Simon’s Decision Making

The decision-making process starts with the **intelligence phase**; in this phase, the decision maker examines reality and identifies and defines the problem. *Problem ownership* is established as well. In the **design phase**, a model that represents the system is constructed. This is done by making assumptions that simplify reality and writing down the relationships among all the variables. The model is then validated, and criteria are determined in a principle of choice for evaluation of the alternative courses of action that are identified. Often, the process of model development identifies alternative solutions and vice versa.

The **choice phase** includes selection of a proposed solution to the model (not necessarily to the problem it represents). This solution is tested to determine its viability. When the proposed solution seems reasonable, we are ready for the last phase: implementation of the decision (not necessarily of a system). Successful implementation results in solving the real problem. Failure leads to a return to an earlier phase of the process. In fact, we can return to an earlier phase during any of the latter three phases. The decisionmaking situations described in the opening vignette follow Simon’s four-phase model, as do almost all other decision-making situations.

Web impacts on the four phases, and vice versa

**Simon’s Four Phases of Decision Making and the Web**

|  |  |  |
| --- | --- | --- |
| **Phase** | W**eb Impacts** | **Impacts on the Web** |
| Intelligence | Access to information to identify problems and opportunities rom internal and external data sources  Access to analytics methods to  identify opportunities  Collaboration through group support systems (GSS) and knowledge management systems (KMS) | Identification of opportunities for  e-commerce, Web infrastructure, hardware and software tools, etc.  Intelligent agents, which reduce the  burden of information overload  Smart search engines |
| Design | Access to data, models, and solution methods  Use of online analytical processing (OLAP), data mining, and data warehouses  Collaboration through GSS and KMS Similar solutions available from KMS | Brainstorming methods (e.g., GSS)  to collaborate in Web infrastructure design Models and solutions of Web  infrastructure issues |
| Choice | Access to methods to evaluate the impacts of proposed solutions | Decision support system (DSS) tools,  which examine and establish criteria  from models to determine Web,  intranet, and extranet infrastructure  DSS tools, which determine how  to route messages |
| Implementation | Web-based collaboration tools (e.g., GSS) and KMS, which can assist in implementing decisions  Tools, which monitor the performance of e-commerce and other sites, including intranets, extranets, and  the Internet | Decisions implemented on browser  and server design and access, which ultimately determined how to set up the various components that have evolved into the Internet |

**Decision Making: The Intelligence Phase**

Intelligence in decision making involves scanning the environment, either intermittently or continuously. It includes several activities aimed at identifying problem situations or opportunities. It may also include monitoring the results of the implementation phase of a decision-making process.

**Problem (or Opportunity) Identification**

The intelligence phase begins with the identification of organizational goals and objectives related to an issue of concern (e.g., inventory management, job selection, lack of or incorrect Web presence) and determination of whether they are being met. Problems occur because of dissatisfaction with the status quo. Dissatisfaction is the result of a difference between what people desire (or expect) and what is occurring. In this first phase, a decision maker attempts to determine whether a problem exists, identify its symptoms, determine its magnitude, and explicitly define it. Often, what is described as a problem (e.g., excessive costs) may be only a symptom (i.e., measure) of a problem (e.g., improper inventory levels). Because realworld problems are usually complicated by many interrelated factors, it is sometimes difficult to distinguish between the symptoms and the real problem. New opportunities and problems certainly may be uncovered while investigating the causes of symptoms.

The existence of a problem can be determined by monitoring and analyzing the organization’s productivity level. The measurement of productivity and the construction of a model are based on real data. The collection of data and the estimation of future data are among the most difficult steps in the analysis. The following are some issues that may arise during data collection and estimation and thus plague decision makers:

• Data are not available. As a result, the model is made with, and relies on, potentially

inaccurate estimates.

• Obtaining data may be expensive.

• Data may not be accurate or precise enough.

• Data estimation is often subjective.

• Data may be insecure.

• Important data that influence the results may be qualitative (soft).

• There may be too many data (i.e., information overload).

