Multicriteria group decision support system "Group Multichoice"

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Abstract: *This paper presents a group multicriteria analysis decision support system called Group MultiChoice, designed to support decision makers in solving different multicriteria analysis problems in a group manner. 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: *group multicriteria analysis, group multicriteria decision support systems.*

INTRODUCTION

Multicriteria group decision support systems (MGDSS) are interactive software systems, designed to aid a group of decision makers (DM) in solving multicriteria problems for optimisation and analysis. These systems represent a logical continuation of multicriteria decision support systems (MCDSS) in cases of more then one decision maker responsible for making the decision. Such situations have started gaining popularity with the expansion of the Internet with more and more companies going multinational and more people working from home. Many different types of real life problems in management practice can be formulated as multicriteria analysis problems, for instance the problems of evaluation and choice of resources, strategies, projects, offers, policies, credits, products, innovations, designs, costs, profits, portfolios, personnel, etc.

In group solving of multicriteria analysis problems there are two main stages:

1. Getting ordering of non-dominated alternatives by every DM solving the problem for him/herself, according to their personal preferences;
2. Combining the personal orderings in one aggregated ordering and declaring the winner alternative.

In the first stage several criteria are simultaneously optimized in a feasible set of a finite number of explicitly given alternatives [13]. In general, there is not a single alternative that optimizes all the criteria. However, there is a subset of alternatives characterized by the following features: a.) Each improvement in the value of a criterion leads to deterioration in the value of at least one other criterion called a set of non-dominated alternatives; b.) Each alternative in this set could be a solution of the multicriteria problem; c.) In order to select an alternative, additional information is necessary, supplied by the so-called decision maker. d.) 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 (MAP). The methods can be divided into several groups [13], depending of the type of additional information required from the DM and the time of aggregating the individual preferences. Each of these methods has its advantages and disadvantages, connected mainly with the ways of receiving information by the DM relating to his/her preferences. The software systems supporting the group solvling of multicriteria analysis problems can be divided in two classes – software systems with general purpose and problem-oriented software systems.

General-purpose software systems are universal – every problem that can be formulated as a MAP can be solved by that kind of systems. Most of these systems implement more than one method for solving MAP and/or aggregating methods. This gives them flexibility regarding the qualifications of the DM, the specifics of the problem itself, the internal structure of the group of DMs and the time frame available for solving the problem.

Problem-oriented software systems are usually part of a bigger system. What is more, they are built-in modules supplying the Group Decision Support functionality. As a result, their interface is simplified and they are only able to solve a specific problem with the method best suited to it.

This paper describes the MGDSS Group *MultiChoice*, designed to model and solve group multicriteria problems of choice and ranking of alternatives. The first stage of the solving is covered by four methods for solving multicriteria analysis problems. The second stage is covered by four aggregating methods. The system has client-server architecture with user-friendly GUI for the client side and an easy-to-deploy server side. By featuring this four-by-four diversity of methods the system covers almost the entire spectrum of MAPs and group types.

MULTICRITERIA ANALYSIS METHODS

A multicriteria analysis problem can be described with a matrix of alternatives A (n x k)

k_j / a_i	$k_1(.)$	$k_2(.)$	…	$k_j(.)$	…	$k_k(.)$
a_1	a_{11}	a_{12}	…	a_{1j}	…	a_{1k}
a_2	a_{21}	a_{22}	…	a_{2j}	…	a_{2k}
...	…	…	…	…	…	…
a_i	a_{i1}	a_{i2}	…	a_{ij}	…	a_{ik}
..	…	…	…	…	…	…
a_n	a_{n1}	a_{n2}	…	a_{nj}	…	a_{nk}

table 1

where a_i denotes the alternative with index *i, i=1,…,n;*
k_j *(.)* denotes the criterion with index *j, j=1,…,k.*

The assessment of the i-th alternative regarding all criteria is described by the vector-row $(a_{i1}, a_{i2}, \dots, a_{ik})$.

