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A Framework for Evaluating the QoS and Cost of Web Services Based on Its Functional Performance

M. Mohemmed Sha, T. Manesh, A. Mohamed Mustaq Ahmed

***Abstract*—**In this corporate world, the technology of Web services has grown rapidly and its significance for the development of web based applications gradually rises over time. The success of Business to Business integration rely on finding novel partners and their services in a global business environment. However, the selection of the most suitable Web service from the list of services with the identical functionality is more vital. The satisfaction level of the customer and the provider's reputation of the Web service are primarily depending on the range it reaches the customer's requirements. In most cases, the customer of the Web service feels that he is spending for the service which is undelivered. This is because the customer always thinks that the real functionality of the web service is not reached. This will lead to change of the service frequently. In this paper, a framework is proposed to evaluate the Quality of Service (QoS) and its cost that makes the optimal correlation between each other. In addition, this research work proposes some management decision against the functional deviancy of the web service that is guaranteed at time of selection.

***Keywords*---**Web service, service level agreement, quality of a service, cost of a service, QoS, CoS, SOA, WSLA, WsRF.

I. Introduction

IN recent years, web services are considered as the main technique to solve the challenges in distributed web applications. Latest development shows that the mainstream organizations are shifting to Services Oriented Architectures (SOAs) and deploying web services within and across their Information Technology (IT) infrastructure [1]. However, the selection of an appropriate service that fulfills the functional requirement is more challenging when more number of services offered in the market with alike type of functionality. In this paper a framework is proposed to estimate the QoS of a web service based on its functional reach. Here, managing the functional deviation of web service problem is carried out in four phases. Initially the suitable weight is assigned to each of the non-functional attribute like response time, throughput, availability, reliability and successability based on the functionality of the web service. Then the expected QoS is also asserted as per these parameter weightage. Secondly, the actual QoS is evaluated by considering both the assigned weight and the values of the QoS attributes measured by the measurement services of both the provider and the customer systems at run time. In the next phase the Cost of the Service (CoS) is automatically calculated by the third party broker as per the offered QoS. The actual performance of all the attributes are monitored and compared with the asserted values in the Web Service Level Agreement (WSLA). The deviations from the asserted guarantee for the specified period are noted and reported to the top management of both the signing parties. Finally, management of both the provider and the customer can take applicable action to correct the deviation to ensure the expected quality. Here, the non-functional parametric values of 10 real world Web services are analyzed for the time period of continuous invocations to study the advantage of functionality based on cost evaluation. The results experimentally demonstrated that the automatic calculation of cost based on QoS satisfied the customer in quality and profited both the provider and the customer in cost.

The proposed WSLA based monitoring and costing framework and the related methods are discussed in Section III. The next section explained the experimental results and finally concluded this work in Section V.

M. Mohemmed Sha , T Manesh and A.Mohamed Mustaq Ahmed are with the Department of Computer Science and Information, Prince Sattam Bin Abdulaziz University, P O Box.54, Wadi Addawasir, Pin:1199, Saudi Arabia (e-mail: sahalshas@gmail.com, maneshpadmayil@gmail.com and mustaqm55@ yahoo.co.in).

II. Related Work

This section presents the related works according to the main areas aligned with the contributions of this research work: selection of a Web service, assigning weights to non-functional parameters, QoS calculation, cost estimation, and managing deviation of the Web service. Many approaches were analyzed in the research investigations for Web service selection to fulfill the user requirements [6]. However, most of the contributions concentrated on selection of Web service based on the evaluation of QoS. Patrick and Haifei put forward a token-based approach to compute the QoS and CoS (Cost of Service) for reaching integrative solutions [8]. Daniel et al. suggested the basis for exploring the strengths and flaws of the existing tactics as well as the prediction of future possible improvements in Web service selection [11].

In 2009, Alrifai and Risse projected an effective service composition method by considering both generic and domain-specific QoS properties [4]. Yutu Liu et al. presented open, fair, and dynamic QoS calculation model for Web services selection through implementation of a QoS registry in a hypothetical phone service application [2]. However, these investigations did not guarantee the QoS level which is asserted at the time of Web service selection. Zibin et al in 2010 presents distributed QoS evaluation by studying the performance of real-world Web services [5]. In this work, to study the performance, several large-scale evaluations on real-world Web services are used and the QoS datasets are openly released. In 2007, Al-Masri and Mahmoud evaluated

computation of QoS by considering the properties like response time, throughput, availability, accessibility, interoperability, and the cost by calculating the Web service relevancy function [3]. Antonova in 2010 framed an algorithm that allows clients to select the Web service with an optimal correlation between quality and price [7]. These investigations towards evaluation cost do not focus on the actual QoS of Web service. In this research work, the cost based on the offered QoS is dynamically evaluated and thereby satisfy both the customer and provider of the Web service in quality and cost.

