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A Framework for Computer Support in Managerial Decision Making

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ABSTRACT

As with many growing computer areas, the first attempts at developing a framework for the field were based on the software tools being built and the specific tasks undertaken. This paper attempts to draw decision support systems out of these early stages by proposing a more generally applicable framework for computer decision support.

To build this framework, the paper first examines existing dimensions in decision support system frameworks and evaluates them both in their ability to facilitate communication among researchers and designers. The dimension degree of decision structure (unstructured vs structured) is borrowed from existing frameworks and incorporated into a new framework along with the dimension phase of decision making process (intelligence, design, and choice). The proposed framework is then evaluated by the same two criteria used earlier in the paper.

Introduction

Computer decision support refers to the aid provided by computers in human decision making. This aid or support is possible because decision making is an information processing task and computers perform a large variety of certain kinds of information processing tasks more effectively than humans. The purpose of this paper is two-fold: first, to lay out and critique existing dimensions used for categorizing computer decision support systems and, second, to present a new framework for computer support in managerial decision making combining two dimensions.

The term "decision support systems" is widely used and has been applied to a large variety of computer systems that support decision making in many different ways. Researchers in the field have built frameworks for classifying decision support systems (Gorry and Scott Morton, 1971; Alter, 1977), for developing decision support systems (Sprague, 1980), and for research in computer-based management information systems (Mason and Mitroff, 1973; Nolan and Wetherbe, 1980; Ives, Hamilton and Davis; 1980). By analyzing these frameworks, we built a new structure for classifying computer decision support.

Our framework has two specific objectives. First, to facilitate communication among researchers and practitioners about new computer systems available for decision support. Second, to aid the designer of computer decision support systems in the selection of tools and methodologies at the early stages of the design process when the decision problem is being understood. The paper critiques the above decision support systems frameworks by analyzing their classification dimensions and then showing that they did not achieve our objectives.

Our framework classifies computer decision support based on the characteristics of the decision activity being supported. Therefore, it attempts to incorporate the research findings of the last two decades about problem solving and decision making (Newell and Simon, 1972; Simon, 1973; Simon, 1977). It pays special attention to the findings about decision making with regards to ill-structured problems (Aguilar, 1967; Mintzberg, 1973; Mintzberg, Raisinghani, and Theoret, 1976; Brightman, 1978).

Evalution Criteria

Two criteria will be used for evaluating decision support classification dimensions:

1. Communication facilitation

2. Design aid and guidance

These criteria were selected to achieve our framework objectives.

COMMUNICATION FACILITATION

One of the purposes of a decision support framework should be to provide a theoretical background for understanding the different meanings of computer support. It is difficult to achieve any scientific progress if we cannot communicate with each other. Education is facilitated by agreeing on what we know and by consolidating our present knowledge about a particular subject. Research is promoted by discovering those areas where little progress has been made and by predicting the probability of success in those areas under different technological and scientific advances.

In order to facilitate communication among researchers and practitioners and between the two groups, a classification dimension has to be selected taking into account the communication needs of both groups. Some of the features that the dimensions and the framework itself should exhibit for achieving this objective are:

1. Acceptance-Researchers demand that classification dimensions have a solid scientific consensus. They would accept a dimension if it is widely accepted in the decision making literature. Acceptance will come from practitioners only if the dimensions can help in understanding the differences among decision support designs. This allows them to understand the limitations of tools and methodologies.

2. Precision-Both researchers and practitioners prefer dimensions that classify decision support into unambiguous categories. This includes the ease with which computer-supported decision activities can be classified within a dimension.

3. Generality-The dimensions should also be capable of categorizing all types of computer decision support presently implemented, and types of decision support that will be available in the near future. This would facilitate the task of communicating new designs to both researchers and practitioners.