The assessment of all alternatives regarding j-th criterion is described by the vector-colomn $(a_{1j}, a_{2j}, \dots, a_{nj})^T$.

Each criterion k_j is assumed to be either maximized - $\max k_j(a)$ or minimized - $\min k_j(a)$.

Generally there is not a single solution that simultaneously optimizes all *k* criteria. From a mathematical viewpoint there exists a set of so-called non-dominated, or Pareto optimal solutions, and this set is the solution of the multicriteria analysis problem. From a practical point of view, the solution of the multicriteria analysis problem is the finding of a non-dominated alternative, which satisfies the DM to the greatest extent.

A large number of the methods developed to the present can be grouped in three separate classes: weighing methods, outranking methods and interactive methods. Each of these classes of methods has its advantages and disadvantages connected primarily with the ways of deriving information from the DM regarding his/her local and global preferences. The main element of the weighing methods is the way of determining the criteria weights that reflect the DM's preferences to the highest degree. A number of methods for criteria weighing have been developed. A value trade-off method is proposed in [4]. Several versions of the analytic hierarchy process (AHP method) are developed in [9, 10], using pair-wise criteria comparison. The AHP is one of the simplest and most widespread methods as it is easy to comprehend and apply. However, it is not suitable for problems with many criteria due to the pair-wise comparison. The outranking methods use a DM's preference model that 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 compare the criteria and alternatives. However, he/she has to provide the so-called inter- and intra-criteria information. Some of the better-known representatives of the outranking methods are the ELECTRE I-IV methods [8], the PROMETHEE I-II methods [1], the TACTIC method [12], etc. In order to solve multicriteria analysis problems with a large number of alternatives and a small number of criteria, the "optimization motivated" interactive methods have been suggested [5, 11, 7, 6 and 3]. Instead of ranking all the alternatives at one step, they allow the DM to "swim in the pool of alternatives" working only with a small subset (window) of alternatives. This type of methods is suitable for ranking hundreds or thousands of alternatives.

AGGREGATING METHODS

Aggregating methods (AM) aim to combine individual orderings in an aggregated ranking. The initial point of the process is table 2.

E – a set of decision makers, also called experts
A – a set of alternatives
k – the number of alternatives
n – the number of experts
a_{ij} – the position of i-th alternative in the ranking of the j-th expert
a_{ic} – the position of the i-th alternative in the aggregated ranking
A^c – the aggregated ranking

	E_1	**E_2**	**...**	**E_n**
A_1	a_{11}	a_{12}		a_{1n}
A_2	a_{21}	a_{22}		a_{2n}
...	...	...	...	...
A_k	a_{k1}	a_{k2}		a_{kn}

Table 2

There are different types of AMs depending of the relationships of the experts. Some AMs suggest equality of the group members, others rely on a member with more power than the rest – the so-called Supra Decision Maker (SDM). When the aggregation of individual rankings in a single combined ranking is completed in one step, these methods are called aposterior.

However, the methods in which the process is split into steps are of greater interest. These are the so-called interactive methods. The GCBIM method is intended for an individual consultative style of decision making where the SDM takes the entire responsibility for the decision. The experts give their orderings, the aggregated ranking is calculated by one of the aposterior methods, the distance between every expert's ordering and the aggregated ranking or the SDM's ranking is calculated. The SDM chooses the starting point (in the set of alternatives) for the next iteration and the process continues until the SDM is satisfied with the current best alternative. The GCBIM method aids the SDM in finding the members of the expert group who deviate most from the average ranking.

In the BIMBEE1 method it is assumed that all group members are equal, have a single goal and there is no leader (a SDM). On each step an aggregated ranking is calculated and at the end of each ranking alternatives are dropped. The process stops when the number of remaining alternatives reaches a predefined threshold.