Monitoring the QoS and managing the Web service to achieve the expected guarantee in WSLA is proposed in various research works. The quality and usage of Web services is organized and monitored via a set of management mechanisms. Dan et al. described a framework for providing customers of Web services and differentiated levels of service through the use of automated management and SLAs [10]. Qi et al. focused on inspecting the different research problems, solutions, and directions to deploying Web services that are managed by an integrated Web service management system [12]. In the present research work, WSLA based automated management is proposed to take management action against the deviations in the actual QoS and the performance of individual non-functional parameters.

III. Framework

The proposed framework for evaluating the QoS and cost of a web service comprises of the modules for the selection of Web services, assertion of QoS, estimation of actual QoS, calculation of cost for the offered QoS and Managing decisions against the violations of the Web services.

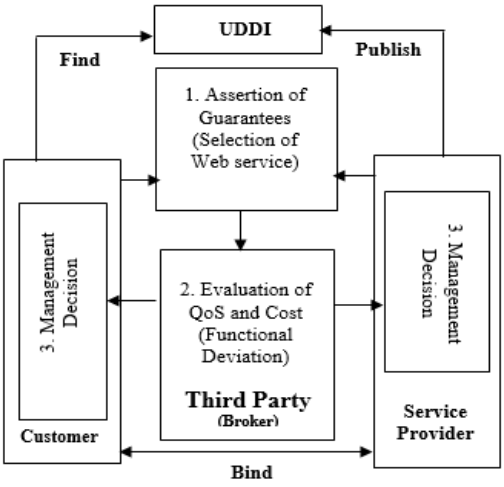

Fig. 1 AWMC Framework

Fig. 1 illustrates the proposed framework and it implementations. The projected framework for managing the deviation and costing of Web services consist of the basic Web service model constituents such as Web service provider, Web service consumer and the UDDI registry. The three basic tasks of the Web service architecture denoted by publish, bind and find quiet exist. In addition, it has a third party broker based Automated Web service Measuring, Monitoring, and Costing system (AWMC) which stores QoS facts for every customer request into a QoS database. The WSLA delivers input to the measurement and management method of an organization that verifies and accomplishes an organization's compliance with the WSLA.

The various phases of evaluation of QoS and management of web service deviation is discussed here as follows:

A. Assertion of Guarantee

The estimated level of performance of a Web service is finalized based on some assertions. Normally, the cost of a service is fixed as per the predictable quality which is settled by the provider and the customer.

In this work, the QoS of the Web service is asserted based on the functionality of the Web service equally agreed by both the signing parties. Such promised values are stated in the WSLA for observing the performance of the Web services while usage.

1. Selection of Web Service

It becomes more and more challenging for consumers to discover valuable Web services among those obtainable on the Web [6]. One of the main goals of this research is to discover the essential Web service based on the preferred quality. The most appropriate Web service is chosen by evaluating the expected QoS by considering the guarantee indicated by the provider. Web service optimization offers methods for finding the “premium” Web services or their composition with respect to the predictable user-provided quality. Due to the vast space of competing Web services, a service demand could be potentially determined by various services. Thus, it is essential for Web service optimization to set a suitable standard to select the “finest” among probable choices [8]. Recent studies show that, QoS of each Web services is vital for their competitiveness. In this proposed work, the selection of the service is purely based on analyzing the functionality of the Web service. The functionality is concluded as per the requirement analysis and primarily based on the customer perspective.

2. Assignment of Functional Weights and Assertion of QoS and Cost

Selection of a Web service is very tedious because of the obtainability of numerous Web services for a particular application. The only possible solution is to select one of the preeminent Web service from the list of functionality similar services. Sometimes it is not supposed to activate the function as per the necessities because of setting the assertions during selection. This leads to the ambiguity about Web services. Always the performance of the Web service is closely linked to QoS (non-functional properties). To evaluate the exact QoS, it is proposed to consider domain dependent and domain independent functionalities of Web service. Using domain dependent functionalities it is easy to fix the actual operation of the Web service because it is absolutely related to technical

aspects of particular Web service. Hence, in this work a method is introduced to assert the QoS by assigning the weights to the non-functional parameters completely based on functionality of the service. For allocating weights to the non-functional parameters, a selection tree based approach is used effectively with real world Web services.

