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Title: THE INCLUSION OF EXPERTISE IN A DECISION SUPPORT SYSTEM FOR STRATEGIC DECISION MAKING

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Fred M. Tonge

A decision support system (DSS) incorporating domain expertise guides, tutors, and consults a decision maker in opportunity, problem, and crisis identification activities. The objective for the system is to promote improved decision making. Using an "Independent Groups" design, an experimental study was conducted to investigate the effects of DSS use on performance in the assessment phase of the strategic planning process.

The findings of the study indicate that decision support systems incorporating expertise can improve the effectiveness of problem recognition in unstructured environments. Experimental treatments consisted of 1) use of a DSS with a complete rule base, 2) use of a DSS with a 10% subset of the complete rule base, and 3) no DSS exposure. Measures of performance from several stages of the decision making process are analyzed.

THE INCLUSION OF EXPERTISE IN A DECISION SUPPORT SYSTEM FOR STRATEGIC DECISION MAKING

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Kenneth Michael Goul

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Redacted for privacy

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It is impossible to return to all of you what you have given to me. I am reminded of the following:

Have you had a kindness shown?
Pass it on;
´Twas not given for thee alone,
Pass it on;
Let it travel down the years,
Let it wipe another´s tears,
´Til in Heaven the deed appears-
Pass it on.

Thanks!

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PREFACE

Decision Support Systems (DSS) have become the recent focus of computer scientists and others whose interests lie in developing computer-based technology to support decision making in semistructured environments. Current findings and conclusions are based on case studies of systems that have been implemented and reviewed. The purpose of this research is to extend the scope of DSS use to unstructured decision environments by 1) proposing a model for the "intelligence" phase of decision making, 2) identifying an environment where the model is appropriate, and 3) using controlled experimentation to test the implications of the model.

The most significant factor in a successful DSS implementation is that decisions made by using the system are "better" than those made without using the system. Due to the nature of unstructured decision environments, it is difficult to assess the effectiveness of a DSS in improving the quality of decisions. For this reason, a secondary objective of this research is to identify a model for the "evaluation" of a specific DSS, in terms of its impact on the decisions it supports.

A DSS for students enrolled in a Strategic Planning Business Administration course is presented. The targeted domain simulates the "corporate audit" phase of the strategic planning process, and as such, qualifies the system as "a DSS tuned to the intelligence phase of decision making in an unstructured environment."

Chapter I reviews fundamental decision making models and emphasizes the "recognition" routine of the decision making process. A formal model of decision making is proposed. Chapter II extends analysis of this formal model and discusses its implications to the strategic planning task. In Chapter III, the foundations of a DSS for the audit phase of the strategic planning process are examined. Chapters IV, V and VI formalize the implementation. Experimental results are presented in Chapter VII. Chapters IV and V have been published and Chapter VII is currently submitted for publication.

THE INCLUSION OF EXPERTISE IN A DECISION SUPPORT SYSTEM FOR STRATEGIC DECISION MAKING

CHAPTER I: DECISION MAKING MODELS

1. INTRODUCTION

The literature on decision making focuses on how decisions are made after a "decision making opportunity" has been identified. The phrase "decision making opportunity" implies that a crisis, opportunity, or problem has been recognized. It is not surprising to find that many proposed models of decision making give only minimal attention to the art of identifying a decision making opportunity. This identification is a topic where there is general disagreement and minimal supporting documentation. Coupled with an inability to develop a general model of decision making, there is evidence that identifying an opportunity for decision making is muddled by the fact that "real problems, opportunities, or crises" are difficult to separate from "symptoms" or "manifestations" (eg. Brightman, 1980).

The majority of decision making models have been formulated as outgrowths of work by Herbert Simon. Before attempting to offer a model for decision opportunity identification as a phase in the decision making process, it is important to first discuss the proposed general models.

2. THE EVOLUTION OF THE THEORY

Decision making theory is based on varying "views" of decision maker behavior. The traditional view is encompassed in the concept of the "classical economic man" (Taylor, 1965). This view assumes that the decision maker has perfect information, the probability of all outcomes is 1.0, the utility of the outcomes are ordered on a continuum, and alternatives are selected that maximize utility. This traditional view has been supplemented to include "risk evaluation." Risk evaluation provides a mechanism whereby the probabilities of outcomes can be other than 1.0, but are known.

A contrasting view is referred to as the "Administrative Model" (Simon, 1957). This view assumes information is not complete, and decisions are made on the basis of expectations of what the future holds. Thus, it is assumed decision makers "satisfice" rather than "maximize" in their selection of an alternative. A slight variation of the view is the "implicit favorite" model, whereby decision makers use (or abuse) known methods of evaluation to produce the "preconceived favorite" decision outcome.

B.F. Skinner proposes the "reinforcement view;" "choice behavior" is the result of retrospection on the specific rewards that have strengthened responses that the decision maker desires as a result of a particular value set (Skinner, 1971). Thus, it is reasoned decision makers "select" on the basis of perceived rewards associated with a particular outcome.

The "controlled anarchist" view assumes information is so imperfect, it would be impossible to "select" an alternative based on perceived outcomes (Allison, 1969). Instead, decision makers evaluate alternatives on the basis of historical data and the consequences of particular choices as they have been implemented in the past.

More recently, scholars have integrated many of these earlier held views with a taxonomy of decision "types." Eric D. Carlson proposes decisions be categorized on a continuum of "structured" to "unstructured." Further, he states decisions can be categorized as "Operational Performance," "Operational Control," "Management Control," and "Strategic Planning" (Bennett, 1983). The terms "structured" and "unstructured" refer to the degree to which a decision making process can be described before the decision is made. Carlson claims the closer to the "structured" end of the continuum a particular decision is, the more likely it is that the decision is currently supported by computer based technology.

As exhibited in this discussion, the focus of decision making theories has evolved to a "decision type" classification. From these classifications, approaches to decision making have been tailor-made to fit a class (or classes) of decision types. By identifying the "type" of a particular decision, a method or approach befitting its characteristics can be identified. For example, if the characteristics fit the "classical economic man" view, one accepted decision technique involves decision tree diagrams and expected value concepts. In reviewing these classifications, computer-based systems have been applied in only a subset of the specified categories.

3. TOWARDS A BETTER CLASSIFICATION OF DECISION TYPES

An improved classification more appropriate for DSS builders is a taxonomy of "decision types." The classification is an extension of the structured, unstructured continuum, and is a synthesis of the various categorizations used by scholars of decision making. The purpose is to focus the approaches DSS builders use in specifying representations, operations, memory aids, and control processes. The underlying goal is to expose decision types and their relationship to design. This theory will be operationalized in a later chapter.

As opposed to Carlson's two dimensional model, it is more appropriate to view three dimensions: 1) The degree to which the decision maker is involved in the decision process 2) the availability of data and its amenability to measurement, and 3) the predictability of the environment the decision is made in. No static criteria classify decisions as being of a specific "type" as categorized by these dimensions; this categorization is left to the particular decision maker.

3.1 Managerial Involvement

A structured decision is one where decision rules can be completely routinized. This implies there is little management involvement in the process. (Note that the term "manager" and "decision maker" will be used interchangeably.) This will be referred to as a "non-involvement" decision type. Some decisions are made with "fragmented" managerial involvement. Managers are involved in the decision process on an irregular basis, perhaps only as crises arise. This decision type will be referred to as "fragmented involvement." The final decision type includes decisions where total managerial involvement is necessary. This will be referred to as the "complete involvement" decision type. This nomenclature is used to reinforce the fact that while some decisions are "programmed" in the view of one manager, the same decision may be viewed as "non-programmed" by another manager. Since DSS purports to be a "custom" approach to decision making, this continuum is likely to be more practical for the DSS builder.

3.2 Nature of Variables

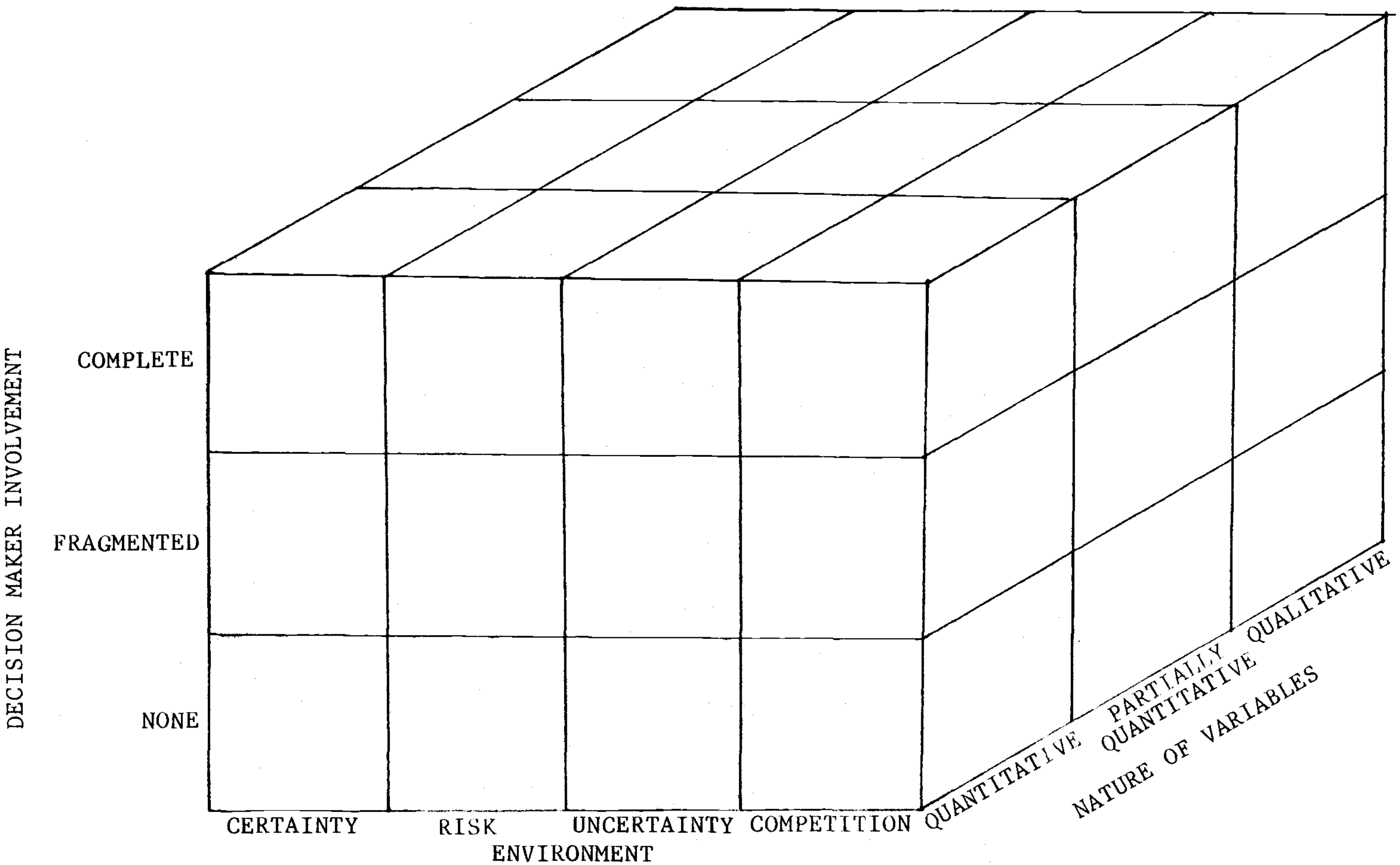
The second dimension categorizes the inputs or variables of the decision in question. When all variables can be identified and can be quantified, the decision type will be referred to as a "quantitative decision." If some of the variables can be quantified, but others cannot, the decision type is a "partially quantitative decision." Finally, a decision that has no quantifiable variables is a "qualitative decision." It should again be stressed that this categorization is distinguishable only by the decision maker, and variables to be addressed by the DSS builder should (at least initially) be those specified by the decision maker.

3.3 Environment

The third dimension positions the decision into the environment in which it is made. For example, if all of the outcomes of each alternative are completely known, the decision is made under "certainty." If probabilities can be assigned to known outcomes, the decision is made under "risk." When there is no knowledge of the probabilities of expected outcomes, the environment is one of "uncertainty." Finally, some decisions are made in an environment where outcomes support goals which are conflicting resulting in "competition." Again, this typology is decision maker dependent.

A three dimensional model is presented in Figure I.1. By identifying a decision as belonging to a single block in the cubic model, or a subset of the cube, the DSS builder has the potential to identify the appropriateness of a particular design. The intent is not to expound on this model of "decision types," but rather to provide a mechanism whereby design considerations relating to a particular DSS can be discussed later.

FIGURE I.1: MODEL OF DECISION TYPES



4. IDENTIFYING AN OPPORTUNITY FOR DECISION MAKING

In addition to classifying decisions by type, general models have been proposed of the decision making process. Simon identified three phases of decision making called "intelligence," "design," and "choice" (Simon, 1957). Mintzberg and associates called the phases "identification," "development," and "choice." (Mintzberg, Raisinghani, and Theoret, 1976) Pounds identified two phases which he called "problem-finding" and "problem solving" (Pounds, 1969). Each model is presented in Figure I.2 a,b, and c.

In order to gain insight into how decision makers identify a decision making opportunity, an analysis of the first phase of the processes presented in the three models is appropriate.

4.1 Intelligence

Simon´s "intelligence" phase is perhaps best characterized by Carlson (Bennett, 1983). Carlson believes this phase would include the following operations (as it would be supported by a DSS):

1. Gather Data
2. Identify Objectives
3. Diagnose Problems
4. Validate Data
5. Structure Problem

FIGURE I.2a: SIMON'S MODEL OF DECISION MAKING

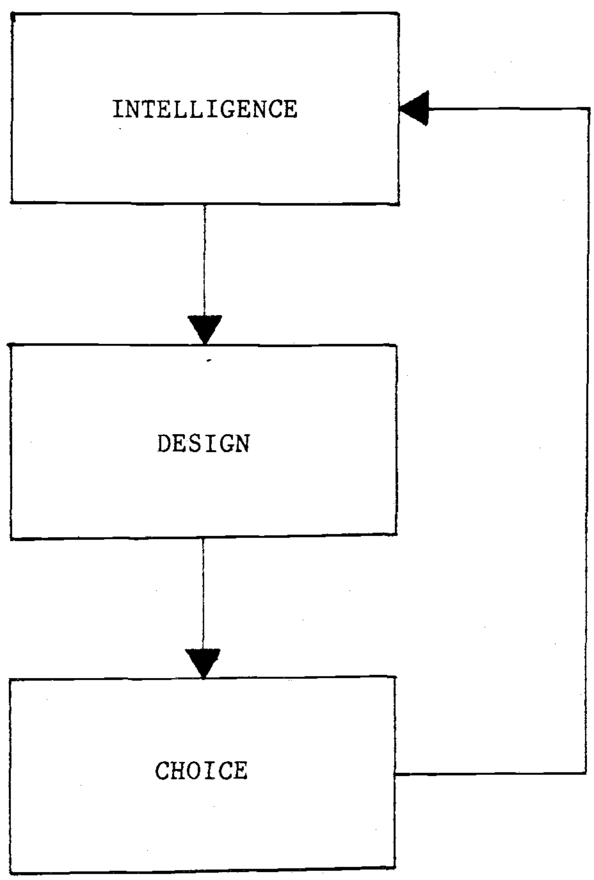


FIGURE I.2b: MINTZBERG´S et. al. MODEL OF DECISION MAKING

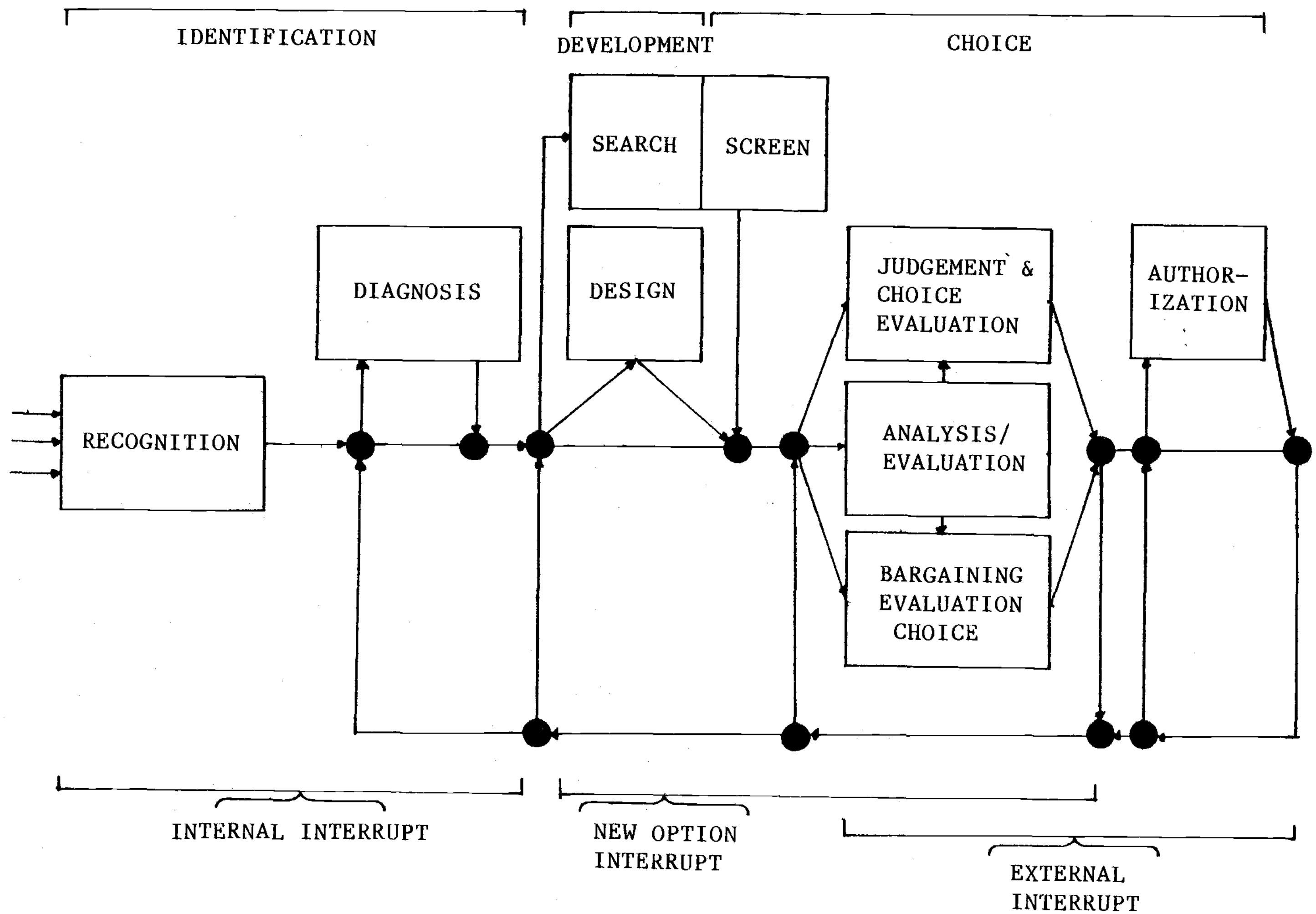
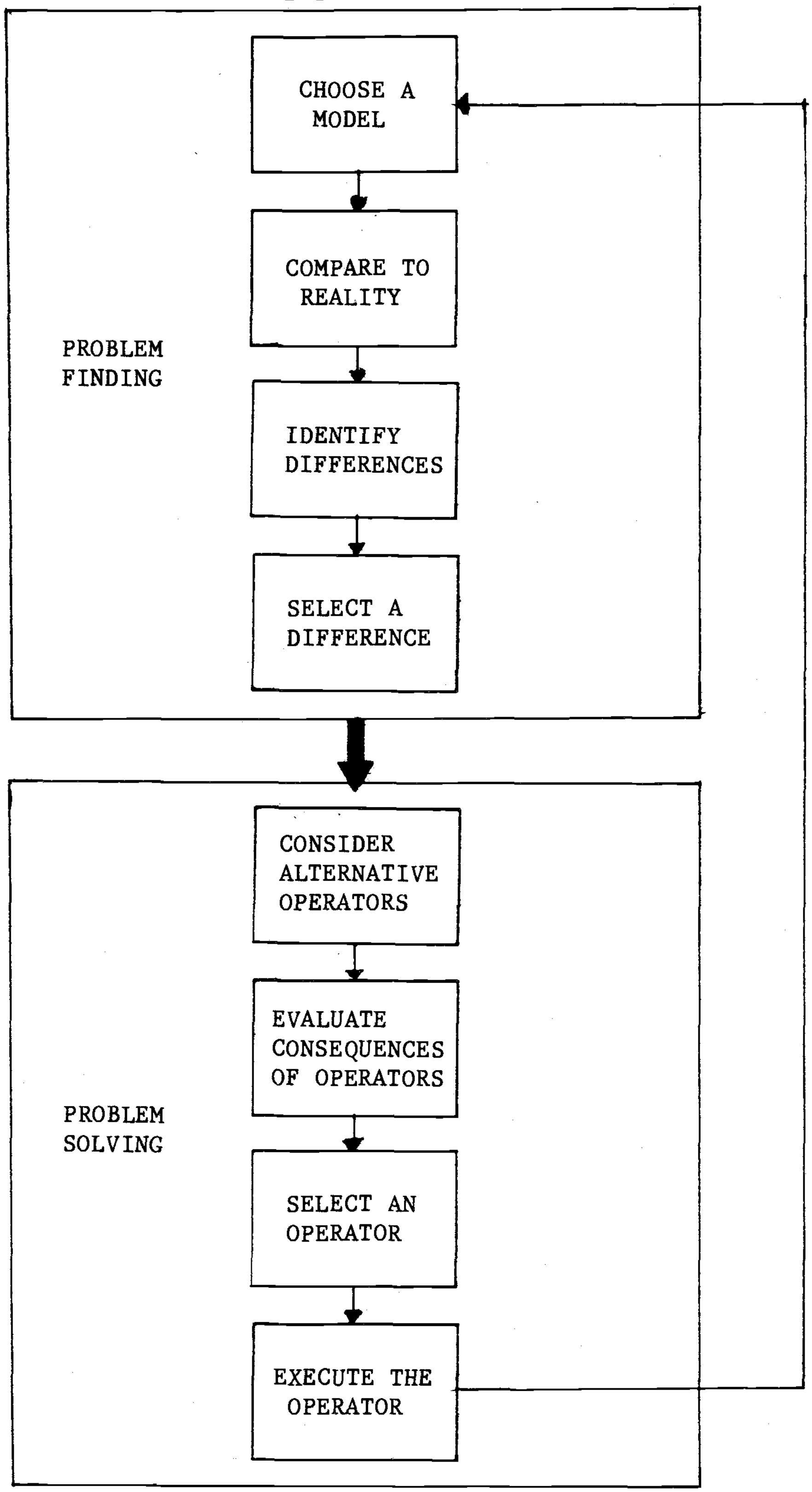


FIGURE I.2c: POUND'S MODEL OF DECISION MAKING



4.2 Identification

Mintzberg and associates speculated Simon´s intelligence phase should be called the "identification" phase (Mintzberg, Raisinghani, and Theoret, 1976). Identification has two component processes called "recognition" and "diagnosis." While "recognition" is a process that always occurs, "diagnosis" is included as an optional process. This article operationalizes the differentiation between opportunity, problem, and crisis recognition as follows:

> "Problem, opportunity, and crisis decisions are most clearly distinguished in the recognition routine. The opportunity decision is often invoked by an idea, perhaps a single stimulis, although it may remain dormant in the mind of the individual until he is in a position to act on it. Crisis decisions are triggered by a single stimuli. They present themselves suddenly and unequivocally, and require immediate attention. Problem decisions typically require multiple stimuli" (Mintzberg, Raisinghani, and Theoret 1976).

"Recognition" is where opportunities are identified in "streams of ambiguous, largely verbal data that decision makers receive." Diagnosis indicates the instigation of the decision process. This phase, although difficult to authenticate by Mintzberg´s own admission, is where old and new information channels are tapped in order that issues can be clarified and defined.

4.3 Problem Finding and Problem Solving

Mintzberg´s approach borrowed theoretical bases from work by Pounds. Pounds is best noted for his research on the art of "problem finding" (1969). He believes the recognition of a problem is characterized by a decision maker who possesses internalized models that predict an expected state of affairs based on specific variables as inputs. Problem finding therefore occurs when an "internalized" model´s output differs from reality, and a particular "difference" is selected for decision action. Internalized models are synthesized by a decision maker from several sources as follows:

1. Historical models which are predicated on the continuity of historical relationships.

2. Other people´s models which are illicited through interview, discussion, formal information flows, and informal information flows.

3. Extra-organizational models that encompass information that flows to the decision maker through the reading of scholarly works, analysis of the competition, and previous work experience in other organizations.

4.4 A NEW MODEL OF DECISION OPPORTUNITY IDENTIFICATION

Both the Mintzberg model and the Pounds model relied on interviewing decision makers and subsequently attempting to model their collective behavior. Little emphasis has been placed on the impact of decision making style on the decision making process. An insight into this factor will be of primary importance to the DSS builder attempting to provide support for the intelligence phase of decision making.

The representation selected for a model of the decision opportunity identification process is McCulloch-Pitts cells. These cells are designed for the "representation and analysis of logic situations that arise in discrete processes, be it in the brain, computer, or anywhere else" (Minsky, 1967). The cells are characterized by a circle which represents the cell, and a single line or output fiber emanating from the cell which can act as an input to other cells. The two types of input signals are referred to as "excitory" and "inhibitory" inputs. An excitory input is represented by a line with a pointing arrow. The inhibitory input is represented by a line ending with a small circle.

The operations of the cells are explained by discussing the functions of excitory and inhibitory inputs. An excitory input, combined with a sufficient number of other excitory inputs, can cause the cell to "fire," or send out a signal, which may, in turn, be excitory or inhibitory. One single inhibitory input can negate the affect of the excitory inputs. The "threshold" of the cell specifies the number of excitory inputs that must be active, assuming no inhibitory inputs are active, in order for the cell to fire. For our use of the representation, outputs of the cells need not be a single fiber; we will assume that the firing of a single cell may stimulate more than one output fiber.

Figure I.3 is a model of decision making with emphasis on the recognition phase. The intent of the model is to provide a representation that is dynamic in nature. Four cells are labeled "Information Attributes," three cells are labeled "Decision Stimuli" and one cell is labeled "Decision Maker." The purpose of this decomposition is to emphasize that opportunity, problem, and crisis

FIGURE I.3: MODEL OF DECISION MAKING WITH EMPHASIS ON RECOGNITION

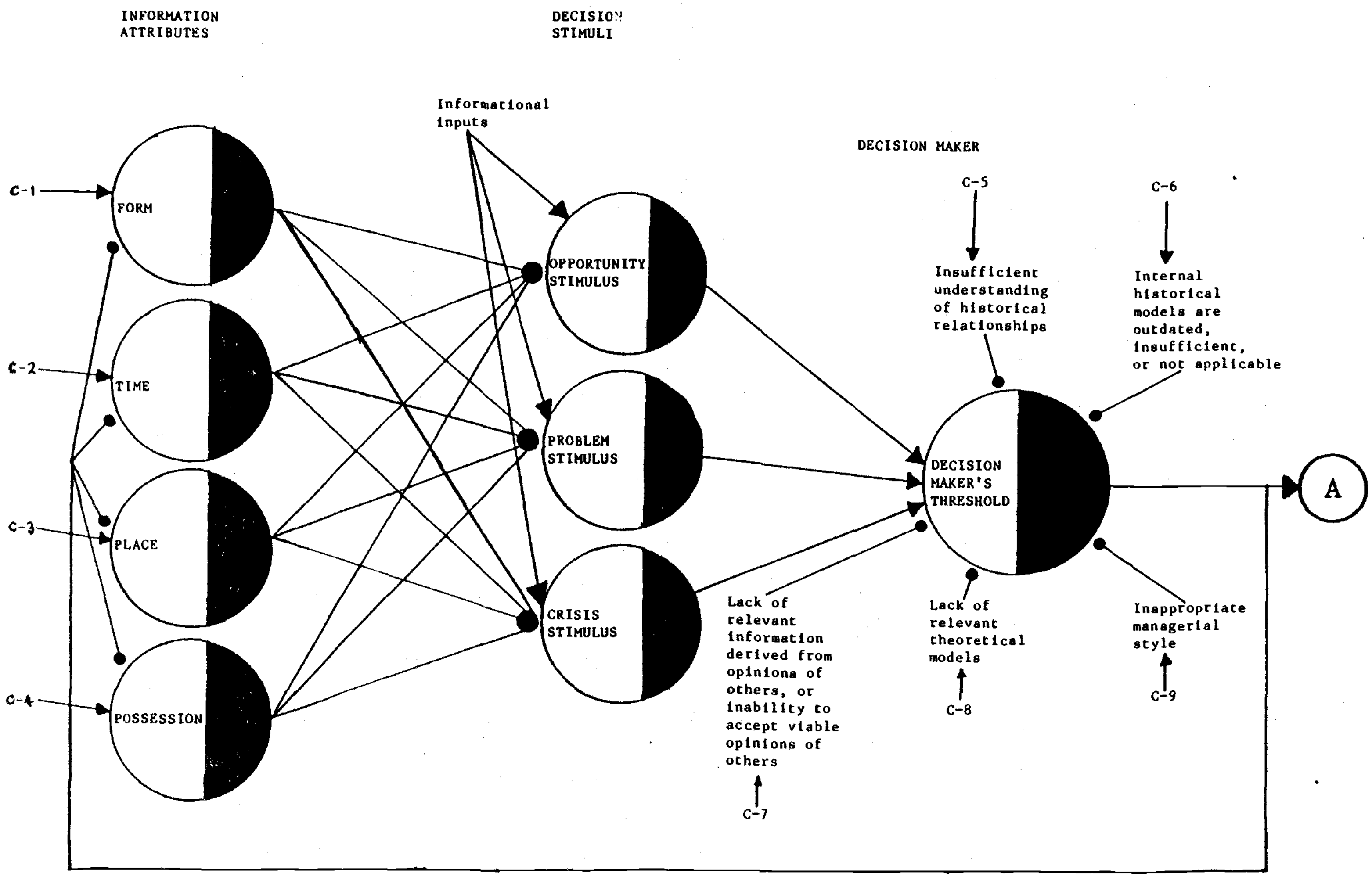
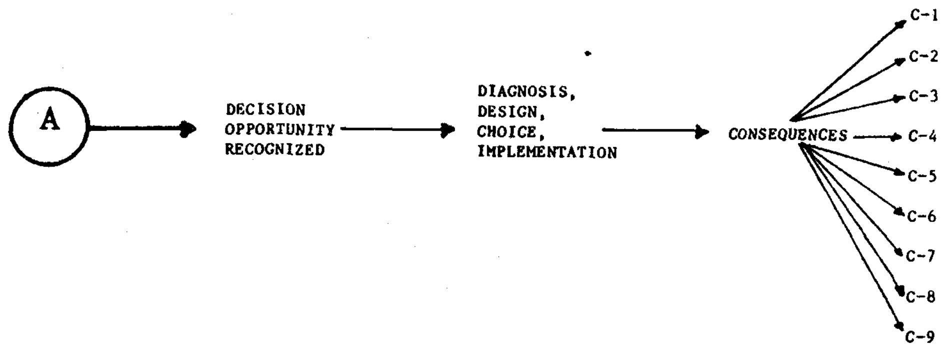


FIGURE I.3 (continued)



stimuli exist in the environment in a natural form, and the decision maker "filters" these stimuli to determine the ones warranting decision action. Note that this filtering process is a decision in itself! To explain the model, we consider the cells in their pure sense, and then discuss an example that will trace the operations of the model.

The three cells characterized as Decision Stimuli represent the environment the decision is made in. At any point in time, the "informational inputs" act as excitory inputs to the appropriate cell. Note that no attempt is being made to specify the types of inputs to each cell; this will be domain specific. The four cells labeled Information Attributes relate to the nature of information as it occurs in the environment. These cells represent those factors which act as inhibitors to the Decision Stimuli cells. This implies that even though information occurring in the environment is theoretically unlimited and available, there are certain constraints inhibiting the firing of the stimuli cells. The informational inhibitors were identified by Roman R. Andrus (Andrus,1971). Andrus addresses the "value" of information. He notes there are four constraints to environmental information as follows:

1. The language or format of the information may not be understandable. Also, the volume may be so excessive as to require an inordinate amount of time to analyze the contents (FORM).
2. The information as it is received may be untimely; information may arrive either too early or too late (TIME).
3. The information is not readily accessible; access to the information would be so costly as to overcome the need for the

information (PLACE).

4. Closed communication prohibits the exchange of information, or the right to use the information is not granted (POSSESSION).

In summary, information occurs in the environment in a variety of forms, and is theoretically unlimited and valuable. The ability of the information to excite the Decision Stimuli cells is assumed to occur naturally. For the informational inputs to cause the stimuli cells to fire, the constraining inhibitors must be nonexistent or sufficiently minimal.

Once the environment triggers the output fiber of a stimuli cell, the impulse becomes an excitory input to the cell representing the decision maker. Opportunity, problem and crisis cells are capable of firing simultaneously. Thus, the decision maker, while acting as a "sponge" to these stimuli, must select an input to consider, and then the "filtration process" ensues. Even though stimuli are occurring in their natural state, it is the decision maker who reviews, selects, and operates on each single stimuli. Some stimuli are not selected and operated on due to the internal state of the decision maker cell. For example, if the decision maker´s threshold is very large, then weak stimuli selected for operation will be filtered in this stage, and not carried forth to "decision opportunity identification." In addition, an inhibitor to the decision maker´s cell might constrain the firing of the cell, which would cancel the evocation of the remainder of the decision making process. Even if the decision maker´s cell is sufficiently excited by a stimuli cell, an inhibitor could totally negate the effect of the stimuli. One additional comment should be made regarding the output fibers from the decision maker´s cell to the Information Attribute cells. This feedback loop reflects the fact that the state of the decision maker cell can have an effect on the informational inhibitors.

Four of the inhibitors to the decision maker´s cell are closely related to the four mechanisms highlighted by Pounds as the types of internal processes associated with problem finding. Pounds hypothesizes that a person´s internalized models are the basis for an "observe, search, and select" type of operation. A corollary to this theory is that lack of pertinent models could provoke substandard problem finding. In addition to the inhibitors from this corollary, an inhibitor called managerial style is included. This inhibitor reflects the fact that the "style" of the decision maker may constrain the filtration process.

In Understanding Understanding, managers are classified on a continuum of time, ie. how they view past, present, and future states (Osmund and Osmundsen, 1976). This work is a slight modification of the work by Jung on behavioral types and is used as the bases for the style inhibitor. The "time" emphasis is appropriate to provide further meaning to the proposed model. Four "types" of managers are identified as follows:

1) Thinking Types: Managers who are logical and consistent, have the ability to think sequentially, and can recall, order and assess the impacts of past actions, using this ability to project the impact of future actions. The main impediment to these managers is an inability to cope with the human dimensions of management.

2) Feeling Types: Managers who tend to look to the past, and

because of this tend to embody the values and norms of the organization. These managers are well liked in the organization, but the tendency to look backward for answers to today's needs negates necessary creativity for solving new problems or recognizing new opportunities.

3) Intuitive Types: Managers who can synthesize vast amounts of information and predict the needs of the future. These managers are rare and are often a source for brilliant new strategies. Their major problems are typically an inability to communicate and a tendency to forego necessary analysis before inventing a new approach. Thus, their ideas may fall on dead ears, because preliminary foundations facilitating the brilliant idea are not present.

4) Sensation Types: Managers who concentrate solely on the present. These managers arrive at quick decisions, and are often the best compromisers or "deal-makers." They thrive on operating in the present tense, exerting their efforts in sensing the present mood of the organization. The major problem of this type of manager is a lack of the "look before you leap" ability. Oftimes, this type of manager creates a crisis in order that it can be solved.

