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A Context-aware Recommender System for Web Service Composition

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***Abstract*—This study explored the use of context-aware recommender system to facilitate web service composition. The needs for composition of existing web services to generate functionality for users are increasing. And an intelligent framework is needed to alleviate users' burden to discover, select, invoke and combine web services. In this study, we focus on using context-aware recommender system to provide users with the most appropriate web services composition. The concept of context-aware collaborative filtering is used here to learn and predict user preferences, and based on this information, to compose necessary web services to achieve user request. We provide a restaurant recommender system prototype for the restaurant search scenario to demonstrate how proposed architecture works.**

Keywords-Recommender system, Web Service Composition, Proactive

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I. INTRODUCTION

Web services and Service Oriented Architecture (SOA) are emerging as a mainstream solution for deploying automated interactions between cross-platform, distributed applications [1]. However, due to the complicated natural of tasks, it is difficult to find a single web service that is capable to handle a specific user request. Several web services need to be composed to solve one problem. A very popular example is making travel arrangements for a trip [2]. Transportations, accommodations have to be arranged through different web services. The exponentially increasing number of web services lead to another problem. That is, large number of available web services may provide similar capabilities and users have to select from those candidate web services and compose them in order to fulfill certain request. And it is not easy to deal with choice explosion.[3]

The rationale behind proposed architecture is that we believe composition task may be benefit form enhanced capability to learn from past user experience. Furthermore, composition task can also benefit from past behavior pattern executed by similar (like minded) users. That is, other users who performed similar composition task before might give guidelines for how to compose services to achieve certain user request. Several previous attempts had been made to deal with web services composition with recommender system. Blake in [4] first described the problem of users not aware of the services that can be of most benefit to them, and focuses on the underlying search and ranking algorithms that enable the recommendations for web services. [3] pointed out the drawback of simply analyze query strings and web service descriptions to generate recommendation, and presented an approach in which take into account historical usage data and apply collaborative filtering technique on user's interactions to generate more appropriate recommendations. Same group of authors described their algorithms based on Vector Space Model and Latent Semantic Indexing in [5]. [6] design of a dynamic web service selection framework that makes use of a semantic matcher to support matching and composition of web services, and the proposed framework takes advantage of a recommendation system which helps a user to select the best service that matches his/her requirements.. We based on these efforts, proposed a novel architecture that takes context information into account to provide recommendation for web services composition which can respond to user's request.

Rest of the paper is organized as follow. Section 2 briefly reviews related technologies; highlights web services and web service composition, context-aware recommender system. Section 3 describes the proposed context-aware recommender system for web services composition. We provide also a restaurant search scenario in this section demonstrate how the proposed architecture works. A prototype of context-aware recommender system for restaurant is build to proactively provide users with places to dine in. Finally, section 4 draws conclusion and identifies future work.

II. LITERATURE REVIEW

W3C defines web service as "…a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format [7]. Other systems interact with the Web service in a manner prescribed by its description using Simple Object Access Protocol (SOAP) messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards." Web services technologies is based on providing common protocols with which clients can discover and contact the services through the World Wide Web. A Web service is an accessible application that other applications and humans can discover and invoke. Web services are nowadays emerging as a major technology for deploying automated interactions

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between distributed and heterogeneous applications. Various standards back this deployment, including 1) Web Services Description Language (WSDL) support the definition of Web services. 2) Universal Description, Discovery and Integration (UDDI) support advertisement to the community of potential users. 3) Simple Object Access Protocol (SOAP) binding for invocation purposes.

The basic idea of web service composition is for a user to mix and match web services dynamically, according to service availability, QoS, price or some other factors, to provide functionality that can not be directly realized by single existing web service. To achieve certain functionality, a successful executable composition needs to be arranged properly. The challenges of web services composition had been mentioned in abundant previous literature [1, 2, 8]. Several interesting studies regarding web services composition had been mentioned in previous section.