The parameters P_1, P_2, P_3, P_4 and P_5 are allotted with functional weights are mentioned in Table I.

TABLE I
QUALITY PARAMETERS AND UNITS

	QoS Parameter	Description	Units
P_1	Response time	Time taken to send a request and receive a response	ms
P_2	Availability	Number of successful invocations/total invocations	%
P_3	Throughput	Total number of invocations for a given period of time	invokes/second
P_4	Successability	Number of response / number of request messages	%
P_5	Reliability	Ratio of the number of error messages to total messages	%

The assigned weights W_1, W_2, W_3…..Wn to the parameters are normalized to 1 for estimating the QoS and its assertion at the time of selection of a Web service.

B. Evaluation of QoS at Runtime

Evaluation of QoS is the central part of this architecture that contributes the actual performance of the Web service. This architecture recommends a third party broker service that involved in metric instrumentation, measurement of the actual performance, comparing the actual metrics with the guarantee, costing based on performance and reporting the deviations, violation to the top managements of the signing parties [2].

Let, S is the Web service selected from the set of Web services that are available with similar functional properties.

To estimate the actual QoS, the quality parameters are collected through lively monitoring and stored in a QoS database for each request.

Let us consider that our billing system make the cost of usage for the period of every N requests for a single term.

Let R_1, R_2,……R_N are the requests to the Web service S for the billing term, TERM -I.

A set of QoS properties are determined for each request for the selected Web service as:

$$RiPj = \{Pi1, Pi2, \ldots..Pim\} \text{ Where n } (1 \le i \le n) \text{ and m } (1 \le j \le m$$

The set Ps AVG is the average value for each quality parameters {P_1 AVG, P_2 AVG …Pm AVG} is as;

$$Ps\ AVG = \left\{\frac{1}{n}\sum_{i=1}^{n} P_{i1}, \sum_{i=1}^{n} P_{i2}, \sum_{i=1}^{n} P_{i3}, \ \ldots\ \sum_{i=1}^{n} P_{im}\right\} \quad (1)$$

where n ($1 \le i \le n$) and m ($1 \le j \le m$)

After normalization, the values of QoS properties will be offered in the range of (0, 1).

The actual QoS for the Web service can be calculated as:

$$Actual\ QoS = \frac{1}{m}\sum_{j=1}^{m} w_j \,.\, P_{jNOR} \quad (2)$$

where m ($1 \le j \le m$).

C. Calculation of Cost Based on QoS

Web services technology offers a novel computing model, in which infrastructures and application systems are presented by service providers and made attainable to service consumers via Web services such that the total welfares of both the service providers and the service consumers are optimized to the QoS requirements of service requests [13]. While currently mainstream of Web services are accessible free, over a period of time increased business needs of customers on Web services are resulting in demands for improved Quality of Service. Investments in innovative technologies to improve Quality of Service effects in increasing cost of service, which wants to be offset by revenues. While service providers seek expectedness in revenues, consumers and users of the Web services look for flexibility in costing by not being charged for services that are not used and service features that are not delivered. QoS thus becomes a crucial element of pricing in Web services [1], [12].

Here the cost of the Web service is intended only for the accessible quality. The quality of the service is calculated based on the functionality of the Web service. The customer constraint is the leading aspect for confirming the functionalities. Therefore, here the goal is to pay the service only for the functionality achieved [9], [12].

Let, Cs is the cost finalized for the Web service S, with guaranteed quality Qs during its selection. Our objective is to compute the actual cost based on the actual QoS of the selected Web service S during its usage.

The actual cost can be calculated as follows:

$$Actual\ Cost = \frac{C_s \times Actual\ QoS}{Q_s} \quad (3)$$

D. Managing the Function of a Deviation of Web Services

Monitoring management rates the performance of Web services in providing their functionalities in terms of the QoS parameters. To decide whether an objective has been met, WSLA available QoS metrics are assessed based on assessable data about a service (e.g. response time, throughput, availability, and so on), performance during definite times, and periodic evaluations. SLAs comprise other noticeable objectives, which are useful for service monitoring. A key aspect of defining computable objectives is to set cautionary thresholds and alarms for compliance failures.

