INTERACTIVE METHODS FOR GROUP DECISION MAKING

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Abstract: This paper aims to present new methods for group decision making that take into account different decision making styles and their implementation in decision making using the Group Multichoice system.

Keywords: decision support systems, group decision support, client-server, multicriteria analysis

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1. Introduction

Decision making problems are unformalized or weakly-formalized problems that in order to be solved require a decision maker (DM). The resulting solutions are subjective, depending on the DM's preferences. The decision making problems are divided into three major classes: multicriteria problems, decision making problems in risk conditions and decision making problems in uncertainty conditions.

Different tasks ranging from planning, management, analysis and control, transport, education to ecology, etc. can be formulated as multicriteria problems. Multicriteria problems are divided in two major classes depending on formal formulation. Multicriteria optimization problems are defined by a finite number of explicitly given functions, which describe an infinite number of alternatives. Multicriteria analysis gives a finite number of alternatives in table form.

In multicriteria analysis problems, a set of criteria are optimized simultaneously in an admissible set of alternatives. Generally, there is no alternative, optimal by all criteria (in this case the solution of the problem is trivial). For practical purposes, it is necessary to select only one alternative – with the help of additional information, extracted from the DM. According to the types of information given by the DM the methods are divided into: weighting methods, outranking methods and interactive methods.

With the development of information technologies, Internet and electronic communications more attention is paid to group decision making problems (GDMP). They are an extension to existing problems. However, in GDMPs the decision is not made by a single DM but a group of DMs, often referred to as experts. There are three different approaches, apriori, aposterior and interactive approach, for aggregating the information provided by the decision makers in GDMP. The methods implementing the apriori approach aggregate the DM's preferences. It is assumed that the group is working as one entity with one hierarchy. Different decision makers lose their identity and they are very consistent. The methods implementing the aposterior methods focuses the final result, final personal ranking of the alternatives of each decision maker where the rankings have to be aggregated in one final ranking. These methods are the crosspoint of multicriteria analysis and voting methods. In voting there are multiple decision makers and multiple alternatives/candidates and the task is to sort them in a priority list. Multicriteria analysis methods provide the personal rankings of the decision makers and voting methods provide the aggregation of the rankings in one final ranking.

So, the development of Internet-enabled decision support systems (DSS), supporting group decisions, is very important in the emerging information society.

In this context the main goal of this paper is to propose new interactive methods for group solving of multiple criteria analysis problems, suitable for different kind of organisational structures.

The rest if the paper is organized as follows. In sections 2 to 4 the author presents several group decision support methods. In section 5 classification of group decision support systems are made, in section 6 the group decision support system Group Multichoice is described and results are summarized in section 7.

2. GECBIM Method

This method is bases on the concept that the final ordering vectors received from each DM can be aggregated by solving a multicriteria problem in which all the criteria are ranging criteria. Like the qualitative criteria, the alternatives of ranging criteria have no numerical values. Like qualitative criteria, they have no verbal values. They are simply ordered (ranged) according to valie, weight, importance. The definition of the newly-created multi-criteria problem is Matrix A. The group leader solves the problem with the method, described below. Overtly or covertly, he/she may attribute different weight to the separate DMs. The decision of his problem shall be the ordering of the alternatives based on the orderings of the DMs taking part in the process and the leader's attitude to them. Thus the decisions are aggregated into a summerised solution.

	Expert 1	Expert 2	…	Expert n
Alternative 1	$v_{1,1}$	$v_{1,2}$	…	$v_{1,n}$
Alternative 2	$v_{2,1}$	…	…	$V_{2,n}$
Alternative 3		…	…	
Alternative 4		…	…	
Alternative 5		…	…	$V_{m,n}$

Matrix A

Definitions:

$K_h^{\geq o} \cup K_h^{>o}$ - is a set of ordering vectors with indexes $j \in R$, for which the leader want to increase their values compared to the values of the currently preferred alternative, where:

$K_h^{\geq o}$ - is a set of ordering vectors with indexes $j \in R$, for which the leader wants to improve their value by aspiration value - Δ_{hj} .

$K_h^{>}$ - is a set of ordering vectors with indexes $j \in R$, for which the leader wants to improve their value in the desired direction.

$K_h^{\leq o} \cup K_h^{<o}$ - is a set of ordering vectors with indexes $j \in R$, for which the leader agrees to deteriorate their values compared to the values of the currently preferred alternative, where:

$K_h^{\leq}$ - is a set of ordering vectors with indexes $j \in R$, for which the leader agrees to deteriorate their values by no more than δ_{hj} ;

$K_h^{<}$ - is a set of ordering vectors with indexes $j \in R$, for which the leader agrees to deteriorate their values in the desired direction;

$K^{\times}$ - is a set of ordering vectors with indexes $j \in R$, for which the leader wants their values in the interval $(a_{hj} - t_{hj}^{-} \leq a_{hj} \leq a_{hj} + t_{hj}^{+})$ compared to their values in the currently preferred alternative;

$K^{=}$ - is a set of ordering vectors with indexes $j \in R$, for which the leader does not want their values changed;

K^{0} - is a set of ordering vectors with indexes $j \in R$, for which the leader is indifferent;

$\bar{a}_{hj}$ - is desired aspiration level of ordering vectors with indexes $j \in K_h^{\geq}$:

$\bar{a}_{hj} = a_{hj} + \Delta_{hj}, \ \ j \in K_h$;

λ'_j – is the different between the minimal and maximal value of ordering vectors with index j:

$\lambda'_{ij} = \max_{i \in I} a - \min_{i \in I} a$.

