Service Selection Algorithm of Two-layer QoS Model based on Functional Grouping

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Abstract
With the development and application of service computing technology, quality of service has become one of the important bases for the selection of services in service composition. In order to avoid the influence of functional difference of services on the QoS of services in the service composition, this paper proposes a two-layer QoS model service selection algorithm based on feature grouping. First of all, in the process of service composition, the services are grouped according to their function, then the services in the same group are further grouped by QoS, which includes common QoS and reputation degree QoS based on the subjective and objective factors. The reliability of service is defined to express the common QoS, while a kind of evaluation method of reputation degree is raised to express the reputation degree QoS. Experimental results show that this method can obtain web services with high reliability and high credit standing; meanwhile it can increase the success rate of web service composition.

Keywords: Web service, service composition, QoS, two-layer model, functional grouping

1. Introduction
In recent years, with the rapid development of Internet the Web service has become a new model of Internet applications and distributed computing, which is characterized by its open, low coupling and platform independence, and getting the attention of people. Web service with WSDL (Web service Description Language), SOAP (Simple Object Access Protocol) platform independent of network communication Protocol for service requester service function, to form the future large-scale service-oriented distributed computing basis. The Internet service provider is numerous which can provide a lot of functionally similar or the same service. The single Web service can only provide a single or limited function, cannot meet the demand of complex service requester, so Web service composition technology arises at the historic moment. In the Web service composition, how to carry on the effective service composition has been one of the questions which widely concerned by academia and industry.

In the process of service selection, service providers are often encounter this problem, that is the service selection should be carried out in a wide range of service information, and the service information is not complete. Therefore, when the service request for the Web service selection should not only consider the functional requirements of the service to be chosen, should also consider choosing services can satisfy non-functional requirements, namely the Quality of Service. When the service requester in the face of many functionally similar or identical to choose services, should consider to choose a Web service QoS at the same time, the QoS in the service of the search, selection and composition process, the QoS into the service search, selection and composition process, for the successful construction of the application system based on Web service and its quality assurance is of great significance.

Literature [1] proposed a based on the degree of similarity between service requester and service, combining with the experience of history service requester to forecast the QoS values which service requester unused. Literature [2] proposed a model, which is based on the immune system's multiple signal mechanism real-time computing QoS model. The model is only given the calculation method of the service reputation; however, the calculation method of the QoS is not given. The above work promotes the study of the dynamic calculation Web service QoS value, but the set of all known service as a single, then calculate each Web service QoS, and there is no clear distinction between whether similar or identical to provide functional
service. Literature [3] studied the credit model of Web service, rely mainly on the service requester feedback, through a service requester subjective score statistics to define the creditworthiness, the reputation degree of this method ignores the QoS attribute value.

The functions of Web service are diverse; the service composition is a process of selecting the better service from the QoS service set according to the functional requirements. The factors in the same function of service are relative. The selection of Web service in the service composition process is based on the service function, so the Web service is function related. QoS describes the quality of the Web service, so the QoS has an indirect response to the service function. The QoS and the service functions are interrelated. Traditional QoS measurement atomic services as a single individual, obtain independent QoS of atomic services, in the process of the next service portfolio, according to the feature to group again, and then choose the better grouping within the QoS service. This method separates the QoS's computing and service function group artificially, the QoS is no longer included in the service function information, so it can not reflect the functional information. In addition, the definition of reputation degree from service request feedback and the subjective vote score of service request cannot guarantee that each service request give real feedback, so that will certainly bring the deviation of evaluation, so the service is not accurate. Therefore, this paper proposes a two-layer QoS service selection model based on functional grouping, and finally gets the best composition of QoS services.