Let S be the particular Web service with the assured level of quality parameters {P1, P2, P3 ……..Pm} where m ($1 \le i \le m$). Where m is the number of non-functional parameters considered for quality assessment.

Let C_S is the cost fixed for the Web service S with quality Q_S agreed by both customer and provider during its selection.

Here the aim is to check the violations and to scrutinise the QoS and cost of the Web service dynamically based on its performance in contrast with the guaranteed levels mentioned in the WSLA. The deviation for each quality parameter is measured by finding the difference from the guaranteed and actual parametric values [2], [14].

Dev (Pi) = Difference (Guaranteed Pi, Actual Pi), Where m ($1 \leq i \leq m$).

The overall deviation of a Web service Ds is measured using (4):

$$D_s = \frac{1}{m}\sum_{j=1}^{m} w_j \times Dev(P_j) \quad (4)$$

where m ($1 \leq j \leq m$).

The deviance from the guaranteed level and the price of usage of the Web service are reported to the chief management of the signatory parties to take speedy action for the update in the next term period. The proposed WSLA schema is studied for the Web services that are under research to recognise the violations occured for implementing the mutually agreed guarantee [9], [11].

IV. Experimental Results

A. Assertion of QoS Based on Functional Weight

The weights are assigned for the non-functional parameters as per the methods stated in Section I and the QoS for each web service is asserted based on the formula in (1). The asserted QoS is the guaranteed value that is mutually agreed by both the signing parties. It displays the expected level of performance of the Web service to grasp the actual functionality of the Web service.

TABLE II
Asserted Guarantees

Web services	P1 (ms)	P3 (%)	P2 (Inv/s)	P4 (%)	P5 (%)	QoS (0-1)
GlobalWeather	416.06	85.1	3.6	82.3	81.8	0.250
CurrencyRates	233.60	85.4	3.5	89.3	58.1	0.349
NewsReaderService	124.97	93.8	13.0	92.0	94.8	0.688
PhoneVerify	131.72	93.1	3.5	91.0	91.9	0.537
LoginService	306.26	84.9	8.2	77.5	82.3	0.489
RouteCalculationService	172.05	79.8	16.3	74.2	72.2	0.490
NumberConversion	123.89	87.3	36.2	82.3	84.2	0.516
matcherService	328.35	75.5	13.0	80.8	73.6	0.494
AddressFinder	147.25	93.9	3.3	92.9	91.5	0.676
AWSECommerceService	121.56	92.5	8.4	92.0	94.3	0.608

B. Comparison between Actual and Asserted QoS and Cost

Table III indication shows that in majority of the cases the actual cost is less than the asserted one because the actual QoS of the Web service is not up to the expectation in contrast with the guaranteed level. However, to some extent the customer is pleased that he is paying only for the quality that is supplied. In some service the price is little higher than the asserted cost because the quality of the service is enhanced in each term. Monitoring the deficits in each term and bring up to date the service to reach the non-functional parametric standards to the guaranteed level results in financial profit to the provider of the service.

C. Advantage over Related Methods

In order to verify the advantage of the proposed method, the following related costing methods are used.

TABLE III
Asserted and Actual QoS & Cost

S.no	Web Services	Asserted QoS (0-1)	Asserted Cost (cent)	Actual QoS (0-1)	Actual Cost (cent)
1	Global Weather	0.338	1.2	0.250	0.89
2	Currency Rates	0.384	3.55	0.349	3.23
3	News Reader Service	0.646	0.85	0.688	0.91
4	Phone Verify	0.502	2.52	0.537	2.70
5	Login Service	0.515	5.58	0.489	5.30
6	Route Calculation Service	0.707	3.15	0.490	2.18
7	Number Conversion	0.447	0.75	0.516	0.87
8	Matcher Service	0.665	1.84	0.494	1.37
9	Address Finder	0.706	2.72	0.676	2.60
10	AWSE Commerce Service	0.585	4.25	0.608	4.42