• Outcomes (or results) may occur over an extended period. As a result, revenues, expenses, and profits will be recorded at different points in time. To overcome this difficulty, a present-value approach can be used if the results are quantifiable.

• It is assumed that future data will be similar to historical data. If this is not the case, the nature of the change has to be predicted and included in the analysis.

When the preliminary investigation is completed, it is possible to determine whether a problem really exists, where it is located, and how significant it is. A key issue is whether an information system is reporting a problem or only the symptoms of a problem. For example, if reports indicate that sales are down, there is a problem, but the situation, no doubt, is symptomatic of the problem. It is critical to know the real problem. Sometimes it may be a problem of perception, incentive mismatch, or organizational processes rather than a poor decision model.

**Problem Classification**

Problem classification is the conceptualization of a problem in an attempt to place it in a definable category, possibly leading to a standard solution approach. An important approach classifies problems according to the degree of structuredness evident in them. This ranges from totally structured (i.e., programmed) to totally unstructured (i.e., un programmed)

**Problem Decomposition**

Many complex problems can be divided into sub problems. Solving the simpler sub problems may help in solving a complex problem. Also, seemingly poorly structured problems sometimes have highly structured subproblems. Just as a semistructured problem results when some phases of decision making are structured whereas other phases are unstructured, so when some subproblems of a decision-making problem are structured with others unstructured, the problem itself is semistructured. As a DSS is developed and the decision maker and development staff learn more about the problem, it gains structure. Decomposition also facilitates communication among decision makers. Decomposition is

one of the most important aspects of the analytical hierarchy process.

**Problem Ownership**

In the intelligence phase, it is important to establish problem ownership. A problem exists in an organization only if someone or some group takes on the responsibility of attacking it and if the organization has the ability to solve it. The assignment of authority to solve the problem is called **problem ownership**. For example, a manager may feel that he or she has a problem because interest rates are too high. Because interest rate levels are determined at the national and international levels, and most managers can do nothing about them, high interest rates are the problem of the government, not a problem for a specific company to solve. The problem companies actually face is how to operate in a high–interest-rate environment. For an individual company, the interest rate level should be handled as an uncontrollable (environmental) factor to be predicted.When problem ownership is not established, either someone is not doing his or her job or the problem at hand has yet to be identified as belonging to anyone. It is then important for someone to either volunteer to own it or assign it to someone.

The intelligence phase ends with a formal problem statement.

**Decision Making: The Design Phase**

The design phase involves finding or developing and analyzing possible courses of action. These include understanding the problem and testing solutions for feasibility. A model of the decision-making problem is constructed, tested, and validated. Let us first define a model.

**Models1**

A major characteristic of a DSS and many BI tools (notably those of business analytics) is the inclusion of at least one model. The basic idea is to perform the DSS analysis on a model of reality rather than on the real system. A *model* is a simplified representation or abstraction of reality. It is usually simplified because reality is too complex to describe exactly and because much of the complexity is actually irrelevant in solving a specific problem.

**Mathematical (Quantitative) Models**

The complexity of relationships in many organizational systems is described mathematically. Most DSS analyses are performed numerically with mathematical or other quantitative

models.

**The Benefits of Models**

We use models for the following reasons:

• Manipulating a model (changing decision variables or the environment) is much

easier than manipulating a real system. Experimentation is easier and does not

interfere with the organization’s daily operations.

• Models enable the compression of time. Years of operations can be simulated in

minutes or seconds of computer time.

• The cost of modeling analysis is much lower than the cost of a similar experiment

conducted on a real system.

• The cost of making mistakes during a trial-and-error experiment is much lower

when models are used than with real systems.

• The business environment involves considerable uncertainty. With modeling, a

manager can estimate the risks resulting from specific actions.

• Mathematical models enable the analysis of a very large, sometimes infinite, number

of possible solutions. Even in simple problems, managers often have a large number of alternatives from which to choose.

• Models enhance and reinforce learning and training.

• Models and solution methods are readily available.

