A Hybrid Approach for Web Service Selection

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Abstract – Web service selection which is specified to evaluate and select the best candidate from discovered Web services became one of the most significant topic in recent research on Service oriented Architecture (SOA). Indeed, current approaches are not sufficient enough to overcome Web service selection problems. Due to the nature of Web service selection, it is important to lead it to Multi Criteria Decision Making (MCDM). However, there are several MCDM methods such as AHP, ANP, TOPSIS and VIKOR. In this paper we propose a hybrid approach to solve Web service selection problem. First, we apply Analytical Hierarchy Process (AHP) to evaluate the weights of criteria instead of collect the weights directly from service consumer. In the next tread, we use VIKOR (VIšekriterijumsko KOmpromisno Rangiranje) to identify and rank the appropriate candidate services. Finally, in order to demonstrate the proposed method we have afforded an example using four criteria of QoS and five alternative services.

Keywords: Web Service, Web Service Selection, MCDM, AHP, VIKOR.

1. Introduction

Nowadays, web services are one of the most widely used groups of SOA and service computing. A lot of organizations and companies develop applications which are accessible through Internet. Therefore, the capability of selecting correctly and combining inter organizational and various services at runtime on the Web is an significant issue in the Web Service applications development [1].

One of the most significant current discussions in SOA is Service Selection which should evaluate discovered services and choose the best candidate from them. Web Service Selection is appears when there is a set discovered Web Services that can fulfill the user's requirements; one of these services should be selected to return back to service consumer [2].

When more than one Web Service which meets functional requirements is available, the Web Service Selection uses some criteria to select the best candidate service. It is essential that this selection is tailored to the users preferences while one user may have need of high quality another may require low price [3]. The value of non functional properties in these matching Web Services may be different, but essentially they should have minimum requirements. The selection criteria may have an interdependent relationship together.

A number of methods for decision making are addressed in Web Service Selection because of the complication that exists during the selection process. [4]. Two significant tasks in the process of using services are selection and ranking in which every solution for them is affected directly on description of services. During describing a service, three items have to be considered: behavior, functional, and nonfunctional. The non functional properties (QoS) of the services are used as criteria for selecting services.

On one hand, the majority of service selection techniques apply QoS and on other hand behavior of QoS based service selection, let researchers to lead service selection problem to Multi Criteria Decision Making (MCDM). There are some MCDM techniques that this paper presented VIKOR to solve service selection problem to identify best candidate service [5].

The VIKOR is a method for multi criteria optimization of complex systems. "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" [6]. Ranking and selecting from a set of alternatives in the presence of conflicting criteria is goal of this method. VIKOR addresses the multi criteria ranking index based on the particular measure of "closeness" to the "ideal" solution [7]. VIKOR is a useful method in Service Selection problem based on MCDM because it can be work on situation where the preference of user is not clarified at the beginning of selection process.

First of all the decision matrix is arranged based on QoS criteria and alternative services and the weights of each criterion will be gathered based on user preference then the VIKOR method will be applied. Consequently, based on the preference of service requester obtainable services will be ranked.

The remainder of this paper is structured as follows: Section 2 outlines the related works of the Web Service Selection based of MCDM; in Section 3 the proposed approach and applying on Service Selection are discussed; Section 4 illustrate the method by an arithmetic example; Section 5 is conclusion of this paper in which the future works for Web Service Selection are discussed.

2. Related Works

There are some Service Selection researches based MCDM [8], [9], [10], [11], [3], [12], [13], [14]. We investigate these researches based on some criteria such as User preference, Automation, Scalability, and aggregation function. These criteria are addressed in previous work [15].

Wang et al [8] present a model to select the exact web service based on user's preference. This model is a fuzzy decision making model that also will be used by independent third-party in an experimental QoS environment in the Internet to distinguish web service level for web service providers and lend a hand to requesters to make the right selection.

In order to assist service providers and requesters with consideration of their preferences, Huang in [9],[10] attempt to propose a method based on fuzzy group decision making with respecting to Similarity Aggregation Method (SAM). Although the Aggregation method in MCDM is addressed, aggregation function and user preference are missed in this research.

Kerrigan [3] presents a vision of Service Selection mechanisms in the WSMX that addressed the decision making in manual, automated, and hybrid selection methods. This paper did not address such criteria as aggregation function user preference and scalability in Service Selection mechanism.

Toma et al [12] proposes a multi criteria ranking approach for web services selection. First the ontological models are applied on non functional properties (QoS) then they used to specify the rules. These rules are evaluated by ranking method evaluates by a reasoning engine and finally a ranked list of services will be generated based on user preference. Also the scalability is addressed in this paper. But regarding the automation there is no information in this research.

