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CF Based and Location Aware Filtering for Web Service Recommendations

Akshitha N[1], Manjunath R[2]
[1,2] Department of CSE, City Engineering College

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Abstract— Collaborative Filtering (CF) is comprehensively used for making Web organization proposal. CF-based Web organization proposition intends to predict missing QoS (Quality-of-Service) estimations of Web organizations. Web organizations are consolidated programming parts for the sponsorship of interoperable machine-to-machine correspondence over a framework. Web organizations have been for the most part used for building organization arranged applications in both industry and the insightful world starting late. An ill-advised organization decision may achieve various issues to the ensuing applications. In this paper, we propose an area mindful customized CF strategy for Web administration suggestion. The proposed technique influences both areas of clients and Web administrations while selecting comparative neighbors for the objective client or administration, furthermore aggregate separating based Web organization recommender structure to offer customers some help with selecting organizations with perfect Quality-of-Service (QoS) execution. Our recommender structure uses the territory information and QoS qualities to gathering customers and organizations, and makes redid organization proposition for customers in light of the bundling results. Differentiated and existing organization recommendation techniques, our system finishes broad change on the proposition precision. The proposed game plan involves two stages: first, we use mixed number programming (MIP) to find the perfect breaking down of overall QoS impediments into close-by prerequisites. Second, we use coursed neighborhood decision to find the best web advantages that satisfy these close-by prerequisites. The outcomes of trial appraisal demonstrate that our system significantly beats existing courses of action similarly as computation time while fulfilling near ideal results.

Keywords— *Collaborative filtering, Web Service Recommendation, QoS prediction, and Location Aware*

I. INTRODUCTION

Web administration is a product framework intended to bolster interoperable machine-to-machine collaboration over a system. With the pervasiveness of Service Oriented Architecture (SOA), more Internet applications are developed by making web benefits. As a result, number of Web administrations has expanded quickly in the course of the most recent decade. Web benefit revelation has turned into a vital and testing errand for clients. Not with standing useful prerequisites, clients like wise need to discover Web benefits that fulfill their own non-utilitarian necessities. Under this situation, administration revelation that joins non-useful execution of Web administrations has excited a lot of hobbies in the administrations registering field.

Quality of-Service (QoS) is generally utilized to speak to the non-utilitarian execution of Web administrations [3], [4]. QoS is normally characterized as an arrangement of non-practical properties, for example, reaction time, throughput, dependability, etc. Because of the central significance of QoS in building effective administration arranged applications, QoS based Web benefit revelation and choice has accumulated much consideration from both the scholarly world and industry [5], [6]. Regularly, a client wants to choose a Web benefit with the best QoS execution, gave that an arrangement of Web administration hopefully fulfilling his/her practical prerequisites are found. As a general rule, be that as it may, it is neither simple nor viable for a client to secure the QoS for all Web benefit applicants, because of the accompanying reasons: (1) Web benefit QoS is exceptionally rely on upon both clients' and Web administrations' circumstances. In this way, the watched QoS of the same Web administration might be unique in relation to client to client. (2) Conducting true Web benefit assessment for getting QoS of Web administration hopefuls is both tedious and asset expending. It is consequently illogical for a client to gain QoS data by conjuring the greater part of the administration competitors. Furthermore, (3) some QoS properties (e.g., notoriety and unwavering quality) are hard to be assessed, since they require both long perception span and countless. These difficulties call for more successful ways to deal with gain benefit QoS data.

Communitarian Filtering (CF) is generally utilized to prescribe brilliant Web administrations to administration clients. In light of the way that an administration client may just have summoned a little number of Web administrations, CF-based Web benefit suggestion method concentrates on foreseeing missing QoS estimations of Web administrations for the client [9]. Utilizing CF advances, Web benefits with ideal QoS can be recognized and prescribed to the client. In this study, we investigated a few persuasive components of Web administration QoS, (for example, client area, administration area and QoS variety) and fuse them into our QoS expectation strategy. Reached out from its preparatory gathering form [10], the commitment of this paper is three-fold:

- We proposed an upgraded estimation for figuring QoS closeness between various clients and between various administrations. The estimation considers the customized deviation of Web administrations' QoS and clients' QoS encounters, with a specific end goal to enhance the precision of comparability calculation.
- Based on the above upgraded likeness estimation, we proposed an area mindful CF-based Web benefit QoS expectation technique for administration suggestion.
- We directed an arrangement of exhaustive investigations utilizing a true Web benefit dataset, which exhibited that the proposed Web benefit QoS forecast strategy essentially beats past surely understood techniques.