These types are not considered "pure" in the sense that a stereotype can be realized, however they are sufficient to highlight differences in decision making approaches. Perhaps the major implication of this typology is that an organization, in order to prosper, must possess each of these types of managers. In this sense, there are "checks and balances" to offset the weaknesses of one type with strengths of another type. If an organization must possess each of the four types, a natural extension is that for an individual decision maker to prosper, each of the four types of behavior must be exhibited at the proper time.

4.5 An Example Application of the Model

Suppose that we are monitoring the behavior of a student enrolled in a Strategic Planning Business Administration course where case assignments are used as a method of instruction. Further, suppose the student has been assigned a particular case requiring identification of the current problems facing a particular organization. Assume that the student recently transferred into the Business Department. The main situation in our hypothetical case that warrants attention is that two divisions of the company build equipment related to microcomputers, and the equipment that has been built is incompatible between the divisions.

The student may focus on the fact that equipment is incompatible and offer a solution mandating each division of the company to share design information with other divisions. The point is, the student is performing analysis with limited internal models applicable to organizational diagnosis. There are actually a myriad of problems that could have been manifested by this symptom, and the mere coordination of design specifications may not solve the larger problem. In fact, the sharing of design information may corrupt the "entrepreneurial spirit" management is attempting to achieve.

This example shows that while a problem can be identified by the decision maker, the lack of applicable models of reasoning can lead to a misdiagnosis of the "real" problem. As exemplified by the use of the case method in this type of course, models of reasoning in unstructured environments are taught by exposing students to "known theoretical relationships" exhibited in carefully selected cases.

Let us trace this example through the model presented in this chapter. Obviously, the recognition of the problem of inconsistency between divisions is triggered and sent to the cell representing the decision maker. Here, the filtration process for our particular student operates on the problem and a decision opportunity is recognized. Even after an incorrect identification of the problem, diagnosis, design and choice phases are completed.

Now let us consider another student faced with the same case. Suppose this student has been enrolled in Business Administration curricula since coming to school. This student analyzes the case and notes the situation of incompatible products. However, the student wants to know more about the state of the organization before assuming that solving the inconsistency problem will result in a better organization, thus aiding in minimizing the potential for future problems of a similar nature. The student studies the organizational structure, the nature by which product designs are initially developed, and the coordination of activities at the corporate level of the organization. Suppose the student discovers the organizational structure is not conducive to building interrelated computer equipment types, and recommends that corporate level management be adjusted to provide more direction to the individual divisions.

In contrasting this student with the previous student, we discover that the problem stimulis triggered recognition of the "real" problem. The student was able to isolate the symptoms from the problem, offering a solution reflecting the nature of the real problem.

5. FINAL REMARKS

In this chapter, several models of decision making have been considered. A new method by which problems, crises, and opportunities can be categorized has been analyzed. In addition, the works of several scholars have been synthesized for an approach to decision opportunity recognition. The model is characterized by inclusion of decision maker specific behavior.

Charles Stabell has vitalized an approach to DSS development called "decision channeling" (Bennett, 1983). This is defined as the "general property of the interface architecture that serves to both support and shift the decision process ... in direction that focuses attention on the decision problem." Given the analyses presented in this chapter, we now have the appropriate tools to operationalize Stabell´s decision channeling, although hereafter we will refer to it as "recognition channeling" to distinguish its use in the intelligence phase of decision making. "Recognition Channeling" is the act of applying computer-based technology to facilitate human recognition of opportunities, problems, and crises in a prescribed domain.

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CHAPTER II: RECOGNITION AND STRATEGIC PLANNING

1. INTRODUCTION

The concept of "recognition channeling" assumes a decision maker´s recognition skills can be modified. The question remains as to how these skills should be enhanced in order that better decisions are made. In search of the answer to this question, we will first review the inhibitors to the decision maker´s cell in order to determine if some operator can minimize the effect of inhibitors in the case of a decision opportunity that should not be neglected. Next, we will discuss the nature of the decision maker threshold and operations on the threshold intended to improve recognition.

In anticipation of a test of the theory proposed, this chapter will conclude with a discussion of the state of the art of strategic planning at the corporate level. The intention is to analyze an environment where recognition channeling can be evaluated.

2. REDUCING THE EFFECT OF INHIBITORY INPUTS

The model of decision opportunity recognition discussed in Chapter I included five inhibitory inputs to the cell representing the decision maker. Any attempt to facilitate recognition would have to address the five inhibitors. The question remains of how to operate on these inhibitors. To attempt to answer this question, we will extend the model presented in Chapter one. We begin by discussing the Decision Stimuli cells.

The excitory input to the "stimuli" cells is "informational inputs." The model has no connectors to this input due to the fact they cannot be modified or acted upon by a decision maker in order to improve the quality of decision making. This line of reasoning is in keeping with the earlier discussion regarding the fact that information occurs naturally. Some management information system (MIS) specialists may take issue to this assumption. Recall the definition of our domain includes decisions of the "unstructured" type. Russell Ackoff addresses this issue in his article titled, "Management Misinformation Systems" (Ackoff,1967).

Ackoff's article begins by attacking the notion that most managers operate with a lack of relevant information. He contends MIS specialists must attend to facilitation of the absorption of the relevant information by the decision maker, as opposed to providing additional reams of relevant information. The point is, there is plenty of information available, but MIS enthusiasts have little perspective on the integration of the information with the decision task. In terms of the model presented in this paper, MIS is faulted because of its over-emphasis on the informational inputs existing in the environment.

3. THE MODEL OF DECISION MAKING AS A SYSTEM

We are now ready to examine an updated model of recognition which includes a mathematical orientation to the system as a whole. The decision maker dependent representation of the model will be maintained,i.e. no attempt is made to idealize types of decision makers by the mathematical statement of the model. Preliminary specifications follow:

1. F(v,w,x,y,z): To specify the intensity of the excitory output of the opportunity cell, we will use a function F with arguments v,w,x,y,z.

2. G(v,w,x,y,z): To specify the intensity of the excitory output of the problem cell, we will use a function G with arguments v,w,x,y,z.

3. H(v,w,x,y,z): To specify the intensity of the excitory output of the crisis cell, we will use a function H with arguments v,w,x,y,z.

Where:

v represents the raw informational input,
w represents the excitory output of the "FORM" cell
x represents the excitory output of the "TIME" cell
y represents the excitory output of the "POSSESSION" cell
z represents the excitory output of the "PLACE" cell

4. R(F,G,H): To represent the relationship between excitory outputs of the "Stimuli" cells as considered together when they excite the decision maker´s cell, R is a function that will be used which takes arguments of the excitory outputs of each individual stimuli cell. The function is of primary importance when more than one stimulus cell is firing simultaneously.

5. D(R,p,q,r,s,t): To represent the threshold of the decision maker´s cell, a function called D is used with arguments R,p,q,r,s,t. The nature of this function is to provide information on the internal state of the decision maker´s cell in terms of the excitory inputs to the cell, and the inhibitors to the cell.

Where:

p represents the "internal model" inhibitor
q represents the "external model" inhibitor
r represents the "opinions of others" inhibitor
s represents the "theoretical model" inhibitor
t represents the "managerial style" inhibitor

R and D can be summarized as follows: R represents a composite function of the independent stimuli to the decision maker's cell, and D represents the state of the decision maker's cell given R as input.

To relate these functions to the nature of the system described, we will begin by reviewing Pound's concluding remarks in his article on problem finding. Pounds states, "one could consider the flow of problems through an organization as analogous to the flow of jobs through a job shop..." (Pounds, 1969). Typical heuristics used in a job shop environment to determine processing priorities include the following:

Choose the project -

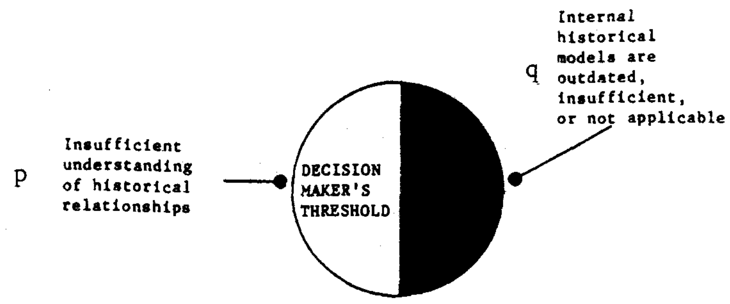
1. with the minimum processing time
2. with the minimum slack time per operation
3. on a first come first served basis
4. with the earliest due date
5. on the basis of a ratio called an "urgency number" computed as follows:

$$\text{Urgency Number} = \frac{\text{Remaining Time to Due Date} - (\text{Remaining Processing Time} + \text{Remaining Queue Time})}{\text{Number of Operations Remaining}}$$

To study the effects of applying the processing rules summarized above, schedulers simulate a job shop using a particular decision rule. The result of these simulations is some one single number that measures the "success rate" of the processing rule. An example may be the number of projects performed on time, the profit resulting from completion of the projects in the simulation, or some weighted combination of factors considered essential for effective job shop performance. To carry out our analysis, we identify a single number, via heuristics, that captures the capability of a decision maker´s ability to perform recognition.

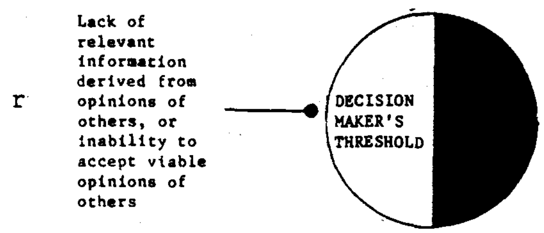
A viable heuristic to specify the state of the system in our model given a particular decision maker is expressed as the ratio of R/D, where R and D are as specified previously. This ratio would capture a "capacity" measure of the system. For example, if R was small, indicating minimal environmental inputs, and D was large, indicating high resistance of the decision maker to the inputs, the capacity of the system for decision opportunity recognition would be minimal. Our objective, therefore, will be to maximize the ratio by operating on several of the arguments to the functions; we will attempt to make R larger and D smaller.

Earlier, a discussion was offered justifying the independence of R. A relationship between F, G, and H can be specified stating "if F is ignored, then G becomes larger, and if G is ignored, then H becomes very large." For this reason, to maximize the numerator of our ratio, one must attempt to make the decision maker more sensitive to opportunity (F) stimuli and problem (G) stimuli. Further, we must attempt to minimize the decision maker´s threshold (D) for responding to F and G. This threshold can be minimized by negating the effects of the inhibitors to the decision maker's cell for opportunity stimuli. Thus, our DSS design must attempt to operate on p,q,r,s, and t in order that F and G stimuli will pass through the decision maker's cell.



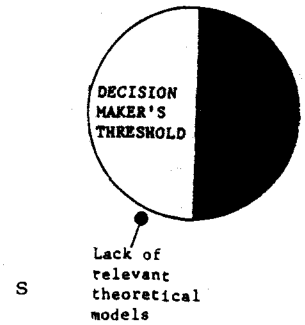
3.1 Minimizing the Effects of p and q

A DSS designed to minimize the impact of p and q would address the issues being investigated in the current field of Computer Aided Instruction. It will be sufficient for us to realize that to "teach" a decision maker better internal models and external models would be the goal of a successful DSS. This will be accomplished in a DSS discussed later by repeated exposure to models, specifically models promoting responsiveness to opportunity and problem stimuli. The models selected will be the result of scholarly research and expert opinion.



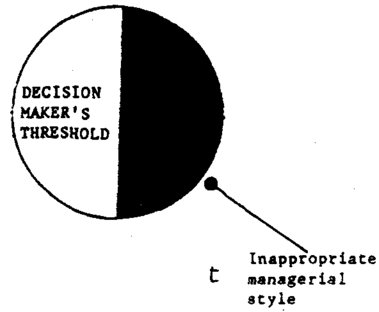
3.2 Minimizing the Effect of r

Communication between decision makers and other people within an organization has been a stated goal of MIS designers. A problem that has developed is when managers of divisions within a company have increased information regarding the functions of other divisions in the organization, heightened competition occurs, and suboptimizing behavior is promoted (Ackoff, 1967). Therefore, to facilitate "proper" communication, the models of decision making should be the topic of communication, rather than the outcomes of decisions. In other words, communication should facilitate the recognition of more appropriate synergistic models rather than increase inter-division competition (unless, of course, this competition has proven to be an effective way to motivate and train decision makers).



3.3 Minimizing the Effects of s

Theoretical models are provided by researchers for particular types of decisions. To increase the awareness of decision makers of available theoretical models, the DSS builder must possess the skills to perform research related activities, and build proper components of the research into initial versions of systems. This will effect the need for adaptive design methodologies and stringent model validation procedures.



3.4 Minimizing the Effects of t

Recall in Chapter I it was pointed out that managerial behavior could be classified on a time continuum as follows:

1. The Thinking Types
2. The Feeling Types
3. The Intuitive Types
4. The Sensation Types

The successful organization must have managers who exhibit each of the four types of behaviors at the appropriate time, as this provides a system of checks and balances tending to negate the impact of problems of a single type. From this system of checks and balances, we can synthesize several guides to recognition channeling. These are:

1. Compel the "thinking type" to consider human dimensions.
2. Compel the "feeling type" to be concerned with the present and future, and to view recognition as a function of more inputs than internal historical models.
3. Compel the "intuitive types" to check necessary foundations before spinning wheels on a fruitless adventure.
4. Compel the "sensation types" to adopt historical and futuristic perspectives to balance with their strong orientation to the

present.

The necessary characteristics of a DSS for recognition channeling are drawn from this analysis of the stimuli and inhibitors. The next topic relates to a "type" of decision situation where the concepts presented can be tested.

4. STRATEGIC PLANNING: THE STATE OF THE ART

To discuss strategic planning, we will first turn to a DSS that was created for the Gotaas-Larson Shipping Corporation as analyzed by S. Alter and S. Anand, who acknowledged the assistance of A. Goldenberg and P. Lorange (Alter, 1980). In an overview of the planning and control system of Gotaas-Larson, the authors review ten general planning and control activities, with emphasis on those activities for which computer-based technology provided support. These ten activities, listed with applications of the computer-based technology, are as follows:

1. Defining Company Missions and Goals: Computer systems played no role.
2. Setting Goals: Computer Systems played no role.
3. Finding Business Opportunities: Computer systems played no role.
4. Evaluating Opportunities Individually: The role of the computer was to make the quantitative part of analysis easier.
5. Evaluating and Choosing among Opportunities in the Overall Context of Gotaas-Larson's Resources: A strategic-plan consolidation system was implemented to act as a feasibility tester

and as a way by which "fine tuning" of the strategic plan could be performed. The main advantage to the system was to allow the strategic plan to be stated at the level of individual projects, evaluate the individual projects, and determine if the consolidation of the individual projects provided the synergistic glue to be operational as a long term plan.

6. Reporting and Justifying Plans to Top Management: The strategic-plan consolidation system was used as a communication device in transmitting plans to top management. The consolidation system was devised so that the system's output was in a format ready for upward communication. Using the output also was claimed to have provided credibility to the plan proposed.

7. Setting Detailed Goals for Operational Units: An operational-plan consolidation system incorporated the same design as the strategic-plan consolidation system. The system provided for immense detail in planning for operational level concerns.

8. Comparing Actual Performance to Goals: Clerical work to evaluate the variances in actual performance to established goals was replaced by this system. Such reports were previously routinized as a clerical responsibility.

9. Diagnosing Difficulties in Meeting Goals: Computer systems played no role.

10. Taking Appropriate Action: Computer systems played no role.

The purpose for discussing Gotaas-Larson is threefold. First, the series of ten phases in strategic planning are well identified and well supported by strategic planning literature. Second, we can compare the manner by which the computer was used to the "types" of decisions it assisted from the model presented in Chapter I. Lastly, we can offer an approach to recognition channeling that, when integrated with the types of systems developed for Gotaas-Larson, will support a broader range of the strategic planning activities. Before this, however, we must document that the stages or phases identified are reinforced by the manner in which strategic planning is performed at large.

4.1 How Companies Plan

Planning "watchers" have surveyed companies at specific intervals to determine the shifts in tools and techniques applied to strategic planning. In addition, an enduring project which endeavored to summarize the critical strategic factors that influence the economic performance of a business has been undertaken by the Strategic Planning Institute, a nonprofit organization. This Institute initiated a project called PIMS (Profit Impacts of Marketing Strategies). This project included a database containing 1200 businesses for more than 100 companies (Lorange, 1980). The database was used in conjunction with a multiple regression technique to predict the impacts of a host of independent variables to Return on Investment (ROI). In terms of impact on ROI, the following categories are rank ordered:

1. Investment Intensity
2. Productivity
3. Market Position
4. Growth of Served Market

5. Quality of Product/Service

6. Innovation and Differentiation, when supported by market share

7. Vertical Integration, when markets are stable, not growing, or growing very rapidly

8. Cost push influence

9. Current Strategy thrust; the direction of change of the variables.

The limitations of the PIMS data are mainly the arguments that are entertained when too much emphasis is placed on historical data. However, there is evidence that planning changed somewhat when the results of the study were widely available. We will now review the main shifts in planning methodology observed to have occurred between 1974 and 1979.

In an article titled "How are Companies Planning Now? - A Survey," by Boulton, Franklin, Lindsay, and Rue, it was noted that shifts in the extent and contents of plans have changed between 1974 and 1979 (1982). The specific changes noted were made: in the mix of objectives included in the plan, use of external factors, methods for controlling the plan, and plans for growth. The major implication of the study for the purpose of this analysis was the extent to which computer use has changed in the planning process and the use of outside consultants hired to assist plan development. The results of the survey in this context is presented in the following table taken from the article (Boulton, 1982):

Planning Tools	Percent of 142 Respondents in 1974	in 1979
Use of outside consultants	24	33
Use of consulting firms	14	25
Use of research firms	9	8
Use of individual consultants	8	7
Use of computers or models	47	61

An additional shift was identified in the number of responding firms which reported that the number of Chief Executive Officers of the organization who are responsible for the planning activity has increased from 6% of the respondents to 17% of the respondents in the time period. In conclusion, one could say that the use of computers in some phase of the planning process is on the increase, however slowly, and that the top level managerial involvement is increasing slowly. Further, the outside influence of consultants has slightly increased. This is exemplified, in part, in our previous discussion of the Gotaas-Larson case by the fact that the computer improved the evaluation of specific alternatives and provided a mechanism for upward communications and plan vs. actual evaluation. The implications of these conclusions to this paper are formulated as follows:

1. Managers are more likely to use a computer to assist in stages of the planning process.

2. Outside advice is increasingly recognized as necessary for the unbiased evaluation of an organization's planning needs.

3. Top level managerial involvement has increased because of the complex nature of the planning process and the ability of the chief executive officer to view the business of the organization in its entirety.

4.2 How the Computer Supports Strategic Planning

The Gotaas-Larson case and the results of the planning survey indicate that computer-based technology is currently used to support subsets of the types of decisions categorized by the cubic model of decision types presented in Chapter I. A collection of the types of decisions currently addressed can be summarized as those decision types that are in the environment categorized as certainty, and those where variables are quantifiable, and those where variables are partially quantifiable. This leaves a subset of decision types minimally addressed, characterized by qualitative variables, environments of risk, uncertainty, and competition, and all realms of managerial involvement. (See Figure II.1) Therefore, to address such decision types by offering computer-based support, we must clearly specify what portions of the planning process are characterized by the isolated subset of decision types.

5. RECOGNITION CHANNELING FOR STRATEGIC PLANNING

Successful planning obviously hinges on the first phase of the process as presented in the discussion of Gotaas-Larson. The definition of "Business mission and philosophy" is of paramount importance to organizational success. The definition of mission and goals hinges on the answer to the question of where the organization is, and where would it like to be in the future. The task of determining where the organization is now, with emphasis on

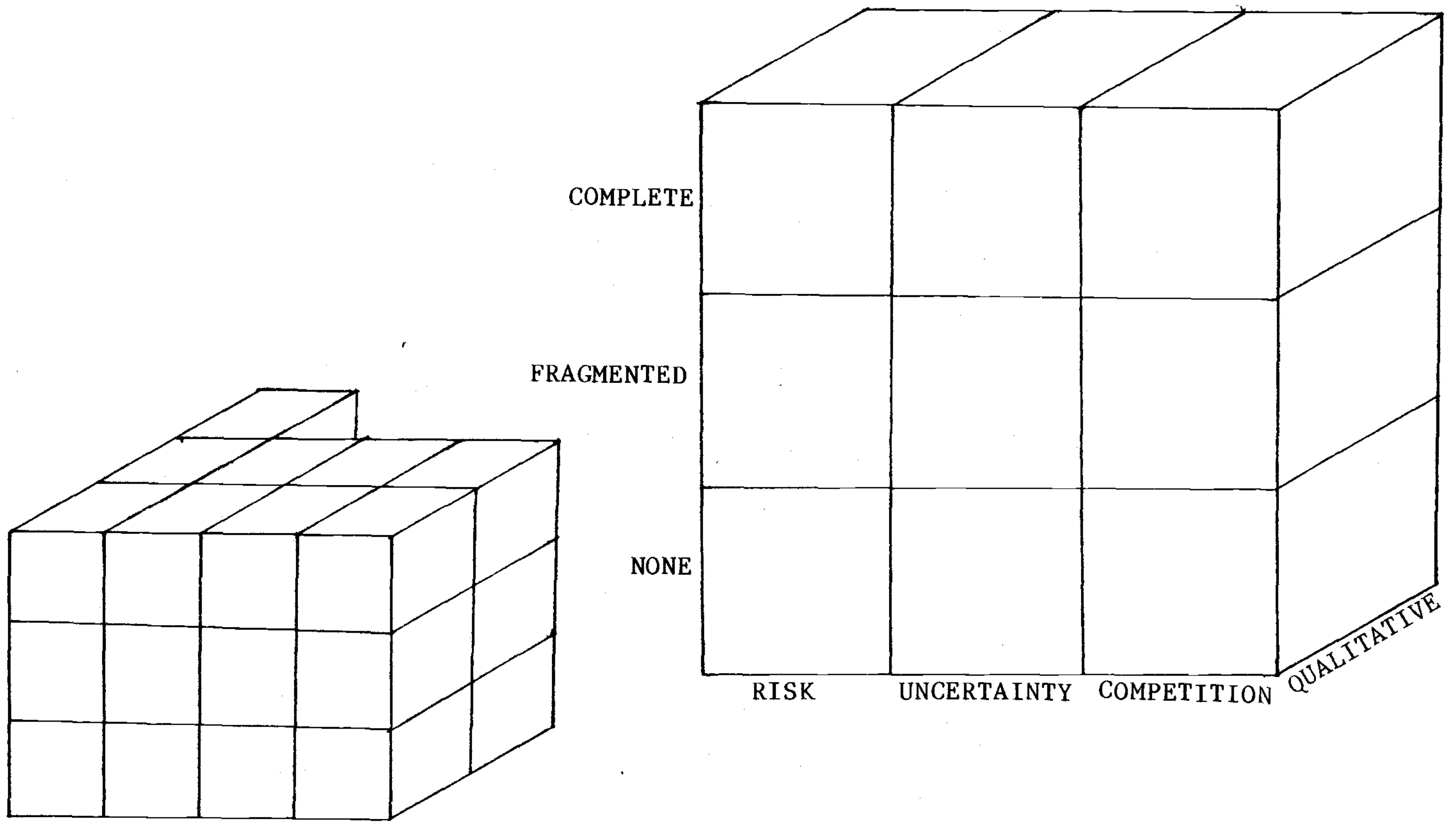


FIGURE II.1: DECISION TYPES MINIMALLY ADDRESSED BY COMPUTER-BASED SUPPORT where it should be, currently is not widely supported by computer-based technology, as exemplified by the Gotaas-Larson case. The major concern in evaluating the current positioning of the organization is to determine the opportunities, problems, and crises that the firm must face to be able to reach the desired state in the future. From this viewpoint, a strategic plan is the actions to be taken to close the "gap" between the current state of affairs and the desired state of affairs.

The manner by which the company's mission should be determined is widely debated, and in practice, is inconsistent. We will view two scholars' opinions on how this process should be operationalized. First, we will discuss Peter Lorange's approach which is called the "strategic audit." Second, we will explore William King's approach which is called "strategic issue analysis."

5.1 The Corporate Audit

Chapter Three of Peter Lorange's book titled, "Corporate Planning: An Executive Viewpoint" offers a method by which a company can perform an audit of its strategic positions in anticipation of implementing a strategic plan (1980). The auditing process calls for a definition of the product/market elements operating within the firm. The PIMS study mentioned previously included 1200 "businesses" within over 100 organizations. It is the definition of these businesses the term product/market element analysis applies to. Lorange's own words are perhaps best:

> To analyze the strategic position of a business, it is useful to adopt as a unit of measurement or building block the concept of product/market elements. A product/market element can be defined as the smallest organizational unit that performs an identifiable general management business task, ie., the creation of a specific and distinct product or service that serves a well-defined market, distinguishable from and relatively independent of other product/market element combinations. (Lorange, 1980)

Lorange contends that this definition assumes that an operational mission can be identified for each product/market element. This definition also implies that management will have the opportunity to focus on the "unique potentials and risks" that characterize this entity. Lorange submits that the identification of a product/market element remains an art, as it is not suited to classifications of analysis.

Using this definition, Lorange discusses a method for viewing each product/market element in terms of its strategic potential, and ultimately incorporating the analysis of each element into an integrative audit of the firm's current position. From this integrated viewpoint, a manager is in a position to assess the planning needs of the entire organization. The major objective of the corporate audit is to "identify the <u>differences</u> between reality and the internalized models, specifically, those differences that will require attention in the master plan of the organization." This "audit" is identified as a "recognition activity."

5.2 Strategic Issue Analysis

W. King in his article titled, "Using Strategic Issue

Analysis" identifies an alternate approach to evaluating an organization's planning needs (1982). King submits his method of answering the question as to what the organization must do in its plan to close the gap (as discussed previously), "widens the scope of judgement and focuses disagreement on specific sub-issues."

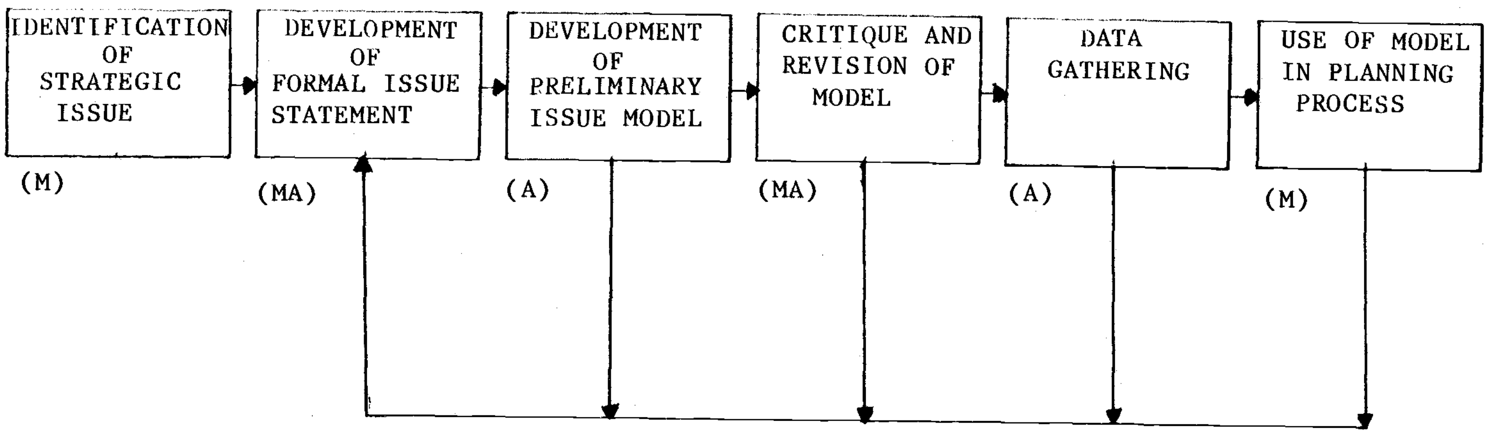
The strategic issue analysis proposed by King is embodied in a flowchart of the process (See Figure II.2). The first stage in the process is called "Identification of Strategic Issue." King states that issue identification is primarily an activity of managers, as opposed to analysts. Further, the identification phase is characterized by the fact that issues may be derived from various points in the organization. For example, competitors' actions, the current economic climate, or controversy remaining from a previous year's planning process, are all suggested as keys to issue identification.

Strategic issue analysis seems to be a likely outcome of a successful audit as was suggested by Lorange. The corporate audit, therefore, may serve as an "issue identification phase." For this reason, Lorange's corporate audit approach would be the appropriate stage of the planning process to test "recognition channeling."

6. Conclusion

From King's view of strategic issue analysis, it has been noted that "identification of a strategic issue" is a responsibility of the manager, and thus, signifies total managerial involvement and environments of risk, uncertainty, and competition.

FIGURE II.2: KING´S STRATEGIC ANALYSIS PROCESS



KEY
(M): MANAGER INVOLVEMENT ONLY
(A): ANALYST INVOLVEMENT ONLY
(MA): MANAGER & ANALYST INVOLVEMENT

As such, the subset of decision types with which strategic issue identification addresses, are those characterized as the top three cubes of the subset identified in Figure Two as being minimally supported by computer-based technology. This subset is an area of great concern to managers, and attempts to offer computer assistance are not addressed by current literature.

We have now identified a domain where recognition channeling can be tested; strategic planning presumes the quality of foundation work that specifies where an organization is and what its current opportunities, problems, and crises are. Furthermore, we have shown that this foundation work must be correct for plans to be effective in ensuring the survival of an organization. What remains is an analysis of how recognition channeling can be realized in this environment.

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CHAPTER III: OPERATIONALIZING RECOGNITION CHANNELING

1. Introduction

Thus far, it has been proposed that the intelligence phase of decision making, specifically "recognition," provides the DSS builder with new opportunities for exploration. Further, the potential for computer-based support to decision types that have long been side-stepped by conventional approaches has been discussed. In Chapter I, the literature of decision making was reviewed with an objective of recognizing a new domain for Decision Support Systems. In Chapter II, a methodology for a new approach was proposed, and an example decision type was defined as belonging to a territory that has been minimally addressed by conventional systems analysis approaches. There is one additional bridge before us: to show that a DSS possessing recognition channeling capabilities can be designed, implemented and validated.

The validation of a DSS as described raises a series of questions. The major issue is whether operations can be designed that do, in fact, produce improved decision making. This begs the question, "How can one evaluate improved decision making?" This question might be shown to be mappable to the "Halting Problem!" Our emphasis, therefore, is to develop a heuristic for this validation. To use the heuristic, however, compels us to slightly alter our domain to one where results will be more tenable. A heuristic for validation is not a novel approach, current expert systems have been validated by randomized trials and case studies.

This chapter opens with a complete definition of the domain for testing the DSS approach. An overview of expert systems that have been implemented and tested follows; concepts applicable to the design of a DSS for recognition channeling are emphasized. The chapter concludes with an introduction to the next four chapters.

2. A DSS for Strategic Planning

Strategic planning, in its pure sense, is a process employed by large organizations. In another sense, each person performs some sort of strategic planning in their day to day activities, for example, in selecting a school or a job and providing for a family. Therefore, to map the strategic planning process to a domain other than large corporations is justifiable. For example, it seems a "strategic audit" of ones skills, values, and desires might be appropriate before selecting a career.

To isolate an environment for the validation procedure, we look to the roots of people performing strategic planning in today´s large corporations. Many of today´s managers and analysts have been trained in general business principles by colleges and universities throughout the world. As students, they were taught principles by the "Case Method."

Schools of Business Administration have long attempted to integrate students´ rudimentary skills by an approach relying on the use of "cases." These cases provide a set of "real" data for an actual organization. The student is expected to assimilate the facts of the case, identify the problems, opportunities, and crises presented by the case information, and propose a plan of action to correct noted problems and crises and take advantage of opportunities. The first stage of case analysis closely resembles Lorange's "corporate audit." The difference between a case audit and auditing an actual organization is that information is constrained to the case description. The purpose of the case is to increase skill level in some particular realm of business management, although after preliminary skills have been taught, the cases take on broader orientations. One course, called "Strategic Planning," uses the case method to prepare students for jobs as planners in business organizations.

To document the impacts of a DSS on strategic planning, an experiment using subjects from a strategic planning course is appropriate. If a DSS for the strategic planning course supports the corporate audit phase of case analysis, a DSS can be created for the corporate audit phase of strategic planning in actual organizations. If recognition channeling is shown to be operational, then other disciplines may be potential candidates for recognition channeling DSS's.

2.1 A Description of the Case Method

Case descriptions in the Strategic Planning course include balance sheets, income statements, competitive analyses, descriptions of organizational structure, production methods, financial methods, marketing methods, and overall managerial policies. Students read and analyze the case, identify problems, crises, and opportunities, and develop a proposed plan of action. A recognition channeling DSS supports a student in the determination of problems, opportunities, and crises.

As students develop their skills for case analysis, the cases assigned require a broader scope of organizational perspectives. Also, as students progress, their time to perform the case analysis for a "broader" case is increasingly constrained. We therefore have heightened "TIME" inhibitors and "FORM" inhibitors to the assimilation of the "informational inputs" in the case.

The Strategic Planning course is an elective course in the sense students may choose to enroll in the course, even though they may have emphasized earlier courses in accounting, financial management, management science, personnel management, general management, marketing, production, or other areas which are identified with business administration curricula. Because the skills emphasized by disciplines are somewhat different, students bring differing managerial styles and models of reasoning based on earlier training.

In an article titled, "Problem Solving Style of Students - Are Educators Producing What Business Needs?" the managerial styles of students are investigated in terms of those styles that were identified in a previous chapter (Hoy, Boulton, 1983). The results of this study gave the following convincing analyses:

<u>Sensation vs. Intuitive</u>

1. Sensation types accounted for 28.7% of the sample; the number

of students in the sample which were identified as of this style was 51.

2. Intuitive types accounted for 71.3% of the sample; the number of students in the sample which were identified as of this type were 127.

Thinking vs. Feeling

1. Thinking types accounted for 31.5% of the sample; the number of students in the sample which were identified as of this type were 56.

2. Feeling types accounted for 68.5 % of the sample; the number of students in the sample which were identified as of this type were 122.

The authors of this article tested incoming students for style types, and contrasted the results with outgoing students. Incoming students did not display a different set of styles than the outgoing students; hence, it was concluded that Business Schools have not altered the problem solving styles of the students. The major finding of the study is summarized as follows:

> "Perhaps the greatest contribution that can be made by management educators would be to increase student awareness of alternate problem solving styles and the contingencies under which these styles are most appropriate." (Hoy, Boulton, 1983).

Having discussed the environment of an experiment designed to test the impact of a DSS on decision making, we now turn our attention to the design of the DSS.

3. ARTIFICIAL INTELLIGENCE (AI) TECHNIQUES FOR DECISION SUPPORT

Mechanisms of knowledge representation and manipulation have long been the emphasis of a subset of AI scholars. The purpose of the remainder of this chapter is to review those techniques that apply to recognition channeling in the strategic audit environment. We begin by reviewing the state of the art of expert based system techniques, in order that we may draw from the current systems those components and characteristics applicable to the strategic planning task.

The goals of recognition channeling are summarized as follows:

1. Decision makers need support to broaden the limitations of their current capacity for reasoning in an unstructured environment where variables are qualitative.

2. Decision makers need exposure to the differing managerial styles with emphasis on contingent applications of styles to a particular type of problem.

3. Decision makers need a method whereby the models of decision making can be made the focus of inter-organizational communication; at the same time, the insistence on suboptimizing behavior must be minimized.

4. Decision makers need support for incorporating relevant theoretical models into the decision making process.

5. Decision makers need a method by which direct action can result in the reduction of informational input inhibitors, in such a manner as to promote the availability and relevance of information.

3.1 A Review of Current Expert Systems

We will discuss six systems currently in use exhibiting the behavior we wish to capture in the DSS. The six systems are as follows:

1. Meta-DENDRAL and DENDRAL
2. TIERESIAS used in conjunction with MYCIN
3. CASNET
4. INTERNIST I and II
5. R1 or XCON
6. SOPHIE

These systems were selected on the basis of their current acceptance and inherent characteristics. We will now briefly review each system and emphasize its implications for the DSS design.

