Expectation Value Calculation of Grid QoS Parameters Based on Algorithm Prim

Kaijian Liang
School of Application & Technology, Hunan Institute of Engineering, Xiangtan, China
Email: liangkaijian@sina.com

Linfeng Bai
School of Information Engineering, Henan Institute of Science and Technology, Xinxiang, China

Xilong Qu
School of computer and communication, Hunan Institute of Engineering, Xiangtan, China

Abstract—From the perspective of selecting service by QoS attributes, a computation method of QoS expectation value, which is based on Algorithm Prim, was presented to provide support for selection of service. On the basis of the ability of service providers, by Algorithm Prim, this method succeeded in calculating a set of balanced expectation values of QoS. Selection of service based on these QoS values would be beneficial to optimization of system resources and protection of the users of those services. An example with analysis has been provided to demonstrate the feasibility and effectiveness of the method.

Index Terms—grid computing, service matchmaking, QoS parameters, algorithm prim

I  INTRODUCTION

To network technique as the core, new generation network computing environment is a hotspot and leading edge domain of current international research. The goal of network system construction combining with network technique is integrating computing facility; storage device; service facility and instrument from different place, building large computing and data processing shoring of foundation construction and achieving wide range sharing; effective aggregating and full releasing abased on computing resource; data resource and service resource on the internet. Traditional internet achieved the connection of computer hardware, Web achieved the connection of web page, when grid try to achieve the connection of all resource, including computing resource; storage resource; communication resource; software resource; information resource and knowledge resource. In Service-Oriented network environment, discovering and selection is a very important link, in the process, we need not only guarantee the veracity of service location, but also consider the need of user, so foundation and selection abased on QOS service arise.

Service foundation is a process which could meet the need of specific service of user in the network, and achieve automation and intellectualization. There is not strict divide between service foundation and service selection, in some research work, service foundation includes service selection. Generally speaking, service foundation emphasizes the process in founding candidate service collection, namely the way on gaining candidate service, but service selection emphasizes selecting a suitable service for user from candidate service collection. In this sense, service foundation is the preorder step of service selection, as a roughing process, the result collection is the object of service selection operating. The size of result collection; the way of gaining; and veracity have direct effect on service selection strategy. If it adopts a very strict standard for the need of all users in service foundation, service selection has to do nothing, and vice versa.

From the view of user, they always want to find an optimal service, but they can’t, owing to price; service; times; factors. Practical application, users take two sides into consideration: one side, meeting the need of QOS with a better cost performance; on the other side, different user has different attention on the attributive of QOS except satisfy basic QOS needs, some have specific requests on service price, others may pay attention to the response time of service or creditworthiness. So you say, when taking the two side into consideration, aiming at specific user, it is user to measure the satisfaction of QOS needs at last. User has different attention on the attributive of QOS; it is the QOS needs predilection of user. But in practical application, it is very important to study the QOS needs predilection to satisfy QOS needs of specific user.

It has important significance to realize the potential value of gridding service resource. In microeconomics, price is the effective lever of adjusting supply-demand relations between consumer and commodity. In foreseeable gridding technology application domain, there are many similarities between behaviors of gridding service with user and consuming behavior of commodity in market with consumer. Combining microeconomics theory, it can introduce market mechanism into “paid service” of gridding service. In fact, “paid service” itself reflect an effective mechanism that configures “gridding service” resource, and it is beneficial for the whole operation order of gridding environment. Because lever of price can have an effect guiding impact on
network using behavior in different user, as a adjusting user incentive mechanism in using “griding service” resource, despite “paid service” cannot distribute resource and restrain it’s behavior explicitly when facing limitless condition at present network environment. Therefore, this paid use in gridding service has “benefit” property in commercial activity.