II. Related Work

Shared sifting is a standout amongst the most wellknown suggestion strategies, which has been generally utilized as a part of numerous recommender frameworks. In this segment, we give a brief review of CF calculations, and compress late work on CF-based Web benefit suggestion.

2.1 Collaborative Filtering (CF)

Collaborative sifting is a technique for making programmed forecasts (separating) about the hobbies of a client by gathering inclinations or taste data from numerous clients (teaming up). Formally, a CF area comprises of an arrangement of clients U, an arrangement of things I, and clients' evaluations on things. The latter is regularly spoken to by a client thing framework R, where every section r(x, y) (thing y. The rating r(x, y) is void if client x has not yet evaluated thing y. Since the quantity of things that are gathered and appraised by a client is typically little, the client thing lattice R is liable to be exceptionally meager. Under this definition, the errand of CF is to anticipate the values for particular exhaust sections (i.e., foresee a client's evaluating for a thing).

2.2 Web Service Recommendation

Various suggestion methods have as of late been connected to Web benefit proposal, for example, the substance based [13], [14], join expectation based [15], and CF-based [7], [8], [9].CF has pulled in the most consideration for its effortlessness and viability. Shao et al. [7] proposed a client based CF technique for QoS-mindful Web benefit suggestion. Zheng et al. [8], [9] consolidated both user based and thing based CF calculation to foresee Web benefit QoS values. Their contended that, for each combine of dynamic client and target Web benefit, both the QoS experience of the clients like the dynamic client and the QoS estimations of the administrations like the objective administration can be utilized for QoS expectation. In any case, these past methodologies neglected to abuse the qualities of QoS in the closeness calculation.

In light of the customary CF approaches, a few upgraded strategies have been proposed to enhance the forecast exactness. Wu et al proposed an enhanced CF technique by utilizing information smoothing for the client benefit QoS framework. Qiu et el joined clients' notoriety into CF for Web benefit QoS forecast and suggestion. Chen et al. perceived the impact of client area in Web benefit QoS forecast and proposed a versatile CF technique.

As of late, Matrix Factorization (MF) has been effectively utilized for precise and versatile Web benefit QoS forecast. Be that as it may, these modelbased CF strategies may experience issues in taking care of progress of the client benefit connection grid. At the point when new communications in the middle of clients and administrations happen, the MF show must be recomputed starting with no outside help to perform QoS forecast. Consequently, this work concentrates on enhancing memory based CF by abusing the attributes of Web administrations and administration clients.

2.3 Incorporating QoS Variation into User and Service Similarity Measurement

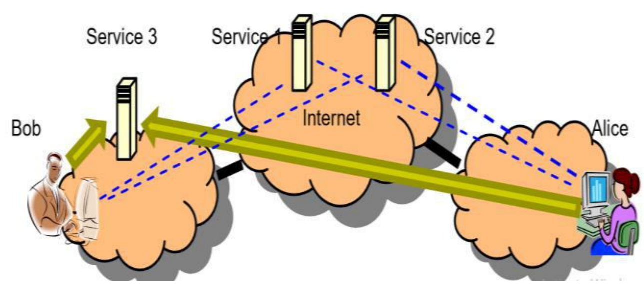

Fig. 1. Influence of user location on QoS prediction

Previous QoS forecast techniques expect that the co invoked Web benefits have meet commitment weights when processing closeness between two clients. We contend that the customized attributes (e.g., QoS variety) of both Web administrations and clients ought to be fused into measuring the similitude among clients and administrations.

Web benefit QoS variables, for example, reaction time, accessibility and unwavering quality, are generally client subordinate. From various Web benefits, we can determine diverse customized qualities, taking into account their QoS values, according to receive by an assortment of clients. Some Web administrations may have a decent QoS for all clients. For instance, the accessibility is constantly 100%. This is plausible if the Web administrations are sent in an elite Cloud environment. In the event that the QoS is sufficient (as in this example), a little variety of QoS values over all clients is liable to be watched. Some Web administrations may have an extremely poor QoS for all clients.