4. Parsimony-Besides having the previous features, both groups, but especially the practitioners, demand simplicity. The framework should be kept as simple as possible by reducing its number of dimensions to the minimum (without compromising previously stated requirements). In the case of a large overlap between the categories of two acceptable dimensions, one or both of the dimensions should be reworked to select more succint and restricting criteria. The inclusion of overlapping dimensions in the framework would not add substantial discrimination power to the overall classification, but only make the framework more complex. A deeper review of the classification scheme may show that the two dimensions are actually the same or that their main features are heavily correlated.

DESIGN AID AND GUIDANCE

Classification dimensions should also be evaluated by their contribution to the design of decision support systems by:

1. Providing guidelines on how to approach the design phase at the early stages: this implies guidelines on what evidence to look for and where. For example, a dimension that classifies decision support into two categories that require two completely different types of design features is very useful because it reduces the search for tools and methodologies. A dimension with this characteristic encourages the designer to gather specific data about the support needed before selecting among the large number of vailable tools and methodologies.

2. Identifying implementation problems of decision support categories. By classifying decision support systems into homogeneous groups we can discover the nature of their common implementation difficulties and possibly recommend solutions to these difficulties.

Current Dimensions and Their Critiques

This section presents dimensions used to classify decision support systems and provides a critical analysis of their strengths and shortcomings based on the evaluation criteria presented in the previous section.

The dimensions to be analyzed were not originally developed for the specific purpose of classifying decision support, except in the case of Alter (1977). They were developed for classifying decision making in general, but they have been used in information systems frameworks (Mason and Mitroff, 1973) and in decision support frameworks (Gorry and Scott Morton, 1971). The dimensions to be studied are:

1. Degree of decision determination by system outputs.

2. Degree of decision structure.

3. Level of managerial activity.

In the remainder of this section, each dimension will be evaluated as a candidate for classifying decision support using the two evaluation criteria.

DEGREE OF DECISION DETERMINATION BY SYSTEM OUTPUTS

This dimension was developed by Alter (1976, 1977, 1980) and was used as the only dimension in his decision support systems framework. The dimension categorizes computer decision support by "the degree of action implication of system outputs (i.e. the degree to which the system's outputs could directly determine the decision). This is related to a spectrum of generic operations which can be performed by decision support systems. These generic operations extend along a single dimension from extremely data oriented to extremely model oriented," (1977, p. 197).

Alter identifies seven types of support along this dimension ranging from systems that only retrieve data (data drawer systems) to systems that give the "answer" to the decision problem (suggestion models). Alter's dimension classifies systems according to the operations which can be performed by the system. The dimension is closely related to the type of software tool used in the system. The seven categories can be reclassified into four according to the tools used in each category. The first three categories use data manipulation tools such as data retrieval systems, statistical packages, graphics, etc. The fourth category relies on financial planning tools. The fifth on simulation techniques. The last two categories may be described as using operations research/management science tools. This dimension is evaluated according to our two evaluation criteria.

Communication Facilitation

The degree of decision determination dimension divides computer systems for decision support into unambiguous categories. Knowing the software tool used in the computer system, the decision of classifying the system can easily be made. But this is only true if the software tools used in the system have been located in the spectrum between extremely data oriented to extremely model oriented. Alter's framework only identifies seven categories along this spectrum as a result of analyzing a sample of decision support systems. The problem is that new computer decision support designs have been created since then and will continue to be invented and it is not evident how to classify them in the spectrum. For example, where in the spectrum do we classify a decision support system using an expert system as its main software tool? Is this system more towards the data oriented or the model oriented extreme?

This dimension is not a dimension accepted in the management literature for classifying decision making. A similar tool classification was developed by the operations research field (Ackoff and Sasleni, 1968; Rivett, 1972) and was heavily criticized because of the lack of attention given to the problems faced by the decision maker. Many authors blamed this tool classification for some of the early disasters of using operations research/management science tools.

