Weighted Quality of Service based Ranking of Web Services

F. Ezhil Mary Arasi*, S. Govindarajan and A. Subbarayan

Department of Master of Computer Applications, SRM University, Kattankulathur,
Chennai - 603203, Tamil Nadu, India;
ezhilmary.f@ktr.srmuniv.ac.in, govindaraja.n@ktr.srmuniv.ac.in, subbarayan.a@ktr.srmuniv.ac.in

Abstract

Background/Objectives: The primary objective of the study is to evaluate the performance of Composite Web Service based on the parameters relating to Quality of Service by using statistical methodologies. **Methods/Statistical Analysis:** By using Web Service Crawler Engine we have collected data on eleven parameters of interest from a more number of Web Services. Among the eleven parameters we have selected six parameters of importance using the sampling of thirty Web Services. We have constructed the weight matrix for the parameters. By using Web Services Relevancy Function ranking has been done for three different scenarios. Using Spearman's Rank Correlation Coefficient we have compared the scenarios. **Findings:** The graphical representation of the three scenarios shows varying pattern. The Spearman's Rank Correlation coefficient of the Web Services Relevancy Function varied widely among the sampled Web Services. F-Test revealed that there are no significant differences in respect of weights of Quality of Web Services for three different scenarios. We concluded that weight assigned for Quality of Service parameters in Scenario I is preferred than the scenarios II and III through the evaluations. **Application/Improvements:** The technique developed in this research paper can be applied for the comparison of Web Services during discovery to enhance the performance of the Composite Web Service.

Keywords: F-Test, Quality of Service, Rank Correlation, Selection, Web Services

1. Introduction

In Service Oriented Architecture, a service is an autonomous and platform independent computational entity, which can be described, published, discovered and dynamically assembled for developing distributed systems. The three main components of the SOA are service consumer, service providers and service brokers. Service providers offer services to the consumer. Service consumer requests services from service providers, while service brokers mediate between the two of them. Service providers register the service with the service broker and service consumer finds the service from the service broker. Service registry is referred as Universal Description, Discover and Integration (UDDI). SOAP (Simple Object Access Protocol) is used to access the service. Services are described by using Web Service Description Language (WSDL).

An important application of the web services is web service composition. In many situations an individual web services are not able to satisfy the complex requirements of an application. Therefore they are combined to construct applications that meet the needs of the clients. It is essential to select those which meet the criteriato create a Composite Web Service.

In[1] World Wide Web Consortium (2004) has given a common definition of service: "A service is an abstract resource that characterizes a capability of performing tasks that form a coherent functionality from the point of view of provider's entities and requester's entities. To be used, a service must be realized by a concrete provider agent".

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* Author for correspondence

A web service can be defined as a web accessible function that is well defined, self-contained, and does not depend on the functionality of other web services. When any single web service fails to provide service requestor's multiple function requirements, multiple web services need to be dynamically configured together to form a web service composition to satisfy both the functional and nonfunctional requirements such as Quality-of-Service (QoS).

Web service selectionis essential to provide clients with proper results according to their requirements[2].

2. A Selected Review of Related Literature on QOS

Web service selection and discovery system is essential to provide clients with proper results according to their requirements[2].

The author[3] determined the Semantic Web Services composition aspects and discovery processes that can be evaluated as performance criteria in rubric tables. Comparison of semantic web service selection methods based on Quality of Service (QoS) attributes has been performed[4].

In[5] presented a middleware platform for addressing the issue of selecting web services for web service composition in a way that maximizes user satisfaction expressed as utility functions over QoS attributes. They described two selection approaches and compared.

In[6] Quality of Service (QoS) has examined by the author to identify its role for service providers, consumers, and parallel transactions and shown how it fits into composite Web services.

Based on QoS a fuzzy multi attribute decision making algorithm[7] was formulated for Web services selection. They have noted that the algorithm can select the most appropriate web service with the highest degree of membership. With the experimental results they also proved that their algorithm outperforms the random and round robin selection policies.

Author in[8] developed soft probabilistic contracts that consist of a probability distribution for the QoS parameter. They have focused on timing factor and proposed a statistical technique for runtime monitoring of soft contracts.

