REQUIREMENTS FOR AND LIMITATIONS ON DESIGNING DECISION SUPPORT SYSTEMS

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Abstract

Decision Support Systems (DSS), which combine the capabilities of modern computers and human skills in solving complex ill-structured problems of organizational management, has been created as an evolution and development of Decision Theory, Management Information Systems and Data Base Management Systems. The DSS help users to formulate and analyze decision alternatives in a number of ways by making use of objective and subjective data, models, knowledge.

The main components of a conceptual DSS model are "user-system" interface, block of problem analysis and structuring, decision-making block, data base, model base, and knowledge base. The "user-system" interface contains facilities for generating and controlling the dialogue. The blocks of problem analysis and decision-making incorporate procedures and methods which help formulate the problem, analyze approaches to its solution, and generate the result by making use of the data, model and knowledge bases. The DSS also contains facilities for data and knowledge elicitation, model construction, data and model management.

The preliminary analysis and structuring of the problem are carried out either by the decision maker alone or jointly with a skilled consultant-analyst. The ability to conceive the structure of a problem correctly is an art reinforced by experience and intuition. The complexity of even a preliminary analysis, and the presence of numerous ill-defined factors, set a number of requirements to DSS. An effective decision-making depends on both the harmony of decision maker and consultant efforts and the DSS capacities. Problems arising in designing each of DSS blocks and examples of its successful implementation are considered in paper.

At the early stages of its development DSS was treated as a computer-based facility for assisting in processing huge amounts of data with rigidly assigned models and in presenting decision results. It was explicitly assumed that the problem solved was sufficiently clear and understandable. We believe, the major purpose of the next generation of DSS must be: assistance in providing for a better understanding of the problem solved; assistance in the problem solution; assistance in decision analysis. The future systems will be able to adjust to the style of human thinking, simulate his techniques, and will be a sort of extension of the manager's ego.

1. INTRODUCTION

Decision Support Systems (DSS), which combine the capabilities of modern computers and human skills in solving complex management problems, has been created as an evolution and development of Decision Theory, Management Information Systems and Data Base Management Systems. There are various DSS definitions. Many researchers view DSS as a system helping user to solve ill-structured and unstructured problems. According to paper [7] the DSS concept is shifting gradually from explicit statement "what a DSS does" to operational characteristics "how the DSS's objective can be accomplished".

In our opinion DSSs are computer-based systems that help users to formulate and analyze decision alternatives in a number of ways, to solve complex ill-structured problems by making use of objective and subjective data, models, knowledge.

2. CONCEPTUAL DSS MODEL

The main components of a conceptual DSS model consistent with the above definition are "user-system" interface, block of problem analysis and structuring, decision making block, data base, model base, and knowledge base [13].

The "user-system" interface contains facilities for generating and controlling the dialogue. The blocks of problem analysis and decision-making incorporate procedures and methods which help formulate the problem, analyze approaches to its solution, and generate the result by making use of the data, model and knowledge bases. The DSS also contains facilities for data and knowledge elicitation, model construction, data and model management.

The block of problem analysis and structuring is one of the major DSS's blocks: it helps examine and structure a problem. The purpose of the problem structuring stage is to "tune" the DSS to the user's object area, define the basic characteristics of the source information, formulate the necessary requirements to decision techniques, models, and knowledge. The problem structuring involves compilation of a list of the considered objects (alternatives, factors, etc.), description of the objects' properties (characteristics and attributes), identification of constraints, and evaluation of criteria.

The decision making block is a core element of the DSS which assists users in finding the most adequate means for solution of the preliminary structured problems. In the block inputs there are, on the one hand, a formal representation of the problem, and, on the other, requirements to the form of the ultimate decision, for example:

- ranking (quasiordering) the set of objects;
- dividing the set of objects into groups (classification);
- singling one or several best objects out of the set.

The formal representation of the problem and requirements to the form of decision set certain demands on the types of the necessary models and data, determine the need for subjective expert knowledge, impose constraints on the employed decision techniques. In order to perform its functions the decision making block must contain a library of decision methods including those for solution of multicriteria and single criterion problems on objective and subjective models. Apart from the library this block should incorporate a set of rules or an expert system, adjusted by an experienced consultant, permitting selection of the most adequate tools for the problem solution.

The decision making block should enable the user to combine the structures, data, models, knowledge, and methods in an integral whole, choose between different decision techniques, make use of different models and data. Note that such behavior of the user is characteristic of practical situations: people use some decision method, analyze the obtained result, then try another method. An opportunity for a DSS application in a similar manner looks rather attractive. From a methodological point of view, however, the decision block operation in the above manner gives rise to considerable difficulties. At present, we may identify only individual components of the mentioned functions implemented in some or other DSSs. The development of a decision block intended for a wide range of applications is a task for the future.

