A Global Optimization Method of Web Services Composition Based on QoS

Fan YAN
School of Electrical and Electronic, North China Electric Power University, Beijing, China
Email: fanqiu@ncepu.edu.cn

Abstract: As a new application pattern, knowledge service has been rapidly developed in recent years. How to integrate the existent knowledge services to form a newly complex service is a popular research area. This paper presents a framework to support dynamically service composition. And then we focus on the global optimal model of knowledge services composition. The essence of the model is that the problem of dynamic service selection with QoS global optimal is transformed into a liner integer programming with QoS constraints. At last, a set of optimal service composition is produced by means of optimizing objective function, which fulfills requires of users and improves the dynamical and flexible capability of service composition.

Keywords: Knowledge service composition; global optimization; QoS; liner integer programming

1 Introduction

Knowledge service as a kind of new service form in knowledge management field, has gradually been paid attention to in industry and academic circles in recent years. However, the content of the individual knowledge service is limited and usually can't meet the complex knowledge demand. So how to integrate a single knowledge service to form a more powerful combination of services to meet complicated demand has become a new hot spot. Combination of services is refers to the integration the existing service and the process according to a certain business logic to better meet users’ requirements. It mainly can be divided into static combination and dynamic combination. Due to the dynamic characteristic of Web environment, most of the application and research about combination of services are focused on the dynamic way. Firstly dynamic knowledge service combination needs to decompose users’ knowledge demand and then carry on the knowledge service choice according to the current system state and the decomposition in each sub-demand. Finally, the choice will be the final combination to get the results. However, in the practical environment, for each sub-demand, there may be several knowledge services, which meet the conditions but have different QoS (quality of service) parameters (such as the execution time, cost and reliability etc.) .Take the agricultural area for example, if a customer need a knowledge of vegetable planting, then the knowledge service should consist at least breeding, fertilizing, tools, storage and other components of the knowledge and in every part of knowledge there is at least a service provider can meet users’ requirements. Therefore, how to conduct optimized service combination in allusion to customers’ QoS needs, so as to form executable service which can meet customers’ function and quality demand has become an important problem in service combination.

At present, most of the researches about service composition optimization use partly optimum principle based on QoS, that is, a sub-need to meet a group of services, then weight and sort each QoS parameter of service. Choose weighted and the largest service to join combination process to conducted. In this kind of methods, the choice of the sub-demand corresponding to specific service is independent, and can't solve the problem of QoS global optimization of services combination. Such as it requires, in combination of services, the execution time must be controlled within a specified range in the circumstance that execution cost and reliability are on a certain condition. Thus, to make up for the shortcomings of the existing technology, the paper puts forward a dynamic combination framework which supports the service and carry on a research on a Global Optimization Model based on QoS combination of service (Global Optimal Model of Knowledge Services Composition) for research. The main idea is to convert the combination of services global optimization problem into a linear integer programming model with QoS constraints, and substitute the objective function approximate with the objective function of the first order expansion of the Taylor, and then through the successive iteration, we will get the approximate optimal solution for the model. Finally has a group of optimization service combination which meet the constraints of QoS. Compared with the existing methods, this method has considered of function, quality and other factors from all views of point. We don't have to assess every optional service and also can improve the efficiency of the combination and meet the QoS needs of different users. Finally we will increase the service of the dynamic and flexibility characteristics.
2 The description of the question

**Definition 1 Service Composition** refers to with the support of combination of services support platform support, according to users’ requirements, automatically choose several services and integrate by some business logic and process to better meet the customers’ demand. It usually consists of a Service Sequence $<WS_1, WS_2, \ldots, WS_n>$. 

**Definition 2 Service Logic Node** is the basic logic unit process which make up a combination of services, logic nodes only contain function description and do not point to specific services. In dynamic combination of services in the modeling, the system establishes a general model of combination of services by using the service logic node according to the certain business logic.

**Definition 3 Service Candidate** refers to a set of Services including process model m service logic node, the service logic node in the form of Services including process model m service logic node according to the certain business logic.

**Definition 4 Services Composition Graph** is a combination of Services including process model m service logic node, the service logic node in the form of Services candidate is $SC_i(1<i<m)$. The combination of services is shown in Figure 1.

