A Framework for Management Information Systems

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Sloan Management Review
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Spring 1989

IN THIS THIRD OF OUR CLASSIC REPRINTS marking SMR's thirtieth anniversary, we revisit an article that has been cited as often as any we ever published. Written in 1971, this piece suggested that management information systems could best be looked at from a decision-making perspective: what categories of decisions are made within an organization? And, given various categories of decision, what type of information (and information system) can best support each kind of decision? In their retrospective comments, the authors note the distance we have traveled since 1971 both in our understanding of how organizational decision making occurs and in our capacity for technological support. Because of that progress, an increasing number of sophisticated, unstructured decisions can be supported technologically. *Ed.*

A FRAMEWORK for viewing management information systems (MIS) is essential if an organization is to plan effectively and make sensible allocations of resources to information systems tasks. The use of computers in organizations has grown tremendously in the 1955 to 1971 period, but very few of the resulting systems have had a significant impact on the way in which management makes decisions. A framework that allows an organization to gain perspective on the field of information systems can be a powerful means of providing focus and improving the effectiveness of the systems efforts.

In many groups doing MIS work, this lack of perspective prevents a full appreciation of the variety of organizational uses for computers. Without a framework to guide management and systems planners, the system tends to serve the strongest manager or react to the greatest crisis. As a result, systems activities too often move from crisis to crisis, following no clear path and receiving only *ex post facto* justification. This tendency inflicts an unnecessary expense on the organization. Not only are costly computer resources wasted, but even more costly human resources are mismanaged. The cost of systems and programming personnel is generally twice that of the hardware involved in a typical project, and the ratio is growing larger as the cost of hardware drops and salaries rise.[1] Competent people are expensive. More important, they exist only in limited numbers. This limitation actively constrains the amount of systems development work that can be undertaken in a given organization, and so good resource allocation is critical.

Developments in two distinct areas within the last five years offer us the potential to develop altogether new ways of supporting decision processes. First, there has been considerable technological progress. The evolution of remote access to computers with short turnaround time and flexible user interfaces has been rapid.

Powerful minicomputers are available at low cost, and users can be linked to computer resources through inexpensive typewriter and graphical display devices. The second development has been a conceptual one. There is emerging an understanding of the potential role of information systems within organizations. We are adding to our knowledge of how human beings solve problems and of how to build models that capture aspects of the human decision-making processes.[2]

The progress in these areas has been dramatic. Entirely new kinds of planning and control systems can now be built—ones that dynamically involve the manager's judgments and provide sup-

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port with analysis, models, and flexible access to relevant information. But to realize this potential fully, given an organization's limited resources, there must be an appropriate framework within which to view management decision making and the required systems support. The purpose of this article is to present a framework that helps us to understand the evolution of MIS activities within organizations and to recognize some of the potential problems and benefits resulting from our new technology. Thus, this framework is designed to be useful in planning for information systems activities within an organization and for distinguishing between the various model-building activities, models, computer systems, and so forth that are used for supporting different kinds of decisions. It is, by definition, a static picture, and it is not designed to say anything about how information systems are built.

In the next section we shall consider some of the general advantages of developing a framework for information systems work. We shall then propose a specific framework that we have found to be useful in the analysis of MIS activities. We believe that this framework offers us a new way to characterize the progress made to date and offers us insight into the problems that have been encountered. Finally, we shall use this framework to analyze the types of resources required in the different decision areas and the ways in which these resources should be used.

Framework Development

The framework we develop here is one for managerial activities, not for information systems. It is a way of looking at decisions made in an organization. Information systems should exist only to support decisions, and hence we are looking for a characterization of organizational activity in terms of the type of decisions involved. For reasons made clear later, we believe an understanding of managerial activity is a prerequisite for effective systems design and implementation. Most MIS groups become involved in system development and implementation without a prior analysis of the variety of managerial activities. This situation has, in our opinion, prevented them from developing a sufficiently broad definition of their purpose and has resulted in an inefficient allocation of resources.

In attempting to understand the evolution and problems of management information systems, we have found the work of Robert Anthony and Herbert Simon particularly useful. In *Planning and Control Systems: A Framework for Analysis*, Anthony addresses the problem of developing a classification scheme that will allow management some perspective when dealing with planning and control systems.[3] He develops a taxonomy for managerial activity consisting of three categories and argues that these categories represent activities sufficiently different in kind to require the development of different systems.

