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A Hybrid Recommender System for Service Discovery

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ABSTRACT: In this paper, a recommender system for service discovery is presented. It helps the consumers of service-oriented environment to discover and select the most appropriate services from a large number of available ones. The recommender system uses the switching hybrid method, and combines two methods of collaborative filtering and context-aware. The collaborative filtering method uses the known taste of a group of users to produce recommendation to other users. The Context-aware method provides recommendations to the users regarding their environment and the details of the situation in which they are. The proposed approach is yielded to overcome the problem of grey sheep, new consumer, and new service entrance to Collaborative Filtering Recommender system.

Keywords:: Collaborative Filtering Recommender Systems, Context-Aware Recommender Systems, service discovery in service-oriented architecture, New Consumer, New Service

I. INTRODUCTION

The rapid growth of the number of web services on the internet makes the users spend a lot of time on finding a service considering their needs. Therefore, discovery and selection of services is an absolutely critical issue in the service-oriented architecture.

In the service-oriented architecture, service providers publish their services in service repository, and service requesters or consumers find and discover their needed services in service repository.[4]

One idea for solving the problem of loads of services is a recommender system that can recommend the most appropriate service among the available services to the users.

A. Literature Review

Recently, the use of recommender system for discovery and selection of services has been followed in diverse articles that some of them are mentioned here:

Sofiane Abbar and et al.(2009) have presented context-aware recommender systems with a service-oriented approach. [6] In this work, it is claimed that the application of user profiles and contexts (data on environment and user's situation) in the process of recommendation is useful for all Recommender Systems because the user's rates and preferences may differ in different situations. Also Ohbyung Kwon and et al. (2009) used context-aware recommender systems for service recommendation.[7] In the same year, Jongyi Hong and et al. have used Context-aware system for proactive services based on context history. [8] In another work in 2009, Zibin Zheng and et al. used a collaborative filtering for web service recommendation. [5]

Konstantinos Tserpes and et al. (2011) presented a recommender system for service selection in service-oriented environments [4] in which the goal is to find services that not only have needed capability, but also have demanded quality for the consumer. In this work, a memory-based Collaborative Filtering technique has been used for recommendation.



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Nguyen Ngoc Chan and et al. (2012) presented a collaborative filtering recommender system that for service discovery focuses on user name and the history of used web services rather than describing services. [2]

Generally, a collaborative filtering recommender system has been investigated in a lot of research. Yet, this mechanism, besides being one of the most powerful and successful ones, has also some problems and limitations. Namely, new item, new user, scalability, synonymy, and Grey Sheep problem can be mentioned.

Lately, Context-Aware has also been applied in numerous works. Merely using this mechanism is a time-consuming task because context needs to be discovered and updated under any circumstances. Furthermore, the need for context discovery tools is also of the limitations of it.

In this paper, a recommender system for service selection and discovery is presented that not only has a rather high performance, but also overcomes the problem of Grey Sheep, new consumer, and new service entrance.

The proposed recommender system uses the switching hybrid method and combines two methods of Item-based Collaborative Filtering and Context-aware. In this method, the system switches between the available techniques of recommendation in terms of the current situation. [3] In other words, when item-based collaborative filtering is not able to respond, the system switches on Context-aware.

II. DEFINITION

A. Recommender System

A Recommender System is a kind of data filtering system that tries to suggest a set of data items to the users that may be their preferred ones. A data filtering system is a system which, automatically or semi-automatically, discards unfavorable or extra data before displaying to the user. The major purpose of these systems is management of extra data.

II.A.1) Collaborative Filtering Recommender Systems,

This method is one of the most powerful techniques that have ever been demonstrated, and works with collecting data from a large number of users. In this type of systems, the main hypothesis is that the users who agreed on a subject in the past will also agree on it in the future. These users form a group called a neighbor. A user receives recommendations on the items that they did not rate before. Yet, those items have already been rated by the users in the same neighborhood. In the method, the predictions are made for a particular user, but they are in accordance with the data collected from a large number of users.[19]

collaborative filtering technique uses the database of user preferences on items. In this scenario, there is a list of m users $\{u_1, u_2, \dots, u_m\}$ and n items $\{i_1, i_2, \dots, i_n\}$, and each user has a list of his/her rated items.[9]

II.A.2) Context-Aware Recommender Systems,

Context is the data about the user's environment and details of the situation in which they are. Namely, the time zones, weather conditions, location, and so forth. Such data play a fundamental role in recommendations. The systems that exploit these kinds of data in the process of recommending are termed Context-Aware Recommender Systems.[19]

Contextual data can be obtained through various ways: explicitly and directly, by interacting with the user, and implicitly, by using resources like GPRS also through analyzing the users with regard to their behavior or by means of data mining techniques.

III. PROPOSED METHOD

In the proposed method, the recommender system was exploited for discovery and selecting a service in the service-oriented architecture. With a difference that an phase_ called service evaluation _ is added to the process, that is, the user will be requested to rate the proposed service of the recommender system after using it. This rate shows the consumer satisfaction of the recommended service. This work leads to making a history of the diverse users' rates. Then, the history is used to recommend the service to the other consumer.

