SOME PERSPECTIVES ON COMPUTERIZED MANAGEMENT DECISION MAKING SYSTEMS*

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The title of this paper is somewhat of a misnomer, perhaps a more appropriate one would be "Some Perspectives on Computerized Management Decision Support Systems." I personally think that the difference between decision making and decision support is a key concept. The use of computers to support decision making and the use of computers to actually make decisions are both important areas, particularly in a management setting the way it is in the 1970's. The technological shifts over the past two years have made new things possible, and the range of decisions that can now be usefully supported by computers is vastly different than it was even three or four years ago. There are a number of technological changes that have made this possible, but in particular three come to mind: the first of these is the development of powerful, robust, low cost mini-computers, the second is the availability of good interactive terminals, and the third the availability of decent data management languages which permit accessing data in a variety of ways at problem solution time. Each of these areas, and others, can and will have further development, but we have now reached the stage where we can deliver a computer "system" that contains enough power to be used on problems of real world complexity. In fact we have reached the stage where Decision Support Systems (DSS's) are not just imaginary toys of management but actually exist and are used as

very effective tools by line and staff management.[1,5,8]

To provide a little perspective on the status and differences between these two broad areas let us look at some examples of each. The framework that is used to help structure the management setting is provided by a simple matrix. This is developed elsewhere[7] but consists for our purposes here of the two axes in Figure 1. For one of these we are using Anthony's familiar Strategic Planning Management Control Operations Control view of the classes of decision that exist in an organization. The other axis consists merely of four of the functional areas in a firm. Using this structure to think about the status of computer based decision making systems in organizations today it is possible to see that there are very few such systems actually in use in organizations in the Strategic Planning and Management Control areas. It is not that computers are never used in these domains, but simply that they form a trivial part of the eventual decision process. However, the picture is very different in the operational control aspects of organizations. In all the functional areas there is almost always an example in any given firm, of the computer being used to actually make decisions. Taking each of these functional areas in turn we have the following examples. Marketing - Technical Specification.

In technical areas some firms find that detailed specifications can be effectively provided by computer. The salesman inputs the customer requirements for the system and the computations are then made that provide the detail requirements, costs and prices.

Production - Refinery Scheduling.

Examples in the production area are by now legion. Real time process control for example is a commonplace application in process industries and has advanced enormously in the last 15 years. One only has to visit a modern refinery to realize the total dependence such a complex production system has on the process control and computer based decisions that are made throughout. It is in fact a classic illustration of computer based decision making.

Production-Line Balancing.

There are many examples in non-process applications, they are typically not real time applications, but they exploit our advances in math programming to provide optimal decisions in some aspect of the manufacturing process. For those companies with production lines manufacturing relatively standard products, and where the production lines must be balanced so as to provide maximum through-put from the factory we find that computer based programming systems are making decisions that used to be made by managers and first line supervision.

Finance - Credit Checks.

For a number of companies the question of whether credit should be extended to a customer for a particular purchase is a matter of some importance. Where the company is large with a fast moving business, computer based systems are employed which have the necessary decision rules to make a decision as to whether to extend credit or not.

Personnel - Availability.

By maintaining a skills and preference data base some firms make personnel assignments on the basis of computer executed decision rules. The most extreme example of this is probably the United States Military forces, but such systems are also used in private industry.

These examples are obviously merely illustrative. However in these and all other decision making systems the problem involved has a number of common characteristics. For example;

1. They are structured problems. That is using Simon's[7] terminology the three problem solving stages of intelligence, design, and choice can be specified unambiguously ahead of time. The data for each of these stages are known in advance and the relationships and decision rules that apply are also known.

2. These problems exist in a predictable environment or if that does not hold in an environment where there is not time pressure.

3. There is no special requirement for communication between various managers or between sections of the organization.

Where problems have characteristics such as these then computers can be used to replace or supplant the human decision maker and one can build a decision making system which is effective and valuable to the organization. It is an interesting and important area and will continue to be of major significance to companies and their data processing and operations research groups. However, as we suggested above, the recent changes in technology have made it

possible to develop systems in a different but related area which we call Decision Support Systems. The emphasis here as the name suggests is to support managers in making complex decisions and not to focus on replacing them. Such an approach is appropriate for semi-structured decisions, that is decisions where there exists a sufficient degree of ambiguity that it cannot be automated and given to the machine in its entirety and yet the situation is also such where pure management intuition can be improved upon and therefore the human being alone is not doing as good a job as is possible. In such a situation where neither the human nor the machine do as good a job as the two combined we have found an extraordinary mushrooming of applications over the last two years. Using the same framework to look at a company as we have done in the case of fully structured problems we have the situation as depicted in Figure 2. Across all three levels of management decision making we find actual systems in use in companies today. Some sample examples are given in Figure 2 and the numbers in parantheses with each of the examples refers to the items in the bibliography which provide a fuller discussion of the application. These numbered items are not discussed here but can be referred to in the original source documents. However in Figure 2 there are two areas in which there does not exist adequate written material at this point and so a word or two is in order.

