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Service organization and recommendation using multi-granularity approach

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ABSTRACT

Due to the rapid growth of all kinds of Web services on the Internet, how to help users discover services to meet their personalized and diverse requirements becomes a challenging and hot issue. In this paper, we propose a multi-granularity oriented service organization and recommendation approach in consideration of users' role, requested goal, and service execution process. Based on modeling the Role (R), Goal (G), Process (P), and Services (S) models that are related to a specific domain problem (SDP), we use the dependency relationships among RGPS elements to realize on-demand service organization. Four kinds of service recommendation algorithms are designed according to different representations of users' requirements. Then the services with different granularity and partnerships are provided to users. In addition, the corresponding services evolution algorithms are designed to make the organized services adapt to dynamic changing environments. Finally, we conduct experiments to validate the effectiveness of the proposed methods.

1. Introduction

Service-oriented computing is emerging as a new promising computing paradigm, which has a significant impact on academia and industry. At the same time, users' requirements on the Internet are usually diverse and personalized. In order to provide services with high quality of experience (QoE) and facilitate the realization of on-demand service [1], it is required to organize and recommend services effectively in the user-centric mode.

In the environment of service computing, users' diverse and individualized requirements make sense in the following two aspects. On one hand, there exist great difference of the QoS (Quality of Service) values among services, such as execution time, cost, and reliability. Faced with a large number of services which realize the same function but have different QoS values, users with different preferences will select different services. On the other hand, a user may play different roles in different situations, and he/she will choose different services accordingly. In addition, users may choose different service execution processes for the same goal. This leads to significant difference of the services that have been discovered to realize the same process. The two aspects mentioned above should be considered when organizing services, and thus meeting users' needs in high quality. To address the first problem, many service clustering methods [2–5] have been proposed. This kind of approach clusters services which realize the same functional goal but have different QoS values into different service clusters. Users find the service cluster which realizes the particular function firstly, and they will find the proper services directly according to their personal request information on QoS. This paper concentrates on the second aspect and the proposed approach organizes services which have a collaborative relationship in the view of users' common requirements. There are some research work about service organization, such as workflow method [6] which uses business spanning tree, GODSS [7], VINCA [8], and APDR4AWS [9]. These methods mainly organize services from the aspects of service execution process constraint relationship, service behavior and so on. And these methods organize services according to the interaction and collaboration information between services. But the objective of service interaction and collaboration is to satisfy users' particular role requirements, or to meet users' specific requested goals in general. Existing research works mainly consider the process execution constraint relationship, without considering the users' role, requested goal and some other characteristics about users. This leads to the level and granularity of the organized services is too single for users. In addition, users' requests have different expression modes when users search for services. They can propose their goals directly, such as querying delivery information, and weather

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information. Users also find the needed services directly through the basic service information, such as service name, input, output, QoS. For example, they can find *weather service*, *delivery query service* with a price less than 1 dollar. In addition, users may use their role information to find services, e.g. retrieving the services which are suitable for students. The existing approaches concentrate on using service description information (service name, input, output and so on) to find services, and it often makes the discovered services independent. These methods cannot recommend services with collaborative relationships between them for users. Therefore, the quality of on-demand service will be negatively influenced. In addition, the existing approaches do not consider users' own requirements. The efficiency and accuracy of services discovery will be negatively influenced as well.

To address the above problems, the main work of this paper includes the following aspects.

(1) Based on the modeling of users' role, requested goals, service execution process and services which are related to specific domain problem (*SDP*), we define the corresponding RGPS models which include elements and relationships between them.
(2) It designs the multi-granularity service organization algorithm in the consideration of users' requested goal, role, and execution constraint relations among services. Services are organized and managed at different levels and in different granularity. Service evolution algorithms are also designed in consideration of the involved elements operation in models.
(3) Four kinds of multi-granularity service recommendation algorithms are designed according to the different requirements expression from users. These algorithms are designed based on the features of users' requests. Services with different granularity or the service set with collaborative relationship will be found quickly to meet users' requests.
(4) According to the proposed multi-granularity oriented service organization and recommendation approach, experiments are conducted to validate the proposed methods.

The rest of the paper is organized as follows: the related work is described in Section 2. The overall architecture of our framework is given in Section 3. In Section 4, the definition of RGPS models and the service organization algorithms are introduced. The algorithms of multi-granularity service recommendation and evolution are elaborated in Section 5. In Section 6, we conduct experiments to verify and analyze the proposed approaches. The conclusion and future work are given in Section 7.

2. Related work

2.1. Service granularity

The factors that influence service granularity in SOA mainly include functionality, flexibility, reusability, complexity, context-independence, performance, generality/genericity and source of service. Service granularity in [10] is discussed from the following levels: Process Service, Business Service, Composite Service, Informational Service, Data Service, Utility Service, Infrastructure Service and Partner Service. Service granularity in this work refers to service size and the scope of function of service exposes. Lina et al. have proposed an efficient multi-granularity service composition method [11]. Their approach mainly deals with a large number of complex requirements that cannot be met by individual services. It considers service granularity from the point of service function, and service task is decomposed from the point of functional granularity. The task-based pruning and plan-based pruning methods are used to reduce the number of possible combinations of services for composition. Service granularity in above method actually refers to the coarse-grained and finer-grained service granularity. This is different from the service granularity which is considered in our method. Zhou et al. have proposed an approach of QoS-based selection of multi-granularity Web services for the composition [12]. In the paper, granularity denotes the extent to which the Web service composition is broken down into small parts. This approach mainly discusses service granularity from the aspect of service composition, which means it mainly considers the service granularity from the service function level, and is different from the method of considering service granularity from the users' request level in our method. In [13], the authors presented an approach called TROLL, to larger-granularity service composition for business-users. The larger-granularity service refers to services for personalized applications, and these services can realize more functions.

2.2. Service organization

2.2.1. Service clustering

Service clustering refers to group the Web services which realize same function and have same interface into service clusters. The services in the same service cluster have different QoS values. There exits some research work about service clustering, e.g., the SWSC method [4], agglomerative hierarchical service clustering algorithm [3], Service ontology based approach [5], using service function and process execution model to realize service clustering [2] and some other approaches.

2.2.2. Service classification

Service classification refers to classify the Web services into different categories in a registry center to enhance service discovery efficiency. UDDI classifies the services based on the standard classification of industry sectors. Some other approaches include the intelligent clustering technology [14], support vector machine [15], automatic semantic annotation and ensemble learning method [16], QoS-aware Web service classification and recommendation method [17], semantic-based approach [18], the focused crawling method for automatic service discovery, annotation, and classification [19] and so on.

2.2.3. Service ranking

There are some research works about service ranking, such as using semantic profile information to rank Web services [20], QoS-based service ranking [21–23], common preference model [24], experience-aware service ranking and selection approach [25], using service multi-criteria dominance relationships to cluster and rank Web services. Dimitrios et al. mainly used the dominance relationship among services and they proposed the service ranking and clustering algorithms [26]. Their method mainly focuses on service function, and discusses the way to use the matching rules to determine the dominance and dominated relationship among services. Then they determined the service ranking, and authors mainly ranked and clustered services according to users' requirements in time. Rong et al. have proposed a Web service ranking framework [27] in which a set of users with similar interest are firstly identified. Then the framework finds the association rules by analyzing all Web service composition transactions which are related to users. Their approach realizes a personalized Web service ranking mechanism.

2.2.4. Service organization

The methods of organizing services mainly include the following two aspects. On one hand, services are organized and obtained