The data base is a component common for all computer systems. As applied to decision problems it must, to a certain degree, replicate the structure of the problem and contain both objective and subjective data (should they be necessary).

The model base must involve a library of possible standard models resulting from problem structurization for the considered object area. The library must contain both traditional objective models such as assignment, transportation, game models and the like, and subjective expert models.

The knowledge base of an effective DSS should contain objective information on the user's area and the subjective rules reflecting the decision maker and experts' experience. It is also highly desirable to accumulate, in the knowledge base, information concerning the past DSS applications to solution of concrete problems.

The problem of knowledge elicitation from experienced experts is one of the poorly studied and developed points of designing knowledge-based systems - intelligent DSSs and expert systems [5]. Additional requirements to the knowledge elicitation techniques are imposed by the methods of knowledge presentation: hierarchical structures, graphs, semantic networks, frames, production systems. It is very important, in constructing knowledge bases, to take account of the specifics and limitations of the human information processing system which are practically neglected by the existing methods of knowledge elicitation.

In real decision situations, the formulation (formal statement) of a problem, selection of a method for its solution, structurization of the source information in the form suitable for some or other solution technique are rather complex. The difficulties are overcome with special facilities for the design of man-computer interaction when the problem is specified, and the system's capacities for the problem solution become more clear for the user.

The user-system interface, providing for the user communication with the DSS components, comprises facilities for the data, model, and knowledge base management, as well as dialogue management and generation. The data, model, and knowledge bases management facilities serve for the creation, retrieval, and modification of the contents of the respective bases. In solving the problem the user interacts with each base through the dialogue management and generation system.

The range of functions performed by the user-system interface determines the system's capacities in the decision support. One of the most important requirements to the interface is its friendliness toward the user. The availability of a friendly man-machine interface is one of the distinguishing characteristics of DSS. The conveniency of user-system interaction facilities involves flexibility of the dialogue, clarity of the system's behavior for the user, easiness of training, simplicity of use, reliability of operation.

3. COMPUTER APPLICATIONS IN DECISION MAKING

A variety of computer applications in decision making requires to analyze principal capabilities of and constraints on usage of computer in decision techniques, to consider computer's correspondence with human abilities in decision making.

There are a lot of discussed problems on man-machine interactions in decision making [13]. One of the most important issues is the correctness of procedures of information transformation. The dialogue correctness includes the following requirements:

- in information processing making use of elementary operations correspond to data character;
- in information elicitation and exchange making use of a language which is routine and clear for users;
- in dialogue making use only the questions within the range of human possibilities.

The second requirement is a comfortability of man-machine dialogue that denotes:

- effective procedures of information processing and representation;
- ability of promts and explanations at each stage of a dialogue;
- checking possible mistakes and contradictions in decision maker's preferences and answers.

The third requirement is a correct determination of the dialogue initiator. On some step of the dialogue it could be a computer containing a complete scheme of a decision method. And a decision maker is considered only as an information source. On other steps a decision maker could handle dialogue himself choosing necessary options from menus.

Yet another issue under discussion is computer application to problem structuring [7,8]. As is known, the first stage of decision making process is the preliminary analysis and structuring of the problem. Usually this stage is carried out either by the decision maker alone or together with a skilled consultant-analyst making no use of computer. The ability to conceive the structure of a problem correctly is an art reinforced by experience and intuition.

But now there are some DSSs which help decision makers to formulate and structure the problem solved. The complexity of even a preliminary analysis, and the presence of numerous ill-defined factors, set a number of requirements to tools for problem structuring. A successful analysis depends on both the harmony of decision maker and consultant efforts and the DSS capacities.

The above requirements to various components of the DSS are only partially and to a different extent accounted for in the present-day DSS. The most suitable for the DSS application are multicriteria problems with objective models associated with processing and analysis of huge data bases. In the course of their solution the decision maker learns, gets a deeper insight into the capacities and constraints of the objective model, and realizes the necessity of a tradeoff between the conflicting criteria. Poorly studied so far is an area of decision problems with subjective models.

4. EXAMPLES OF DSS

One of the first DSS, capable of problem structuring, was MAUD [8]. This system, designed for assisting decision makers in individual choice situations, a priori does not contain any information on the problem under study. The problem formulation, selection of the objects considered, assignment of criteria and criterion estimate scales are exercised by the decision maker in the course of interaction initiated by the system.

In operating the system, the decision maker can institute necessary corrections, introduce and eliminate objects and criteria, change his estimates and preferences. The system identifies the absence of contradictions in user's operations, checks the information consistency, and prompts the user the procedure stages to be carried out following the introduction of changes. The user may interrupt the process practically at any stage and resume it any time. As a result, the system ranks the studied objects on the basis of decision maker's preferences (weighted significance of the objects).