Meta DENDRAL and DENDRAL

The DENDRAL programs were created to assist chemical analysis of unknown compounds (Lindsay, Buchanan, Feigenbaum, and Lederberg, 1980). The basis of the system is a heuristic algorithm that seeks to generate a set of molecular structures that could account for a particular analysis of a newly identified compound. The system is somewhat unique in that it automatically builds its rule base, ie. it has a learning capability. The system is one of the few that is currently in wide use. The major implication is that the system is capable of aiding a user in identifying new compounds, thus providing insight into unknown arenas of thought. This is a type of opportunistic outlook which we will seek to capture in the design of a system for recognition channeling.

TIERESIAS Used In Conjunction with MYCIN

MYCIN was created to act as a consultant in the process of medical diagnosis for a subset of bacterial infections (Duda,Shortliffe, 1983). Subsequent to its introduction, the system was updated with TIERESIAS which gave MYCIN the capability to interact with the user to offer reasoning explanations and to allow an expert to update rules (Duda, Shortliffe, 1983). The system is characterized by a set of "attribute, object, and value" tuples which are referenced via production rules. The major implications of this composite system applicable to the system presented in this paper are the following (derived from Shortliffe,1980):

1. The design criteria are well established:

a. Performance reliability is in need of constant attention.

b. Recommendation justification procedures must be included in the interface.

c. The fit of the system into the daily routine of the user must be a factor in implementation.

d. The nature of the system as a teaching tool must be attended to.

e. The development of techniques to permit knowledge acquisition from experts without a programmer as intermediary must be a component of the design.

2. The system addresses the issues of:

a. Expert systems <u>can</u> be used to interact with a physician to improve diagnosis.

b. Expert systems <u>can</u> be used to teach models of reasoning.

c. Expert systems <u>can</u> offer potential for codifying knowledge, emphasizing the communication between experts about the nature of the diagnosis process.

CASNET

The CASNET system was designed to perform medical diagnosis specifically for the disease of glaucoma (Weiss, Kulikowski, Amarel, and Safir, 1978). The system is characterized by a network model which is used in a search procedure to pinpoint applicable causal pathways between nodes which represent possible symptoms and manifestations. A confidence factor is used to represent the strength of the connecting nodes in the ultimate determination of a diagnosis. The implications of this system to our particular design are related to the networking component of the system which relies on the causal relationships between nodes. Furthermore, the bottom up and top down approach which relies on the user's assessment of the situation will be a design concern.

INTERNIST I and II

Like CASNET and MYCIN, the INTERNIST programs perform diagnosis in the field of medicine (Miller, Pople, and Myers, 1982). The program's domain is more generic than the previous two;

it attempts to operate in the entire field of internal medicine. The program utilizes a bottom up and top down approach by analyzing patient data to form hypotheses, and then queries the user as to other symptoms that would differentiate between possible diagnoses. The program uses a "disease tree" that forms a taxonomy relating the nodes of the tree to parent nodes. The implication of this system to our domain is that the approach elicits additional information as it deems it is needed in order to completely review the relationships necessary to perform diagnosis. Further, the pruning process provides a convenient interface for the user in that a vast amount of unrelated information does not have to be supplied to the program.

R1 or XCON

The R1 system is used to configure VAX computers by supplying information relative to needed equipment that will facilitate the complete configuration of a system given the system components (McDermott, 1982). R1 supplies information relative to such items as needed cables to interconnect the components of a VAX system. The program operates on a rule search procedure based on a set of production rules. This system implies that information in an environment can be built into an expert system that will minimize the time for a decision maker to evaluate such things as total system cost, and particular items that are needed in order to make a VAX computer system complete can be elicited.

SOPHIE

The SOPHIE system is an example of the use of artificial intelligence in the field of education (Barr, Feigenbaum, 1982). Although the system is not generally referred to as an expert system, it does provide some implications to the design of a DSS to support recognition channeling. The program's purpose is to improve the problem solving skills of the user. A problem simulator is used to pose a situation to a user, and the program can evaluate the hypotheses of the user, generate hypotheses, and answer hypothetical questions. The idea of sensitivity analysis on answers and hypotheses the program can provide is a desirable characteristic of a program attempting to perform recognition channeling. By the process of variable manipulation, the user should be able to view the changes in approach that the system takes in order to gain insight into the delicate interrelationship existing between the variables to which the program responds. For example, suppose a set of inputs were provided to a program that aided in identifying models that may be appropriate in a particular situation. By changing a single input, the program would be able to offer a type of "sensitivity analysis."

3.2 The Current State of Expert System Methodologies

It is intended that the discussion of the six programs above provide an insight into the current state of the art of expert system techniques. As a synopsis to the preceeding discussion, a table is offered in Figure III.1 summarizing the systems on the characteristics of: purpose, from what the program resulted, the knowledge acquisition procedures utilized, the knowledge representation techniques utilized, the underlying mechanism that drives the system, the method of evaluation that was used to test the system, and whether or not the system is in current use.

In discussing the design of the system proposed in this paper, the components borrowed from these systems will not be mentioned specifically; the intent was merely to focus on a set of guidelines and assumptions which will be regarded in the DSS design.

4. CONCLUSION

The first three chapters have emphasized literature on decision making theory and the strategic planning process. In addition, a formal model of "recognition" has been described. From this model, the fundamental purposes of a DSS for strategic planning have been discussed. We have drawn from current expert systems those characteristics deemed desirable for the DSS. Chapter IV is a manuscript synthesizing concepts from chapters I, II, and III. Chapter V is a manuscript detailing the design of the DSS. The construction of the knowledge base is discussed in Chapter VI. A controlled experiment is the subject of Chapter VII. Some concepts from chapters I, II, and III are repeated in summary

FIGURE III.1: A REVIEW OF EXPERT SYSTEMS

NAME	PURPOSE	RESULTED FROM	KNOWLEDGE ACQUISITION	KNOWLEDGE REPRESENTATION	UNDERLYING MECHANISM	METHOD OF EVALUATION	IN USE?
SOPHIE	ALLOW STUDENTS TO LEARN BY TRYING OUT IDEAS, RATHER THAN INSTRUCTION	DESIRE TO IMPROVE PROBLEM SOLVING SKILLS	N/A	USES A MODEL OF PROBLEM SOLVING KNOWLEDGE AND HEURISTIC STRATEGIES FOR ANSWERING QUESTIONS, CRITICIZING HYPOTHESES, AND SUGGESTING THEORIES	ANSWER HYPOTHETICAL QUESTIONS, PERFORM HYPOTHESIS EVALUATION AND GENERATION. A PROBLEM SIMULATOR IS USED	RANDOM TRIALS	YES
META-DENDRAL, DENDRAL	ANALYZE MASS SPECTRAL PATTERNS TO SUGGEST CHEMICAL STRUCTURE OF UKNOWN COMPUNDS	CONSULTATION WITH EXPERTS IN THE FIELD	AUTOMATIC RULE FORMATION "LEARNING"	PRODUCTION RULES	HEURISTIC ALGORITHM TO GENERATE A SMALL SET OF POSSIBLE MOLECULAR STRUCTURES THAT COULD ACCOUNT FOR A SPECTROSCOPIC ANALYSIS OF AN UKNOWN COMPOUND	CASE STUDIES	YES
TIERESIAS AND MYCIN	PROVIDE CONSULTATIVE ADVICE ON DIAGNOSIS AND THERAPY FOR INFECTUOUS DISEASES	CONSULTATION WITH EXPERTS IN THE FIELD	EXPERT INTERVENTION TO PROVIDE NEW RULES AND UPDATE CURRENT RULES	"ATTRIBUTE, OBJECT, VALUE" TUPLES AND PRODUCTION RULES	GOAL ORIENTED, BACKWARD REASONING. CERTAINTY OR CONFIDENCE FACTORS ARE USED TO DECIDE BETWEEN ALTERNATIVES	RANDOM TRIALS	NO

FIGURE III.1 (continued)

NAME	PURPOSE	RESULTED FROM	KNOWLEDGE ACQUISITION	KNOWLEDGE REPRESENTATION	UNDERLYING MECHANISM	METHOD OF EVALUATION	IN USE?
CASNET	MEDICAL DIAGNOSIS, SPECIFICALLY IN THE DOMAIN OF GLAUCOMA	CONSULTATION WITH EXPERTS IN THE FIELD	UPDATED BY COMPUTER-BASED NETWORK OF COLLABORATORS	A DISEASE IS REPRESENTED AS A DYNAMIC PROCESS: PLANES OF STATE ARE NODES AND ARCS REPRESENT CAUSAL CONNECTIONS. A CONFIDENCE FACTOR EXPRESSES THE "STRENGTH" OF THE CAUSAL RELATION.	CAUSAL MODEL: DISEASES ARE DETERMINED BY SEARCHING FOR THE CAUSAL PATHWAYS BETWEEN NODES.	CASE STUDIES	NO
INTERNIST I,II	INTERNAL MEDICINE CONSULTATION PROGRAM	CONSULTATION WITH EXPERTS IN THE FIELD	N/A	A "DISEASE TREE" IS USED WHICH FORMS A TAXONOMY OF "FORM OF" RELATIONS. A DISEASE IS CONSIDERED AS A STATIC ENTITY.	BOTTOM-UP AND TOP-DOWN APPROACH: PATIENT DATA EVOKES DISEASE HYPOTHESES THAT INVOKE A QUERY FOR OTHER MANIFESTATIONS THAT SHOULD BE PRESENT IF THE HYPOTHESIS IS VALID. THE PROGRAM CANNOT PROVIDE THE REASONING FOR ITS DECISIONS.	CASE STUDIES OF CASES IN MEDICAL JOURNALS	NO
R1 OR XCON	CONFIGURES VAX COMPUTERS	A NEED FOR DETAILED SPECIFICATIONS TO MINIMIZE TECHNICIAN TIME	EXPERT INTERACTION	PRODUCTION RULES	RULE SEARCH PROCEDURE	CASE STUDIES	YES

form in chapters IV, V, VI, and VII.

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CHAPTER IV:
USE OF AN EXPERT SUBSYSTEM IN DECISION RECOGNITION CHANNELING

Mike Goul*, Barry Shane**, Fred Tonge*
Oregon State University
Corvallis, OR 97331

*Computer Science Department
(503) 754-3273

**School of Business
(503) 754-4033

Abstract

This paper presents an approach to including decision opportunity identification within a DSS. The design incorporates an expert subsystem for problem recognition (recognition channeling). This method can be used for expert subsystems in many domains. An actual subsystem for identifying strategy planning issues is included.

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1. INTRODUCTION

With few exceptions, the literature on decision making focuses on activity after an opportunity for decision making has been identified. Many models are proposed that give only minimal attention to identifying those opportunities. There is general disagreement and little supporting documentation for proposed theories of identification. Further, there is evidence (Brightman, 1980) that identifying an opportunity for decision making is muddled by the fact that real problems, opportunities, or crises are difficult to separate from symptoms or manifestations.

This paper presents an approach to computer-based support for the opportunity identification phase of decision making. Following the decision channeling approach of Stabell (Stabell, 1983), it focuses the decision maker's attention on recognizing decision opportunities. The paper presents 1) a model of decision opportunity identification, 2) discussion of an expert subsystem for recognition channeling, and 3) use of this approach in an example domain: strategic planning.

2. RELATED WORK

Simon identifies three phases in decision making: intelligence, design, and choice (Simon, 1960). Carlson characterizes the intelligence phase (as it would be supported by a DSS) as including the operations: gather data, identify objectives, diagnose problems, validate data, and structure problem

(Carlson, 1983).

Mintzbèrg and associates call the three phases identification, development, and choice (Mintzberg, Raisinghani, and Theoret, 1976). Identification is composed of recognition and diagnosis. Recognition is a process by which decision opportunities are identified in "streams of ambiguous, largely verbal data that decision makers receive." Their article distinguishes between opportunity, problem, and crisis recognition.

Pounds identifies two phases: problem finding and problem solving (Pounds, 1969). Problem recognition occurs when actual events differ from the state of affairs predicted by a decision maker's internalized models. These models are synthesized from such sources as historical data, models held by other decision makers, and formal theory.

Our work draws upon these sources, focusing on the first phase of decision making and incorporating Mintzberg's view of recognition and the notion of internalized models introduced by Pounds.

3. MODEL OF THE DECISION ENVIRONMENT

The decision system is represented in our model by a network of McCulloch-Pitts logic cells. These cells are designed for the "representation and analysis of logic situations that arise in discrete processes" (Minsky, 1967). Each cell is represented by a circle, with (possibly) several input lines and a single output line, which acts as input to other cells. Input lines may carry excitory or inhibitory signals, represented respectively by a pointing arrow or a small circle at the cell end of the line.

A sufficient number of excitory inputs may cause a cell to fire, sending out a signal that may be excitory or inhibitory to other cells. The threshold of a cell specifies the number of excitory inputs that must be active to cause the cell to fire. A single inhibitory input can negate the excitory inputs.

Figure IV.1 represents the recognition aspect of a decision situation with a three-layered network of cells. Two layers, labeled "Information Attributes" and "Decision Stimuli," represent the environment surrounding the decision maker. This decomposition emphasizes that stimuli exist naturally in any environment, and the decision maker in effect filters these stimuli (a decision in itself) to determine which ones warrant decision action.

The Environment. The three decision stimuli cells represent the three types of stimuli proposed by Mintzberg:

> The opportunity decision is often invoked by an idea, perhaps a single stimulus, although it may remain dormant in the mind of the individual until he is in a position to act on it. Crisis decisions are triggered by a single stimuli. They present themselves suddenly and unequivocally, and require immediate attention. Problem decisions typically require multiple stimuli (Mintzberg, Raisinghani, Theoret, 1976).

These cells are decision maker independent; informational inputs may act as excitory inputs at any time.

The four information attribute cells generate inhibitors to the firing of decision stimuli. They represent four contraints on environmental information proposed by Andrus (Andrus, 1971):

FIGURE IV.1: THE RECOGNITION ASPECT OF A DECISION SITUATION

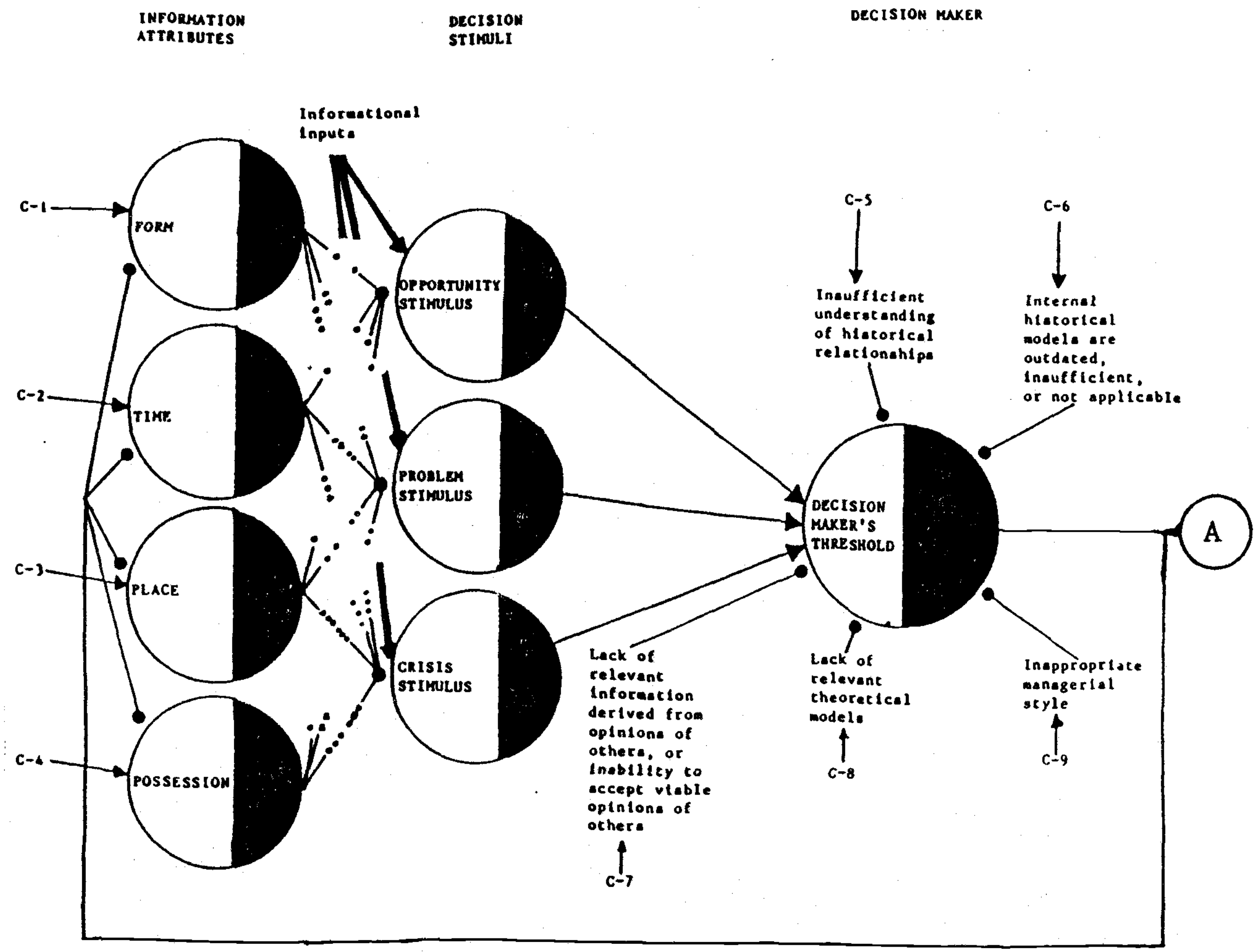
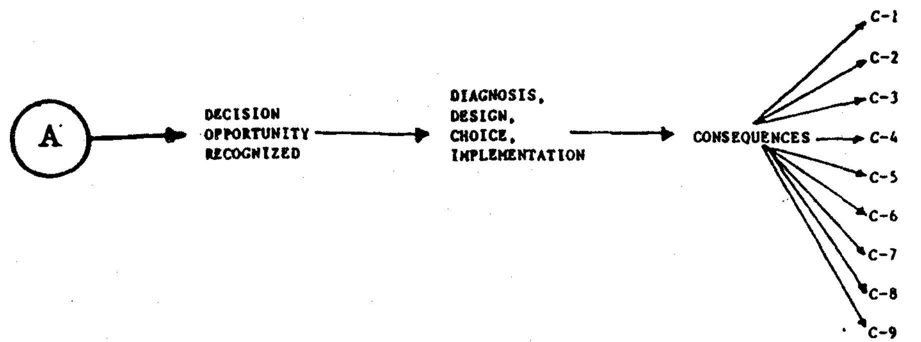


FIGURE IV.1 (continued)



FORM. The language or format of information may not be understandable. The volume may be so excessive as to require inordinate time to analyze the contents.

TIME. Information may arrive too early or too late.

PLACE. The information is not readily accessible; access would be so costly as to overcome the need.

POSSESSION. Closed communication prohibits exchange of information, or the right to use the information is not granted.

The Decision Maker. Output signals of a stimulus cell become excitory inputs to the decision maker cell. Several stimuli may fire simultaneously. Even though stimuli are occurring in their natural state, the decision maker reviews, selects, and operates on each of them. Some stimuli are not selected due to the internal state of the decision maker cell. For example, if the threshold is very large, small stimuli will be filtered at this stage and not carried on to decision opportunity recognition. Or, an inhibitor may constrain the firing of the decision maker cell.

Several inhibitors to the decision maker cell are suggested by Pounds´ discussion of internalized models (Pounds, 1969):

Historical models that are predicated on the continuity of historical relationships.

Other people´s models that are elicited through interview, discussion, formal and information information flows.

Extra-organizational models that encompass information acquired through the reading of scholarly works, analysis of the competition, and previous work experience.

Lack of pertinent models can lead to substandard problem finding.

Another inhibitor reflects the effect of decision maker style on the problem recognition process. Managerial style is classified in this model following the Jungian typology of Osmond and Osmundson, which emphasizes how the managers view time and the relative importance given in their decision making to past, present, and future states (Sayles, 1979):

> Thinking type managers are logical and consistent, think sequentially, and can recall, order and assess the impact of past actions and project the impact of future actions.
>
> Feeling type managers tend to look to the past and to embody the values and norms of the organization.
>
> Intuitive type managers can synthesize vast amounts of information and predict the needs of the future, often producing new strategies.
>
> Sensation type managers concentrate solely on the present, arriving at quick decisions the compromises and exerting their efforts to sense the present mood of the organization.

Every manager is a mixture of these types, with the strengths and weaknesses of each. For an individual decision maker to prosper, each of the four types of behavior must be exhibited at the proper time.

Note that the decision maker's activities in recognition lead not only to the later phases of diagnosis, design, choice, and implementation but also affect the information attributes inhibiting the presentation of decision stimuli.

4. RECOGNITION CHANNELING

This model makes Stabell's concept of a DSS based on decision channeling operational in the intelligence phase of decision making. This activity, called recognition channeling, is the act of applying computer based support to facilitate human recognition of opportunities, problems, and crises within a prescribed domain.

The concept of recognition channeling focuses attention on how a decision maker's recognition skills can be modified. The model suggests that the inhibitors to the decision maker cell and the threshold of that cell are appropriate targets for change. The DSS should be designed to reduce the effect of inhibitory inputs and to overcome an excessively high threshold.

For example, the DSS may help to overcome the inhibitory effect of inappropriate historical models and understanding of historical relationships by specific exposure to models that promote responsiveness to opportunity stimuli. As another example, the DSS may assist the "feeling type" manager to be concerned with the present and future, to view recognition as depending on more than internal historical models.

One important class of components of a DSS to support recognition channeling are expert subsystems that assist the decision maker in overcoming these inhibitory factors (Feigenbaum and McCorduck, 1983; Gorry and Rand, 1983).

5. NEED FOR AN EXPERT SUBSYSTEM

An expert subsystem makes available to the decision maker expert knowledge in a specific problem domain. The following considerations suggest including expert subsystems in a DSS for recognition channeling:

> Decision makers need support to broaden the limitation of their current capacity for reasoning in an unstructured environment where inputs and outputs are typically nonquantifiable.
>
> Decision makers need exposure to differing managerial styles with emphasis on contingent applications of styles to a particular type of problem.
>
> Decision makers need a method whereby models of decision making may be made the focus of intraorganizational communication.
>
> Decision makers need a method by which theoretical models provided by researchers may be incorporated into their decision making process.
>
> Decision makers need guidance in recognizing opportunities in the environment.
>
> Decision makers need a method by which direct action will reduce information inhibitors.

In the remaining sections a general design for an expert subsystem is presented, followed by an example subsystem.

6. DESIGN OF AN EXPERT SUBSYSTEM

Typically a DSS is tailored to a specific decision making task or set of tasks. Similarly, an expert subsystem within a DSS must be tuned to a particular decision domain, encompassing a single activity or a cluster of related activities.

The approach to expert subsystem design presented here is intended to be domain independent. This generic approach is achieved through a general organization of the database underlying the subsystem and through use of a menu-based interface for specifying the database contents. The following discussion of the database is presented in terms of entities represented and the relationships among those entities.

Entities. For a particular domain, the entities within the expert subsystem database are:

The domain itself
A set of diagnostic questions and answers (diagnostic module)
Models relevant to the domain
Model specific questions and answers
Model specific rules
Reasons why the rules are included

These entities are used as follows. Within a domain, a decision maker identifies applicable models of reasoning by posing a set of questions. Using the answers to these diagnostic questions, specific models are selected and invoked. These models are also question-answer. Answers related to a model's questions suggest decision rules that initiate the recognition phase or imply that other diagnostic questions or models of reasoning should be considered.

Relationships. Figure IV.2 presents a static view of the entities within the database. The relationships among these entities can also be described as a chain of casual connections. Figure IV.3 presents such a dynamic view of the entities and their relationships. These relationships are represented within the system by deterministic rules of the form "if ... then ...". The rules also show the dependencies among entities within the database.

Constructing an Expert System. For a particular domain, appropriate diagnostic modules, models, and rules must be identified and interconnected. An expert on the domain in question may advise a DSS designer in subsystem construction. A menu-based interface that facilitates entry and modification of modules, models, and rules directly by the expert relieves the system designer of attempting to interpret expert knowledge. Such an interface is a necessary component of an expert subsystem.

Once constructed, an expert subsystem can use the question-answer format to perform recognition channeling. Prescribed diagnostic questions and pertinent models of reasoning are invoked, some of which may be unfamiliar to the decision maker. Rules are activated based on single or combinations of answers. When the decision maker's ability to recognize an opportunity is inhibited, the subsystem can act to focus on appropriate models, eventually leading to clusters of decision rules based on expert

FIGURE IV.2: STATIC VIEW OF DATABASE ENTITIES

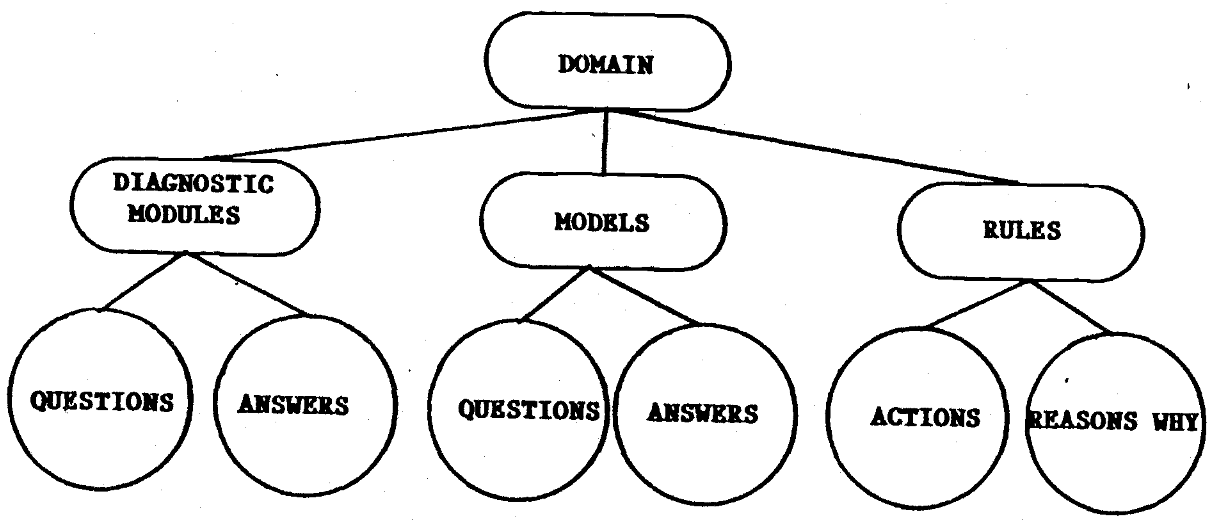
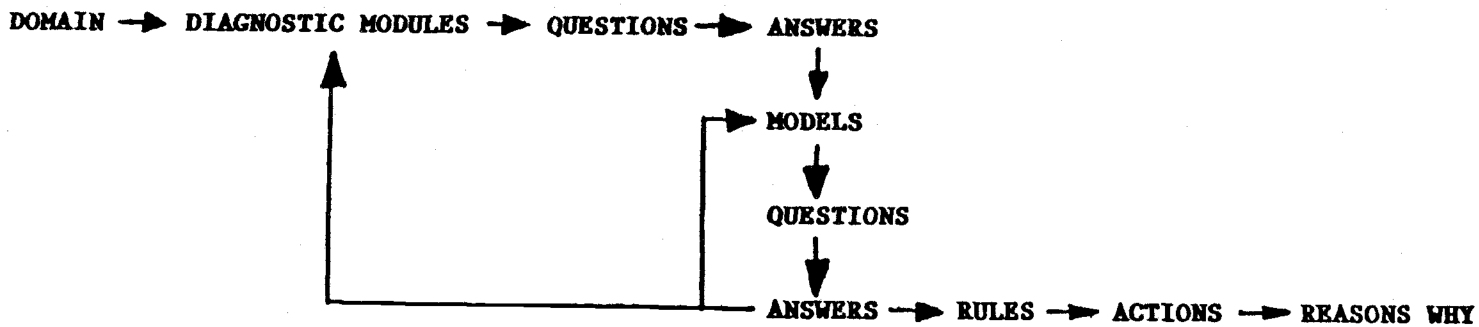


FIGURE IV.3: DYNAMIC VIEW OF DATABASE ENTITIES



knowledge. Thus, the subsystem can broaden the decision maker's scope of analysis and can narrow or widen the definition of applicable information needs.

7. EXPERT SUBSYSTEM FOR STRATEGIC MANAGEMENT

This section presents a broad outline of strategic management and a sample of diagnostic modules (along with specific issue areas) assessing current competitive positions and industry and organizational characteristics. Also there is a sample of theoretical and applied models frequently used in the process of strategic formulation. These models vary in size, domain and emphasis. The answers to the diagnostic questions act as stimuli to invoke the use of a specific analytical model.

A strategy may be considered a pattern in a stream of decisions that (a) guides the organization's ongoing alignment with its environment and (b) shares internal policies and procedures (Hambrick, 1983). These patterns are usually interdependent among three levels of organization: corporate, business and operational. However, the study of strategic issues focuses upon corporate and business level decision making. Decision patterns for corporate level strategy (in what businesses should the organization be) are distinct from business level strategy (how to compete within a given business). Managing a portfolio of different businesses determines the decision scope for the corporate strategist; identifying distinctive competencies and/or market niches to achieve a competitive advantage is the decision domain of the business strategist. Both require an awareness of emerging and shifting sets of variables which characterize their operating domains.

Strategic formulation at both levels has become increasingly complex. The size and combinations of the source, timing, form and possession of information for strategy have required decision makers to impose ever narrowing limits to strategic assessments. At the business level, industries appear to have their own key environmental and technical characteristics (Datta, 1979). The network of interorganizational relationships in which any single organization is embedded requires, at least, recognition (Fombrun and Astley, 1983). Changing one's strategy obviously affects the existing patterns; but a change in the relationships among others in the network may also determine the suitability of current strategy. The corporate or business level does not just manage its environment but is, in part, managed by it. All of these concerns are becoming increasingly prevalent and dealing with them vital to a healthy survival.

Recognition and diagnosis are a function of the efficacy of the original data search. There are many general modules used to assess current strategic position (Duncan, 1972; Hofer, 1973; Palla, Hitt, Ireland, and Godiwalla, 1982). Their use systematizes an heuristic approach to strategic problem definition. This expert subsystem uses a synthesis of several such approaches to generate a description of current conditions. Through a set of questions, these diagnostic modules prompt the decision maker for data to invoke appropriate theoretic models. The names of these modules are self explanatory. A partial listing of one is provided to illustrate the range of initial inquiry.

Diagnostic Modules

1. Managerial Perception of Environmental Uncertainty
2. Market Characteristics
   a. diversity
   b. size
   c. portfolio balance
3. Work Technology (production)
4. Competitive Position
5. Industry Strength
6. Administrative Philosophy/Human Resources
7. Strategic History
8. Financial Position
9. Organization Structure and Growth Stages

Each of the diagnostic modules prompts the decision maker for facts about the strategic setting. An example of these data or conditions is in Figure IV.4.

Strategic Analysis Models. There are several models widely used in the pursuit of strategic problem definition and assessment. Two problems arise for the strategist. First, which models provide the most powerful assessments? Second, because of bounded rationality, how can the salient information from several analyses be kept in an orderly fashion? To guide the decision maker with these difficulties, many of the commonly used analytic paradigms are interconnected to highlight their power and provide alternative views from the same database. Listed are the models currently installed:

1. Political/Values Model
2. Miles and Snow Model (Miles and Snow, 1978)
3. Porter´s Competitive Analysis
4. Industry Factors Model (Porter, 1980)
5. Profit Impact of Market Share Model (Anderson and Pain, 1983)
6. Functional Models (corporate environmental

FIGURE IV.4: MANAGERIAL PERCEPTION OF ENVIRONMENTAL UNCERTAINTY

General Areas:
1. Publics
2. Technology
3. Domestic Markets
4. International Markets
5. Ecology
6. Financial/Capital Markets

1. Publics

A. Suppliers
   1. Price Changes
   2. Quality Changes
   3. Design Changes
   4. New Materials

B. Competitors
   1. Price Changes
   2. Quality Changes
   3. Design Changes
   4. New Products

C. Customers
   1. Demand for Existing Products
   2. Demand for New Products
   3. Demographic Structure of Current Markets

D. Government Regulatory Agencies
   1. Changing Laws on Pricing, Standards, or Financial Practices
   2. Changes in Labor Law
   3. Changes in Accounting Practices

E. Labor Unions
   1. Expected Changes in Wages or Working Conditions
   2. Changes in Security
   3. Expected Major Grievances

marketing financial
production management)

7. Strategic Consistency Model
8. Boston Consulting Group Model (Boston Consulting Group)

8. VALUES MODEL

The traditional framework used in strategy formulation has been composed about a set of related elements, one of which is "the personal values of key implementers" (Porter, 1980).

The decision to enter certain businesses or markets is often influenced as much by a value set as by a technical analysis of whether it would be a prudent business decision (Tichy, 1983). Hence, the need to examine the personal values of the dominant coalition or organization's key decision makers. Supporting a technical analysis when members of the dominant coalition are against something because of a value position does not improve the likelihood of adopting the technical solution. Successfully implemented strategies are aligned closely to reflect the values or culture of the dominant coalition (Tichy, 1983).

To consider a values set as a facet in the strategic process draws attention to its relationship with other models used in analysis. Clearly, organization structure or design (Galbraith and Nathanson, 1978), Porter's generic marketing strategies (Porter, 1980), and the Miles and Snow typologies model of strategy formulation (Miles and Snow, 1978) would be related to and affected by the values set determined. Hence, these other models are invoked by specific responses the decision maker provides in the values model. As an example, if the dominant coalition seemed to express professional values then the Miles and Snow strategy typology invoked would be the "prospector" set.

A set of twenty rules adapted from Hage (Hage, 1980) representing the relationships among the "values of key implementers" and the constraints bounding the strategic formulation process is presented together with the set of questions in Figures IV.5 and IV.6. Answers provided by the decision maker invoke the appropriate rule(s). The invocation relationships are explained by the Rules - Questions Matrix. (See Figure IV.7.)

9. CONCLUSION

With current design methodologies underlying the typical DSS, unstructured problems have been difficult to support. Generally, design criteria have been developed from attempts to model the collective behavior of decision makers. These models focus upon the problem solving phase of the decision process; minimal attention has been devoted to the problem recognition phase.

The first part of this paper presents a model of decision opportunity identification. The second part presents the design of an expert subsystem within a DSS for recognition channeling. This capability is supported by a menu drive interface for building and modifying expert subsystems. This general purpose design can be used for expert systems in many domains. The third part presents a specific expert subsystem for recognition channeling in the strategic planning domain.

This approach expands the usefulness of a DSS by extending the

FIGURE IV.5:

RULES FOR VALUES MODEL

1. If decision making is centralized at the top of an organization, the dominant coalition will choose goals of quantity and low cost with little emphasis on innovation.
2. If the organization is decentralized, then the dominant coalition will choose goals of quality and moderate cost with little emphasis on innovation.
3. If the organization is mixed centralized-decentralized; the dominant coalition will choose goals of quantity, moderate low cost with some emphasis on innovation.
4. If there is a great concentration of specialists / professionals, the dominant coalition will choose goals of quality and innovation.
5. If the dominant coalition focuses much more on the internal environment, they will tend to choose cost efficiency as a goal.
6. If the dominant coalition focuses much more on the external environment, they will tend to choose innovation as a goal.
7. If professionalism is highly valued by the dominant coalition, they will tend to choose quality as a goal.
8. If non-professionalism is highly valued by the dominant coalition, they will tend to choose quantity as a goal.
9. If non-professionalism is highly valued together with a focus on the external environment by the dominant coalition, they will tend to choose a combination quality/quantity and moderate innovation as goals.
10. If non-professionalism is highly valued together with a focus on the internal organization by the dominant coalition, they will tend to choose quantity as a goal with no innovation.
11. If professionalism is highly valued together with a focus on the external environment by the dominant coalition, they will tend to choose high quality and high innovation as goals.
12. If professionalism is highly valued together with a focus on the internal organization by the dominant coalition, they will tend to choose quality with little innovation as goals.
13. If the dominant coalition overemphasizes some goals of the organization, it will create ineffectiveness in others and be replaced.
14. If standards of effectiveness change, then the dominant coalition will be evaluated as ineffective and be replaced.
15. If the size of the dominant coalition is large, it will attempt to achieve a balanced emphasis in the organization's goal mix.
16. If effectiveness of the organization is not very visible, the dominant coalition will tend not to change.
17. If a new dominant coalition emerges, it will tend to emphasize the opposite goals of the previous elite.
18. If a successful strategy has been in place for a long period, the dominant coalition will strongly resist any transformation because of their vested interests.
19. If the dominant coalition values and emphasizes efficiency and growth, it will attempt to dominate its environment and eliminate competitors (increase market share).
20. If the dominant coalition values and emphasizes innovation and quality, it will attempt to achieve equality with competitors (compete on differentiation).