![Figure 1. Combination of services](image)

**Definition 5 QoS-Constrained Optimal Path.** to the combined services figure SCG above, there exists $k(k>2)$ constraints $C_i$ $(i = 1, \ldots, k)$. At the same time, each path $P$ has $m(m>2)$ non-negative measure of performance criteria $f_1, \ldots, f_m$ from start to finish, $P$ conditions for the multi-constraint optimal path if and only if $\forall Q(P \neq Q)$. When both $P$ and $Q$ satisfy the constraint $C_i$, then all the criterion of measurements make $P(f_1, \ldots, f_m) > Q(f_1, \ldots, f_m)$.

Global optimization of services composition based on QoS is- when in the process of implementation in the combination process, choose specific services from a candidate set of services corresponding each logical node to form an executable workflow service, making the workflow to meet the specific QoS constraints to achieve the target under the premise of optimization, and to meet the needs of the users. **Definition 5** shows that service composition based on QoS global optimization problem can be transformed into a solution from start to finish in the SCG with QoS constraints of the optimal path problem. The following article will first study the overall framework of the combined system, and then come up with the combination of global optimization service on the basis of it.

3 QoS-based service composition framework and global optimization model

3.1 framework and global optimization model

Currently, the service portfolio still lacks a unified theoretical model. It can not be full support for the design and implementation of the portfolio of services. It also does not have valid Synthesis authentication methods and quality control means. This paper argues that a complete Service portfolio should be at least includes the following systems several modules, requirements decomposition, processing model, path optimization, portfolio of services, workflow management, services portfolio monitoring and evaluation and so on. System operation can be divided into the following specific steps.

Step 1 Requests decomposition: decompose the user's query requests by logic function and query rewrite it according to the system template.

Step 2 Service retrieval: conduct UDDI search against decomposed logic functions and sorting the weighted results of QoS.

Step 3 Service portfolio: use global optimization methods for service composition according to the logical processes and quality requirements combined with the users.

Step 4 Combination of calls: choose service calls and implement process management According to the thought of a workflow management system.

Step 5 Operation monitoring: real - time monitoring the process of calling the service composition and timely adjusting the QoS parameters of each service.

3.2 QoS-based global optimization model for service composition

In reality, different applications have different requirements for QoS. Therefore, when considering the integration of QoS service path selection, it doesn’t need to be optimized for all QoS parameters. Priority should be given to the focused QoS parameters of the application. This paper analysis the partial optimization methods of service portfolio first, and then presents a mathematical model of the overall planning service integration route choice for its lack. And solution algorithm is given, this mathematical model has scalability on QoS parameter.
ters. Provide a appropriate decision-making framework to QoS analysis for service integration and determination of a Integrated path.

### 3.2.1 Analysis of partial optimization methods

Suppose there are m logic nodes {O_1, O_2,..., O_m} in service composition T. After UDDI’s functional inquiry, a logical node may correspond to several optional services to complete the node function. Which S_i={s_i1, s_i2,..., s_in_i} is the service candidate set of logical node O_i, i = 1, 2,..., m. Services portfolio optimization results are usually expressed as CS = {<O_1, S_1>, <O_2, S_2> ... <O_m, S_m>}. Next step is to focus to select a service to perform this logical node task on the corresponding service through a selected strategy at the running time. Selection strategy can be an evaluation function, shown in the following equation:

\[ U(s) = \sum_{q \in Q} w_q v_q(s) \]

Here, \( U(s) \) is on behalf of the value of evaluation function \( U \) of the service \( s \), \( v_q(s) \) is about the property value that \( q \) should be taken. \( Q \) is the set of service attributes, \( w_q \) is the weight assigned to the property \( q \), which meets \( w_q \in [0,1] \) and \( \sum_{q} w_q = 1 \). Users or application designers can provide a number of different options strategies corresponding to the evaluation function. Users select strategy and calculate the highest weighted attributes and services according their preferences.