Design Aid and Guidance

The main problem with this dimension is the limited help provided for the design of decision support systems. The dimension focuses on the tools used in the computer systems but it does not advise on how to select among them for supporting different decision making needs. Alter suggests that "a system designer might attempt to *sketch out a system of each type as a potential solution to the system design problem,* and would then combine the most useful features of each solution into his final design," (1977, p. 206). This is nearly equivalent to designing the system without these guidelines. A better approach may be to use dimensions to categorize decision making activities and then to recommend design requirements for each decision activity category. This is the approach we take in the proposed framework.

This classification dimension was not selected to be used in the proposed framework. The main problems of the dimension, according to our evaluation criteria, are that it does not provide guidance on how to approach the design phase at the early stages and it does not provide guidelines on how to classify decision support designs that do not use tools presented in Alter's framework.

DEGREE OF DECISION STRUCTURE

The degree of structure dimension was first formally stated by Simon (1977) who distinguished between programmed and nonprogrammed decisions. We have selected the more elaborated definition put forth by Mason and Mitroff (1973) in their framework for research on management information because it fits our discussion purposes better.

According to their definition, problems can be classified into two main categories: unstructured and structured. They also lay out three kinds of structured decision problems: structured decisions under certainty, under risk, and under uncertainty. In order to explain the differences, a definition of the decision process is presented.

Mason and Mitroff defined the decision process as the process of choosing among a set of acts that in some sense optimize the utility of the decision maker. Utility is determined by the outcomes of solving the problem and the outcomes depend on the actions selected.

Unstructured decision problems are those for which one or more of the following sets of information are unknown: actions to be taken, possible outcomes, and the utility of those outcomes. The difficulties with unstructured decision problems are in defining the nature of the problem, investigating the problem solution space, or assessing utilities for different outcomes.

If the set of actions to be taken, the possible outcomes produced by these actions, and the utilities assigned to these outcomes are all known, then this is called a structured problem. The differences between the three kinds of structured problems are the uncertainty of outcomes for each action taken and the probabilities of the occurrence of each outcome. The degree of structure dimension is evaluated below according to our two criteria.

Communication Facilitation

The dimension has been used by frameworks that categorize information systems or decision support systems and is widely accepted in the managerial decision making literature. Even when the definition of the decision process presented above is not accepted, researchers and practitioners find it useful to talk about unstructured and structured problems.

The categories produced by this definition are unambiguous if the characteristics of the decision activity are known. These characteristics should be identified during the process of analyzing the existing or potential decision problem. But the unstructured decision category contains a large number of decision activities that seem to require more detailed categorization. For example, the decision activities (and therefore, the computer support needed) are different depending on which decision components are unknown. The computer support needed when the actions to be taken are not known, is different from the computer support needed when the unknown information is the utilities of the decision outcomes.

Design Aid and Guidance

This classification aids the designer in understanding the usefulness of different computer support designs. There is a sharp difference in the nature of the support needed when the problem is unstructured vs. structured. In unstructured problems support is needed for assessing the problem, in structured problems support is required for solving the problem. This distinction will be further explained when the proposed framework is presented.

The degree of decision structure dimension provides guidelines on what evidence to look for and where to look for it at the early stages of the design phase. Using this dimension the designer is guided to analyze the decision activity before selecting tools. The designer may also reduce the number of tools to choose from by determining the category of the decision activity. This is because some tools are better suited for one category than for others. For example, artificial intelligence tools are best suited for unstructured problems where they can provide support by suggesting courses of actions and/or by evaluating the logical arguments of already proposed actions.

Although classifying decision support by the degree of decision structure may provide some aid in identifying technical implementation problems, the scientific literature identifies organizational variables as the main determinants of implementation success (Keen, 1981; Markus, 1983(a); Markus, 1983(b); Robey and Markus, 1984). Therefore, this dimension alone does not dramatically improve our predictions about implementation problems.

