multidimensional view, drill-down to details, and so on. These are presented in Chapter 6.
2. *Advanced analytics.* Advanced analytics include many statistical, financial, mathematical, and other models that are used in analyzing data and information (see Chapter 6).
3. *Data, text, and Web mining, and other sophisticated mathematical and statistical tools.* **Data mining** (described further in Chapter 7) is a process of searching for unknown relationships or information in large databases or data warehouses, using intelligent tools such as *neural computing*, predictive analytics techniques, or

advanced statistical methods (see Chapter 8). For an application in customer relationship management, see Online File W1.1.3. As discussed further in Chapter 7, mining can be done on Web data as well. Two examples of useful applications of data mining follow:

Example 1

National Australia Bank uses data mining to aid its predictive marketing. The tools are used to extract and analyze data stored in the bank's Oracle database. Specific applications focus on assessing how competitors' initiatives are affecting the bank's bottom line. The data mining tools are used to generate market analysis models from historical data. The bank considers initiatives to be crucial to maintaining an edge in the increasingly competitive financial services marketplace.

Example 2

FAI Insurance Group uses its data mining to reassess the relationship between historical risk from insurance policies and the pricing structure used by its underwriters. The data analysis capabilities allow FAI to better serve its customers by more accurately assessing the insurance risk associated with a customer request. Through the use of neural networks and linear statistics, the analysts comb the data for trends and relationships.

Business Performance Management

Business performance management (BPM), which is also referred to as **corporate performance management (CPM)**, is an emerging portfolio of applications and methodology that contains evolving BI architecture and tools in its core (see Hyperion Solution Corporation, 2004). BPM extends the monitoring, measuring, and comparing of sales, profit, cost, profitability, and other performance indicators by introducing the concept of management and feedback. It embraces processes such as planning and forecasting as core tenets of a business strategy. In contrast with the traditional DSS, EIS, and BI, which support the bottom-up extraction of information from data, BPM provides a top-down enforcement of corporate-wide strategy. BPM is the topic of Chapter 9 and is usually combined with the *balanced scorecard methodology* and dashboards.

The User Interface: Dashboards and Other Information Broadcasting Tools

Dashboards (which resemble automobile dashboards) provide a comprehensive visual view of corporate performance measures (also known as key performance indicators), trends, and exceptions. They integrate information from multiple business areas. Dashboards present graphs that show actual performance compared to desired metrics; thus, a dashboard presents an at-a-glance view of the health of the organization. In addition to dashboards, other tools that broadcast information are corporate portals (see Chapter 17), digital cockpits, and other visualization tools (see Chapter 6). Many visualization tools, ranging from multidimensional cube presentation to virtual reality, are integral parts of BI systems. Recall that BI emerged from EIS, so many visual aids for executives were transformed to BI software (see Chapter 6). Also, technologies such as geographical information systems (GIS) play an increasing role in decision support.

STYLES OF BI

The architecture of BI depends on its applications. MicroStrategy Corp. distinguishes five styles of BI and offers special tools for each. The five styles are report delivery and alerting; enterprise reporting (using dashboards and scorecards); cube analysis (also

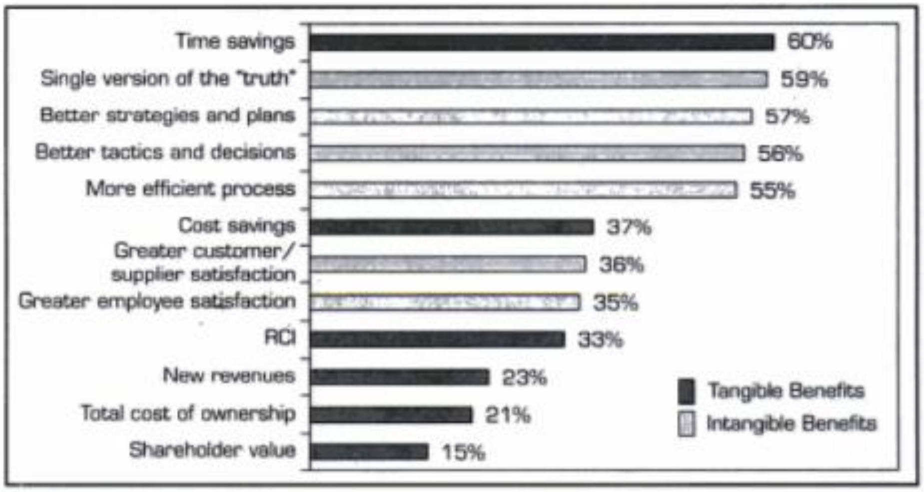


FIGURE 1.8 Benefits of BI

Source: Eckerson (2003)

known as slice-and-dice analysis); ad-hoc queries; and statistics and data mining. For further details, see Chapters 6 and 7, as well as **microstrategy.com**.

