

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(24), 2014 [16267-16274]

A novel web service recommendation approach based on credible user comment

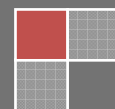
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ABSTRACT

User comment is an important criterion for the approach of web service recommendation. But estimating the credibility of user comment is always a big challenge. This paper proposes a novel method to calculate the trust degree of the user evaluation. In the proposed method, the trust degree of the user evaluation is estimated with difference value derived by comparing the user satisfaction degree with user comment. Then the paper proposes an approach of web service recommendation based on the credible user evaluation. In the final, we present an experiment to prove the new approach which is accurate and effective can avoid the influence of false user comment.

KEYWORDS

User evaluation; Trust degree; Web service recommendation.



INTRODUCTION

With the development of network technology, web services are applied widely. There exist a number of available web services providing similar or identical functional characteristics, so users need a recommendation approach that can help them choose the best web service^[4]. Recently more and more researches about web service recommendation are proposed.

User comment can evaluate a web service from multiple aspects. It constitutes the user experience of the web service. However, there is a problem when recommendation system applies user comment to evaluate web service composition, that is, dishonest consumers might reply a false feedback to affect the evaluation results^[3]. False user comment issue might cause to raise an improper recommendation due to the lacking of a good trust degree measure scheme. To cope with this problem, it is necessary to avoid false comment by dishonest consumers in the recommendation process. In this paper, a web service recommendation approach, based on reliable user evaluation, is proposed which takes past consumer behaviors.

This paper is organized as follows: in the second sections, we emphatically introduce the related work about web service recommendation. The third section introduces user evaluation model and user requirement model for evaluate user comment. The fourth section explains the method to calculate the trust degree of user evaluation. And then we present a recommendation approach of web service composition that is based on reliable user evaluation. The fifth section proposes the experiment that leads to prove the method is accurate and effective. The sixth section gives the final conclusion.

RELATED WORKS

The QoS is the measurement of the non-functionality attribute of web services. There is a lot of service recommendation methods were expanded in this regard. Reference^[1] proposed an algorithm to combine global QoS constraints with local selection. Reference^[2] presented an open, fair and dynamic QoS computation model for web service selection. These QoS-based service selection methods require the user to specify the functional details of the web service and their QoS constraints, but in fact users may not know how to express their demand for services, therefore, these methods is blind and harsh for user^[5]. And these methods always assume that the QoS data coming from service providers and users are effective and trustworthy, which is actually impossible in reality and will directly affect the results of web service selection. So the method of web service recommendation that use QoS as the only standard is not perfect. In the reference^[10], the authors introduced user comment as the standard of web service composition recommendation method. The appearance of recommended system made a breakthrough, as a widely used technology in the electronic commerce and other areas, it can recommend the users pleased and useful information. Collaborative filtering is the most widely used and the most successful recommender system. The biggest advantage of it is no need specific content description but the user rating set^[6]. Reference^[7] presented a trustworthy services selection based on preference recommendation method that assists users in selecting the right web service, according to their own preference. This method can effectively solve the weaknesses of recommendation systems. Thus, this paper based on the above study, proposed a novel web service recommendation method based on credible user comment.

USER EVALUATION MODEL

User requirements model

The consumers always have their own requirements when they choose web service. The requirements can be a single target or multi-target. And every target must be provided with constraint. These constraints are a kind of very important parameter that can measure of web service. In addition, the consumer should provide the preference degree of every target.

According to these requirements that are mentioned above, we established a new user requirement model that consists of three elements. Assuming UR_i represents the requirement of the i^{th}

user, we can get $UR_i = \{(V_j, W_j, T_j), 0 < j < N\}$, where V_j represents the expected value of the j^{th} target, W_j represents the weight value of the j^{th} target, T_j represents the target type. The user requirement target can be divided into two types, one is the recordable type, and the other one is the un-recordable type. The recordable type is characterized in that the numerical value can be counted by UDDI. It is recorded in execution log. The un-recordable type is characterized in that the numerical value cannot be gotten during execution.

Web service model

WS denotes abstract web service that includes four elements such as $WS = \langle \text{Input, Output, Precondition, Results} \rangle$. WS represents one kind of web services which have similar function interface but different effect. There is a set of web service instances for each abstract service type on network. In order to obtain the user satisfaction degree, we need to record the results of web service after every execution. ER denotes the execution result of web service that includes the real value of the recordable type target.