Overall, this dimension provides indispensable information about the nature of the decision activity to be supported. For example, a structured decision problem under certainty may need support to identify when the decision has to be made or to evaluate the utility of different actions, but it does not require support for defining the causal links between actions and outcomes because they are known. On the other hand, a structured decision problem under uncertainty may require computer support to estimate the probabilities of the outcomes of an action. Researchers and practitioners can more easily identify the objectives of a decision support design given that the decision problem is categorized in this dimension.

The dimension is also a determining factor to be taken into account at the early stages of the design of computer support because of the need to know the objectives of the system before the design is started. Therefore, the dimension should be a strong candidate to be incorporated into any decision support framework and is one of the dimensions in the proposed framework.

LEVEL OF MANAGERIAL ACTIVITY

This is another often-used dimension for classifying decision activities. The dimension was first proposed by Anthony (1965). He laid out three levels of managerial activity: strategic planning, management control, and operational control. Strategic planning is the process of setting objectives for the organization and of setting policies to acquire, use, and dispose of resources to attain the objectives. Management control refers to the monitoring process for the acquisition, use, and disposal of resources. Operational control means assuring that tasks are carried out effectively.

Each activity uses different types of information, for example, strategic planning requires more external information than operational control. This implies that computer support for the strategic level either allows for the manual inclusion of external information or in some way is connected to such external information via data communications facilities. In contrast, computer support for the operational control level can be based on day-to-day information gathered internally. Furthermore, the aggregation and presentation of both types of information is quite different for each level of managerial activity.

Communication Facilitation

This dimension is widely accepted in the management literature. Anthony recognizes that the boundaries between these three categories are often not clear. Our main objection against incorporating this dimension into the proposed framework is the substantial overlap that its categories have with the categories produced by the previously discussed dimension of decision structure. The continuum between strategic planning and operational control often conveys the same information that the continuum between unstructured decisions and structured decisions conveys in terms of the type of support required. This occurs because most strategic planning decisions are unstructured decisions and most operational control decisions are structured decisions. The two dimensions are not equivalent, but are heavily correlated. The degree of decision structure dimension is concerned with the characteristics of the decision activity per se while the level of managerial activity dimension focuses on the organizational level where the decision is made. It just happens that the characteristics of the decision activity are largely determined by the level where the decision is made.

This overlap is found in the framework developed by Gorry and Scott Morton (1971). That framework classifies computer support by using both dimensions. The result is that most decision support systems fall nicely along the diagonal of the framework's categories: unstructured-strategic planning, semistructured-management control and structured-operational control. At the same time the framework struggles to find examples of structured and strategic planning decision problems or examples of unstructured and operational control decision problems.

Design Aid and Guidance

The evaluation of the level of managerial activity dimension, under this criteria, is similar to that for the degree of the decision structure dimension-except for the guidelines provided on how to approach the design phase at the early stages. This dimension encourages the designer to identify the managerial level at which the decision is being made while the degree of decision structure dimension structure dimension leads the designer to immediately analyze the nature of the decision activity.

The framework to be proposed uses the degree of decision structure instead of the level of managerial activity. The main reason for this is that the categories of decision structure offer more precision, which facilitates the classification process. The proposed framework draws some of its properties from the classification advantages of the degree of structure dimension as discussed in this section and adds new properties by using a second dimension: the phase of the decision making process being supported. It was decided not to critique this last dimension here, but to present the framework and then to evaluate the classification produced by both dimensions in the next section.

There are many other dimensions to be considered. The best candidates are user and organizational dimensions. These dimensions constitute the environment where the decision is being made: the characteristics of the decision maker (i.e., cognitive style), and the characteristics of the organization (i.e., organizational goals, structure, management philosophy). The problem with these dimensions is that either they are an unsatisfactory basis for deriving design guidelines or there is not enough empirical research to assess their importance individually. For example, the best researched decision maker characteristic has been cognitive style. This dimension was included in an information system framework (Mason and Mitroff, 1973) identified as significant for explaining implementation success (Zmud, 1979). After a certain amount of research there is evidence for dismissing the importance of cognitive style in the design of computer decision support (Huber, 1983). In the case of organizational dimensions there is a need for more empirical research. But, as previously mentioned, they have been identified as playing an important role for explaining information systems implementation success (Markus, 1983(a); 1983(b)). Taking into account these considerations we decided that our framework objectives are best achieved with the two dimensions already selected.