The first of Anthony's categories of managerial activity is *strategic planning*: "Strategic planning is the process of deciding on objectives of the organization, on changes in these objectives, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use, and disposition of these resources."[4] Certain things can be said about strategic planning generally. First, it focuses on the choice of objectives for the organization and on the activities and means required to achieve these objectives. As a result, a major problem in this area is predicting the future of the organization and its environment. Second, the strategic planning process typically involves a small number of high-level people who operate in a nonrepetitive and often very creative way. The complexity of the problems that arise and the nonroutine manner in which they are handled make it quite difficult to appraise the quality of this planning process.

The second category defined by Anthony is *management control*: "The process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization's objectives."[5] He stresses three key aspects of this area. First, the activity involves interpersonal interaction. Second, it takes place within the context of the policies and objectives developed in the strategic planning process. Third, the paramount goal of management control is the assurance of effective and efficient performance.

Anthony's third category is *operational control*, by which he means "the process of assuring that specific tasks are carried out effectively and efficiently."[6] The basic distinction between management control and operational control is that operational control is concerned with tasks (such as manufacturing a specific part) whereas management control is most often concerned with people. There is much less judgment to be exercised in the operational control area because the tasks, goals, and resources have been carefully delineated through the management control activity.

We recognize, as does Anthony, that the boundaries between these three categories are often not clear. In spite of their limitations and uncertainties, however, we have found the categories useful in the analysis of information system activities. For example, if we consider the information requirements of these three activities, we can see that they are very different from one another. Further, this difference is not simply a matter of aggregation, but one of fundamental character of the information needed by managers in these areas.

Strategic planning is concerned with setting broad policies and goals for the organization. As a result, the relationship of the organization to its environment is a central matter of concern. Also, the nature of the activity is such that predictions about the future are particularly important. In general, then, we can say that the information needed by strategic planners is aggregate information, and obtained mainly from sources external to the organization itself. Both the scope and variety of the information are quite large, but the requirements for accuracy are not particularly stringent. Finally, the nonroutine nature of the strategic planning process means that the demands for this information occur infrequently.

The information needs for the operational control area stand in sharp contrast to those of strategic planning. The task orientation of operational control requires information of a well-defined and narrow scope. This information is quite detailed and arises largely from sources within the organization. Very frequent use is made of this information, and it must therefore be accurate.

The information requirements for management control fall between the extremes for operational control and strategic planning. In addition, it is important to recognize that much of the information relevant to management control is obtained through the process of human interaction.

In Table 1 we have summarized these general observations about the categories of management activity. This summary is subject to the same limitations and uncertainties exhibited by the concepts of management control, strategic planning, and operational control. Nonetheless, it does underscore our contention that because the activities themselves are different, the information requirements to support them are also different.

This summary of information requirements suggests the reason that many organizations have found it increasingly difficult to realize some of their long-range plans for information systems. Many of these plans are based on the "total systems approach." Some of the proponents of this approach advocate that systems throughout the organization be tightly linked, with the output of one becoming the direct input of another, and that the whole structure be built on the detailed data used for controlling operations.[7] In doing so, they are suggesting an approach to systems design that is at best uneconomic and at worst based on a serious misconception. The first major problem with this view is that it does not recognize the ongoing nature of systems development in the operational control area. There is little reason to believe that the systems work in any major organization will be complete within the foreseeable future. To say that management information systems activity must wait "until we get our operational control systems in hand" is to say that efforts to assist management with systems support will be deferred indefinitely.

The second and perhaps most serious problem with this total systems view is that it fails to represent properly the information needs of the manage-

Table 1 Information Requirements by Decision Category

Characteristics of Information	Operational Control	Management Control	Strategic Planning
Source	Largely internal	⟶	External
Scope	Well defined, narrow	⟶	Very wide
Level of Aggregation	Detailed	⟶	Aggregate
Time Horizon	Historical	⟶	Future
Currency	Highly current	⟶	Quite old
Required Accuracy	High	⟶	Low
Frequency of Use	Very frequent	⟶	Infrequent

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ment control and strategic planning activities. Neither of these areas *necessarily* needs information that is a mere aggregation of data from the operational control database. In many cases, if such a link is needed, it is more cost effective to use sampling from this database and other statistical techniques to develop the required information. In our opinion, it rarely makes sense to couple managers in the management control and strategic planning areas directly with the masses of detailed data required for operational control. Not only is direct coupling unnecessary, but it can also be an expensive and difficult technical problem.

