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Efficient Selection of QoS Based Web Services using Modified TOPSIS Method

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***Abstract**: Nowadays, due to the ease of availability of internet technology large numbers of people are using the World Wide Web. The companies are changing their way to do business. They are shifting from a data-oriented system to a service-oriented system. Now companies are able to depict their business in the form of web services and make them available on the internet. Due to this number of web services are available for satisfying the user's need. But to select the best web service that satisfies user specification is a challenging issue. So, it is necessary to consider not only the functional requirement of the web services but also the nonfunctional requirements of the web services. On the other hand, users are not able to specify the exact nonfunctional parameter requirements so, there is a need for QoS processor which can understand the user's need and can extract the parameters for QoS. In this paper, a modified TOPSIS approach based on MCDM is proposed for the selection of efficient web service. The web services that are near to user expectations are selected out using the proposed method. Experimental outcomes show that the proposed approach determines the most promising results.*

***Index Terms**: Quality of Service (QoS), Universal discovery Description and Integration (UDDI), Web service Description Language (WSDL), Ontology Web Language (OWL), Simple object Access Protocol (SOAP), Multi criteria based Decision making (MCDM)*

I. INTRODUCTION

In the modern era, the web service technologies are playing a crucial role in the development of BTB and BTC applications. The companies like Facebook, Google, and Amazon use web services to provide simple access to their resources and also allow third parties to reuse their web services. Most common example of web service is OLA and Uber cab. As both the companies want to track their cabs around the user who want to book a cab. They use Google map service to track the movement of their cabs. But due to exponential growth of internet technology huge amount of information is accessible for the user. Most of the web services provide the same functionalities, due to this reason it is very difficult for the user to identify the right one among them. So, there is a requirement to focus also on the nonfunctional aspect of the web services.

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The nonfunctional aspect of the web services includes response time, throughput, availability, reliability, etc. Web services are self-contained, self described, distributed, dynamic, modular applications that can be published, located, or invoked across the web [2][3]. Web services use the standard protocol for communication such as XML, SOAP, WSDL, and UDDI [9]. In the process of web service discovery, the main requirement is to find the web services according to the user's need. Generally the process of web service discovery is done through the match making between the query fired by the user and the available web services descriptions. The services can be discovered either on the basis of keyword based approach or semantics match based approach. Sometimes it may be possible that the discovered web services could be similar based on their functionality but they may differ on the basis of their nonfunctional parameters. So, there is a need to provide a mechanism that concentrate on nonfunctional issues during the selection of web services. Web service framework is generally characterized into three main components as shown in Fig.1 [19]. These components often do interaction between each other. A Service provider is the actual implementer of the web services and makes it available on the internet by publishing it into the registry. A Service requester is the actual user which actually uses the already available web services in the registry. The Web service registry is a directory of services.

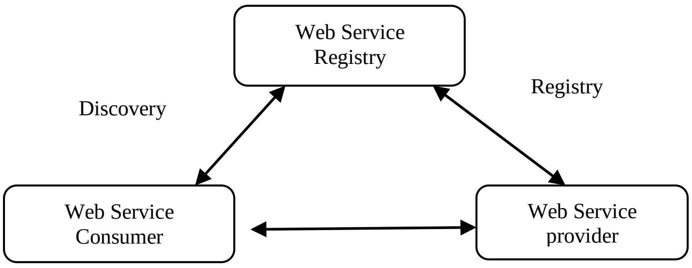

Figure 1: Web service framework

The centralized directory such as UDDI is sometimes used to represent the functional aspect of the web services. But being a keyword based approach it suffers from the limitation of loss of potential web services returned to the user. To resolve this issue, it is necessary to add semantic description to the web service. Sometime it is difficult for the users to specify precise values for nonfunctional requirements so there is a need of QoS processor which can understand the user needs and can extract the parameter for QoS.

There is also a need to provide correct weight value to the nonfunctional parameter and to use the efficient ranking mechanism for selection of web services. In this paper the following points has taken into the consideration:

- There is a need to help the user in formulating the query. Sometimes, it may be possible that naive user is not able to specify the weight value of each nonfunctional parameter. So there is a need of mechanism that helps the users.
- To eliminate the irrelevant web services from the search space it is necessary to incorporate a filtering layer which can classify the web services into the relevant and irrelevant group.
- Some researchers have used different MCDM approaches for ranking of web services according to their requirement. So, to judge the effectiveness of proposed approach this paper has taken the rank aggregation approach into the consideration for the appropriate selection of the web services.

