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A Survey on Optimal Web Service Selection

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Abstract: ***The last decade has witnessed a tremendous growth of web services as a major technology for sharing data, computing resources, and programs on the web. With the increasing adoption and presence of web services, design of novel approaches for effective web service recommendation to satisfy users' potential requirements has become of paramount importance. Service-oriented computing and Web services are becoming more and more popular, enabling organizations to use the Web as a market for selling their own Web services and consuming existing Web services from others. Nevertheless, with the increasing adoption and presence of Web services, it becomes more difficult to find the most appropriate Web service that satisfies both users' functional and nonfunctional requirements. QoS values are important criteria for service selection or recommendation. Most of the former works in web service selection and recommendation treat the QoS values as constants. However, QoS values of a service as perceived by a given user are intrinsically random variables because QoS value prediction can never be precise and there are always some unobserved random effects. Web services are not always able to fulfill customer requirements on their own, so in those cases it can choose to make a composition of web services. However, this is a complex problem since it must take into account the large number of available services, performance requirements, and other factors related to quality of service (QoS). With the fast development of Web services in service oriented systems, the requirement of efficient Quality of Service (QoS) evaluation methods becomes strong. However, many QoS values are unknown in reality. Therefore, it is necessary to predict the unknown QoS values of Web services based on the obtainable QoS values.***

Keywords: Web service,sevice oriented computing,QoS, collaborative filtering, hidden markov models

1. Introduction

Service reuse is often considered as a key aspect of Service-Oriented-Architecture (SOA). With tens of thousands of web services available on the Internet, and many of them are of equivalent functions, choosing the web services that meet a user's requirement becomes the core task of service-based software development.

Service-Oriented computing and Web services are becoming more and more popular, enabling organizations to use the Web as a market for selling their own Web services and consuming existing Web services from others [1]. Based on the latest statistics1, there are 28,593 Web services being provided by 7,728 different providers over the world and these numbers keep increasing in a fast speed. The explosive growth of Web services increases the difficulty for users to choose among a large number of Web service candidates. Therefore, how to effectively select the Web services becomes a key challenge for the Web service community.

Recently, recommending qualified and preferred web services to users has attracted much attention in terms of the information overload problem. Web service recommendation is a process of proactively discovering and recommending suitable web services to end users. A number of works have been done on service recommendation based on quality of service (QoS). Most of them employed collaborative filtering (CF) techniques some of them applied content-based approach, and a few of them combined CF approach with content-based techniques.

Collaborative filtering (CF) is a widely used technique for Web service QoS prediction [2]–[4], which can be divided into memory-based CF, model-based CF, and other hybrid CF methods. Matrix factorization (MF) is a typical model-based approach in CF, which has been employed for QoS value prediction by academia and industry in recent years [5], [6]. In MF technology, the QoS values of Web services observed by different users can be represented as a user-service matrix. In the matrix, rows represent users, columns represent services, and each entry represents the QoS value of a service observed by a user. The main idea of MF-based QoS value prediction approaches is to train a model according to the available QoS values in the user-item matrix (i.e., historical QoS values contributed by different users) to predict missing QoS values in the user-item matrix [7]. Therefore, the reliability of user-contributed QoS values will highly influence the prediction accuracy of MF approaches. Unreliable users can cause negative impact on the prediction accuracy by providing unreliable QoS values.

There are also works that focus on the QoS of composite services, and they have proposed methods to select a set of constituent services, by which a composite service can be formed and its end-to-end QoS satisfies global constraints. The QoS value prediction for a composite service can be conducted by aggregating the QoS values of its component services with considering different workflow composition constructs and QoS types. Some optimization methods, such as integer linear programming (ILP), genetic algorithm, and PageRank have been proposed to find an optimal solution with maximum weighted QoS utility while ensuring that the predicted QoS values of the composite service conform to the global constraints.

In this paper we were discussing about different approaches for selecting an optimal web service from available web services and various techniques for predicting the optimal web service. The paper is segmented into various sections in which section 2 is for related work, section 3 consists of optimal web service selection methodology, section 4 have conclusion of this paper.

