The 8th International Conference on
Computer Science & Education (ICCSE 2013)
April 26-28, 2013. Colombo, Sri Lanka

A Web Service Composition Selection Approach based on Multi-Dimension QoS

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***Abstract*—With the development of web service, web service composition is used widely. How to guarantee the non-functional requirement of users under the precondition of satisfying functional requirement of users is an important problem in web service composition. To address this problem, this paper presents a web service composition selection approach based on multi-dimension quality of service(QoS) which introduces multi-dimension QoS to describe the QoS of web service composition and computes the QoS of web service composition according to the type of web service composition. Then the web service composition which can best satisfy the non-functional requirement of users can be found from the web service compositions which can satisfy functional requirement of users according to this approach. At last, an application example is used to explain this approach.**

***Index Terms*—Web service, web service composition, quality of service , multi-dimension qos.**

I. INTRODUCTION

With the rapid development of distribution, web applications have developed from localization to globalization, which promotes the wide use of web service. Web service, which is a new web application mode, creates a good condition for establishing a flexible cooperation relationship in network environment. Users can seek, use and publish web service based on a series of technology criterions such as SOAP, UDDI and WSDL[1] and establish a flexible web application.

With the wide use of web applications in various fields, the number of web service has increased and the kind of web service has become more abundant. With the development of research in web service, more researchers realize that the function of a web service is very single and is difficult to complete the complex web application. So it is necessary to compose the web services to provide much stronger function. Now, the research aiming at web service composition mainly considers how to satisfy the functional requirement of web service composition. How to satisfy the non-functional requirement of web service composition under the precondition of satisfying the functional requirement of web service composition has become an important problem in web service composition[2].

Firstly, this paper introduces some concepts of web service, web service composition and QoS. Aiming at the problem that How to satisfy the non-functional requirement of web service composition under the precondition of satisfying the functional requirement of web service composition, this paper introduces multi-dimension QoS to describe the QoS properties of web service composition and presents a web service composition selection approach. Then this paper introduces how to use this approach to select the web service composition that best meets the non-functional requirement of users from some web service compositions which can satisfy the functional requirement of users. At last, an application example is used to explain how to use this approach to guarantee the non-functional requirement of web service composition. Comparing with other web service composition selection approaches, this approach introduces multi-dimension QoS to describe the QoS properties of web service composition carefully and is helpful to make a deep study of the QoS of web service composition.

II. WEB SERVICE COMPOSITION AND QOS

A. Web Service

Web service based on a series of technology criterions such as SOAP, UDDI and WSDL is a service-oriented architecture technique. It provides services by standard web protocol to implement the interaction of application services between different platforms. The basic framework of web service is composed by participants and basic operations. Participants are the service provider, the service requester and the service agent. Basic operations are publishing, binding and finding. According to the development process, web service includes the basic web service and the composite web service[3]. Basic web service is the native service or the service which has already existed. Composite web service is composed by a set of other services.

B. QoS

In a web application, the requirement of users is divided into two groups, one is the functional requirement, the other is the non-functional requirement. Functional requirement describes the function which system should provide. Non-functional requirement describes the service which system provides or the restriction of function. Definition of QoS is given initially by CCITT: QoS is an integrated indicator to measure satisfaction with a service and describes some performance characteristics of a service. The definition of QoS property in web service is: a series of non-functional properties that influence the quality provided by web service[4]. It describes the quality information in some aspects of web service and is very important for combining web services and constructing the web application which is according with the requirement of users[5].

C. Web Service Composition

Web service composition comes from software reuse. Its basic idea is combining the existing web services according to a certain sequence to construct a new or better web service for satisfying the requirement of users. According to composition plan, web service composition can be divided into two kinds, one is static composition and the other is dynamic composition. Static composition is the web service composition that the designer selects the service provider according to the requirement of users and composes services according to a certain sequence in the design stage. Dynamic composition is the web service composition that the system automatically selects the service provider according to the requirement of users and produces a new web service in the run time. Now the industry standard such as WSDL, UDDI, WS-BPEL can provide the powerful technology support for web service composition. But there are also many challenges in how to compose a new service according to the QoS requirement of users and it has grasped more attention from industry and academe[6].