Because of basic mechanism sustained by QOS attribute, it can configure, discover, select, distributes resource on the basic of QOS attribute. In current many system, not only grid system, but also distributed system and Peer-to-Peer system, all its introduce SLA mechanism, which can describe QOS information resource and bind specific application. Some researcher introduces Service data into grid service, which can be used to describe a kind of grid service information including QOS information. G-QOSM base on OGSA, provides a QOS management model facing service, and expand grid service description on the foundation of service data. It sustains resource based on QOS attribute and service foundation, also the latest GGF standard, and match OGSA' latest standard. QGS in G-QOSM frame exist in every domain, keeping in touch with user application program, and catch service request constrained by QOS parameter. According to the given parameter, it can find the best matching service and consult SLA; Base on foundation sign a contract to guarantee user service quality.

The discovery and selection of service based on QoS attributes can facilitate the optimization of system resources and guarantee the quality of customer service, which has been a hot research topic in grid computing. Moreover, it is also an issue to be sorted out for the application and commercialization of grid computing. In the commercialized environment of service-oriented grid application, the users will consider their own benefit and efficiency while using the service. Whereas among a number of candidate services, the way users determine the equilibrium requirements of QoS appears critical as equilibrium requirements of QoS have a direct impact on QoS matchmaking parameters and the selection of services. Therefore, it is essential for users to present the expected value of QoS parameters and method of computing [1].

Up to date, similar researches have focused on models of service selection and algorithm, esp. introducing effective and applicable models combining closely the system structure so as to improve the system efficiency [2,3]. As for Algorithm, the main interest lies in how to improve the precision and accuracy of algorithm and stress the effectiveness of computing [4, 5]. About the estimation of parameter, some researchers have been carried out in related fields. For example, for the estimation of network performance, the reference literature no.6 [6] as listed has proposed a method of computing which can be used to estimate path capacity, on the basis of algorithm which can deal with the estimation of capacity of end-to-end single congestion path and available bandwidth. In literature no.7 as listed [7] the estimation method of discrete wavelet transform is applied in the research of synthesized business flow of high-speed Internet. The related work in parameter estimation has received adequate attention and plays a great role in the corresponding fields. These achievements have provided useful theoretical basis and method for selection of service and protection of quality of user service, although the function of QoS requirements was ignored and no specific result was achieved. For the optimization of system resources and protection of the user service efficiency, this paper will study how to calculate the value of expected QoS parameters.

Source reservation technology in service-oriented computing environment is a basic technology for service quality control, but there are still great difficulties. On one hand, factors such as network environment heterogeneity, the breadth of distributed independent nodes, node management and complexity of security strategies, etc, increase the difficulty of resource reservation; on the other hand, reservation has a lot of key issues to be resolved, including reservation technical fault tolerance, the validity of reserved resources, resource sharing to be faced by reservation, etc, which require valid, reliable and robust reservation technology; while not increase too much system expense and ensure not affect the overall system performance.

With the development of computer science, graph theory progress at an alarming rate, and it is a major embranchment in applied mathematics. On one hand, computer science provides computing equipment for graph theory; on the other hand, it needs graph theory to describe and solve many problems in modern sciences practical application. Graph theory was applied to many domains as a method or tool in describing the relation of affairs at present, such as computer science, physics, chemical, operational research, information theory, cybertechmics, network communication, social science, economic management, military, national defense, and agriculture and industry production. Prim is an important method to solve the weighted graph shortest or the optimal path problem in graph theory, and then it can be used to project decision described by graph theory.

II. QOS PARAMETERS OF GRID SERVICES AND SERVICE MATCHMAKING

A Efficiency Type Qos Parameters

"Efficiency" is a term used in the field of economic management and means "income", "interest" originally [8].Network application should also follow the principles of "market economy" and commercialized "efficiency" also exists. As economic grid environment is concerned, owing to the existing "commodity market", economic laws also function. Users of service expect not only the basic function but also others such as the most convenient and safe service at the minimum cost. Consequently, the users’ requirement of QoS is also accompanied by pursuit of "efficiency" and the QoS attributes of service also include the consideration of "benefit". Both parties of supply and demand of the service follow the rules of market economy for QoS matching parameters. On the users’ side, economic benefits constitute the prior consideration, of which service the price, response time may be included in the cost efficiency type QoS parameters which the smaller, the better. But, for other
QoS parameters such as credit and reliability which can be listed in economic and social efficiency type parameters, the bigger value is preferred.