2. Service Selection Framework Based on Two-layer QoS Model of Functional Grouping

Sometimes a single Web service cannot meet the needs of service requests in the service composition process, and several Web service are required to complete a service request from a service request, so all the candidate which in the service library being group according to the function, and then the optimal Web service is selected. As shown in Figure 1, Web service QoS attributes are divided into two levels by two-layer QoS model: common QoS layer and reputation degree QoS layer. The common QoS layer is a commonly used nonfunctional properties of Web service, mainly includes: service execution time, cost, efficiency, usability, reliability, and security, etc; reputation degree QoS layer is a property that contains the reputation of the service. In this paper, we focus on the service execution time, reliability, and credit attributes. Two-layer QoS service selection framework makes service selection process more clear, clear logical relations, through the two-layers of QoS service selection calculation model to draw each Web service QoS comprehensive value in the group, in order to select the optimal quality Web service.

![Figure 1. Two-layer QoS model](image)

2.1. The Division of Two-Layer QoS Model

In a two-layer model, common QoS layer contains a Web service has the QoS attributes, which is the objective factors that affect the QoS, in this paper, we consider the
reliability and service execution time; reputation degree QoS layer contains service prestige related attributes, namely the subjective factors that affect the QoS, this article considers only reputation degree attributes. Reputation degree of QoS layer properties is a description of Web service quality, but it has the very big difference with other layer QoS attributes. Other QoS attributes are published by the service provider, and the property of the reputation degree is basically monitored by a neutral mechanism, which corresponds to the service provider's evaluation of the service (credit). It is not the same as the common layer because it is an evaluation of the service from another perspective.

Common QoS that contains all areas of mutual service quality attributes which the Web service QoS layer applies to [4]. As the two-layer QoS model has a good expansibility, properties of each layer can be expanded to meet the need of its own. For the convenience of description, this article selects the reliability and service execution time to define the common QoS. Execute time refers to the time spent on calling the Web service, in other words, the service be requested, the service provider responds to the service request, and the results are returned to the service provider, the time taken for the above process named execute time. Reliability is the probability that the correct response of a request in the maximum expected time, it is a measure of the reliability of the service. The measurement of reliability is closely related to the hardware and software configuration of the Web service, and also closely related to the network connection between the Web service provider and the Web service requester.

Reputation QoS consists of the Web service QoS credibility [5]. Reputation is dependent on the evaluation of the service and the use of their own experience. Reputation evaluation method, on the one hand, pay attention to the experience of the service. On the other hand, it can be divided according to historical feedback, only a certain level of service requests are qualified to recommend the service, so as to ensure the reliability of the recommended credibility. According to the actual situation of the service to call the direct credit and the recommended credit, and the selection of Web candidates can meet the actual needs.

2.2. Two-Layer QoS Model Service Selection Framework Based on Functional Grouping

Traditional Web service framework including the service provider, the service requester and the service registry [6, 7]. The service provider to the service registry for registration, publishing service related information, the service requester through the registry to find the service for need, access to the specific information, and then call, service. With the development of semantic Web service, based on ontology semantic description has been introduced into the service registry center, using the semantic description of services, the information registry can automatically find the required services for the service request.

In this paper, the traditional Web service framework is extended, and a two-layer QoS model service selection framework based on functional grouping is proposed (Figure 2). In the two-layer QoS service selection process that based on feature grouping, the Web service will be grouped according to the function, real-time and dynamically calculate each service QoS in the group. At the same time in order to ensure that each service requester can use high reputation degree of the service, this paper puts forward reputation degree evaluation method, according to the actual service invocation is calculated directly and recommend the credibility, select candidate services can meet the practical requirements [8, 9].
The specific process of Web service selection framework which based on the two-layer QoS model is as follows:

1) Service providers publish Web service to expand the UDDI center, and service providers to extend the UDDI center to provide services to the corresponding Web service information, also the impact of QoS factors, such as reliability, etc.

2) Monitor real-time monitoring the service quality, the information from service provider feedback and the level of the service provider, the monitoring information storage in the extended UDDI.

3) The service requester sent to the extended UDDI center to find a request for a service, and also to send a request for the QoS property.

4) The extended UDDI center receives the service request information from the request. The function of the same service to be grouped, and then within the group to carry out the two-layer QoS model of service selection, based on the impact of QoS subjective and objective factors for QoS dynamic calculation, to choice the high real-time, high reliability and high credit Web service.