User evaluation model

The traditional user evaluation model is always global and convenient that consists of single user evaluation. It reflects overall impression of web service. But the global user evaluation is great ambiguity. It cannot fully reflect the user experience. So sometimes the user evaluation model consists of the local user evaluation. The local model is a good complement to the global model, which evaluates web service from several aspects. So the local model is comprehensive. But now the evaluated index of local model is basically provided by service provider or third parties according to their own professional. In fact some indicators are not concerned by the consumer, or the professional degree of consumer is not enough to give an accurate evaluation. Therefore in this paper we established a new user evaluation model according to user requirements. These evaluation indexes are modeled using fuzzy sets.

The fuzzy representation of a service is based on the assumption that the ratings of a service can be expressed as a number in the range [0, 1]. That means a user evaluation of web service can be presented by assigning values in the range [0, 1]. Thus user evaluation of web service WS is represented as a fuzzy set UE:

$$UE = \{x, \mu_k(x) | x \in UR\} \tag{1}$$

where $\mu_{ws}(x)$ represents the grade of membership of x evaluation index from consumer k. The membership function of a fuzzy set representing a service is a function of ratings. We define the membership function for x in a fuzzy set defining WS as follows:

$$\mu_k(x) = \begin{cases} 0, & 0 \leq x \leq \alpha \\ \frac{1}{1 + \left[\frac{\beta}{(x - \alpha)} \right]}, & \alpha < x \leq 100 \end{cases} \tag{2}$$

A NOVEL RECOMMENDATION APPROACH BASED CREDIBLE USER EVALUATION

According user requirement model, we can get user expected value V_i . In this paper we use it to compare with the real value EL_i which is recorded in execution log to calculate the user satisfaction degree. And then we compare it with the user evaluation for obtaining user trust degree.

User expected value set

User requirement model contains several requirement indexes, and the consumer provided the corresponding constraint condition for every index. But the expression of every index is different, so we

need to normalize these indexes. The expression of user requirement indexes can be divided into the following two types. One is the value type. And the other one is the interval type. In order to compare to the real value facilitate, we need to transform the interval type to the value type. At present, there is a variety of deterministic methods. In this paper we use the expanded ordered weighted averaging operator as determining the mathematical formula.

Definition 1: Assumed $f: \mathbb{R}^n \rightarrow \mathbb{R}$, if $f(a_1, a_2, \dots, a_n) = \sum \omega_j b_j$, where in $W = (\omega_1, \omega_2, \dots, \omega_n)^T$ is weighted vector which is associated with F and $\omega_j \in [0, 1]$, $\sum \omega_j = 1$, b_j is the j th big value in a group of data (a_1, a_2, \dots, a_n) , the F function is called the n -dimensional ordered weighted averaging operator.

Assume that $a = [a^L, a^U] = \{x \mid a^L \leq x \leq a^U\}$, then a is an interval value. The F function is formula (3):

$$f_k(a^L, a^U) = \frac{a^U + r a^L}{r + 1} \quad (3)$$

We transform the interval value to the value type through the formula (4):

$$EV_k(a^L, a^U) = f_k(a^L, a^U) = \begin{cases} a^U, & r \rightarrow 0 \\ \frac{a^L + a^U}{2}, & r \rightarrow 1 \\ a^L, & r \rightarrow \infty \end{cases} \quad (4)$$

After normalized every user requirement index, we can get the user expected value set EV .

User satisfaction degree

Then we need to calculate the distance between the real value of execution log and the user expected value. We use the gray correlation analysis method to get the user satisfaction degree. Assumed that $r(EV_i, EL_i)$ represents the correlation value between the user expected value and real value of operation. So we can get the formula (5) as follows:

$$d_k(j) = |EV_j - EL_j| \quad (5)$$

$$Q_k(j) = r(EV_j, EL_j) = \frac{\rho d_{\max}}{d_k(j) + \rho d_{\max}}$$

where $\rho \in [0, 1]$ represents the resolution value. $Q_{ws}(j)$ represents the user satisfaction degree of the j^{th} recordable user requirement index.