With the notations defined above the scalarisation problem is:

$$(S): \min_{i \in I'} S(i) = \min_{i \in I'} \left\{ \max\left[\min_{j \in K_h^{\geq}} (a_{hj} - a_{ij}) / \lambda_j, \max_{j \in K_h^{\leq} \cup j \in K_h^{<}} (a_{hj} - a_{ij}) / \lambda_j \right] + \max_{j \in K_h^{>}} (a_{hj} - a_{ij}) / \lambda_j \right\},$$

with constraints:

$a_{hj} \geq a_{ij}$, $i \in \Gamma$, $j \in K_h^{>} \cup K_h^{=}$;

$a_{hj} \geq a_{ij} - \delta_{hj}$, $i \in \Gamma$, $j \in K_h^{\leq}$;

$a_{hj} \geq a_{ij} - t_{hj}^{-}$, $i \in \Gamma$, $j \in K_h^{\times}$;

$a_{hj} \leq a_{ij} + t_{hj}^{+}$, $i \in \Gamma$, $j \in K_h^{\times}$;

where:

$$\Lambda_j = \begin{cases} \varepsilon & ако \quad \Lambda'_j \leq \varepsilon, \\ \Lambda'_j & ако \quad \Lambda'_j > \varepsilon, \varepsilon > 0 \end{cases}$$

When solving the discrete optimisation problem S, the value S(i) is calculated for every alternative with index i, satisfying the constraints. Function S(i) represents the the distance between the alternative with index i and the aspiration alternative, using Tchebishev's metric.

3. Interactive Method for Group Decision Support GCBIM

The GCBIM method is designed for supporting group decision making in the individual consultative style (*1*). In this style the leader defines the problem and shares his vision with the members of the group. The leader solicits ideas regarding causes of problems and their potential solutions. The leader may also use these individuals' expertise in evaluating alternative solutions. Once this information is obtained, the leader makes a choice of the individual alternative solution which is to be implemented.

In the GCBIM method all decision makers are working in one and the same space of alternatives. In GCBIM it is the rankings, not the preferences that are aggregated and because of that the criteria by which the alternatives are evaluated can be different. The whole process of decision making is iterative. In the first iteration every DM starts with a given alternative and gives aspiration levels, directions and intervals of change and finally gets the ranking of the currently admissible alternatives.

All rankings are sent to the leader. He has solved the problem by himself and has a ranking of his own. When all decision makers send their rankings to the server, the aggregated ranking is calculated with the help of borda score. The leader determines “the chosen” ranking for this iteration by evaluating the rankings, which are closest to the aggregated ranking or to his/her ranking. If he is satisfied with the solution the process is terminated and the first alternative in the chosen ranking is the winner. If the current iteration does not give a solution which satisfies the leader, the process goes on with the next iteration where the best (first in the ranking) alternative in preferred ranking is taken as a reference alternative for the next iteration.

If a_{ij} is the position of the alternative *i* in the ranking of expert *j*; a_{ic} is the position of the alternative *i* in the aggregated ranking and λ_i – is the difference between the maximal and the minimal position on which alternative *i* is placed, then we are seeking $\min(\max(a_{ij}-a_{ic})/\lambda_i)$ which gives us the ranking closer to the aggregated ranking.

4. GCBIM-bee method

This method is inspired by the decision making process bees use when searching, evaluating and choosing a new hive, as described in (*2*).

This method is different from the previous one because it assumes that group goals are the same for all members of the group and they differ only in their vision of achieving these goals. In this method no leader is required, so it is suitable for leaderless team style. The process is iterative and the group work in turns, but instead of sending every ranking for aggregating, the experts can move trough several points in the alternatives space with the help of the CBIM method (*3*) before choosing an alternative to vote for in this turn. Every alternative already voted for is added to the list of "discovered" alternatives. If a DM votes for an alternative more then once, every time after first the weight of his vote is dropped by 15%. This stimulates the DM to search for other possible solutions (alternatives) and gives chance to later found alternatives. The DM can keep voting for one and the same alternative at every turn, but he/she can also choose other alternatives to vote for from the list of "discovered" alternatives.

A system implementing this method should offer a communication between decision makers and using this feature they should be able to "advertise" their currently preferred alternatives at every turn, so that other decision makers will eventually be able to choose an alternative to vote for.

