A REVIEW ON MULTI-CRITERIA DECISION MAKING METHODS FOR CLOUD SERVICE RANKING

[1]Saroj S, [2]Dileep V K
[1]M.Tech Student, [2]Assistant Professor
[1]Departmentof Computer Science and Engineering,
[1]LBS Institute of Technology for Women, Thiruvananthapuram, India

Abstract— In this paper, we present an overview of different Multi-Criteria Decision Making methods and an evaluation of cloud services based on these techniques. The Multi-Criteria Decision Making (MCDM) contains various methods including AHP, SMI, TOPSIS, ELECTRE, PROMETHEE, outranking method, etc. which are useful for almost all problems related with decision making. The Selection problems are deals with the evaluation of set of alternatives in terms of a set of decision criteria. Different type of techniques are there to evaluate the cloud services and each of which having their own specifications. We can use these methods for the implementation of various applications and services in the field of cloud computing. In this paper we presents brief introduction of Multi Criteria Decision Making and discussed about the widely used Multi Criteria Decision Making methods and finally the evaluation of the cloud services by using MCDM.

Index Terms—Cloud Computing, Cloud Service, Multi-Criteria Decision Making Methods (MCDM)

I. INTRODUCTION

Cloud computing is emerging technology that refer to internet based application development and their services. Currently, it is the strong adoption in the IT market and this trend is expected to continue. Therefore we have to consider about the risks and costs in integration with different Cloud Services available in the market. But the problem is that the decision makers in the organizations do not know how to evaluate the available Cloud services which are offered by different cloud service providers. Cloud Computing ensure to deliver all the functionality of existing services [1].

There are different MCDM methods to evaluate the available cloud services. The Multiple criteria decision making (MCDM) [2] can be defined as a process that allows to make decisions in the presence of multiple conflicting criteria. MCDM is a useful tool in many fields including defense, education, economic, IT and other industries etc. The main goal of the Multi-Attribute Decision Making is to identify and choose the alternatives based on the values and preferences of the decision maker. Making a decision means that there are alternative choices to be considered. And in such cases we won't only to identify as many of these alternatives as possible but to choose the one that best fits with our requirements.

II. VARIOUS MULTI-CRITERIA DECISION MAKING (MCDM) METHODS

There are a number of effective MCDM methods that can be used to analyze the problem and to find out the best alternative. Decision has inspired the reflection of many thinkers since ancient times. MCDA [2] methods are considering multiple criteria in the decision-making environments. Typically multiple conflicting criteria are needed to be evaluated for making decisions in organizations. Cost is usually one of the main criteria in all organizations together with measure of service quality that conflicts with the cost. Various MCDM methods are discussed below;

1. Multi-Attribute Value Theory (MAVT)

The main goal of MAVT is to construct a means of associating a real number with each alternative in order to produce a preference order on the alternatives consistent. MAVT approach generates preferences that are required to be consistent with a strong set of axioms. The preference of the component modeling is achieved by constructing a marginal value functions for each criteria. A fundamental property of the partial value function must be that the alternative is preferred to *b* in terms of criterion *i* if and only if *vi (a) > vi (b).* The core feature of MAVT is that the properties required of the partial value functions and the forms of aggregation used are critically interrelated.

2. Multi-Attribute Utility Theory (MAUT)

Multi-Attribute Utility Theory (MAUT) is an extension of Multi-Attribute Value Theory, related to the use of probabilities and expectations to deal with uncertainty. This method based on different sets of axioms that are appropriate for use in different contexts. MAUT is the simplest method that combines various preferences in the form of multi-attribute utility functions (MAUF). In MAUT, the utility functions for each criterion are combined with weighted functions. The advantage of using MAUT is that the problem is constructed as a single objective function after successful assessment of the utility function. Thus, it becomes easy to ensure the achievement of the best compromise solution based on the objective function. MAUT is an elegant and useful model of preference suitable for applications involving risky choices.

3. Outranking Methods

Outranking methods can directly applied to partial preference functions, which are assumed to have been defined for each criterion. These preference functions may correspond to natural attributes on a cardinal scale, or may be constructed in some way, as ordinal scales and do not need to satisfy all of the properties of the value functions, only the ordinal preferential independence would still be necessary. In

Outranking methods, for two alternatives *a* and *b*, where $zi(a) \geq zi(b)$ for all criteria *i*, we can say that *a* outranks alternative *b* if there is sufficient evidence to justify a conclusion that *a* is at least as good as *b*, taking all criteria into account.