FIGURE IV.6: QUESTIONS FOR VALUES MODEL

1. Decisions determining strategic direction tend to be:
   1. centralized.
   2. decentralized.
   3. mixed; somewhat centralized and decentralized.

2. Is there a high concentration of specialists or professionally trained members of the group determining strategic direction?
   1. yes. 2. no.
   3. cannot be determined.

3. The group determining strategic direction
   1. primarily focuses on internal organizational matters.
   2. primarily focuses on meeting external demands upon the organization.
   3. balances both internal and external concerns.

4. Do the strategic decision makers consider themselves to be professionally trained?
   1. yes. 2. no.
   3. cannot be determined.

5. Are any goals currently being overemphasized?
   1. yes. 2. no.

6. With regard to measuring the effectiveness of the current strategy, which of the following conditions exist?
   1. the old measures of performance are changing.
   2. the current measures of performance are not readily visible.
   3. none of the above.

7. About the group that sets strategic direction:
   1. a majority of the members are new.
   2. a large number seem to be involved in the process.
   3. none of the above.

8. Has the current strategy been successful for a period of time?
   1. yes. 2. no.

FIGURE IV.7: RULES/QUESTIONS MATRIX

RULE	ANSWER(S)
1	1.1
2	1.2
3	1.3
4	2.1
5	3.1
6	3.2
7	4.1
8	4.2
9	3.2 and 4.1
10	3.1 and 4.2
11	3.2 and 4.1
12	3.1 and 4.1
13	5.1
14	6.1
15	7.2
16	6.2
17	7.1
18	8.1
19	3.1 and 4.2
20	3.2 and 4.1

range over which the DSS assists the decision maker. Guided interaction serves to channel the search for relevant information. Different models supplement the decision maker's initial judgements.

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CHAPTER V:
THE DESIGN OF AN EXPERT SUBSYSTEM FOR A DECISION SUPPORT SYSTEM WITH AN APPLICATION TO STRATEGIC PLANNING

Michael Goul*, Barry Shane** and Fred Tonge*
Oregon State University
Corvallis, Oregon 97331

* Department of Computer Science
(503) 754-3273

** College of Business Administration
(503) 754-4033

ABSTRACT

An expert subsystem forms the basis for providing the DSS user with augmented opportunity, problem, and crisis recognition. This paper presents a multi-domain oriented expert subsystem design. The design includes a question-answer analyzer based on production rules invoking models of reasoning and rule-based inference. An application of the methodology described is given in the domain of strategic planning.

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1. INTRODUCTION

The inclusion of an ´expert component´ in a decision support system provides the potential for novel approaches to offering computer-based support to decision makers faced with unstructured problems. The intelligence or problem-finding phase of the strategic decision making process is an appropriate arena for expert system application. Earlier work on enhancing recognition of opportunities, problems, and crises, work that focuses on the intelligence phase of strategic decision making, serves as a basis for this paper (Goul, Shane, and Tonge, 1984, pp. 558-567).

Carlson characterizes the operations constituting the intelligence phase as: gather data, identify objectives, diagnose problem, validate data, and structure problem (Bennett, 1983 p. 25). An expert subsystem can aid a decision maker carrying out those operations by leading the decision maker to pertinent models of reasoning, offering theoretical conclusions, and providing supporting justification for those conclusions. Data gathering can be improved as the decision maker´s scope is narrowed or widened as necessary, dictated by the expert subsystem´s requests for information. A secondary outcome of this approach is that repeated use will reinforce effective decision making habits and teach new models of reasoning.

Decision Channeling has been defined by Stabell as the general property of an interface architecture that serves to both support and shift the decision process (Bennett, 1983 p. 251).

Characteristics of the user interface should be selected for their potential effect on the use of the DSS in improving the quality of decision making. This paper presents an expert system design intended to apply the concept of decision channeling to the intelligence phase of decision making. We refer to this as "recognition channeling."

Note that we are interested in what might be termed a "shallow" use of an expert subsystem, in which the subsystem guides, tutors, and consults for the ultimate user. This is in contrast to expert systems that attempt to capture the problem solving knowledge of an expert so that the system itself can replace a human in the decision environment. The experts involved in specifying the knowledge base for a DSS expert subsystem are providing information to support and guide the problem exploration activities of the ultimate system users. In contrast, the experts involved in providing the knowledge base for a "production" expert system are concerned with a complete specification of their problem solving expertise.

2. RELATED WORK

There are several themes of current research that will facilitate our discussion of a multi-domain expert subsystem design. First, we review the adaptive design process of a decision support system. Second, we consider reported approaches to expert subsystems in light of the requisites for accomplishing recognition channeling. Finally, we discuss two expert systems that are applicable to the DSS environment.

The adaptive design process for a decision support system has been characterized by Keen as a graph with ´System,´ ´User,´ and ´Designer´ nodes, and ´Cognitive,´ ´Implementation,´ and ´Evolution´ arc loops (Keen, 1980). The cognitive loop captures the relationship of system to user, and specifies that the system must be capable of personalized uses and must foster user learning. The implementation loop expresses the need for middle-out design and facilitative implementation in the relationship between designer and user. The evolutionary loop describes the ongoing process of system tuning, the designer´s observations of needs for changes in the system and the evolution of system functions to reflect these adjustments. This framework will be enhanced in later discussion to include an expert subsystem.

Feigenbaum and Mccorduck have characterized the development of an expert system as an "elaborate and tricky pas de deux" (Feigenbaum and Mccorduck, 1983 p. 83). This development requires a delicate exchange, between expert and programmer, of processes with which the expert is familiar, but which are not constrained by known artificial intelligence methodologies. The programmer must attempt to realize the process described by the expert using current knowledge representation heuristics and algorithms. There are a variety of potential mismatches which can lead to an unused expert system. Even when a successful system is developed, decision makers may not rely on the output because of a hesitancy to trust reasoning which is not completely explained or justified.

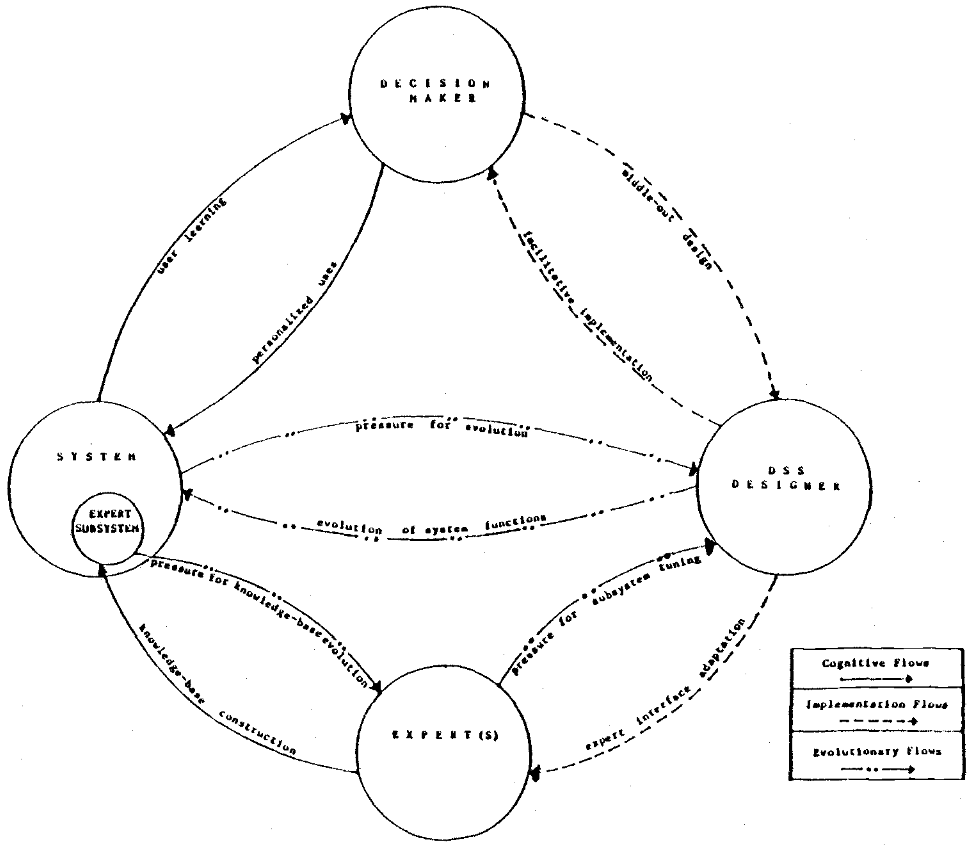
Several design concepts are exemplified by existing expert systems. TIERESIAS used in conjunction with MYCIN offers a methodology for acquiring new information and modifying erroneous knowledge (Davis and Lenat, 1982). INTERNIST I and II elicit information from the system user as deemed appropriate (Miller and Pople, 1982). This implies that a partial knowledge base can be constructed and tested dynamically. That is, a system can be constructed that requires increasingly pertinent information from the user as additional knowledge and meta-knowledge is provided the system. As the knowledge base grows, so too does the system's abilities to filter information from the user into a more meaningful response and to update its current context.

3. DSS DESIGN PROCESSES AND THE EXPERT SUBSYSTEM

Figure V.1 gives an enhanced version of Keen's original conception of the DSS design process. An additional node representing the Expert Subsystem Designer(s), and arcs from this 'Expert' node to 'System' and 'DSS Designer' have been included to reflect the dynamism of including an expert subsystem. The arc representing 'knowledge-base construction' implies a transfer of Expert knowledge to the expert subsystem. We now discuss the methodology adopted to accomplish such a transfer.

Several components of Keen's implementation and evolution loops can be used in analyzing the construction of an expert subsystem (more specific design criteria can be found in Alter, 1982, pp. 165-180). The major concept is that of dynamic system design. In contrast to a "systems life cycle" approach requiring

FIGURE V.1: ENHANCED DSS DESIGN PROCESS



heavy involvement of the expert in the initial conception and design of the system, followed by little contact until a final product is implemented, an approach can be implemented that allows the expert to interact directly, playing the role of both expert and ultimate user as system development progresses. Removal of the programmer from the initial developmental process will ease problems of communication, focusing the programmer on how to represent the system developed by the expert and performing validation by ensuring that the final system produces responses that the expert encoded into the preliminary model. In some cases, the preliminary model developed by the expert may need no further tuning; it will be sufficient to stand on its own merit.

To provide an environment in which an expert can interact directly with the development system, we again turn to DSS design processes to find guidance. Such a development system can be thought of as a decision support system for the construction of expert subsystems, a 'shell' for developing, testing, and using the expert subsystem. Our overall DSS must therefore be designed to support two classes of users: the expert (or a group of experts) and the decision makers who are the ultimate users of the system.

We take the following criteria for designing the expert subsystem:

1. Facilitate the direct interaction of the expert and the expert subsystem throughout the course of development.
2. Provide a system capable of supporting dynamic acquisition of new knowledge.
3. Allow the expert flexibility in the knowledge structuring process, middle-out design as opposed to top-heavy design.
4. Guarantee that reasoning processes are fully explained

and justified for the ultimate user.

4. AN OVERVIEW OF THE EXPERT SUBSYSTEM

An expert subsystem is organized into two parts as depicted in Figure V.2. The interface manager includes a "decision maker interface" and an "expert interface." The database contains knowledge of the decision domain: a diagnostic module for selecting among domain-relevant models, and model specific questions, answers, rules, and reasons for those rules.

The expert subsystem plays a role in the user's learning process as well as provide the user (hereafter referred to as decision maker or DM) with the potential for personalized use. In addition, refinements are captured as the expert reviews the decision maker's use of the expert subsystem to determine if adjustments are required. The flows between expert and DSS designer imply that the expert subsystem shell, the developmental DSS, be adapted to the expert(s).

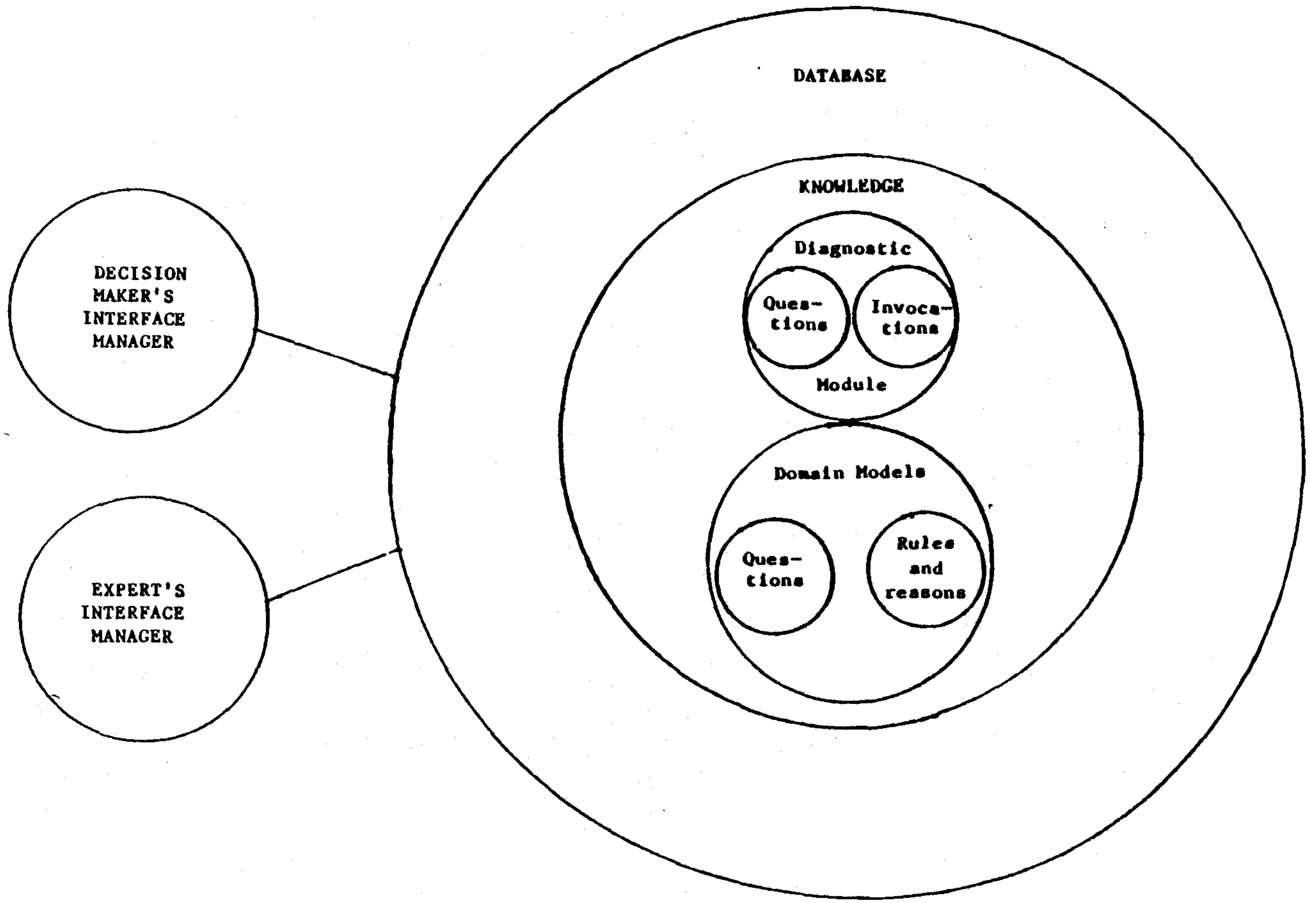
In the following sections, we discuss the two interfaces and then the database organization and algorithms.

5. THE DECISION MAKER INTERFACE

The non-expert user of the subsystem is faced initially with an interface environment. This environment has several functions:

1. Identify the user and determine whether she is an expert or a

FIGURE V.2: EXPERT SUBSYSTEM ORGANIZATION



non-expert.

2. Load the expert system(s) accessible to this decision maker.

3. Initiate a trace of the upcoming interactive session that will include all answers that the DM has entered, all responses given by the system, and any comments the DM wishes to enter into the trace log.

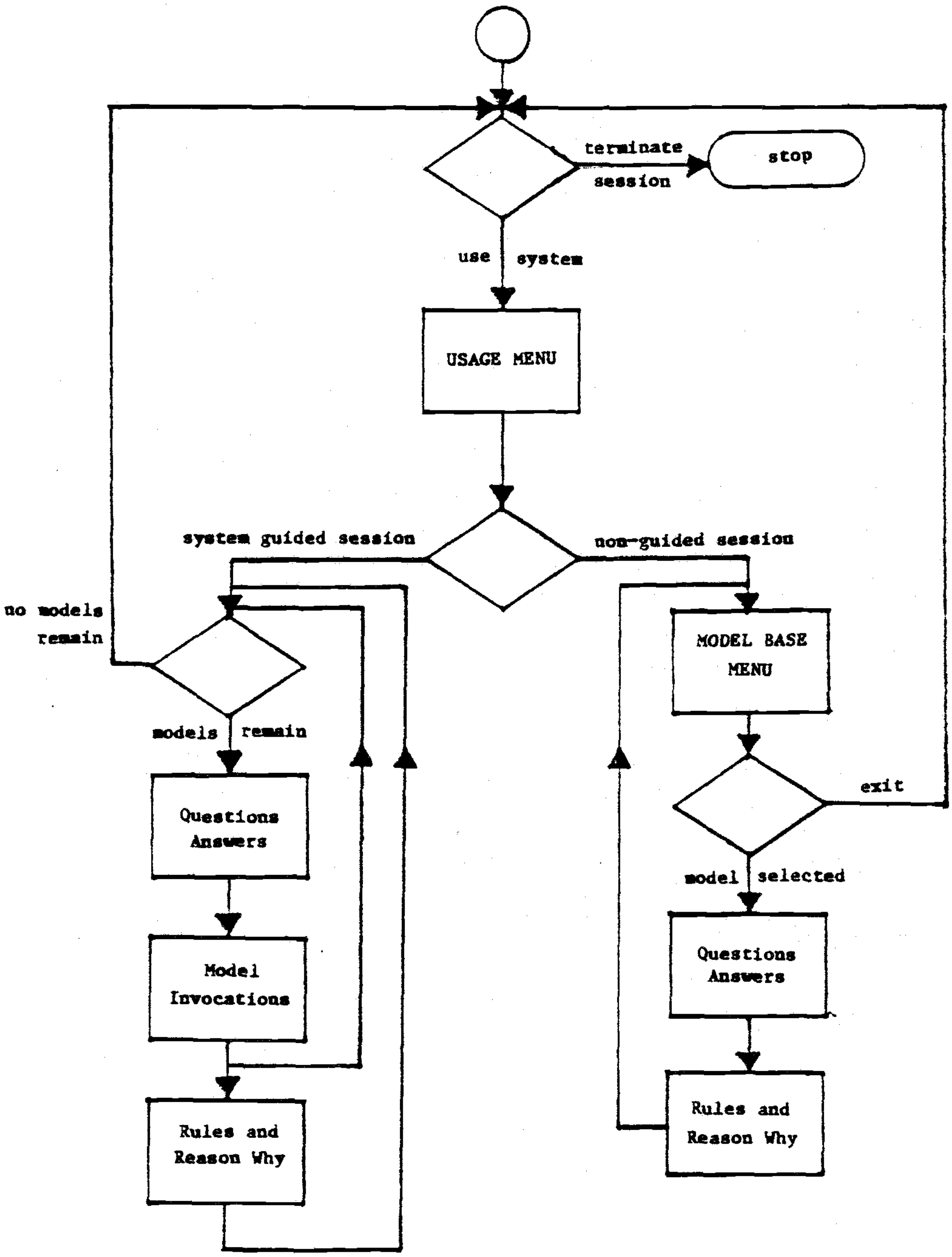
Upon passing through the environment, the DM is presented the main menu of the system. Here, she may choose to initiate a decision making session or terminate the interaction. The remaining interaction alternatives shown in Figure V.3.

After initiating a decision making session, the DM is offered the alternative of having the system guide the question-answer interaction, or of receiving no guidance; she may select a "strong" or "weak" approach to be taken by the system. A system-guided session invokes a particular "model of reasoning" that asks the DM for answers to a set of multiple choice questions. Based upon the answers provided by the DM, the system then invokes other models of reasoning deemed appropriate given the current context. Additionally, rules categorized by type are offered for consideration by the decision maker. Each rule includes a justification sequence that the DM may review.

If the decision maker chooses to control the course of the session (to receive no guidance), the available models of reasoning are displayed. Selection of a particular model will begin the question-answer and rule display interaction. Other models of reasoning are not invoked as in the system-guided interaction.

As an example of the decision maker interface, consider the

FIGURE V.3: DECISION MAKER INTERFACE FLOWCHART



portion of a session shown in Figure V.4. This example shows the automatic invocation of models of reasoning. As it was determined that the decision maker wishes to discuss administrative philosophy/history , the appropriate model of reasoning was invoked.

There are several primitive commands that the DM may enter at any time during the session. In Figure V.4, a command illustrated is DEFINE:. This command causes the system to reference an internal dictionary and display for the DM the definition of a particular term or phrase. Another command illustrated is COMMENT:. This allows the DM to enter a statement directly into the log of the current session. This trace can be used at a later time to remind the DM of ideas that arose during the session. Also, the decision maker may enter a comment on the way a particular question is stated, or disagree with a rule produced. Such information can support tuning the expert system.

6. THE EXPERT INTERFACE

The expert interface allows the expert to enter new models of reasoning, invocation relations that conceptually integrate the models, and rules with their ´reasons why´ and references. A flowchart of the alternatives of interaction is included as Figure V.5. The expert can control access to the models that she has created, allowing other experts to modify the model or maintaining security of the model. The expert interface also includes the decision maker´s interface. Using this, the expert can evoke a

FIGURE V.4: DECISION MAKER'S EXAMPLE SESSION

```
*********** E N V I R O N M E N T ***********

enter password:  DECISION-MAKER

    *** user category:  non-expert                           ***
    *** system trace initiated in file:  decision-maker1 ***
```

```
*********** U S A G E   E N V I R O N M E N T ***********
                    MAIN MENU

    1    ---->    select session type

    2    ---->    end session

enter the number associated with your selection:  1
```

```
*********** U S A G E   E N V I R O N M E N T ***********

    1    ---->    system guided session

    2    ---->    non-guided session

    3    ---->    return to main menu

enter the number associated with your selection:  1 a
```

QUESTION / ANSWER PHASE

```
Now invoking:  G E N E R A L   D I A G N O S T I C   M O D U L E
This module assesses the general business conditions preceeding business
strategy formation and assists in selecting an appropriate set of strategies for
analysis.

1.  Enter an area of assessment
        1.  Managerial perception of uncertainty
        2.  Market characteristics
        3.  Work technology
        4.  Industry strength
        5.  Administrative philosophy/history
        6.  Financial position
        7.  Organization Structure and growth

your selection:  5
```

FIGURE V.4 (continued)

Now invoking: ADMINISTRATIVE PHILOSOPHY/HISTORY MODULE
This module determines which general strategies would be appropriate.

The reason for invoking this module is: This module attempts to offer suggestions given that you have stated that the assessment is in the administrative philosophy/history area.

1. The dominant coalition determining strategy
    1. Has primarily focused upon internal organization matters
    2. Has primarily focused upon meeting external demands on the organization
    3. Balances both internal and external concerns

your selection: DEFINE: DOMINANT COALITION [b]
*** dominant coalition: an informal group of powerful managers located generally near the top of the organization whose interests are reflected in major policies.

your selection: 1

---

2. Do the strategic decision makers consider themselves to be professionally trained?
    1. Yes
    2. No
    3. Cannot be determined

your selection: 2

BEGINNING RULE DISPLAY PHASE

Rule Type: Suggested Business Strategies-

overall cost leadership
Enter W for why, C for continue: W [c]

Cost leadership strategies emphasize efficient scale facilities, vigorous cost reductions, tight overhead control, and avoiding marginal customer accounts. Overall cost leadership yields the firm above-average returns in its industry despite the presence of strong competitive forces.

References include:
-Porter, Michael. Competitive Strategy (New York, NY. Free Press, 1980)
-Thompson, Arthur. "Strategies for Staying Cost Competitive." Harvard Business Review. Jan-Feb, 1984. No. 1, p. 110.

You have said :
- Examine the Administrative History/Philosophy
- The dominant coalition focuses primarily upon internal matters
- The dominant coalition has little or no training

FIGURE V.4 (continued)

Rule Type: Major Assumptions-

Overall cost leadership strategy: Dominant coalitions focusing upon internal organizational matters tend to select cost efficiency as a strategy. Non-professionally trained coalitions select quantity as a strategy and with a focus on both internal matters and non-professionalism, little innovation is detected in strategy. All these characteristics are consistent with cost leadership as a strategy - independent of industry.

Enter W for why or C to continue: COMMENT: CHECK THIS ASSUMPTION ABOUT COST LEADERSHIP STRATEGIES IN VARIABLE COST INDUSTRIES.[d]

Enter W for why or C to continue: C

Rule Type: Typical Applications-

industry competitive positions in which:

- maintaining a wide line of related products hence spreading fixed costs is required
- high, initial, non-recoverable investment is required to enter competitive market
- costs of substitute products are decreasing

Enter W for why or C to continue:

GO: COST LEADERSHIP[e]

Notes to accompany the Decision Maker Interface:

[a] The decision maker requests a 'strong' session as opposed to a 'weak' session.

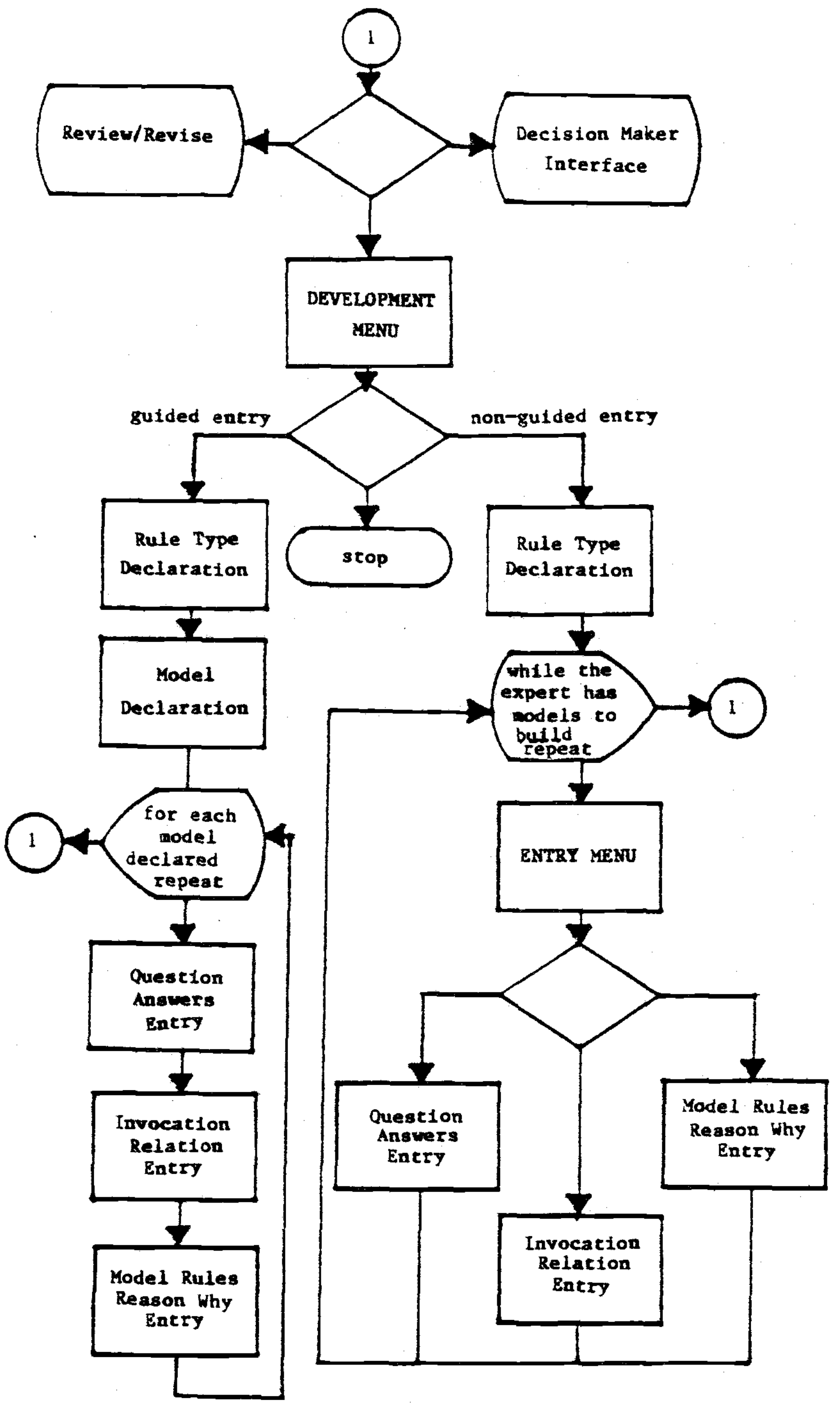
[b] The decision maker requests the definition of the term 'dominant coalition.'

[c] The decision maker wishes to know why the expert system has specified cost leadership as a possible business strategy.

[d] The decision maker enters a reminder into the system log.

[e] The decision maker requests that the 'cost leadership' subsystem be loaded and executed.

FIGURE V.5: EXPERT INTERFACE FLOWCHART



particular model of reasoning to test its behavior.

As in the decision maker interaction, the session is traced, allowing the expert or DSS designer to analyze the log and determine if adjustments to the system are indicated. An example expert session to create the system illustrated previously is shown in Figure V.6.

This session fragment has illustrated the declaration of rule types and models, the building of the questions and possible answers in a model, and the establishment of "invocation relations" that interrelate the declared models. The system supports both invocation rules and model rules. The process of forming a rule was demonstrated in the Invocation Relation Entry Phase of the example session in Figure V.6. More complex rules than those shown can be formed using "and" and "or" connectives.

7. DATABASE ORGANIZATION

The database for the expert subsystem is based upon the relational data model (Codd, 1970). Figure V.7 shows two relations in a partial database for the expert subsystem demonstrated in Figures V.4 and V.6. As the expert builds the knowledge base, a relation named GENERAL evolves as the root directory. The names of each model that the expert declares form the key for this relation. For each model in the system, GENERAL stores the purpose of the model, the number of questions in the model, the number of invocation relations in the model, the number of rules in the model, and the security code assigned by the creator. The

FIGURE V.6: EXPERT'S SAMPLE SESSION

```
********** E N V I R O N M E N T **********

enter password:  EXPERT

     *** user category:  expert                    ***
     *** system trace initiated in file:  expert1  ***

will this be a new system (N) or will
we be using an existing system (E):  N  a
```

```
********** D E V E L O P M E N T   E N V I R O N M E N T **********
                 MAIN MENU

    1 ----> select development session type

    2 ----> select usage session type

    3 ----> end session

enter the number associated with your selection:  1  b
```

```
********** D E V E L O P M E N T   E N V I R O N M E N T ***********

    1 ----> create a new system: guided entry

    2 ----> create a new system: non-guided entry

    3 ----> revise the current system

    4 ----> review the current system

    5 ----> return to main menu

enter the number associated with your selection:  1  c
```

```
*** R U L E   T Y P E   E N T R Y ***

Enter a rule type, F for finished:
SUGGESTED BUSINESS STRATEGIES

Enter a rule type, F for finished:
MAJOR ASSUMPTIONS

Enter a rule type, F for finished:
TYPICAL APPLICATIONS

Enter a rule type, F for finished:
F
```

FIGURE V.6 (continued)

```
--------------------
Input Review

Are the following rule types correct?
SUGGESTED BUSINESS STRATEGIES
MAJOR ASSUMPTIONS
TYPICAL APPLICATIONS
            (Y or N):  Y d
------------------------------------------------------------

*** M O D E L   D E C L A R A T I O N ***

Enter the names of the models to be included in the system.  Recall that the
first model entered will always be automatically invoked if the decision maker
selects the "Cycled Session" option.

Enter a model name (D for done):   GENERAL DIAGNOSTIC MODULE
    Security Codes:
              R  --> allow other experts to only read the model
              W  --> allow other experts to read and modify the model
              P  --> allow no other person to read or write to the model

    Enter the security code for this model:  W e

Enter a model name (D for done):  ADMINISTRATIVE PHILOSOPHY/HISTORY MODULE
    Security Codes:
              R  --> allow other experts to only read the model
              W  --> allow other experts to read and modify the model
              P  --> allow no other person to read or write to the model

    Enter the security code for this model:  P

Enter a model name (D for done):  D
--------------------------
Input Review

Are the following model names correct?
GENERAL DIAGNOSTIC MODULE
ADMINISTRATIVE PHILOSOPHY/HISTORY MODULE
(Y or N):  Y
------------------------------------------------------------
*** M O D E L   B U I L D I N G   P H A S E ***
      Model Name:  GENERAL DIAGNOSTIC MODULE

Enter a brief description or phrase that represents the purpose of this model:
THIS MODULE ASSESSES THE GENERAL BUSINESS CONDITIONS PRECEEDING BUSINESS
STRATEGY FORMATION AND ASSISTS IN SELECTING AN APPROPRIATE SET OF STRATEGIES FOR
ANALYSIS.
```

FIGURE V.6 (continued)

```
----------------
Question/Answer Phase:

Enter question number   1  (D for done):
ENTER AN AREA OF ASSESSMENT:

    Enter a word or phrase that envelopes the purpose of this question:

     ASSESSMENT f
-----------
      Enter possible answer    1   (D for done):
MANAGERIAL PERCEPTION OF UNCERTAINTY

      Enter possible answer    2   (D for done):
MARKET CHARACTERISTICS

      Enter possible answer    3   (D for done):
WORK TECHNOLOGY

      Enter possible answer    4   (D for done):
INDUSTRY STRENGTH

      Enter possible answer    5   (D for done):
ADMINISTRATIVE PHILOSOPHY/HISTORY

      Enter possible answer    6   (D for done):
FINANCIAL POSITION

      Enter possible answer    7   (D for done):
ORGANIZATION STRUCTURE AND GROWTH

      Enter possible answer    8   (D for done):
D
--------------------------
Input Review

Is the following question and possible answers correct?  (Y or N)

ENTER AN AREA OF ASSESSMENT
       1  MANAGERIAL PERCEPTION OF UNCERTAINTY
       2  MARKET CHARACTERISTICS
       3  WORK TECHNOLOGY
       4  INDUSTRY STRENGTH
       5  ADMINISTRATIVE PHILOSOPHY/HISTORY
       6  FINANCIAL POSITION
       7  ORGANIZATION STRUCTURE AND GROWTH

? Y
--------------------------------------------------------------------
Question/Answer Phase

Enter question number   2   (D for done):
D
--------------------------------------------------------------------
```

FIGURE V.6 (continued)

Invocation Relation Entry Phase

Models Declared:
GENERAL DIAGNOSTIC MODULE
ADMINISTRATIVE PHILOSOPHY/HISTORY MODULE

What is the name of the model that will be invoked by the upcoming rule? (D for done)
ADMINISTRATIVE PHILOSOPHY/HISTORY MODULE

What is the reason why this model should be invoked? THIS MODULE ATTEMPTS TO OFFER SUGGESTIONS GIVEN THAT YOU HAVE STATED THAT THE ASSESSMENT IS IN THE ADMINISTRATIVE PHILOSOPHY/HISTORY AREA.