A web service functional configuration problem haveexamined by using Petri nets[9]. The have analyzed the graph structure and algebraic properties of the model. The multiple attribute QoS optimization problem to a linear programming problem have formulated by the authors.

For Web Service selection in[10] introduced a novel QoS measure approach to efficiently measure QoS of web service. The authors considered service providers, the context of customers and historical statistics factors for QoS measure.

A web service selection method based on credible user recommended QoS presented by[11]. They introduced the QoS model to provide more objective service selection and satisfy the users' preferences on QoS technical support.

To find the best Web Service[12] have proposed QoS-Broker architecture by using Web Service client's query and QoS requirements.

2.1 Motivation for the Present Study

It is evident that there are many requirements that influence the selection of the service providers in Composite web service. These requirements also vary for different applications. Therefore, service selection is an important research challenge as it requires an efficient selection of best service providers based on user preferences.

Most of the studies carried out have not ensured the services balance of functionality and nonfunctionality of user preferences. The author wishes to note that practicality and versality are the prime factors in the selection of services. Keeping this in view an attempt has been made to develop appropriate weights to QoS metrics based on certain statistical tools.

3. Methodological Aspects of QOS

3.1 Taxonomy of Composite Web Service

Several abstract Services[13] with the same functionality constitute the composite Web Service. The definition of composite web service is given by

$$C = \{N_i\} \ (\ i \ \epsilon \ [1... n] \ )$$

Let us denote the following

n = Number of nodes in the composite web service
Ni = Basic unit of Composite web Service
S_i = Primary Service in the Composite web service

B_{ij} = Backup Service for S_i
q = Number of backup services

Then we can write

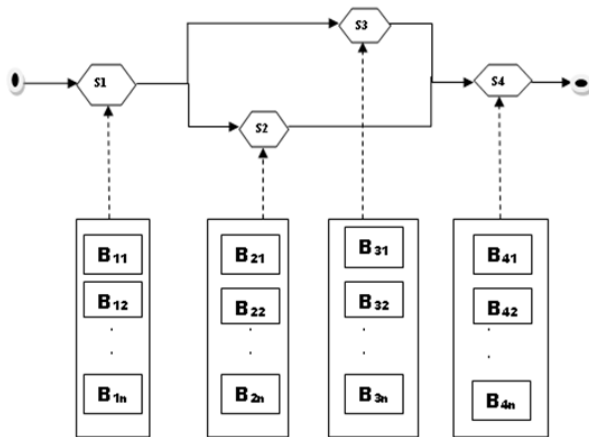$$N_i = \{S_i, B_{ij}\}(i \in [1...n], j \in [0...q])$$

Figure 1. Composite web service (C).

When q > 1 implies a redundancy service pool and j = 0 implies that there is no backup service for the primary service. An atomic web service is treated as an independent unit.

3.2 Service Selection Problem

The user requirements in respect of functional and nonfunctional properties based web services selection is termed as service selection. The aspects relating to non functional properties based selection needs to be investigated to satisfy the user requirements. The formation of composite service involves selecting a component service from the collection of candidate services[14]. The weighted QoS based service selection will affect the composition of services[15].

Service selection is the process of identifying the service that satisfies a client's requirement.

The above fact clearly shows that service selection is a prerequisite requirement and main problem that need to be addressed for successful processing of Composite Web Service.

In[16] have included the important aspects such as Client Service requirement, Service provisions from the Service provider and evaluation of the results for the selection of web services.

The approaches for dealing with QoS metrics for Web Services have outlined[17–19]. In this context they have cautioned that the user need not depend on service providers for QoS values.

3.3 Non Functional Parameters (QoS) based Ranking

Researchers are of the opinion that the usage of non functional properties for web services improves to a great extent the probability of obtaining results relative to output. We have proposed the web service selection for composite web service purely on the association between QoS parameters and their weights.