For these reasons it is easy to understand why so many companies have had the following experience. Original plans for operational control systems were met with more or less difficulty, but as time passed it became increasingly apparent that the planned systems for higher management were not being developed on schedule, if at all. To make matters worse, the systems developed for senior management had relatively little impact on the way in which the managers made decisions. This last problem is a direct result of the failure to understand the basic information needs of the different activities.

We have tried to show how Anthony's classification of *managerial* activities is a useful one for people working in information systems design and implementation; we shall return later to consider in more detail some of the implications of his ideas.

In *The New Science of Management Decision*, Simon is concerned with the manner in which human beings solve problems regardless of their position within an organization. His distinction between "programmed" and "nonprogrammed" decisions is a useful one:

> Decisions are programmed to the extent that they are repetitive and routine, to the extent that a definite procedure has been worked out for handling them so that they don't have to be treated *de novo* each time they occur. . . . Decisions are nonprogrammed to the extent that they are novel, unstructured, and consequential. There is no cut-and-dried method of handling the problem because it hasn't arisen before, or because its precise nature and structure are elusive or complex, or because it is so important that it deserves a custom-tailored treatment. . . . By nonprogrammed I mean a response where the system has no specific procedure to deal with situations like the one at hand, but must fall back on whatever *general* capacity it has for intelligent, adaptive, problem-oriented action.[8]

We shall use the terms "structured" and "unstructured" for programmed and nonprogrammed because they imply less dependence on the computer and more dependence on the basic character of the problem-solving activity in question. The procedures, the kinds of computation, and the types of information vary depending on the extent to which the problem in question is unstructured. The basis for these differences is that in the unstructured case the human decision maker must provide judgment and evaluation as well as insights into problem definition. In a very structured situation, much if not all of the decision-making process can be automated. Later in this article we shall argue that systems built to support structured decision making will be significantly different from those designed to assist managers in dealing with unstructured problems. Further, we shall show that these differences can be traced to the character of the models relevant to each of these problems and the way in which these models are developed.

This focus on decisions requires an understanding of the human decision-making process. Research on human problem solving supports Simon's claim that all problem solving can be broken down into three categories:

> The first phase of the decision-making process—searching the environment for conditions calling for decision—I shall call *intelligence* activity (borrowing the military meaning of intelligence). The second phase—inventing, developing, and analyzing possible courses of action—I shall call *design* activity. The third phase—selecting a course of action from those available—I shall call *choice* activity. . . . Generally speaking, intelligence activity precedes design, and design activity precedes choice. The cycle of phases is, however, far more complex than the sequence suggests. Each phase in making a particular decision is itself a complex decision-making process. The design phase, for example, may call for new intelligence activities; problems at any given level generate subproblems that in turn have their intelligence, design and choice phases, and so on. There are wheels within wheels. . . . Nevertheless, the three large phases are often clearly discernible as the organizational decision process unfolds. They are closely related to the stages in problem solving first described by John Dewey: "What is the prob-

lem? What are the alternatives? Which alternative is best?"[9]

A fully structured problem is one in which all three phases—intelligence, design, and choice—are structured. That is, we can specify algorithms, or decision rules, that will allow us to find the problem, design alternative solutions, and select the best solution. An example here might be the use of the classical economic order quantity (EOQ) formula on a straightforward inventory control problem. An unstructured problem is one in which none of the three phases is structured. Many job-shop scheduling problems are of this type.

In the ideas of Simon and Anthony, then, we have two different ways of looking at managerial activity within organizations. Anthony's categorization is based on the purpose of the management activity, whereas Simon's classification is based on the way in which the manager deals with the existing problems. The combination of these two views provides a useful framework within which to examine the purposes and problems of information systems activity. The essence of this combination is shown in Figure 1. The figure contains a class of decisions we have called "semi-structured"—decisions with one or two of the intelligence, design, and choice phases unstructured.

Decisions above the dividing line in Figure 1 are largely structured, and we shall call the information systems that support them "Structured Decision Systems" (SDS). Decisions below the line are largely unstructured, and their supporting information systems are "Decision Support Systems" (DSS). The SDS area encompasses almost all of what *has* been called Management Information Systems in the literature—an area that has had almost nothing to do with real managers or information but has been largely routine data processing. We exclude from consideration here all of the *information handling* activities in an organization. Much computer time in many organizations is spent on straightforward data handling with no decisions, however structured, involved. Payroll, for example, is a data-handling operation.

In Figure 1, we have listed some examples in each of the six cells. It should be stressed, however, that these cells are not well-defined categories. Although this may sometimes cause problems, the majority of important decisions can be classified into their appropriate cell without difficulty.