Modeling involves conceptualizing a problem and abstracting it to quantitative and/or qualitative form. For a mathematical model, the variables are identified, and their mutual relationships are established. Simplifications are made, whenever necessary, through assumptions. For example, a relationship between two variables may be assumed to be linear even though in reality there may be some nonlinear effects. A proper balance between the level of model simplification and the representation of reality must be obtained because of the cost–benefit trade-off. A simpler model leads to lower development costs, easier manipulation, and a faster solution but is less representative of the real problem and can produce inaccurate results. However, a simpler model generally requires fewer data, or the data are aggregated and easier to obtain.

The process of modeling is a combination of art and science. As a science, there are many standard model classes available, and, with practice, an analyst can determine which one is applicable to a given situation. As an art, creativity and finesse are required when determining what simplifying assumptions can work, how to combine appropriate features of the model classes, and how to integrate models to obtain valid solutions.

Models have **decision variables** that describe the alternatives from among which a manager must choose (e.g., how many cars to deliver to a specific rental agency, how to advertise at specific times, which Web server to buy or lease), a result variable or a set of result variables (e.g., profit, revenue, sales) that describes the objective or goal of the decision-making problem, and uncontrollable variables or parameters (e.g., economic conditions) that describe the environment. The process of modeling involves determining the (usually mathematical, sometimes symbolic) relationships among the variables.

**Selection of a Principle of Choice**

A **principle of choice** is a criterion that describes the acceptability of a solution approach. In a model, it is a result variable. Selecting a principle of choice is not part of the choice phase but involves how a person establishes decision-making objective(s) and incorporates the objective(s) into the model(s). Are we willing to assume high risk, or do we prefer a low-risk approach? Are we attempting to optimize or satisfice? It is also important to recognize the difference between a criterion and a constraint. Among the many principles of choice, normative and descriptive are of prime importance.

**Normative models** are models in which the chosen alternative is demonstrably the best of all possible alternatives. To find it, the decision maker should examine all the alternatives and prove that the one selected is indeed the best, which is what the person would normally want. This process is basically **optimization**. This is typically the goal of what we call prescriptive analytics (Part IV). In operational terms, optimization can be achieved in one of three ways:

**1.** Get the highest level of goal attainment from a given set of resources. For example, which alternative will yield the maximum profit from an investment of $10 million?

**2.** Find the alternative with the highest ratio of goal attainment to cost (e.g., profit per dollar invested) or maximize productivity.

**3.** Find the alternative with the lowest cost (or smallest amount of other resources) that will meet an acceptable level of goals. For example, if your task is to select hardware for an intranet with a minimum bandwidth, which alternative will accomplish this goal at the least cost?

Normative decision theory is based on the following assumptions of rational decision makers:

• Humans are economic beings whose objective is to maximize the attainment of goals; that is, the decision maker is rational. (More of a good thing [revenue, fun] is better than less; less of a bad thing [cost, pain] is better than more.)

• For a decision-making situation, all viable alternative courses of action and their consequences, or at least the probability and the values of the consequences, are known.

• Decision makers have an order or preference that enables them to rank the desirability of all consequences of the analysis (best to worst).

Are decision makers really rational? Though there may be major anomalies in the presumed rationality of financial and economic behavior, we take the view that they could becaused by incompetence, lack of knowledge, multiple goals being framed inadequately, misunderstanding of a decision maker’s true expected utility, and time-pressure impacts. There are other anomalies, often caused by time pressure.

The idea of “thinking with your gut” is obviously a heuristic approach to decision making. It works well for firefighters and military personnel on the battlefield. One critical aspect of decision making in this mode is that many scenarios have been thought through in advance. Even when a situation is new,

it can quickly be matched to an existing one on‑the-fly, and a reasonable solution can be

obtained (through *pattern recognition*).