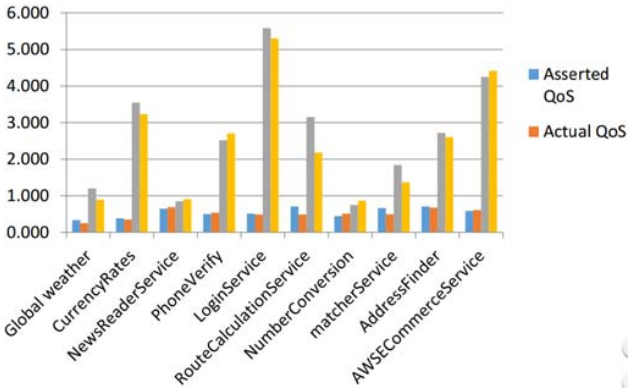

Fig. 2 Comparison between Asserted and Actual QoS

Antonova in 2010 presented an algorithm for Cost Dependent QoS-based Discovery of Web services that allows clients to select the Web service with an optimal correlation between quality and price by ranking the same functionality Web service based on QoS [7].

Al-Masri and Mahmoud [1], [5] introduced the Web service Relevancy Function (WsRF) used for measuring the relevancy ranking of a particular Web service based on QoS metrics and client preferences.

The QoS and the corresponding costs are given in Table IV to discuss the advantage of the proposed method over the other approaches. These data is retrieved during execution of the Web service "EmailVerificationService" from the provider XMLLogic.

TABLE IV
Advantages Over Related Methods

Approaches	Provider	Actual QoS (0-1)	Asserted Cost (cent)	Actual Cost (cent)
Dessislava Petrova-Antonova [7]	XMLLogic	0.340	1.2	1.2
Al-Masri and Mahmoud [1]	XMLLogic	0.322	1.2	1.2
Proposed Method	XMLLogic	0.328	1.2	1.16

From Fig. 3 it is obvious that the cost of the service for the proposed technique is 1.16 for the offered QoS of 0.328. In the other two related methods the cost is estimated as 1.2 for the closely offered quality. Therefore, customer fulfilment is high

in the proposed method because they are spending only for the service delivered. In addition, the algorithm offered by Annotova agrees the clients to select the Web service with an optimal correlation between quality and cost by grading the similar functionality Web services based on QoS but unsuccessful to present dynamic calculation of cost based on the asserted QoS parameters [7]. The algorithm suggested by Al-Masri and Mahmoud [1], [3] does not present the common correlation between the cost and QoS and failed to determine cost dynamically based on the actual QoS over a period of time. In the proposed work, the customer satisfaction is attained by computing the optimal cost based on actual QoS.

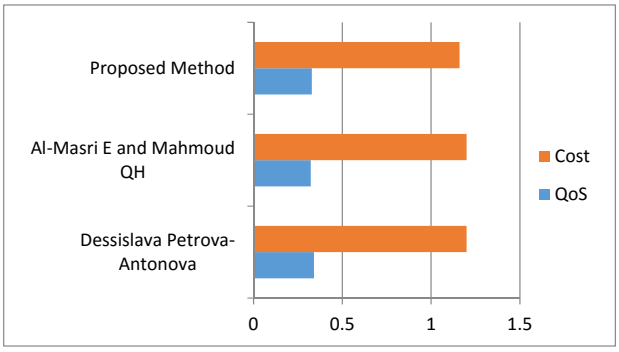

Fig. 3 Advantage over related methods

V. Conclusion

Service Oriented Systems include the services working on different platforms, presented by service providers outside the scope of the enterprise boundaries. The discovery of relevant services and selection of right business associates that guarantee the best Quality of Service are the major issues. As several Web services are predictable to deliver like functionalities, QoS is considered as a key idea in distinguishing amongst competing Web services. Several methods were proposed for the assessment of QoS of the Web service and these approaches used various architectures, methods, models, and procedures for this evaluation but there is no precise effort that focused on the functionality based evaluation of QoS and cost. So in the preliminary stage of this research work, much significance is given for the functionality based weight assignment for the non-functional parameters by analysing the domain specific and independent attributes of the Web service.

In the evaluation procedure apart from using the non-functional parameter values, the assigned non-functional weights are also used for the functionality based QoS estimation. The projected guarantee level check service of the third party broker compares the evaluated values with the guaranteed values in the WSLA document to check whether any violations from the jointly agreed levels by the signing parties. The dynamic pricing and recording system proposed in this research work estimate the cost of the Web service based on the offered QoS and report it to the upper management of the signing parties for a period of time. In conclusion, the management analyses the violations from the guaranteed level of performance and proceeds necessary actions to attain the probable quality level for the fourth coming terms of billing phases. In addition, it is evident from the experimental studies the proposed method have the advantage over similar methods and it benefits both the authorities in cost and quality.

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