The proposed approach provides the ideal solution by comparing its closeness to the ideal solution. To know the validation of the proposed approach the result has compared with the other approaches. The rest of the paper is organized as follows. Section 2 evaluates the techniques proposed by the different researchers. Sections 3 provide the detailed overview of the proposed model. In section 4 with the help of suitable example experimental analysis is presented and finally in section 5 the paper is concluded.

II. RELATED WORK

QoS parameter gives requester assurance and confidence to use the services. Karpagam [7] considered seven parameter execution time, response time, throughput, scalability, reputation, accessibility and availability to access the Quality of service. But it has not considered the security as QoS parameters. There are very limited numbers of well defined standard for describing the properties of QoS .S. Ran [2] proposed a QoS Model that extended the basic component of web service framework along with a new component called certifier. It verifies the advertised QoS before binding it to the web services. But it does not take the user feedback into the consideration. Diamadopoulou et al. [9] proposed an intermediary broker that maintain a database of web service with their QoS information .It also used a web service selection module that select the web services which is having maximum QoS parameter value as compare to the other services. Benaboud et. al. [3] used a mediator agent for efficient selection of web services. To provide dynamic nature they have used a concept of QWL-S and domain ontology. After that using JENA –API the concept of Agent based framework was developed. But they have not kept the user preference in to the account. To keep in the account of user preferences, Raluca [15] used OWL-Q ontology to address the issues related to QoS. Some of the researcher had applied the Multi criteria Based Decision making approach to estimate the nonfunctional parameters and to find the best web services. Young Jun et al. [5] proposed a web service selection method which helps the service provider to provide the optimal quality solution. For providing optimal solution the multi criteria based decision-making approach PORMETHEE had taken into the consideration. It is very difficult to know the user preference regarding QoS so; Mojtaba *et al.* [11] proposed a MCDM based hybrid approach for the efficient selection of the web services.

Majid *et al.* [12] also considered the power of decision makers in order to determine the weight age value of nonfunctional parameters, after that VIKOR approach was used as an alternative technique for helping the decision maker in decision making for web service selection. Negi et. al. [14] considered the preference of consumer with the help of AHP techniques to calculate the weight age value of nonfunctional parameters .After that TOPSIS had been used to determine the rank of the web services which provide the optimal solution. But if the user is not a domain expert then it is very difficult for the user to specify the weight of attributes. Sometime selections of web services are done on the basis of reputation mechanism where customer provides the feedback for the services. But Quality of service plays a significant role in automatic web service selection. QoS parameters are key factors to establish legitimate and consistent web services and to identify the best web service systematically from a set of functionally equivalent services. Maheswari et al.[16] proposed a replication algorithm to provide the availability of web services and after that for optimal solution a ranking approach based on fuzzy TOPSIS method was applied on the result .To efficiently find a web service solution .W Serrai et al.[18] used a hybrid approach based on MCDM to rank the ideal web services. First of all to eliminate the redundant entries from the search space it used a skyline method and after that BMW method was applied to find the weight associated with QoS. To find the weight value there is a need of user interaction .It might be possible that the user is not able to take decision in term of best and worst web services.

So, by keeping in mind the above issues a model has been proposed in this paper which helps the user to formulate their QoS requirements in an efficient manner and also select the web services which fulfill the user requirements in best possible ways.

III. PROPOSED METHODOLOGY

Generally the web services are selected only on the aspect of their functionality but the nonfunctional parameters such as (cost, reliability) sometime play a significant role for the consumer. So, to keep in view of user requirements there is a need of a model which keeps in the account of all the requirements (functional and nonfunctional) of the user into the consideration during the selection process. But it is difficult for the layman user to exactly indicate their non functional requirements. So, a novel approach has been proposed which also incorporate all these user's requirements in to the consideration as depicted in Fig. 2. In the proposed approach web service selection is done in three major steps: Service Matching, Ranking and selecting. First of all the web services are matched on the basis of their functionality .After that the web services are filtered out by the filtering layer based on their QoS parameters. Finally the ranking algorithm provides the best suitable web services.