### 3.2.2 Global Optimization Model

The partial optimization requirements need to solve one by one for each sub-optimal execution services, although the result is partially optimal, some of the global services portfolio requirements can’t be met. For example, customers require the total cost of the service can’t exceed $500 and the time can’t be longer than 5 minutes and so on. This article presents a method for global services, it can obtain the optimal solution based on global parameters of the control objective function constraints and there is no need for each optional service-by-path assessment, through this way, the complexity of the algorithm is reduced. Here for the sake of brevity, only the failure rate and time for running are selected as QoS parameters, and we assume they are independent of each other. In practical, if we consider more than two QoS parameters, we only need to add the corresponding constraints in processing. In addition, this article discusses only the order type of service integration path, the path for other conditions, such as parallel, conditional and looping, etc. can be recursively into sequential path as long as the appropriate quality of service can make some transformations. Take the service composition diagram in the picture 1 as an example, given a task \( O_1 \) and final task \( O_m \), suppose there are two m-2 for Service node between them, for each task node \( O_k \) there are \( n_k \) optional service (k = 1, 2,..., m). The optional service uptime of task node \( O_k \) is \( t_k \), failure rate is \( f_k \) (i = 1, 2,..., n_k). This goal is find an execution plan (the first task is the O1, the final task is Om, require the minimum failure rate and running time is not greater than the given time delay \( t_0 \). Clearly, the integration of services in a given path exists. Introduce decision variables \( x_{ki} \) (k = 1, 2,..., m, i = 1, 2,..., n_k), whose value is \( x_{ki}=1 \), if and only if the task Ok can be implementation by the i-th selected services; otherwise value takes 0. The decision variables must fit the situation that \( \sum_{i=1}^{n_k} x_{ki} = 1 \), k=1, 2...m, so the running time of the selected service planning \( t = \sum_{k=1}^{m} \sum_{i=1}^{n_k} t_{ki} x_{ki} \), reliability \( r = \prod_{k=1}^{m} (1 - \sum_{i=1}^{n_k} f_{ki} x_{ki}) \).

Let \( t_0 \) the maximum average delay on services implement users required, and then the implementation plan with the lowest failure rate and meeting the requirements of average delay can be attributed to following model:

**The objective function:**

\[ \text{max } r = \prod_{k=1}^{m} (1 - \sum_{i=1}^{n_k} f_{ki} x_{ki}) \]

**Constraints:**

\[ \sum_{i=1}^{n_k} x_{ki} = 1, k=1,2...m \]

\[ x_{ki} \in \{0,1\}, (k=1,2...m, i=1,2...,n_k) \]

The objective function is a geometric variable with 0-1 programming problem, there is no effective algorithm found its exact solution. A more practical solution algorithm is approximate. This idea is by solving the objective function of the first-order Taylor expansion approximation instead of the objective function, the geometric programming into linear integer programming, and then successive iterative approximation of the objective function to find the approximate optimal solution. Specific algorithm is as follows:

**Step 1**

\[ x = (x_{11}, x_{12},..., x_{mn_m})^T \]

\[ t^* = \sum_{k=1}^{m} \min(t_{ki} | i=1,2,...,n_k) \text{, if } t_0<t^*, \text{ no answer,} \]

Stop the calculation. Else, take any issue initial feasible solution \( x_0 \). So that \( k = 0 \), and accuracy of the selected solution end until \( \varepsilon > 0 \).

**Step 2**

Take the objective function approximately as a linear function, \( R(x) = r(x^*) + \nabla r(x^*)^T (x-x^*) \) at the point
Step 3 solving programming problems max, with the constraints. Let $x_{k+1}$ is the optimal solution.

Step 4 If, that is, stop calculating at the specified accuracy of the results, take $x^* = x_k + 1$ the optimal solution; Otherwise, let $k = k + 1$, return to step 2.

Solution obtained in the first element represents the location of the optimal service for each service binding, this solution will meet the global demand. From the computational complexity of the analysis, the model presented in this paper a linear approximation of nonlinear optimization methods approximate method for solving optimization problems is generally considered practical and effective way, a lot of theoretical research and application examples help illustrate this point.

4 Conclusion and Outlook

Dynamic service portfolio in the application of knowledge services is an important problem, research achievements of the existing service composition technology at home and abroad mostly focused on the partial optimization of QoS, considering the global optimization of working is fewer and one-sided. So this paper presents a dynamic service composition based on QoS global optimization model, the service portfolio QoS global optimization problem with constraints into a linear programming problem and was solved, while the effectiveness of the algorithm is analyzed. Although the proposed model can achieve global optimization portfolio of services, but this model is only formal description of the primary model, there are some deficiencies, still need to constantly expand and improve services to more in-depth to explain the combination behaviour on services. Based on the limitations of this model, the next major focus of the work has two aspects: on one hand, take the characteristics of a complex portfolio of services for further study, to study the transaction processing and compensation mechanisms $y$, to better simulate the actual service portfolio operation; the other hand, make specific applications of the model to verify the feasibility of algorithms in combination with the knowledge chain planning problems in agricultural supply chains project which undertook.

References