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COMPUTER BASED MEDIATION SUPPORT

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Abstract

The paper presents and discusses techniques of mediation support in multicriteria bargaining situations. The techniques consist in application of interactive learning procedures aiding analysis of the problem and derivation of mediation proposals. An interactive mediation procedure inspired by the Raiffa ideas of negotiation support is described. Application of the technique in case of international cooperation referring to acid rains problem is discussed.

Key words: decision support systems, negotiations, bargaining problem.

1 Introduction

In the paper techniques of negotiation support, in particular mediation support, with use of a computer based, decision support system are discussed. A class of bargaining situations is considered in which there are several parties - players, each having multiple objectives and conflicting interests, and there is also one mediator trying to lead them to a consensus, aiding in finding an agreeable solution.

The problem is formulated in a case of n players. Each player has a given number of decision variables and a given number of criteria measuring his outcomes. The criteria can be minimized or maximized, and are in general conflicting and different for each player. It is assumed that a computerized model of the bargaining situation (called the substantive model of the game) has been developed with some specific interpretation in real life. The model should describe in mathematical relations outcomes of the players as dependent on their decision variables. Using the model a set of outcomes should be derived that can be obtained by the players under their unanimous agreement. The set is called as an agreement set. It is assumed, that there exist outcomes in the agreement set, that are mutually beneficial for all the players in comparison to a disagreement point (the disagreement point describes the outcomes of all the players in a case the agreement is not reached). In such a case the players have an incentive to cooperate. The bargaining problem consists of selection of a point from the agreement set that would be accepted by all the players. The players can of course differ in their opinions which point in the agreement set should be selected, therefore a consensus can be reached, looked for by a negotiations process.

The problem presented above has two decisive aspects. First - each player deals with his own multicriteria decision making problem defined in his multicriteria space, and the problem consists in looking for outcomes being possibly close to his preferences. Second - the players outcomes are mutually dependent, and therefore there is a question how to divide the benefits resulting from a cooperation. The decision support in the above problem is meant as an interactive process in which a computer based system aids the players in the analysis of the bargaining situation, and in the selection of an agreeable solution from the agreement set. In the second case a mediation support is considered.

In general, the proposed decision support approach consists in application of an interactive learning procedure aiding the players in the problem analysis as well as in the mediation process. The procedure links iterative solution concepts in multicriteria bargaining and aspiration led approach in multicriteria decision making.

2 Example concerning acid rains problem

Let us consider n countries disputing programs reducing sulfur emissions. Each country is assumed to have an adopted plan for emission control and expects the emission level $\underline{E}_i$. However it is also assumed that the deposition levels resulting from the $\underline{E}_i, i = 1,2$ are regarded as unacceptable, therefore an additional emission control program is requested and expenditures required for the program are discussed.

For each country $i = 1,2,\ldots,n$ there is a given cost function $f_i(E_i)$ describing minimal required total cost C_i of reducing the total emission from the level $\underline{E}_i$ to the level E_i. The function is assumed to be decreasing and piece-wise linear. Formally the relation between the cost and the emission can be described by the inequality $C_i \geq f_i(E_i)$.

The sulfur depositions in country i is described by the equation:

$$D_i = \sum_{j\in N} a_{ij}E_j + \underline{D}_i,\ i = 1,2,\ldots,n$$

where

$N = \{1,2,\ldots,n\}$ is the set of the considered countries,

$a_{i,j}$ $(i,j = 1,2)$ are the parameters of the atmospheric transportation matrix (in case of Europe so called European Monitoring and Evaluation Programme matrix),

$\underline{Q}_i$ are depositions resulting from the emission of the countries other then the belonging to the set N.

This simple example has been developed under inspiration of the RAINS model (Alcamo, Show, Hordijk, 1990).

The following two cases can be considered.

The first case deals with independent actions of the countries. In this case each country is assumed to enforce independently his additional program reducing sulfur emission.

Paying $\overline{X}_i = \overline{C}_i$, it achieves the emission $\overline{E}_i$ and deposition $\overline{D}_i$ calculated with use of the cost function and the deposition equation (where $\overline{C}_i$ is the cost of the assumed program).

In the second case a cooperation of the countries is assumed, in the form of a multilateral agreement on a joint reducing program. In this case a joint fund is created which should be spent for the joint reducing program to be beneficial to all the countries. Let X_i denote a share in the joint fund, that is paid by the country i. However in comparison to the first case the expenditures C_i spent for the reducing program in particular country can be in general different than the paid share X_i. We assume that each country tries to minimize the sulfur deposition D_i, and the share X_i. The minimization holds subject to the following constraints:

$$C_i \geq f_i(E_i)\ i = 1,2,\ldots,n$$

$$D_i = \sum_{j=1,2,\ldots,n} a_{ij}E_j + \underline{D}_i,\ i = 1,2,\ldots,n$$

$$\sum_{i \in N} X_i = \sum_{i \in N} C_i$$

where: X_i, $i = 1,2,\ldots,n$ are shares of the countries in the joint fund,
C_i, $i = 1,2,\ldots,n$ are expenditures spent for reducing the emissions in particular countries.