But before the service selection it is necessary that the consumer should specify the required constraints for the selection. For an example the web service requester can ask for free SMS service satisfying the following requirements : response time less than 200 ms, reliability 90%,cost below $50.So according to the proposed approach the web services that fails to meet the requirement are dropped out and the rest of the web services are considered for further processing. Now a day's, due the lack of semantic description of the web services it is very difficult to find out the suitable web service.

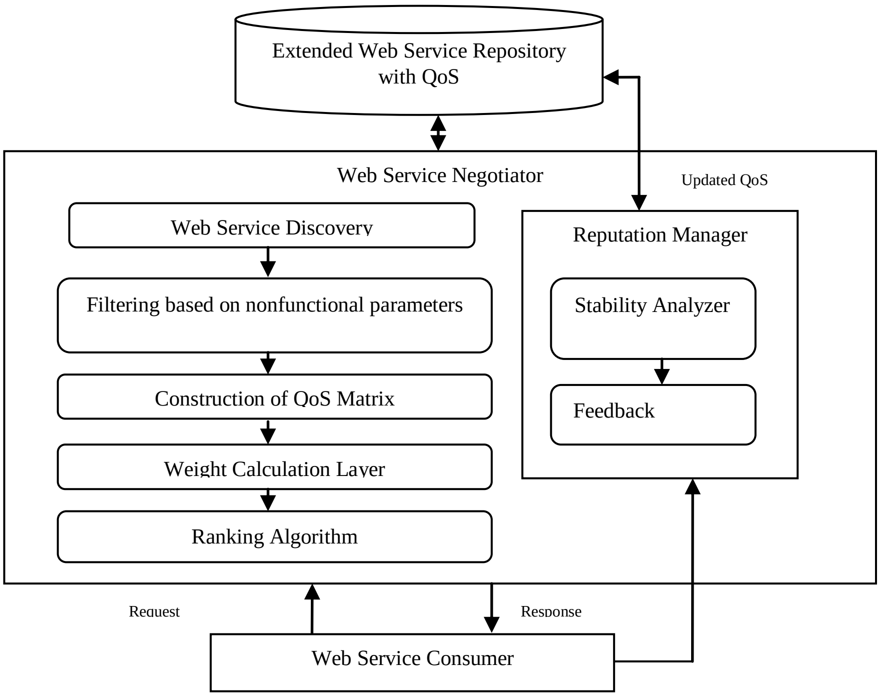

Figure 2 Web Service extended frame worrk

To make the repository semantically enabled, extended OWL-S with QoS is taken into the consideration. As shown in Fig 2. When a web service consumer makes a request for the web service, web service negotiator select the desired web service from the web service repository. During the selection of the web service the web service negotiator consider the user preference into the consideration. The web service negotiator also takes the consultation from the reputation manager to know the feedback score of the service. The web service selection process is illustrated in detail in Fig 2 where a user submits the query as input. The filter layer filters the web services so that the focus can be put only on the required web services set. If the user is capable enough to specify the weight value of the attributes then AHP method can be used for weight calculation. Otherwise the weight calculation layer does this on the behalf of the user. In our approach, to find out the exact rank of the web services the modified TOPSIS algorithm is used. To know the validation of the algorithm it is compared with the other existing approaches. After that using the rank aggregation approach the calculated rank generated by the Modified TOPSIS is justified based on similarity score.

A. Assign weight using AHP

AHP (Analytic hierarchy process) is a technique that is used to analyse the critical decision in a better way AHP. In this technique each criteria is compared with other criteria on the basis of their significance level and a corresponding score can be assigned to that criteria. The different numerical value has been assigned corresponding to The values can be calculated as based on positive and negative criteria their significance level as shown in table 1[20][21].

Table I: Numerical Value corresponding to their Significance level

Significance level	Intensity of Significance
Equivalent Significance	1
Equivalent to average Significance	2
Average Significance	3
Average to strong Significance	4
Intense Significance	5
Intense to very Intense Significance	6
Very Intense Significance	7
Very Intense to extreme Significance	8
Extreme Significance	9

Nowadays, the following MCDM approaches are currently used by the researchers: ARAS, TOPSIS, and VIKOR. In this paper the TOPSIS approach is modified (Modified TOPSIS) to find the suitable rank of web services.