**Suboptimization**

By definition, optimization requires a decision maker to consider the impact of each alternative course of action on the entire organization because a decision made in one area may have significant effects (positive or negative) on other areas. Consider, for example, a marketing department that implements an electronic commerce (e-commerce) site. Within hours, orders far exceed production capacity. The production department, which plans its own schedule, cannot meet demand. It may gear up for as high demand as possible. Ideally and independently, the department should produce only a few products in

extremely large quantities to minimize manufacturing costs. However, such a plan might result in large, costly inventories and marketing difficulties caused by the lack of a variety of products, especially if customers start to cancel orders that are not met in a timely way. This situation illustrates the sequential nature of decision making.

A systems point of view assesses the impact of every decision on the entire system. Thus, the marketing department should make its plans in conjunction with other departments. However, such an approach may require a complicated, expensive, timeconsuming analysis. In practice, the MSS builder may close the system within narrow boundaries, considering only the part of the organization under study (the marketing and/ or production department, in this case). By simplifying, the model then does not incorporate certain complicated relationships that describe interactions with and among the other

departments. The other departments can be aggregated into simple model components.Such an approach is called **suboptimization**.

If a suboptimal decision is made in one part of the organization without considering the details of the rest of the organization, then an optimal solution from the point of view of that part may be inferior for the whole. However, suboptimization may still be a very practical approach to decision making, and many problems are first approached from this perspective. It is possible to reach tentative conclusions (and generally usable results) by analyzing only a portion of a system, without getting bogged down in too many details. After a solution is proposed, its potential effects on the remaining departments of the

organization can be tested. If no significant negative effects are found, the solution can be implemented.

Suboptimization may also apply when simplifying assumptions are used in modeling a specific problem. There may be too many details or too many data to incorporate into a specific decision-making situation, and so not all of them are used in the model. If the solution to the model seems reasonable, it may be valid for the problem and thus be adopted.

Suboptimization may also involve simply bounding the search for an optimum (e.g., by a heuristic) by considering fewer criteria or alternatives or by liminating largeportions of the problem from evaluation. If it takes too long to solve a problem, a goodenough solution found already may be used and the optimization effort terminated.

Simulation is probably the most common descriptive modeling method. **Simulation** is the imitation of reality and has been applied to many areas of decision making. Computer and video games are a form of simulation: An artificial reality is created, and the game player lives within it. Virtual reality is also a form of simulation because the environment is simulated, not real. A common use of simulation is in manufacturing. Again, consider the production department of a firm with complications caused by the marketing department. The characteristics of each machine in a job shop along the supply chain can be described mathematically. Relationships can be established based on how each machine physically runs and relates to others. Given a trial schedule of batches of parts, it is possible to measure how batches flow through the system and to use the statistics from each machine. Alternative schedules may then be tried and the statistics recorded until a reasonable schedule is found. Marketing can examine access and purchase patterns on its Web site. Simulation can be used to determine how to structure a Web site for

improved performance and to estimate future purchases. Both departments can therefore use primarily experimental modeling methods.

Classes of descriptive models include the following:

• Complex inventory decisions

• Environmental impact analysis

• Financial planning

• Information flow

• Markov analysis (predictions)

• Scenario analysis

• Simulation (alternative types)

• Technological forecasting

• Waiting-line (queuing) management

A number of nonmathematical descriptive models are available for decision making. A cognitive map can help a decision maker sketch out the important qualitative factors and their causal relationships in a messy decision-making situation. This helps the decision maker (or decision-making group) focus on what is relevant and what is not, and the map evolves as more is learned about the problem.The map can help the decision maker understand issues better, focus better, and reach closure.

Another descriptive decision-making model is the use of narratives to describe a decision-making situation. A *narrative* is a story that helps a decision maker uncover the important aspects of the situation and leads to better understanding and framing. This is extremely effective when a group is making a decision, and it can lead to a more common viewpoint, also called a *frame*.