Which of the following questions applies to invocation relation 1, clause 1 ?

QUESTION	KEY PHRASE
1	ASSESSMENT

Enter the number of a question to be in the current clause (0 for done): 1
Enter the number of a question to be in the current clause (0 for done): 0

Question 1 is:
ENTER AN AREA OF ASSESSMENT
1 MANAGERIAL ASSESSMENT OF UNCERTAINTY
2 MARKET CHARACTERISTICS
3 WORK TECHNOLOGY
4 INDUSTRY STRENGTH
5 ADMINISTRATIVE PHILOSOPHY/HISTORY
6 FINANCIAL POSITION
7 ORGANIZATION STRUCTURE AND GROWTH

Enter an answer that should cause invocation of: ALLOCATION MODULE (0 for done): 5

Enter an answer that should cause invocation of: ALLOCATION MODULE (0 for done): 0

Current rule: 1.1 --> ADMINISTRATIVE PHILOSOPHY/HISTORY MODULE[g]

Should there be any more clauses in rule 1 (Y or N) ?: N

Rehersal of invocation relation 1:
Given the following entries by the user, ADMINISTRATIVE PHILOSOPHY/HISTORY MODULE will be automatically invoked:
1 ENTER AN AREA OF ASSESSMENT
5 ADMINISTRATIVE PHILOSOPHY/HISTORY

Is this rule correct? (Y or N): Y

FIGURE V.6 (continued)

Notes to accompany the Expert Interface:

[a] The expert indicates that a new system will be created in this session.

[b] The expert requests the menu for building an expert subsystem.

[c] The expert requests that the expert system shell guide the building of the new expert subsystem.

[d] In the Input Review phase, the expert can modify any errors in what has been most recently entered.

[e] The expert indicates that any expert with access to this subsystem will be able to modify this model.

[f] The key phrase is used to remind the expert of the purpose of the question during the rule building phase.

[g] After each boolean clause is entered, the expert reviews the current status of the 'rule' in its encoded form

FIGURE V.7: TWO RELATIONS IN DATABASE

GENERAL

model names	model purpose	used	marked	# of questions	# of invocations	# of rules	permissions
General Diagnostic Module	The model assesses business conditions preceeding business strategy formation and assists in selecting an appropriate set of strategies for analysis			1	1	0	W
Administrative Philosophy / History	This model determines which business strategies would be appropriate given administrative philosophy / style and past history			2	0	5	P

RULE TYPES

TYPE
Suggested Business Strategies
Major Assumptions
Typical Applications

attributes "used" and "marked" are utilized to maintain the context of a session.

The rule types that the expert declares are contained in a relation called RULE TYPES. Rule types are not model dependent; every rule in the system has a particular rule type. The ultimate user of the system is presented a model's rules, listed by rule type, as illustrated in Figure V.4.

For each model in the expert subsystem, three relations store questions and answers, invocation relations, and the model's rules and justifications. Figure V.8 shows the INVOCATION RELATIONS and QUESTIONS relations for the GENERAL DIAGNOSTIC MODULE of the sample sessions. The QUESTIONS relation stores each question and possible answer. In addition, the "keyword" attribute is maintained to provide the expert with a convenient way of distinguishing questions. INVOCATION RELATIONS contains encoded rules which, when evaluated to true, cause the indicated model to be invoked. The reason for a particular automatic invocation is also stored as an attribute. Our sample database contains no rules for the GENERAL DIAGNOSTIC MODULE, therefore, no RULES relation is shown in Figure V.8.

Figure V.9 shows the QUESTIONS and RULES relations for the ADMINISTRATIVE PHILOSOPHY MODULE of the sample sessions. The RULES relation is similar to INVOCATION RELATIONS; attributes are encoded Boolean rules, a statement of the rule, the reasoning supporting the rule, and the rule type.

FIGURE V.8: GENERAL DIAGNOSTIC MODULE DATA

GENERAL DIAGNOSTIC MODULE QUESTIONS

# of ans.	module questions	answers								keyword
7	Enter Area of Assesssment	Managerial Perception of Uncertainty	Market Character-istics	Work Techn-ology	Industry Strength	Admin-istrative Philosophy /History	Financial Position	Organiz-ational Structure & Growth		Assessment

GENERAL DIAGNOSTIC MODULE
INVOCATION RELATIONS

encoded boolean rule	model to be invoked	reason for invocation
1.1	Administrative Philosophy / History Module	This module determines which business strategies would be appropriate given administrative philosophy/ style and history

FIGURE V.9: ADMINISTRATIVE PHILOSOPHY MODULE DATA

ADMINISTRATIVE PHILOSOPHY MODULE

# of ans.	question	answers			keyword
3	The dominant coalition determining strategy:	primarily focus on internal organization matters.	primarily focus on external demands on the firm.	balances both internal and external matters	internal /external matters
3	Do the strategic decision makers consider themselves to be professionally trained?	yes	no	cannot be determined	training

ADMISTRATIVE PHILOSOPHY MODULE RULES

encoded boolean rules	rule statement	reason why	rule types
1.2 and 2.1	overall cost leadership	The objective of a cost leadership strategy is to maintain a profitable competitive position within an industry using relative low cost as the critical success factor.	suggested business strategies
1.2 and 2.1	overall cost leadership	Dominant coalitions who focus upon internal organization matters select cost efficiency as a strategy. Non-professionally trained coalitions select quantity as a strategy. With a focus on both little innovation is detected in strategy. All these characteristics are consistent with a cost leadership strategy.	major assumption
1.2 and 2.1	competitive positions in which maintaining a wide line of related products spreading fixed costs is required.	buyer demand for wide product lines requires strategies which would stress quantity and spread fixed costs. This is especially valid for mature industries , less so for growing industries.	typical application
1.2 and 2.1	competitive positions in which high initial non-recoverable investments are required to enter competitive markets.	industries with high entry barriers would offer low margins to new entrants, discouraging any attempts at initial investment.	typical application
1.2 and 2.1	competitive positions in which costs of substitute products are decreasing.	relative industry cost position determines financial soundness when substitute products encroach on the marketplace.	typical application

FIGURE V.10: DECISION MAKER INTERFACE ALGORITHM

```
Procedure GUIDEDSESSION
/ This procedure supports a "strong" session for the ultimate user of the expert
subsystem. The algorithm relies on a "swapping" process whereby models are
loaded, one at a time, answers to the questions in the model are solicited,
invocation rules are evaluated given the current context, and model rules are
similarly evaluated. The cycling continues until no new models are marked for
invocation. There are three primitive sub-procedures that are called by
GUIDEDSESSION: LOAD, QUESTION, and PROCESS. /

 set current-model to the first model in relation GENERAL
 LOAD (current-model)
 QUESTION (current-model)
 PROCESS (current-model)
 while models remain that are marked but not used do
         current-model = first model in GENERAL marked but not used
           / note that this part of the algorithm can be easily
             modified to provide either a breadth first search or a
             depth first search of the active models /
         LOAD (current-model)
         QUESTION (current-model)
         PROCESS (current-model)
end /procedure GUIDEDSESSION/

        Sub-procedure LOAD (current-model)
        /  This procedure loads a new model into the internal working space
           given that a model has been "marked," but not yet used. The
           procedure relies on the summary information for each model
           contained in relation GENERAL. The internal relations QUESTION,
           INVOCATION RELATIONS, and RULES are filled with the current-model./
               for acounter = 1 to the #-of-questions in current-model do
                         retrieve and store the #-of-answers to the question
                         for bcounter = 1 to the #-of-answers do
                                 retrieve and store a possible-answer
                         retrieve and store the question
               for acounter = 1 to the #-of-invocations in current-model do
                         retrieve and store the encoded-boolean-rule
                         retrieve and store the model-to-be-invoked
                         retrieve and store the reason-for-invocation
               for acounter = 1 to the #-of-rules do
                         retrieve and store the encoded-boolean-rule
                         retrieve and store the rule-statement
                         retrieve and store the reason-why
                         retrieve and store the rule-type
        end /sub-procedure LOAD/
```

FIGURE V.10 (continued)

```
Sub-procedure QUESTION (current-model)
/ This procedure asks the ultimate user each of the multiple
  choice questions contained in current-model. The answers
  solicited from the user are stored for evaluation in terms of
  invocation rules and model rules in procedure PROCESS. /
       display name of current-model
       if this is not the first model then
            display reason-for-invocation of the current-model
       for acounter = 1 to the #-of-questions in current-model do
            display the question
            for bcounter = 1 to the #-of-answers do
                 display the possible answer
       query the user for the one best answer
       store the answer the user selected
end /sub-procedure QUESTION/

Sub-procedure PROCESS (current-model)
/ This procedure utilizes the user's answers to questions from
  procedure QUESTION to fire invocation rules and model rules.
  The procedure marks the current-model as being used in relation
  GENERAL. Invocation rules cause models to be marked in relation
  general, and model rules that fire are listed by rule type. The
  user is asked if justifications for the current rule should be
  reviewed. /
       indicate that current-model has been used in relation GENERAL
       for acounter = 1 to #-of-invocations do
               evaluate the encoded-boolean-rule
               if the evaluation is TRUE then
                       mark the appropriate model in relation GENERAL
       for each rule-type do
               for acounter = 1 to #-of-rules do
                       if the rule-type of this rule = the rule-type
                          under current consideration then
                               if the rule evaluates to TRUE then
                                      display the rule
                                      see if the user wants the
                                         reason-why
end /sub-procedure PROCESS/
```

8. SELECTED ALGORITHMS

Two major algorithms are discussed relating to the system guided or "strong" sessions available to both decision maker and expert. Hereafter, the algorithm corresponding to the decision maker session of Figure V.4 will be referred to as GUIDEDSESSION. Likewise, the "strong" design oriented algorithm enabling the expert to build the knowledge base will be referred to as GUIDEDENTRY. Figures V.10 and V.11 show GUIDEDSESSION and GUIDEDENTRY respectively.

We now discuss several concepts underlying both algorithms. The knowledge base is stored in files that each contain an individual model, its rules, and justifications. In GUIDEDSESSION, a particular model is brought to internal storage to reside in relations QUESTIONS, INVOCATION RELATIONS, and RULES. After the model has been used or "fired," the three relations are emptied and the next model to be explored is loaded. This "swapping" process is also evident in GUIDEDENTRY; as each model is built, it is transferred out of internal storage. Two relations are independent of the individual models: RULE TYPES, and GENERAL; they remain in internal storage throughout both guided execution and guided entry.

The algorithms as shown omit their interaction with the general parser that operates on all entries by expert or decision maker. This parser is responsible for handling the DEFINE:, COMMENT:, and GO: primitives illustrated in Figure V.4.

FIGURE V.11: EXPERT INTERFACE ALGORITHM

```
Procedure GUIDEDENTRY
/ Assuming an expert has selected to build a new expert subsystem, and has
requested that the session be guided, procedure GUIDEDENTRY leads the expert
through the processes of: Rule Type declaration, Model declaration, and the
Model Building phase. The user is requested to rehearse data entered at logical
checkpoints throughout the processes. Procedure BUILDRULE, which guides the
expert through the development of a boolean rule, will be omitted in the detail
of this algorithm. /
        while the expert has rule types to declare do
                read rule types
        rehearse rule types
        store in relation RULE TYPES
        while the expert has models to declare do
                read the model-name
                obtain a security code for the model
        rehearse model names
        store in relation GENERAL
        for each model declared by the expert do
                read the model purpose
                while the expert has questions and answers for the model do
                        read a question
                        read a keyword for the question
                            /The keyword provides the expert a way of
                             quickly recalling the nature or purpose
                             of the question./
                        read the possible answers
                        rehearse
                        store in relation QUESTION
                while the expert has invocation rules to enter do
                        BUILDRULE (invocation-rules, INVOCATION RELATIONS,
                                                               QUESTIONS)
                while the expert has model rules to enter do
                        BUILDRULE (model-rules, RULES, QUESTIONS)
                for relations QUESTION, INVOCATION RELATIONS, and RULES do
                        commit the relation to long term storage
                        empty the internal copy of the relation in preparation
                                for the next model to be built
end /procedure GUIDEDENTRY/
```

9. CONCLUSION

This paper provides a blueprint for the design of an expert subsystem intended to accomplish decision channeling in the recognition phase of the decision making process. A domain independent design supports both the expert in the construction of a subsystem and the ultimate user in a decision making application. Two classes of rules, encoded using Boolean operators and specific answers to particular questions, interrelate the various models in the system and offer appropriate consultation, tutoring, and guidance. The interconnection between other DSS subsystems and the expert subsystem is achieved utilizing the GO command. A "scratch-pad" for the systems users provides a log of each session using the "COMMENT" command. Both the expert developer and the decision maker may select "strong" or "weak" algorithms to accomplish their respective tasks.

An expert subsystem for recognition channeling in the domain of strategy formation is being developed using the design presented. Before forming appropriate strategies, decision makers must assess both internal and external conditions. An appropriate strategy is then matched to their assessment of competitive conditions. Utilizing a DSS with an expert subsystem in the assessment phase of strategic planning improves recognition channeling for users. Future research includes further development of the strategic assessments expert subsystem and empirical testing of the efficacy of its use.

Another domain in which the expert subsystem is being implemented is in the field of entomology. The expert subsystem will assist in pest identification and offer remedial methods given particular infestations.

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CHAPTER VI:
THE DSS KNOWLEDGE BASE

1. INTRODUCTION

This chapter discusses computer-based support designed to assist an expert in construction of a knowledge base for an expert subsystem. In addition, the database structure and algorithms for both the expert and decision maker interfaces are discussed. The expert interface detailed in Chapter V is presented as adapted for the strategic planning domain. Decision support system design criteria were the basis for building the expert's interface.

The expert interface is organized in a manner consistent with the DSS design principles: Representations, Operations, Memory Aids, and Control Aids (Bennett, 1983). The system execution sequence of Chapter V is enhanced with graphical representations. This chapter begins with a discussion of these representations. We then review operations, memory aids, and control. Several session fragments are used to illustrate the concepts.

The database structure is based on the relational model as discussed in Chapter V. The decision maker and expert interface algorithms were given in Chapter V. This chapter concludes with a complete analysis of these algorithms.

2. REPRESENTATIONS

From a technical standpoint, the expert subsystem design of

Chapter V calls for the construction of a knowledge base to be used in a "deterministic state machine." A "state" is characterized as a specific point in time in the system execution sequence. The initial state requires the decision maker to answer questions from a "Diagnostic Module." The machine poses questions to a user and offers a series of answers from which one must be selected. Based on the answers selected, there are two possible types of "state changes." The first type of state change directs the decision maker to "models of reasoning" that are deemed to be applicable. The second type of state change involves "expert advice" deemed relevant to the decision maker's context. Each piece of advice belongs to a single system-wide category; all categories are collectively referred to as "rule types."

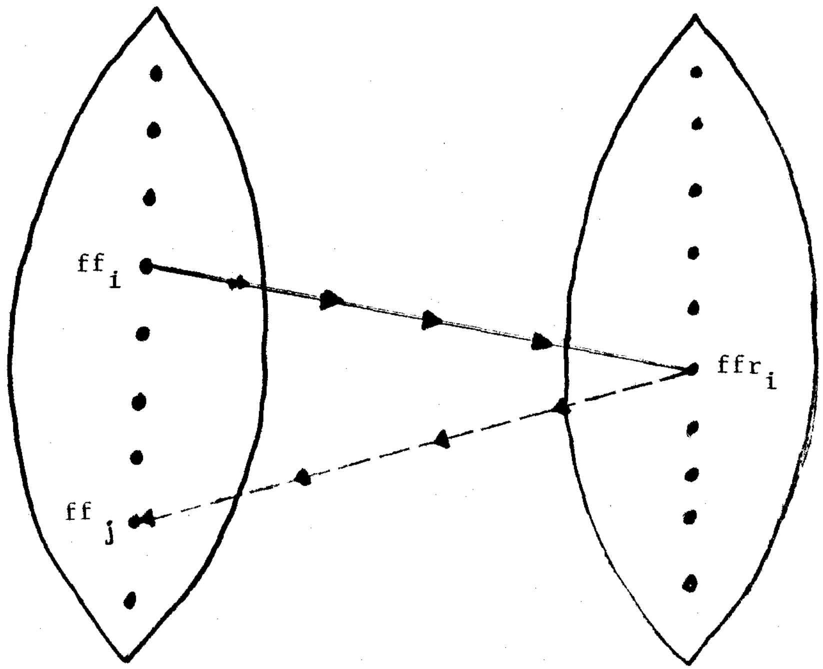
The expert knowledge base designer specifies the rule types, the models of reasoning included in the system, and the state change relationships. In order to facilitate the construction of the knowledge base by the expert, special representations have been adapted for the strategic planning domain. The intent is to provide the expert with a decision support system designed to facilitate direct interaction during knowledge base construction and modification.

Nomenclature more conducive to system construction has been adopted. The basis for the representation is a set of "file folders" that correspond to the "diagnostic modules" and the "models of reasoning." Each file folder contains three pamphlets: 1) The questions and possible answers, 2) The "file folder relationships," and 3) The "expert advice." In constructing a folder, the expert builds a semantically consistent subset of the overall system. File folder relationships are the state changes leading to pertinent models of reasoning. Figure VI.1A shows the database structure for file folder relationships. There may be many folder relationships in one folder, and when one is appropriate for the decision maker´s situation, that relationship identifies another folder to be explored.

There are three representations used for the system-wide components. The rule types are referred to as "expert advice orientations." All of the file folders collectively are viewed via a "file folder index." A "dictionary" contains all words and phrases the expert deems necessary for support of the ultimate decision maker user of the system. All file folders are contained in a "file cabinet." The expert advice orientations, the dictionary, and the file cabinet index are represented as books on the expert´s bookshelf. Figure VI.1B shows the database structure of expert advice. While in a specific folder, the decision maker´s situation may make particular expert advice appropriate, and this advice is oriented towards one element of the set of expert advice orientations.

Figure VI.2 depicts the operation of the DSS from the decision maker´s perspective. The "states" of the DSS are presented as nodes, and arcs represent changes in state during a "Guided" session with the DSS. When another folder is suggested for exploration, an explanation may be reviewed by asking, "Why?" Similarly, when expert advice is suggested, a justification may be reviewed by asking, "Why?"

FIGURE VI.1A: DATABASE STRUCTURE: FILE FOLDER RELATIONSHIPS



FF: The set of file folders

FFR: The set of all file folder relationships

FIGURE VI.1B: DATABASE STRUCTURE: EXPERT ADVICE

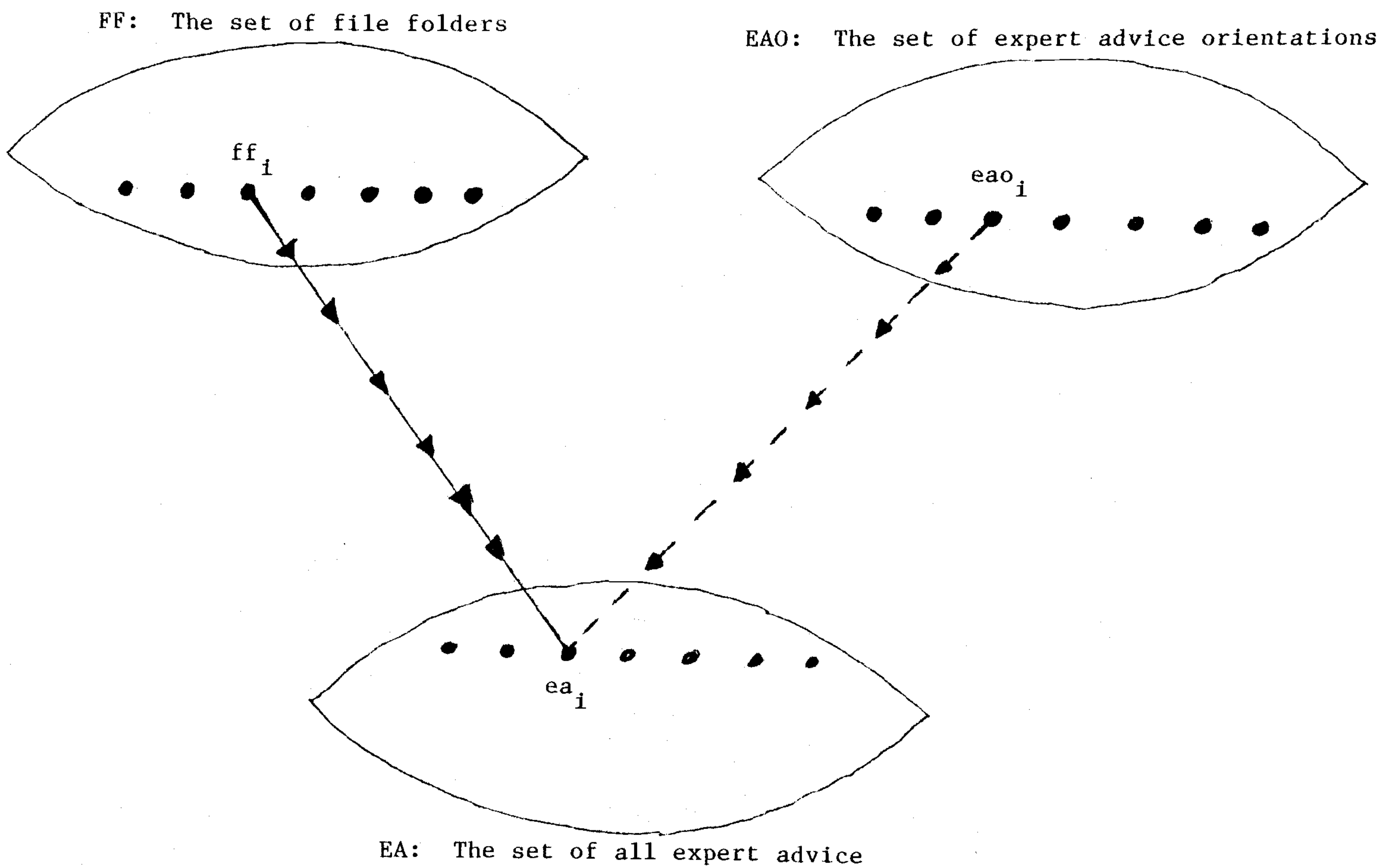
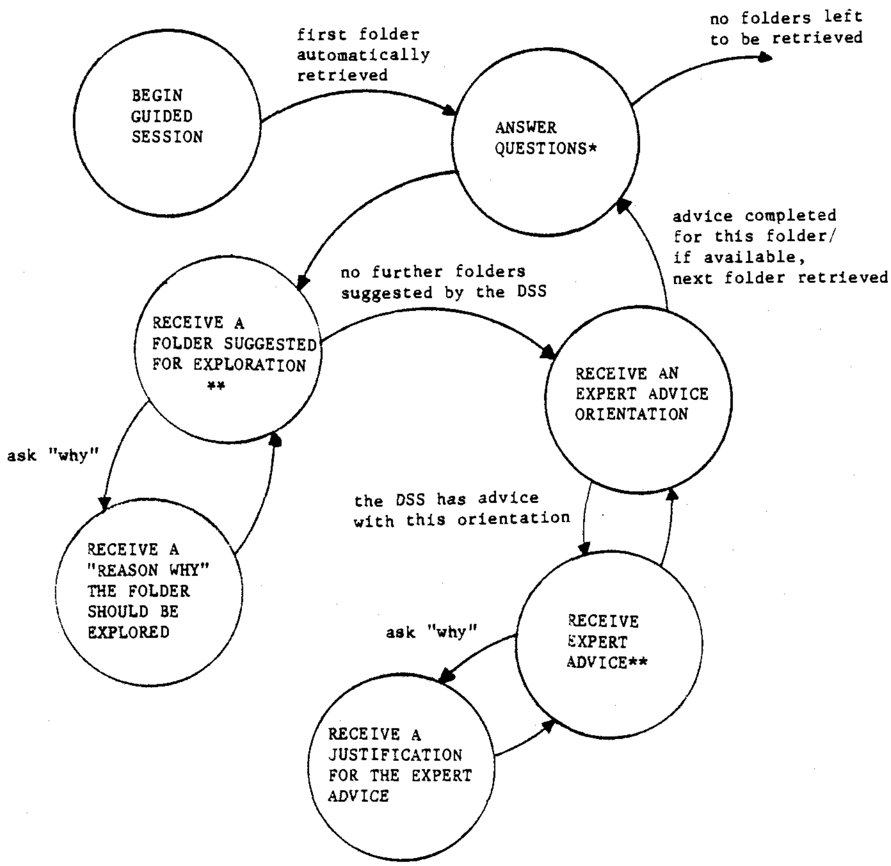


FIGURE VI.2: STATE DIAGRAM OF DECISION MAKER'S GUIDED SESSION



* The dictionary and scratchpad may be used by the decision maker.
** The dictionary and scratchpad may be used by the decision maker, and a remark may be left for the expert builder of the DSS.

3. OPERATIONS

The operations of the decision support system are more simply described using these representations. The expert begins by creating a set of expert advice orientations into which expert advice is categorized. For example, in a strategic planning environment, expert advice relative to factors influencing entry barriers, the power of suppliers, the power of buyers, the potential for substitute products, and the intensity of industry rivalry are appropriate general categories. When a decision maker is given expert advice, that advice belongs to a particular category. For example, if the system specifies that new competitors are unlikely to enter the market, this information relates to "entry barriers." Likewise, if the system suggests a friendly stance be taken towards competitors, this information relates to the "intensity of industry rivalry."

The file folders are initially "labeled" or declared after the advice orientations. The expert enters labels representing each subset of the knowledge base. For example, the label "Diagnostic Questions" may be the first folder declared. This folder might contain questions whose answers are interpreted in order to direct the decision maker to other pertinent folders in the file cabinet. Continuing the strategic planning example, one folder might contain knowledge relevant to "emerging industries," while another folder contains knowledge relevant to "mature industries." The diagnostic questions would be designed to determine when the decision maker user of the system is investigating an industry that is either emerging or mature, and direct that decision maker to the appropriate folder, while not directing her to the other (these two industries are somewhat mutually exclusive in their characteristics).

For each of the labeled folders, the expert enters the questions and possible answers. Based on particular question/answer combinations, the expert enters "file folder relationships," ie. those answers the expert deems to be indicative of the need for exploration of another folder. Finally, the expert enters expert advice based on particular question/answer combinations. An explanation for the advice is entered in order to answer the question "Why?" in regards to a particular piece of advice. In addition, the expert enters the expert advice orientation to which the advice is related.

In summary, the knowledge base construction sequence begins with a "declaration stage" requiring the identification of expert advice orientations and file folder labels. For each folder labeled, the expert completes the three pamphlets: Questions, Folder Relationships, and Expert Advice, respectively. This entire sequence is referred to as the "create system" component of the DSS for knowledge base construction.

4. MEMORY AIDS

Throughout the process of knowledge base construction, the expert is provided a "scratchpad" to record observations and items needed for later reference. The scratchpad is represented as a book on the expert's bookshelf. An example use of the scratchpad for an expert might be to record the general nature of questions and answers the expert deems appropriate for a particular file folder. When entering the questions, the expert might review the scratchpad to insure all necessary bases have been covered.

5. CONTROL

To discuss the control of the knowledge building DSS, we will trace an example session. Fragments from throughout the process will be included for clarity.

The major control mechanisms in the system are evident in Figure VI.3. This main menu of the system depicts an expert's desk, complete with bookshelf, file cabinet, and control switches placed on the desk. A bell is provided for requesting help relative to system use. Before being allowed to use items from the menu, (with the exception of the scratchpad and the dictionary) the expert must first create a knowledge base by selecting the appropriate switch. The system need not be complete, but must include at least one folder and one question. The selection of the "create system" option sets in motion the activities described in the Operations section above.

After a knowledge base has been created, either partially or completely, all books on the bookshelf are available, and all switch settings, except the "create system" setting, are available. This implies the expert may modify the existing system, ("Make Revisions") print the current knowledge base, ("Print System"), review the expert advice orientations, enter words or phrases into the dictionary, use the scratchpad, review the file cabinet index, or look into the file cabinet ("0", "1", "2", "3", "8", respectively). The system can be exited through the door ("9"). A resource status message at the top of the menu shows the capacity remaining in the associated representation. Using the "Make

FIGURE VI.3: EXPERT INTERFACE MAIN MENU

```
 RESOURCE STATUS:  Percentage of Resources Utilized
filefolders-  0.00%     scratchpad-  0.00%    rule orientations-   0.00%

                                                 oo
                                                oooo
      ___________________________________________\/ ______          9>  _____________
 |\ ___________________________________________ [] ______\              |xxxxxxxxxxxxx|
 | |############|%%%%%%%%%%%%|""""""""""""|++++++++++|              |xx E X I T xx|
 | |## EXPERT ###|%%%%%%%%%%%%|""""""""""""|+ FILE   +|              |xxxxxxxxxxxxx|
 | |#  ADVICE  ##| DICTIONARY | SCRATCHPAD| CABINET  |              |o xxxxxxxxxxx|
 | | ORIENTATIONS|%%%%%%%%%%%%|""""""""""""|+ INDEX  +|              |             |
 | |############|%%%%%%%%%%%%|""""""""""""|+ + + + + |              |             |
 \|      ^0^          ^1^           ^2^        ^3^   |              |             |
   ______________________________________________________               ___________
  |       ?                  o          o        o         |         | FILE        |
  |      _ __                |          |        |         |    8>   | CABINET     |
  |4> (HELP!)               =#=        =#=      =#=        |         |  ________   |
  |   ( ______)            CREATE     PRINT     MAKE       |         | |   __   |  |
  |       !                SYSTEM     SYSTEM  REVISIONS    |         | |________|  |
  |                         ^5^        ^6^       ^7^       |         | __________  |

Enter the number of your selection.
5
```

Revisions" switch, the expert can add to the knowledge base, modify it, or delete elements of it.

Figure VI.4 shows an example of the entry of an expert advice orientation given the "create system" option has been selected. The "Status Report" at the top of the display indicates the current context as the expert progresses through the entry sequence. Once all orientations have been entered, the expert is free to review, delete, add, modify, use the scratchpad or enter words/phrases into the dictionary. Figure VI.5 shows the culmination of the orientation entry phase and a selection demonstrating the selection of the "review" option.

After declaring the expert advice orientations, the expert is queried for the file folder labels. Figure VI.6 shows the sequence for entry of a folder label. Should the expert wish to "work with one of the items on the desk," the advice orientation book and the file folder index are made available for reviewing, adding, deleting, and modifying. When all folders have been declared, and the expert wishes to review the file folder index, the display shown in Figure VI.7 is offered.

After declaring orientations and folder labels, a sequence of operations for each folder to enter questions, folder relationships, and expert advice for each folder begins. Questions and possible answers are entered as demonstrated in Figure VI.8. Folder relationships are entered as demonstrated in Figure VI.9. Expert advice is entered as demonstrated in Figure VI.10.

When an initial system has been created, the "Revise" switch setting can be used to add, delete, and modify the existing

FIGURE VI.4: EXPERT ADVICE ORIENTATION ENTRY

```
                                          Status Report
ADVICE          ---> FILE FOLDER    ---> QUESTIONS     ---> FOLDER         ---> EXPERT
ORIENTATIONS         LABELS                                 RELATIONSHIPS       ADVICE
^^^^^^^
                                         ___________________________________
    |  ___________________________________/| 3> EXPERT ADVICE ORIENTATIONS |
    |                                     || Capacity remaining:100.00%
Enter an Expert Advice Orientation
Increase Entry Barriers
```

FIGURE VI.5: CULMINATION OF ORIENTATION ENTRY PHASE

```
                                          1> SCRATCHPAD
                                        Capacity remaining:100.00%

                                          2> DICTIONARY


                                        3> EXPERT ADVICE ORIENTATIONS
                                        Capacity remaining: 50.00%
Enter the number of the item you wish to work with (C to continue)
3
```

FIGURE VI.5 (continued)

```
                                          Status Report
ADVICE         ---> FILE FOLDER  ---> QUESTIONS      ---> FOLDER          ---> EXPERT
ORIENTATIONS        LABELS                                RELATIONSHIPS        ADVICE
                    ^^^^^^^
^^^^^^^

                                     ______________________________
    |  _____________________________/| 3> EXPERT ADVICE ORIENTATIONS |
    |                                || Capacity remaining: 50.00%
Expert Advice Orientation Menu   .

 S --> Scratchpad
 A --> Add
 R --> Review
 D --> Delete
 M --> Modify
 C --> Continue

Enter the letter corresponding with your request
r
```

FIGURE VI.6: FOLDER LABEL ENTRY

```
                                          Status Report
ADVICE          ---> FILE FOLDER  ---> QUESTIONS    ---> FOLDER          ---> EXPERT
ORIENTATIONS         LABELS                              RELATIONSHIPS        ADVICE
                     ^^^^^^^
OK

Enter file folder label  7
Market Signals


The following permission codes pertain to who will be
   allowed to revise this folder at a later time.
Please enter the desired permission value (0 or 1).

 0 -->  All experts can modify the model
 1 -->  Only I can modify the model
0
Are there more file folders to be labeled? [y.n]
y

Would you like to work with one of the items on your desk?[y.n]
n
```

FIGURE VI.7: REVIEW OF THE FILE FOLDER LABELS

1 Diagnostic Questions

3 Capacity Expansion

5 Industry Evolution

7 Market Signals

9 Fragmented Industry

11 Declining Industry

2 Emerging Industries

4 Buyers and Suppliers

6 Competitive Actions

8 Entry: New Business

10 Maturing Industry

12 Global Industry

FIGURE VI.8: QUESTIONS ENTRY

```
                                            Status Report
ADVICE              ---> FILE FOLDER        ---> QUESTIONS        ---> FOLDER             ---> EXPERT
ORIENTATIONS             LABELS                                        RELATIONSHIPS           ADVICE
                                                 ^^^^^^^
OK
Enter question number  4.
The majority of customers are

Enter the keyword for this question.
customer majority

Enter the number of possible answers.
4
Enter answer number  1.
First time customers (buyers)

Enter answer number  2.
Repeat sales

Enter answer number  3.
New customers, not first time buyers

Enter answer number  4.
Cannot determine

Was this the last question? [y,n]
n
```

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FIGURE VI.9: FOLDER RELATIONSHIP ENTRY

```
                                      Status Report
ADVICE          ---> FILE FOLDER  ---> QUESTIONS      ---> FOLDER          ---> EXPERT
ORIENTATIONS         LABELS                                RELATIONSHIPS        ADVICE
                                                           ^^^^^^^

   ____________________/ Diagnostic Questions
/
|   5> QUESTIONS

|   6> FILE FOLDERS TO BE EXPLORED
For each file folder relationship, you will be prompted for
the name of the other file folder, and an explanation
for the user as to why this correlation was made.

File folder relationships for Diagnostic Questions


Q --> review Questions
S --> Scratchpad
E --> Enter the boolean rule

Enter the letter associated with your selection
e
Enter boolean expression of the file folder relationship number:   1.
1.1
```

FIGURE VI.9 (continued)

```
Enter the file folder that should be explored 1.
Would you like to review the file folder labels?[y,n]
n
Enter the filefolder label
Emerging Industries

Enter the users explanation as to why this file folder
is to be investigated.  A period<cr> at the
start of a line will terminate input.

Many new products and processes characterize an emerging industry.
.
We will now review this expression
IF
THE FOLLOWING QUESTION:
   The production or process technologies in the industry are:
 HAS THE FOLLOWING ANSWER:
   Uncertain and changing
--THEN SUGGEST INVESTIGATION OF FILE FOLDER--
Emerging Industries

--WITH THE FOLLOWING REASON--
Many new products and processes characterize an emerging industry.
IS THIS RULE CORRECT?[y.n]
y

Is there more expert advice for this folder? [y,n]
y
```

FIGURE VI.10: EXPERT ADVICE ENTRY

```
                                        Status Report
ADVICE          ---> FILE FOLDER   ---> QUESTIONS    ---> FOLDER            ---> EXPERT
ORIENTATIONS         LABELS                               RELATIONSHIPS          ADVICE
                                                                                  ^^^^^^^
OK


Q --> review Questions
S --> Scratchpad
E --> Enter boolean rule

Enter the letter associated with your selection
e
 Enter the boolean expression
2.2

 Enter the number associated with the expert advice orientation this rule fits into.
Would you like to review the expert advice orientations?[y,n]
n
Enter the number
8

Enter the statement of the rule.
Input will terminate when you hit a period<cr> on a new line.
Buyers who cannot achieve valuable benefits with rudimentary versions of
the new product cannot create earlier market segments than buyers who
require highly sophisticated varieties from the new product.
.
```

FIGURE VI.10 (continued)

```
Enter justification for the rule
Input will terminate with a period <cr> on a new line
The early products will tend to be rudimentary versions with increasing
sophistication occuring as technologies develop and new markets are
discovered.
Source: Porter, p. 227
.
We will now review the expression
IF
THE FOLLOWING QUESTION:
   Can benefits be realized by early, primitive versions of the product/service?
 HAS THE FOLLOWING ANSWER:
   No
--THEN OFFER THE FOLLOWING ADVICE--
Buyers who cannot achieve valuable benefits with rudimentary versions of
the new product cannot create earlier market segments than buyers who
require highly sophisticated varieties from the new product.

--WITH THE FOLLOWING JUSTIFICATION--
The early products will tend to be rudimentary versions with increasing
sophistication occuring as technologies develop and new markets are
discovered.
Source: Porter, p. 227
IS THIS RULE CORRECT?[y,n]
y


Is there more expert advice for this folder? [y,n]
y
```

knowledge base. When selected, the expert may pull a folder from the file cabinet and work with one of the pamphlets contained in the folder as demonstrated in Figure VI.11. In this example, an additional question is added to the "Emerging Industry" file folder.