B. Adaptive Ratio Assessment (ARAS)

Adaptive ratio assessment is a technique that is used to find the optimal solution [10].

Step1 : Formulate a Decision matrix(mxn) based on QoS parameter .where m is the number of alternatives and n is the number of nonfunctional parameter considered.

$$X = \begin{bmatrix} dm_{01} & \cdots & dm_{0n} \\ \vdots & \ddots & \vdots \\ dm_{m1} & \cdots & dm_{mn} \end{bmatrix}$$

(1)

Where i=0-m and j=0-n

And now on the basis of decision matrix find the ideal value of j criteria

Step 2: If ideal value of j criterion is not known, then

$$dm_{oj} = max_{\,i}\ dm_{ij} \qquad if\ max_{\,i}\ dm_{ij}\ is\ preferable\ and \qquad (2)$$

$$dm_{oj} = min_{\,i} dm_{ij}{}^{*} \qquad if\ min_{\,i} dm_{ij}{}^{*}\ is\ preferable$$

Step3: Now normalized the value of decision matrix

The criteria whose desired values are maximum, are normalized as

$$norm_{ij} = \frac{dm_{ij}}{\sum_{i=0}^{m} dm_{ij}} \qquad (3)$$

The criteria, whose desired values are minima, can be normalized as

$$dm_{ij} = \frac{1}{dm_{ij^*}}$$

$$norm_{ij} = \frac{dm_{ij}}{\sum_{i=0}^{m} dm_{ij}} \qquad (4)$$

Step4: Now find the weighted normalized matrix by multiplying it with the weight values determined by AHP

$$Wnorm_{ij} = norm_{ij} * w_j \qquad (5)$$

Step 5: The optimality function can be calculated as

The optimality function Si can be calculated as

$$S_i = \sum_{j=1}^{n} wnorm_{ij}\ ;\ i = 0 - m \qquad (6)$$

Step6: Find the approximate distance to the optimal solution

The degree of the alternative utility can be calculated by comparisons of different variant which are analyzed wrt. optimal solution S_o.

Degree of Alternative Utility is

$$K_i = \frac{S_i}{S_0} \qquad (7)$$

$$i = 0 - m$$

C. TOPSIS Algorithm

Many of the researchers [1] have used TOPSIS algorithm to find the best alternative solution.

Step1: Formulate the Normalised Matrix:

$$norm_{ij} = \frac{dm_{ij}}{\sqrt{\sum dm_{ij}^2}} \qquad (8)$$

For i =1, 2 ………. n, j=1, 2…….m where dm_{ij} and $norm_{ij}$ are the original and the normalized score decision matrix.

Step2: Now apply the weight value to the normalized matrix

$$wnorm_{ij} = w_j * norm_{ij} \qquad (9)$$

Where wj is the weightage value for jth criteria.

Step3: Find the positive ideal and negative ideal solution

$$Apos^+ = \{wnorm_1^+ \ldots\ldots\ldots wnorm_n^+\} \qquad (10)$$

Where $wnorm_i^+$=max ($wnorm_{ij}$) if j∈J; min ($wnorm_{ij}$) if j∈J'

$$Aneg^{''} = \{wnorm_1' \ldots\ldots\ldots wnorm_n'\} \qquad (11)$$

Where $wnorm_i'$=min ($wnorm_{ij}$) if j∈J; max ($wnorm_{ij}$) if j∈J'

Step 4: Calculate the distinct measure for each alternatives

$$Sep_i^+ = \left[\sum \left(wnorm_i^+ - wnorm_{ij}\right)^2\right]^{1/2} \qquad (12)$$

Where i=1, 2…..n

Negative ideal solution

$$Sep_i' = \left[\sum \left(wnorm_i' - wnorm_{ij}\right)^2\right]^{1/2} \qquad (13)$$

Where i=1, 2…..n

Step5: find the result that is close to the optimal solution.

$$CI_i^+ = {Sep_i'}\Big/{Sep_i' + Sep_i^+} \qquad (14)$$

D. VIKOR Algorithm

VIKOR Algorithm is used as a ranking and selection technique [11].VIKOR use a linear normalization technique. In VIKOR method a VIKOR index is calculated and based on the index value the best and worst solution is identified. If the VIKOR index close to zero then it can be the best solution otherwise it is worst solution closest to 1.The VIKOR algorithm follows the following approach.