In the area of Finance and Strategic Planning a number of firms have had models to help look at the impact of potential acquisitions on the financial status of the acquiring firm. The details and use of such systems are obviously closely held by the companies in question as there is the inevitable confidential nature of the

material with which they are dealing. However firms such as Westinghouse claim to find these interactive tools to be of inestimable value and from our research projects here at M.I.T. they appear to be in very wide use among the major corporations. The second area without a reference is in the Strategic Planning-Personnel domain where the illustrative example has to do with long term manning needs. Both the military and civilian government agencies have had extensive experience with computer based support for this area. NASA has a number of internal documents which provide some insight into the use of interactive planning models to support key decisions on the manning levels and shifts in these as NASA looked out over its somewhat uncertain future.

There is obviously not enough space to describe any one of these in any detail nor have we begun to cover the range of functions in a firm, or the range of types of DSS's that actually exist at this point in time. The Center for Information Systems Research (CISR) at the Sloan School of Management at M.I.T. has a number of fascinating case studies documenting aspects of this area and from this work it is clear that there is an enormous range of DSS's that are possible. Some of these run from very small time-sharing based systems with a budget of a few thousand dollars and others run to major projects involving substantial dollars and substantial organizational effort. For example the very innovative moves recently by International Harvester in providing interactive support for their purchasing agents, who are responsible for purchasing well over 4 billion dollars annually,

shows a case with high payoff and also demonstrates how some relatively rigid tools such as IBM's IMS can be exploited to provide effective information to managers if the focus on decision support is made clear.

In all of these DSS examples we can say, using Simon's view of decision making, that either one or two of the "Intelligence", "Design" or "Choice" stages in the decision making process continue to require management judgment. As a result the overall decision process cannot be said to be structured, and, therefore, requires the manager to stay actively involved in the decision making process. Thus we find in all of the applications listed above that the DSS's developed are management tools used by managers either directly themselves or by their personal staff. Paranthetically it is not a coincidence that all of these example systems have not involved data processing departments to date.[8] The reasons for this lack of involvement are several, among which are the phenomena that the process of building such systems, the models that are appropriate to help support managers in these conditions, the kinds of computers, and the type of analyst that is successful in these efforts, are all quite different from the classical MIS applications. This point is not elaborated on here but is developed further elsewhere.[8]

To illustrate the differences between decision making systems and decision support systems, and at the same time to highlight some of the many similarities between the two let us look at an illustration using a set of games.

Tic-tac-toe is a fully structured game in which we have long been able to build a computer system that plays a faultless game. It will always win or draw. This degree of structure is somewhat deceptive as can be seen when one looks at the five year old child who plays the game. The child may well understand the surface decision rules so that in fact the child can play the game, on the other hand the child does not understand the deep structure involved (borrowing the term from Minsky) and therefore is unable to play a faultless game.

Checkers on the other hand is not as easy a game. We understand surface rules and we can write computer programs to play a very respectable game of checkers. However it is too large to allow brute force answers and so a number of people have been working on the deep structure which is yielding to their efforts slowly. In fact we have been at the point for some years where the heuristics from good checkers players when programmed as part of a checkers playing system can be very effective. As a result of this work with heuristics there are now a number of excellent checkers playing systems that do very well and in fact can regularly beat a decent player. Samuels work at IBM is perhaps one of the earliest examples of this.

Chess presents a different picture. It is effectively unstructured still and there does not seem to be any evidence that the middle game has yielded thus far to any of the research efforts going on around the world. In fact we are still at the point that no game playing computer system provides any serious opposition to a good chess player. Now supposing we decided to change the

ground rules in working with computers and chess. Instead of struggling to build a computer program that would replace the human chess player we take as our goal a quite different one, not commonly used in the past, that is to provide support to the chess player so as to improve the player's game.

If we were to do this we might find ourselves in the following situation: the computer would be dominant in two areas. In the opening game the computer could draw on a data base of past "great moves" and provide the human player with a substantially wider basis of experience. Similarly in the end-game it would be possible to turn the play over to the computer system and allow it to use algorithms that involve exhaustive search. Thus the computer would likely dominate the human it is supporting in both the "opening game" and the "end game" although in quite different ways in both cases. However in the "mid game" where computers have been singularly inept in the work thus far, the computer would drop to a supportive role and would merely suggest obvious moves or pitfalls if it sees them, and otherwise react in a "what if" mode to suggested moves by the human player.

With such a support system it seems highly likely that the chess game of many players would be substantially improved.

