Multi-Criteria Decision Making: An overview of different selection problems and methods

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Abstract— **This Article presents an overview of different selection problems of Multi-Criteria Decision Making and their methods. Multi-Criteria Decision Making contains different methods which has been useful in almost all problems related with decision making. The typical Selection problem deals with the evaluation of a set of alternatives in terms of a set of decision criteria.**

In this paper section I presents brief introduction of Multi Criteria Decision Making, Section II presents widely used Multi Criteria Decision Making methods, Section III and IV presents selection problems in Cloud Computing and other area respectively with its applied Multi Criteria Decision Making method.

Keywords—**Cloud Computing, MCDM, Selection problem,Methods.**

I. INTRODUCTION

Multiple criteria decision making (MCDM) is a process that allows to make decisions in the presence of multiple, usually conflicting criteria. The problems of MCDM can be broadly classified into two categories:

- **Multiple attribute decision making (MADM):** MADM involves the selection of the "best" alternative from pre-specified alternatives described in terms of multiple attributes;
- **Multiple objective decision making (MODM):** MODM involves the design of alternatives which optimize the multiple objectives of Decision Maker (DM)

Multi-Criteria Decision Making is a useful tool in many economical, manufacturing, material selection, military, constructional, etc. problems specifically plays an important role in fields of investment decision, project evaluation, economic benefit evaluation, Staff appraisal and so on. So far many techniques have been proposed to solve multiple attribute decision making problems. Multi-Attribute Decision Making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker. Making a decision implies that there are alternative choices to be considered and in a such case we won't only to identify as many of these alternatives as possible but to choose the one that best fits with our goals, objectives, desires, values and so on.

The remaining paper is structured as follows: In the next section we give detailed survey of Multi-criteria decision making techniques. In section III and IV we describe selection problems in other area and cloud computing respectively and Finally, Section V concludes this paper.

II. SURVEY OF VARIOUS MCDM TECHNIQUES

Following are the effective MCDM methods which will be used to analyze the problem and to find out best alternative.

1. Analytical Hierarchy Process(AHP)

One of the most popular techniques for complex decision-making problems is the analytic hierarchy process (AHP) developed by Saaty, which decomposes a decision-making problem into a system of hierarchies of objectives, attributes (or criteria), and alternatives. An AHP hierarchy can have as many levels as needed to fully characterize a particular decision situation. A number of functional characteristics make AHP a useful methodology. These include the ability to handle decision situations involving subjective judgments, multiple decision makers, and the ability to provide measures of consistency of preference. Designed to reflect the way people actually think, AHP continues to be the most highly regarded and widely used decision-making method. AHP can efficiently deal with tangible (*i.e.*, objective) as well as non-tangible (*i.e.*, subjective) attributes, especially where the subjective judgments of different individuals constitute an important part of the decision process [1].

Strengths:

- The advantages of AHP over other multi criteria methods are its flexibility, intuitive appeal to the decision makers and its ability to check inconsistencies. Generally, users find the pair wise comparison form of data input straightforward and convenient.
- The AHP method supports group decision−making through consensus by calculating the geometric mean of the individual pair wise comparisons.

Weaknesses:

- With AHP the decision problem is decomposed into a number of subsystems, within which and between which a substantial number of pair wise comparisons need to be completed. This approach has the disadvantage that the number of pair wise comparisons to be made, may become very large (n(n−1)/2), and thus become a lengthy task.
- Another important disadvantage of the AHP method is the artificial limitation of the use of the9−point scale. Sometimes, the decision− maker

might find difficult to distinguish among them and tell for example whether one alternative is 6 or 7 times more important than another.

2. Technique of Order Preference by Similarity of Ideal Solution(TOPSIS)

This method is based on the concept that the chosen alternative should have the shortest Euclidean distance from the ideal solution, and the farthest from the negative ideal solution. The ideal solution is a hypothetical solution for which all attribute values correspond to the maximum attribute values in the database comprising the satisfying solutions; the negative ideal solution is the hypothetical solution for which all attribute values correspond to the minimum attribute values in the database. TOPSIS thus gives a solution that is not only closest to the hypothetically best, that is also the farthest from the hypothetically worst [1].

Strengths:
- It takes input as any number of criteria and attributes.
- Fairly intuitive physical meaning based on consideration of distances from ideal solutions.

Weaknesses:
- Easy, can give unreliable results.
- TOPSIS in its standard form is deterministic and does not consider uncertainty in weightings.

3. ViseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR)

It determines the compromise ranking list, the compromise solution, and the weight stability intervals for preference stability of the compromise solution obtained with the initial (given) weights. This method focuses on ranking and selecting from a set of alternatives in the presence of conflicting criteria. It introduces the multi criteria ranking index based on the particular measure of "closeness" to the "ideal" solution [2].

Strengths:
- The best alternative is preferred by maximizing utility group and minimizing regret group.
- VIKOR method calculates ratio of positive and negative ideal solution; thus, VIKOR method proposes a compromise solution with an advantage rate.

Weaknesses:
- The performance rating is quantified as crisp values.
- Under many circumstances, crisp data are inadequate to model real-life situation. In addition, in case of conflicting situations or criteria, a decision maker must also consider imprecise or ambiguous data.