6. STRUCTURE OF THE DSS KNOWLEDGE BASE

The structure of the knowledge base is consistent between the decision maker interface and the expert interface. The data structures used in the Pascal program implement the database design of Chapter V. Arrays of records are used for each relation including GENERAL, QUESTIONS, INVOCATION RELATIONS, and RULES. The implementation of each relation will be discussed in turn.

Relation GENERAL stores important summary information for the DSS. For each file folder label, the number of questions, file folder relationships, and expert advice rules are stored. The label is a character string, and the remaining attributes are integers. GENERAL has an additional attribute which allows the expert to give each folder a "permission code." This code is a single character which designates whether other experts are allowed to modify the contents of the folder. Two additional attributes are used in the decision maker interface, the "guided session" option, to record the current state of the session. Whenever a file folder relationship rule designates that another folder should be investigated, an attribute named MARK for the designated folder is tagged with an integer. Also, an attribute named USED is tagged

FIGURE VI.11: REVISION EXAMPLE

```
                                  _____________________________
 ____________________________/|  1> SCRATCHPAD                 |
|                             || Capacity remaining:100.00%
                                  _____________________________
 ____________________________/|  2> DICTIONARY                 |
|                             ||
                                  _____________________________
 ____________________________/| 3> EXPERT ADVICE ORIENTATIONS |
|                             || Capacity remaining: 50.00%
                                  _____________________________
 ____________________________/|  4> FILE CABINET INDEX        |
|                             || Capacity Remaining:  60.00%
                                  _____________________________
 ____________________________/ Emerging Industries
    ____________      ________________________     _______________
  | 5> QUESTIONS    | 6> FOLDER RELATIONSHIPS   | 7> EXPERT ADVICE

Enter the number of the item you wish to work with (D for done)
5
```

FIGURE VI.11 (continued)

```
                              / Emerging Industries
/
|      QUESTIONS
Questions Menu
 S --> Scratchpad
 A --> Add
 R --> Review
 C --> Continue

Enter the letter corresponding with your request
a
Enter the new keyword for the question
advertising

Enter the question
Are competitors  increasing advertising budgets?

Enter the number of possible answers (1 through 6)
3
Enter answer number:   1
Yes. rapidly

Enter answer number:   2
No

Enter answer number:   3
Cannot determine
```

whenever a folder has been explored in the session. Relation RULE TYPES holds the expert advice orientations. Each expert advice orientation is stored as a character string.

The contents of the GENERAL relation and the RULE TYPES relation are retrieved from disk storage. A single text file stores the number of folders, the number of expert advice orientations and the character strings and integers discussed above.

The QUESTIONS, INVOCATION RELATIONS, and RULES relations are used to store the "current" file folder contents. Both the decision maker interface algorithm and the expert interface algorithm rely on a "swapping" process. The database is stored on secondary storage (disk), as text files, until a subset (single "file folder") is swapped into internal storage. The contents of a single file folder are stored in internal memory only as long as the folder is being used. For the decision maker, this is only as long as the time it takes to answer the questions in the folder, review the pertinent file folder relationships, and review the pertinent expert advice. For the expert, this is as long as it takes to create the questions, folder relationship rules, and expert advice rules for the folder. Relation GENERAL's attributes pertaining to the number of questions, folder relationship rules, and expert advice rules are used for reading the text file.

QUESTIONS, INVOCATION RELATIONS, and RULES are implemented as Pascal arrays of records. Upon creation of a complete folder by an expert, the contents of the relations are written to disk as a text file. The file name matches the name of the folder as stored in relation GENERAL. When a folder is swapped into internal memory during a decision maker's session, the entire contents of the text file is retrieved.

Relation QUESTIONS is filled with character strings for the statement of the question, the possible answers to the question, and a "key-word" for the question. The key-word is used by the expert to provide a quick way of recalling the nature of the question. A single integer specifying the number of possible answers for each question is also retrieved.

INVOCATION RELATIONS stores the file folder relationships. The Boolean encoded rules and the file folder label stipulated by a particular relationship are stored as character strings. A "reason why" for each relationship is stored as an independent text file.

RULES stores the expert advice. Boolean encoded rules and the expert advice orientation for the rule are implemented as character strings. The statement of the expert advice and the "reason why" for the advice are stored as two independent text files.

The "reason why" for a file folder relationship, the statement of particular expert advice, and the "reason why" for that advice are retrieved from disk only when being used in the context of the session.

7. ALGORITHM ANALYSIS

A formal analysis of the space and time complexities of the algorithms requires specification of the parameters involved.

Nomenclature consistent with the representations used in the DSS facilitate the analysis. Figure VI.12 details the symbols used in the analysis.

The space requirements of the expert interface and the decision maker interface algorithms are very similar. One exception is storage for the answers selected by the decision maker during a session with the DSS. The following formula expresses the space requirements for the answers entered by the decision maker during a session with a single file folder. The maximum number (function MAX) of questions in a folder is the worst case space complexity as shown in equation E. Each answer is stored as a single character.

$$E^{*} = \max_{1 \leq I \leq F} (NQ_I)$$

Relations RULETYPES and GENERAL store the expert advice orientations and the folder labels, respectively. The size of the relations is dependent on the sums of the lengths of the expert advice orientations and file folder labels. Equations F and G express the space complexity of RULETYPES and GENERAL, respectively.

$$F = \sum_{M=1}^{E} L(E_M) \qquad G = \sum_{M=1}^{F} L(F_M)$$

Relation QUESTIONS stores the possible questions to a single folder

FIGURE VI.12: SYMBOLS FOR TIME AND SPACE COMPLEXITY ANALYSIS

E: NUMBER OF "EXPERT ADVICE ORIENTATIONS"

$L(E_I)$: LENGTH OF EXPERT ADVICE ORIENTATION I

F: NUMBER OF "FILE FOLDERS"

$L(F_I)$: LENGTH OF FILE FOLDER LABEL I

NQ_I: NUMBER OF "QUESTIONS" IN FOLDER I

$L(F_I, Q_J)$: LENGTH OF QUESTION J IN FOLDER I

NA_{IJ}: NUMBER OF ANSWERS TO QUESTION J IN FOLDER I

$L(F_I, A_{KJ})$: LENGTH OF ANSWER K FOR QUESTION J IN FOLDER I

FIGURE VI.12 (continued)

FFR_I: NUMBER OF "FILE FOLDER RELATIONSHIP" RULES IN FOLDER I

$L(FFR_I, B_J)$: LENGTH OF FILE FOLDER RELATIONSHIP BOOLEAN RULE J IN FOLDER I

$O(FFR_I, B_J)$: NUMBER OF OPERATORS IN FILE FOLDER RELATIONSHIP BOOLEAN RULE J IN FOLDER I

$L(FFR_I, W_J)$: LENGTH OF FILE FOLDER RELATIONSHIP "REASON WHY" J IN FOLDER I

EA_I: NUMBER OF "EXPERT ADVICE RULES" IN FOLDER I

$L(EA_I, B_J)$: LENGTH OF EXPERT ADVICE BOOLEAN RULE J IN FOLDER I

$O(EA_I, B_J)$: NUMBER OF OPERATORS IN EXPERT ADVICE BOOLEAN RULE J IN FOLDER I

$L(EA_I, S_J)$: LENGTH OF EXPERT ADVICE RULE "STATEMENT" J IN FOLDER I

$L(EA_I, W_J)$: LENGTH OF EXPERT ADVICE RULE "REASON WHY" J IN FOLDER I and the possible answers to each question. We are interested in the folder with the maximum size of questions and possible answers for assessing the worst case space complexity, since only one folder is internally stored at a time. Equation H expresses the worst case space complexity.

$$H = \max_{1 \leq I \leq F} \left(\sum_{K=1}^{NQ_I} \left(L(F_I, Q_K) + \sum_{M=1}^{NA_{IK}} L(F_I, A_{MK}) \right) \right)$$

Relation INVOCATION RULES includes space for the Boolean encoded folder relationship rules and space for the current "reason why" for the folder relationship. As with the QUESTIONS relation, we are interested in the maximum size over all folders in the knowledge base. Since the Boolean encoded rules are stored internally, we take the sum of their lengths for the first term in equation I. The second term accounts for the longest "reason why" for a particular folder relationship.

$$I = \max_{1 \leq I \leq F} \left(\sum_{K=1}^{FFR_I} L(FFR_I, B_K) + \max_{1 \leq T \leq FFR_I} \left(L(FFR_I, W_T) \right) \right)$$

Relation RULES includes space for the Boolean encoded expert advice rules for a particular folder. The space for a piece of expert advice and its associated "reason why" is read from disk only when presented to the decision maker. Equation J specifies the maximum over all folders of the sum of the lengths of the Boolean encoded rules and the maximum length of the statement of expert expert advice and reason why, is the worst case space complexity.

$$J = \max_{1 \le I \le F} \left(\sum_{K=1}^{EA_I} L(EA_I, B_K) + \max_{1 \le T \le EA_I} \left(L(EA_I, S_T) + L(EA_I, W_T) \right) \right)$$

During a decision maker's session with the system, the evaluation of a Boolean rule is accomplished by a conversion of the expression to postfix notation, and then evaluation of the postfix expression. The maximum size of the stacks involved in this process is proportional to the number of operators in the Boolean expression. Equation K specifies the maximum size of the stacks required in this process for the worst case space complexity:

$$K^* = \max_{1 \le I \le F} \left(\max_{1 \le J \le FFR_I} \left(2 \cdot O(FFR_I, B_J) + 1 \right), \max_{1 \le K \le EA_I} \left(2 \cdot O(EA_I\, B_K) + 1 \right) \right)$$

The space complexity of the DSS is expressed in the following formula: (Note that values labeled "*" are only associated with the decision maker interface algorithm.)

$$C_1 \left(E^* + F + G + H + I + J + K^* \right) + C_2$$

The space required by the program is only a subset of the complete database at any given point in time. In practice, the QUESTIONS relation is the largest, as detailed in equation H. The swapping method and the method of storing folder relationship "reasons why" and expert advice "statements" and "reasons why" as independent files minimizes the internal space consumed.

The time complexity of the expert interface algorithm is proportional to the size of the knowledge base created by the expert. The algorithm is of polynomial time complexity as no manipulations of the text entered by the expert takes place. The manipulation of the knowledge base in the decision maker interface algorithm is somewhat more complicated and will be reviewed in detail.

The decision maker interface algorithm first requires loading from disk the text file containing the contents of relations GENERAL and RULETYPES. The time required is related to the sum of the lengths of the expert advice orientations and the file folder labels. The following formula expresses the time complexity of this process:

$$L = \sum_{K=1}^{F} L(E_K) + \sum_{K=1}^{F} L(F_K)$$

For a particular file folder, relations QUESTIONS, INVOCATION RELATIONS, and RULES are filled. The time to load the questions is proportional to the sum of the lengths of each question and possible answer. The time to fill INVOCATION RELATIONS and RULES is proportional to the sum of the lengths of the Boolean encoded rules. The time complexity of these processes are shown in the following formulas:

$$M = \sum_{T=1}^{NQ_I} \left[L(F_I, Q_T) + \sum_{M=1}^{NA_{IT}} L(F_I, A_{MT}) \right]$$

$$N=\sum_{K=1}^{FFR_I} L(FFR_I, B_K) \qquad O=\sum_{K=1}^{EA_I} L(EA_I, B_K)$$

For a particular folder, the questions are asked of the decision maker with the possible answers displayed. The time to perform this operation is consistent with the time it takes to load the questions and posssible answers. The time complexity of this process is expressed as follows:

$$P=\sum_{K=1}^{NQ_I}\left[L(F_I, Q_K) + \sum_{M=1}^{NA_{IK}} L(F_I, A_{MK})\right]$$

After soliciting answers to the questions, the file folder relationship rules are evaluated and folders suggested for exploration are reviewed. Next, the expert advice Boolean rules are evaluated and expert advice with the associated "reason why" is reviewed. The evaluation requires two passes over the Boolean expression, once to convert the expression to postfix, and once to perform the evaluation. The evaluation process time complexity is expressed as follows:

$$Q=\sum_{K=1}^{FFR_I} 2(L(FFR_I, B_K) + E\sum_{K=1}^{EA_I} 2(L(EA_I, B_K))$$

The worst case time complexity takes place when the decision maker explores all of the file folders and when all folder relationship rules and expert advice rules are presented by the DSS. The time to fill GENERAL and RULETYPES (Equation L) is the first term of the expression, and the time to load, question, and process each file folder is the sum of M, N, O, P, and Q. This is expressed in the following formula (The C's in the formula reflect constants.):

$$C_1\left(L+\sum_{I=1}^{F}(M+N+O+P+Q)\right)+ C_2$$

Since M, N, O, P, and Q are all polynomially proportional to the lengths of elements of the knowledge base, the algorithm for the decision maker inteface is polynomial in worst case time complexity.

8. KNOWLEDGE BASE IMPLEMENTATIONS

The DSS for strategic planning is implemented in a single hierarchy of folder relationships. The "Diagnostic Questions" folder contains the entire set of folder relationship rules. Figure VI.13 shows the implementation of the file folder structure. More complex hierarchies may be created with the expert interface.

Figure VI.14 shows a hypothetical hierarchy where folder relationships exist in more than a single folder. A "Guided" session could lead the decision maker through the folders in the directed graph hierarchy. If a folder has already been explored, but is suggested by a folder relationship rule, the decision maker would be given the options of skipping the folder or reviewing it again.

FIGURE VI.13: KNOWLEDGE BASE FOLDER STRUCTURE, STRATEGIC PLANNING DSS

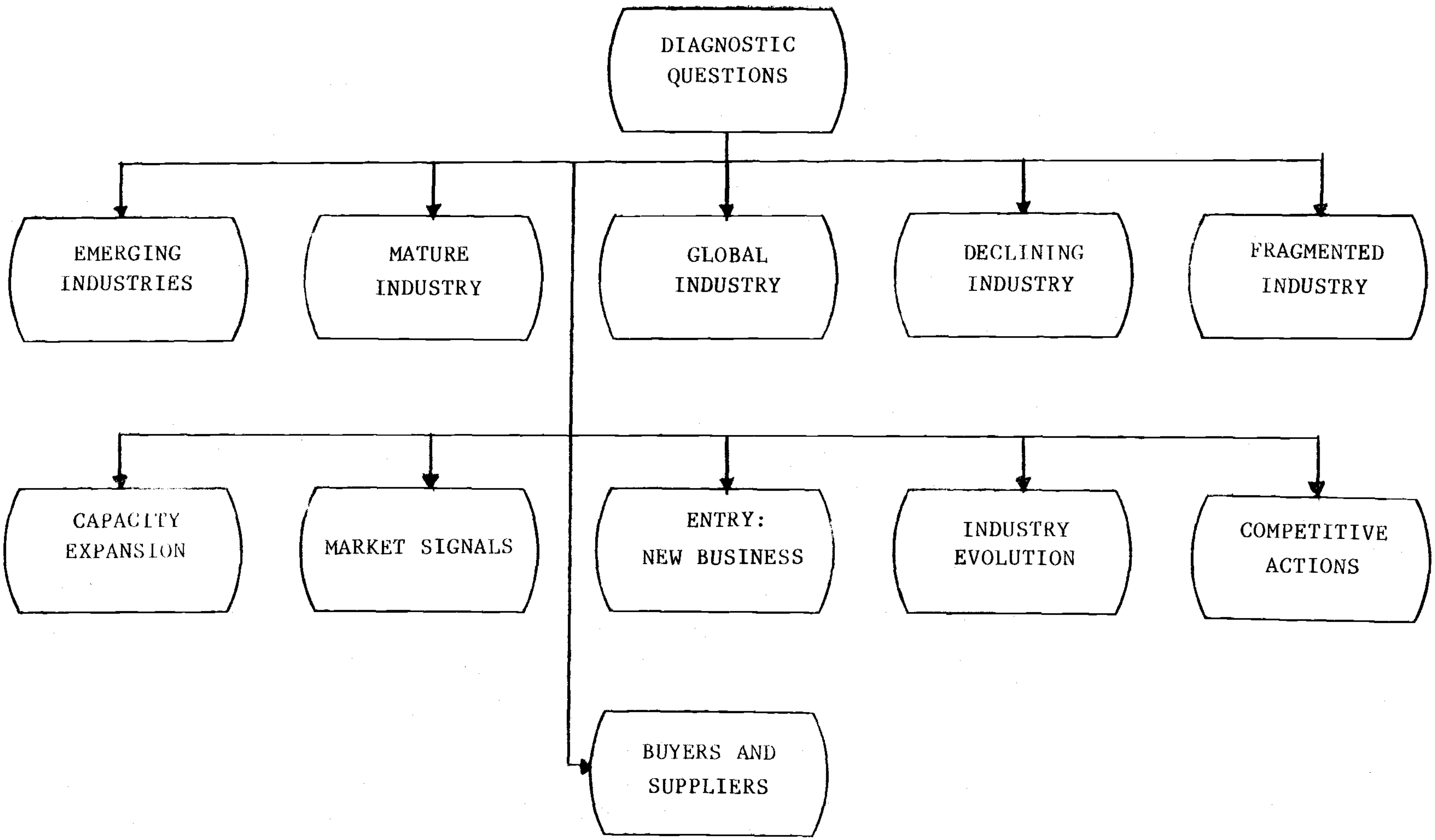
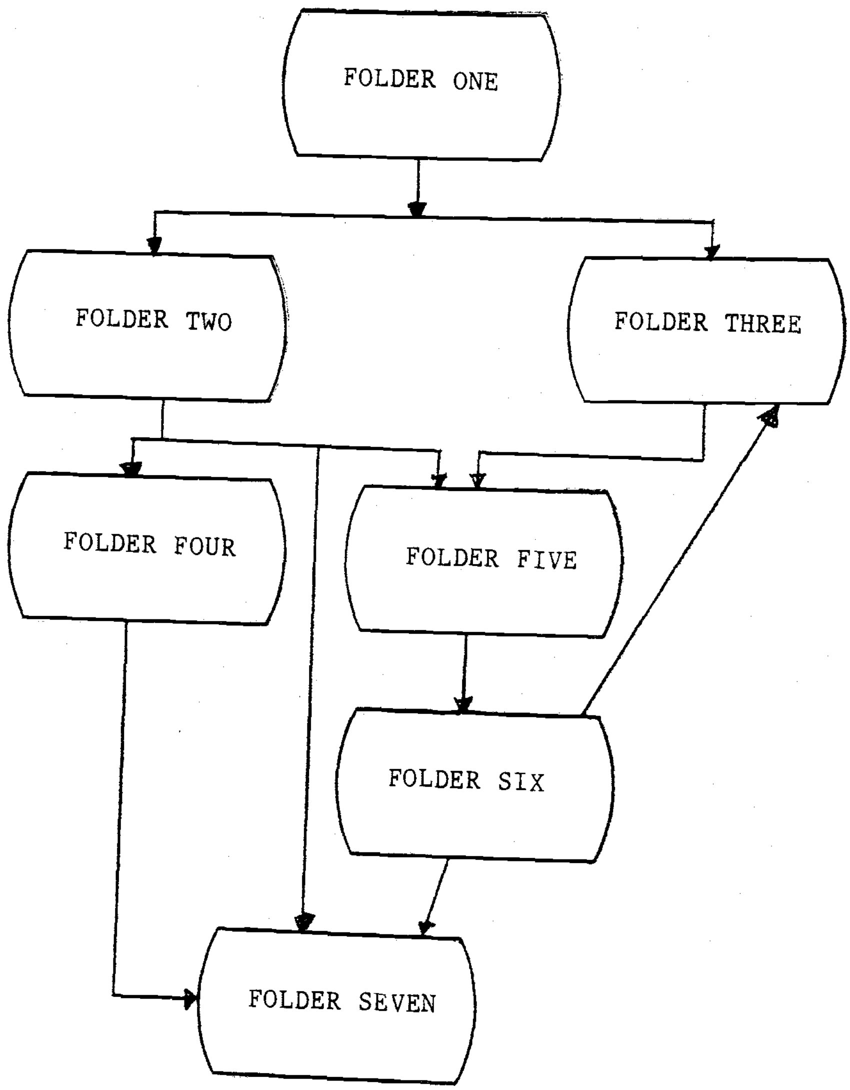


FIGURE VI.14:

KNOWLEDGE BASE FOLDER STRUCTURE, HYPOTHETICAL COMPLEX HIERARCHY



9. CONCLUSION

This chapter explained the "Expert Interface" discussed in Chapter V as adapted for the strategic planning domain. As will be evident in Chapter VII, representations have been selected consistent with the "Decision Maker Interface" for the strategic planning DSS. The expert is provided both interface selections for validation of the system, i.e. the expert can build portions of the system and enter the decision maker interface to explore the operations of the DSS as will be used by the ultimate user.

In addition, this chapter has discussed the structure of the knowledge base and the algorithms that manipulate it. The interfaces were analyzed separately, and it has been shown that polynomial space and time complexities characterize both algorithms.

Chapter VII discusses an experiment designed to test the strategic planning system developed by using the expert subsystem construction DSS described in this chapter.

REFERENCES

Bennett, J. Building Decision Support Systems. (Menlo Park, CA: Addison-Wesley Publishing Company, 1983)

CHAPTER VII: THE EFFECT ON STRATEGIC DECISION MAKING OF EXPERTISE IN A DECISION SUPPORT SYSTEM: AN EMPIRICAL STUDY

Michael Goul*, Barry Shane**, and Fred Tonge*
Oregon State University
Corvallis, Oregon 97331

* Department of Computer Science
(503) 754-3273

** College of Business
(503) 754-4033

ABSTRACT

A decision support system (DSS) incorporating domain expertise guides, tutors, and consults a decision maker in opportunity, problem, and crisis identification activities. The objective for the system is to promote improved decision making. Using an "Independent Groups" design, an experimental study was conducted to investigate the effects of DSS use on performance in the assessment phase of the strategic planning process.

The findings of the study indicate that decision support systems incorporating expertise can improve the effectiveness of problem recognition in unstructured environments. Experimental treatments consisted of 1) use of a DSS with a complete rule base, 2) use of a DSS with a 10% subset of the complete rule base, and 3) no DSS exposure. Measures of performance from several stages of the decision making process are analyzed.

SUBMITTED TO MANAGEMENT SCIENCE

1. INTRODUCTION

Scholars of unstructured decision making have primarily concentrated on the decision making process subsequent to the recognition of opportunities, problems, and crises (Noted exceptions include Mintzberg and Raisinghani, 1976 Pounds, 1969, and Simon, 1960). The portion of the decision making process that precedes diagnosis, design, choice and implementation, in which recognition takes place, is commonly called "Problem-Finding" (Pounds, 1969) or the "Intelligence" phase (Simon, 1960). The basis for this paper is earlier work on computer support for the intelligence phase of the strategic planning process (Goul, Shane and Tonge, 1984 and 1985). In this work is examined the process called "recognition channeling," which incorporates Stabell´s idea of decision channeling applied to the intelligence or "recognition" phase of the decision making process (See Stabell, 1983 for an exact description of decision channeling).

Figure VII.1 is a model of decision making with emphasis on the recognition phase of the decision making process. The representation for the model is the McColloch-Pitts logic cell, drawn as a circle with lines as inputs and outputs. Input lines are one of two types: 1) excitors which, when coupled with a sufficient number of other excitors thereby exceeding the cell´s threshold, cause the cell to "fire" and send a signal along the output lines, and 2) inhibitors which, when active, stop the cell from firing regardless of the level of excitors. Excitors are represented as lines with arrows, and inhibitors are shown as lines

FIGURE VII.1: MODEL OF DECISION MAKING WITH EMPHASIS ON RECOGNITION

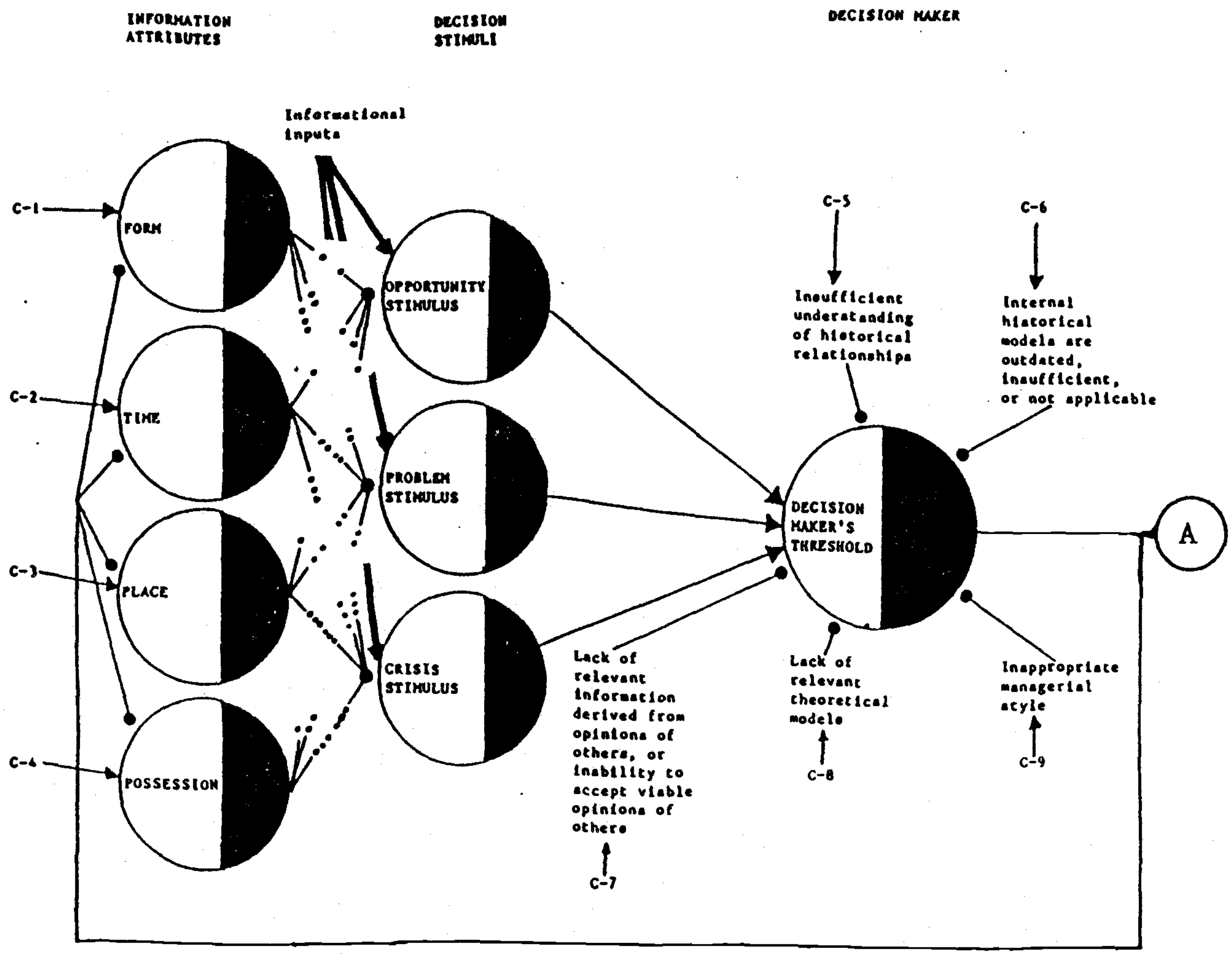
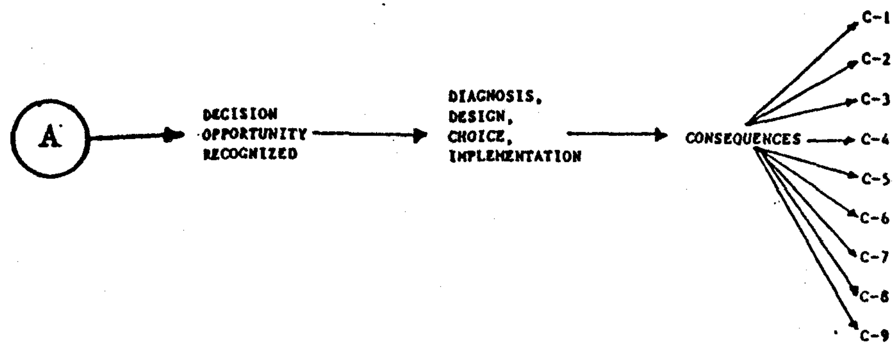


FIGURE VII.1 (continued)



with circles.

This experiment focuses on the inhibitor to the decision maker cell labeled "Lack of relevant theoretical models" (See Figure VII.2). When a decision maker is unaware of relevant theoretical models or when such models do not exist, the recognition of opportunities, problems, or crises may be thwarted.

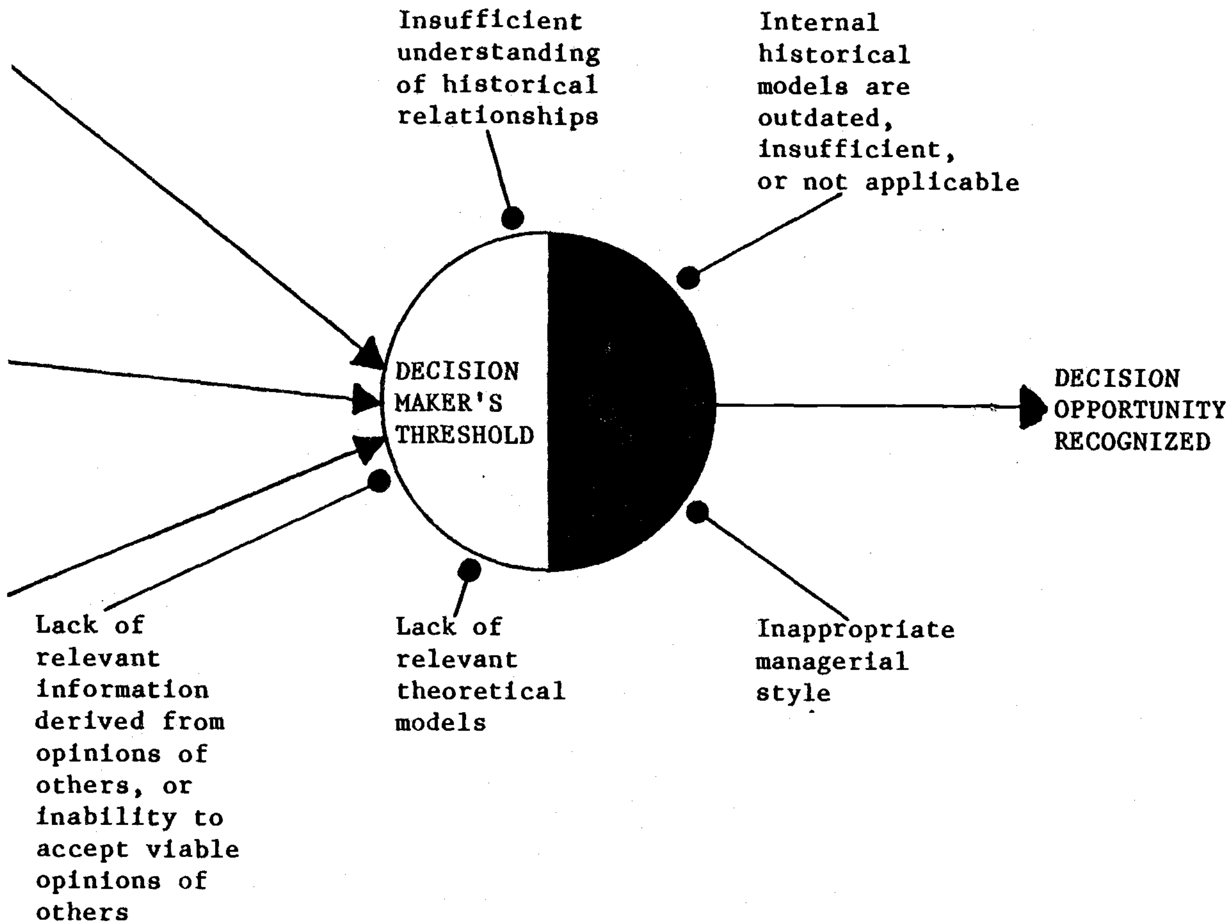
The approach is to provide a DSS that incorporates a rule base designed to guide a decision maker toward investigating and using relevant theoretical models. Once a model is suggested, recommendations, conclusions, and consultation are offered as a result of integrating the decision maker´s assessment with that model. The intent of the DSS is not to capture problem-solving expertise fait accompli or make actual decisions. Instead, the decision maker is guided, consulted and tutored as the theoretical model is explored. Additionally, the DSS provides an explanation for the selection of each relevant model.

This paper presents the results of an experiment designed to test the DSS approach described above. The aim of the DSS is to overcome the inhibitor associated with a decision maker´s lack of theoretical models in the domain of strategic assessment. Below is a statement of the problem, the research hypothesis, an explanation of the DSS used in the experiment, and the experimental design, methodology and findings.

2. PROBLEM STATEMENT

Developing and implementing a strategic plan for an

FIGURE VII.2: FOCUS OF EXPERIMENT



organization is a series of interrelated activities. A primary activity of the on-going process is referred to as the "strategic audit" (Lorange, 1980) and as "strategic issue identification" (King, 1982). This activity relates to the assessment of the organization's current state of affairs, specification of the desired state of affairs, and identification of the "gap" between the current state and the desired state. Once defined, "closing" the gap becomes the focus of the remaining planning activities.

Decision Support Systems (DSS) have typically been studied by implementing a system and formulating findings and conclusions from systematic evaluation of the implementation. A DSS configured to assist the planning and control activities of the Gotaas-Larson Shipping Corporation exemplifies this methodology (Alter, 1980). S. Alter and S. Anand, acknowledging the assistance of A. Goldberg and P. Lorange, provided computer-based support for a subset of the organization's planning activities. The first three of these activities, for which computer systems played no role, are: 1) Define Company Mission and Goals, 2) Setting Goals and, 3) Finding Business Opportunities. Obviously, these three activities are closely related to assessing the organization's current state, identifying the desired state, and the establishment of goals for plans designed to close the gap. Computer systems did play a role in other activities of the planning and control process.