The primary purpose of providing best Web Service is based on quality driven ranking. In[20] collected QoS information based on WSRB. The framework of WSRB is given in Figure 2.
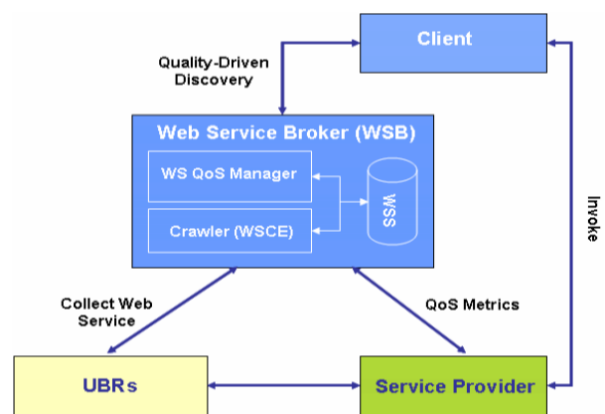

Figure 2. Quality driven Ranking using WSRB.

Clients use WSRB for web service selection and Web Service Relevancy Function (WsRF) process the client's request based on ranking. The author has used the data available from WSRB for selecting QoS matrix using certain statistical tools.

QoS parameters determine the best web services based on WsRF values. The following WsRF values are determined for each of the QoS parameters noted below:

- **Response Time (RT):** The time taken between request made by the client and the response received from the web service provider (Unit: milliseconds).
- **Availability (AV):** A percentage of time duration a Web service is available for the client (Unit: % / 3-day period).

- **Throughput (TP):** Request handled at the maximum level for a given time (Unit: requests/min).
- **Reliability (RE):** Ratio between the error messages and the total messages (Unit: %)
- **Compliance (COMP):** The percentage of WSDL document utilizations (Unit: %)
- **Latency (LA):** Server processing time (Unit: milliseconds).

3.4 Formation of WsRF matrix

Let us assume that there is a set of Web service providers. All Web Service providers' functions are the same.

WS [WS={WS$_1$, WS2 …WSi}]

The QoS attributes relating to each of the Web Service providers one given by

P [P= {P$_1$, P2…..P$_j$}]

The client has to identify that which web service provider gives the best services and an algorithm has to be developed for this purpose.

Based on this we develop a matrix of the following form and the same will be used for identifying/evaluating the best web service provider with associated characteristics. This matrix is termed as WsRF matrix.

Each row of the matrix given below identifies a single web service and the QoS attributes are represented in columns

$$E = \begin{bmatrix} q_{1,1} & q_{1,2}……q_{1,j} \\ q_{2,1} & q_{2,2}……q_{2,j} \\ . \\ . \\ . \\ q_{i,1} & q_{i,2}……q_{i,j} \end{bmatrix} \tag{1}$$

The unit value and magnitude of QoS parameters differs from each other. Normalization of QoS parameters is attempted for ranking process and helps for unification of the data structure. This in turn helps the client for effective selection of web services.

Initially the following steps are followed in computing WsRF (WS$_i$)

- The array N is formed ,where
  N= {n1, n$_2$ ….n$_m$}
  Such that N (j) $= \sum_{m}^{i} q\,m,\,j$ (2)

Where qm,j represents the actual value from the WsRF matrix Equation (1)
- The following equation is formed for comparing each element of the WsRF matrix with their maximum QoS values in the coloumns.

$$h_{i,j} = \frac{q_{i,j}}{\max[N_j]} \tag{3}$$

h$_{i, j=>}$ measures the differences of q$_{i,j}$ from the maximum normalized value in the corresponding jth column.

3.5 Matrix Associated with Weights:

We know that there is an important need for assigning weights to each of the attributes included in enhancing the system. Weights are assigned for each factor keeping its importance and further we rank web services. The weights are represented for each P$_j$ and

W = {w$_1$, w$_2$ …wj}. The value of the weight ranges between 0 and 1. The larger the weight of a specific parameter, the more important that parameter is to the client and vice versa.

In this work we have considered three different scenarios in forming the array of weights and the same are discussed in the following sections.

Introducing different weights to Equation (3) results in the following equation:

$$h_{i,j} = w_i \left[\frac{q_{i,j}}{\max(N(j))} \right] \tag{4}$$

Using the above formulation (4), we get a weighted matrix as shown below:

$$E' = \begin{bmatrix} h_{1,1} & h_{1,2}….h_{1,j} \\ h_{2,1} & h_{2,2}….h_{2,j} \\ . \\ . \\ h_{i,1} & h_{i,2}……h_{i,j} \end{bmatrix} \tag{5}$$

Then we can compare WsRF for each web service provider as shown below

$$W_sRF\,(WS_i) = \sum_{i=1}^{N} h_{i,j} \tag{6}$$

where N represents the number of web services from a given set.