III. MULTI-DIMENSION QOS PARAMETERS OF WEB SERVICE COMPOSITION

A. Multi-dimension QoS

With the further research on QoS, the kind of QoS parameters in web service becomes more abundant and the range of QoS parameters is much wider. For exploring QoS more deep researches of Carnegie Mellon present multi-dimension QoS.

The concept of dimension is from geometry. In geometry, dimension is the coordinates of points in space and is the basic element to make up of space. According to the concept of n dimensions, QoS of an application can be considered as a space of n dimensions. Every kind of QoS parameters is one dimension which makes up the space. So the relation among QoS parameters of different dimensions can be expressed by the restrictive condition among different dimensions, which is helpful to research the intrinsic relation among QoS parameters.

B. Multi-Dimension QoS Parameters of Web Service Composition

Web service composition is composed by some single web services. So it is necessary to quantize QoS properties of web service before computing QoS properties of web service composition. QoS properties of web service can be interpreted as a group of parameter set that can be quantified used to measure the satisfaction of the service provided by service provider. In web applications, simplex QoS parameter is difficult to describe QoS requirement of users systemically because QoS requirement of users are usually different. In order to describe QoS properties of web service more exactly, the concept of Multi-Dimension QoS is introduced to this paper. QoS properties of web service involve various aspects of web service. So their QoS parameters are more complicated. For describing QoS properties of web service accurately, we think QoS of web service as a space of four dimensions which includes time dimension, spatial dimension, reliable dimension and cost dimension. It is showed as table Ⅰ.

TABLE I. MULTI-DIMENSION QOS PARAMETERS OF WEB SERVICE

Dimension	QoS Parameters	
time dimension	Execution time	Communication time
spatial dimension	Storage capacity	Message length
reliable dimension	Availability	Reliability
cost dimension	Service cost	

QoS of time dimension describes QoS parameters related to time. It includes execution time and communication time. Execution time stands for the time of executing a web service. Communication time stands for the communication time of sending requests and returning results between the service requester and the service provider.

QoS of spatial dimension describes QoS parameters related to space. It includes storage capacity and message length.

Storage capacity stands for the space which web service uses. Message length stands for the maximum message length when the service requester communicates with the service provider.

QoS of reliable dimension describes QoS parameters related to reliability. It includes availability and reliability. Availability stands for the probability of the service running normally in a period of time. Reliability stands for the probability of the service executing successfully in a period of time. We mark a period of time with t, the time of the service running normally in the period of time with T(s), the times of the service executing successfully with R(s), the total times of the service executing with R(t), thereout the availability Q(t) and the reliability Q(r) can be denoted as follows:

$$Q(t)=T(s)/t \tag{1}$$

$$Q(r)=R(s)/R(t) \tag{2}$$

QoS of cost dimension describes parameters related to cost. It includes service cost. Service cost stands for the cost which the service requester pays for the service provider in order to call the service.

IV. A Web Service Composition Selection Approach based on Multi-Dimension QoS

A. Normalization of QoS Parameters

In multi-dimension QoS, QoS described by every dimension QoS parameters is different while there are differences among meaning and values range expressed by every QoS parameter of every dimension. For comparing QoS on a uniform platform, it is necessary to normalize QoS parameters to map these different QoS parameters into the same interval. Or else, similarity of QoS which is contributed by numerical value in different domains should bring error.

The QoS properties of web service can be divided into positive properties and negative properties. For positive properties, the bigger are QoS properties, the better is QoS, such as availability and reliability. For negative properties, the smaller are QoS properties, the better is QoS, such as execution time of service and cost of service. Based on above considerations, we use two different formulae to normalize the two types of QoS properties. They can map QoS properties of every dimension into the interval between 0 and 1 and make them in the same growth direction.