In the BIMBEE2 method it is assumed that the number of alternatives is of the order of hundreds and thousands and the number of experts is of the order of tens or hundreds. In this method experts can be in either role: a scout or a drone. In the BIMBEE2 no orderings are used. Experts cast votes for a certain alternative. Scouts use one of the multicriteria analysis methods for selecting the alternative currently preferred by the individuals and this alternative is added to the list of discovered alternatives. Drones vote for an alternative in this list. Every time an expert votes for an alternative he/she has already voted for, the weight of the vote is dropped by 25%. The process stops when there is an informal consensus that the current step should be the last (and the currently preferred alternative is the winner) or when there was no alternative for the last four steps.

In the GCBIM-NN method it is also assumed that all group members are equal, but they have contradicting opinions on how to solve the problem. In such cases it is important to find the focus of disagreement so that a consensus can be achieved. That is why in the GCBIM-NN a coefficient of agreement is calculated valuating the agreement regarding the position of a given alternative on a certain iteration. Alternatives with high degree of agreement are placed on their calculated positions, so that conflict alternatives are left for further investigation. When in several consecutive steps an alternative has no improvement in its agreement coefficient, it is placed on a free position, nearest to to the position of aggregated ranking for that step.

GROUP MULTICHOICE SYSTEMS

The MGDSS *Group MultiChoice* presented is this paper is a client-server system. The client is a Windows¨ application that implements four methods for solving MAPs – a weighing method (AHP), two outranking methods (PROMETHEE and ELECTRE) and an interactive method (CBIM)[7]. The criteria can be one of four types, which gives the users great flexibility in defining the MAP and expressing their preferences. These methods are the most widely used methods in each category. Method routines are modules of the client, so new methods can be easily added. A major effort has been put in the interface, as in multicriteria analysis the user is a part of the solving process and as a result the interaction between him/her and the system is of vital importance. This interaction includes the entry of the data for the multicriteria problems, the entry of information specific to every method, information about the DM's preferences, visualization of the current results and of the final result, graphical presentation of the solutions, print-outs, reading and storing of files, multi-language support, etc. The workflow is based on the wizard concept, so it is broken into steps, which increases the usability of the system. The DM has the possibility to move forward to a following step or to move backwards in order to make corrections to the information already entered. The windows, which must be accessible at more than one stage of the DM's operation with the MGDSS *Group MultiChoice*, are included in the menu or in the instruments band. *Group MultiChoice* possesses dynamic context help information. It gives a brief description of every visual component just by dragging the mouse over it. In addition, a debug window that outputs service information about the system internal processes is used. It can be printed out or stored in a text file. This allows the obtaining of exact debug information when an error occurs. *Group MultiChoice* enables the storing in a file of the input data for every multicriteria problem and of the data on the solution process. Thus the solution process of a multicriteria problem can be interrupted at any stage and activated at any time from the place of its interruption. The MGDSS *Group MultiChoice* has comparatively wide printing functions – every piece of the data (entered or computed) may be printed. In this way the entire process of decision making is documented – the DM can review the input data of the multicriteria problem, the entered preferences, the current values obtained as well as the final result, which in its turn can be printed out in the form of values or graphics.

The server part of the system is written in Python [4], making it a cross-platform. It does not have GUI and is rather easy to configure. The only parameters needed are the network interface and the port on which the system will run. It implements the GCBIM, BIMBEE1, BIMBEE2 and GCBIM-NN interactive methods and the Borda score aposterior method. The server part of the system provides the chat-functionality needed for informal communication between group members. A simple protocol for messages and values exchange gives the possibility for using different clients and even console telnet testing.

Group MultiChoice operates in two languages – English and Bulgarian. However, other languages can be added. The system can be updated via the Internet.

CONCLUSIONS AND FUTURE WORK

The future development of the system may include encrypting the data traffic between server and client, adding new methods in both server and client and supporting databases.

Group MultiChoice group multicriteria decision support system operates under a hybrid MS Windows/Linux environment and is intended to aid group solving of different multicriteria analysis problems. The system is characterized by a user-friendly interface with reference to the input data entry, the presentation of the DMs' local and global preferences, the output and documentation of the results obtained.

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