5) After analyzing the service information of the two-layer QoS model, the monitor is used to find the best service in the service composition, and the result of statistical analysis is passed to the binding device and the calling device.

6) Binding and call the optimal or recommend service portfolio to meet the demand of the service requester, and let the service requester to invoke the Web service.

7) After the service is used by the Web service, the feedback information of the service is transmitted to the binding and the calling device, and then the feedback information is stored in the extended UDDI center.

2.3. Two-layer QoS Service Selection Calculation Model

In the above chapters, this paper discusses the two-layer QoS model and the two-layer QoS model service selection framework based on functional grouping. But eventually we need to calculate the value of each Web QoS within a grouping to compare, get the best Web service within the group.

First in the common QoS layer, the main consideration is the reliability of Web service and service execution time. When a service provider releases a Web service, the system will give the Web service's reliability initial value $C_{init(i)}$ for each QoS message, which is given by the service provider. When the service is published, the number of calls to the record service calls named $C_s$ and the number of calls to meet the QoS information named $S_i$ are all initialized to zero. But after the service requester selected and successfully invoke a Web service, the monitor will automatically receive real-time reliability of the service after the call. If you call a service execution time is too long, you can also be seen as its reliability is not high, it is also need to consider the execution time of the service. Therefore, in order to obtain the service with
Among them, \( t_i \) is the total time of the \( i \)-th service accumulation calling in the Web service group; \( n \) is the Web service group size, which is the service group there were so many services, \( n \geq 1 \); \( S_i \) is the number of successful calls to the \( i \)-th service in the Web service group. \( C_i \) is the total number of calls to the \( i \)-th service in the Web service group. \( C_{\text{ini}(i)} \) is the initial reliability value of the \( i \)-th service in the Web service group; \( S_u \) is the positive integer \((u < n)\), \( S/u + S_{\text{ini}(i)} \) is the weighted number of times of \( C_{\text{ini}(i)} \); with the increase of the total number of the \( i \)-th service calls \( C_i \) within the Web service group, \( S_u \) is constant, so the proportion of \( C_{\text{ini}(i)} \) to reduce the proportion and reliability of the operation of the increase.

Secondly, in the Reputation degree of QoS layer, mainly in order to complete the service requester's own experience as well as the feedback provided by the different levels of service requesters to find out the optimal quality of the task of Web service.

(1) The direct reputation degree

The direct reputation degree is the service's reputation, which is based on the practical experience of the service, and it is the service request that the service request is generated. If the service request user and the service \( i \) process a total of \( C_i \) times, calling, which successfully call \( S_i \) times, then the reputation degree of its access to:

\[
R_{\text{user},i} = \frac{C_i}{S_i + \frac{\sum q_j}{q_{\text{ini},j}}} \sqrt{\frac{\sum q_j}{C_i}}
\]

(2) Service requester’s reputation level

The service requester in the process of using the service, the service provider for the service requester is trustworthy has some evaluation mechanism. Through the service request user calls the service’s historical QoS feedback information service requestor reputation stratification.

The closer the greater the distance of the call time reference for QoS property values estimated services, the introduction of time decay factor \( \lambda (0 < \lambda < 1) \), so that more recent data from the current the greater the impact on the calculation.

(3) Service requestor’s reputation level

The service requester in the process of using the service, the service provider for the service requester is trustworthy has some evaluation mechanism. Through the service requestor user calls the service’s historical QoS feedback information service requestor reputation stratification.
\[ R_{\text{user}} = \begin{cases} 0.5 & |C_{\text{user}}| = 0 \\ \frac{d}{1 - d |C_{\text{user}}|} \left( \sum_{j \in C_{\text{user}}} (q^{user}_{ij} - q^j) \right) & |C_{\text{user}}| > 0 \end{cases} \] (4)

\( C_{\text{user}} \) are all the services for service requester calls, \(|C_{\text{user}}|\) is the total amount of this set of services, \(q^{user}_{ij}\) said the service requester calls the \(j\)-th QoS attribute values of service \(i\), \(d\) is a regulating factor, \(0 < d < 1\).