The research discussed below was directed at extending the scope of DSS applications to this primary activity of the strategic planning process, that activity exemplified by the strategic audit, strategic issue identification, and the three activities identified at Gotaas-Larson. Embedded in this activity is the constant surveying of the environment for potential opportunities, current problems, and attention deserving crises. One technique espoused by Porter for identifying characteristics of the environment is the specification of "strategy determinants" (Porter, 1980). Factors such as "Entry Barriers," "Power of Suppliers," etc. are considered general areas requiring analysis in order to assess the organization's current state of affairs. The ultimate goal of this technique and the strategic decision making process in general is to arrive at improved plans of actions which lead organizations to their desired state of affairs.

2.1 RESEARCH HYPOTHESIS

This study investigated the effect of decision maker exposure to a DSS, designed to curtail the "lack of theoretical models" inhibitor, on strategic planning decision making. Stated in the null form, the primary hypothesis was:

HO_1: There is no significant difference in strategic planning decision making effectiveness between subjects who use a DSS and subjects who do not use a DSS.

To assess differences in strategic planning decision making, measures from throughout the decision making process were used. Three treatments involving differing knowledge base access within the DSS and no DSS exposure constituted the independent variable for the study. The dependent variables: 1) assessed the subject's identification of strategy determinants, 2) assessed the subject's identification of opportunities, problems, and crises existing in the environment, and 3) evaluated the plans of action subjects proposed. In the next section, we will review each of these in turn.

Given that expert strategic planning decision makers are increasingly consulted by in-house planners (See Boulton, Franklin, Lindsay, and Rue, 1982), we selected as a basis for several measures the opinions of experts; for example, we compared strategic planning expert identification of the determinants to the subject's identification to derive measurement. We utilized a "matching" method whereby if a subject's identification matched an expert's identification, this relationship was tallied. Similarly, one of the measures was an expert's evaluation of each subject's plan of action.

2.1.1 Strategy Determinants

Planning participants consider the environment in conjunction with the internal state of affairs to arrive at an assessment of important strategic concerns. An organization's competitive position is identified by the "strategy determinants" within its industry. As constraints, these determinants define the feasible region of choices for a company's long range strategy. Recognizing the domain within which a strategy would be successful and defensible increases the likelihood of future organizational strength. Determinants include "Threat of New Entrants," "Intensity of Industry Rivalry," "Threat of Substitute Services," "Strength of Buyers," and "Strength of Suppliers." Each product/market element, such as the "educational market" for a large microcomputer manufacturer, is viewed in isolation of other product/market elements, such as the "business market" and the "home computer market" (See Lorange, 1980 for a precise definition of a "product/market element"). Thus, for each element, each determinant is explored in order to provide background for the specification of plans of action. Outcomes of this analysis are the opportunities, problems, and crises for the product/market elements of the organization.

Strategy determinants were one focus of evaluation for the purpose of diagnosing the impact of a DSS on strategic decision making. Subjects' identification of those determinants considered primary in terms of impact on the organization's on-going success were matched with expert's identification. Measures from several points in the strategic planning decision making process were taken. The strategy determinant measure is early in the process, implying the measure is at the beginning stage of "recognition." A corollary hypothesis to HO_1 is stated in the null form as follows:

$HO_{1.1}$: There is no significant difference in strategy determinant assessment between subjects who use a DSS and those who do not use a DSS.

2.1.2 Opportunities, Problems, and Crises

With the identification of opportunities, problems, and crises, the recognition stage of the decision making process is completed. In terms of strategic planning, definitions have been adapted from the following:

> "Problem, opportunity, and crisis decisions are most clearly distinguished in the recognition routine. The opportunity decision is often invoked by an idea, perhaps a single stimulus, although it may remain dormant in the mind of the individual until he is in a position to act on it. Crisis decisions are triggered by a single stimuli. They present themselves suddenly and unequivocally, and require immediate attention. Problem decisions typically require multiple stimuli." (Mintzberg, 1976 p. 251).

These definitions place opportunities and crises at two ends of "stimulus" and "timing" continuums, with problems somewhere in the middle. To operationalize these definitions for the purposes of this research, we added an additional dimension based on the potential outcome of failing to address the stimuli.

An opportunity is an idea that may lay dormant for a period of time, is invoked by any number of stimuli, and possesses a potential outcome for improving the current state of affairs. However, it is not imperative that short-term resources be apportioned in order to stave off organizational failure.

A problem is an incongruency between the current state of affairs and the expected or standard state of affairs. It is caused by multiple stimuli, and requires allocation of short-term resources to prevent future crises.

A crisis is a situation that may seriously impede the organization's short-term operations, and requires immediate resource allocation. Crises are invoked by a single, unequivocal stimulus.

Recognition of opportunities, problems and crises were the second area of measurement for evaluating the effects of the DSS on strategic decision making. Expert opinion as to the opportunities, problems, and crises facing an organization was matched with subject responses. Thus, three additional hypotheses in support of HO_1, involving measurements that are designed to diagnose DSS effects at the end of the recognition portion of the decision making process, are stated in the null form as follows:

$HO_{1.2}$: There is no significant difference in opportunity recognition between subjects who use a DSS and those who do not use a DSS.

$HO_{1.3}$: There is no significant difference in problem recognition between subjects who use a DSS and those who do not use a DSS.

$HO_{1.4}$: There is no significant difference in the crisis recognition between subjects who use a DSS and those who do not use a DSS.

2.3 Plan of Action

As a final measure of the impact of the DSS on subjects' strategic decision making, the subject's reported plan of action was evaluated. This plan is a consolidation of recognizing pertinent areas of concern and specification of recommended steps to close the gap. Thus, the measure is designed to evaluate the entirety of the decision making process. The measure falls at the culmination of the decision making process, ie. after recognition, diagnosis, design, and choice activities. The final hypothesis in support of HO_1 is stated in the null form as follows:

$HO_{1.5}$: There is no significant difference in proposed plans of action between subjects who use a DSS and those who do not use a DSS.

3. A DSS WITH STRATEGIC DECISION MAKING EXPERTISE

The general design for the DSS used in the experiment was presented in previous work (Goul, Shane, and Tonge, 1985). The main purpose of the ensuing discussion is to emphasize adaptations to the general design for the purpose of the experiment. First, the goals of the adaptations are presented, followed by representations, operations, memory aids, and control mechanisms designed to accomplish these goals. Actual session segments serve to facilitate the explanation.

Our first objective was to create within the DSS an environment easily understood by strategic planners. The major representation is an office, complete with desk, dictionary, scratchpad, and file cabinet. Located in the file cabinet are labeled file folders, each containing three pamphlets. One pamphlet contains a set of questions, another contains a set of file folder relationships, and the third contains expert advice. These easily understood representations were the focus of a second objective: minimize the training time required for experiment participants.

One of the most important objectives related to memory aids. The dictionary is made available for the purpose of reviewing definitions of terms and phrases. A scratchpad is accessible for recording noteworthy discoveries, and two types of trace files summarize a decision maker´s session with the DSS. These tools were chosen to maximize decision maker understanding of system-provided explanations and advice, to encourage the decision maker to record insights, and to provide a "hard copy" of the session with the DSS designed to enhance decision making even after system use.

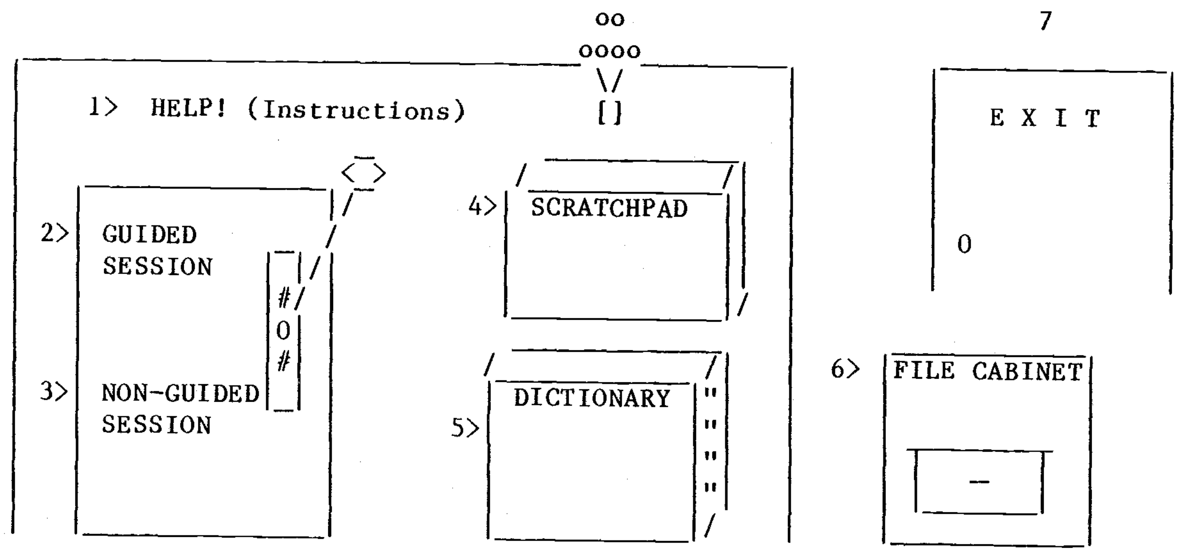
A final objective was to provide both strong and weak control mechanisms. The strong mechanism guides the decision maker through the file folders in the cabinet, while the weak mechanism allows the decision maker to explore the file folders on an ad hoc basis.

3.1 Representations

Figure VII.3 is the main menu of the DSS. Representations are presented graphically to the decision maker. The underlying

FIGURE VII.3: MAIN MENU OF THE DSS

Desk of: goul



Enter the number associated with your selection:

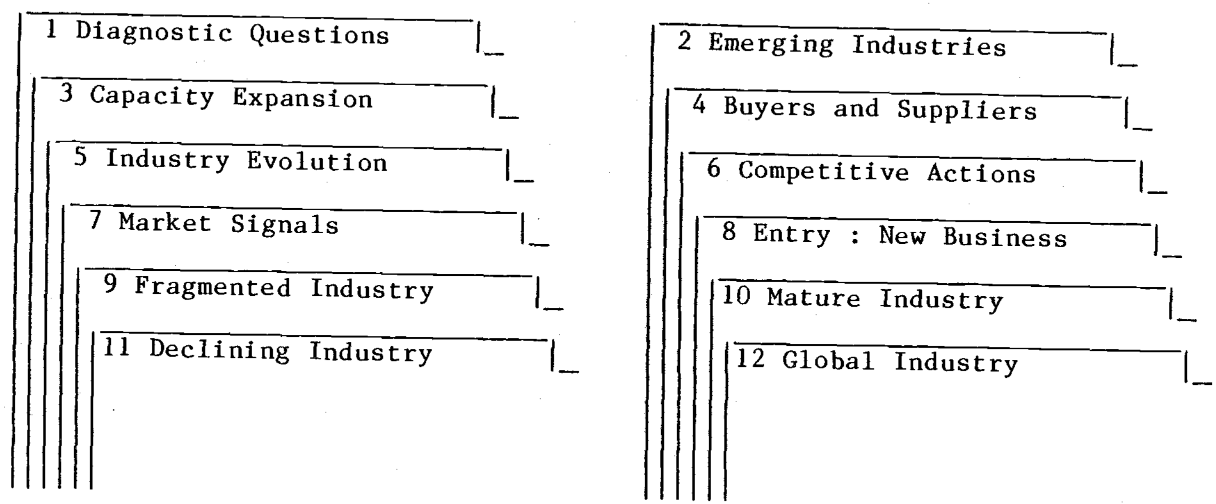
database is best explained by analyzing the contents of a specific file folder. Inside the file cabinet are labeled folders which contain expert knowledge for a subset of the strategic planning database. Each subset is semantically consistent, ie. the knowledge is related to one aspect of the strategic planning decision domain. Questions in the folder are answered by the decision maker, and based on the answers selected, relationships that suggest other folders to be investigated are presented. In addition, the decision maker is offered "theoretical advice," related to that particular aspect of the decision task. This advice is categorized into general areas that are consistent throughout folders. In summary, the decision maker, once "inside" a file folder, answers questions related to the folder´s semantics, and the DSS suggests other folders for exploration and offers expert advice. Figure VII.4 shows all of the folders inside the file cabinet for the DSS used in the experiment.

3.2 Operations

The operations of the DSS are distinguished from the control mechanisms provided the decision maker. This section discusses the operations of the DSS, while the "Control" section will discuss the decision maker´s options for using the DSS. There are two discrete modes of operation, hereafter referred to as "Guided Session" and "Non-Guided Session." Each will be discussed in turn.

The Guided Session, once selected by the decision maker,

FIGURE VII.4: THE FOLDERS IN THE FILE CABINET



Folders Remaining = 0
Enter any key <carriage return> to continue

causes the DSS to assume control of directing the flow of file folder exploration. The first file folder is automatically retrieved from the file cabinet. This folder is labeled "Diagnostic Questions" and has a special role. The folder contains questions that allows the system to predict which other folders in the database should be explored given the context of the decision maker's situation. Thus, its role is to ask questions that identify the environment of the decision maker, and suggest folders that pertain to this environment. The knowledge base contains rules (based upon possible answers to questions) that, found to be valid in the decision maker's context, suggest exploration of another folder. Each folder is presented, in turn, to the decision maker for investigation. Figure VII.5 is an example of the explanation sequence presented the decision maker upon system determination that the folder "Emerging Industries" should be explored.

The Non-Guided Session is distinguished by the freedom provided the decision maker to peruse file folders at will. The decision maker is queried for a folder to be investigated, and this folder is explored in isolation, ie. the DSS does not automatically bring other folders forth from the file cabinet. In this manner, the sophisticated decision maker is provided a more facilitative interface, one that assumes the decision maker possesses prior knowledge of the portions of the knowledge base that are to be explored given her task. Figure VII.6 shows the selection of the file folder "Emerging Industries."

Both session types require the decision maker to answer

FIGURE VII.5: EXAMPLE OF THE EXPLANATION SEQUENCE

/ Diagnostic Questions

QUESTIONS

FILE FOLDERS TO BE EXPLORED

I suggest that you explore folder:
Emerging Industries

```
ENTER -
        W : for WHY
        C : for CONTINUE
        D : to use the DICTIONARY
        S : to use the SCRATCHPAD
        R : to leave remark for expert
```

FIGURE VII.5 (continued)

IF
THIS QUESTION:
    The marketing methods of the company appear

IS ANSWERED: New and untested

Enter any key <carriage return> to continue

I SUGGEST INVESTIGATION OF FILE FOLDER:
Emerging Industries

MY REASONING IS:
Many different product approaches, technological variations and conflicting claims are offered in emerging industries.

Enter any key <carriage return> to continue

FIGURE VII.6: SELECTION OF A PARTICULAR FOLDER

1 Diagnostic Questions	2 Emerging Industries
3 Capacity Expansion	4 Buyers and Suppliers
5 Industry Evolution	6 Competitive Actions
7 Market Signals	8 Entry : New Business
9 Fragmented Industry	10 Mature Industry
11 Declining Industry	12 Global Industry

Folders Remaining = 0
Enter any key <carriage return> to continue

Enter the folder number associated with your selection
2

questions. The answers to these questions are evaluated in terms of boolean encoded rules. Figure VII.7 shows the explanation sequence for expert advice in the category "Increase Entry Barriers." This advice relates to theoretical outcomes that will result in, or have resulted in, an increase in entry barriers for a particular product/market element.

3.3 Memory Aids

Two types of traces are provided to the decision maker upon exiting the DSS. The first is a trace of the entire session, the questions asked and the answers selected, the file folders suggested for exploration and the reasoning used, and the expert advice offered by the system with reasons for the advice. The second is a summary of advice received in each general category from throughout the file folders. Each category is prefaced by a brief introduction, followed by the expert advice and "reasons why" relating to that category. An example of the two traces are shown in Figures VII.8 and VII.9, respectively.

The dictionary and the scratchpad are other memory aids available throughout the question/answer phase and the rule presentation phase. When the dictionary is queried, the decision maker is asked for the term or phrase to be defined, and the definition is provided. Figure VII.10 shows the operation sequence of the dictionary. The scratchpad is a memory aid designed to facilitate a decision maker's recording of especially noteworthy observations. Figure VII.11 shows an example use of the

FIGURE VII.7: EXPERT ADVICE

/ Emerging Industries

QUESTIONS

FILE FOLDERS TO BE EXPLORED

EXPERT´S ADVICE

Basic Competitive Forces:
Increase Entry Barriers

Enter any key <carriage return> to continue

FIGURE VII.7 (continued)

IF
THIS QUESTION:
Would poor product/service performance be a costly error for purchasers?

IS ANSWERED: Yes

Enter any key <carriage return> to continue

THEN, MY ADVICE IS:
The greater the cost of product failure for the customer, the slower that customer will be in adopting the new product.

MY JUSTIFICATION IS:
Customers will seek to thoroughly evaluate and test new products if the cost of product failure is high.
Source: Porter, p. 227

Enter any key <carriage return> to continue

FIGURE VII.8: ENTIRE SESSION TRACE

-Now beginning RECOG with: goul

-Non-guided session

-Reviewing file folder labels

-Current file folder: Emerging Industries

Q: What type of emerging industry is this?
A: Combination of both of the above

Q: Can benefits be realized by early, primitive versions of the product/service?
A: Yes

Q: Would poor product/service performance be a costly error for purchasers?
A: Yes

Q: Would changing suppliers or distribution channels be very disruptive?
A: Yes

Q: Might initial market success attract different types of very large competitors?
A: Yes

Q: Can the organizational learning from developing products be protected?
A: Cannot determine

Q: Are purchasers generally brand loyal in the targeted market segment?
A: Cannot be determined

Q: Costs of opening a new market are
A: High

Q: Are technological advances made by industry suppliers
A: Rapid

Q: Will competition and market segmentation change as the product/service matures?
A: Yes

Q: Are competing products easily differentiated in these emerging markets?
A: Yes

Q: Can a defensible position be maintained with market maturity and competition?
A: Yes

-Category: Increase Entry Barriers

-Expert Advice:
The greater the cost of product failure for the customer, the slower that customer will be in adopting the new product.

-Why?
Customers will seek to thoroughly evaluate and test new products if the cost of product failure is high.
Source: Porter, p. 227

-Expert Advice:
The greater the costs of opening up a market, (customer education, regulatory approvals, and technological advancements) the more risky is early entry.

-Why?

FIGURE VII.8 (continued)

Customers entering early may pay these costs and then be faced by competition which enters later and avoids such costs.
Source: Porter, p. 233

-Expert Advice:
The greater the chance that technological change will make early investments obsolete, the more risky is early entry into a market.

-Why?
Firms entering later will have the advantage of the newest processes without paying the development costs for early technologies.
Source: Porter, p. 233

-Expert Advice:
The greater the probability that early competition and market segmentation are developed on a basis different from that which will be important later in industry development, the more risky early entry is.

-Why?
Firms entering early may develop wrong skills and face high changeover costs.
Source: Porter, p. 233

-Category: Increase Power of Suppliers

-Expert Advice:
Buyers who can achieve valuable benefits with rudimentary versions of the new product create earlier market segments than buyers who require highly sophisticated varieties in order to benefit from the new product.

-Why?
The early products will tend to be rudimentary versions with increasing sophistication occurring as technologies develop and new markets are discovered.
Source: Porter, p. 227

-Expert Advice:
Organizations in emerging industries will face shifts in the orientation of suppliers and distribution channels.

-Why?
Suppliers and distributors become more willing to respond to the industry's special needs as expected returns become more lucrative.
Source: Porter, p. 231

-Category: Increase Threat of Substitutes

-Expert Advice:
Entry into an emerging industry is attractive if the industry's ultimate structure (not initial structure) is consistent with above average returns and the company can create a position which is defendable in the long run.

-Why?
Entry into an industry should be based on a structural analysis rather than reasons of high initial growth rate, high profitability of industry incumbents, or because the industry size promises to be large.
Source: Porter, p.226

-Category: Increase Intensity of Industry Rivalry

-Expert Advice:

FIGURE VII.8 (continued)

The nature of entrants to an emerging industry shifts to more and larger firms who are attracted by less risk and established markets.

-Why?
New bases of competition such as large economies of scale and marketing clout can be marshalled in such developed markets.
Source: Porter, p. 232

Category: Decrease Threat of Substitutes

-Expert Advice:
Customers in non-emerging industries are not often confused by the various products offered by industry competitors.

-Why?
There are few product approaches, technological variations, and conflicting claims.
Source: Porter, p. 222

FIGURE VII.9: ADVICE SUMMARY TRACE FILE

THREAT OF ENTRY

INTRODUCTION:
New entrants to an industry bring added capacity, the desire for market share and often substantial resources. Prices may be bid down or costs inflated reducing profitability.

ADVICE:
The greater the cost of product failure for the customer, the slower that customer will be in adopting the new product.

WHY?
Customers will seek to thoroughly evaluate and test new products if the cost of product failure is high.
Source: Porter, p. 227

ADVICE:
The greater the costs of opening up a market, (customer education, regulatory approvals, and technological advancements) the more risky is early entry.

WHY?
Customers entering early may pay these costs and then be faced by competition which enters later and avoids such costs.
Source: Porter, p. 233

ADVICE:
The greater the chance that technological change will make early investments obsolete, the more risky is early entry into a market.

WHY?
Firms entering later will have the advantage of the newest processes without paying the development costs for early technologies.
Source: Porter, p. 233

ADVICE:
The greater the probability that early competition and market segmentation are developed on a basis different from that which will be important later in industry development, the more risky early entry is.

WHY?
Firms entering early may develop wrong skills and face high changeover costs.
Source: Porter, p. 233

FIGURE VII.10: DICTIONARY EXAMPLE

2> DICTIONARY

```
Would you like to have a term or phrase defined? [y,n]
?y


Enter the term or phrase: (Use lower case characters)
market segment


 ***
A market segment is composed of groups of consumers who possess similar
characteristics and/or needs.


Enter any key <carriage return> to continue
```

FIGURE VII.11: SCRATCHPAD EXAMPLE

1> SCRATCHPAD
Capacity remaining: 96.00%

Scratchpad Menu

1 --> Make a new note
2 --> Review a note
3 --> Throw away a note
4 --> Exit Scratchpad

Enter the number associated with your request:
1
Enter a term that summarizes the purpose of this note.
Letter to VP Operations

Enter the note (not to exceed one typed line):
Write to Jan about developing standard tests for the new disk drives.

scratchpad.

3.4 Control

The decision maker begins a session by selecting from the main menu a setting for the "switch" shown in Figure VII.3. The switch invokes either the Guided or Non-Guided session described above. The other important control offered the decision maker is in the explanation sequence for both folder invocation rules and expert advice. Figure VII.5 shows the menu presented in the explanation sequence. The "WHY" selection offers the explanation sequence shown. The dictionary and scratchpad are accessible, as well as a "REMARK" selection that allows the decision maker to leave a message for the knowledge system builder(s).

4. EXPERIMENTAL DESIGN

To test our five hypotheses, a controlled experiment was conducted using the DSS described above. The experiment was conducted during an academic term. Subjects were enrolled in a course titled "Strategic Planning," for which the required text was Porter, M. Competitive Strategy. (New York, NY: Free Press) 1980. The subjects were required to prepare a case analysis of "Apple Computer" as adapted from a description of the organization by Steve Gauthier (Gauthier, 1983).

4.1 Subjects

All fifty-one students enrolled in an undergraduate senior level elective business course participated in the experiment. The majority of students were senior year business majors who enrolled in the "Management" concentration for their undergraduate major (95% of the subjects). The other students were enrolled in School of Education and School of Engineering graduate programs who opted for the course as an outside minor selection. The course consisted of two sections, taught by the same instructor. Section sizes were seventeen and thirty-four. There were 51% females and 48% males in the combined sections. Student´s self-reported cumulative GPA´s ranged from 2.00 to 4.00 on a 4.00 scale. 50% of the students reported a cumulative GPA of between 2.5 and 2.99.

Given the homogeneous nature of students enrolled in the course, no measures of individual differences, either work-experience-related or computer-experience-related, were incorporated into the experimental design. There is little research that supports or does not support the selection of students as appropriate surrogates for the strategic planning population.

4.2 The DSS Knowledge Base

The knowledge base for the DSS contained those theoretical assumptions, relationships and advice espoused by Porter in the text for the course (Porter, 1980). Thus, all students had access to the required text, and the system was intended to amplify and filter textual material for the subjects using the DSS. The knowledge base was constructed for use across the full range of organizational settings and characteristics; it was left to the subjects to answer relative to the organization under study the general questions posed by the DSS.

The folders in the DSS were organized in a manner consistent with the text, ie. chapter headings were used as file folder labels, and the textual content of each chapter was the basis for advice generated by the DSS. Terms and phrases consistent with those used in the text were used in the knowledge base.

4.3 The Case Assignment

The case analysis assigned to students was intended to encapusulate the objectives of the Strategic Planning course. The case accounted for 20% of the final course grade. Subjects were required to submit a two page, typewritten case analysis report addressing the following:

1. List and explain the major competitive issues (strategic strengths and weaknesses) that you feel are significant for the Apple Computer Company.

2. What choices are reasonable for the Apple Computer Company, that is, in what areas is it possible for their competitive position to be improved, and what areas should cause immediate

concern? Justify your choices with reasoning.

The case was assigned in the eighth week of a ten week term. The entire text book had been covered in lecture prior to the assignment date. Students had one week to complete the assignment. An entire class period was devoted to teaching subjects the operations of the DSS. A dummy knowledge base related to automobile repair was used as an example.

5. METHODOLOGY

Subjects were randomly assigned to one of three groups in an independent groups experimental design (Siegel, 1956). Two of the three groups used the DSS and one group did not use the DSS. The DSS knowledge base consisted of twelve file folders, an average of twenty questions per folder, and a overall total of 475 rules. Of the two groups using the DSS, one group had access to the complete knowledge base reflecting the material in Porter, while the other group had access to only a subset of the complete knowledge base. This subset, or partial knowledge base, contained three questions per folder and an overall total of 25 rules. The questions and rules included in the partial knowledge base were selected at random.

The DSS was installed on IBM personal computers, some with hard disk drives, and others with dual floppy drives. The six machines and the DSS were made available throughout the week of the assignment for approximately ten hours per day. Subjects were able to use the machines without prior scheduling and without significant waiting. A monitor stayed in the room with the machines throughout the day, answering questions on system operation and recording usage patterns. Complete traces of each subject's sessions were collected. Each subject turned in a case analysis report to the course instructor. The case report was the focus of measures for testing hypotheses.

The data obtained from "checklist" grading of the subjects' case reports and from the instructor's evaluation of the proposed plan of action were analyzed using nonparametric statistical techniques (Siegel, 1956). The selection of nonparametric statistics was based on the "ordinal" nature of the data collected. Parametric statistics assume "interval" measurement. We assume that the matching and instructor evaluation processes place measurements in a group of equivalence classes where the relation of ">" holds for all pairs of classes so that these classes can be ordered or ranked. Since we cannot assume that classes are differentiated by a specific distance, "interval" measurement was not attained. All checklist grading was done "blindly;" there was no knowledge of the group the subjects were assigned to.

The experimental design included a component to reduce the "Hawthorne effect" (See Kerlinger, 1973) possibly resulting from extra attention given to subjects selected to use the DSS. The effect states that better subject response would be realized just by the special attention associated with the use of the DSS. Hence, we included two groups of system users, one group with access to a complete knowledge base, and one group with access to a partial knowledge base, i.e. a "superficial" treatment.

5.1 Data Summary

Figure VII.12 graphically shows the raw data collected by hypothesis. Five bar charts correspond to the five hypotheses. For each chart, the y-axis labeled "OBSERVATIONS" refers to the number of subjects observed. Each of the three independent groups are coded as shown in the Graph Codes. The first chart presents the number of determinants identified by subjects that matched the experts' identification of determinants. Similarly, opportunities, problems, and crises are presented in the next three charts. The last chart presents the instructor's evaluation of subjects' plans of action. Letter grades ranging from D- to A form the x-axis.

Table VII.1 shows the medians and modes of the dependent variables under analysis. The variables by hypothesis are the rows in the table, and the first three columns are the independent variable, ie. the treatment. The fourth column shows medians and modes by dependent variable for the entire sample. Entries in the table are the number of matching strategy determinants, opportunities, problems, and crises, and a letter grade assigned to the plan of action. For example, the median for strategy determinants for the group not using the DSS is "1 determinant that matched."

FIGURE VII.12: RAW DATA BY HYPOTHESIS

	N	GRAPH CODES
COMPLETE KNOWLEDGE BASE	22	
PARTIAL KNOWLEDGE BASE	19	
NO SYSTEM EXPOSURE	10	
TOTAL OBSERVATIONS	51	

FIGURE VII.12 (continued)

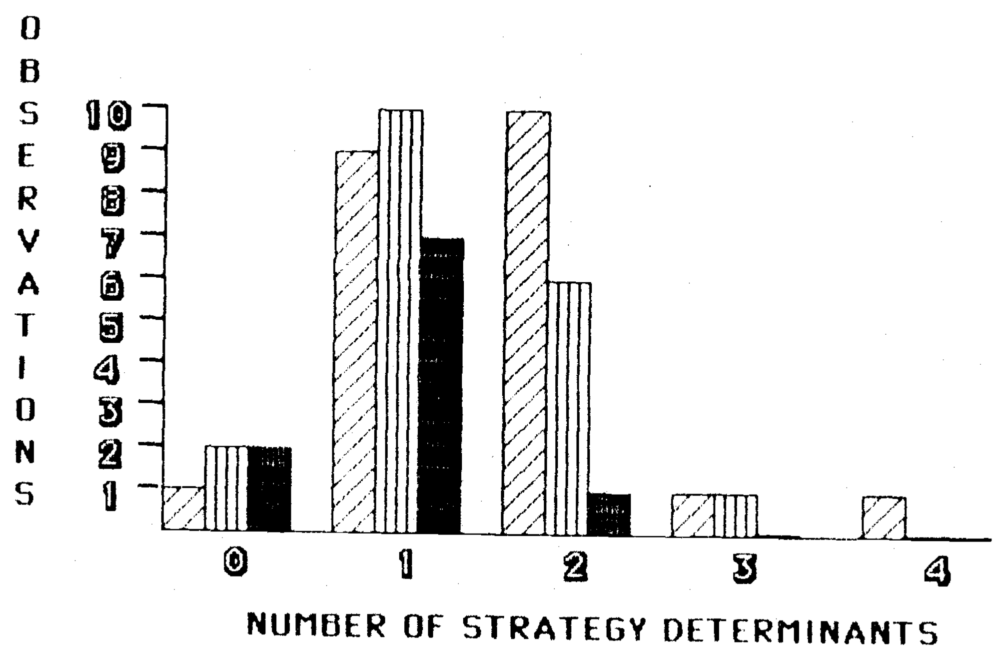


FIGURE VII.12 (continued)

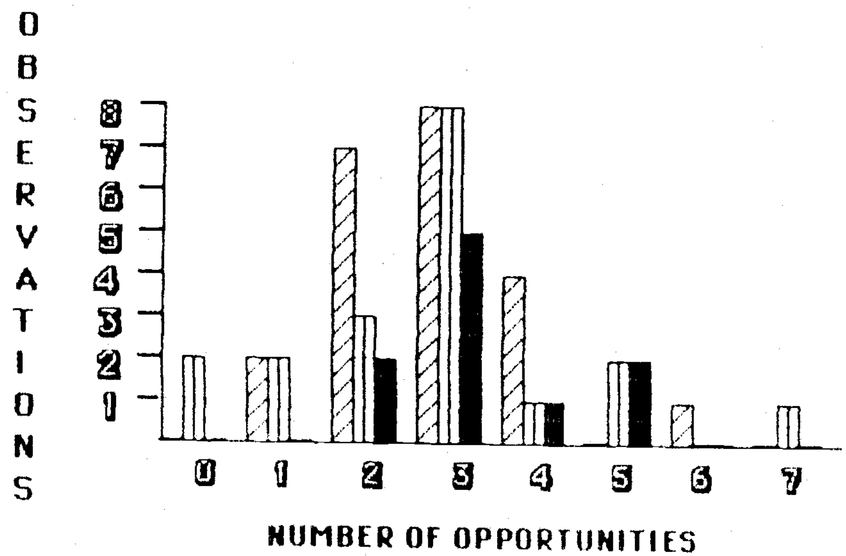


FIGURE VII.12 (continued)

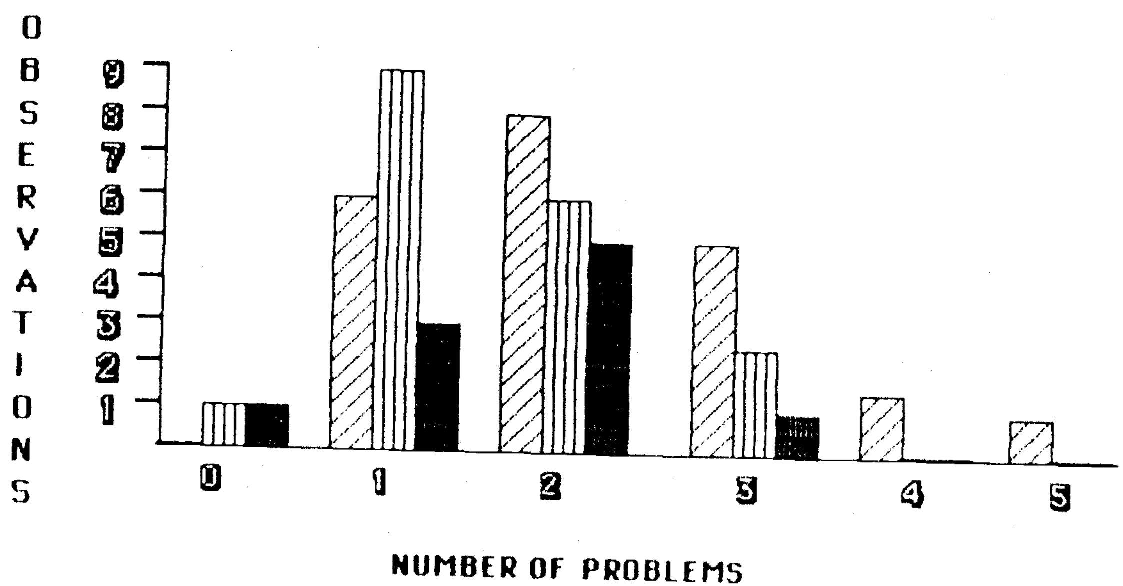


FIGURE VII.12 (continued)

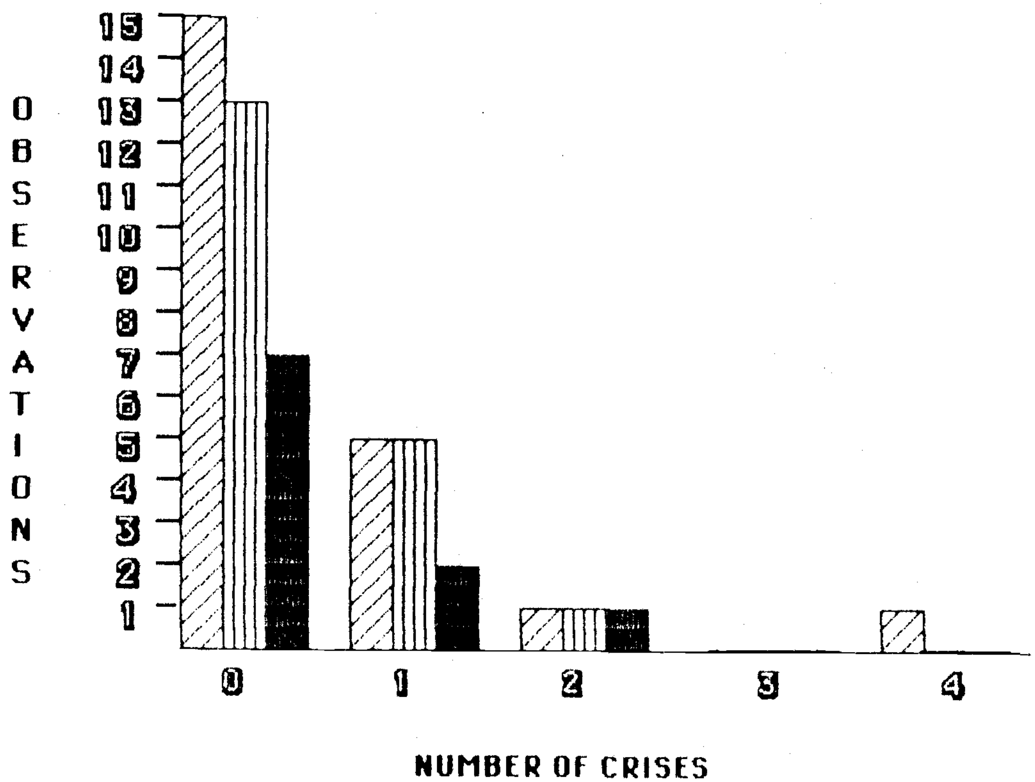
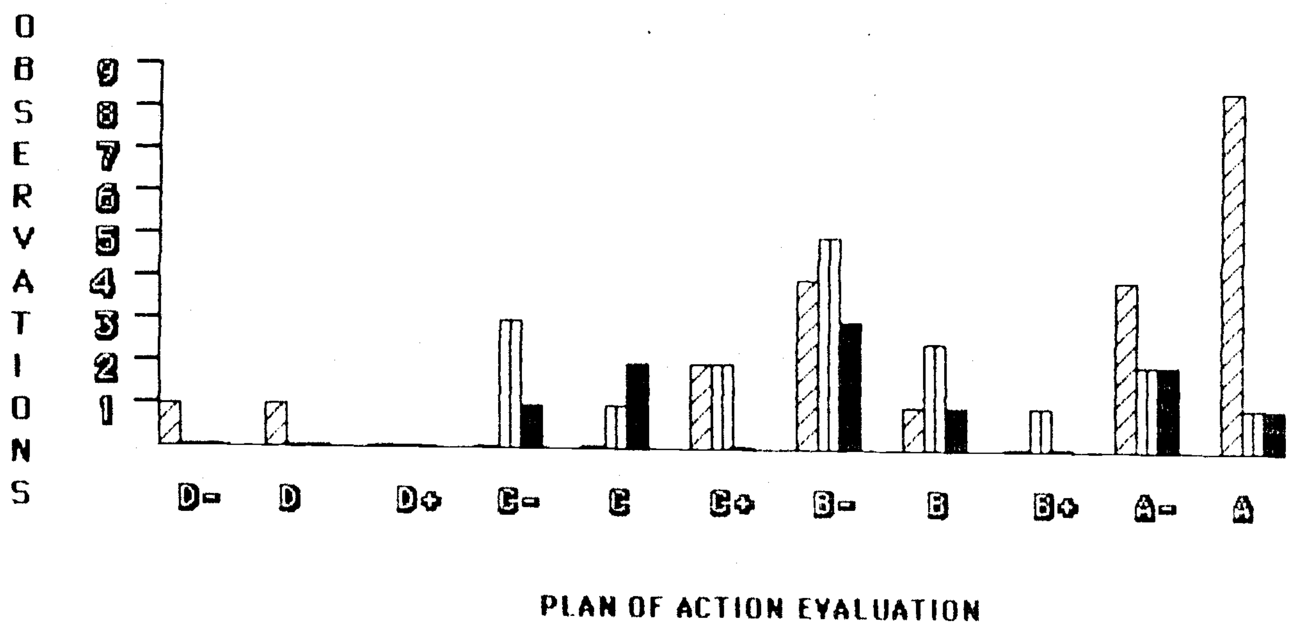


FIGURE VII.12 (continued)



OBSERVED MEDIANS AND MODES
BY HYPOTHESIS

	GROUP							
	SYSTEM USERS							
	COMPLETE KNOWLEDGE BASE		PARTIAL KNOWLEDGE BASE		NO SYSTEM EXPOSURE		COMBINED GROUPS	
N	22		19		10		51	
	MEDIAN	MODE	MEDIAN	MODE	MEDIAN	MODE	MEDIAN	MODE
HO 1.1: STRATEGY DETERMINANTS	2	2	1	1	1	1	1	1
HO 1.2: OPPORTUNITIES	3	3	3	3	3	3	3	3
HO 1.3: PROBLEMS	2	2	1	1	2	2	2	2
HO1.4: CRISES	0	0	0	0	0	0	0	0
HO 1.5: PLAN OF ACTION	A-	A	B-	B-	B-	B-	B-	B-

TABLE VII.1: OBSERVED MEDIANS AND MODES

5.2 Methods of Statistical Analysis

To test HO_1, we have proposed five corollary hypotheses, $HO_{1.1}$ through $HO_{1.5}$. The dependent variable data has been displayed and discussed. The technique of analysis we utilized is the Mann-Whitney U Test (described in Siegel, 1956). This technique was used in two stages to 1) test the significance of differences in subjects´ scores between the group using the DSS including a partial knowledge base and the group with no DSS exposure, and 2) directionally test the significance of differences in subjects´ scores between the group using the DSS including the complete knowledge base and the group formed by combining the groups using the DSS including a partial knowledge base and the group having no DSS exposure. Stage 1 of the analysis tests the hypothesis that there are no differences between using the DSS with a partial knowledge base and using no DSS. Stage 2 tests the hypothesis that there are no differences between subjects using the DSS with a complete knowledge base in contrast to the combined remaining two groups. $HO_{1.1}$ through $HO_{1.5}$ were tested in both stages. Based on these tests, a qualitative argument will be presented for analysis of HO_1.

