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Decision Support Systems (DSS) : A Knowledge Oriented Approach

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ABSTRACT

The design of decision support systems (DSS) is an important research area within the field of management information systems (MIS). The design is based on models that consider decision making either as an act which takes place within a socio-technical environment (an organization) or as a cognitive process. The decision support systems' current architecture and conceptual framework seems to present several weaknesses. Recent research in artificial intelligence shows that decision support systems must increasingly incorporate explicit knowledge in order to meet the objectives set by DSS designers. This paper presents a conceptual framework and a DSS architecture based on the processing of knowledge.

Key Words : problem formulation, DSS, knowledge processing systems

1 - INTRODUCTION

This paper presents a diagnosis of the limitations posed by Decision Support Systems (DDS) as they are traditionally conceived thereby confirming the interest of pursuing the trend observed in the literature over the past several years over incorporating explicit knowledge into DSS. A conceptual framework is proposed based on the the processing of knowledge for the design and study of DSS.

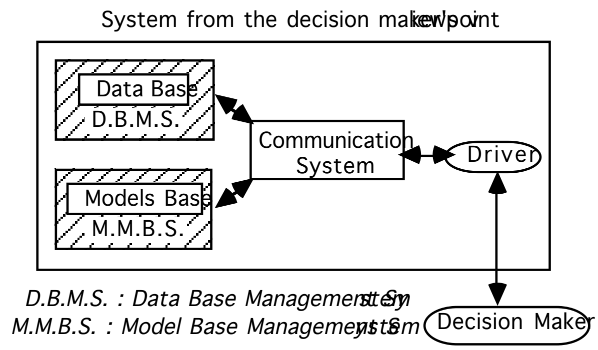
2 - CONCEPTUAL FRAMEWORK NORMALLY USED IN DSS

Throughout the rather abundant literature on the subject, authors agree that DSS refers to computer systems built to assist managers in making that semi-structured or poorly stuctured decisions. Consensus has been estabished around some well defined characteristics (R.H. SPRAGUE and E.D. CARLSON, 1982). Decision support systems

- assist managers faced with semi-structured problems;
- combine the use of analytical models or techniques with access to transactional databases;
- must be easy to use for non-specialist users in conversational mode, directly or via a driver;
- must take the environmental particularities and the cognitive characteristics of the decision maker into consideration.

The conceptual framework used for DSS design and study are generally inspired by the various decision process models proposed by H.A. SIMON : decision process in three interlocking phases (intelligence, conception, selection), programmable versus non-programmable[1] decisions and the concept of limited rationality. The conceptual framework most often quoted, that of G.A. GORRY and S. SCOTT MORTON (1970), relies on the programmable versus non-programmable decision model and on the classification of management levels proposed by R.N. ANTHONY[2]. A psychological component is sometimes included, notably in McKENNEY and KEEN (1974).

The basic architecture upon which most authors in the domain agree, for specific as well as general DSS, is as follows:



Architecture of Present DSS□

3 - PRESENT DSS LIMITATIONS

The success and impact of DSS remains rather limited within organisations. This can be explained by a certain number of weaknesses or limitations related in part to the conceptual frameworks underlying current DSS and in part to the computer technology used.

The first and most important weakness resides in the failure of the systems to provide assistance in problem identification, formulation or structuring (M. LANDRY, D. PASCOT, D. BRIOLAT, 1985). In most cases, the systems require that the manager provide an adequate formulation of the problem before using the system. Therefore DSS are of little help to managers in the decision maker (MINTZBERG 1973), or environment scanner role as discussed by M.S. FELDMAN and J.G. MARCH (1981).

The second weakness of DSS is that they are rarely able to explain the process they followed to arrive at the proposed solution in a manner that is natural to the manager. This weakness can largely be attributed to the analytical nature, in the mathematical sense, of the information processes at work within DSS. Indeed, any such system implies the building of an abstract model to represent reality and then operating the mathematical model; each operation, however, cannot be transposed into reality: only the result can be interpreted.

The third weakness of DSS is their failure to assist in the validation of data and models; it is indeed very difficult to ensure that the data required by the DSS is contained in the various databases in the organisation.

Finally, DSS are not adaptable; they are unable to adapt to the decision maker's cognitive style and to the situation he/she faces. This adaptivity or flexibility has been identified by numerous authors, KEEN (1980), SPRAGUE and CARLSON (1982).