4. Experiments and Results

The data set contains 2507 real web service

implementations extracted from the Web. These services were collected using the WSCE. The sampled Web services were obtained from public sources on the Web including Universal Description, Discovery, and Integration (UDDI) registries, search engines, and service portals.

A sample of 30 web services with same functionality was selected for an evaluation. Using QoS values as inputs we obtain matrix in Eqution (1). The above exercise reduces the clients search time for the QoS metrics as the web services are already ranked based on their QoS parameters. Thus economy in time was achieved through the weighted QoS based ranking.

Table 1. QoS metrics for sampled web services

WS.No	RT	AV	TP	RE	COMP	LA
1.	302.75	89	7.1	73	78	187.75
2.	482.0	85	16.0	73	100	1.00
3.	3321.40	89	1.4	73	78	2.60
4.	126.17	98	12	67	78	22.77
5.	107.00	87	1.9	73	89	58.33
6.	107.57	80	1.7	67	78	18.21
7.	255.00	98	1.3	67	100	40.80
8.	136.71	76	2.8	60	89	11.57
9.	102.62	91	15.3	67	78	0.93
10.	93.37	96	13.5	67	89	41.66
11.	133.00	86	7.7	73	78	10.67
12.	221.48	90	10.9	53	89	37.26
13.	114.00	86	16.1	73	89	67.00
14.	269.83	85	4.5	53	89	74.96
15.	134.07	84	12.2	60	89	8.21
16.	67.50	86	6.0	73	78	1.50
17.	131.57	80	2.3	53	67	6.50
18.	213.20	88	1.6	73	100	7.80
19.	1360	83	10.4	83	89	3.00
20.	108.00	86	0.7	73	78	0.33
21.	50.00	72	13.3	73	78	4.00
22.	1069.50	71	3.0	83	89	744.00
23.	132.00	83	14.3	73	78	16.00
24.	265.09	94	10.2	73	89	48.18
25.	124.17	94	2.1	73	100	30.84
26.	408.21	56	5.0	73	78	121.46
27.	259.00	97	1.2	58	100	7.20
28.	408.00	83	15.2	83	89	3.00
29.	173.00	46	3.8	78	89	4.83
30.	320.48	86	1.2	53	89	125.18

5. Scenarios for Evaluation of Web Services

Scenario 1: The results based on Figure 3 reveals that the

maximum WsRF value (0.686054) was obtained for the second sampled web service and the weights assigned for QoS attributes are given below:

RT	AV	TP	RE	COMP	LA
0.14	0.16	0.25	0.18	0.12	0.15

Scenario 2: Figure 4 also shows that second sampled web service has the highest WsRF value (0.761077) or has the highest performance. The weights assigned for QoS attributes are tabulated below:

RT	AV	TP	RE	COMP	LA
0.05	0.02	0.23	0.35	0.02	0.15

Scenario 3: The results relating to Figure 5 indicates that the twenty eighth sampled web service has the highest WsRF value (0.813447), or the one that has the highest performance. The weights assigned for QoS attributes are noted below:

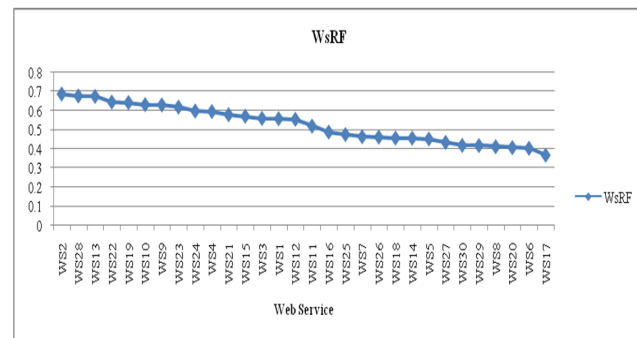| RT	AV	TP	RE	COMP	LA
0.07	0.3	0.25	0.27	0.05	0.06