Step 1: Construct the normalized matrix.

$$norm_{ij} = \frac{dm_{ij}}{\sqrt{\sum_i^n (dm_{ij})}} \ ;\ \forall j \qquad (15)$$

Step 2: Calculation of positive perfect and negative perfect solution

$$Apos^+ = \{(\max norm_{ij},\ j \in J) or\ (\min norm_{ij}, j \in J')\}$$
$$= \{norm_1^+, norm_2^+ \ldots\ldots\ldots norm_n^+\} \qquad (16)$$

$$Aneg^- = \{(\min norm_{ij},\ j \in J) or\ (\max norm_{ij}, j \in J')\}$$
$$= \{norm_1^-, norm_2^- \ldots\ldots\ldots norm_n^-\} \qquad (17)$$

The positive perfect solution Apos+ and the negative perfect solution $psol^-$ are determined as Here, *J* corresponds to benefit criteria and J' corresponds to cost criteria.

Step 3: Calculation of utility rate and regret rate

$$S_i = \sum_{j=1}^{n} w_j \frac{(norm_j^+ - norm_{ij})}{(norm_j^+ - norm_j^-)} \ ;\forall i \qquad (18)$$

$$R_i = Max_j \left[w_j \frac{(norm_j^+ - norm_{ij})}{(norm_j^+ - norm_j^-)}\right] ;\forall i \qquad (19)$$

Where, Si and Ri, represent the utility rate and regret rate respectively and wj is the corresponding weight assigned to the jth attribute.

Step 4: Find the VIKOR index.

$$Q_i = \begin{Bmatrix} \left[\frac{R_i - R^-}{R^+ - R^-}\right] \\ \left[\frac{S_i - S^-}{S^+ - S^-}\right] \\ \left(\left[\frac{S_i - S^-}{S^+ - S^-}\right] v + \left[\frac{R_i - R^-}{R^+ - R^-}\right](1 - v)\right) \end{Bmatrix} \qquad (20)$$

$$S^+ = Min_i(S_i)$$
$$S^- = Max_i(S_i)$$
$$R^+ = Min_i(R_i)$$
$$R^- = Max_i(R_i)$$

Where, Qi denotes the VIKOR index for the ith alternative, v is the cluster utility weight; it is usually taken as 0.5.The solution having the least value is preferred index in the VIKOR.

E. Modified TOPSIS Algorithm

The TOPSIS suffers from the rank reversal due to the normalization approach followed by the TOPSIS. So in this paper the normalized approach is modified by normalizing the decision matrix based on the maximum value of each criterion.

Step1: Normalization

$$norm_{ij} = \frac{dm_{ij}}{max_i dm_{ij}} \qquad (21)$$

Where $norm_{ij}$ is the normalized value of dm_{ij}

Step2: Now apply the weight value to the normalized matrix

$$wnorm_{ij} = w_j * norm_{ij} \qquad (22)$$

Where w_j is the weight value for jth criteria.

Step3: Find the positive ideal and negative ideal solution

$$Apos^+ = \{wnorm_1^+ \dots\dots\dots wnorm_n^+\} \qquad (23)$$

Where $wnorm_i^+$=max ($wnorm_{ij}$) if j∈J; min ($wnorm_{ij}$) if j∈J'

$$Aneg^{''} = \{wnorm_1^{'} \dots\dots\dots wnorm_n^{'}\} \qquad (24)$$

Where $wnorm_i^{'}$=min ($wnorm_{ij}$) if j∈J; max ($wnorm_{ij}$) if j∈J'

Step 4: Calculate the distinct measure for each alternatives

$$Sep_i^+ = \left[\sum \left(wnorm_i^+ - wnorm_{ij}\right)^2\right]^{1/2} \qquad (25)$$

Where i=1, 2…..n

Negative ideal solution

$$Sep_i^{'} = \left[\sum \left(wnorm_i^{'} - wnorm_{ij}\right)^2\right]^{1/2} \qquad (26)$$

