A Multicriteria Analysis Decision Support System

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Abstract: *The paper presents a multicriteria analysis decision support system called MultiChoice, designed to support decision makers in solving different multicriteria analysis problems. Various well-known methods and software systems are discussed. The basic features of the solving modules, the interface modules and the system modules are described.*
Key words: *multicriteria analysis, multicriteria decision support systems.*

INTRODUCTION

Different types of real life problems in management practice can be formulated as multicriteria analysis problems. Such are the problems of evaluation and choice of resources, strategies, projects, offers, policies, credits, products, innovations, designs, costs, profits, portfolios, etc.

In multicriteria analysis problems several criteria are simultaneously optimized in a feasible set of a finite number of explicitly given alternatives [23]. In the general case it does not exist one alternative, which optimizes all the criteria. There is a subset of alternatives however, characterized by the following: each improvement in the value of one criterion leads to deterioration in the value of at least one other criterion. This subset of alternatives is called a set of the non-dominated alternatives. Each alternative in this set could be a solution of the multicriteria problem. In order to select one alternative, additional information is necessary, supplied by the so-called decision maker (DM). The information that the DM gives, reflects his/her preferences with respect to the quality of the alternative sought.

Different methods have been developed to solve multicriteria analysis problems, which can be divided into several groups [23]. Each one of these methods has its advantages and shortcomings, connected mainly with the ways of receiving information by the DM relating to his/her preferences. The software systems supporting the solution of multicriteria analysis problems (MADSS) can be divided in two classes – software systems with general purpose and problem-oriented software systems.

The general-purpose MADSS aid the solution of different multicriteria analysis problems by different decision makers. One method or several methods from one and the same group are usually realized in them for solving multicriteria analysis problems. This is due to the following two reasons:

- in the methods from the different groups, different types of procedures are used to get information from the DM, which leads to considerable difficulties in the realization of appropriate user's interface modules in the software systems;

- the designers of the software systems are usually interested in the realization of their own method (methods) or have distinct preferences towards methods from one and the same group.

The problem-oriented software systems are included in other information-control systems and serve to support the solution of one or several types of specific multicriteria analysis problems. Hence some simplified user's interface modules are usually realized in them. That is why methods from different groups of multicriteria analysis problems solution are included in some of these systems.

A MADSS *MultiChoice* is described in the paper, designed to model and solve multicriteria problems of choice and ranking of the alternatives. Three methods are realized in the system for solving multicriteria analysis problems. MADSS *MultiChoice* has a user-friendly interface similar to that of a general-purpose system, but it comprises more than one method realized, as the problem-oriented systems. The including of three methods in *Multichoice* system has got two advantages: the positive features of each one of the methods are aggregated in the system; the different DMs can select a certain method for solution (especially if is preferred), but they can also solve the problems with the help of more than one method, so that they can set in different ways their preferences.

MULTICRITERIA ANALYSIS METHODS AND SYSTEMS

The multicriteria analysis problem can be defined [6] as (*AL,f*), where AL is a finite feasible set of alternatives $AL = \{a_1, a_2, ..., a_n\}$ and *f* is a vector-valued (*k* -dimensional) criterion $f = \{f_1, f_2, ..., f_k\}$. For an alternative $a \in AL, \quad f_j(a), j \in \{1,...,k\}$, represents the evaluation of the *j*-th criterion. Each criterion f_j is assumed to be either maximized - $\max_{a \in AL} f_j(a)$ or minimized - $\min_{a \in AL} f_j(a)$. The notation $a_{ij} = f_j(a_i)$ may also be used to denote the *j*-th criterion value for alternative a_i. The matrix $A = \{a_{ij}\}, \quad i = 1,...,n; \qquad j = 1,...k$ is denoted as a decision matrix.

In the general case there does not exist a solution, which optimizes all *k* criteria simultaneously. From a mathematical viewpoint there exists a set of so-called non-dominated or Pareto optimal solutions and this set is a solution of the multicriteria analysis problem. It can be described as follows:

$P(AL, f) = \{a \in AL / \; not \; exist \; b \in AL, b \text{ dominates } a\}$,

where the alternative $b \in AL, \text{dominates } a \in AL \; if \;\; f(b) \neq f\{a)$ and

$f_j(b) \geq f_j(a), if \;\; f_j \text{ is to be maximized}$ or $f_j(b) \leq f_j(a), if \;\; f_j \text{ is to be minimized}$,

for each $j = 1,...k$.