Figure 1 **Information Systems: A Framework**

	Operational Control	Management Control	Strategic Planning
Structured	Accounts Receivable	Budget Analysis—Engineered Costs	Tanker Fleet Mix
	Order Entry	Short-Term Forecasting	Warehouse and Factory Location
	Inventory Control		
Semi-Structured	Production Scheduling	Variance Analysis—Overall Budget	Mergers and Acquisitions
	Cash Management	Budget Preparation	New Product Planning
Unstructured	PERT/COST Systems	Sales and Production	R&D Planning

Decision Making within the Framework

• **Planning and Resource Allocation Decisions.** An immediate observation can be made about the framework. Almost all the so-called MIS activity has been directed at decisions in the structured half of the matrix, specifically in the "operation control" cell. On the other hand, most of the areas of greatest concern to managers, areas where decisions have a significant effect on the company, are in the lower half of the matrix. That is, managers deal for the most part with unstructured decisions. This implies, of course, that computers and related systems that have so far been largely applied to the structured operational control area have not yet had any real impact on management decision making. The areas of high potential do not lie in bigger and better systems of the kind most companies now use. To have all the effort concentrated in only one of the six cells suggests at the very least a severe imbalance.

A second point to be noted on the planning question is the evolutionary nature of the line separating structured from unstructured decisions. This line is moving down over time.' As we improve our understanding of a particular decision, we can move it above the line and allow the system to take care of it, freeing the manager for other tasks. For example, in previous years the inventory reordering decision in most organizations was made by a well-paid member of middle management. It was a decision that involved a high degree of skill and could have a significant effect on the profits of the organization. Today this decision has moved from the unstructured operational control area to the structured. We have a set of decision rules (the EOQ formula) that on average do a better job for the standard items than most human decision makers. This movement of the line does not imply any replacement of managers, since we are dealing with an almost infinite set of problems. For every one we solve, there are ten more demanding our attention.

It is worth noting that the approach taken in building systems in the unstructured area hastens this movement of the line because it focuses our analytical attention on decisions and decision rules. We would therefore expect a continuing flow of decisions across the line, or at least into the "grey" semi-structured decision area.

Through the development of a model of a given problem-solving process for a decision in one of the cells, we can establish the character of each of the three phases. To the extent that any of these phases can be structured, we can design direct systems support. For those aspects of the process that are unstructured (given our current understanding of the situation), we would call on the manager to provide the necessary analysis. Thus a problem might be broken down into a set of related subproblems, some of which are "solved" automatically by the system and the remainder by the user alone or with varying degrees of computational and display support. Regardless of the resulting division of labor, however, it is essential that a model of the decision process be constructed *prior* to the system design. It is only in this way that a good perspective on the potential application of systems support can be ascertained.

• **Structured/Unstructured Decisions.** Information systems ought to be centered on the important decisions of the organization, many of which are relatively unstructured. It is therefore essential that models be built of the decision process involved. Model development is fundamental because it is a prerequisite for the analysis of the value of information, and because it is the key to understanding which portions of the decision process can be supported or automated. Both the successes and failures in the current use of computers can be understood largely in terms of the difficulty of this model development.

Our discussion of Structured Decision Systems showed that the vast majority of the effort (and success) has been in the area of structured operational control, where there is relatively little ambiguity as to the goals sought. For example, the typical inventory control problem can be precisely stated, and it is clear what the criterion is by which solutions are to be judged. Hence we have an easily understood optimization problem. This type of problem lends itself to the development of formal "scientific" models, such as those typical of operations research.

Another important characteristic of problems of this type is that they are to a large extent "organization independent." By this we mean that the essential aspects of the problem tend to be the same in many organizations, although the details may differ. This generality has two important effects. First, it encourages widespread interest and effort in the development of solutions to the problem. Second, it makes the adaptation of general models to the situation in a particular organizational setting relatively easy.

The situation with regard to areas of management decision making is quite different. To the extent that a given problem is semi-structured or unstructured, there is an absence of a routine procedure for dealing with it. There is also a tendency toward ambiguity in the problem definition because of the lack of formalization of any or all of the intelligence, design, or choice phases. Confusion may exist as to the appropriate criterion for evaluating solutions, or as to the means for generating trial solutions to the problem. In many cases, this uncertainty contributes to the perception of problems of this type as being unique to a given organization.