Where i=1, 2…..n

Step5: find the result that is close to the optimal solution.

$$CI_i^+ = {Sep_i^{'}}\Big/{Sep_i^{'} + Sep_i^+} \qquad (27)$$

F. Rank aggregation method: MedRank

To find out the accuracy of the MCDM techniques, here we have applied a MedRank method to find the appropriate rank score. After that based on the ranking score the web services are arranged in the ascending order Let us assume the four rankings, Rankv, Rankt, Rankw and Rankr resulted by applying the TOPSIS, VIKOR, ARAS and Modified TOPSIS MCDM ranking approach on the decision matrix D.∀r ∈ {t, v, w,a}, ∀i = 1..I, RKr(i) gives the ranking of the web service i obtained by using the method r. Then MedRank can be applied to know the exact rank of the web services .If a1,a2…an are the observed rank in the order. Then their frequencies f1,f2,…fn can be calculated. When an element appeared in more than half of the rankings, then it is considered in aggregated ranking list. The MedRank method is a generally used as a voting method on which the score is obtained by accessing sequentially. After that on the basis of score the web services can be arranged in the ascending order.

G. To Find out the relevance of each Ranking Approach

The similarity ration can be used as a mechanism to find out the relevance of the result obtained by the MCDM Ranking approaches with respect to the MedRank aggregation approach. Based on Serrai [18] the similarity ratio of each approach is calculated as:

$$Sim_r = \sum_i s[RK_r(i), RK_M(i)] \qquad (28)$$

$$where\ s[RK_r(i), RK_M(i)] = 1\ if\ RK_r(i) = RK_M(i),$$
$$s[RK_r(i), RK_M(i)] = 0\ otherwise$$

$$SR_r = \frac{Sim_r}{n} \qquad (29)$$

IV. EXPERIMENT/SIMULATION DETAILS AND RESULTS

For creation of ontology, ontology editor Protégé 4.3 has been used. To apply the MCDM techniques on dataset, QWS Al-Masri et. al. [7] [8] dataset has been taken into the consideration. A Negotiator has been implemented in JAVA which accepts the request from the user and searches the desired result according to the query. After that the selected service has been selected out .For the selection and the efficient ranking of the web services MCDM techniques have been implemented in JAVA. The AHP has been used to calculate the weight score of the QoS parameters. After that TOPSIS, VIKOR, ARAS and Modified TOPSIS is applied to find the rank of the web services. As all the approaches are providing the rank but to find the compromise solution the rank aggregation method has been applied to find the suitable rank.

For example suppose a user wants to find out the web service that provides the information on Stock.

Table II: Decision Matrix

Criteria Alternatives	Response time	Availability	Reliability	Latency
WS1	96	100	94.1	68.75
WS2	225.36	100	62.6	225.36
WS3	119.33	88	76.5	65
WS4	123.5	60	78.6	41
WS5	409	100	67.6	409
WS6	544	100	70.5	492
WS7	281.07	68	8.7	250.73

Consider the decision matrix as shown in table II based on the QoS parameter.

If the user is a domain expert then the weight value of each nonfunctional parameter can be calculated by applying AHP as follows.

Table III: Pair wise comparison matrix

	Response time	Availability	Reliability	Latency
Response time	1	1	3	2
Availability	1	1	2	1
Reliability	1/3	½	1	1
Latency	½	1	1	1

W1=0.36, W2=0.28, W3=0.15, W4=0.20

Now apply the MCDM approaches on table II to find out the rank .As shown in Table IV the MCDM approaches provide different rank value to the web services.

Table IV: Results of different MCDM approaches

Web Services	VIKOR Rank	TOPSIS Rank	Modified TOPSIS Rank	ARAS RANK
WS1	0	0.970537	0.971762	0.889415
WS2	0.325667	0.681736	0.689542	0.505766
WS3	0.212685	0.908817	0.883311	0.773167
WS4	0.645751	0.823751	0.753408	0.810348
WS5	0.724834	0.34739	0.401267	0.415009
WS6	1	0.222285	0.296253	0.391474
WS7	0.682793	0.516156	0.477849	0.328006

Now apply the rank aggregation method on the table IV to compute the final rank of the web services.