For the selection of a logistic service provider (LSP) Ying et al [13] present a comprehensive methodology based on ANP and VIKOR. As it is an important aspect to choose the best logistics service provider for logistics management, it is divided two components. ANP is addressed to assure weight of criteria and in second division the VIKOR method is applied to solve MCDM problem.

Lo et al [14] apply fuzzy TOPSIS method for solving the service selection problem with respect of user's vision. First for estimating the weights of each criteria the linguistic terms stands for triangular fuzzy numbers are exploited then the fuzzy TOPSIS is applied to resolve the MCDM problem in service selection.

In this paper the AHP method is used to evaluate weights of criteria and VIKOR method is applied to resolve the service selection problem in view of decision making. In the research first the pair wise comparison matrix is arranged then we apply AHP to reach weights of criteria. Moreover, the decision matrix based on QoS criteria and a set of alternative services is generated and finally the VIKOR method is concerned.

3. Proposed Approach for Web Service Selection

In this section we proposed our approach. In this approach, as shown in Figure 1, first the weighting of criteria will be evaluated by the AHP and then for decision making we use the VIKOR method. The steps of our approach are shown in below:

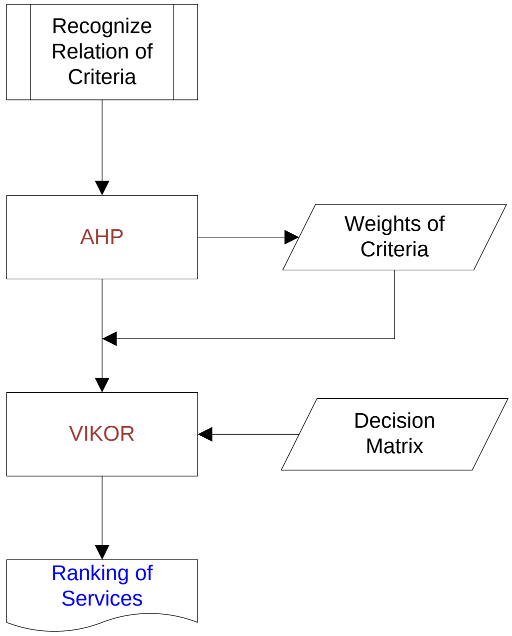

Figure 1 Process of the Proposed Approach

3.1. Weighting of Criteria by AHP

AHP is a process for developing a numerical score to rank each decision alternative based on how well each alternative meets the decision maker's criteria [16]. In this paper, we explain briefly how to apply AHP for finding the weighs of criteria and explaining of the formulas in more details is out of the scope of this paper. AHP is a pair wise comparison method that each criterion is comparing to each other and gets the score with respect to Table 1:

Table 1. Standard Preference Table

PREFERENCE LEVEL	NUMERICAL VALUE
Equally preferred	**1**
Equally to moderately preferred	**2**
Moderately preferred	**3**
Moderately to strongly preferred	**4**
Strongly preferred	**5**
Strongly to very strongly preferred	**6**
Very strongly preferred	**7**
Very strongly to extremely preferred	**8**
Extremely preferred	**9**

The criterion that has better level will get the numerical number mentioned in the table and the other will get the reciprocal of the value. To evaluate weights of criteria a matrix should be created; based on the definition the sample of matrix for three criteria is shown below:

	A	B	C
A	1	x	1/y
B	1/x	1	1/z
C	y	z	1

Figure 2: Matrix for evaluating weights of criteria

In the following the steps of AHP are described:

Step1: sum all the values in each column.
Step2: The values in each column are divided by the corresponding column sums.
Step3: Convert fractions to decimals and find the average of each row. This sum is corresponding to weight of the criterion of the row.

3.2. Decision Making by VIKOR

In this section we focus on how to apply VIKOR on Service Selection. VIKOR method is suitable for the system which the preferences of criteria are not clear at the beginning of system and it can compromise the result during the process of system.

To propose the method on service selection we suppose that there are *m* alternative services $(A_1, A_2, A_3, \ldots A_m)$ with respect of *n* criteria $(C_1, C_2, C$ which are used for evaluating the decision matrix:

$$d = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{bmatrix} C_1 & C_1 & \cdots & C_1 \\ \hline X_{11} & X_{12} & \ldots & X_{1n} \\ X_{21} & X_{22} & \ldots & X_{2n} \\ \vdots & \vdots & & \vdots \\ X_{m1} & X_{m2} & \ldots & X_{mn} \end{bmatrix}$$

The steps of VIKOR method on service selection are as follows:

Step 1. As the scales of each criterion are not equivalent the decision matrix should be normalized, while the scales of "Response time" and "Cost" are different. For this purpose VIKOR method uses linear normalization. In VIKOR method once the scale of criteria will be changed the result is stable because the linear normalization. In Eq. (1), (2) the normalization formulas are shown:

$$S_i = \sum_{j=1}^{n} w_j \left(\frac{X_j^* - X_{ij}}{X_j^* - X_j^-}\right) \tag{1}$$

And

$$R_i = \underset{j}{Max}\left[w_j \left(\frac{X_j^* - X_{ij}}{X_j^* - X_j^-}\right)\right] \tag{2}$$

Where $X_{i,j}(i = 1,2,3,\ldots, m\ and\ j = 1,2,3,\ldots, n)$ are the elements of the decision matrix (alternative *i* respect to criteria *j*). are best and worst elements in criteria *j* respectively and represents the weights of criteria *j* (relative importance).

Step 2. Compute the index values. These index values are defined as:

$$Q_i = \begin{cases} \left[\dfrac{R_i - R^-}{R^+ - R^-}\right] & \text{if } S^+ = S^- \\ \left[\dfrac{S_i - S^-}{S^+ - S^-}\right] & \text{if } R^+ = R^- \\ \left[\dfrac{S_i - S^-}{S^+ - S^-}\right] v + \left[\dfrac{R_i - R^-}{R^+ - R^-}\right](1 - v) & \text{Otherwise} \end{cases} \quad (3)$$

Where

$$S^- = Min\, S_i \,, S^+ = Max\, S_i \quad (4)$$

And

$$R^- = Min\, R_i \,, R^+ = Max\, R_i \quad (5)$$

In the formula, v is introduced as a weight for the strategy of "the majority of criteria" (or "the maximum group utility"), whereas 1- v is the weight of the individual regret. The value of v lies in the range of 0_1 and these strategies can be compromised by v=0.5.

Step 3. The results are three ranking lists. By sorting the values S, R, and Q in decreasing order.

Step 4. Propose as a compromise solution the alternative which is the best ranked by the measure Q (minimum) if the following two conditions are satisfied:

***C1*. Acceptable advantage:**

$$Q(A^{(2)}) - Q(A^{(1}$$

Where $A^{(2)}$ is the alternative with second place in the ranking list by *Q*; DQ. *M* is the number of alternative services.

***C2*. Acceptable stability in decision making:** The alternative should also be the best ranked by *S* or/and *R*. A set of compromise solutions is proposed as follow, if one of the conditions is not satisfied:

Alternatives $A^{(1)}$ and $A^{(2)}$ if only the *C2* is not satisfied, or

Alternatives $A^{(1)}, A^{(2)}, \ldots, A^{(M)}$ if the *C1* is not satisfied; $A^{(M)}$ is determined by the below relation for maximum *M.*

$$Q\left(A^{(M)}\right) - Q\left(A^{(1)}\right) \prec DQ$$

The service which has minimum value of Q is the most excellent alternative. The core ranking result is the compromise ranking list of alternative services, and the compromise solution with the "advantage rate"[6].

4. Illustrative Example

In this part, an example is concerned to illustrate the VIKOR method and how to apply it on service selection. We assume that there are five alternative services with respect to four criteria. These criteria are most popular criteria based on QoS and these are: *Response Time, Security, reliability, and Cost.* The relationship between the criteria and alternatives can be seen in Figure. 3:

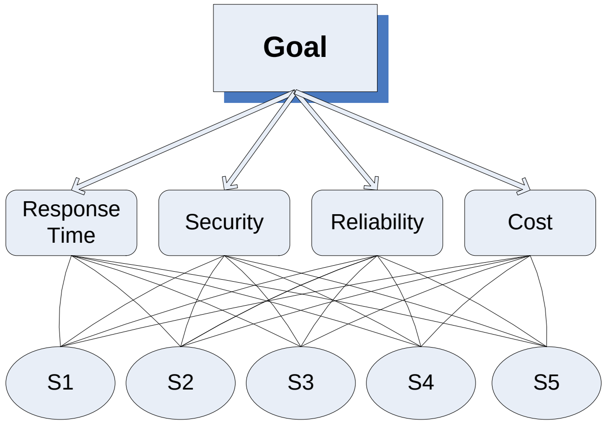

Figure 3. Relationship between Criteria and Services

There are some solutions to evaluate the weights of criteria: 1) from the feedback of service requester whom used the service before [15]; it calls Trust & Reputation method 2) it can be evaluate by some decision making method that in this research we apply AHP method. We do pair wise comparing between criteria and the below matrix is the result of the comparison with respect to Table 1.