There could be some administration clients situating in the problem areas of Internet and with high transfer speed who are liable to watch great execution on most administrations, and there likewise could be some administration clients situating in the less prevalent spots of Internet and with low data transmission who are liable to watch poor execution on generally benefits. These administration clients are viewed as less administration delicate, and in this way ought to contribute less to the administration similitude calculation. Alternate clients with more typical QoS variety ought to contribute more to the administration likeness calculation.

2.4 Incorporating Locations of Users and Services into Similar Neighbor Selection

Web administrations are sent on the Internet. Accordingly, QoS of Web administrations, (for example, reaction time, unwavering quality and throughput) is exceedingly reliant on the execution of the basic system. On the off chance that the system between an objective client and an objective Web administration is of superior, the likelihood that the client will watch high QoS on the objective administration will increment. There are a few components influencing the system execution between the objective client and the objective administration. The most imperative elements incorporate system separation and system transfer speed, which are exceptionally significant to areas of the objective client and the objective administration. At the point when the client and the administration are situated at various systems which are far from each other on the Internet, system execution is liable to be poor because of both the exchange defer and the restricted transfer speed of connections between various systems. Conversely, when the client and the Web administration are situated in the same system, the client will probably watch high system execution. In this manner, the areas of client and administration are vital components influencing QoS.

Fig. 1 gives a case to represent why areas of two clients can be abused to enhance both the precision and proficiency of QoS forecast. Comparative cases can likewise be found to show why benefit area is additionally critical for QoS forecast. For the purpose of succinctness, we just concentrate on client area in this illustration. Assume Bob and Alice are two clients situated in various systems that are a long way from each other (see Fig. 1). Each watched comparable QoS, for example, reaction time and throughput, on two Web benefits, e.g., Service 1 and Service 2 (The two administrations may be conveyed in a few systems that have comparative execution to Alice and Bob). As per customary CFbased QoS forecast techniques, the two clients are to some degree comparative. In this manner, they are prone to watch comparable QoS on other Web benefits (e.g., Service 3). Nonetheless, gave Service 3 was conveyed in the same system as Bob, in this manner being near Bob yet far from Alice, it's profoundly likely that the two clients will watch entirely diverse QoS values on Service 3. This is in inconsistency with the desire of traditional CFbased expectation techniques. Really, Alice and Bob are not so much comparative, yet happen to have comparative QoS encounters on a couple Web benefits. Routine QoS forecast techniques misuse this case. By thinking about areas of clients, we can abstain from picking wrong neighbors for the objective client, consequently enhancing the precision of QoS forecast.

III. LOCATION INFORMATIOM REPRESENTATION, ACQUISITION, AND PROCESSING

Web services in a Web service discovery system or the system is recommending high-quality Web services to an active user. In these scenarios, predicting QoS values for Web services unknown to the active user is firstly required; then, Web services with satisfactory QoS can be identified and recommended to the user. This work focuses on predicting QoS values of Web services for recommendation. As shown in Figure 2,

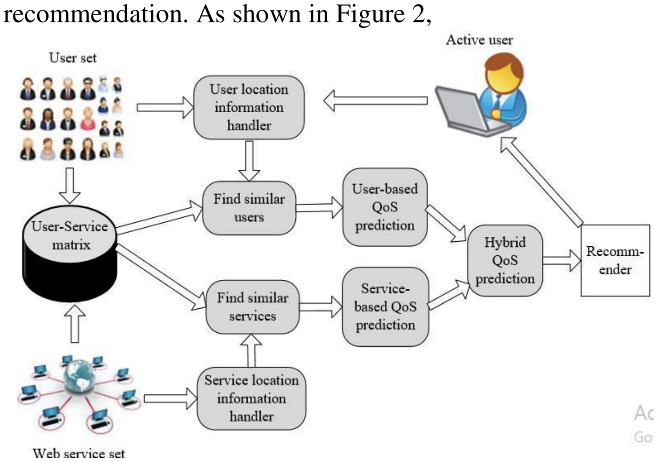

Fig. 2. Overview of our Web service recommendation method

(1) *User location information handler:* This module obtains location information of a user including the network and the country according to the user’s IP address. It also provides support for efficient user querying based on location
(2) *Service location information handler:* This handler gains extra area data of Web administrations as indicated by either their URLs or IP addresses. The area data incorporates the system and the nation in which the Web administration are found. It additionally gives functionalities to supporting proficient location based Web administration question.
(3) *Find similar users:* This module discovers clients who are like the dynamic client by considering both the clients' QoS encounters and areas. For exact client comparability estimation and adaptable comparative client determination, we propose a weighted client based PCC by means

of investigating QoS variety of Web administrations and fuse client areas into comparable client choice.