As different MCDM approaches provide the different web services rank so the rank aggregation approach is applied here to find out the compromise rank

Table V: Final rank

	VIKOR	TOPSIS	Modified TOPSIS	ARAS	Aggregated RANK
WS1	1	1	1	1	1
WS2	3	2	4	4	4
WS3	2	4	2	3	2
WS4	4	3	3	2	3
WS5	6	7	6	5	6
WS6	7	5	7	6	7
WS7	5	6	5	7	5

Table VI: Similarity Score

	VIKOR	TOPSIS	Modified TOPSIS	ARAS
Similarity matrix	5	2	7	2
Similarity Score	5/7=0.71	2/7=0.28	7/7=1	2/7=0.28

The similarity score of each ranking approach is calculated here using equations 28 and 29 as shown in table 6. According to the similarity Score Modified TOPSIS performs well as compare to the other. Rank aggregation approach provides the appropriate rank to different web services in keeping view of all perspectives.

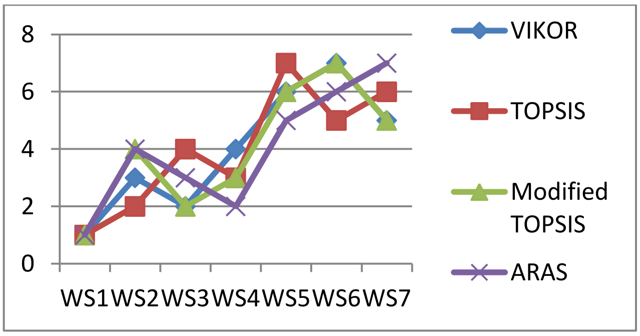

Figure 4: Web service Rank based on MCDM approaches

Here MedRank is used to provide a compromise solution based on the rank obtained by the MCDM techniques. So, MedRank rank can be used as final solution and can be used to find out the correctness of each ranking approach by computing the similarity score.

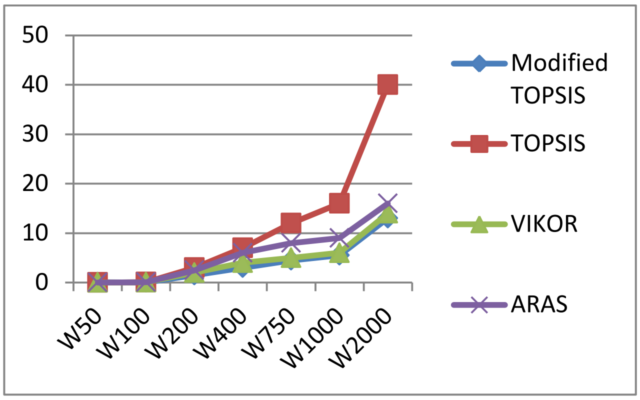

Figure 5: Execution time response of different approaches

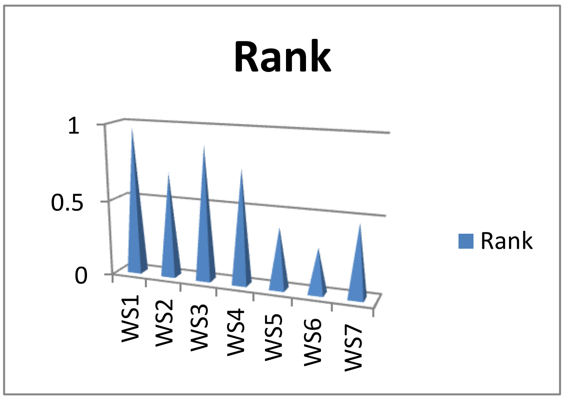

Figure 6: Web service ranking

V. CONCLUSION

In this paper, we introduced a web service selection model that keeps the requirement of the layman user into the consideration. As due to the availability of large information it is very difficult for the normal user to formulate its request and to find out the desired information from the web. This paper provided a feasible solution to the user so that users can provide his query in the efficient manner. This paper has compared the upcoming MCDM approaches that can be used for providing the ranking solution and to select the best web service among them a hybrid rank aggregation approach has taken into the consideration. In the future work more focused should be given on the selection of the web service based on their functionality and collaborative filtering.

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