For time dimension QoS, we mark the maximum of execution time among all web services with maxet, the minimum of execution time among all web services with minet, the maximum of communication time with maxct, the minimum of communication time with minct, the execution time of current web service with Et, the communication time of current web service with Ct. t1 and t2 denote the value of weight of QoS parameters in time dimension QoS and the sum of t1 and t2 is 1. Thereout after normalizing the execution time et, the communication time ct and the time dimension QoS T can be denoted as follows:

$$et=(maxet-Et)/(maxet-minet) \tag{3}$$

$$ct=(maxct-Ct)/(maxct-minct) \tag{4}$$

$$T=t1* et+t2* ct \tag{5}$$

For spatial dimension QoS, we mark the maximum of storage capacity among all web services with maxsto, the minimum of storage capacity among all web services with minsto, the maximum of message length with maxlen, the minimum of message length with minlen, the storage capacity of current web service with Sto, the message length of current web service with Len. s1 and s2 denote the value of weight of QoS parameters in spatial dimension QoS and the sum of s1 and s2 is 1. Thereout after normalizing the storage capacity sto, the message length len and the spatial dimension QoS S can be denoted as follows:

$$sto=(maxsto-Sto)/(maxsto-minsto) \tag{6}$$

$$len=(maxlen-Len)/(maxlen-minlen) \tag{7}$$

$$S=s1* sto+s2* len \tag{8}$$

For reliable dimension QoS, we mark the maximum of availability among all web services with maxava, the minimum of availability among all web services with minava, the maximum of reliability with maxrel, the minimum of reliability with minrel, the availability of current web service with Ava, the reliability of current web service with Rel. r1 and r2 denote the value of weight of QoS parameters in reliable dimension QoS and the sum of r1 and r2 is 1. Thereout after normalizing the availability ava, the reliability rel and the reliable dimension QoS R can be denoted as follows:

$$ava=(Ava-minava)/(maxava-minava) \tag{9}$$

$$rel=(Rel-minrel)/(maxrel -minrel) \tag{10}$$

$$R=r1* ava+r2* rel \tag{11}$$

For cost dimension QoS, we mark the maximum of service cost among all web services with maxpri, the minimum of service cost among all web services with minpri, the service cost of current web service with Pri. Thereout after normalizing the service cost pri and the cost dimension QoS C can be denoted as follows:

$$pri=(maxpri-Pri)/(maxpri-minpri) \tag{12}$$

$$C=pri \tag{13}$$

B. A Web Service Composition Selection Approach based on Multi-Dimension QoS

The QoS of web service composition are mainly composed by the QoS of single web service and composition type of web services. Although there are many composition types of web services such as sequence, probability and cycle, they all can be resolved into sequence type by some methods[7][8]. Based on this fact, this paper presents a web service composition selection approach based on multi-dimension QoS. This approach introduces multi-dimension QoS to describe the QoS properties of web service composition carefully and mainly studies how to compute the QoS of web service composition which is sequence type. In this way, this approach can select the web service composition that best meets the non-functional requirement of users from some web service compositions which can satisfy the functional requirement of users.

The concrete procedure of this approach is showed in Fig1. Firstly, introduce multi-dimension QoS to describe the QoS parameters of web service composition and normalize these QoS parameters in order to map them into the same interval. Secondly, compute the average QoS of every dimension of the web service which is in the web service composition to measure the QoS of every dimension of web service composition. Finally, compute the QoS of web service composition according to the improved Euclidean Distance to select the web service composition which meets the requirement.

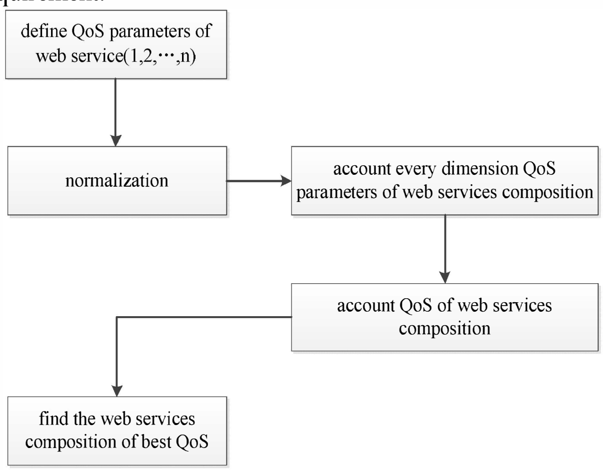

Figure 1. Web service composition selection approach based on multi-dimension QoS