**Good Enough, or Satisficing**

According to Simon (1977), most human decision making, whether organizational or individual, involves a willingness to settle for a satisfactory solution, “something less than the best.” When **satisficing**, the decision maker sets up an aspiration, a goal, or a desired level of performance and then searches the alternatives until one is found that achieves this level. The usual reasons for satisficing are time pressures (e.g., decisions may lose value over time), the ability to achieve optimization (e.g., solving some models could take a really long time, and recognition that the marginal benefit of a better solution is not worth the marginal cost to obtain it (e.g., in searching the Internet, you can look at only so many Web sites before you run out of time and energy). In such a situation, the decision maker is behaving rationally, though in reality he or she is satisficing. Essentially, satisficing is a form of suboptimization. There may be a best solution, an optimum, but it would be difficult, if not impossible, to attain it. With a normative model, too much computation may be involved; with a descriptive model, it may not be possible to evaluate all the sets of alternatives.

Related to satisficing is Simon’s idea of *bounded rationality*. Humans have a limited capacity for rational thinking; they generally construct and analyze a simplified model of a real situation by considering fewer alternatives, criteria, and/or constraints than actually exist. Their behavior with respect to the simplified model may be rational. However, the rational solution for the simplified model may not be rational for the real-world problem. Rationality is bounded not only by limitations on human processing capacities, but also by individual differences, such as age, education, knowledge, and attitudes. Bounded rationality is also why many models are descriptive rather than normative.This may also explain why so many good managers rely on intuition, an important aspect of good ­decision making.Because rationality and the use of normative models lead to good decisions, it is natural to ask why so many bad decisions are made in practice. Intuition is a critical factor that decision makers use in solving unstructured and semistructured problems. The best decision makers recognize the trade-off between the marginal cost of obtaining further information and analysis versus the benefit of making a better decision. But sometimes decisions must be made quickly, and, ideally, the intuition of a seasoned,

excellent ­decision maker is called for. When adequate planning, funding, or information is not available, or when a decision maker is inexperienced or ill trained, disaster can strike.

**Developing (Generating) Alternatives**

A significant part of the model-building process is generating alternatives. In optimization models (such as linear programming), the alternatives may be generated automatically by the model. In most decision situations, however, it is necessary to generate alternatives manually. This can be a lengthy process that involves searching and creativity, perhaps utilizing electronic brainstorming in a GSS. It takes time and costs money. Issues such as when to stop generating alternatives can be very important. Too many alternatives can be detrimental to the process of decision making. A decision maker may suffer from information overload. Generating alternatives is heavily dependent on the availability and cost of information and requires expertise in the problem area. This is the least formal aspect of **problem solving**. Alternatives can be generated and evaluated using heuristics. The generation of alternatives from either individuals or groups can be supported by electronic brainstorming software in a Web-based GSS. Note that the search for alternatives usually occurs after the criteria for evaluating the alternatives are determined. This sequence can ease the search for alternatives and reduce the effort involved in evaluating them, but identifying potential alternatives can sometimes aid in identifying criteria.

The value of an alternative is evaluated in terms of goal attainment. Sometimes an outcome is expressed directly in terms of a goal. For example, profit is an outcome, profit maximization is a goal, and both are expressed in dollar terms. An outcome such as customer satisfaction may be measured by the number of complaints, by the level of loyalty to a product, or by ratings found through surveys. Ideally, a decision maker would want to deal with a single goal, but in practice, it is not unusual to have multiple goals. When groups make decisions, each group participant may have a different agenda. For example, executives might want to maximize profit, marketing might want to maximize market penetration, operations might want to minimize costs, and stockholders might want to maximize the bottom line. Typically, these goals conflict, so special multiple-criteria methodologies have been developed to handle this.

**Risk**

All decisions are made in an inherently unstable environment. This is due to the many unpredictable events in both the economic and physical environments. Some risk (measured as probability) may be due to internal organizational events, such as a valued employee quitting or becoming ill, whereas others may be due to natural disasters, such as a hurricane. Aside from the human toll, one economic aspect of Hurricane Katrina was that the price of a gallon of gasoline doubled overnight due to uncertainty in the port capabilities, refining, and pipelines of the southern United States. What can a decision maker do in the face of such instability?