From a practical point of view, the solution of a multicriteria analysis problem is finding of a non-dominated alternative (alternative, belonging to the set *P*(*AL,f*)), which satisfies the DM to the greatest extent.

A great number of the methods developed up to now, can be grouped in three separate classes: weighting methods, outranking methods and interactive methods. Each one of these methods has its advantages and shortcomings, connected mostly with the ways of deriving information by the DM regarding his/her local and global preferences. The main element in the weighting methods is the way of determining the criteria weights, which reflect DM's preferences to the highest degree. Many methods for criteria weighting have been developed. A value tradeoff method is proposed in [7]. Several versions of the analytic hierarchy process (AHP method) are developed in [18, 19], using pair-wise criteria comparison. A reciprocal pair-wise comparison matrix is constructed. This method is generalized in [21] to reflect DM's uncertainty about the estimates in the reciprocal matrix. A direct ranking and rating method is proposed in [24], in which the DMs first rank all the criteria according to their importance. After that on this basis and under certain assumptions the criteria weights defining their relative importance, are obtained. A mathematical programming model with sensitivity analysis is used in [10] to determine the intervals of weights, within which the same ranking result is produced. The weighting methods use a DM's preference model, which does not allow the existence of incomparable alternatives and the preference information obtained by the DM (different types of criteria comparison) is sufficient to determine whether one of the alternatives must be preferred or whether the two alternatives are equal for the DM. The outranking methods use a DM's preference model which allows the existence of incomparable alternatives and the preference information obtained by the DM may be insufficient to determine whether one of the alternatives is to be preferred or whether the two alternatives are equal for the DM. The criteria and the alternatives are not compared by the DM in these methods, but he/she has to provide the so called inter- and intra-criteria information. Some of the more well-known representatives of the outranking methods are ELECTRE I-IV methods [17], PROMETHEE I-II methods [1], TACTIC method [22] and others. In order to solve multicriteria analysis problems with a large number of alternatives and a small number of criteria, the "optimizationally motivated" interactive methods have been suggested [8, 20, 13, 9 and 5]. The first three methods use the first type of DM's preference model and the DM must define the desired or acceptable values of the criteria at every iteration. The last two methods use the second DM's preference model and the DM has to give not only the desired values of the criteria but also inter- and intra-criteria information at every iteration.

The general-purpose MADSS systems developed (Expert Choice [19], Web-HIPRE [12], HIVIEW [15], ELECTRE III-IV [17], PROMCALC and GAIA [2], Decision Lab [3], VIMDA [8]) realize one method or several methods from one and the same group, above described. One representative of the problem-oriented MADSS systems called Agland Decision Tool is discussed in [14]. It comprises one weighting and one outranking method.

In *MultiChoice* system, described in the present paper, an attempt has been made to realize three methods – a weighting method, an outranking method and an interactive method. These methods are respectively AHP method [19], PROMETHEE II method [1] and CBIM method [13]. They are the most often used methods in the three groups of methods. The interface modules in the system allow the successful realization of different types of procedures for obtaining information by the DM and also for the entry of different types of criteria – quantitative, qualitative and ranking criteria.

MULTICHOICE SYSTEM DESCRIPTION

MADSS *MultiChoice* system consists of solving modules, interface modules and internal-system modules. This modularity enables greater flexibility when including new methods or new interface realizations.

The current version of MADSS *MultiChoice* system contains three solving modules. Every module encloses a software realization of one of the three methods - AHP method, PROMETHEE II method and CBIM method and help procedures for each method as well.