The basic idea of recommender systems focus on recommending the most relevant items to individual users, and traditionally recommender systems deal with applications having only two types of entities, users and items[9]. Recommender systems had been used widely in variety of domains, e-commerce for example, users who visit Amazon.com can easily find suggested readings via recommender system. Recently, the importance of contextual information has been recognized by researchers and practitioners, they started to take into consideration contextual information, such as time, place, etc. The context related researches started way back in time, in 90's we've seen research that review context-aware applications such as[10].{{117 Schilit, B. 1994}} and [11], the later is based on a literature review of context-aware systems from 2000 to 2007 using a keyword index and article title search; specific application, such as [12]describe a mobile context aware tour guide, [13] also reported their experience in developing context-aware electronic tourist guide, [14] highlighted the use of context-aware recommender system in a restaurant recommendation scenario via smartphones.. In [9], authors argue that relevant contextual information does matter in recommender systems and that it is important to take this information into account when providing recommendations. In their work they first defined what is context and then discussed how to incorporate contextual information in recommendation process. Different means to provide recommendations were developed, in [15], multi-dimensional approach were present to support multiple dimensions, profiling information, and hierarchical aggregation of recommendations.

III. PROPOSED ARCHITECTURE

Such a proposed architecture can help predict the user's behavior in different situations without the user actively defining it. Figure below describe how this architecture works.

A) Data layer

The purpose of data layer is to collect data from variety of data sources. For example, to collect user demographic data from user profile, context information from sensors.

B) Context module/preference module

These two modules calculate and define user preference.

C) Recommender system

In recommender system, collaborative filtering is used to generate recommendations without the user actively defining it

D) WSC layer (brokering, invocation)

Based on the recommendation from recommender system, WSC layer can match and select appropriate web services to achieve user's request

E) Application layer

Application layer handles the result of web services compostion and deliver the result to end user in an appropriate way, via appropriate device. For example, for restaurant recommender system, the result can be a list of restaurants shown in user's smartphone.

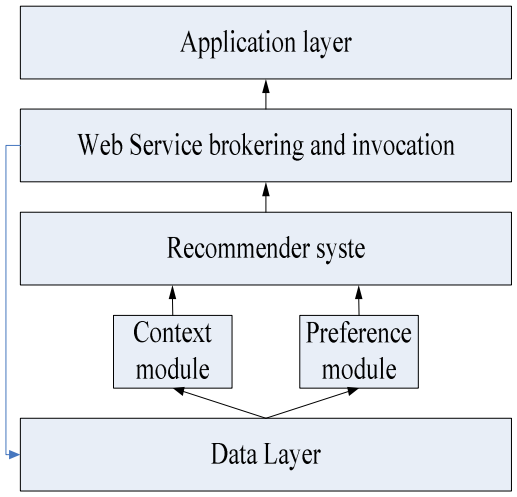

Figure 1. Proposed architecture.

We can walk through a restaurant search scenario with the proposed architecture. When it is appropriate time for the user, smartphone can serve as sensor as well as information receiver. It can collect contextual information such as user's whereabouts and time of the day, and receive notification of nearby restaurants that may be of interest to the user. The recommendation list is generated through the composition of multiple web services; include data retrieve service, preference calculation service, contextual information incorporation services. Snap shots of user interface for restaurant recommender system can be found in figure 2.

IV. CONCLUSION AND FUTURE WORK

The challenge of web services composition is described in this study and a context-aware recommender system architecture is proposed to facilitate composition of web services. Recommendation is generated based on user feedback and preference, as well as collaborative filtering techniques. Restaurant recommender system is used in this study to demonstrate how the proposed architecture works.

Future work will first focus on solve the difficulty of need real user data to validate whether the preference predictions match the user's actual decision. Moreover, the collaborative nature of the system requires large user participation to generate good, convincing predictions. We plan to test this application on a group of students in our campus, and the data collected from this deployment will allow us to evaluate and calibrate our proposed architecture.

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Figure 2 Snap shots of user interface for restaurant recommender system. a) notification b) recommended restaurants c) user feedback.