However, methodologies for handling extreme uncertainty do exist. For example, a way to make good decisions based on very little information, using an information gap theory and methodology approach. Aside from estimating the potential utility or value of a particular decision’s outcome, the best decision makers are capable of accurately estimating the risk associated with the outcomes that result from making each decision. Thus, one important task of a decision maker is to attribute a level of risk to the outcome associated with each potential alternative being considered. Some decisions may lead to unacceptable risks in terms of success and can therefore be discarded or discounted immediately.

In some cases, some decisions are assumed to be made under conditions of certainty simply because the environment is assumed to be stable. Other decisions are made under conditions of uncertainty, where risk is unknown. Still, a good decision maker can make working estimates of risk. Also, the process of developing BI/DSS involves learning more about the situation, which leads to a more accurate assessment of the risks.

**Scenarios**

A **scenario** is a statement of assumptions about the operating environment of a particular system at a given time; that is, it is a narrative description of the decision-situation setting. A scenario describes the decision and uncontrollable variables and parameters for a specific modeling situation. It may also provide the procedures and constraints for the modeling. Scenarios originated in the theater, and the term was borrowed for war gaming and large-scale simulations. Scenario planning and analysis is a DSS tool that can capture a whole range of possibilities. A manager can construct a series of scenarios (i.e., what-if cases), perform computerized analyses, and learn more about the system and decision making problem while analyzing it. Ideally, the manager can identify an excellent, ­possibly

optimal, solution to the model of the problem.

Scenarios are especially helpful in simulations and what-if analyses. In both cases, we change scenarios and examine the results. For example, we can change the anticipated demand for hospitalization (an input variable for planning), thus creating a new scenario. Then we can measure the anticipated cash flow of the hospital for each scenario. Scenarios play an important role in decision making because they:

• Help identify opportunities and problem areas

• Provide flexibility in planning

• Identify the leading edges of changes that management should monitor

• Help validate major modeling assumptions

• Allow the decision maker to explore the behavior of a system through a model

• Help to check the sensitivity of proposed solutions to changes in the environment,

as described by the scenario

**Possible Scenarios**

There may be thousands of possible scenarios for every decision situation. However, the

following are especially useful in practice:

• The worst possible scenario

• The best possible scenario

• The most likely scenario

• The average scenario

The scenario determines the context of the analysis to be performed.

**Errors in Decision Making**

The model is a critical component in the decision-making process, but a decision maker may make a number of errors in its development and use. Validating the model before it is used is critical. Gathering the right amount of information, with the right level of precision and accuracy, to incorporate into the decision-making process is also critical. Sawyer (1999) described “the seven deadly sins of decision making,” most of which are behavior or information related.

**1.** Define *optimization* and contrast it with *suboptimization*.

**2.** Compare the normative and descriptive approaches to decision making.

**3.** Define *rational decision making*. What does it really mean to be a rational decision maker?

4.Define *scenario*. How is a scenario used in decision making?

**Decision Making: the Choice Phase**

Choice is the critical act of decision making. The choice phase is the one in which the

actual decision and the commitment to follow a certain course of action are made. The

boundary between the design and choice phases is often unclear because certain activi

ties can be performed during both of them and because the decision maker can return

frequently from choice activities to design activities (e.g., generate new alternatives while

performing an evaluation of existing ones). The choice phase includes the search for,

evaluation of, and recommendation of an appropriate solution to a model. A solution to a

model is a specific set of values for the decision variables in a selected alternative. Choices

can be evaluated as to their viability and profitability.

Note that solving a model is not the same as solving the problem the model represents.

The solution to the model yields a recommended solution to the problem. The problem is

considered solved only if the recommended solution is successfully implemented.

Solving a decision-making model involves searching for an appropriate course

of action. Search approaches include **analytical techniques** (i.e., solving a formula),

**algorithms** (i.e., step-by-step procedures), heuristics (i.e., rules of thumb), and blind

searches (i.e., shooting in the dark, ideally in a logical way). These approaches are

examined in Chapter 9.

Each alternative must be evaluated. If an alternative has multiple goals, they must

all be examined and balanced against each other. **Sensitivity analysis** is used to deter

mine the robustness of any given alternative; slight changes in the parameters should

ideally lead to slight or no changes in the alternative chosen. **What-if analysis** is

used to explore major changes in the parameters. Goal seeking helps a manager deter

mine values of the decision variables to meet a specific objective.