(4) *Find similar services:* As opposed to finding comparable clients, this module finds comparable Web administrations for an objective administration, considering both QoS of Web administrations and in addition administration areas. A weighted administration based PCC for measuring likeness between administrations is proposed.

(5) *User-based QoS prediction:* After a certain number of similar users are identified for the active user, this function aggregates the QoS values they perceived on target Web services, and predicts the missing QoS values for the active user.

(6) *Service-based QoS prediction:* After a certain number of similar services are identified for a target Web service, this function aggregates their QoS values to predict the missing QoS values for the active user.

(7) *Hybrid QoS prediction:* This capacity joins the user based QoS expectation and the administration based QoS forecast results, making last QoS forecasts. The frosty begin issue and information sparsity issue in QoS expectations are additionally tended to in this module.

(8) *Recommender:* In the wake of anticipating missing QoS values for all applicant Web benefits, this capacity prescribes Web administrations with ideal QoS to the dynamic client.

3.1 Location Representation

We represent a user's location as a triple (IPu, ASNu, CountryIDu), where IPu denotes the IP address of the user, ASNu denotes the ID of the Autonomous System (AS)1 that IPu belongs to, and CountryIDu denotes the ID of the country that IPu belongs to. Typically, a country has many ASs and an AS is within one country only. The Internet is composed of thousands of ASs that inter-connected with each other. Generally speaking, intra-AS traffic is much better than inter-AS traffic regarding transmission performance, such as response time. Also, traffic between neighboring ASs is better than that between distant ASs. Therefore, the Internet AS-level topology has been widely used to measure the distance between Internet users. Note that users located in the same AS are not always geographically close, and vice versa. Similarly, we model a Web service's location as (IPs, ASNs, Country IDs), where IPs denotes the IP address of the server hosting the service, ASNs denotes the ID of the AS that IPs belongs to, and Country IDs denotes the ID of the country that IPs belong to.

3.2 Location Information Acquisition

Acquiring the location information of both Web services and service users can be easily done. Because the users' IP addresses are already known, to obtain full location information of a user, we only need to identify both the AS and the country in which he is located according to his IP address. A number of services and databases are available for this purpose (e.g. the Who is lookup service2). In this work, we accomplished the IP to AS mapping and IP to country mapping using the GeoLite Autonomous System Number Database3. The database is updated every month, ensuring that neither the IP to AS mapping nor the IP to country mapping will be out-of-date.

3.3 Location Information Processing

To efficiently determine which user is close to the target user, we group users according to their location information so that those within the same group are really close. Likewise, we group Web services according to their location information so that those within the same group are close to each other.

In work [29], users are grouped mainly according to the similarity of their IP addresses. That is, if two users have close IP addresses, they are considered close in location. This seems reasonable but may, in reality, cause inaccuracies. Due to several factors, such as the shortage of IPv4 addresses and the wide application of provider independent IP addresses, fragmentation of IP prefixes (i.e., IP address blocks allocated to ASs) are increasing. Therefore, two IP addresses with close values do not necessarily belong to the same AS or country. Table 2 shows an example that the IP addresses possessed by a network (e.g. AS 863) are unnecessarily continuous. The IP prefixes that are close in value are unnecessarily belonged to the same network or country (e.g. 4.67.68.0 and 4.67.64.0 in Table 2). This indicates that identifying either near users or near Web services using only IP addresses could be problematic.

EXAMPLES OF IP TO AS AND IP TO COUNTRY MAPPING

Start IP Address	End IP Address	AS Number	Country Name
4.56.0.0	4.67.63.255	AS863	Canada
4.67.64.0	4.67.67.255	AS9996	Japan
4.67.68.0	4.68.247.255	AS863	Canada
4.68.248.0	4.68.249.31	AS1148	Netherlands
4.68.294.32	4.71.36.3	AS863	Canada
4.71.36.4	4.71.36.7	AS1148	Netherlands

Table.1. Example of IP to AS and IP to Country Mapping

Figure 3 illustrates the hierarchy of groups. In a similar matter, we also cluster Web services into groups. In our method, if two users or Web services are located in the same

AS, we regard them as close. Likewise, if two users (or Web services) are located in the same country, they are regarded as close. However, the latter has less closeness than the former. In order to efficiently search for both closeby users and Web services, in our implementation, we employ a data structure of hash tables to map every AS number or country

ID to the group it represents. Therefore, given the AS number or country ID of a user (or Web service), it costs very little time to retrieve close-by users (or Web services).