THE BENEFITS OF BI

As illustrated by the Toyota TLS case, the major benefit of BI to a company is the ability to provide accurate information when needed, including a real-time view of the corporate performance and its parts. Such information is a must for all types of decisions, for strategic planning, and even for survival (refer to Application Case 1.5). Eckerson (2003) reported the results of a survey of 510 corporations that indicates the benefits as viewed by the participants (see Figure 1.8).

Thompson (2004) reported the following to be the major benefits of BI, based on the results of a survey:

- Faster, more accurate reporting (81 percent)
- Improved decision making (78 percent)
- Improved customer service (56 percent)
- Increased revenue (49 percent)

Notice that many of the benefits of BI are *intangible*. This is why, according to Eckerson (2003), so many executives *do not* insist on a rigorous cost-justification for BI projects (see the detailed discussion in Chapter 15).

Thompson (2004) also noted that the most common application areas of BI are general reporting, sales and marketing analysis, planning and forecasting, financial consolidation, statutory reporting, budgeting, and profitability analysis. An interesting data mining application using *predictive analytics* tools (discussed further in Chapters 6 and 7) is illustrated in Application Case 1.6.

Application Case 1.6

Predictive Analytics Helps Texas Collect Taxes

Tax gaps exist between taxes owed and the amount collected in many public entities. The state of Texas is no exception. To overcome the problems, tax collectors use audits, which are expensive and time-consuming to conduct. Also, many audits are unproductive, resulting in little or no tax recovery. In order to make better decisions on whom to audit (and thus increase the percentage of productive audits), the state of Texas uses predictive analytics.

Millions of records are stored in the state's data warehouse. Using data mining-based software from **spss.com**, Texas can cross-match millions of records to identify promising leads. Specifically, the system has helped identify thousands of businesses that were operating in the state without complying with the tax obligations. Also, it has helped field auditors adopt better audit target selections. When the employees gained confidence in the program, they started to use it extensively, saving over $150 million per year.

Sources: Compiled from L. Gates, "State of Texas Recovers $400 Million Through Predictive Analytics," *ADTmag.com*, May 26, 2005, **adtmag.com/article.asp?id=11214** (accessed March 2006); and "SPSS Predictive Analytics Helps Texas Recover $400 Million in Unpaid Taxes," *Business Intelligence Network*, May 16, 2005. **b-eye-network.com/view/868** (accessed March 2006).

THE DSS–BI CONNECTION

By now, you should be able to see some of the similarities and differences between DSS and BI. First, their architectures are very similar because BI evolved from DSS. However, BI implies the use of a data warehouse, whereas DSS may or may not have such a feature. BI is therefore more appropriate for large organizations (because data warehouses are expensive to build and maintain), but DSS can be appropriate to any type of organization.

Second, most DSS are constructed to *directly* support specific decision making. BI systems, in general, are geared to provide accurate and timely information, and they support decision support *indirectly*. This situation is changing, however, as more and more decision support tools are being added to BI software packages.

Third, BI has an executive and strategy orientation, especially in its BPM and dashboard components. DSS, on the other hand, is oriented toward analysts.

Fourth, most BI systems are constructed with commercially available tools and components that are fitted to the needs of organizations. In building DSS, the interest may be in constructing solutions to very unstructured problems. In such situations, more programming (e.g., using tools such as Excel) may be needed to customize the solutions.

Fifth, DSS methodologies and even some tools were developed mostly in the academic world. BI methodologies and tools were developed mostly by software companies. (See Zaman, 2005, for information on how BI has evolved.)

Sixth, many of the tools that BI uses are also considered DSS tools. For example, data mining and predictive analysis are core tools in both areas.

Although some people equate DSS with BI, these systems are not, at the present, the same. It is interesting to note that some people believe that DSS is a part of BI—one of its analytical tools. Others think that BI is a special case of DSS that deals mostly with reporting, communication, and collaboration (a form of data-oriented DSS). Another explanation (Watson, 2005) is that BI is a result of a continuous revolution and, as such, DSS is one of BI's original elements. In this book, we separate DSS from BI. However, we point to the DSS–BI connection frequently.

Management Support Systems (MSS)

Due to the lack of crisp and universal definitions of DSS and BI, some people refer to DSS and BI, as well as their tools either independently or in combination, as **management support systems (MSS)**. MSS is a broad enough concept to be viewed as a technology that supports managerial tasks in general and decision making in particular. In this book, we use *MSS* when the nature of the technology involved is not clear, and we use it interchangeably with the combined term *DSS/BI*.

In addition to the major frameworks of decision support presented so far, we need to look at a new proposed framework—the *work system*—which we present next.

Section 1.7 Review Questions

1. Define *BI*.
2. List and describe the major components of BI.
3. List and describe the major tangible and intangible benefits of BI.
4. What are the major similarities and differences of DSS and BI?
5. Define *MSS*.

1.8 A WORK SYSTEM VIEW OF DECISION SUPPORT

Claiming that the revolutionary DSS agenda is now "ancient history," Alter (2004), a DSS pioneer, suggested a new approach to managerial decision support. Alter dropped the word *systems* from DSS, focusing on *decision support*, which he defines as the use of any plausible computerized or noncomputerized means for improving decision making in a particular repetitive or nonrepetitive business situation in a particular organization.