Classification of grid QoS parameters on the basis of efficiency has it practical value in application. Based on efficiency, users can carry out their calculation of QoS parameters matchmaking by means of certain effective algorithm when they implement resources discovery and selection of service so as to decide the most appropriate service for themselves and get the best efficiency and provide grounds for the specific service finally. On the other hand, it also helps keep the balance between supply and consumption of the resources and improves the level of optimization of the system and operational effectiveness of resources.

B Service Matchmaking based on Qos Attributes

In the service-oriented computation, a unified port can be abstracted from service for designated access to various resources including computation, storage and network. In practical implementation a unified service port can be formulated hidden to users. For example, a computation service can be done by a single or multiple processing machines, of which details need not directly be expressed in the service contract. In other words, the granularity of service function is changeable and the function can be realized by a single host or distributed system [9]. It thus provides a possibility that the QoS attributes are made as a part of the port so that the system can select among services based on QoS attributes, which makes it easier to ensure the QoS requirements of users.

To make service discovery and selection based on the attributes of QoS, it is required to establish the QoS attribute set for each service and determine the corresponding QoS parameters. When the user applies for service, firstly they are supposed to declare their QoS requirements, then the system can make matchmaking calculations according to the candidate QoS service attributes to discover the service to satisfy the requirements. To be specific, it is to match the QoS parameters of the service with the required parameter of the user. In this way the quality of customer service is ensured [9].

One of the ways to establish QoS attributes is to extend WSDL&UDDI. The purpose of extending WSDL is to better describe service, add QoS attributes to the description of WSDL and expand the service attributes. For instance, a new genre of service QoS can be added to WSDL [10] to describe the various QoS attributes of service. Meanwhile, corresponding extend is also supposed to be implemented in UDDI so that when the service in the UDDI is published, users can discover and select service according to QoS attributes. With the support of the service discovery and QoS attributes, we guarantee the demand of users for QoS more closely.

There are three functions in pretreatment of data named standardization: firstly, comparing size by different type’ attribute value. If QOS attribute data is different, weight comparison would not express easily. Secondly, the not dimension, if the QOS attribute dimension is different, attribute would not common measure. Even the same attribute, it may use different prickle, then the different numerical value. In various kinds multiple target assessment method, assessing require remove the effect of dimensional selection on assessment result, this is the not dimension. It tries to eliminate dimension, reflecting the good or bad of attribute value with only the size of numeric. Thirdly, the normalization, different type attribute value numerical value size is different in the primary attribute value table, putting it into the interval between 0 to 1.

Besides, it also could solve the incomplete compensatory by nonlinearity transformation or other methods in pretreatment of data. There are many data preprocessing method, including linear transformation, standard 0-1 transformation, vector standardization, and so on. This text adopts the following method to dispose.

III ESTIMATION OF QOS PARAMETER EXPECTATION VALUE BASED ON PRIM ALGORITHM

A The Prim Algorithm of Minimum Spanning Tree (MST)

The minimum spanning tree of the graph can be obtained by means of prim algorithm in an undirected connected graph. This algorithm, like Kruscal algorithm, is also widely used in multitudinous domains such as network, civil engineering and so on to solve many practical problems [11].

Kruscal is a very mature arithmetic in graph theory, it can evaluate shortest path tree in a weighted undirected connected graph. According to limbic weight number compositor from a small beginning into a force, it investigates each side of graph G side collection T. If the been investigated two peaks belong to two different connected component, then putting this side into the selected side collection TE, meanwhile, connecting two connected component to one connection component; else rounding this side. And so on, if the connected component number of T is 1, this connected component is one of G’ minimum spanning tree.

