Web-based Interactive System for Multicriteria Decision Analysis

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Abstract – **The multicriteria decision analysis problems are decision problems, in which a finite number of decision alternatives are evaluated in terms of multiple conflict criteria. A web-based software system is presented in the paper, which implements an interactive optimizationally motivated method, appropriate for solving problems with a big number of alternatives. The information, which the decision maker (DM) has to set, includes the desired or acceptable changes in the values of some criteria and the desired or acceptable changes in the direction of other criteria. In this way the DM is able to manage the solving process of finding the most preferred solution, which makes him/her feel more confident in the final results obtained.**

Keywords – **Multicriteria decision analysis, Interactive method, Web-based system.**
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I. INTRODUCTION

In problems for multicriteria analysis (MA) (also called multicriteria problems with discrete alternatives), several conflicting criteria have to be simultaneously optimized in a feasible set of alternatives [20]. In the general case there does not exist one alternative which could be optimal for all the criteria. However, there does exist a whole set of alternatives, called non-dominated set of alternatives, which possess the following property: every improvement in the value of one criterion leads to deterioration in the value of at least one other criterion. Each alternative from this set is called a non-dominated alternative and can be the final Pareto optimal solution of the multicriteria analysis problem.

The multicriteria analysis problems can be formulated in different areas of resources management /financial, natural, etc./, communications, production, commerce, services, education and others. In these problems the set of alternatives usually consists of a not very large set of variants for choice, ordering or ranking. However, there also exist such, that might have hundreds of alternatives [4, 7]. In some MA problems the evaluations of the alternatives with respect to the criteria have got an uncertain value. The evaluations may be quantitative, qualitative or ranking.

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The methods for solving multicriteria analysis problems, developed by now, can be grouped into three groups. Each one of these methods has its own advantages and disadvantages, which are connected with the ways of setting the preference information, given by the DM.

The first class of methods includes the multiattribute utility theory methods [8] and the analytical hierarchy process (AHP) methods [16]. There are differences in the way in which the DM's global preferences are aggregated in the two subclasses of the methods. In the first one a generalized functional criterion is directly synthesized, whereas in the second subclass it could be said that such a criterion (additive form) is indirectly synthesized. The two subclasses of methods are based on the assumption that there does not exist limited comparability among the alternatives. They use a DM’s preference model, which does not allow the existence of incomparable alternatives and the preference information, obtained by the DM, is sufficient to determine whether one of the alternatives is to be preferred or whether the two alternatives are equal for the DM. The second class of methods are called outranking methods [1, 2, 14, 15] and they 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. In these methods the DM does not make comparison of the criteria or alternatives, but he/she has to provide the so called inter- and intra-criteria information. 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 [5, 9, 10, 12, 18]. The creation of this kind of methods for solving problems for multicriteria analysis has been inspired by some well-known methods for solving problems of multicriteria optimization. Their aim is to elicit and use implicit information about the decision maker's preferences in order to help steer the decision maker to his most preferred solution. An important result of the interactive process is that the DM can realize better the decision making problem which is to be solved, as well as enrich his/her knowledge about the preferences set, which he/she may alter during the process. The DM usually needs to modify his/her preferences in order to find solutions that are close enough to the goals (values of the criteria), that are both attainable and have trade-off between the criteria that fit the user preferences.

The usage of the different methods for solving real-life problems of multicriteria analysis depends not only on the efficiency of these methods, but also on the development of user-friendly software systems, in which these methods are implemented. The case studies with application of MADSS (multicriteria analysis decision support system) of general purpose (Expert Choice [17], HIVIEW [13], ELECTRE III-IV [15], PROMCALC and GAIA [2], Decision Lab [3], VIMDA [9]) are most often published. In them one method or several methods, which belong to of the above described group, are implemented. MADSS ensures successive approach of problem structuring – definition of the overall goal, of the essential criteria and alternatives, evaluation of each one of the alternatives with respect to every criterion, and it also aids the deriving of DM's preferences. The development of Internet communications and World Wide Web has considerably extended the possibilities for public interaction, interactive extraction of data and results exchange [19]. The first web-based general purpose MADSS, which provides instruments for structuring of problems, setting preference information and sharing of results over Internet, is Web-HIPRE [11]. Nowadays many researchers apply the methods they have developed in Internet environment [22].