In general, then, we can say that the information systems problem in the structured operational control area is basically that of implementing a given general model in a certain organizational context. On the other hand, work in the unstructured areas is much more involved with model development and formalization. Furthermore, the source of the models in the former case is apt to be the operations research or management science literature.

In the latter case, the relevant models are most often the unverbalized models used by the managers of the organization. This suggests that the procedure for the development of systems, the types of systems, and the skills of the analysts involved may be quite different in the two areas.

Although the evolution of information systems activities in most organizations has led to the accumulation of a variety of technical skills, the impact of computers on the way in which top managers make decisions has been minimal. One major reason for this is that the support of these decision makers is not principally a technical problem. If it were, it would have been solved. Certainly there are technical problems associated with work in these problem areas, but the technology and the technological skills in most large organizations are more than sufficient. The missing ingredient, apart from the basic awareness of the problem, is the skill to elicit from management its view of the organization and its environment, and to formalize models of this view.

To improve the quality of decisions, a systems designer can seek to improve the quality of the information inputs or to change the decision process, or both. Because of the existence of a variety of optimization models for operational control problems, there is a tendency to emphasize improvement of the information inputs at the expense of improvement in the decision-making process. Although this emphasis is appropriate for structured operational control problems, it can retard progress in developing support for unstructured problem solving. The difficulty with this view is that it tends to attribute low quality in management decision making to low-quality information inputs. Hence, systems are designed to supply more current, more accurate, or more detailed information.

While improving the quality of information available to managers may improve the quality of their decisions, we do not believe that major advances will be realized in this way.[10] Most managers do not have great informational needs. Rather, they have need of new methods to understand and process the information already available to them. Generally speaking, the models that they employ in dealing with this information are very primitive, and as a result, the range of responses that they can generate is very limited. For example, many managers employ simple historical models in their attempts to anticipate the future.[11] Further, these models are static in nature, although the processes they purport to represent are highly dynamic. In such a situation, there is much more to be gained by improving the information-processing ability of managers in order that they may deal effectively with the information that they already have, than by adding to the reams of data confronting them, or by improving the quality of that data.[12]

If this view is correct, it suggests that the decision support systems area is important and that these systems may best be built by people other than those currently involved in the operational control systems area. The requisite skills are those of the model building based on close interaction with management, structuring and formalizing the procedures employed by managers, and segregating those aspects of the decision process that can be automated. In addition, systems in this area must be able to assist the evolution of the manager's decision-making ability through increasing understanding of the environment. Hence, one important role of a DSS is educative. Even in areas in which we cannot structure the decision process, we can provide models of the environment from which managers can develop insights into the relationship of their decisions to the goals they wish to achieve.

In discussing models and their importance to systems in the DSS area, we should place special emphasis on the role managers assume in the process of model building. To a large extent they are the source upon which the analyst draws. That is, although a repertoire of "operations research" models may be very valuable for analysts, their task is not simply to impose a model on the situation. These models may be the building blocks. The analyst and the manager in concert develop the final structure. This implies that the analyst must possess a certain empathy for the manager, and vice versa. Whether the current systems designers in a given organization possess this quality is a question worthy of consideration by management.

This approach in no way precludes normative statements about decision procedures. The emphasis on the development of descriptive models of managerial problem solving is only to ensure that the existing situation is well understood by both the analyst and the manager. Once this understanding has been attained, various approaches to improving the process can be explored. In fact, a major benefit of developing descriptive models of this type is the exposure of the decision-making process to objective analysis.

In summary, then, we have asserted that two sets of implications flow from our use of this framework. The first set centers on an organization's planning and resource allocation decision in relation to information systems. The second set flows from the distinction we have drawn between structured and unstructured types of decisions. The focus of our attention should be on the critical *decisions* in an organization and on explicit modeling of these decisions prior to the design of information systems support.

The second major point in relation to the structured/unstructured dimension that we have raised is that the kinds of implementation problems, the skills required by the managers and analysts, and the characteristics of the design process are different above and below the dashed line in Figure 1. In discussing these differences, we have tried to stress the fundamental shift in approach that is required if decision support systems are to be built in a way that makes them effective in an organization. The approach and technology that have been used over the last fifteen years to build information systems in the structured operational control area are often inappropriate in the case of decision support systems.

Implications of the Framework

• **System Design Differences.** The decision categories we have borrowed from Anthony have a set of implications distinct from those discussed in connection with the structured and unstructured areas. The first of these has to do with the systems design differences that follow from supporting decisions in the three areas.