A second example is ASSIGNMENT system for solving a multicriteria assignment problem [16]. The system adjustment to the subject area involves the construction of data and knowledge bases, compilation of the lists of estimated objects and subjects, identification of their mutual requirements and capacities, forming criteria scales followed by an expert assessment of the objects and subjects.

The problem is solved iteratively, and the decision maker can interrupt the process, turn back to any stage, introduce changes in the source data, criteria, and constraints, modify decision rules. The solution process is registered by the system, and the information on its current state is generated on the user request. The system provides certain services to the user such as prompts, instructions, and test examples. The system enables the decision maker to evaluate opportunities for problem solution with the available source data, quickly analyze the assignment alternatives differing in sets of criteria, estimates, and constraints, assess the impact of changes in decision maker preferences on the quality of generated decisions.

An example of a correct and scientifically valid decision technique is provided by ZAPROS system which permits quasiordering of a given set of multicriteria objects on the basis of decision maker preferences [10]. The questions to the decision maker are in the form of verbal definitions in a language he is accustomed to (the criterion scales are ordinal). Presumably, the criteria and scales have been identified and constructed in advance. During an interview the decision maker is requested to compare sequentially the pairs of multicriteria estimates near the so-called reference situations determined by combinations of the best or worst estimates upon all criteria.

The information elicited from the decision maker is tested for consistency by special closed procedures. Note that the amount of information increases as the problem complicates. Should inconsistencies arise, the decision maker is presented the inconsistent pairs of estimates for spelling out a correct answer. The rules of information conversion, built in the computer, permit quasiordering of a variety of multicriteria alternatives.

An example of DSS with subjective model is provided by MEDIAN system which permits ranking of a set of R&D projects on the basis of decision maker preferences [14]. The DSS adjustment to the programme object field is a procedure of expert ordering general document file by a degree of document correspondence with the programme. By making use of special man-machine procedures "information weights" of documents from general file are calculated. The "information weight" of a document is determined by the quantity of informative lexical units (words or terms and their combinations) in a document's text and characterizes a document's relevance to information needs of the user. According to their information weights all documents from general file are ordered by degrees of their correspondence with the programme.

An output of documents is executed from the ordered file. So documents having the highest degree of correspondence with the programme come first. The programme manager can abort an output when he/she receives a sufficient number of relevant documents. DSS MEDIAN is to help a programme manager to structure his/her information needs, to quickly analyse large files of R&D documents, to search for and integrate a great number of R&D projects related to programme matter.

One of possible approaches to constructing a complete and consistent knowledge base in the form of hierarchical structure for a diagnostic DSS was suggested in [6,12]. The system MEDICS treats the diagnostic problem as an expert classification of multidimensional objects. Each object under study is described with a set of attributes having a different degree of intrinsicalness (expression) for different decision classes (types of diseases). The values of each attribute are assumed to be ranked by an expert with respect to their relation with some class of decisions; this procedure does not depend on the values of other attributes.

The expert interview involves a successive consideration of states of the object under study (of certain sets of symptoms or attributes of the object) and assigning of each state, with different degree of certainty, to one or several classes of decisions (diseases). The dialogue with the expert is in the form of a menu in a language the expert is accustomed to. The interview implies systematization of classification rules used by the expert, check of the obtained information for consistency, identification and correction of errors. Built in the interview procedure is an algorithm minimizing the number of questions to the expert.

The interview results in construction of an expert knowledge base containing a complete (in terms of examination of all hypothetically possible states) and consistent (agreement in estimates and lack of errors) classification of states of the object under study. The thus developed knowledge base, reflecting the professional experience of a highly skilled expert, is conducive to efficient DSS for a differential diagnosis of diseases.

5. CONCLUSIONS

At the early stages of its development DSSs was treated as a computer-based facility for assisting in processing huge amounts of data with rigidly assigned models and in presenting decision results. It was explicitly assumed that the problem solved was sufficiently clear and understandable. We believe, the major purpose of the next generation of DSS must be: assistance in providing for a better understanding of the problem solved; assistance in the problem solution; assistance in decision analysis. The future systems will be able to adjust to the style of human thinking, simulate his techniques, and will be a sort of extension of the user's ego.

DSSs are becoming an effective means for problem solution. But it is important to emphasize the term "support" in the name of the system. DSSs themselves could not make new decision, they only help people to make better decisions in a more effective way. New computer tools may prompt an unusual question, help to get a deeper insight into the situation, but they do not and will be unable to substitute a creative human being.

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