A web-based software system, called Web-MKA, intended for multicriteria analysis, is presented in the current paper. The system is developed on the basis of the interactive partition-based method [12] and the system for multicriteria analysis MKA-1 [21], which operates in Windows environment. The system was developed, using Visual Studio.NET and programmed in Visual Basic. The architecture is client-server oriented. The system is easy-to-use software, which does not require deep knowledge in MA methodology. Users with different levels of qualification can easily enter their problems and set the preference information in terms of desired or acceptable changes of the values, directions or intervals of change of the values of some or all the criteria on the basis of comparisons with the current non-dominated alternative.

The rest of the paper is organized as follows: a short presentation of the main characteristics of the interactive partition-based algorithm for discrete multicriteria problems [12], which is the core of the web-based software system developed, is given in Section II. In Section III the architecture and functions of the Web-MKA software system is developed. The results achieved and the trends for future work are described in the last Section.

II. Features of the Interactive Partition-Based Algorithm

The multicriteria analysis problem is defined with the help of the so called $n \times k$ decision matrix $A = \{a_{ij}\}$, $i = 1,...n$, $j = 1,...k$, where I is a set of $n\,(>1)$ deterministic alternatives and J is a set of $k\,(\geq 2)$ criteria. The element a_{ij} of the matrix A denotes the evaluation of the alternatives $i \in I$ with respect to the criterion $j \in J$. From a mathematical point of view there exists a set of so called non-dominated or Pareto optimal solutions, and each of them could be the final solution of the multicriteria analysis problem being solved. The alternative $i \in I$ is called non-dominated if there is no other alternative $s \in I$, for which $a_{sj} \geq a_{ij}$ for all $j \in J$ and $a_{sj} > a_{ij}$ for at least one $j \in J$ (the confirmation is true, when maximal values for the criteria $j \in J$ are sought). From a practical point of view, the solving of a problem for multicriteria analysis is finding of one non-dominated alternative, which satisfies the preferences of the DM to the highest extent.

At every iteration of the interactive partition-based method [12], the DM has the possibility to choose from the current ranked set of the alternatives the one, which satisfies mostly his/her preferences (the most preferred alternative) or the current preferred alternative a_{hj}. In order to obtain the current ranked set, we use a Tchebychev type optimization scalarization problem that is a discrete analog of the scalarization problem, described in [22]. This scalarizing problem is based on the information given by the DM for the desired changes of the values for some or all the criteria in relation to their values in the current preferred alternative. The DM has to choose one from the following options:

- improvement by desired (aspiration) values Δ_{hj};
- improvement as a desired direction of change;
- acceptable deterioration by no more than δ_{hj};
- acceptable deterioration as a desired direction of change;
- the criteria value to lie within an interval, ($a_{hj} - t_{hj}^{-} \leq a_{hj} \leq a_{hj} + t_{hj}^{+}$) around the current value a_{hj}
- to either preserve or improve the current value of the criteria;
- the DM is indifferent about the value of these criteria and as such they may be altered freely.

Using this scalarizing problem, the alternatives are ranked in an increasing order by the value of the objective function of the scalarizing problem. The smaller the value of the objective function of a given alternative, the closer the alternative is to the preferences set by the DM. The first l alternatives in this ranking order establish the current set of alternatives that are shown to the DM for evaluation and choice of the current preferred alternative, where $l << n$ is specified by the decision maker. It is possible that there may not exist l alternatives that satisfy the requirements of the DM.

This interactive partition-based method uses the advantages of the interactive methods and provides opportunity for the DM to control the process of finding the most preferred alternatives choosing from sets of current ranked alternatives. The main advantage of the method is the reduced burden of the DM, connected with the necessity of direct comparisons of two or more alternatives at each iteration.

III. Structure and Functions of Web-Based System Web-MKA

The Web-based software system is developed, using MS Visual Studio .NET and MS SQL Express database server.

It contains three main modules:

- a user module - used to store user personal information, like names, contact information, login information, etc.;

- a solving module - used for the interactive process of solving multicriteria analysis problems;

- an archive module - used to store and keep all user defined problems and their decisions in the database for later revision or resolving.

The general system structure is given in Fig 1.