**Decision Making: the Implementation Phase**

In *The Prince*, Machiavelli astutely noted some 500 years ago that there was “nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things.” The implementation of a proposed solution to a problem is, in effect, the initiation of a new order of things or the introduction of change. And change must be managed. User expectations must be managed as part of change management.

The definition of *implementation* is somewhat complicated because implementation is a long, involved process with vague boundaries. Simplistically, the **implementation phase** involves putting a recommended solution to work, not necessarily implementing a computer system. Many generic implementation issues, such as resistance to change, degree of support of top management, and user training, are important in dealing with information system supported decision making. Indeed, many previous technologyrelated waves (e.g., business process reengineering (BPR), knowledge management, etc.) have faced mixed results mainly because of change management challenges and issues. Management of change is almost an entire discipline in itself, so we recognize its importance and encourage the readers to focus on it independently. Implementation also includes a thorough understanding of project management. Importance of project management goes far beyond analytics, so the last few years have witnessed a major growth in certification programs for project managers. A very popular certification now is Project Management Professional (PMP).

Implementation must also involve collecting and analyzing data to learn from the previous decisions and improve the next decision. Although analysis of data is usually conducted to identify the problem and/or the solution, analytics should also be employed in the feedback process. This is especially true for any public policy decisions. We need to be sure that the data being used for problem identification is valid. Sometimes people find this out only after the implementation phase. The decision-making process, though conducted by people, can be improved with computer support, which is the subject of the next section.

**How Decisions are Supported**

Databases, data marts, and especially data warehouses are important technologies in supporting all phases of decision making. They provide the data that drive decision making.

**Support for the Intelligence Phase**

The primary requirement of decision support for the intelligence phase is the ability to scan external and internal information sources for opportunities and problems and to interpret what the scanning discovers. Web tools and sources are extremely useful for environmental scanning. Web browsers provide useful front ends for a variety of tools, from OLAP to data mining and data warehouses. Data sources can be internal or external. Internal sources may be accessible via a corporate intranet. External sources are many and varied.

Decision support/BI technologies can be very helpful. For example, a data warehouse can support the intelligence phase by continuously monitoring both internal and external information, looking for early signs of problems and opportunities through a Web-based enterprise information portal (also called a dashboard). Similarly, (automatic) data (and Web) mining (which may include expert systems [ES], CRM, genetic algorithms, neural networks, and other analytics systems) and (manual) OLAP also support the intelligence phase by identifying relationships among activities and other factors. Geographic information systems (GIS) can be utilized either as stand-alone systems or integrated with

these systems so that a decision maker can determine opportunities and problems in a spatial sense. These relationships can be exploited for competitive advantage (e.g., CRM identifies classes of customers to approach with specific products and services). A KMS can be used to identify similar past situations and how they were handled. GSS can be used to share information and for brainstorming.

Another aspect of identifying internal problems and capabilities involves monitoring the current status of operations. When something goes wrong, it can be identified quickly and the problem can be solved. Tools such as business activity monitoring (BAM), business process management (BPM), and product life-cycle management (PLM) provide such capability to decision makers. Both routine and ad hoc reports can aid in the intelligence phase. For example, regular reports can be designed to assist in the problem-finding activity by comparing expectations with current and projected performance. Web-based OLAP tools are excellent at this task. So are visualization tools and electronic document

management systems.

Expert systems (ES), in contrast, can render advice regarding the nature of a problem, its classification, its seriousness, and the like. ES can advise on the suitability of a solution approach and the likelihood of successfully solving the problem. One of the primary areas of ES success is interpreting information and diagnosing problems. This capability can be exploited in the intelligence phase. Even intelligent agents can be used to identify opportunities.