Figure 3. QoS ranking with RT(14%), AV(16%), TP (25 %), RE(18 %), COMP(12 %) and LA(15 %).
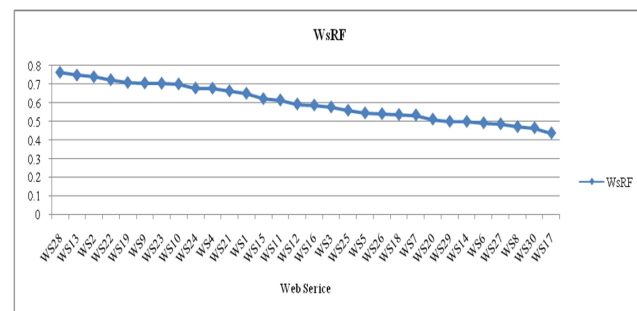

Figure 4. QoS ranking with RT (5%), AV (2%), TP (23 %), RE (35 %), COMP(2 %) and LA (15%).
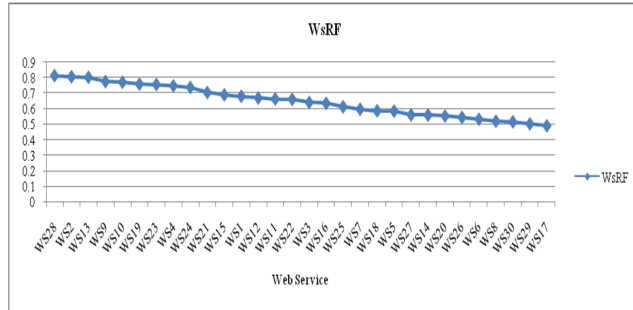
Figure 5. QoS ranking with RT (7%), AV (3%), TP (25 %), RE (27 %), COMP(5 %) and LA (6%).

Table 2. Computational layout

WS.No	Scenerio 1		Scenerio 2		Scenerio 3	
	WsRF	Rank	WsRF	Rank	WsRF	Rank
1	0.5580	14	0.6489	12	0.6806	12
2	0.6860	1	0.7373	3	0.8063	2
3	0.5594	13	0.5755	17	0.6408	16
4	0.5951	10	0.6760	10	0.7477	8
5	0.4529	23	0.5436	19	0.5847	21
6	0.4041	29	0.4909	26	0.5319	26
7	0.4644	19	0.5331	22	0.5968	19
8	0.4125	27	0.4703	28	0.5196	27
9	0.6295	7	0.7041	6	0.7753	4
10	0.6307	6	0.6989	8	0.7712	5
11	0.5196	16	0.6130	14	0.6629	14
12	0.5547	15	0.5915	15	0.6693	13
13	0.6738	3	0.7463	2	0.8030	3
14	0.4568	22	0.4982	25	0.5587	23
15	0.5708	12	0.6201	13	0.6897	11
16	0.4886	17	0.5859	16	0.6344	17
17	0.3685	30	0.4363	30	0.4898	30
18	0.4573	21	0.5350	21	0.5868	20
19	0.6417	5	0.7068	5	0.7589	6
20	0.4078	28	0.5106	23	0.5529	24
21	0.5789	11	0.6619	11	0.7047	10
22	0.6443	4	0.7216	4	0.6609	15
23	0.6182	8	0.7023	7	0.7566	7
24	0.5978	9	0.6768	9	0.7375	9
25	0.4758	18	0.5577	18	0.6129	18
26	0.4626	20	0.5397	20	0.5439	25
27	0.4351	24	0.4850	27	0.5602	22
28	0.6761	2	0.7610	1	0.8134	1
29	0.4183	26	0.4984	24	0.5020	29
30	0.4195	25	0.4640	29	0.5156	28

5.1 A comparison of Scenarios based on Certain Statistical Techniques

In[21] have outlined the usage of rank correlation test for agreement in multiple judgments for inferring data based on certain domains. We use Spearman's Rank Correlation Coefficient to compare the three scenarios explained in the earlier sections. We rank two sets of outcomes i.e., two types of scenarios and compare the rank correlation coefficient.

Spearman's Rank Correlation Coefficient is given by

$$\rho = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2 - 1)}$$

where n is the number of data points in the sample and d_i is the difference between the ranks of two sets of outcomes. This measure may also be thought of as a measure of the correspondence of ranks for the two outcomes.