Prim Algorithm suppose an undirected connected graph is $G = (V, E)$, the two tuples represents the set of points and edge set respectively, then the minimum spanning tree of $G$ is $T = (U, TE)$. The basic idea of prim algorithm is: the initial status is $U = \{v_0\}$, $TE = \emptyset$ and then repeat execution of the following operations: among all sides of $u \in U, v \in V - U$, find a side of minimum cost $(u, v)$ and merge it into the collection $TE$ and at the same time merge $v$ into $U$ until $U = V$. Then in $TE$ there must be $n - 1$ sides. $T$ makes the Minimum Spanning Tree. The specific algorithm pseudo-code is described as :

1. Initialization: $U = \{v_0\}$ ($v_0$ means any vertex in $V$); $TE = \emptyset$ ;
2. The cycle stops until $U = V$
   (1)Among all sides of $u \in U, v \in V - U$ find a side of minimum cost $(u, v)$;
   (2) $TE = TE + \{(u, v)\}$ ;
(3) \( U = U + \{ v \} \).

Obviously, the key in Prim algorithm is to find the shortest side to connect \( U \) and \( V - U \) to expand the spanning tree \( T \). The spanning tree selected in this way bears the minimum overall weights. With regard to the efficiency type QoS parameters of users in grid computing environment, by means of proper method of modeling, these parameters can be converted to the form of undirected connected graph, by prim algorithm, a spanning tree of minimum overall weights can be produced. Namely, a QoS parameter expectation value which keeps equilibrium between both parties of demand and supply can be obtained.

\section*{B Efficiency Type QoS Parameter Modeling}

The description of candidate services shows the ability of the QoS grid services to provide users service. For the modeling of QoS parameters by graph structure, the QoS parameters of the values in same or different types should be unified by a common measure standard. Owing to the difference in the capacity of each candidate service, there can be a huge discrepancy in the values so that standardization is necessary for the unification of the measure.

Definition 1. The standardization of numeric QoS parameters. It includes QoS Parameters such as service price, response time etc. If a numeric QoS parameter is \( q_i, i \in Z \), and the corresponding standarized one is \( q'_i \) then

\[ q'_i = q_i / \sum_{i=1}^{n} q_i, i, n \in Z \]

Definition 2. Standardization of ratio type QoS parameters. It includes QoS Parameters such as reliability, credit etc. Suppose a ratio type QoS parameter is \( q_i, i \in Z \) and the corresponding standarized one is \( q'_i \), then

\[ q'_i = (1 - q_i / \sum_{i=1}^{n} q_i), i, n \in Z \]

The following theorem will show many a side will require at least \( n \) vertexes to form a single connected complete graph or dense graph.

Theorem 1. Suppose there are \( e \) sides and \( n \) vertexes are required to construct a single connected complete graph or dense graph. And \( n \) satisfies:

\[ n = \left\lfloor \sqrt{1 + 8e} / 2 + 1 \right\rfloor \]

Proof: Mathematical induction is applied. When \( e = 1, 2 \) and by calculation with the theorem, we get \( n = 2, n = 3 \). Obviously it is true. Suppose \( e = k \) and at least

\[ n = \left\lfloor \sqrt{1 + 8k} / 2 + 1 \right\rfloor \]

vertexes is required; when

\[ e = k + 1 (k \in Z), \]

\[ n' = \left\lfloor \sqrt{1 + 8(k + 1)} / 2 + 1 \right\rfloor. \]

Obviously, there is:

\[ \sqrt{1 + 8(k + 1)} / 2 + 1 \geq \sqrt{1 + 8k} / 2 + 1 \]

within, and

\[ \sqrt{1 + 8(k + 1)} - \sqrt{1 + 8k} = \sqrt{8k + 9} - \sqrt{8k + 1} \leq 2 \]

when the equality establishes, a single noncomplete connected graph is formed, \( n' = n \), only one side is to be added to the original graph; if the equality doesn’t establish, then definitely \( n' = n + 1 \), when one side and one vertex are added to the original graph, a single connected dense graph is formed. The above two situations conform to the reality. Q.E.D

Definition 3. Weighted-edge of QoS. It represents QoS parameter and the weight of the side is the standardized value of such QoS parameters.