The Internet and advanced database technologies have created a glut of data and information available to decision makers—so much that it can detract from the quality and speed of decision making. It is important to recognize some issues in using data and analytics tools for decision making. First, to paraphrase baseball great VinScully, “data should be used the way a drunk uses a lamppost. For support, not for illumination.” It is especially true when the focus is on understanding the problem. We should recognize that not all the data that may help understand the problem is available. To quote Einstein, “Not everything that counts can be counted, and not everything that can be counted counts.” There might be other issues that have to be recognized as well.

**Support for the Design Phase**

The design phase involves generating alternative courses of action, discussing the criteria for choices and their relative importance, and forecasting the future consequences of using various alternatives. Several of these activities can use standard models provided by a DSS (e.g., financial and forecasting models, available as applets). Alternatives for structured problems can be generated through the use of either standard or special models.

However, the generation of alternatives for complex problems requires expertise that can be provided only by a human, brainstorming software, or an ES. OLAP and data mining software are quite useful in identifying relationships that can be used in models. Most DSS have quantitative analysis capabilities, and an internal ES can assist with qualitative methods as well as with the expertise required in selecting quantitative analysis and forecasting models. A KMS should certainly be consulted to determine whether such a problem has been encountered before or whether there are experts on hand who can provide quick understanding and answers. CRM systems, revenue management systems, ERP, and SCM systems software are useful in that they provide models of business processes that can test assumptions and scenarios. If a problem requires brainstorming to help identify important issues and options, a GSS may prove helpful. Tools that provide cognitive mapping can also help. Cohen et al. (2001) described several Web-based tools that provide decision support, mainly in the design phase, by providing models and reporting of alternative results. Each of their cases has saved millions of dollars annually by utilizing these tools. Such DSS are helping engineers in product design as well as decision makers solving business problems.

**Support for the Choice Phase**

In addition to providing models that rapidly identify a best or good-enough alternative, a DSS can support the choice phase through what-if and goal-seeking analyses. Different scenarios can be tested for the selected option to reinforce the final decision. Again, a KMS helps identify similar past experiences; CRM, ERP, and SCM systems are used to test the impacts of decisions in establishing their value, leading to an intelligent choice. An ES can be used to assess the desirability of certain solutions as well as to recommend an appropriate solution. If a group makes a decision, a GSS can provide support to lead to consensus.

**Support for the Implementation Phase**

This is where “making the decision happen” occurs. The DSS benefits provided during implementation may be as important as or even more important than those in the earlier phases. DSS can be used in implementation activities such as decision communication, explanation, and justification.

Implementation-phase DSS benefits are partly due to the vividness and detail of analyses and reports. For example, one chief executive officer (CEO) gives employees and external parties not only the aggregate financial goals and cash needs for the near term, but also the calculations, intermediate results, and statistics used in determining the aggregate figures. In addition to communicating the financial goals unambiguously, the CEO signals other messages. Employees know that the CEO has thought through the assumptions behind the financial goals and is serious about their importance and attainability. Bankers and directors are shown that the CEO was personally involved in analyzing cash needs and is aware of and responsible for the implications of the financing requests prepared by the finance department. Each of these messages improves decision implementation in some way.

As mentioned earlier, reporting systems and other tools variously labeled as BAM, BPM, KMS, EIS, ERP, CRM, and SCM are all useful in tracking how well an implementation is working. GSS is useful for a team to collaborate in establishing implementation effectiveness. For example, a decision might be made to get rid of unprofitable customers. An effective CRM can identify classes of customers to get rid of, identify the impact of doing so, and then verify that it really worked that way.

All phases of the decision-making process can be supported by improved communication through collaborative computing via GSS and KMS. Computerized systems can facilitate communication by helping people explain and justify their suggestions and opinions.

Decision implementation can also be supported by ES. An ES can be used as an advisory system regarding implementation problems (such as handling resistance to change). Finally, an ES can provide training that may smooth the course of implementation. Impacts along the value chain, though reported by an EIS through a Web-based enterprise information portal, are typically identified by BAM, BPM, SCM, and ERP systems. CRM systems report and update internal records, based on the impacts of the implementation. These inputs are then used to identify new problems and opportunities—a return to

the intelligence phase.