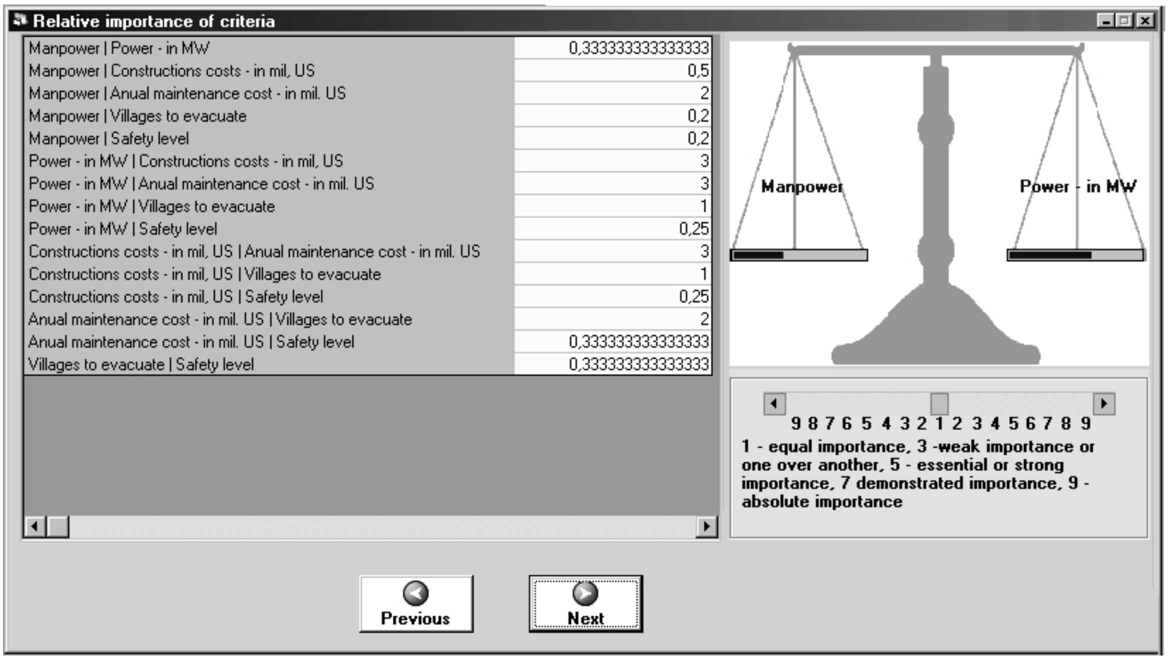

Fig. 1. *MultiChoice* AHP solving windows.

The interface modules ensure the interaction between MADSS *MultiChoice*, the DM and the operating system. This interaction includes the entry of the data for the multicriteria problems, the entry of information specific for every method information about DM's preferences, visualization of the current results and of the final result, graphical presentation of the solutions, print out, reading and storing of files, multi-language support, etc.

Fig. 1 shows a window with information about the pair-wise comparison of the criteria for one real multicriteria analysis problem, concerning the selection of an appropriate site for building a new European electric plant [11]. This is information about DM's preferences in operation with AHP method. Fig. 2 presents a window with information about DM's preferences in operation with PROMETHEE II method.