In an analogous fashion it is true that the performance of companies and of managers can be improved if computers are used to provide the classical decision making activities as well as providing decision support activities. By shifting the ground rules on the way computers are used in companies to include not only replacing managers and clerical work forces but also to include the notion of supporting them we add a whole new range of activities to the things

that can be done in corporations and from the experience gained thus far these are activities with substantial pay off. To many people coming from a background of elegant algorithms and extraordinarily complex computer systems this movement into decision support systems seems somewhat trivial and not particularly challenging. It does not require the phenomenal sense of completeness that a human replacing system requires, simply because the manager or clerk is still there and can still provide the necessary guidance and insight to override the system it is seems appropriate. From talking to the builders of such DSS's thus far it appears that in fact this is an area that is no less challenging either conceptually or in practice than the previous computer work.[8,11] The technology available to managers and computer people has changed dramatically over the last two years, this change has opened up a whole new domain that contains considerable potential. I would expect that over the next few years we are going to see a lot of exciting and quite different developments than those we have seen over the previous ten. It is likely to be an interesting challenge.

Figure 1

Examples of Computer-Based Decision Making

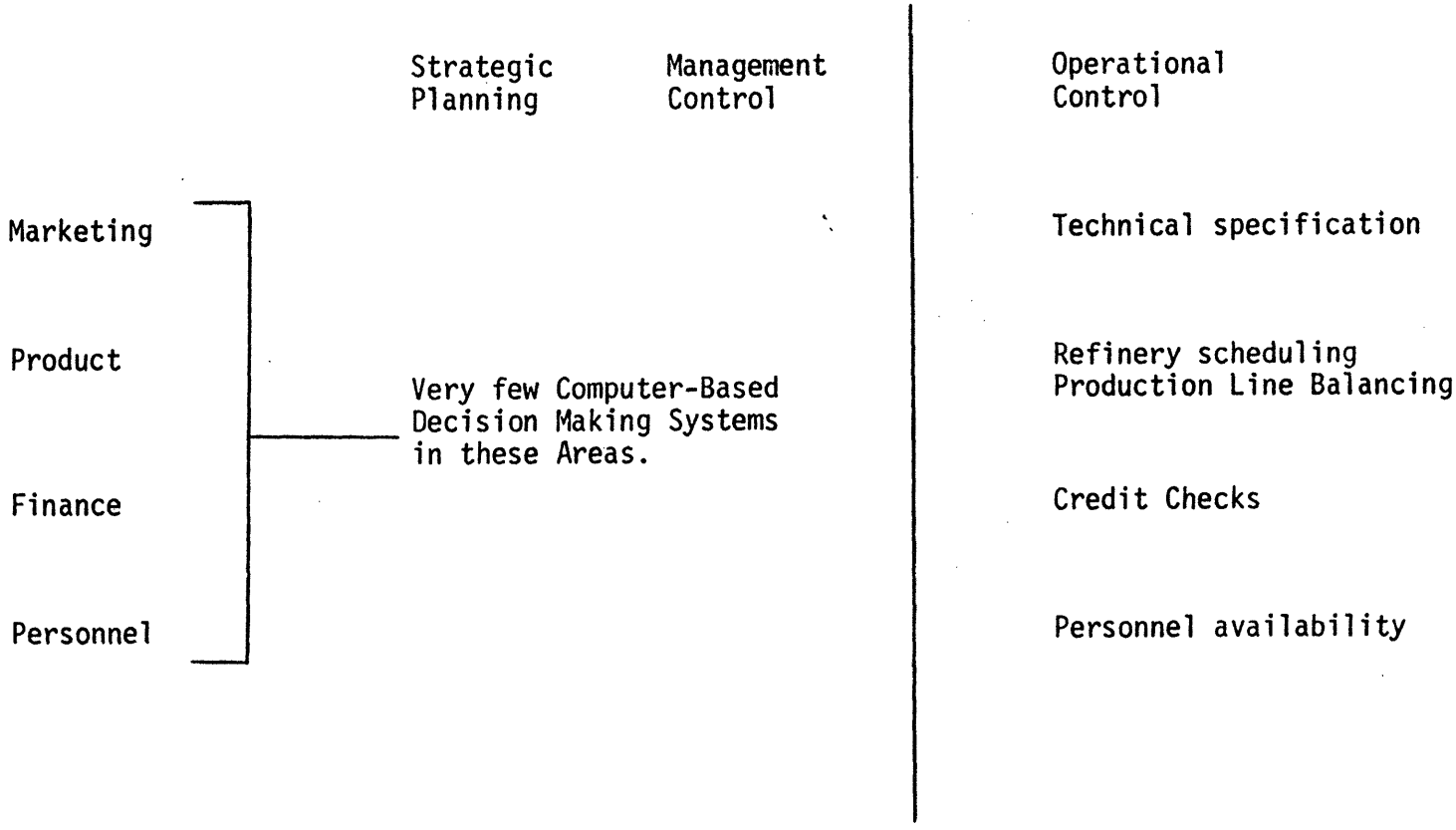

Figure 2

Examples of Computer-Based Decision Support Systems

	Strategic Planning	Management Control	Operational Control
Marketing	New Product Introduction (14)	Brand Management (9)	Media Selection (10)
Production	New Facilities Location (4)	Setting Production Plan (13)	Portfolio Management (6)
Finance	Impact of Acquisition	Setting Budget Levels (11)	Cash Flow Management (12)
Personnel	Long-Term Manning Needs	Staffing Strategies (3)	Personnel Selection (3)

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