By adding noncomputerized means, Alter expanded the landscape of decision support to include nontechnical decision-improvement interventions and strategies. To cope with the possibility of a huge field with many disciplines, Alter postulated that decision support may come from the different aspect of *work systems*. He defined a **work system** as a system in which human participants and/or machines perform a business process, using information, technology, and other resources, to produce products and/or services for internal or external customers. A work system operates within a surrounding environment, often using shared infrastructure, and sometimes within a conscious strategy for the organization or work system. Furthermore, Alter postulated that a work system usually has nine elements. Each of these elements can be varied or modified in order to provide better organizational performance, decision quality, or business process efficiency. The following are the nine elements, along with some possible sources of improvements:

1. *Business process.* Variations in the process rationale, sequence of steps, or methods used for performing particular steps
2. *Participants.* Better training, better skills, higher levels of commitment, or better real-time or delayed feedback
3. *Information.* Better information quality, information availability, or information presentation

4. *Technology.* Better data storage and retrieval, models, algorithms, statistical or graphical capabilities, or computer interaction
5. *Product and services.* Better ways to evaluate potential decisions
6. *Customers.* Better ways to involve customers in the decision process and to obtain greater clarity about their needs
7. *Infrastructure.* More effective use of shared infrastructure, which might lead to improvements
8. *Environment.* Better methods for incorporating concerns from the surrounding environment
9. *Strategy.* A fundamentally different operational strategy for the work system

The work system concept is interesting, and it has considerably expanded the field of managerial decision support. Much more research is needed before this concept can be used as a guide to both the academic and practical worlds.

Now that you are familiar with the major frameworks of the field, we can look at its major tools.

Section 1.8 Review Questions

1. What is Alter's definition of *decision support*?
2. Define *work system*.
3. List the nine elements of a work system.
4. Explain how decision making can be improved by changing an element of a work system.

1.9 THE MAJOR TOOLS AND TECHNIQUES OF MANAGERIAL DECISION SUPPORT

How DSS/BI is implemented depends on which tools are used.

THE TOOLS AND TECHNIQUES

A large number of tools and techniques have been developed over the years to support managerial decision making. Some of them appear under different names and definitions. (For a list of tools and demos, see **dmreview.com/rg/resources/demos.cfm.**) The major computerized tool categories are summarized in Table 1.3. A brief description of each major category is provided in Online File W1.1. Full descriptions are provided in other chapters of this book, as shown in Table 1.3.

THE TOOLS–WEB CONNECTION

All these tools are available today either solely as Web-based versions or in both Web-based and non-Web-based formats. The relationships between these tools and the Web can be viewed as a two-way street. We present the potential impacts of the Web on each of the major categories of tools in Online File W1.3. In that file, we also show the potential impact of each tool on Web technologies. In the following chapters, we provide more details on the tools–Web connection.

TABLE 1.3 Computerized Tools for Decision Support

Tool Category	*Tools and Their Acronyms*	*Chapter in the Book*
Data management	Databases and database management system (DBMS)	3, 5
	Extraction, transformation, and load (ETL) systems	5
	Data warehouses (DW), real-time DW, and data marts	5
Reporting status tracking	Online analytical processing (OLAP)	6
	Executive information systems (EIS)	6
Visualization	Geographical information systems (GIS)	6
	Dashboards	9
	Information portals	17
	Multidimensional presentations	6
Business analytics	Optimization	4
	Data mining, Web mining, and text mining	7, 8
	Web analytics	4, 6
Strategy and performance management	Business performance management (BPM)/Corporate performance management (CPM)	9
	Business activity management (BAM)	9
	Dashboards and scorecards	9
Communication and collaboration	Group decision support systems (GDSS)	10
	Group support systems (GSS)	10
	Collaborative information portals and systems	17
Knowledge management	Knowledge management systems (KMS)	11
	Expert locating systems	11
Intelligent systems	Expert systems (ES)	12
	Artificial neural networks (ANN)	8
	Fuzzy logic	13
	Genetic algorithms	13
	Intelligent agents	13
	Automated decision systems (ADS)	6, 12
Enterprise systems	Enterprise resource planning (ERP), customer relationship management (CRM), and supply-chain management (SCM)	17

HYBRID SUPPORT SYSTEMS

The objective of computerized decision support, regardless of its name or nature, is to assist management in solving managerial or organizational problems (and assess opportunities and strategies) faster and better than possible without computers. To attain this objective, a support system may use several of the tools and techniques mentioned in Table 1.3 in what is known as a **hybrid (integrated) support system**. Every type of tool has certain capabilities and limitations. By integrating several tools, we can improve decision support because one tool can provide advantages where another is weak (see Chapter 16).

Machine repair provides a useful example of a hybrid support system. A repair technician diagnoses a problem and identifies the best tools to make the repair. Although