(3) The indirect reputation degree
The service request through the third indirect recommendation forms the reputation as the indirect reputation degree. In order to expand the scope of the trusted service request, the level of the recommended service request is \(R_{\text{user}} \mu \leq \gamma \leq R_{\text{user}} / \mu\), then the service user \(s\) obtained by the indirect trust of the service \(i\):

\[ R_i (\text{user}, i) = \sum_{\gamma \in \gamma} R(\text{user}, i) / |\text{user}, \gamma| \] (5)

Among them, \(\mu\) is the regulator \((0 < \mu < 1)\), and \(|\text{user}, \gamma|\) is the number of people who are eligible for the service requesters.

(4) The initial reputation degree
The reputation of the service provider, which is released on the network, and without any interaction with the new individual service instance, is the initial credit degree of service:

\[ R_{\text{init}}(\text{user}, i) = \sum_{i=1}^{n} \omega_i \alpha_i \] (6)

Among them, \(\omega\) is for the service requester preference and \(\sum_{i=1}^{n} \omega_i = 1\); \(\alpha_i\) is the \(i\)-th service QoS after normalized values.

(5) Enhancing the reputation degree QoS values
For service requesters, it can be predicted that call services, but it will choose to call the service \(i\), it will be more depends on the direct reputation degree and the indirect reputation degree, the corrected QoS value is enhanced reputation, namely \(QoS_i = \omega_1 R_{\text{init}}(\text{user}, i) + \omega_2 R_{\text{user}}(\text{user}, i) + \omega_3 R_{\text{user}}(\text{user}, i)\), among them, \(\alpha_1\), \(\omega_2\), \(\omega_3\) are service requester to the initial reputation degree, direct reputation degree and indirect reputation degree of preference, \(\alpha_1 + \omega_2 + \omega_3 = 1\).

(6) Comprehensive QoS values
By considering the common QoS, reputation degree QoS layer to calculate the service composition in a service QoS value, namely: \(QoS_i = \alpha_1 QoS_i + \alpha_2 QoS_i + \alpha_3 QoS_i\), \(\alpha_1 + \alpha_2 = 1\). After a QoS value comparison, the set of the best quality service Web service is returned to service requester.

3. Simulation Experiment and Performance Experiment
This part adopted the data of WS-DREAM (Distributed Reliability Assessment Mechanism for Web service), which include 5825 QoS assessment reflection about Web service from 339 service requester around 24 countries, and this reflection contain 2 real data, they are response time and throughput. Besides, this article expand this data and add 5 other QoS attributes, which are service time, reliability, availability, success rate and reputation. Because
this article focused more on service composition and reputation, so the writer mainly payed service time, reliability and reputation into attention. Willfully select 10 already distributed and test-passed Web service (see Table 1), collect its data about response time, reliability and reputation.

Web service composition is made up by several Web service, every Web service is able to complete some service demand from composition, but they have their own different attribute of service quality. This experiment tries to simulate a Web service composition, which contains 4 functions: fun1, fun2, fun3, fun4. The service list will have the same or similar service, and it adopted sequence structure among different services.

3.1. Common Layer QoS Simulation Experiment and Comparison

(1) Randomly select Web service

Table 2 shows the five service randomly combined to achieve fun1 service call request the data returned by the normalization algorithm to calculate the normalized value of each attribute, as shown in Table 3. Due to different measure methods, units and standards of different attributes, it is necessary to adapt Gauss method to normalize the data and reflect it to the area of \([0, 1]\), which can avoid abnormal value (influence of extremely large or small number) better. After all the data normalized, calculate a service's QoS according to Web service' different QoS's weight ratio. This experiment mainly considered service time and reliability, so given the weight ratio is 3:2. The data of every text is different because of the stability of the net environment and the quality of the service provided, so only one set of data is distributed here. As for the initial reliability, it is decided by service provider's type and country's type. For example, if it is a foreign website, and the service provider's suffix is".com", the value is 0.4; "net", 0.45. It is a website at home, the reliability is 0.6, the suffix is".com", the value is 0.5;".net", 0.6. And the reliability of ". cn" is 0.5.