Trust degree of user evaluation calculation

In the final, we compare the user evaluation with user satisfaction degree. The distance of two values is closer, the trust degree of the user evaluation is higher. Assumed TD_{ws} represents the trust degree of user evaluation. We can get the formula (6):

$$TD_k(j) = 1 - |Q_k(j) - \mu_k(j)| \quad (6)$$

$$TD_k = \frac{\sum_{j=1}^N TD_k(j)}{N}$$

The novel web service recommendation approach

After obtaining the trust degree of each user evaluation, we have to assign the performance ratings to service alternative WS_i with respect to user requirement UR_j . The fuzzy performance rating matrix R is shown as:

$$R = [r_{ij}]_{m \times n} = \begin{matrix} & \begin{matrix} UR_1 & UR_2 & \dots & UR_n \end{matrix} \\ \begin{matrix} WS_1 \\ WS_2 \\ \vdots \\ WS_m \end{matrix} & \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix} \end{matrix} \tag{7}$$

where r_{ij} represents the individual fuzzy rating of web service WS_i with respect to attribute UR_j . the trusted user evaluation-based rating is derived by the additive rule as follows:

$$r_{ij} = \frac{\sum_{k=1}^m (TD_k * \mu_k(ij))}{\sum_{k=1}^m TD_k} \tag{8}$$

where TD_k indicates the consumer's trust degree, measured by formula (6).

$$P(WS_i) = [r_{ij}] \otimes [\omega_j]^T = \begin{bmatrix} P(WS_1) \\ P(WS_2) \\ \vdots \\ P(WS_n) \end{bmatrix}$$

$$= \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix} \otimes \begin{bmatrix} \omega_1 \\ \omega_2 \\ \vdots \\ \omega_n \end{bmatrix}$$

$$= \begin{bmatrix} (r_{11} \otimes \omega_1) \oplus (r_{12} \otimes \omega_2) \oplus \dots \oplus (r_{1n} \otimes \omega_n) \\ (r_{21} \otimes \omega_1) \oplus (r_{22} \otimes \omega_2) \oplus \dots \oplus (r_{2n} \otimes \omega_n) \\ \vdots \\ (r_{m1} \otimes \omega_1) \oplus (r_{m2} \otimes \omega_2) \oplus \dots \oplus (r_{mn} \otimes \omega_n) \end{bmatrix} \tag{9}$$

Since service customers have their different subjective perception on user requirement target, it needs to define an index of priority on candidate service. In the context, web service priority (denoted as P) is defined to specify the consumer perception on web services WS_i . It can be formulated by the inference rule using fuzzy simple additive weighting rule as formula (9).

A CASE STUDY

In this section we design an experiment to prove the efficiency of the novel web service recommendation method that is based the credible user evaluation. Assume that we have four candidate web services which have similar function. And there are six consumers who use every web service several times. Firstly we give their requirement indexes which are presented in TABLE 1.

Through TABLE 1 we can see there are six consumers who use every web service times. The requirement indexes are presented as different way. We use formula (3) and (4) to quantize requirement indexes. TABLE 2 presents the execution log of four candidate web services. We compare it to the

expected values which are calculated from TABLE 1. We use formula (5) to get the user satisfaction degrees which are presented in TABLE 3.

TABLE 1: User requirement indexes

Indexes	Cost	Response time	Throughout	Reliability	Available
Type	Recordable	Recordable	Recordable	Un-recordable	Un-recordable
User1 (Weight)	8 (0.1)	0.3s (0.3)	>80 (0.1)	>90 (0.3)	>95 (0.2)
User2 (Weight)	<10 (0.2)	<0.6s (0.4)	88 (0.2)	93 (0.1)	90 (0.1)
User3 (Weight)	7 (0.2)	0.6 (0.1)	92 (0.3)	>95 (0.2)	>90 (0.2)
User4 (Weight)	[8,15] (0.1)	0.8s (0.2)	[80, 90] (0.2)	[90, 95] (0.2)	>98 (0.3)
User5 (Weight)	6 (0.2)	[0.2, 0.8] (0.2)	90 (0.2)	88 (0.2)	85 (0.2)
User6 (Weight)	10 (0.1)	0.10s (0.3)	>70 (0.3)	80 (0.1)	80 (0.2)