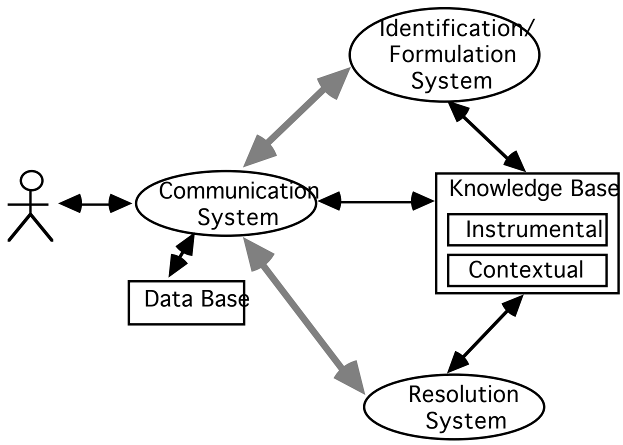
4 - A CONCEPTUAL FRAMEWORK BASED ON THE KNOWLEDGE PROCESSING

To overcome the weaknesses and limitations in current DSS designs, a DSS framework was developed to take into consideration problem identification, formulation and resolution. It is argued that these limitations are largely due to the fact that DSS have no knowledge and that reasoning processes should not only be analytical in the mathematical sense but also logical. These limitations can be offset by resorting to knowledge processing systems associated with knowledge based systems developed in the field of artificial intelligence. Over the last few years, several authors have tried to integrate artificial intelligence into DSS, in particular R.H. BONCZEK, C.W. HOLSAPPLE and A.B. WHINSTON (1981).

The conceptual framework proposed in this paper is based on an epistemological reflexion on the notion of problem (M. LANDRY 1983, 1985) dealing with problem identification, formulation and resolution as a cognitive process of knowledge acquisition and organization. This leads us to consider more explicitly the knowledge affecting this cognitive process.

Each of the three DSS functions, communication, formulation and resolution, requires knowledge. This knowledge can be separated into instrumental or contextual knowledge.

<u>Instrumental knowledge</u> is related to the use of the computer as a tool, and comes into play at each function. For example, in communications, it assures a dialogue with the decision maker ("natural" language) and with databases (representation languages). At the resolution level, it implies resolution techniques and methods (for example, statistical techniques). At the formulation level, it allows the definition of a representation language. Finally, such knowledge assures the interactions among the three different knowledge processing systems.



Functional Layout of a DSS Based on Knowledge Processing.

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<u>Contextual knowledge</u> is related to problematic situations as much from a representation (formulation) as from a solution (resolution) point of view. Contextual knowledge, that also intervenes in the three sub-systems, may be classified in several ways:

- specific or general knowledge
- knowing or know-how : knowing represents the information that the decision maker can obtain on a problem situation as well as what he/she has learned in books, procedures and organisational rules dealing with the domains concerned with the problem; know-how is acquired by practice, (for example, the use of the above mentioned knowing according to the context of the problem situation.
- in-depth or superficial knowledge : in-depth knowledge is knowledge related to specific domains implied by the problem situation, be it the nature (the intrinsic properties) of the situation components or objects, or the interpretation or anticipation of the behavior of these objects (for example, the laws governing them,...). This knowledge may be related to the scientific or technical acquisition in one or several particular areas. Superficial knowledge is developed by dealing with the problem, through experience, while solving a large number of similar cases. This knowledge may be associated with new abstractions, associations between descriptive elements in the problematic situation and formulation elements as well as resolution solutions.

- endogenous and exogenous knowledge : endogenous knowledge relates to the decision maker's expertise or to an important aspect of the problem situation. Exogenous knowledge relates to the domains in which the decision maker has little expertise and must therefore consult.

4.1 - System of problem identification/formulation

The main objective of this system is to construct an abstract representation of the problem situation. It facilitates the intelligence phase of the decision making process. The decision maker identifies the difference between the existing and the desired situation, based on a delimitation and observation of the problem situation, and then defines a course of action. This cognitive activity implies a certain amount of work on the representation of the problem leading to its stabilization: this implies the balancing of the abstract representation as described by Piaget[3]. The latter is done using two (2) adaptive mechanisms: assimilation, where observation of the problem situation reinforces representation; and reconcilation where observation leads to a modification of the representation that is more or less in-depth.

The formulation of the problem may be defined as the process of acquiring and organizing knowledge in any situation on which the decision maker intends to act: DSS must allow for the construction of the abstract representation of the problem situation. DSS must provide a language facilitating the construction and organisation of new knowledge concerning the problem, and possess knowledge on the decision maker's behavior, i.e. objective and subjective rationalities specific to the decision maker or set by the organisation.