5.2.1 Stage One Analysis

Table VII.2 shows the results of applying the Mann-Whitney U statistical technique to assess the following hypotheses:

$HO_{1.1.1}$: There is no significant difference in strategy determinant assessment between subjects who used a DSS with a

STAGE ONE ANALYSIS TREATMENTS: PARTIAL KNOWLEDGE BASE and NO DSS EXPOSURE			
	MANN-WHITNEY OBSERVED U VALUE	CRITICAL VALUE OF U FOR A TWO-TAILED TEST AT ALPHA = .05 *	DECISION
HO 1.1: STRATEGY DETERMINANTS	66	58	ACCEPT HO 1.1
HO 1.2: OPPORTUNITIES	74.5	58	ACCEPT HO 1.2
HO 1.3: PROBLEMS	90.5	58	ACCEPT HO 1.3
HO1.4: CRISES	95	58	ACCEPT HO 1.4
HO 1.5: PLAN OF ACTION	84	58	ACCEPT HO 1.5
* FROM TABLE K, P. 276 SIEGEL, 1956			

TABLE VII.2: STAGE ONE ANALYSIS

partial knowledge base and subjects who had no exposure to the DSS.

HO $_{1.2.1}$: There is no significant difference in opportunity recognition between subjects who used a DSS with a partial knowledge base and subjects who had no exposure to the DSS.

HO $_{1.3.1}$: There is no significant difference in problem recognition between subjects who used a DSS with a partial knowledge base and subjects who had no exposure to the DSS.

HO $_{1.4.1}$: There is no significant difference in crisis recognition between subjects who used a DSS with a partial knowledge base and subjects who had no DSS exposure.

HO $_{1.5.1}$: There is no significant difference in proposed plans of action between subjects who used a DSS with a partial knowledge base and subjects who had no DSS exposure.

In all cases, an alpha of .05 for a two tailed test was deemed necessary for rejection of the null hypothesis. The observed Mann-Whitney U was too large in each test to reject the null hypothesis at the specified level of significance. We conclude that there is no difference in strategy determinant assessment, opportunity, problem, and crisis identification, and proposed plan of action between the treatments under analysis.

5.2.2 Stage Two Analysis

The results of the stage one analysis support combining the subjects under the treatments of "DSS with a partial knowledge base" and "no DSS exposure" into a single group. We will hereafter refer to this group as the "control group." Stage two of the analysis tests for directional significance. That is, the following alternative hypotheses (designated HA) were tested in stage two:

$HA_{1.1}$: Subjects using a DSS with a complete knowledge base scored (stochastically) higher in strategy assessment than subjects in the control group.

$HA_{1.2}$: Subjects using a DSS with a complete knowledge base scored (stochastically) higher in opportunity recognition than subjects in the control group.

$HA_{1.3}$: Subjects using a DSS with a complete knowledge base scored (stochastically) higher in problem recognition than subjects in the control group.

$HA_{1.4}$: Subjects using a DSS with a complete knowledge base scored (stochastically) higher in crisis recognition than subjects in the control group.

$HA_{1.5}$: Subjects using a DSS with a complete knowledge base scored (stochastically) higher in an evaluation of proposed plans of action than subjects in the control group.

Table VII.3 presents the results of applying the Mann-Whitney U test for the stage two analysis. For each hypothesis, we deemed an alpha level of .05 necessary for rejection of the null hypothesis and acceptance of the alternative hypothesis (HA). The tests applied were one tailed tests, in the direction specified by the corresponding alternative hypothesis.

For the opportunity and crisis hypotheses, the observed z values were not sufficiently extreme to reject the null hypothesis. We conclude there is no significant difference in opportunity and crisis identification between the control group and the group using the DSS with a complete knowledge base.

For strategy determinant assessment, problem recognition, and plan of action evaluation, the observed z values (in which the difference is in the predicted direction) had a probability under the null hypotheses sufficiently extreme to accept the alternative hypotheses. We conclude the DSS with a complete knowledge base has favorably enhanced subjects' strategy determinant assessment, problem recognition, and proposed plans of action.

5.3 Implications of Results to HO 1

The results of the Stage Two analysis do not categorically indicate rejection of the primary hypothesis stated in the Research Problem section of this paper. They do indicate that a subset of processes in strategic planning decision making have been improved.

STAGE TWO ANALYSIS
TREATMENTS: COMPLETE KNOWLEDGE BASE and CONTROL GROUP

	MANN-WHITNEY OBSERVED z VALUE	PROBABILITY UNDER HO OF OBSERVED z FOR A ONE-TAILED TEST * P (Z >= OBSERVED z)	DECISION AT ALPHA = .05
HO 1.1: STRATEGY DETERMINANTS	2.05	.0202	ACCEPT HA 1.1
HO 1.2: OPPORTUNITIES	-.47	.6808	ACCEPT HO 1.2
HO 1.3: PROBLEMS	2.15	.0158	ACCEPT HA 1.3
HO1.4: CRISES	.28	.3879	ACCEPT HO 1.4
HO 1.5: PLAN OF ACTION	2.48	.0066	ACCEPT HA 1.5

* FROM TABLE A, P. 247 SIEGEL, 1956

TABLE VII.3: STAGE TWO ANALYSIS

The major limitation of the study is that some uncontrollable variables were not easily identifiable. For example, there is evidence in the literature on strategic decision making that current theoretical models are not predisposed to enhance opportunity identification (Day, 1981). By including opportunity recognition as a component of analysis, we have assumed that relevant theoretical model exposure would indeed affect recognition of opportunities. But, because of the nature of the theoretical models, this may not be possible. The study validates the impact of the theoretical models to a subset of the strategic decision making process. This study does not distinguish whether the failure to enhance opportunity and crisis recognition lies with the DSS mechanism itself or the theoretical models represented in the DSS knowledge base.

6. CONCLUSION

This paper described empirical research designed to assess the impact of a DSS on the recognition phase of strategic decision making. The DSS was constructed with a knowledge base intended to promote user exposure to relevant theoretical models. The results indicate a level of success, specifically in the early phases of recognition, the identification of problems, and the ultimate choices made by decision makers. The study was limited by the nature of the theoretical models selected for use in the DSS.

Relative little research has focused on the impact of the computer on decision making in unstructured domains. Future achievements hinge on documented successes and failures in this arena. It is our hope that this paper will contribute to a dialogue that ultimately serves to broaden the scope of current DSS practices.

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CHAPTER VIII: CONCLUDING REMARKS

1. INTRODUCTION

The purpose of this chapter is to review the research presented in this paper, discuss additional information relative to the experiment detailed in Chapter VII, discuss another domain for the DSS approach, and conclude by offering future research directions.

2. RESEARCH REVIEW

In this paper, a model of the recognition stage of unstructured decision making processes was presented, and a DSS to operate on the "lack of relevant theoretical models" inhibitor was implemented and analyzed by controlled experimentation. The model of decision making characterizes recognition as the stage where opportunities, problems, and crises are recognized by a decision maker. The implications of the model were tested by developing a DSS and using it in an experiment where its contributions to recognition could be identified. The results of the experiment indicate a level of success, particularly in the area of problem identification.

3. NOTES ON THE EXPERIMENT

Six appendices have been included to detail the experimental methodology and findings. To control the likely contamination of data by communication between subjects assigned to the different independent groups, each subject was asked to sign an informational form shown in Appendix One. This method served sufficiently as indicated by answers to two questions in the post-case questionnaire. Questions 26 and 28 of the questionnaire asked for the amount of time subjects spent discussing the case with others and reviewing other subjects´ printouts from the DSS. Relative to the total amount of time subjects spent preparing the case analysis report, the amount of time dedicated to inter-communication was limited to less than 2%. Only one subject reported reviewing the DSS printout of another.

Appendix Two contains the post-case questionnaire. The questionnaire was given to subjects prior to return of the graded case analysis report. Two errors in the questionnaire were announced to subjects. First, the question numbering sequence had skipped two numbers (18 and 19), however, no actual questions were omitted. Second, question 16 contained a typographical error, the word "understood" was meant to have read "understand." Two questions in section II were designed to informally cross-reference the validity of a subject´s responses. Question 13 and 21 related to the "ease of use" of the DSS interface, one stating the menus were easy to use, and one stating the general design of the program wasn´t easy to use. No major inconsistencies in responses on these two questions was noted.

The checklist graded method discussed in Chapter VII relied on the use of documented expert identification of strategy determinants, opportunities, problems, and crises. Appendix Three contains the checklist of strategy determinants, as prepared by Paine, Webber, Mitchell, Hutchins, Inc. This appendix was included in the orginal Apple Computer, Inc. case, but was omitted in the case description assigned students. Appendix Four contains the checklist for grading of opportunity, problem, and crises identification. Sources from the same time period as that of the case description were used as bases for the checklist grading. While subjects may not have used the exact terminology as in the checklists, a match was tallied when it was recognized the subject had identified the gist of the concept.

Appendix Five contains a list of the comments subjects made relative to their personal assessment of the impact of the DSS on preparation of the case analysis report. The lists are separated by group; the subjects assigned to the group not using the DSS did not respond to this question. Interestingly, both groups who used the DSS in one of its forms, did not offer significantly different comments. Subjects assigned to the group using the DSS with a complete knowledge base did offer somewhat more comprehensive comments.

While much data was collected from the questionnaire and the trace file of each subject's session with the DSS, some was not useful for the purposes of this particular research. Those additional items deemed indirectly pertinent to this research, and not discussed in Chapter VII, are summarized in frequency distributions in Appendix Six. Information relative to the characteristics of the groupings, system use, and responses for

Section II of the post-case questionnaire are presented.

During the experiment, there were several noteworthy observations as follows:

A. It was the intention to give students only the trace file organized by expert advice orientation, rather than the trace of the entire session. Beginning with the very first student to use the DSS, each subject requested a printout of the entire trace file. Evidently, the questions contained in the knowledge base and the answers selected during the session were important for review. These were not included in the expert advice orientation printout.

B. Subjects assigned to the DSS with a partial knowledge base spent almost as much time on the system as subjects using the DSS with a complete knowledge base. These subjects were performing a type of "sensitivity analysis," permuting the answers to each question to detect the impact on the expert advice offered. Subjects using the complete knowledge base DSS did not perform this sensitivity analysis due to the amount of time it took just to answer all of the questions and review all of the advice.

C. Some subjects specifically stated that they were initially disappointed that the DSS didn't produce the "answers." Yet, these students were the ones back for a second session with the DSS!

D. The course instructor seemed interestingly anxious on the third day of the experiment. He stated that some students had been asking him questions about the case, and he was amazed at the quality of the questions relative to his previous experience with students working on case assignments.

E. The last two days of the experiment, subjects modified their approach to using the DSS. Prior to this time, subjects took time to read the expert advice generated by the system as it was listed. The last two days, subjects took time to answer the questions, but did not read the advice. They were depending on the trace files for review of what the system had generated.

4. ANOTHER DOMAIN FOR THE DSS

The focus of this research has been in the domain of strategic planning. The DSS designed for this research is currently being adopted in the domain of entomology. The system will be designed to assist fruit growers in the assessment of pest infestations and remedial strategies. The first system will be for pears, with cherries, apples, and other fruits to follow. Two experts, Dr. Peter Westergard and Dr. Brian Croft of the OSU Department of Entomology are serving as experts for the system. The two recently received a grant of $35,000 to pursue the pear system.

To date, adaptations of the DSS interface have been planned including an adjustment of the "desk" menu to a "manual" orientation. Several consultative sessions have been directed at the knowledge building process, and the two experts are currently designing the knowledge base. A prototype DSS will be completed by June, 1985.

5. FUTURE RESEARCH DIRECTIONS

Decision Support Systems have been most frequently developed for the middle management of organizations. Expert systems have been developed and implemented for operational levels of the organization and only minimally for the middle management of organizations. There is little literature on the future directions for both DSS and Expert System techniques in terms of the top management of the organization. Research relative to the current strengths and weaknesses of these techniques at the associated organizational levels is minimally available. Future research should be directed towards this assesment, in order that new opportunities can be identified for both types of systems.

The DSS used in this research is limited to "monotonic logic," and the potential for introducing "non-monotonic logic" should be investigated. Monotonic logic is a reasoning process whereby the reasoner´s beliefs are true, and these truths never change. The current set of beliefs are augmented with more beliefs. In contrast, non-monotonic logic allows for routine assumptions to enable "commonsense reasoning," reasoning that accomodates corrections to the assumptions. The current set of beliefs is revised, and invalid conclusions are discarded.

There is currently no information exchange among file folders, i.e. when one folder´s question is answered, that answer is not available for use by other folders. It seems a "blackboard" could be implemented, where the results of one folder´s questioning might be saved for other folders. In this way, Boolean encoded rules could include a reference to the blackboard for information already secured from the decision maker. Some of the information on the blackboard could be assumptions by the expert regarding the decision maker´s situation. Such "default reasoning" would introduce the notion of non-monotonic logic to the DSS.

While monotonic logic relies on known relationships, non-monotonic logic provides for the use of default reasoning. When pertinent information is not available, the default information is used in its place. The question of updating defaults and the resulting question of dealing with information presented the decision maker that is no longer valid, are important considerations for introducing non-monotonic logic. This research direction should be coupled with a sustained attempt to facilitate direct interaction between the expert knowledge base builder and the DSS. Increasing complexities must be balanced with the need for an "easy to use" interface for the non-computer oriented expert.

The results of this research are limited to one domain. While now adapting the system to the entomology domain, similar adaptations for other domains are necessary to assess the full impact of the approach. The combined findings from several domains will enhance the generality of the DSS design presented in this research.

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APPENDICES

APPENDIX ONE:
SUBJECT AGREEMENT FORM

Ba 497 Strategic Planning Fall, 1984

TO: Students of BA 497

FROM: Professor Shane

SUBJECT: Use of the Strategic Planning Software

The purpose of this letter is to provide information about this expert system experience in which you are participating. When using the strategic planning software, a trace is made of your progress. Data is collected on the amount of time you spend using the software, and you'll be asked to complete a questionnaire after you use it. All data is recorded in such a way as to guarantee your anonymity.

The strategic planning software has two "levels" of ability. You will be assigned a system with one of these levels for your use.

All students are expected to do their own work. Please do not share your printouts with others.

Lastly, please sign the following to indicate that you have read the above.

____________________________ ____________________
name date

APPENDIX TWO:
SURVEY INSTRUMENT

BA 497 STRATEGIC PLANNING

Autumn, 1984 | Professor Shane

POST-CASE QUESTIONNAIRE

Please EXERCISE THE SAME DEGREE OF CARE AND JUDGEMENT in completing this questionnaire as you would expect your instructor to use in assigning grades.

SECTION I:
Write the number corresponding to your response in the space provided to the right of each question.

1. Your class standing: Junior(1) Senior(2) Grad(3) Other(4) 1. _____

2. Your cumulative GPA: Below 2.00(1) 2.00-2.49(2) 2.5-2.99(3) 3.00-3.49(4) 3.5-4.00(5) 2. _____

3. Your School is: Bus(1) Engr(2) Educ(3) Other(4) 3. _____

4. Sex: Female(1) Male(2) 4. _____

***** IF YOU DID NOT USE THE STRATEGIC PLANNING SOFTWARE, PLEASE SKIP *****
***** TO QUESTIONS 22 - 32. *****

5. What was your password for using the Strategic Planning Software?

____

SECTION II:
For each of the following statements, circle the number that most accurately reflects your opinion.

	Strongly Agree				Strongly Disagree
6. The Strategic Planning Software was helpful in preparation of my case analysis.	5	4	3	2	1
7. The expert advice offered by the Strategic Planning Software was believable.	5	4	3	2	1
8. The expert advice offered by the Strategic Planning Software was difficult to understand.	5	4	3	2	1
9. The explanations (Why's) for the expert advice improved my understanding of the reasoning.	5	4	3	2	1
10. Some of the expert advice contradicted itself, thereby confusing me.	5	4	3	2	1

	STRONGLY AGREE				STRONGLY DISAGREE
11. Computer programs similar to the Strategic Planning Software should be used in other courses.	5	4	3	2	1
12. It took too much time to answer the questions posed by the computer program.	5	4	3	2	1
13. The menus in the computer program helped make it easy to use.	5	4	3	2	1
14. The printout from running the program helped me prepare my case analysis.	5	4	3	2	1
15. I would be interested in one day helping to develop programs that operate like the one we used in class.	5	4	3	2	1
16. When I made an error while using the computer program, I didn't understood what I had done wrong.	5	4	3	2	1
17. If I had another case to do for this course, I would want to use the computer program again.	5	4	3	2	1
20. Overall, I would say that using the Strategic Planning Software was a good experience.	5	4	3	2	1
21. It wasn't very easy to use the general design of the program.	5	4	3	2	1

SECTION III:
Indicate the time in hours and minutes you estimate you spent in each of the following activities:

ACTIVITY	HOURS	MINUTES
22. Reading the case.	_____	_______
23. Analyzing the financial data in the case.	_____	_______
24. Reviewing the text book(s).	_____	_______
25. Reviewing lecture notes.	_____	_______
26. Discussing the case with other students.	_____	_______
27. Reviewing printouts from my sessions with the Strategic Planning Software.	_____	_______

	HOURS	MINUTES
28. Reviewing printouts from other student's sessions with the Strategic Planning Software.	____	____
29. Looking at other articles, research, etc. that dealt with the company in the case.	____	____
30. Developing an outline for my case report.	____	____
31. Writing a rough draft of the case report.	____	____
32. Typing the case report.	____	____

SECTION IV:

Please offer your comments on the following: (If you did not use the software,answer question 34 only.)

33. I would suggest that the Strategic Planning Software could be improved by:

34. I would estimate that the grade I will receive for my case report is:

35. Would you have liked to pose specific questions to the computer program, and if so, what questions would you have liked to ask?

36. How could the dictionary have been made more helpful?

37. Did the computer program help you to identify the important strategic issues in the case, and if so, how did it help?

APPENDIX THREE: STRATEGY DETERMINANT ASSESSMENT CHECKLIST

Strategy Determinants for Personal Computer Manufacturers

	Business Market	Consumer Market	Education Market
Threat of New Entrants	Greatest here because: 1. market is most active personal computer segment now, and 2. large computer manufacturers already sell into much of this market and can exploit existing distribution channels to enter the market.	Not as great here because: 1. market has not developed as fully yet, and 2. it is more difficult to cultivate; specialized software is required and price limits are restrictive.	It is necessary to work with schools on bids and payment schedules; therefore, this market may not attract smaller or more specialized manufacturers. Tandy, Commodore, Apple and Atari appear to be strongest in this market and all have corporate involvement in facilitating sales to schools.
Jockeying Among Current Contestants	Centers on advertising campaigns, price, service, and capability comparisons (especially software support); some manufacturers seek specialized clientele (scientists, engineers, and at least one company has a portable unit designed for salesmen).	Centers on reliability, price, software, and "friendly" image computer.	Schools are expected to be large continuing buyers of software, so manufacturers are willing to sell hardware at low prices to ensure an installed base which will be continuing software consumers.
Threat of Substitute Services	Substitute services exist: Time sharing Data processing services Large computers	There is currently no viable substitute for the home market.	There is no good substitute for teaching computer literacy, but there are alternatives to using personal computers for other educational purposes. (remedial work or teaching math, etc.)
Strength of Buyers	Potential multiple purchases by large corporations give those buyers some leverage.	No collective forces are operative within the buyer population.	Since most school purchases are done on the local level, buyer groups are not strong; however, manufacturers perceive educational exposure as very important for security brand loyalty, which will be carried over into the consumer market.
Strength of Suppliers	Those manufacturers which have office product distribution channels already in place can offer more complete office product service (e.g., IBM, Xerox); those manufacturers which have large installed bases can offer better software support immediately, as well as established service channels.	Those manufacturers whose visibility is highest (through advertising or through educational and job site penetration) come to be identified by consumers as generic.	Computer Literacy Schools are more likely to choose a variety of machines so suppliers are not as strong. Teaching Aids Schools may choose the machine with the software that serves their needs best. Administrative Software is an important determinant.

Source: "Basic Analysis, Personal Computers," Paine, Webber, Mitchell, Hutchins, Inc., (October 28, 1981), p. 10.

APPENDIX FOUR: OPPORTUNITIES, PROBLEMS, AND CRISES CHECKLIST

INTRODUCTION TO APPENDIX FOUR

Appendix Four lists the expert opinion extracted from a literature review of articles related to the Apple Computer, Inc. case description. The experts´ opinions were either directly stated in the cited article, or were evidenced by statements in the cited article. Checklists for Crises, Problems, and Opportunities are listed separately. A complete list of references is included at the end of the appendix. Each checklist item includes a reference number to the source of the item.

The lists contained in the appendix were used to score subjects´ case analysis reports. Scoring results are discussed in Chapter VII.

KEY TO NOTATION

"Dn": Directly stated in source n
"En": As evidenced by source n

CRISES

1. D9

Apple has an image of "failure" from premature launching of the Apple III computer and the technical flaws ailing the early manufactured machines.

2. D11

There is litigation with High and Omega.

3. D4

The stock price is at only $15.00.

4. E2

Apple must control memory add-ons by retailers. The "cannibalized equipment" has caused a reduced quality perception when failures occur.

5. E2

Delivery problems exist, most likely due to time lags for accomplishing FCC required equipment updates.

6. E3

Apple cut off orders for Apple II's with 16k memory by making the 48k memory machine less expensive and delaying 16k machine delivery. Some dealers are removing memory chips from the 48k machine to meet 16k orders. This is the reverse of what Apple wanted and has enhanced the cannibalized equipment situation.

7. E10

Apple must learn how to keep corporate secrets secure.

8. E11

Foreign competition is selling Apple "look-alikes."

PROBLEMS

1. D10

Serious inventory fluctuations exist at Apple.

2. E3

Dealers (distributors) feel a bit shaky since all mail-order business has been outlawed by Apple. Dealers may start to exert more power over Apple as they gain strength from this move, and large competitors with strong distribution channels enter the market.

3. E2

Dealers are upset over lagging deliveries and when price changes go into effect, there is no price protection for non-delivered goods.

4. D4

IBM is a more significant threat than it has ever been because it has the economies of scale.

5. D4

Apple, running frantically to keep ahead of the competition and put new technologies into production, is forced to spend money at a faster rate.

6. D4

The growing need for capital has caused competition for investment dollars.

7. D4

Barriers to entry are low because capital can be exerted by large entering firms that won't incur the big initial development costs.

8. D5

...profits are coming from individuals in organizations...managers of corporate information see this as undisciplined purchasing...So, big customers want to deal directly with the manufacturers. For Apple, this mode of purchasing presents a serious difficulty: the dealers aren't set up to compete in this market.

9. D10

Apple will need strong managerial guidance to handle its breakneck growth.

10. E11

Apple is very dependent on single computer launchings, eg. "As Mac goes, so goes Apple."

11. E10

Apple is currently using only 60% of its production capacity.

OPPORTUNITIES

1. D4

Capital requirements are increasing entry barriers in the PC industry. Apple has the capital to meet this crunch, but there is a need to "tool up like the auto companies to run true assembly lines that automate production, testing, and material handling." Apple could use its unused capacity to produce peripherals like disk drives.

2. E5

Apple should enlist independent programming concerns to begin producing software for its new machines before the machine is marketed. This minimizes Apple's risk for large costs of program development and the associated perspective that would be attached to the company for software failures. For successful software, Apple will be credited by consumers, and likely sell more machines.

3. E5

There is currently very little foreign competition for PC sales. Apple should move quickly to the foreign market in order to realize the benefits.

4. D5

Apple's dealer network is growing stronger. Apple can maintain this strength, and enhance it, by communicating with dealers and force quality service departments by requiring company sponsored training.

5. E5

Apple has a reputation for bringing computer technology to "the masses." To continue this reputation, Apple should develop a machine that requires little time to learn to operate and smooth the interface between man and machine.

6. E6

Apple has a reputation for "general purpose, flexible machines." It behooves Apple to avoid massive market segmentation.

7. D7

A portable version of Apple's computer would enhance sales.

8. E11

Apple is selling well to educational institutions. By continuing this arrangement, Apple will create "kids that grew up with an Apple." If effective equipment has been used, a brand loyal market can be created.

9. E8

Apple has not backwards integrated into chip manufacturing. This is advantageous because of the velocity of change in this environment. Apple won't be caught locked into outdated technology. The challenge for the company is to stay atop the chips being produced and use its market clout to obtain good deals from suppliers.

10. E10

Apple must continue to heavily invest in Research and Development to produce a machine that takes less time to learn.

SOURCES

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APPENDIX FIVE:
QUESTIONNAIRE COMMENTS

The following subject responses were recorded for questionnaire question number 37. Responses for the group using the DSS with the "Partial Knowledge Base" are listed first, followed by comments from the group using the DSS with the "Complete Knowledge Base." A total of 38 of 41 students who used one of the two systems wrote comments.

Question 37 is: Did the computer program help you to identify the important strategic issues in the case, and if so, how?

GROUP USING DSS WITH A PARTIAL KNOWLEDGE BASE

1. Yes, it outlined the main areas and filled in questions under each topic.

2. Yes, a few of the issues.

3. Yes. It helped by pointing out the main issues that I should look at enabling me to further research the areas given in the text.

4. No

5. Yes, it did help because it kept pointing back to specific strategies to look at.

6. It helped me in reinforcement of my ideas.

7. Yes, it directed me to the right issues in my books thereby reducing the reading I had to go through.

8. Yes, focused my attention toward related issues to the case.

9. It directed you straight to them.

10. It helped somewhat when dealing with competition issues.

11. Yes, it helped me to see if I was on the right track.

12. It helped in a general sense, then I had to refer to the book.

13. No

14. Yes, mainly by giving me a definite page to refer to which helped me save alot of time.

15. Yes, identified areas of importance in the case, gave me key words and terms to explore.

16. By knowing which folders I should look at.

17. I feel that it was helpful in determining the strategic issues in the case as it moved me toward the most likely areas of

strategic planning.

GROUP USING DSS WITH A COMPLETE KNOWLEDGE BASE

1. Not really, I knew the general direction to follow, but it did give me some insights.

2. Yes, when going back and reviewing the case, I could see information that applied to the program directly.

3. I don´t think it really applied very well, although it would be more helpful for someone wanting to analyze their own business.

4. Yes, gave me information that pointed in a general area, which, when backed up by other information, gave me a solid clue as to what the problems were.

5. Yes, through the last part of the printout. It was fantastic.

6. Yes, helped me to narrow down my view of the case. Made me define it more exactly.

7. Showed me where to look, pointed me in the right direction.

8. Yes, gave me the major areas to look in.

9. It provided me with areas to consider that I could have easily forgotten about. Also, it provided many options and considerations, maybe too many, didn´t narrow down enough.

10. It helped me to have all the knowledge in the book put together in a format that applied to the class.

11. Yes, because they were specifically stated.

12. Yes, it keyed me in to certain areas and helped me disregard others. It allowed me to then research only those pertinent areas and thus save time.

13. Yes, because it helped me identify areas that I had not thought of. Also, it gave reference as to where areas were located in "Porter."

14. Yes, just the fact that there was a menu served to help me look at possible factors pertinent to the case. Questions were good, but at times their cumulative focus was less than complete.

15. Just mentioning key words such as "emerging industries" and "entry barriers" prompted me to look further into it.

16. Not really.

17. The main thing it did was narrow it down. I did the rest. I think I was looking for something that would give me the answers.

18. I don´t know anything about the industry, for people who do, it would be great.

19. The program takes you by the hand and leads you through.

20. Sure, it helped, but was difficult because of my relative unfamiliarity with the exact meaning of many of the terms.

21. I don´t think it helped that much. The main reason being that I didn´t answer some of the questions correctly. So, in this area, it was my own fault if it didn´t help me.

APPENDIX SIX:
SELECTED FREQUENCY DISTRIBUTIONS

KEY TO FREQUENCY DISTRIBUTION OF QUESTIONNAIRE RESPONSES
(Table entries are "number of subjects")

C: Group using DSS with complete knowledge base
P: Group using DSS with partial knowledge base
N: Group with no DSS exposure

(Note: Several questionnaires were not returned, and some answers were not entered on those returned.)

I. Group Characteristics

	C	P	N
1. Class Standing			
Senior	21	17	6
Graduate	1	1	1
2. Self-reported GPA			
2.00 - 2.49	1	0	0
2.50 - 2.99	12	11	3
3.00 - 3.49	7	7	2
3.50 - 4.00	2	0	2
3. School			
Business	19	16	7
Engineering	1	1	0
Education	0	1	0
4. Sex			
Female	10	8	5
Male	12	10	2

II. SYSTEM USE

	C	P	N
1. Time on system (minutes)			
0 - 21	0	0	-
22 - 42	1	5	-
43 - 63	2	5	-
64 - 84	9	4	-
85 - 105	5	4	-
106 - 127	2	0	-
128 - 148	2	0	-
149 - 169	1	0	-
170 - 190	0	0	-
191 - 212	0	1	-
2. Number of Sessions			
1	15	12	-
2	7	7	-

III. Section II of Post-Case Questionnaire

QUESTION #	Strongly Agree 5	4	3	2	Strongly Disagree 1
6. HELPFULNESS					
C	4	11	7	0	0
P	1	7	6	3	1
7. BELIEVABLE					
C	9	13	0	0	0
P	7	10	1	0	0
8. HARD TO UNDERSTAND					
C	1	2	6	11	2
P	0	3	4	9	2
9. EXPLANATIONS IMPROVED UNDERSTANDING					
C	8	10	4	0	0
P	1	13	2	2	0
10. CONTRADICTING ADVICE CAUSED CONFUSION					
C	1	5	7	8	0
P	0	1	6	9	2
11. USE SIMILAR PROGRAMS IN OTHER COURSES					
C	9	10	3	0	0
P	4	5	7	1	1
12. TOOK TOO MUCH TIME TO USE PROGRAM					
C	2	6	5	6	3
P	0	0	2	10	6
13. MENUS MADE PROGRAM EASY TO USE					
C	14	7	1	0	0
P	9	8	1	0	0
14. PRINTOUT HELPED IN DOING ANALYSIS					
C	6	9	6	1	0
P	3	7	4	3	1
15. I WOULD HELP TO DEVELOP A PROGRAM LIKE THIS					
C	7	6	6	1	2
P	3	4	8	1	2
16. HARD TO UNDERSTAND WHEN ERROR WAS MADE					
C	1	1	2	13	5
P	1	4	4	5	4
17. WANT TO USE PROGRAM AGAIN					
C	8	8	5	0	0
P	3	9	3	1	2
20. OVERALL GOOD EXPERIENCE					
C	11	9	2	0	0
P	5	12	1	0	0
21. WASN'T EASY TO USE PROGRAM					
C	0	0	1	14	7
P	0	0	1	10	7