2. Related Work

To discover high quality web services, a number of QoS models for web services and QoS-driven service selection approaches have been proposed in the service computing field [8], [9], [10]. In their study, it is usually assumed that a user explicitly specifies his/her interests (e.g., by using keywords) and QoS requirements, and submits them to the service discovery system. Then the service discovery system matches the user's interests and QoS requirements with corresponding attributes of web services, and returns those with the best matching degrees to the user. The scenarios for service selection can be divided into two categories. The first scenario aims to select a set of services for a composite service, which is widely studied by existing work on service selection. The second scenario is to select a single service for a user request or to select multiple services with the same function for multiple user requests [11], [12]. Recently, there has been an increasing interest in actively recommending qualified and preferred web services to users without initiating service requests. Existing web service recommendation approaches can be roughly divided into three categories: CF-based approaches, content-based approaches, and hybrid approaches. In the following, we survey the related work on service recommendation in these three categories, and on diversity-based ranking algorithms.

2.1 Collaborative Filtering Methods for Service Recommendation

The main idea of collaborative filtering is to recommend new items of interest to a user regarding the other users' experiences over a set of items. Existing collaborative filtering algorithms can be divided into two categories: memory based and model-based. Memory based methods are more popular in service recommendation, partially because they are more intuitive to interpret the recommendation results. Memory-based collaborative filtering can be further divided into user-based approaches and item-based approaches. User-based collaborative filtering methods recommend a user the items preferred by the users with similar interests, while item-based collaborative filtering methods recommend a user the items similar to those he/she preferred in the past. Shao et al. [13] proposed a user based CF approach that uses Pearson Correlation Coefficient (PCC) to compute similarity between users in terms of their experiences on used web services. Zheng et al. [3] proposed a hybrid CF approach for QoS-aware service recommendation by combining both item-based PCC (IPCC) and user-based PCC (UPCC). They exploited not only similarity among users but also similarity among services for missing QoS prediction. Jiang et al. [3] improved the hybrid CF-based service recommendation approach of by taking the personal characteristics of users and services into consideration when measuring similarity among users and services using PCC. Zheng et al. [14] proposed a context aware service recommendation model, which simultaneously considered users' experiences, the target user's environment factor and his/her input factor to make recommendation decisions. Chen et al. [4] observed that user perceived QoS metrics of services are highly related to users' physical locations on the Internet. They proposed an efficient region model with the properties of QoS for QoS prediction. Tang et al. [15] incorporated both users' and services' location information into QoS prediction, and proposed a location-aware CF method for service recommendation. Lo et al. [16] observed that QoS performance of services is highly related to the service status and network environments which are variable against time. They proposed a QoS prediction framework, called WSPred, to provide time aware personalized QoS value prediction for different service users. Wu et al. [17] presented a neighborhood-based collaborative filtering approach to predict such unknown values for QoS-based service selection. Most recently, some CF based service recommendation approaches employed the matrix factorization theory to improve the accuracy of QoS prediction.

2.2 Content-Based Methods for Service Recommendation

Content-based service recommendation approaches focused on exploring the description information of web services and the user's own service usage history. Generally, the web services which are highly relevant to the user's service usage history and own high QoS utility would be recommended to users. Kang et al. [18] proposed an active web service recommendation approach based on service usage history which incorporates both user interest and QoS preference into web service recommendation. With the user interest and QoS preference, recommender systems can recommend top-k optimal services with user-desired functional and non-functional requirements. In [18], a user's potential QoS preference is acquired by the average QoS preference from service usage history. This potential QoS preference is used for all the service candidates. However, the QoS preference may be not accurate because a user may have different QoS preferences to different services. Therefore, this approach should be further improved. Liu et al. [19] proposed a semantic content-based recommendation approach that analyzes the context of intended service use to provide effective recommendations in conditions of scarce user feedback. Hu et al. [20] proposed a personalized search approach for web service recommendation, in which interests are extracted from users' records. While these two works do not consider QoS preferences and potential user interests of users, which will be addressed in this work.

2.3 Hybrid Methods for Service Recommendation

Hybrid service recommendation approaches combined both collaborative filtering and content-based recommendation techniques. Freddy [21] proposed a semantic content-based recommendation system that provides end-users with recommendations about semantic web services that could be of their interest. Firstly, this approach considers the neighbors of the active user by computing similarities between different users' personal information. Then, web services manipulated by similar users, except the services already used by the active user, are ranked depending on their semantic similarity with services the active end-user used to interact with. Finally, the top k services are recommended to the user. Yao et al. [22] proposed a hybrid service recommendation approach by combining CF with content-based features of web services. This approach

exploited both rating data and content data of services via using a three-way aspect model. In their work, user interests are represented by a set of latent variables, which is developed offline. However, QoS preferences of users are not considered in these works.