As was seen earlier, information requirements differ sharply among the three areas. There are few occasions in which it makes sense to connect systems directly across boundaries. Aggregating the detailed accounting records (used in operational control) to provide a base for a five-year sales forecast (required for a strategic planning decision) is an expensive and unnecessary process. We can often sample, estimate, or otherwise obtain data for use in strategic planning without resorting to the operational control database. This statement does not imply that we should *never* use such a database, merely that it is not necessarily the best way of obtaining the information.

This point is also relevant in the collection and maintenance of data. Techniques appropriate for operational control, such as the use of on-line data collection terminals, are rarely justified for strategic planning systems. Similarly, elaborate environmental sampling methods may be critical for an operational control decision. In looking at each of the information characteristics in Table 1, it is apparent that quite different databases will be required to support decisions in the three areas. Therefore, the first implication of the decision classification in our framework is that the "totally-integrated-management-information-systems" ideas so popular in the literature are a poor design concept. More particularly, the "integrated" or "companywide" database is a misleading notion, and even if it could be achieved it would be exorbitantly expensive.

Information differences among the three decision areas also imply related differences in hardware and software requirements. On the one hand, strategic planning decisions require access to a database that is used infrequently and may involve an interface with a variety of complex models. Operational control decisions, on the other hand, often require a larger database with continuous updating and frequent access to current information.

• **Differences in Organizational Structure.** A second distinction is in the organizational structure and the managerial and analytical skills that will be involved across the three areas. The managerial talents required, as well as the numbers and training of the managers involved, differ sharply for these categories. The process of deciding on key problems that might be worth supporting with a formal system is a much smaller, tighter process in the strategic-planning area than in the operational control area. The decision to be supported is probably not a recurring one and will normally not involve changes in the procedures and structure employed by the remainder of the firm. Because it is a relatively isolated decision in both time and scope, it need not involve as many people. However, the process of defining the problem must be dominated by the managers involved if the right problem and hence the best model formulation are to be selected. Similarly, the implementation process must be tightly focused on the immediate problem. The skills required of the managers involved are analytical and reflective, rather than communicative and procedural. In the strategic-planning case, the manager must supply both the problem definition and the key relationships that make up the model. Doing this requires an ability to think logically and a familiarity with models and computation. In the case of operational control, the particular solution and the models involved are much more the concern of the technical specialist. This is not to say that in unstructured operational control the manager's judgment will not be involved in the process of solving problems. However, the manager's role in *building* that model can be much more passive than in the strategic area.

The decision process, the implementation process, and the level of analytical sophistication of the managers (as opposed to the staff) in strategic planning all differ quite markedly from their counterparts in operational control. The decision makers in operational control have a more constrained problem. They have often had several years in which to define the general nature of the problem and to consider solutions. In addition, to the extent that these managers have a technical background, they are more likely to be familiar with the analysis involved in solving structured and unstructured problems. In any event, the nature of the operational control problem, its size, and the frequency of the decision all combine to produce design and implementation problems of a different variety. The managers involved in any given problem tend to be from the decision area in question, be it strategic planning, management control, or operational control. As a result, their training, background, and style of decision making are often different. This means that the types of models to be used, the method of elucidating these from the managers, and the skills of the analysts will differ across these three areas.

As the types of skills possessed by the managers differ, so will the kinds of systems analysts who can operate effectively. We have already distinguished between analysts who can handle structured as opposed to unstructured model building. There is a similar distinction to be made between the kind of person who can work well with a small group of senior managers (on either a structured or unstructured problem) and the person who is able to communicate with the various production personnel on an unstructured job-shop scheduling problem, for example.

In problems in the strategic area, the analyst has to be able to communicate effectively with the few managers who have the basic knowledge required to define the problem and its major variables. The skills required to do this include background and experience which are wide enough to match those of the line executives involved. Good communication depends on a common understanding of the basic variables involved, and few analysts involved in current MIS activity have this understanding.

A breadth of background implies a wide repertoire of models with which the analyst is familiar. In the operational control area, an analyst can usefully specialize to great depth in a particular, narrow problem area. The depth, and the resulting improvement in the final system, often pays off because of the frequency with which the decision is made. In the strategic area the coverage of potential problems is enormous and the frequency of a particular decision relatively low. The range of models with which the analyst is familiar may be of greater benefit than depth in any one type.

