MULTICRITERIA DECISION SUPPORT FOR PROBLEMS WITH NUMEROUS AND STRUCTURED CRITERIA

Bartosz Kozlowski* **and Wlodzimierz Ogryczak****

Warsaw University of Technology, Institute of Control & Computation Engineering, 00-665 Warsaw, Poland
e-mails: `B.Kozlowski@elka.pw.edu.pl` and `W.Ogryczak@ia.pw.edu.pl`

Keywords: multicriteria optimization, decision support, reference point method, numerous structured criteria

1. PROBLEM

This paper elaborates on how to deal with multicriteria decision problems characterized by structured criteria. This problem is not new but no satisfactory solution procedure is known. For instance, in the case of discrete set alternatives with large number of criteria the AHP approach was utilized but no solution was found which properly addresses numerous criteria of different kinds (Solnes, 2003).

Let a set of decision alternatives $\mathbf{D}$ be known (either finite or infinite given implicitly by constraints) on which there is a defined set $\mathbf{C}$ of criteria numbered by i ($i \in \mathbf{I}$; $\mathbf{I} = \{1, 2, ..., i, ..., I\}$). Each criterion $c_i \in \mathbf{C}$ ($\mathbf{C} = \{c_1, c_2, ..., c_i, ..., c_I\}$) assigns a real value to each of decision alternatives, $c_i : \mathbf{D} \to R$. Criteria are are organized in a multilevel hierarchy $\mathbf{H}$. Values of those c_i which correspond to end nodes in the hierarchy are known. For all other nodes there is a need to define respective c_i functions. Indeed, for each criterion c_i from set of decision alternatives known for each of J_i existing subordinate nodes, that is of the form $c_i' : \mathbf{D} \to R^{J_i}$, where $c_i'(d) = (c_{j_1}(d), c_{j_2}(d), ..., c_{j_{J_i}}(d)),\ d \in \mathbf{D}$, it is necessary to convert to the form $c_i : \mathbf{D} \to R$. Performing the above defined task requires acquiring for each node (those which have subordinate nodes) a solution in "its" multicriteria space and presenting to the stakeholder to obtain guidelines considering preferences of the DM (decision maker).

* Partially done within the IME Project in IIASA, Laxenburg, Austria.

** Partial financial support from The Ministry of Science and Information Society Technologies under grant 3T11C 005 27.

2. REFERENCE POINT METHOD

The Reference Point Method (RPM) is an interactive technique implementing the so-called quasi-satisficing approach to multiple criteria decision problems developed mainly by (Wierzbicki, 1982) as the reference point method. The reference point method was later extended to permit additional information from the DM and, eventually, led to efficient implementations of the so-called aspiration/reservation based decision support (ARBDS) approach with many successful applications (Lewandowski and Wierzbicki, 1989). The basic concept of the interactive scheme is as follows. The DM specifies requirements in terms of reference levels, i.e., by introducing reference (target) values for several individual outcomes. Depending on the specified reference levels, a special scalarizing achievement function is built which may be directly interpreted as expressing utility to be maximized. Maximization of the scalarizing achievement function generates an efficient solution to the multiple criteria problem. The computed efficient solution is presented to the DM as the current solution in a form that allows comparison with the previous ones and modification of the reference levels if necessary.

The RPM is based on the so-called augmented max-min aggregation of individual achievements, i.e. the worst individual achievement is essentially maximized but the optimization process is additionally regularized with the term representing the average achievement. This simple scalarization function performs very well for the limited number of criteria while deserving special reconstruction to take into account the multilevel structure of criteria.

3. RPM FOR NUMEROUS AND STRUCTURED CRITERIA

The concept of the solution process gets down to (iterative) execution of following tasks:

Algorithm 3.1: rpmnsc( )

for each $node$
- **if** $node$ has subordinate nodes
  - **then** mark it as active
  - **else** mark it inactive

repeat
- **for each** $node$ with all subordinates active
  - establish function c_i (based on subordinate criteria, multicriteria methodologies, and interaction with a user)
  - mark all subordinate nodes as inactive
  - mark processed $node$ as active

until no $node$ with active subordinates exists

Appropriate identification of the preferences of the DM is a critical aspect of an optimization problem. The optimal solution is useless (sometimes even maleficent) if preferences of DM have been badly identified. In case of big number of criteria, the method identifying preferences has to consider limited time and patience of DM. Especially, that it has to be done for every non-end node separately. Free choice of method has to be limited to these, which save the DM a workload. One of such methods might be identification of DM's preferences based on 'sample' of DM preferences and the approximation preferences on set of all possible decision alternatives. In addition 'sample' itself should be prebuilt as much as possible on objective preference points (obtained without DM participation) to allow for a DM to point out his own preferences against the background of these objective ones in a relatively easy way. In other words, the method should define some rational solutions and its criteria values (objective satisfaction levels) and next should identify DMs opinion concerning points between those levels. Based on objective satisfaction levels and DM points, the approximation of preferences on the whole set of decision alternatives is possible to be done. Proposed method suggests usage of typical RPM achievement functions based on aspiration and reservation levels (Granat et.al., 2006) as well as a novel concept of the solidarity point. What is important is that the method can be used on every level of hierarchical structure criteria.

Further, the regularization by the average achievement is easily implementable but it may disturb the basic max-min model in the case of large number of criteria. The only consequent regularization of the max-min aggregation is the lexicographic max-min (nucleolar) solution concept where in addition to the worst achievement, the second worst achievement is also optimized (provided that the worst remains on the optimal level), the third worst is optimized (provided that the two worst remain optimal), and so on. Although within the multilevel criteria structure rather an analytic approximation to the nucleolar regularization must be used.

In this work we focus on a case study which deals with alternatives from energy technologies domain characterized by economic, environmental, and social criteria. Two separate sets of alternatives are considered in this work. The first consists of about 50 general technology alternatives. The second one contains ca. 50 so called system expansion scenarios combining these technologies. It also is quite possible that by the way of specifying preferences stakeholder points restrictions which will appear to be a basis for definition of a new scenario. In general case process is iterative not only as it comes to specifying preferences but also in redefining the set of alternatives.

REFERENCES

Solnes, J. (2003): Environmental quality indexing of large industrial development alternatives using AHP. Environmental Impact Assessment Review, vol. 23 (3), 283–303.

Granat, J., M. Makowski and A.P. Wierzbicki (2006): Hierarchical Reference Approach to Multiple Criteria Decisions and Objective Ranking. IIASA, Laxenburg, 2006.

Lewandowski, A. and A.P. Wierzbicki (1989): Aspiration Based Decision Support Systems – Theory, Software and Applications. Springer, Berlin.

Wierzbicki, A.P. (1982): A Mathematical Basis for Satisficing Decision Making. Mathematical Modelling, vol. 3, 391–405.