TABLE 2: The average real value of execution log

WS	Cost	Response time	Throughout
WS1	9	0.7	80
WS2	8.5	0.5	85
WS3	8	0.6	95
WS4	10	0.4	90

TABLE 3: The satisfaction degree of consumer

WS	Index	User1	User2	User3	User4	User5	User6
WS1	Cost	0.62	0.47	0.55	0.64	0.52	0.62
	Response time	0.45	0.44	0.62	0.76	0.44	0.44
	Throughout	0.48	0.44	0.44	0.62	0.44	0.44
WS2	Cost	0.80	0.49	0.63	0.59	0.56	0.52
	Response time	0.62	0.49	0.62	0.52	1.0	0.55
	Throughout	0.55	0.70	0.58	1.0	0.62	0.52
WS3	Cost	1.0	0.50	0.72	0.56	0.62	0.44
	Response time	0.52	0.44	1.0	0.62	0.62	0.50
	Throughout	0.78	0.48	0.70	0.44	0.77	0.76
WS4	Cost	0.45	0.44	0.44	0.75	0.44	1.0
	Response time	0.80	0.55	0.44	0.44	0.62	0.62
	Throughout	0.62	0.77	0.83	0.62	1.0	0.62

TABLE 4 presents the user comment that is evaluated by fuzzy set. Assumed that $\alpha=30, \beta=20$, We use formula (2) to get the degree of membership. Then we use formula (6) to calculate the trust degree of user evaluation. The trust degree is presented in TABLE 5.

Through the result of TABLE 5, we can know obviously that the trust degree of User2 and User6 is lower. That means the user evaluation of User2 and User6 is uncredible.

TABLE 6 shows the experiment result. If we use traditional web service recommendation approach without trust degree, which is called Approach1 from TABLE 6, we can get $WS1 > WS2 > WS4 > WS3$. But In fact WS1 is not the best candidate web service composition. We use novel recommendation approach which is called Approach2 to get $WS3 > WS1 > WS2 > WS4$. That is the correct solution. So we can see the novel approach of web service composition recommendation can avoid the reflection of uncredible user evaluation.

TABLE 4: User comment

WS	Index	User1	User2	User3	User4	User5	User6
WS1	Cost	60	40	60	70	50	80
	Response time	50	40	60	80	50	80
	Throughout	50	40	50	60	50	80
	Reliability	70	60	60	80	60	80
	Available	60	60	60	80	60	80
WS2	Cost	90	40	60	60	60	80
	Response time	70	40	60	50	90	70
	Throughout	50	40	60	90	60	70
	Reliability	80	60	60	60	60	70
	Available	80	60	60	60	50	70
WS3	Cost	95	40	70	60	70	70
	Response time	50	40	90	60	70	70
	Throughout	80	40	80	50	90	70
	Reliability	80	40	70	70	70	70
	available	80	40	70	70	70	70
WS4	Cost	50	40	50	80	50	90
	Response time	80	50	50	50	60	90
	Throughout	60	60	60	60	90	90
	Reliability	60	60	70	70	70	90
	available	60	70	60	70	70	90

TABLE 5: The trust degree of user evaluation

User	User1	User2	User3	User4	User5	User6
TD	0.84	0.65	0.82	0.85	0.82	0.73

TABLE 6: Experiment result

WS	WS1	WS2	WS3	WS4
Approach1	0.9	0.8	0.68	0.7
Approach2	0.8	0.7	0.88	0.6

CONCLUSION

In this paper, the content of the research is to apply credible user evaluation to web service recommendation method. According to the user requirement model, this paper established user evaluation model which consist of recordable type and un-recordable type. And then according to the real value of execution log, we use gray correlation algorithm to calculate the consumer satisfaction degree. Comparing the user evaluation with consumer satisfaction degree, we obtain the trust degree of user evaluation. Then we used fuzzy analysis method to get the best candidate web service. Finally, through one case we prove the new method can effectively avoid the influence of exaggerated and false user evaluation.

ACKNOWLEDGMENT

Denghui Wang would like to extend sincere gratitude to corresponding author, Hao Huang, for his instructive advice and useful suggestions on this research. And we thank the anonymous reviewers for their valuable feedback and suggestions.

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