Definition 4. Single connected graph of QoS attributes. The single connected graph made with certain type of QoS \( G_{QoSType} = (V, E), E \) stands for the collection of QoS weighted edges, \( v \) stands for the collection of vertexes related to the QoS weighted side. If \( |E| = e, e \in Z \), then

\[ |V| = \left\lfloor \sqrt{1 + 8e} / 2 + 1 \right\rfloor. \]

Among the multiple candidate services, definition 4 establishes an association model for the related QoS attributes and each QoS parameters are closely related to each other via the model which thus provided basis and groundings for examining the relationships between those QoS parameters.

\section*{C Estimation of QoS parameter expectation value}

By establishing the QoS attributes single connected graph of each candidate service by Definition 4, with Prim algorithm we can get a spanning tree of minimum dissipation value, namely, the QoS parameter expectation value of minimum dissipation value, which can be used for next stage of selection of service.

Suppose the candidate service collection is

\[ S = \{ s_i \} \ (i \in Z^+) \]

and the corresponding QoS attributes collection is:

\[ QoS_S = \{ q_{ij} \} \ (i \in [1, n], j \in [1, m]) \]

in which \( j \) actually stands for the type of QoS attributes. Here follows the actual method of calculation:

While \( j \leq m \)
do
{  
1. Establish the QoS attributes single connected graph
$G_j$ of $|E| = n$ ;
2. Initialize $G_j : U = \{v_0\} , TE = \{}$ ;
3. The cycle goes on until $U = V$
   (1) Among all sides of $uU \in U, vVU \in - U$ find a
   side at minimum cost $(u,v)$ ;
   (2) $(u,v)$
   $TE = TE + \{(u,v)\}$ ;
   (3) $U = U + \{v\}$ ;
4. To get the expectation value of $q_j$ ,
   $E(q_j) = \sum_{i=1}^{n} q_{ij} \times \left( \sum_{k=1}^{i} e_k / |TE| \right)$
Or
   $E(q_j) = 1 - \left( \sum_{k=1}^{i} e_k / |TE| \right)$ ,
in which $e_k \in TE$ .
}

Then the target QoS parameter expectation value is:
$E(QoS) = (E(q_j) \mid j \in [1, m])$ .

As far as the density of probability is concerned, a random
Collection of candidate services can reflect the equilibrium
Distribution of the service provider. Consequently, with such
capacity of service provision, users can estimate the
Reasonable QoS expectation parameter value by means of the
above mentioned method and use it as the groundings for
discovery and selection of service so that then they can
maximize the efficiency while using the paid service.

IV THE EXAMPLE AND ANALYSIS

Hereby let's demonstrate the process of the specific
Method of calculation and compare it with Kruscal algorithm
$S = \{s_j \mid i \in [1, 5] \}$ ,

$QoS_s = \{q_{ij} \mid i \in [1, 5], j \in [1, 3] \}$ ,

in which $q_{i1}$ , $q_{i2}$ , $q_{i3}$ stand for service price
(currency unit), response time (millisecond) and reliability
(percentage). Specific value will be offered in the following matrix:

$$
\begin{bmatrix}
100 & 10 & 82 \\
120 & 20 & 90 \\
150 & 16 & 80 \\
80 & 30 & 92 \\
200 & 6 & 88 \\
\end{bmatrix}
$$

$QoS_s = \begin{bmatrix}
0.15 & 0.12 & 0.26 \\
0.18 & 0.24 & 0.15 \\
0.23 & 0.20 & 0.29 \\
0.12 & 0.37 & 0.12 \\
0.31 & 0.07 & 0.18 \\
\end{bmatrix}$

According to the above-mentioned method of QoS
Parameter expectation value, we firstly process the data by
Standard and get the following matrix of numbers:

$QoS^* = \begin{bmatrix}
0.15 & 0.12 & 0.26 \\
0.18 & 0.24 & 0.15 \\
0.23 & 0.20 & 0.29 \\
0.12 & 0.37 & 0.12 \\
0.31 & 0.07 & 0.18 \\
\end{bmatrix}$

Following that the QoS attributes single connected graph
$G_1 = (V_1 , E_1 )$ of $q_{i1}$ and weighted edge sets
$E_1 = \{0.15 , 0.18 , 0.23 , 0.12 , 0.31 \}$ are established.