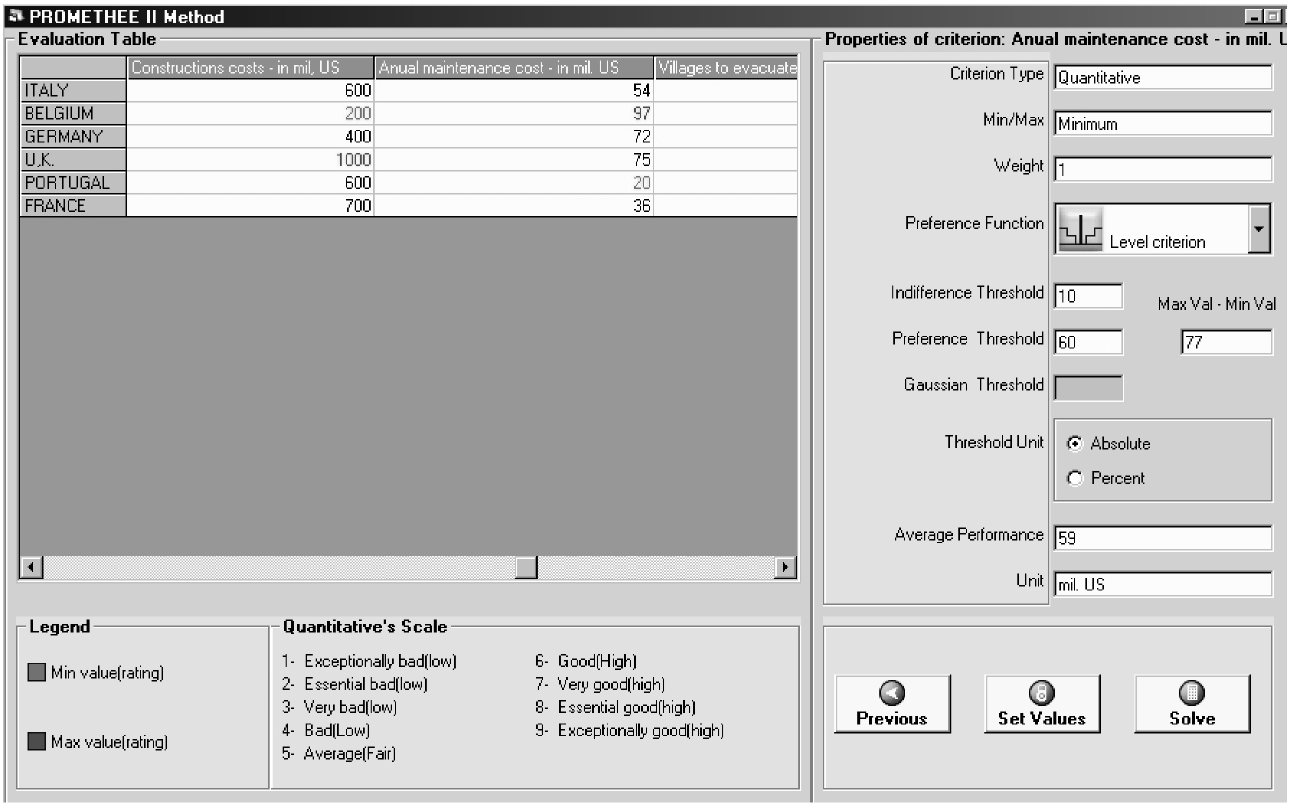

Fig. 2. *MultiChoice* PROMETHEE solving windows.

The interface with the DM is realized on the principle of an adviser – a sequence of windows (steps), each one with a distinctly expressed function, which considerably assists and facilitates DM's work. The DM has the possibility to move forward to a following step and also backward, returning for some corrections to the information already entered. The windows, which must be accessible in more than one stage of DM's operation with MADSS *MultiChoice*, are included in the menu or in the instruments band. *MultiChoice* possesses dynamic context help information. It gives a brief description of every visual component just by dragging the mouse over it. In addition to this a debug window is used, that outputs service information about the system internal processes. It can be printed out or stored in a text file. This allows the obtaining of exact debug information when an error occurs. MADSS *MultiChoice* enables the storing in a file of the input data for every multicriteria problem and of the data about the solution process. Thus the solution process of a multicriteria problem can be interrupted at any stage and activated from the place of its interruption at any time. MADSS *MultiChoice* has comparatively rich printing functions – every piece of the data (entered or computed) may be printed. In this way the entire process of decision making is documented – you can review the input data of the multicriteria problem, the DM's preferences entered, the current values obtained, and the final result also, which on its turn can be printed out in the form of values or graphics.

The system modules contain all global definitions of variables, functions and procedures of general purpose. The object possibilities of Visual Basic are utilized in

MADSS *MultiChoice*, creating several classes with respect to internal system structures. They are: a class for messages, which capsules the output of error messages, dynamic context help information and registering of events in the debug window; a class matrix with some specific procedures, necessary for AHP method, a class for storing the information specific for the criteria in PROMETHEE method and a class for storing elements of the interactive method history.

MADSS *MultiChoice* operates in two languages – Bulgarian and English. Each element of the interface modules is translated. The translation module is responsible for the immediate translation of all the visible components after a language is chosen. The translation module is thus organized that it allows the easy including and maintenance of other languages also. MADSS *MultiChoice* has a renewal function via Internet. In case there is information for a new version on the system site, the renewal function starts the installation procedure.

MADSS *MultiChoice* is a local software system, realized in Visual Basic programming language. It is designed to solve problems of multicriteria choice and multicriteria ranking. The future development of the system will be realized in two directions. The first direction is connected with the addition of new methods and particularly of multicriteria classification methods. The second direction refers to web-based versions of the system, enabling distant decision making.

CONCLUSION

MultiChoice multicriteria decision support system operates under MS Windows operating system and is intended to solve different problems of multicriteria analysis. The system is characterized by user-friendly interface with reference to the input data entry, the presentation of DM's local and global preferences, the output and documentation of the results obtained.

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