Table 2. Pair wise Comparing Matrix

	R.T	Security	Reliability	Cost
R.T	1	1	3	2
Security	1	1	2	1
Reliability	1/3	1/2	1	1
Cost	1/2	1	1	1

Based on the above table we apply steps1-3 in section 3.1 and the weights of criteria are as follow:

$$W_1 = 0.37; W_2 = 0.15; W_3 = 0.28; W_4 = 0.20$$

In the second step we must apply VIKOR as a MCDM method. We assume that based on above example the data of five alternatives with respect of four QoS criteria is gathered and the decision matrix is prepared based on the example:

Table 3. Decision Matrix with reverence to the QoS Criteria

Criteria / Alternatives	Response Time	Security	Reliability	Cost
A1	0.590	0.255	0.665	0.135
A2	0.745	0.745	0.500	0.955
A3	0.410	0.665	0.745	0.410
A4	0.665	0.410	0.590	0.500
A5	0.135	0.745	0.865	0.335

Right now the necessary feeds for the VIKOR method is ready, so in the following based on given example, we show how VIKOR method can resolve a MCDM problem in area of Service Selection:

First S_i and R_i will be computed, but as some of criteria are negative (*Response Time*, *Cost*) and some are positive (*Security*, *Reliability*) the calculating and comparing these criteria together is complex effort, thus the decision matrix should be normalized, and the normalized matrix can be seen in Table 4:

Table 4. Normalized Decision Matrix

Criteria / Alternatives	Response Time	Security	Reliability	Cost
A1	0.746	1	0.548	0
A2	1	0	1	1
A3	0.451	0.163	0.329	0.335
A4	0.869	0.648	0.753	0.445
A5	0	0	0	0.244

Right now, the data in matrix are normalized and it means that there is no different between the type of criteria and all data are in same scale. In this situation there is possibility of comparing data together. After normalization, S_i and R_i can be calculated based on Eq. (1) , Eq. (2):

$$S_i = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \end{matrix} \begin{bmatrix} 0.638 \\ 0.720 \\ 0.329 \\ 0.715 \\ 0.049 \end{bmatrix} \quad \& \quad R_i = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \end{matrix} \begin{bmatrix} 0.280 \\ 0.370 \\ 0.167 \\ 0.321 \\ 0.049 \end{bmatrix}$$

Followed by the index values is computed but before that S^- , S^+ , R^- , and R^+ be supposed to calculate by Eq. (4) and Eq. (5). S^- is the minimum value and S^+ is the maximum value in table S also R^- and R^+ are minimum and maximum value in table R .

$$S^- = 0.049\,, S^+ = 0.720 \quad \& \quad R^- = 0.049\,, R^+ = 0.370$$

At this time based on the above matter the can be accessible. is the index value for ranking the alternatives; it can be calculated based on Eq. (3). Below the and are shown:

$$Q_i = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \end{matrix} \begin{bmatrix} 0.799 \\ 1 \\ 0.392 \\ 0.920 \\ 0 \end{bmatrix} \quad \& \quad Q_{sorted} = \begin{matrix} A_5 \\ A_3 \\ A_1 \\ A_4 \\ A_2 \end{matrix} \begin{bmatrix} 0 \\ 0.392 \\ 0.799 \\ 0.920 \\ 1 \end{bmatrix}$$

Step4. In this part we check whether the *C1* and *C2* are satisfied? For this point, first we calculate the *DQ* then use the Eq. (6):

$$0.392 - 0 \geq 0.25$$

The *C1* is satisfied and *A3* has best situation in S_i and R_i so condition *C2* also is satisfied. At this time we can confirm that service alternative *A3* is the best option with respect to criteria of QoS and weight of them. The final ranking list is shown below:

$$A_5 \succ A_3 \succ A_1 \succ A_4 \succ A_2$$

5. Conclusion

In this paper, first we have studied the most prominent related researches and we propose a hybrid approach to support Web service selection. In our previous work [5], however, we have collected the weights of criteria directly from service requester. The evaluation of relative importance of weights of criteria has not been considered. In this paper, although, the data related to weights of criteria are gathered from user, we address AHP method for evaluation weighting of criteria instead of using the preference of service consumer without evaluation. Subsequently, the VIKOR method is addressed as a MCDM method to tackle service selection problem. Finally, the VIKOR method is applied step by step to overcome service selection problem in the view of MCDM. Moreover, in order to demonstrate how normalization of proposed method works and how it can be applied on service selection, we provide an example using QoS criteria and some other alternative services. The result shows that our approach can select the best and most related candidates.

Acknowledgment

This research is supported by Ministry of Higher Education (MOHE) Malaysia and RUG at Universiti Teknologi Malaysia (UTM) by Vot No. 00H68.

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