In this attempt we would like to investigate the significance of the correlation between 'n' series of rank numbers, i.e., Thirty Web Services with three different Scenarios.

The test is applied to know whether the scenarios (assigned weights for different QoS) significantly among themselves with reference to the Web Services.

The test procedure consist of 'n' scenarios each with k Web Services considered (i.e., n = 30, k = 3).Computation of S_D = The sum of squares of the differences between Web Services mean rank and the overall mean rank.

Computation of the following

$$S = \frac{nK(K^2 - 1)}{12}, \quad D_1 = \frac{S_D}{v_1}, \quad D_2 = S - D_1,$$

$$S_1^2 = \frac{D_1}{v_1}, \quad S_2^2 = \frac{D_2}{v_2}, \quad v_1 = K - 1, v_2 = K(n-1)$$

The test statistics is given by

$$F = \frac{S_1^2}{S_2^2} \sim F(v_1, v_2) \, d.f \, (s_1^2 > s_2^2)$$

The computed values of rank correlation coefficient ρ for three different Scenarios are

$\rho_{12} = 0.9697$ $\rho_{13} = 0.9466$ $\rho_{23} = 0.9488$

Table 3. Rank based on weighted QoS for three Scenarios

WS. No	S1	S2	S3	Total	Mean	D =Mean-Total	D²
1	14	12	12	38	46.5	8.5	72.25
2	1	3	2	6	46.5	40.5	1640.25
3	13	17	16	46	46.5	0.5	0.25
4	10	10	8	28	46.5	18.5	342.25
5	23	19	21	63	46.5	-16.5	272.25
6	29	26	26	81	46.5	-34.5	1190.25
7	19	22	19	60	46.5	-13.5	182.25
8	27	28	27	82	46.5	-35.5	1260.25
9	7	6	4	17	46.5	29.5	870.25
10	6	8	5	19	46.5	27.5	756.25
11	16	14	14	44	46.5	2.5	6.25
12	15	15	13	43	46.5	3.5	12.25
13	3	2	3	8	46.5	38.5	1482.25
14	22	25	23	70	46.5	-23.5	552.25
15	12	13	11	36	46.5	10.5	110.25
16	17	16	17	50	46.5	-3.5	12.25
17	30	30	30	90	46.5	-43.5	1892.25
18	21	21	20	62	46.5	-15.5	240.25
19	5	5	6	16	46.5	30.5	930.25
20	28	23	24	75	46.5	-28.5	812.25
21	11	11	10	32	46.5	14.5	210.25
22	4	4	15	23	46.5	23.5	552.25
23	8	7	7	22	46.5	24.5	600.25
24	9	9	9	27	46.5	19.5	380.25
25	18	18	18	54	46.5	-7.5	56.25
26	20	20	25	65	46.5	-18.5	342.25
27	24	27	22	73	46.5	-26.5	702.25
28	2	1	1	4	46.5	42.5	1806.25
29	26	24	29	79	46.5	-32.5	1056.25
30	25	29	28	82	46.5	-35.5	1260.25
Total				1395			19603.5

The computed values are:

$$S = 6742.5, S_D = 19603.5,$$
$$D_1 = 675.893, D_2 = 6066.67,$$
$$S_1{}^2 = 23.31, S_2{}^2 = 101.11$$
$$F = 0.154, F_{29.60.05} = 1.66$$

The above test results clearly reveals that the weights of QoS assigned for three different Scenarios do not indicate significant difference among themselves. We wish to conclude that the weights assigned under Scenario 1 can be preferred than Scenario 2 and Scenario

3. This is due to the fact that we get higher value for the Rank Correlation Coefficient for Scenarios 1 and 2 than the other Scenario under comparison. The value of these weights will be helpful in ranking web services based on client functionality preferences and QoS metrics.

6. Conclusion

The selection procedure adopted in this research paper is highly useful for improving the effectiveness of Composite Web Service. The client can select a web service using weighted QoS matrix constructed based on Rank Correlation Coefficient profounded by Prof. Spearman. We have also performed a statistical test associated with the computation of Rank Correlation Coefficient. We can conclude that the usage of weighted QoS will improve the probability of obtaining the output results. The method proposed has several advantages compared to other methods available in the literature in identifying the weights for QoS and for finding most relevant services for clients required functionality. The authors propose to include trust information to prioritize Web Services for further research.