Proposed Framework

The objectives of the framework are 1) to be a useful communication vehicle among researchers and practitioners, and 2) to guide the decision support designer in the early stages of the design process. The framework focuses on the analysis of the characteristics of the decision activity that is receiving computer support. This perspective makes it possible to accomplish most of the goals of both objectives as will be shown after the framework is presented. Before presenting the framework, the second dimension of the framework (the phase of the decision making process) is defined.

Research on human decision making supports Simon's claim that decision making can be broken into three phases: "[T]he first phase of the decision-making process—searching the environment for conditions calling for decision—I shall call intelligence activity (borrowing the military meaning of intelligence). The second phase—inventing, developing, and analyzing possible courses of action—I shall call design activity. The third phase—selecting a particular course of action from those available—I shall call choice activity," (Simon, 1977, pp. 40-41).

There is one problem when using this dimension as a classification; the interweaving of the phases. Simon describes this penomenon as "[G]enerally speaking, intelligence activity precedes design, and design activity precedes choice. The cycle of phases is, however, far more complex than this sequence suggests. Each phase in making a particular decision is itself a complex decision-making process. The design phase, for example, may call for new intelligence activities; problems at any given level generate subproblems that, in turn, have their intelligence, design, and choice phases, and so on. There are wheels within wheels within wheels," (1977, p. 41).

But at the same time he states that "the three major phases are often clearly discernable as the organizational decision process unfolds. They are closely related to the stages in problem solving first described by John Dewey: What is the problem? What are the alternatives? Which alternative is best?" (1977, p. 43).

Using this dimension challenges the idea that decision support should be provided for the whole decision process (Sprague, 1980). Mintzberg (1976) shows that often the decision problem is localized in one of the phases, even in the case of unstructured problems. For example, he found decision problems that were difficult to recognize (intelligence phase) because no crisis was present. But after the problem was identified the other two phases were easily solved because the managers used a ready-made solution. In this situation support is only needed for the first phase. Another example is a case where the situation is understood, the alternative actions are perfectly defined and the problem is selecting the best choice because there are a great number of alternatives or because it is difficult to evaluate them. These problems only require computer support for the choice phase. In fact, existing decision support systems often support only one or two of the three phases (as will be shown when the framework categories are presented).

Using this dimension the framework implicitly proposes that the design of decision support systems should be approached by recognizing which decision phases required support and then by assessing the economic feasibility of providing it for each phase selected.

The framework defines twelve categories for classifying computer decision support as the result of having three decision phases and four degrees of decision structure (one unstructured and three structured: under certainty, under risk, and under uncertainty). Although there is some evidence that the unstructured decision categories require subdivision (Brightman, 1978), a better understanding of unstructured decision differences is needed to make a reliable sub-categorization. Figure 1 shows the 12 different categories. Note that "design phase" has been renamed to "development phase" in order to avoid naming confusion in the framework evaluation.

The reader should note that the categories do not classify decision support *systems*, but decision support. Decision support systems may provide support for more than one category because the designer may decide to provide support for more than one decision phase.

A Classification of Decision Support Systems in the Proposed Framework

In the text which follows, examples of computer support in selected categories are presented as well as a set of representative tools best suited for these categories. The three categories under unstructured decisions (one for each decision making phase) are discussed at length because little has been written about their computer support needs. In order to avoid long definitions for the other nine categories, they are discussed in groups of three: one group for each of the three phases (intelligence, development and choice) containing all the structured decisions (under certainty, under risk and under uncertainty) in the group.