Table 2 shows the data reflected by fun1 after 5 times of service composition's request, table 3 is the standardized value calculated by normalized method.

<table>
<thead>
<tr>
<th>service</th>
<th>Service time</th>
<th>The initial reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>GeoIPService</td>
<td>Call fails</td>
<td>Call fails</td>
</tr>
<tr>
<td>IP2Geo</td>
<td>4610</td>
<td>0.4</td>
</tr>
<tr>
<td>Service</td>
<td>5135</td>
<td>0.6</td>
</tr>
<tr>
<td>Service</td>
<td>4620</td>
<td>0.6</td>
</tr>
<tr>
<td>IpAddressSearchWebService</td>
<td>6831</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 3. Standardization after each attribute values

<table>
<thead>
<tr>
<th>service</th>
<th>Service time</th>
<th>The initial reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>GeoIPService</td>
<td>Call fails</td>
<td>Call fails</td>
</tr>
<tr>
<td>IP2Geo</td>
<td>0.37376</td>
<td>0.2487</td>
</tr>
<tr>
<td>Service</td>
<td>0.46995</td>
<td>0.6508</td>
</tr>
<tr>
<td>Service</td>
<td>0.37559</td>
<td>0.65076</td>
</tr>
<tr>
<td>IpAddressSearchWebService</td>
<td>0.7807</td>
<td>0.44975</td>
</tr>
</tbody>
</table>

This experiment considered service time and reliability and the weight numbers are 0.4 and 0.6, the QoS can be calculated by the data of Table 2.
(2) Select Web Service According to the Group
Firstly, divide the sub-services of composition service into 4 groups according to their functions, that is fun1, fun2, fun3, fun4. The composition and Web selection are decided by the demand of service requester. During this procedure, it is necessary to record how long it is needed to invoke a service, how many times we could invoke them successfully in all invoke times. The QoS of a service in one group can be gotten by formula (1), the number of service is 4, that is \( n=4 \), so \( S_i \) is 2. (other positive integer smaller than \( n \) is available).

(3) The comparison of two methods
This experiment collected 5 times of data, at the first time, the time of the composition request is 3; the second time is 5; the third time is 10; the fourth time is 15; the last time is 20. The composition request adopt both of these method, choose the Web service of the list and got its QoS value. Figure 3 is the comparison between grouping and randomly select.

![Figure 3. Comparison between grouping and randomly select](image)

From the Figure 3, we could get the conclusion that the QoS that got by the service according to the function is higher than random choosing method. So it is necessary to divide them into groups according to their function.

3.2. Reputation Degree QoS Layer Simulation Experiment and Analysis
This experiment simulated the service composition request of 5 requester, and grouped them by their request, altogether produced 80 times of composition. Every time the composition is conducted, the candidated Web service's QoS value that chosen by a sub-service and requester's level of Web service composition would be changed. From the Figure 4, when the service request came to nearly 40 times, the degree of the preference influences little to the successful ratio, but with the increasing of the times of the composition, the times of the intro service choice increased, too. The higher the degree of the direct and indirect reputation, the better the choice of the Web service could satisfied the demand.

![Figure 4. Number of service composition request and the successful rate of service composition](image)
4. Conclusions
This article came up with the concept that based on two levels of QoS service model. Divide the common QoS into several groups according to the functions, and complete the calculation in the internal Web service group. It also provided a dynamic method of QoS calculation. The simulation experiment shows that the dynamic method could provide a more qualified service. In the level of reputation, the statistical analyst of service requester invoked the history of the operational circumstances then divides the level of the requester, and proposed a method based on the direct and indirect reputation, which take both the dynamics of the service and the complexity of the net, as well as raised the successful ratio of the composition.

Conflict of Interest
The authors confirm that this article content has no conflicts of interest.

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References