3. Optimal Web Service Selection Using Hidden Markov Models (HMM)

Huiyuan Zheng [23] suggested a probabilistic model to analyze QoS attributes of component services with dynamic probabilities. Their main contribution was to compare the efficiency and accuracy of their algorithm with simulation models. However, they did not consider combining various hidden patterns with integrations patterns to compute overall behavior of WS integration.

Joyce EI andMaude [24], Sami [25], Li [26] have considered the transactional properties of web services to define a strategy for reliable web service composition. They have studied in detail transactional dependency among different type of web services. Later, they have suggested web service selection algorithms based on users' preferences. These models also tried to solve design time issues during service composition.

Kaouthar and Zahi [27] have proposed a flexible architecture for dynamic web service composition related to user requirements. Their main contribution was to ensure availability of appropriate web service at runtime. However, they did not define any QoS metrification to find the appropriate web services among functionally equivalent web services.

Tao [28] has suggested an efficient algorithm for selecting appropriate web services based on user's provided weights. They have mapped web service composition with the Knapsack problem and then calculated the optimal path for executing user's requests. However, in an unpredictable environment user defined parameters for calculating WSs behavior are not sufficient.

There is no standard way, however, for the users to weigh their options directly and individually, for themselves. This paper aims to fill this gap providing a standard way to measure and predict WS behavior in terms of response time using HMM. Reliability of service oriented architecture (SOA) based systems heavily depend on various underlying technologies for instance web services, computing environment (CPU, Disk, and Network) and unpredictable internet.

HMM is a powerful statistical tool for modeling generative sequences that can be characterized by an underlying process generating observable sequences. Word hidden specifies that internal structure of the underlying system is hidden from the observer. Observer does not know in which state system may be in, but has only probabilistic insight where it should be. In HMM, one does not know how many hidden states to use. This approach works on real time data unlike in the approach suggested by Tao [28] has suggested an efficient algorithm for selecting appropriate web services based on user's provided weights. Different steps involve in finding optimal web service using HMM model [30] applying on data collected based on response time and network latency [29].

a. Creating sample data of response time and the network latency of the user for a web service.
b. Building a directed graph among hidden states of component web services used in composition.
c. Analyzing the current status of each vertex of directed graph i.e., underlying hidden states.
d. Predicting hidden states' behavior in terms of response time during nth time interval t.
e. Finally, selecting optimal web services used in composition based on hidden states' behavior.

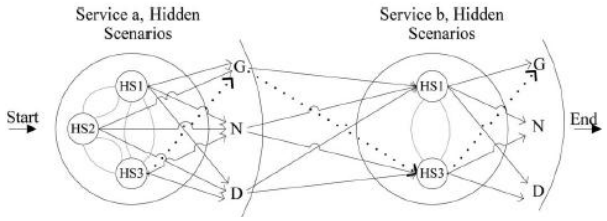

Figure 1: Directed graph of composition in terms of hidden states.

Consider a simple case with two web services ''a'' and ''b'' consisting of hidden states 3 and 2 respectively. Then they can be connected with each other in the form of a directed graph as shown in Fig. 1. Any hidden state i.e., HS1, HS2 or HS3 of the component web service ''a'' can execute users' requests during certain time interval t.

As HMM is normally used to recognize patterns, therefore to predict behavior of the hidden states, idea is to classify suspicious response time patterns i.e., patterns with observation symbols C. This classification will indicate upcoming suspicious patterns. As per proposed technique, response time in a training sequence is divided into equal lengths slots. These time slots having observations symbol ''C'' are termed as ''unreliable''.

4. Conclusions

In this paper, we at first propose a probabilistic model for predicting response time of web service and then selected an optimal web service at runtime from the list of functionally equivalent web services. To know the probabilistic insight of WSs we have used HMM. In our model we have assumed that WS is deployed on a cluster of web servers and sometime the delay or crash during WS invocation is because the bad node in sever clustering responds to users' requests. With the help of HMM we have predicted the probabilistic behavior of these web servers and then selected the WS based on their probabilistic value. Experiment shows that the proposed model is more general and detailed in comparison to existing models. This not only predicts the overall behavior of composite web service but it further provides the solution to complete user requests in the most efficient and reliable way.

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