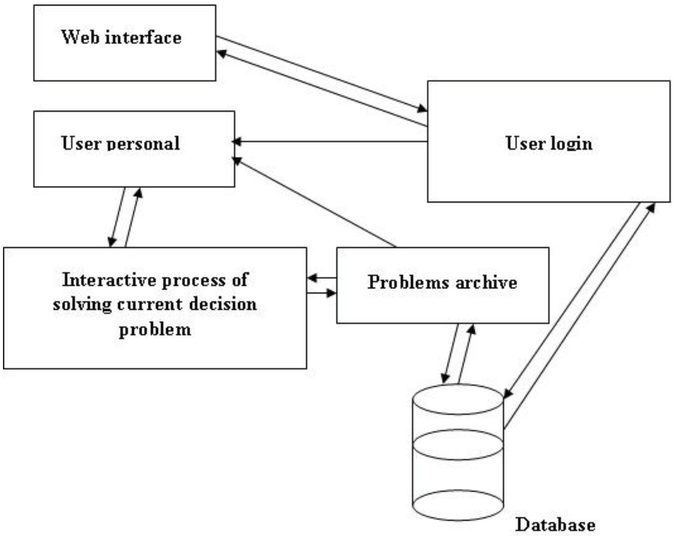

Fig. 1. Web-MKA system structure

The solving module contains a solving core that implements the interactive partition-based algorithm. When calculations are needed, all data information is formatted and passed to the solving core, which on its hand returns a current problem solution or a message that no feasible solution, satisfying the decision maker preferences, can be found.

In order to use the system, one must create a user account and log in the system entering the username and password.

The whole user account information, problem definitions and solving results are stored in the database.

The problem definition is done in a step-by-step manner, as the user enters all the alternatives and criteria types and values. When the definition is done, the solving process can be started. At this point all the information data about the problem is passed to the solving core of the system and an initial solution and ranking are generated and output to the user interface.

One solution contains the following information:

- the current preferred alternative;
- the current inadmissible alternatives;
- the minimal criterion value (rating) for each criterion in each alternative;
- the maximal criterion value (rating) for each criterion in each alternative;

Along with this information, full ranking of the alternatives is also generated and output to the user interface.

At this point, if the current solution satisfies the DM, the process can be stopped. Otherwise the user must define new preferences for each or some of the criteria and generate a new solution.

The decision making process can be described by the block scheme given below (Fig. 2):

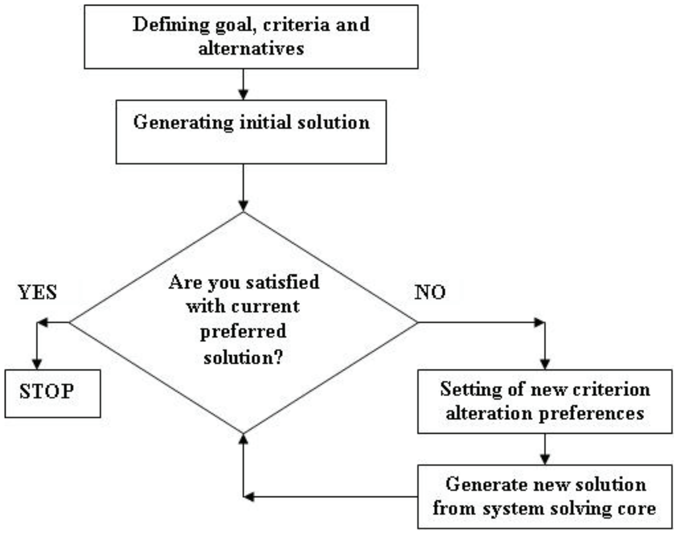

Fig. 2. The working process in Web-MKA

CONCLUSION

An on-line version of the software support system MKA-1, called Web-MKA, is presented in the paper. The architecture and the user interface are developed in such a way that assists the DM in learning about the problem and in evaluating systematically the set of alternatives. At every iteration the DM sets his/her preferences, not using comparison or estimation of the priority of the criteria, but applying a more understandable and easy way. He/she evaluates the current non-dominated alternative and sets the changes in the criteria values, which are acceptable for him/her. In this way the DM can express his/her wish with much more flexibility and select the final non-dominated solution of the problem being solved more confidently.

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