Variant 1

At every iteration/turn alternatives with lowest borda score (the borda score is accumulated trough iterations) are dropped. The number of dropped alternatives may depend on the number of iterations already made, but this may not be necessary as this would mean to compensate for the initial "wandering" of the decision makers. However, this issue is resolved due to the fact that decision makers can make more than one step before finding an alternative to vote for.

Variant 2

After the number of "discovered" alternatives reaches a certain threshold the procedure goes on with the final iteration and experts choosing only among alternatives in the list of "discovered" alternatives. The final solution of the problem is the alternative, chosen at this iteration.

The GCBIM, GCBIM-bee 1 and GCBIM-bee 2 methods are intended for implementation in the Group Multichoice system, which already implements four methods for solving multicriteria analysis problems – one weighting method, two outranking and one interactive. The group decision support features are provided by the interactive GCBIM, GCBIM-bee1 and GCBIM-bee2 methods and one aposterior method, based on borda score powered aggregated ranking.

The GCBIM-noname method is designed for facilitating decisions in groups of type Participative Style, Leaderless group and Group consulting style. These type of decisions are based on the idea of equal rights of all participants in the decision process. This allows situations, where there are disagreements in the group and achieving satisfying decision is not possible. In these cases it is important to locate the focus of the disagreement and to be eventually discussed and overcome, and to achieve final decision on this part of the problem for which there is consensus. These goals are achieved by calculating the coefficient of agreement λ_i, which represents a measure of agreement for alternative with index I on a given iteration. To find it, first the table P is calculated:

	P_1	P_2	...	P_k
A_1	p_{11}	p_{12}		p_{1k}
A_2	p_{21}	p_{22}		p_{2k}
...	...	...	...	...
A_k	p_{k1}	p_{k2}		p_{kk}

Table 1

p_{ij} – how many times alternative with index i is positioned on position j

q_i – number of not empty position on row with index i in table 1

m_i – maximal value of row with index i in table 1

Then the coefficient of agreement is $\lambda_i = m_i / q_i$.

On each iteration the alternatives with agreement coefficient λ above given threshold are placed on their positions in the final ranking. This process actually sifts the "easy" alternatives -those, for which there is agreement for their position. For the rest there is obviously no consensus. Therefore discovering of these alternatives is important because:

- in the decision process takes part supra DM, for him/her is important to see this critical alternatives
- finding these alternatives helps experts to focus on critical alternatives
- in usual cases those are the alternatives headed for the first positions, otherwise the problem would be trivial.
- Makes calculating the overall agreement for an iteration easy: $\lambda = \sum_{i=1}^{n} [m_i / q_i]$

Definition:

An alternative A_i is conflict, if in t_k iterations its agreement coefficient λ_i does not improve. After t_k iterations without increase in its agreement coefficient the alternative is positioned on its place based on borda score. If the position is not empty, the alternative occupies the next free position.

5. Classification of group decision support systems

Decision support systems are divided in two major classes – universal systems and problem-oriented systems.

Depending on the number of the decision makers, the systems can be local, intranet and Internet-based. Local systems are installed on one computer and are used either by one DM, or (in group decision making) by a number of decision makers using the computer in turns. Intranet based systems are deployed in LAN environment, where every decision maker uses his/her own computer. Depending on the software architecture there can be a central server. The time for decision making/using the system is limited due to the use of telecommunication technologies for providing communication between the group participants. The minimum is a text chat, but audio or video conference lines are also recommended.

Internet based systems allow the team to be spread over a large geographic area. This systems has a central server used not only for relaying information but also for storing it, and that is what provides the opportunity for a decision making process extended over a longer periods of time. Every GDSS should provide two functions: communication and decision support.

6. Description of the *Group Multichoice* system

The system interface is designed as a wizard – a sequence of steps where each step is a logical operation. Every stage of the work with the system corresponds to one or more windows in the wizard. The DM is able to go forward or to go back in order to make some changes or to try another option.

Group Multichoice system operates in client or server mode. Every decision making session has only one server and all clients are connected to this server. The leader/group facilitator works with the server.

Group Multichoice offers dynamic context help. The user can get information for every element of the interface just by moving the mouse over it. The system operates in two languages – Bulgarian and English. Whole interface is translated and language can be switched at every stage of working with the system. The translation module is designed in a way that makes adding new languages easy. The system performs automatic software updates if Internet connection is available when it is started.

7. Conclusions and Future Work

GCBIM, GCBIM-bee1 and GCBIM-bee2 are interactive method for solving group decision making problems of multicriteria analysis. Their application covers large part of the specter of different decision making styles.

Group Multichoice is an experimental software system, supporting group decision making and solving multicriteria analysis problems. The system implements four methods for this class of problems and four methods for supporting group decision making. The group decision can be taken in autocratic style with advisors or in democratic style, when all participants are equal. The systems allows network communication, provides user-friendly interface and rich help information. Every decision maker is able to reach a final result using HIS/HER preferred method.

Future work targets the development of commercial system, implementing the presented methods.

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