W(w1, w2, ...,wn) denotes a web service composition, wi is a atom service in the web service composition and i is between 1 and n. Ti denotes the time dimension QoS of web service wi. Si denotes the spatial dimension QoS of web service wi. Ri denotes the reliable dimension QoS of web service wi. Ci denotes the cost dimension QoS of web service wi. Thereout the time dimension QoS T of web service composition W can be denoted as follows:

$$T=1/n(T1+T2+\dots+Tn)=1/n\Sigma Ti \tag{14}$$

The spatial dimension QoS S of web service composition W can be denoted as follows:

$$S=1/n(S1+S2+\dots+Sn)=1/n\Sigma Si \tag{15}$$

The reliable dimension QoS R of web service composition W can be denoted as follows:

$$R=(R1*R2*\dots*Rn)^{1/n}=\exp(1/n\Sigma \ln Ri) \tag{16}$$

The cost dimension QoS C of web service composition W can be denoted as follows:

$$C=1/n(C1+C2+\dots+Cn)=1/n\Sigma Ci \tag{17}$$

In multi-dimension QoS, QoS can be taken as points of a space of multi-dimension QoS. So the QoS of web service composition can be measured by the distance between the origin and the point which stands for the QoS of web service composition in multi-dimension QoS. The distance between points of a space usually uses Euclidean distance to measure. But Euclidean distance only calculates distance between points of a space of multi-dimensions, and considers no about different weight among different dimensions. So this paper improves the formula of Euclidean distance and introduces weight factor[9]. Supposed that W(w1,w2,w3,w4) is a point in a space of four dimensions QoS, k1, k2, k3 and k4 denote the value of weight of each dimension in a space of multi-dimensions QoS respectively and the sum of k1, k2, k3 and k4 is 1. So the improved Euclidean distance L between the origin and the point in a space of four dimensions QoS can be denoted as follows:

$$L=\mathrm{sqrt}(k1*(w1)^2+k2*(w2)^2+k3*(w3)^2+k4*(w4)^2) \tag{18}$$

Based on the above analysis, L stands for the QoS of web service composition W. So it is easy to select the web service composition that best meets the non-functional requirement of users from some web service compositions which can satisfy the functional requirement of users by comparing L which stands for the QoS of web service composition.

V. EXPERIMENTS

A. Example used in experiments

In order to show further the web service composition selection approach based on multi-dimension QoS that this paper presents, we use java to realize this approach and use an application example of data processing to elaborate how this approach selects the web service composition that best meets the non-functional requirement of users from some web service compositions which can satisfy the functional requirement of users. In this application example, users want to handle the data. They want to delete null values, remove repetitive values and select the valid information according to the requirement. This process can be completed by a web service composition which contains three web services to separately complete three functions of deleting the null values, removing the repetitive values and selecting the valid information according to the requirement. For ease of presentation, we select web service composition A and web service composition B from web service compositions which satisfy the above-mentioned functional requirement as an example to explain how this approach selects the web service composition that best meets the non-functional requirement from the two web service compositions.

B. Approach explanation

Firstly, describe the QoS parameters of every web service in web service composition by multi-dimension QoS. Supposed that the three web services in web service composition A are web service A1, web service A2 and web service A3. QoS parameters of the three web services in web service composition A are showed as table Ⅱ.

TABLE II. QOS PARAMETERS OF WEB SERVICES IN WEB SERVICE COMPOSITION A

web service composition A		*web service A1*	*web service A2*	*web service A3*
T	Et(ms)	2000	3000	2200
	Ct(ms)	1000	1500	1200
S	Sto(M)	50	100	60
	Len(M)	0.5	0.8	0.4
R	Ava	0.8	0.5	0.7
	Dep	0.8	0.6	0.7
C	Pri(RMB)	800	1000	600

Supposed that the three web services in web service composition B are web service B1, web service B2 and web service B3. QoS parameters of the three web services in web service composition B are showed as table Ⅲ.