4. Analytical Hierarchy Process (AHP)

The AHP [3] is a method for MCDA developed by Saaty, 1980. It is the most popular techniques for complex decision-making problems. And AHP has in its implementation many similarities with multi-attribute value function (MAVF) approach. Both approaches are based on evaluating alternatives in terms of an additive preference function. In this method it decomposes a decision making problem into a system of hierarchies' criteria. I.e., the initial steps in AHP are to develop a hierarchy of criteria and to identify alternatives. Then, it will do pair wise comparisons in comparing alternatives with respect to the criteria, to generate numerical scores for each level of performance. Alternatives are not differentiated from criteria, but are treated as the bottom level of the hierarchy and all comparisons follow the same procedure. Values for each alternative are derived from those of the absolute performance levels for each criterion to which it most closely corresponds. The numerical values used by AHP are a scale of 1 to 9 as follows;

- 1-Equally preferred
- 3-Weak preferred
- 5- Strong preferred
- 7-Demonstrated preferred
- 9- Absolute preferred

Intermediate values are used when DM hesitate between two of the descriptors. Once all pairs of alternatives have been compared this way, the numeric values corresponding to the judgments made are entered into a pair wise comparison matrix. To determine a set of relative priorities amongst *n* alternatives, only $n - 1$ judgment are in principle needed. Then, it is necessary to synthesizing these judgments in a comparison vector. A vector of relative preferences is determined by comparing the alternatives with respect to each of the criteria at next level of the hierarchy. The next step is to compare all criteria, which share the same parent using the same pair wise comparison procedure, deserving a vector indicating the relative contribution of the criteria to the parent. The decision making is asked to compare the criteria and working aggregates the judgments upwards from the bottom of the hierarchy.

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

The concept under TOPSIS is 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 for all type of problems.

6. Elimination Et Choice Translating Reality (ELECTRE)

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). The parts of ELECTRE applications are; 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.

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

PROMETHEE [1] 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 of the criteria considered and 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.

III. COMPARITIVE STUDY

In this section we summarize some of the Multiple Criteria Decision Making methods. Table 1 shows that the comparison between different MCDM methods with their strength and weakness.

MVDM Method	Strength	Weakness
Multi-Attribute Value Theory (MAVT)	• Preference order on the alternatives consistent in MAVT construct a real number with each alternative.	-
Multi-Attribute Utility Theory (MAUT)	• Probabilities and expectations are used to deal with uncertainty • Elegant and useful model for applications involving risky choices.	-
Outranking Methods	• Can directly applied to partial preference functions	-
Analytical Hierarchy Process (AHP)	• More flexible • Pair wise comparison form of data input straightforward and convenient for users	• Decomposition problem-substantial number of pair wise comparisons needs to be completed. (n(n−1)/2) • Difficulty with 9-point scale
TOPSIS	• It takes input as any number of criteria and attributes • The physical meaning consider the distances from ideal solutions	• Unreliable results for user • Not considering the uncertainty in weightings
ELECTRE	• Choosing best actions from a given set of actions • Construct one or several outranking relations • Support fuzzy analysis • Accepts qualitative and quantitative criteria	• Difficult to understand • Concordance and discordance matrices are used
PROMETHEE	• Simultaneous deal with qualitative and quantitative criteria • Need less number of inputs	• Suffers from the rank reversal problem • Do not provide the possibility to really structure a decision problem

IV. CONCLUSION

There are many cloud service providers. To choose the best one from the available services, the customers need to have a way to identify and measure key performance criteria that are important to their applications. Currently there is no standard framework for ranking service for the customers to select the appropriate provider to fit their application and the advanced reservation mechanism which provides the customers to access their services at a right time. Several researchers have proposed different methods for the resource management and service provisioning in cloud computing. Traditional methods only based on single value attributes. Multi-Criteria Decision making methods helps the selection of service with multiple attributes. Each methods having specific features and used in different applications are discussed in this paper. And also we have done a comparative study of various MCDM methods with the strengths and weakness given in the table.

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