COMPUTER SUPPORT FOR THE INTELLIGENCE PHASE—UNSTRUCTURED DECISIONS

Unstructured decisions are characterized by the fact that managers begin with little understanding of the decision situation. Mintzberg suggests that the recognition of unstructured problems is triggered by "a difference between information on some actual situation and some expected standard," (1976, p. 253). The information is largely received on informal and verbal channels of communication (Aguilar, 1967).

The strategic planning field has attempted to systematize these activities under such names as business intelligence (Green, 1966) and more recently, environmental scanning (Fahey and King, 1977; Aaker, 1983). They propose to allocate the effort for recognizing relevant information among the organization's executives and then to have a computerized system for storing, processing, and disseminating this information. One of the problems they found is how to recognize relevant information for future decisions. Another problem is the burden on the executives for transforming verbal information into an appropriate storage medium for the computer.

Another approach was proposed by Goul, Shane and Tonge (1984). They propose using a computerized expert subsystem for actually recognizing the problem. It is difficult, with present technology, to provide computer support in this category if we take into account that we humans are well-equipped for this activity because of our large storage capacity and sophisticated processes for performing associations (Quillian, 1968; Anderson and Bower, 1980; Anderson, 1983). Existing computer systems have also not achieved an acceptable level of competence in processing natural language, therefore computer support is in its infancy in this category. But the potential rewards of effective support for unstructured decisions in the intelligence phase seems to be important enough to insure that efforts will continue.

COMPUTER SUPPORT FOR THE DEVELOPMENT PHASE—UNSTRUCTURED DECISIONS

For this decision activity category, courses of action are researched and prepared based on limited information. Cyert and March (1963) suggest that search begins in immediately accessible areas. If this search fails, the organization uses more active search procedures and searches in less familiar areas. Initial searches often fail in unstructured decisions because these decisions are characterized by novelty and complexity (Mintzberg, Raisinghani, and Theoret, 1976). Managers usually require and look for support when the search is removed from familiar sources of alternatives.

Computer support is beginning to be designed for this category in the form of expert systems. Expert systems is a subdiscipline of artificial intelligence whose main goal is producing expert-level performance in programs. The field investigates methods for constructing systems with specialized problem solving expertise. Expertise consists of knowledge about a particular domain, understanding of domain problems, and skill at solving some of those problems. Expert systems avoid blind search by using rules to reason about the knowledge stored in the computer, constructing inference paths from this reasoning to generate problem solutions.

	Unstructured Decision	Structured Decision		
		under certainty	under risk	under uncertainty
Intelligence Phase	** **	** **		
Development Phase	** **		** **	
Choice Phase	** **			** **

**Indicates that an example is provided under this decision support category.

Figure 1

Computer Decision Support Framework

We discussed the difficulty for supporting the intelligence phase using expert systems. But the expert system characteristics just presented make them more adequate for the support of the development phase. It is easier to justify the investment of building expert systems for this phase because: 1) at this phase the problem has already been recognized and an expert system in the appropriate making resources (Mintzberg, Raisinghani, and Theoret, 1976).

Successful expert systems have been built for medicine (MYCIN, PUFF, EXPERT, CADUCEUS), chemistry (DENDRAL), mathematics (MACSYMA), mineral exploration (PROSPECTOR), etc. Expert systems are beginning to be built to support managerial activities. For example, a system is partially implemented at Oak Ridge National Laboratories to support crisis management in the spilling of oil and hazardous chemicals (Johnson and Jordan, 1984). The system integrates diverse sources of knowledge, reasons heuristically with incomplete data, and accepts data and advice continuously. In this way the system supports the complex iterative process usually associated with the development phase of unstructured problems.