TABLE III. QoS PARAMETERS OF WEB SERVICES IN WEB SERVICE COMPOSITION B

web service composition B		*web service B1*	*web service B2*	*web service B3*
T	Et(ms)	2500	2800	1600
	Ct(ms)	1000	2000	1000
S	Sto(M)	30	80	80
	Len(M)	0.5	0.6	0.5
R	Ava	0.7	0.6	0.8
	Dep	0.6	0.7	0.5
C	Pri(RMB)	500	1200	300

Then, normalize the above QoS parameters with the expressions to map them into the same interval and compute the overall QoS parameters of each dimension according to the expressions. Supposed that the weight ratio of QoS parameters in every dimension is 1:1. The QoS parameters of every web service in web service composition A after normalizing are showed as table Ⅳ.

TABLE IV. ORTHONORMAL QoS PARAMETERS OF WEB SERVICES IN WEB SERVICE COMPOSITION A

web service composition A		*web service A1*	*web service A2*	*web service A3*
T	et(ms)	0.8	0.5	0.3
	ct(ms)	0.5	0.7	0.5
	T	0.65	0.6	0.4
S	sto(M)	0.29	0.33	0.8
	len(M)	0.6	0.25	0.75
	S	0.445	0.29	0.775
R	ava	0.75	0.25	0.5
	dep	0.75	0.33	0.75
	R	0.75	0.29	0.625
C	pri(RMB)	0.33	0.83	0.33
	C	0.33	0.83	0.33

The QoS parameters of every web service in web service composition B after normalizing are showed as table Ⅴ.

TABLE V. ORTHONORMAL QoS PARAMETERS OF WEB SERVICES IN WEB SERVICE COMPOSITION B

web service composition B		*web service B1*	*web service B2*	*web service B3*
T	et(ms)	0.3	0.7	0.9
	ct(ms)	0.5	0.2	0.83
	T	0.4	0.45	0.865
S	sto(M)	0.86	0.67	0.4
	len(M)	0.6	0.75	0.5
	S	0.73	0.71	0.45
R	ava	0.5	0.25	0.75
	dep	0.25	0.67	0.25
	R	0.375	0.46	0.5
C	pri(RMB)	0.83	0.5	0.83
	C	0.83	0.5	0.83

At last, supposed that the weight ratio of every dimension in web service composition is 1:1 and compute the QoS of web service composition A and web service composition B by the improved Euclidean distance(expression 18). By comparing the QoS of the two web service compositions, the web service composition that best meets the non-functional requirement of users is web service composition B. The result is showed as table Ⅵ.

TABLE VI. QoS OF WEB SERVICE COMPOSITION A AND WEB SERVICE COMPOSITION B

	web service A	*web service B*
T	0.55	0.57
S	0.5	0.63
R	0.51	0.44
C	0.5	0.72
QoS	0.52	0.60

VI. CONCLUSION

This paper firstly introduces some concepts of web service, web service composition and QoS. Aiming at the problem that How to satisfy the non-functional requirement of web service composition under the precondition of satisfying the functional requirement of web service composition, this paper presents a web service composition selection approach based on multi-dimension QoS. This approach introduces multi-dimension QoS to describe the QoS properties of web service composition and computes the QoS of every dimension of web service composition. Then this paper takes QoS as points of a space of multi-dimension QoS and computes the QoS of web service composition by the improved Euclidean distance. In this way, we can select the web service composition that best meets the non-functional requirement of users from some web service compositions which can satisfy the functional requirement of users. At last, an application example is used to explain how this approach to select the web service composition which best meets the non-functional requirement of users from some web service compositions which can satisfy the functional requirement of users.

ACKNOWLEDGMENT

This work is partially supported by the Natural Science Foundation of Jiangsu Province of China(BK2011281); Natural Science Foundation of the Jiangsu Higher Education In stitutions of China(10KJB520019).

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