In addition to the managerial and analyst issues raised above, there is a further difference in the way the information systems group is organized. A group dealing only with operational control problems would be structured differently and perhaps report to a different organizational position than a group working in all three areas. It is not our purpose here to go into detail on the organizational issues, but the material above suggests that on strategic problems, a task force reporting to the user and virtually independent of the computer group may make sense. The important issues are problem definition and problem structure; the implementation and computer issues are relatively simple by comparison. In management control, the single user, although still dominant in that one application, has problems of interfacing with other users. An organizational design that encourages cross-functional (marketing, production, distribution, etc.) cooperation is probably desirable. In operational control, the organizational design should include the users as a major influence, but they will have to be balanced with operational systems experts, and the whole group can quite possibly stay within functional boundaries. These examples are merely illustrative of the kind of organizational differences involved. Each organization has to examine its current status and needs and make structural changes in light of them.

• **Model Differences.** The third distinction flowing from the framework is among the types of models involved. Again looking at Table 1 and the information differences, it is clear that model requirements depend, for example, on the frequency of decisions in each area and their relative magnitude. A strategic decision to change the whole distribution system occurs rarely. It is significant in cost, perhaps hundreds of millions of dollars, and it therefore can support a complex model, but the model need not be efficient in any sense. An operational control decision, however, may be made frequently, perhaps daily. The impact of each decision is small but the cumulative impact can involve large sums of money. Models for the decision may have to be efficient in running time, have ready access to current data, and be structured so as to be easily changed. Emphasis has to be on simplicity of building, careful attention to modularity, and so forth.

The sources of models for operational control are numerous. There is a history of activity, the problems are often similar across organizations, and the literature is extensive. In strategic planning, and to a lesser extent management control, we are still in the early stages of development. Our models tend to be individual and have to come from the managers involved. It is a model creation process as opposed to the application of a model.

In summary, then, we have outlined implications for the organization that follow from the three major decision categories in the framework. We have posed the issues in terms of operational control and strategic planning, and with every point we assume that management control lies somewhere between the two. The three major implications we have discussed are the advisability of following the integrated database path; the differences in managerial and analyst skills, as well as the appropriate forms of organizational structure for building systems in the three areas; and differences in the types of models involved. Distinguishing among decision areas is clearly important if an organization is going to be successful in its use of information systems.

Summary

The information systems field absorbs a significant percentage of the resources of many organizations. Despite these expenditures, there is very little perspective on the field and the issues within it. As a result, there has been a tendency to make incremental improvements to existing systems. The framework we suggest for looking at decisions within an organization provides one perspective on the information systems issues. From this perspective, it becomes clear that our planning for information systems has resulted in a heavy concentration in the operational control area. In addition, there is a series of implications for the organization that flows from the distinction between the decision areas. Model structure and the implementation process differ sharply between the structured and unstructured areas. Database concepts, types of analysts and managers, and organizational structure all differ along the Strategic Planning to Operational Control axis.

We believe that each organization must share *some* common framework among its members if it is to plan and make resource allocation decisions that result in effective use of information systems. We suggest that the framework presented here is an appropriate place to start. ■

Retrospective Commentary

IN LOOKING BACK over the eighteen years since the publication of this article, we find much that has changed. Information technology is used more and more in dealing with semi-structured managerial problems, and our call for decision support systems has been productively answered in many corporate settings. The remarkable development of information technology has enabled this change. The mainframe computer of the early 1970s, surrounded by ranks of systems analysts using rigid methods, was an uncongenial host for the growth of decision support systems. Now the computational power of that old mainframe is embodied in the ubiquitous personal computer. The mainframe itself has assumed power that exceeds all but the most wildly optimistic forecasts of that day, and a range of general-purpose and specialized computers span the computational range between the mainframe and the personal computer. Highly developed networks of computers within and across organizations are further evidence of the technical progress made in these years. And while programming is still a demanding task, new information management and analysis tools facilitate the creation of decision support systems. Business leaders, faced with an increasingly turbulent environment, see with greater clarity the role information technology can play in enhancing organizational effectiveness. So today it is a rare organization that is not permeated by computers and in which most vital challenges of organizational life are not mediated by some form of computation.