A. Architecture of Recommender Systems

The demonstrated Recommender Systems, as displayed in Figure 1, uses the switching hybrid method.

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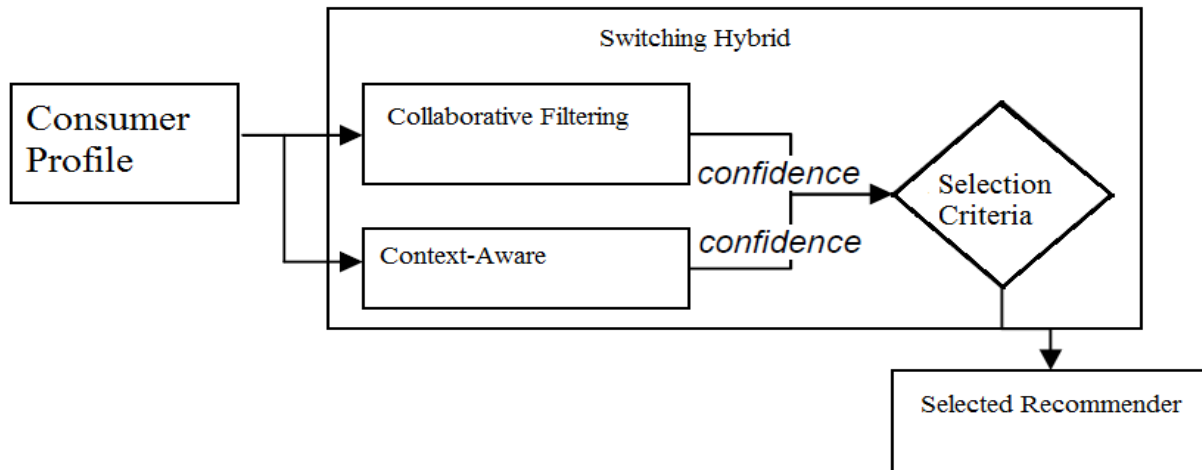


Fig. 1 Switching Hybrid Method

The switching hybrid method begins the recommendation process with selecting one of the available recommender systems regarding selection criteria. When the appropriate recommender system is selected, the other recommender systems will not play any role in the recommendation process.

The presented recommender system consists of two parts: Collaborative Filtering Recommender Systems and Context-Aware Recommender Systems.

When the consumer profile enters the recommender system, at first, the neighbors of the consumers' mentioned service are found according to the below stages.

calculating similarity

The similarity between the services is calculated by Adjust cosine similarity formula, which is one of the most famous and accurate methods:[1]

$$\text{ServiceSim}(i,j) = \frac{\sum_{c \in RB_{i,j}} (r_{ci} - \bar{r}_c)(r_{cj} - \bar{r}_c)}{\sqrt{\sum_{c \in RB_{i,j}} (r_{ci} - \bar{r}_c)^2} \sqrt{\sum_{c \in RB_{i,j}} (r_{cj} - \bar{r}_c)^2}} \quad (1)$$

Where $RB_{i,j}$, denotes the set of consumers who have rated both service i and service j , r_{ci} , the consumer's rate for service i , \bar{r}_c , determines the average of the consumer's rates.

selecting similar neighbors

$$\text{Similarity}(i) = \{S_k \mid S_k \in L(i), \text{ServiceSim}(S_k, S_i) > 0, S_k \neq S_i\} \quad (2)$$

S_k and S_i are service k and service i . $L(i)$ is a collection of services that their similarity rate with service i is calculated. In other words, the services that their similarity rate with service i is positive are considered as neighbors.

If the neighborhood size of service is between 0.2 and 0.5 of the number of the available services, which is the appropriate neighborhood size [17], Collaborative Filtering method drives properly. As a result, the recommender system makes its prediction by means of Collaborative Filtering method and according to the below formula:

$$\text{Pred}(c,i) = \frac{\sum_{j \in \text{ratedServices}(c)} \text{ServiceSim}(i,j) \cdot r_{cj}}{\sum_{j \in \text{ratedServices}(c)} \text{ServiceSim}(i,j)} \quad (3)$$

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ServiceSim(i,j) is calculated by Adjust Cosine Similarity formula and r_{ci} is the consumers rate for service i. After calculating the prediction by item-based Collaborative Filtering, the Mean Absolute Error (MAE) is calculated. MAE is a criterion used for measuring the quality of Collaborative Filtering methods. It evaluates the system accuracy by comparing the predicted rate of Collaborative Filtering methods and the real rate of the consumer's rate. [9],[10]

$$MAE = \frac{\sum_{i=1}^N |p_i - q_i|}{N} \quad (4)$$

P_i is the predicted rate of Collaborative Filtering methods, q_i , the real rate of the rate, and N, the total number of the services in data set. The lower the MAE is, the higher the recommendation accuracy will be. If $MAE < 0.75$, the Collaborative Filtering methods has a perfect accuracy [9],[17] and this method is chosen correctly. Therefore, selection rules are as follows:

$$[0.2N] \leq \text{Neighborhoodsize} \leq [0.5N] \quad (5)$$

If the neighborhood size of service is not in the intended limitation, or when $MAE \geq 0.75$ that shows the system does not have a perfect accuracy, the demonstrated recommender system switches on Context-Aware method.