7. References

1. World Wide Web Consortium (W3C), Web Services Glossary; 2004. Available from: http://www.w3.org/TR/ws-gloss
2. Karimi M, Safi F. Improving response time of web service composition based on QoS Properties. Indian Journal of Science and Technology. 2015 Jul; 8(16). DOI: 10.17485/ijst/2015/v8i16/55122
3. Ghayekhloo S, Bayram Z. A novel rubric and feature-based appraisal and comparison framework for the evaluation of semantic web services composition approaches. Indian Journal of Science and Technology. 2015 Dec; 8(33). DOI: 10.17485/ijst/2015/v8i33/72733.
4. Maheswari S, Karpagam GR. Comparative analysis of semantic web service selection methods. Indian Journal of Science and Technology. 2015 Feb; 8(S3). DOI: 10.17485/ijst/2015/v8i1/60499.
5. Zeng L, Benatallah B, Anne, Ngu HH, Dumas M, Kalananam J, Chang H. QoS–Aware middleware for web services composition. IEEE Transactions on Software Engineering. 2005; 30(5):311–27.
6. Menasce DA. Composing WebServices: A QoS view. IEEE Transactions on Internet Computing. 2004; 8(6):88–90.

7. Tong H, Zhang S. A fuzzy multi-attribute decision making algorithm for web services selection based on QoS. IEEE Asia-Pacific Conference on Services Computing (AP-SCC'06); 2006. p. 1–7.

8. Rosario S, Benveniste A, Haar S, Jard C. Probabilistic QoS and soft contracts for transaction-based web services orchestrations. IEEE Transactions on Services Computing. 2008; 1(4):187–200.

9. Xiong PC, Fan YS, Zhou MC. Web service configuration under multiple quality-of-service attributes. IEEE Transactions on Automation Science and Engineering. 2009; 6(2):311–21.

10. Wang SQ, Sun F, Yang. Quality of service measure approach of web service for service selection. The Institution of Engineering and Technology. 2012; 6(2):148–54.

11. Cui Y, Chen C, Zhao Z. Web service selection based on credible user recommended and QoS. 2012 IEEE/ACIS 11th International Conference on Computer and Information Science; 2012. p. 637–42.

12. Harshavardhanan P, Akilandeswari J, Sarathkumar R. Dynamic web services discovery and selection using QoS-broker architecture. 2012 International Conference on Computer Communication and Informatics (ICCCI); Coimbatore, India. 2012.

13. Wu J, Chen L, Feng Y, Zheng Z. Predicting quality of service for selection by neighborhood - based collaborative filtering. IEEE Transactions on systems, Man, and Cybernetics Systems. 2013. p. 428–39.

14. Xianglan H, Yangguang L, Bin X. A survey on QoS-aware dynamic web service selection. Wireless Communications. Networking and Mobile Computing (WiCOM); 7th International IEEE Conference; 2011.

15. Oh SC, Lee D, Kumara SRT. Effective web service composition in diverse and large – scale service networks. IEEE Transactions on Services Computing. 2008; 1(1):1–18.

16. Shuchao W, Jun W, Jingyu S. Developing a selection model for interactive web services. IEEE Proc of IEEE ICWS 06; Piscataway, NJ. 2006. p. 231–8.

17. Masri A, Mahmoud, QH. Discovering the best web service. In Proceedings of the 16th International Conference on World Wide Web (WWW '07); New York, NY, USA. 2007. p. 1257–8.

18. Masri A, Mahmoud QH. Crawling multiple UDDI business registries. 16th International World Wide Web Conference; 2007. p. 1255–6.

19. Masri A, Mahmoud QH. A framework for efficient discovery of web services across heterogeneous registries. IEEE Consumer Communication and Networking Conference; 2007. p. 415–9.

20. Masri A, Mahmoud QH. qos based discovery and ranking of web services. Proceedings of ICCCN 2007 16th International Conference on Computer Communications and Networks; 2007.

21. Long D, Fox M. An overview and analysis of the results of the 3rd international planning competition. Journal of AI Research. 2003; 20:1–59.