COMPUTER SUPPORT FOR THE CHOICE PHASE—UNSTRUCTURED DECISIONS

Mintzberg suggests that "[T]he evaluation-choice routine may be considered to use three modes: judgement, bargaining and analysis. In judgement, one individual makes a choice in his own mind with procedures that he does not, perhaps cannot, explain; in bargaining, selection is made by a group of decision makers with conflicting goal systems, each exercising judgement; and in analysis, as described above, factual evaluation is carried out, generally by technocrats, followed by managerial choice, by judgement or bargaining," (Mintzberg, Raisinghani, and Theoret, 1976, p. 258).

Most computer support provided in this category has been under the analysis mode. Managers facing the choice phase of unstructured decision problems must consider a multitude of factual issues. The process is difficult because of cognitive limitations and personal biases. Computer support is usually provided to overcome memory overload and unintended biases.

Examples of computer support in this category are found in the area of product positioning (Urban, 1976; Albers and Klaus, 1977; Clark, 1978) and in the area of political candidate positioning. These computer models do not attempt to prescribe an optimal solution, but only support evaluation by alleviating the cognitive problems previously mentioned. The author of one of the models states "[T]he outputs of the model are an understanding of the perception, preference, and purchase process, a framework and procedure for measurement, a structure to use in interpreting experimental results, and a tool for estimating the marketing share for alternate brand designs," (Urban, 1975, p. 858).

The aim of this model is far removed from the goals of optimality pursued by traditional operation research tools. The difference lies in the degree of structure of the problem being solved although both types of tools support the choice phase by evaluating alternatives. It is also evident that these new tools are directed towards a specific problem domain, unlike the more traditional management science tools, i.e. linear programming, simulation, regression analysis, etc.

COMPUTER SUPPORT FOR THE INTELLIGENCE PHASE—STRUCTURED DECISIONS

In the case of structured decisions under certainty or under risk, the traditional data processing activities may replace humans in the intelligence phase. For example, an inventory manager that requires a reorder point control system needs support for recognizing low inventory conditions. Computer systems may replace the human monitoring of inventory levels, but the system may or may not take an action, i.e. write a replenishment order or contact the supplier (external or internal). If it takes an action, then the system is completely replacing labor from the decision problem; but if it does not take an action, then the system is only recognizing the problem, thereby replacing labor for just one phase of decision making (the intelligence phase) and providing support for the decision problem as a whole. Of course, it is possible that the same computer system provides support for the other two phases by, for example, recommending suppliers or suggesting order quantities.

This type of support is often overlooked by decision support researchers and is usually defined as part of transaction processing systems. But the survival of many organizations depends on the aggregate effect of these simple support systems.

In the case of structured decisions under uncertainty, the decision maker, after recognizing the problem, may attempt to produce a diagnosis by searching the environment for conditions that reveal causality between courses of actions and outcomes. This search may be supported by external or internal databases that store historical data. In order to be useful, the system should provide inquiry capabilities because the decision maker may not initially know all the data to gather, but early inquiries and answers may elicit new questions. This may be called structured environmental scanning because the only unknown information in the decision problem is the relationship between actions and outcomes.

COMPUTER SUPPORT FOR THE DEVELOPMENT PHASE—STRUCTURED DECISIONS

In this decision activity category, support is needed for inventing, developing, and analyzing possible courses of action. Sprague (1980) recognizes that computer support has been limited when compared with the computer support available for the other two phases.

For structured decisions under certainty, where the relationships between actions and outcomes are deterministic, computer support can be provided by offering power to develop and analyze a larger number of alternatives. Many financial modelling applications are examples of this type of computer support.

A more difficult task is to provide support for structured decisions under risk or under uncertainty. A good example of this type of decision activity is the product pricing decision. The problem is recognized implicitly by maintaining the same price for the product or service, or explicitly when a new price must be set. Many relationships have been known for centuries but they continue to be probabilistic, i.e. price and demand relationships, quality or promotion, and sales volume relationships.