By Theorem 1 we can get that
$|V_1| = \sqrt{|1+8|E_1|/2+1| = 4}$ .

If the initial status is $TE_1 = \{}$ then the status of the
selected set of points $U$ and edge set $TE_1$ are

$U = \{v_0 , v_3 \} , TE_1 = \{0.12 \}$ ;

$U = \{v_0 , v_3 , v_1 \} , TE_1 = \{0.12 , 0.15 \}$ ;

$U = \{v_0 , v_3 , v_1 , v_2 \} ,
TE_1 = \{0.12 , 0.15 , 0.18 \}$ .

Finally the first QoS expectation value
$E(q_{i1}) = \sum_{i=1}^{n} q_{ij} \times \left( \sum_{k=1}^{i} e_k / |TE_1| \right) \approx 9.8$ is
obtained. Similarly, we can get

$E(q_{i2}) = \sum_{i=1}^{n} q_{ij} \times \left( \sum_{k=1}^{i} e_k / |TE_2| \right) \approx 11$ ,

$E(q_{i3}) = 1 - \sum_{k=1}^{i} e_k / I |TE_3| \approx 0.85$ .

Thus we can get QoS expectation value
$E(QoS) = (9.8 , 11, 0.85)$

From the above example, it is obvious that the calculation
Method has disposed of some QoS parameters and provided
equilibrium combination value of low dissipation. It actually
has reduced the range of service selection, the load of
calculation in matchmaking and clarified the target of
matchmaking, which makes the process of service selection
more precise and accurate. The time complexity of Prim
algorithm is $O(n^2)$ , whereas that of Kruscal algorithm is
O(e(\log_2 e)). The time complexity of the former seems worse than the latter but each has its own advantage. Although the calculation of QoS parameter based on Prim algorithm has no advantage in time complexity, it is more appropriate for the calculation of minimum spanning tree of dense graph, which is very similar to the QoS parameter model. In contrast, the calculation of QoS expectation parameter value based on Kruskal algorithm is more suitable for spares graph. In fact, the results of the two methods of calculation are very close to each other, although it has strengths in time complexity.

V CONCLUSION

From the perspective of selecting service by QoS attributes, a computation method of QoS expectation parameter value based on Algorithm Prim is presented in order to provide support for selection of service, which is beneficial to the optimization of resource consumption and the protection of customers’ efficiency in use. The achievement expressed this article provides a useful perspective and method for selection of service and QoS guarantee and therefore bears significant value in both theory and practice. At the next stage our research will concentrate on combining the method of computation of QoS expectation parameters value with the effective selection of service, testing and assessing its efficiency correctly.

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Liang Kaijian, Male, Born in August 1965, in Dongkou, Hunan, PhD, the professor of Hunan Institute of Engineering, research direction: intelligent technology, funded by Hunan Natural Science Joint Fund leader and current vice president of application technology, manufacturing information in Xiangtan City Group experts. Research Interests: knowledge discovery and intelligent technology. In recent years, chaired the participating countries from the provincial education department Corky gold key projects and scientific research 4; published more than 20 academic papers, which were retrieved included six three.

Linfeng Bai School of Information Engineering, Henan Institute of Science and Technology, Xinxing, China

Xilong Qu (1978-), PhD., the associate professor of Hunan Institute of Engineering. He graduated from Southwest Jiaotong University in 2006 and earned the Doctor degree. His research interesting are networked manufacturing, agile supply chain, and papers with high quality, and more than 20 papers are indexed by ISTP and EI.