For this, DSS may rely on knowledge related to a particular field of decision consisting of a wide array of facts and rules that the decision maker cannot memorize for lack of time, interest or opportunity. The following types of knowledge can be identified:

- definition of objects : permit the definition of a certain number of notions and concepts related to the domain such as the definition of variables and meanings.
- Relationships between objects : this may be a formula explaining variables (for example: total costs = fixed costs + variable costs).
- Rules : allowing, for example, a definition of individual preferences or organisational standards.
- Methods : allowing, for example, an aggregation method (workshop variable costs = Sum of units variable costs for all production programs).
- Goals : for example, fixed costs of the firm must be reduced by 10% yearly.

The system of problem identification and formulation must also be able to generate new knowledge from the data contained in the organisation's databases (for example, by forming classifications, by pointing out the differences, by establishing or questioning cause/effect relationship in a probabilistic way.

These possibilities lead us to the notion of an intelligent information system as discussed by Z.S. ZANNETOS (1968). In order to conduct these operations, the formulation system must be provided with knowledge of an instrumental nature i.e.allowing the databases' internal structure to access and converse with a database management system.

4.2 - Problem Resolution System

Problem resolution consists of building operating models from abstract representations in order to solve the problem; the stabilized representation of the problem obtained in the previous phase is not operational and must be translated into usable models that allow problem solving, i.e. contemplation and generation of possible solutions (the conception phase of the decision process).

The resolution system must be provided with resolutive knowledge or operating models. An interface mechanism must exist between the knowledge of a resolutive nature and that, expressed in the formulation system, related to the expression of the problem; this interface is assured by the DSS's own instrumental knowledge. A large part of the resolutive knowledge may be expressed declaratively, i.e. in the form of production rules.

The adoption of a declarative representation offers numerous advantages. For example, the relation :

total costs = fixed costs + variable costs

a declarative representation of this relationship rather than procedural by an instruction from a sub-program or procedure, allows other uses than those for which it was formulated (calculation of total costs from fixed and variable costs) and serve for example as:

- algebraic reasoning: total cost = x, fixed cost = y, therefore variable cost = x-y
- explanation: why are total costs higher than last year? = because costs of raw materials are higher□
- justification of a result: how are total costs obtained? from fixed costs x and variable costs y .□

4.3 - Communication system

In order to intervene in the resolution phase and particularly in the problem identification and formulation phases as they were defined earlier, DSS must possess a high performance communications system. True interactivity is indispensible and an intelligent interface must be available. The driver has, among others, the role of an analyst translating the manager's questions into the system's own language; the interface should be able to accept questions and formulations a manager would put to a driver. Therefore, the communications system must be provided with knowledge enabling it to understand the language in which the decision maker will express himself/herself. It must also be provided with certain knowledge related to the context in which the dialogue will take place, therefore concerning the type of problem dealt with.

DSS adaptive capacities as defined earlier may not be considered in the absence of basic knowledge of the system itself, concerning namely the type of problem processed or the decision maker's specificities. The communications system must, for example, be able to construct new knowledge related to the cognitive characteristics of the decision maker, to evaluate his level of understanding of the system and his/her preferences with regards to the format of the presentation of results.

The communications system must also take charge of the interaction between DSS and its technical environment, i.e. insure dialogue with the organisation's management databases and communicate through the communications networks. All these possibilities require that the communications system be provided with its own knowledge of an instrumental nature.

5 - CONCLUSION

Present DSS incorporate knowledge only in an implicit way, be it on the data level or models level, which makes them too rigid and unable to adapt to the decision maker as well as to the problem. Over the last decade, important progress has been made in the field of artificial intelligence, particularly in knowledge based systems. This recent type of system opens new development horizons to DSS designers. An in-depth reflexion presented herein on the nature of knowledge and its processing allows the definition of a new overall architecture for these systems.

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NOTES

1 - However varied they may be, decisions in the organisation may be classified according to the following criteria: routine, pre-set, or programmable. Decisions can therefore be placed on an axis where totally programmable decisions are opposed to non-programmable decisions.

2 - a) Strategic planning which consists of defining the objectives and deciding on the allocation of resources; b) managerial control consisting of making efficient and effective use of resources in order to reach the objectives set by the strategic planning level; c) operational control concerns current decisions over the physical inputs crossing the organisation.

3 - Piaget's perspective of decision support is also presented by J.C. COURBON (1982-84).