McCosh and Scott Morton (1978) describe a computer program which supports decision making in this uncertain environment. This computer system allows the manager to graph various demand functions. With this system the decision maker has the opportunity of exploring the problem space under different product characteristics such as price or promotion. The system also adjusts demand functions by accepting feedback from the decision maker about the likelihood of the sales volume given the product characteristics.

COMPUTER SUPPORT FOR THE CHOICE PHASE—STRUCTURED DECISIONS

The nature of computer support in this group of categories has been extensively investigated by the operations research/management science field. Its techniques allow the evaluation of a large number of alternatives, not necessarily in an exhaustive fashion. In the cases of structured decisions under certainty and under risk, many of the tools suggest optimal choices. These tools also facilitate sensitivity analysis, helping the selection process when the behavior of a variable under a range of decisions cannot be incorporated into the basic quantitative models.

Examples of computer support for the choice phase for structured decisions under uncertainty can be found in the design of data communications; for example, the problem of where to locate concentrators or multiplexers and which terminals to associate with which concentrator. In this network design problem the actions, outcomes, and utilities are known, but real situations (involving hundreds of terminals and tens of hundreds of concentrators) are so complex that it is not possible to estimate the outcomes (response time, channel utilization, etc.) for alternative configurations. Computer models use heuristics to provide workable configurations for the problem (Martin, 1972; Gerla, Frank, Chow, and Ecki, 1974).

Evaluation of Proposed Framework

Although frameworks are, in the end, tested by their survival and adoption, we now take some time to discuss the benefits and deficiencies of this framework using the two evaluation criteria presented at the beginning of the paper.

COMMUNICATION FACILITATION

The proposed framework is based on two dimensions commonly accepted by MIS researchers. Both dimensions have been discussed in the decision making literature, have received empirical support, and have been able to characterize a wide range of decision making situations. Therefore, in spite of its simplicity, the framework covers a large variety of computerized decision support systems. The two dimensions are also easily discriminated from each other.

Under the communication facilitation objective, the main deficiency is the difficulty in separating the decision making situations. Therefore, in spite of its simplicity, the framework covers a large variety of computerized decision support systems. The two dimensions are also easily discriminated from each other.

Under the communciation facilitation objective, the main deficiency is the difficulty in separating the decision making phases. The discrimination among the three phases is often more difficult than stated here. In the form presented, it would be very hard for designers to map a given task into its appropriate category or categories. One possible solution is to break down the three phases into smaller units and operationalize the identification of these units as has been attempted in the management field (Mintzberg, Raisinghani, and Theoret, 1976).

DESIGN AID AND GUIDANCE

The proposed framework is not tied to present software implementations avoiding the rapid aging phenomena characteristic of tool-oriented classifications. It also leads the designer to focus on the analysis of the decision problem at the early stages of the design process instead of jumping to the selection of tools.

The framework recognizes and encourages the design of computer support for individual phases of the decision making process. This does not imply that decision support systems should not be integrated when required and economically feasible. But it views the design of decision support systems as the mission of providing support where the computer is needed to supplement human information processing power, as long as it is economically viable.

The framework is not intended to produce a methodology for computer support design, and therefore it fails to provide guidelines for making design decision tradeoffs because:

1. The dimensions are defined at the macro-level of the decision process. No details are given about individual processes within each phase or on how to classify these detailed processes along the degree of structure dimension, and

2. Most implementation problems cannot be categorized because the framework ignores the organizational environment where the computer support will be provided. Although these two issues were not discussed in this paper, we recognize their importance for designing decision support methodologies.

Conclusions

Changes in available software for computer support in managerial decision making have created the need to expand our present frameworks for computer support. A first step is made in this direction by laying out a framework that covers a wide range of computer decision support designs. The framework is kept simple in order to be a vehicle of communication among researchers and practitioners about how present and future software advances are related to traditional techniques. Furthermore, the framework encourages designers and researchers to integrate the analysis of the decision activities into decision support methodologies.

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