In this case we deal with a multiparty (n countries), multicriteria optimization, with the variables: tbe expenditures C_i and the emission levels E_i, $i \in N$. The constraints above create a simplex in the space defined by the depositions D_i and the shares X_i of all the countries $i \in N$ (i.e. in the $2n$ dimensional multicriteria space). Let us denote the simplex by S, and introduce a set S_+ to be defined by

$$S_+ = \{((X_i)_{i \in N}, (D_i)_{i \in N}) :$$

$$X_i \leq \overline{X}_i, D_i \leq \overline{D}_i, i = 1,2,\ldots,n \ for\ all\ ((X_i)_{i \in N}, (D_i)_{i \in N}) \in S\}$$

If S_+ is not empty, it describes benefits tbe countries can achieve as an effect of the cooperation in comparison to the first case. Then there is an incentive to cooperation.

The bargaining problem consists of looking for an efficient solution in the set S_+ being the agreement set, which is the subset of the simplex S, of all points dominating the point $d = ((\overline{X}_i)_{i \in N}, (\overline{D}_i)_{i \in N})$ seeing the disagreement point (status quo point).

Results of simulation runs of the RAIN model shown that the cooperation is really effective, saving costs and efforts. Therefore there is a set of outcomes that are beneficial to all the countries (the agreement set is nonempty) in comparison to the noncooperation case (described by a disagreement point), and it is not simple to specify the outcome that should be selected as a solution. Tbe bargaining problem consists of looking for an efficient solution in the agreement set. The solution should be selected according to the preferences of the players representing the countries, and should be unanimously accepted. Roughly speaking, the problem consists in proper, agreeable to all the countries, allocation of the benefits resulting from the cooperation. We assume that the problem is solved through a negotiation process in which the players and a neutral mediator take part. Decision support in the process is proposed in form of an interactive mediation procedure.

3 Interactive mediation procedure

The interactive mediation procedure has been proposed under inspiration of the single negotiation text procedure described by Raiffa (1982), and of the principle of limited confidence Fandel (1979) and Fandel, Wierzbicki (1985).

The single negotiation text procedure has been originally proposed by Roger Fisher and is often employed in international negotiations. It was used for example in the case of Camp David negotiation. According to the procedure rules, the mediator prepared packages for the consideration of protagonists. Each package was meant to serve as a single negotiation text to be criticized by the both sides, then modified and remodified, in an interactive manner. The single negotiation text was to be used as a mean of concentration the attention of the protagonists on the same composite text. The negotiation process had started from the first single negotiation text which had been far from the expectation of the protagonists. The process was progressive, i.e. each subsequent text improved outcomes of each of the protagonists.

The principle of limited confidence has been proposed as a result of observations of the players behavior in iterative gaming experiments. It says that the players having limited confidence to the substantive model of the game and to the future consequences of their moves try to limit possible improvements of the counterplayers.

The proposed mediation procedure consists in creation of an interactive process in which a sequence of single text outcomes is generated and presented to the players. It is constructed on the base of the following preassumptions:

1. The process starts at a disagreement point.
2. The process is progressive.
3. The process should lead to an efficient outcome in the agreement set S.
4. Each player can limit possible improvements of the counterplayers according to the limited confidence principle.
5. Each player behaves rationally trying to optimize his outcomes in particular rounds according to his preferences.

The iterative mediation procedure has been formulated in form of an algorithm which has been implemented in MCBARG system. The algorithm consists of a number of rounds. Each round starts from the current status quo point (the first round starts from the initial status quo point).

In each round the system supports the players in unilateral, interactive analysis of the problem with stress on learning. Each player can independently scan possible outcome variants according to the rules of aspiration-led approach of multicriteria decision support, for different assumptions on the counterplayers preferences or decisions, and for different assumptions about the possible improvements of counterplayer outcomes due to the limited confidence principle. After the scanning the player is also asked to select his preferred outcome.

The preferred outcomes of all the players are basis for calculation of the result of the round. The result is calculated following the limited confidence principle, improving outcomes of all the players according to the outcomes specified as the preferred ones.

The result of the round can be considered as a single negotiation text proposed to the mediator and to the players, forming a basis for the next round of negotiations. The result can be treated by the players as a status quo point in the next round of negotiation with the system support. The process terminates when the Pareto optimal solution in the agreement set is reached.

Formulation of such an interactive process has been preceded by a theoretical research (Krus 1991, Krus, Bronisz 1991a) on the solution concepts that could be utilized in the procedure. A fairness of the solution is considered according to the theory of bargaining problem (Nash 1950, Roth 1979, Kalai, Smorodinsky 1975, Thomson 1980, and others) in terms of axioms describing behavior and feelings of the players. To assure fairness of the solutions, such properties as independence of linear transformations of objectives, anonymity of players and criteria, monotonicity, players rationality, have been considered. Generalized Raiffa-Kalai-Smorodinsky solution has been proposed based on the concept of utopia point related to the players aspirations. The solution is calculated according to the players preferences. The solution has some nice properties. It is resistant on the players manipulations. The solution has been applied in the interactive process based on the above preassumptions. Uniqueness and convergence of the process has been proved, under typical, not restrictive assumptions.

Such a procedure has been implemented in the MCBARG system (Krus, Bronisz, Lopuch, 1990). The system has been used in experiments with human players for the simplified model presented above. In this paper extensions of the procedure and possible developments of the system will be discussed.

4 Conclusions

The proposed technique of negotiation support consists in application of a computer based decision support system. The system is considered as a tool that enables the players to learn and analyze their bargaining situations, to learn their preferences and attitudes. It makes possible structuring of the negotiation process. In the process the system supports also the mediator calculating single negotiation texts to be analyzed modified and remodified by the players. The research on the negotiation support in the multicriteria, bargaining situations is at the beginning stage, however it seems that the direction is really promising.

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