While the broad thrust of our analysis remains valid today, with the advantage of hindsight we would make some modifications. We still adhere to our basic premise—that a decision-centered view of an organization provides the best basis for information technology development. We argued against a narrow perspective on the range of decisions made in organizations, noting that the data and processing as well as the styles of the decision makers differed across the three major decision categories. This argument remains sound. Today, however, we would change some of the terminology. We would use the phrase *tactical planning* in place of *management control*, and we would emphasize that planning and control are two sides of the same coin. Thus there is a need for planning and control systems at the strategic, tactical, and operational levels.[13]

We should have written in a more contingent, less declarative manner. Part of our new-found caution comes from twenty years of research, teaching, consulting, and practice. Another part comes from the seemingly greater complexity of the world in which organizations find themselves. Had we seen matters more clearly in the early 1970s, we would have acknowledged that the "rational actor" model of decision making does not properly reflect the vagaries of the management setting. To improve on practice there, we need to accommodate the complexities of multiple goals, different organizational cultures, and varying personal styles described by Schein, Mason and Mitroff, Mintzberg, Weick, and others.[14] Further, task complexity often demands that highly integrated groups carry projects forward. These teams must often solve difficult problems of task coordination and information integration; deficiencies in information management support diminish the progress they could otherwise achieve. Advanced information technology, with its enormous capabilities for transmitting and storing information, would seem to hold considerable promise for these groups. But our discussion was generally concerned with facilitating the work of individuals, and we ignored the collective nature of many undertakings, where the coordination of specialized efforts is of utmost importance.[15]

Again, with the advantage of hindsight, we would have put more stress on implementation and evaluation. Innovations such as "decision support systems" are much more likely to succeed if these issues are squarely addressed. The best implementation strategy can be very different in the different cells of our original framework, but in all cases a business need, rather than a fascination with technology, should drive the process. A technological imperative often creates an understandable backlash that stifles change. We should not have ignored the challenge of motivating users to take ownership of a new, systems based way to do their jobs. Such motivation will be even more important as users become the front-line troops in organizational change in the years ahead.

Perhaps most important, we glossed over the distinction between "structured" and "unstructured" problems. While we did spell out Simon's view of the decision-making phases (intelligence, design, and choice), we did not offer alternatives or elaborate on his views. It would have been useful to bring in Alan Newell's robust model of problem solving. (Newell was Simon's collaborator on many projects.)

The distinction between *decision making* and *problem solving* is more than just semantic. "Decision making" suggests a clarity that does not correspond with the real world; much of the time (perhaps most of the time) managers engage (often in groups) in problem solving over extended periods of time. The five components of problem solving as Newell saw them were as follows: specification of the problem space and its states; definition of the appropriate operators; identification and setting of goals; identification and understanding of path constraints; and specification of the relevant search control knowledge.

Such a view adds richness to the decision-making perspective by recognizing the crucial learning that takes place during the complex iterative process of moving toward a solution in anything but the simplest situation. In particular, Newell's view allows us to more easily incorporate the idea of heuristics. These "rules of thumb" used by knowledgeable practitioners are too important to be hidden behind the simple intelligence, design, and choice view.

A related enrichment of our framework would have emphasized the amount and diversity of knowledge that often matters in semi-structured problems. Indeed, it was partly the problem of casting this knowledge in the limited representational framework of the time that led us to classify certain problems as semi-structured and to consider them only briefly. With the fruits of research in artificial intelligence and cognitive science, we are now in a better position to address such problems as "candidates for decision support." The technology represented by expert systems often can be productively applied to organizing the range of knowledge and procedures necessary for such problems. Work of this kind points to the next stage in the evolution of decision support systems.[16]

Looking Forward

Productivity in the manufacturing sector of the U.S. has been poor relative to that of our trading partners. Productivity in the service sector is even worse than it is in manufacturing. "Services" in this case includes workers in banking, insurance, education, government, retail, and so on. Falling logically in this same group, although *not* included in the statistics, are the knowledge workers in the manufacturing sector—designers, accountants, marketing specialists, lawyers, and so forth. For decision support systems to significantly improve the performance of skilled service sector workers and manufacturing sector knowledge workers, these systems must move beyond what we conventionally construe as data processing. The highly structured approach of data processing—its reliance on algorithms and quantitative data—is generally insufficient to meet the needs of these workers. More quantitative and heuristic approaches will be needed.

It is for this reason that the recently developed knowledge based systems (or expert systems) are adding significantly to the classical decision support system view. This approach uses the concepts and tools that have emerged from the field of artificial intelligence. For example, American Express has had considerable economic success using a knowledge based system to improve the quality of their credit authorization decisions. When requests for credit approval come in over the phone lines, the new system leverages the credit analyst by providing a powerful set of heuristics culled from their most experienced personnel. These heuristics analyze and filter the data, ultimately giving the analyst the important facts on which to base a final judgment. This is one example of an expert support system that is enhancing the productivity of knowledge workers. One of the challenges of the 1990s is to expand and continue such work.

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January 1, 1989

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