4. Elimination Et Choice Translating REality (ELECTRE)

ELECTRE method is used for choosing best actions from a given set of actions, but it was applied to three main problems: choosing, ranking and sorting. It evolved into ELECTRE I and the evolutions have continued with ELECTRE II, ELECTRE III, ELECTRE IV, ELECTRE IS and ELECTRE TRI (electre tree).

There are two main parts to an ELECTRE application:
- The construction of one or several outranking relations, which aims at comparing in a comprehensive way each pair of actions.
- An exploitation procedure that elaborates on the recommendations obtained in the first phase. The nature of the recommendation depends on the problem being addressed: choosing, ranking or sorting.

Strengths:
- Allows using fuzzy analysis because thresholds of indifference and preference.
- Accepts qualitative and quantitative criteria.

Weaknesses:
- It is difficult to understand, because of the principles used in determining the concordance and discordance matrices.
- Thresholds can be calculated from these metrics, but are often established according to DM opinion which translates into subjectivity.

5. Preference Ranking Organization METHods for Enrichment Evaluation (PROMETHEE)

PROMETHEE method is based on mutual comparison of each alternative pair with respect to each of the selected criteria. The evaluation table is the starting point of the PROMETHEE method. In this table, the alternatives are evaluated on the different criteria. These evaluations involve essentially numerical data.

The implementation of PROMETHEE requires two additional types of information, namely:
- Information on the relative importance (i.e., the weights) of the criteria considered
- Information on the decision-makers preference function, which he/she uses when comparing the contribution of the alternatives in terms of each separate criterion.

The PROMETHEE is most useful where groups of people are working on complex problems, especially those with several multi-criteria, involving a lot of human perceptions and judgments, whose decisions have long-term impact. It has unique advantages when important elements of the decision are difficult to quantify or compare, or where collaboration among departments or team members are constrained by their different specializations or perspectives.

The PROMETHEE-I provide a partial ranking of the actions and if needed a complete ranking is obtained by PROMETHEE-II [3].

Strengths:
- PROMETHEE (as all outranking methods) can simultaneously deal with qualitative and quantitative criteria.Criteria scores can be expressed in their own units.
- *PROMETHEE needs much less inputs.*

Weaknesses:
- PROMETHEE suffers from the rank reversal problem when a new alternative is introduced
- PROMETHEE does not provide the possibility to really structure a decision problem. In the case of many criteria and options, it thus may become difficult for the decision maker to obtain a clear view of the problem and to evaluate the results.

III. MCDM FOR SELECTION PROBLEMS IN OTHER AREA

Multi Criteria Decision Making provide a convenient, faster way for user to make decision and get final result of the decision by showing best alternative based on the most important criteria.

Multi-Criteria Decision Making is a useful tool in many economical, manufacturing, material selection, military, constructional, etc. problems specifically plays an important role in fields of investment decision, project evaluation, economic benefit evaluation, Staff appraisal and so on.

Following Table shows Selection problems in other area and their applied Multi Criteria Decision Making Method.

Table 1: Selection problems in other area

No.	Selection problems in other area	Applied MCDM Method
1	Machine Tool selection	TOPSIS[15]
2	Selection of Electrical Energy Supplier	ELECTRE[16]
3	Network selection in a heterogeneous wireless network environment	ELECTRE[17]
4	Selection of robot	TOPSIS[18]
5	Safety evaluation in Power supply enterprises	ELECTRE,TOPSIS [19]
6	Choosing e-Learning Platform	ELECTRE[20]
7	Selection of Appropriate Structural System	PROMETHEE[21]
8	Identify best location for call center	TOPSIS,VIKOR[22]
9	Measuring Object Oriented Software Quality	AHP,PROMETHEE [23]
10	Product Development	AHP[24]

IV. MCDM FOR SELECTION PROBLEMS IN CLOUD COMPUTING

Cloud computing has recently attained considerable importance as anew computing paradigm and has become tremendously popular. Consistent with this trend, the number of available cloud services is continuously growing. However at the same time it is important to note that cloud services differ from one another in specification, pricing policies, performance and several other attributes which makes it challenging for service users to select service.

Following Table shows different selection problems and their applied Multi Criteria decision method:

Table 2: Selection problems in cloud computing

No.	Selection Problems in Cloud Computing	Applied MCDM Method
1	SaaS vendor selection	AHP [4]
2	IaaS Cloud Selection	All MCDM methods[6]
3	Adoption of Cloud Computing	SAW,TOPSIS[7]
4	Evaluation of user behavior trust	AHP[8]
5	Selection of SaaS product	AHP[9]
6	Customer Centered Cloud service selection	AHP[10]
7	Task scheduling and Resource Allocation	AHP[11]
8	Distribute Load balancing Allocation	TOPSIS[12]
9	Managing Information Security in Cloud Computing	AHP[13]
10	Ranking of cloud computing Services	AHP[14]

V. CONCLUSION

An attempt has been made in this paper to review and analyze different multi criteria decision making methods. The paper highlights different application areas where multi criteria decision making methods are used. Table No.1 and Table No.2 shows different selection problems in Cloud Computing and other area respectively and their applied multi criteria decision making technique.

Although the searching for finding the best Multi Criteria Decision Making method for selection problems may never end. Research in this area is critical and valuable.

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