IV. EVALUATION OF THE PROPOSED METHOD

The mentioned algorithm, is implemented with programming language of C#, and is tested by data set. In the previous pieces of work [6], [7], [8], [20] that have used Context-Aware Systems, the appropriate contexts have been selected depending on the type of recommended services. In this system, also regarding the services that are in our data set these contexts are considered for the consumer: date, time, location, operating system, device, and browser. Likewise, the data such as sex, age, and education that the consumers have entered while registering in systems are also considered.

When the system switches on Context-Aware method, the consumer's context regarding requested service is obtained. Then, the context information is used for service repository query or search and then a suitable service will recommend to the consumer. Consequently, regarding the present situation of the consumers and without the necessity of the rate history the consumers receive a recommendation.

Despite the demonstrated algorithm is a hybrid of two methods of Collaborative Filtering and Context-aware, each of these methods are compared with the proposed method in the below table. The proposed method always can support new service and new consumer entrance but context-aware method can not support new service and new consumer entrance when it uses history of contexts.

TABLE I
PROPOSED METHOD COMPARED WITH COLLABORATIVE FILTERING AND CONTEXT-AWARE

	Support of New Service entrance	Support of New Consumer entrance	Grey Sheep resolvable	Mathematical-based	No restrictions in Context Discovery Tools	Not required Context Update
Collaborative Filtering	✗	✗	✗	✓	✓	✓
Context-aware	✓	✓	✓	✗	✗	✗
Proposed Algorithm	✓✓	✓✓	✓✓	✓	✗	✗

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The following graph compares the performance of proposed algorithm with Collaborative Filtering method on available data set.

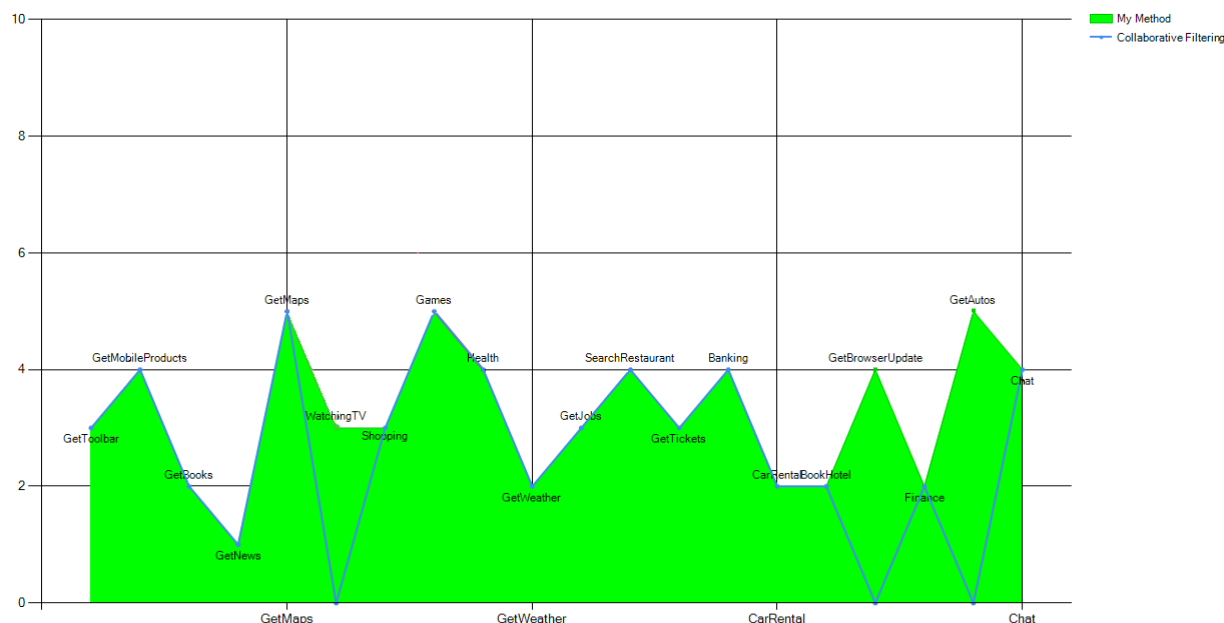


Fig. 2 proposed method compared with Collaborative Filtering

V. CONCLUSION

In this paper, a recommender system is demonstrated that uses the switching hybrid method, and combines two methods of Collaborative Filtering and Context-aware for discovery and selection of service. This algorithm has a rather high performance as well as it overcomes the problem of grey sheep, new consumer, and new service entrance. The practical results show that this hybrid recommender system has more performance and better quality of recommendation in comparison with collaborative filtering methods.

One of The limitations of the proposed method is that it is not an easy work to obtain the contextual information and the context discovery tools is needed that is expensive and time-consuming. Furthermore, obtaining the proper selection rule in switching hybrid method is a hard work.

Whereas most of recommender systems are unable to realize Synonymy problem-existence of similar services with different names-it is suggested to use Antology to develop proposed algorithm.

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