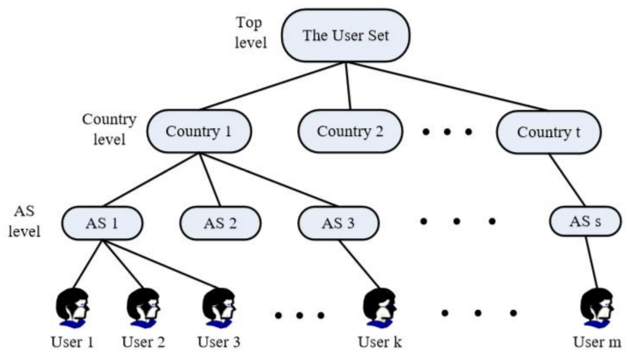

Fig. 3. Hierarchy of user groups

IV. QOS VALUE PREDICTION AND WEB SERVICE RECOMMENDATION

4.1 User-based QoS Value Prediction

In this subsection, we present a user-based location aware CF method, named as ULACF. Traditional user-based CF methods usually adopt:

$$\hat{r}_u(u,i) = \bar{r}(u) + \frac{\sum_{v \in N(u)} Sim(u,v) \times (r(v,i) - \bar{r}(v))}{\sum_{v \in N(u)} Sim(u,v)} \quad (1)$$

for missing worth forecasts. This mathematical statement, be that as it may, might be off base for Web administration QoS esteem forecast for the accompanying reasons. Web administration QoS elements, for example, reaction time and throughput, which are target parameters and their qualities shift generally. Interestingly, client appraisals utilized by conventional recommender frameworks are subjective and their qualities are generally settled. In this manner, anticipating QoS values in view of the normal QoS values saw by the dynamic client is defective. Besides, Eq. (1) does not recognize nearby and remote clients that are like the dynamic client. Instinctively, given two clients that have the same evaluated comparability degree to the objective client, the client nearer to the objective client ought to be put more trust in QoS forecast than the other. In view of the above thought, we utilize Eq. (2) to process the anticipated QoS esteem for the dynamic client taking into account the QoS experience of his/her comparative clients.

$$\hat{r}_u(u,i) = \frac{\sum_{v \in N(u)} Conf(u,v) \times Sim(u,v) \times r(v,i)}{\sum_{v \in N(u)} Conf(u,v) \times Sim(u,v)} \quad (2)$$

where Conf (u,v) is the confidence of Sim(u, v) in the view of u. This work computes the value of Conf (u, v) by considering whether u and v are located in the same AS or country, or neither of them. Usually, the confidence of Sim(u, v) will be larger when u and v is in the same AS or country than when they are in different countries, since nearby users are likely to have more similar QoS experiences than those faraway from each other, as we indicated in our experiments.

4.2 Item-based QoS Value Prediction

In this subsection, we present an item-based location aware CF method, named as ILACF. Based on the similar consideration as ULACF's, we compute the predicted QoS value for a service based on the QoS values of its similar services

$$\hat{r}_i(u,i) = \frac{\sum_{j \in N(i)} Conf(i,j) \times Sim(i,j) \times r(u,i)}{\sum_{j \in N(i)} Conf(i,j) \times Sim(i,j)} \quad (3)$$

where Conf(i, j) is the confidence of, Sim(i, j) to Web service i. Similarly, we compute the value of Conf (i, j) by considering whether i and j are located in the same AS or country, or neither of them.

4.3 Web Service Recommendation

The QoS qualities can be utilized for various Web administration suggestion situations subsequent to foreseeing the missing QoS values for a dynamic client. For example, when a dynamic client is hunting down Web administrations with indicated usefulness, the anticipated QoS qualities can help the clients find the Web administration with ideal QoS esteem from an arrangement of hopeful administrations. The QoS expectation technique can likewise recognize an arrangement of top notch Web administrations, and directly recommend them to an active user for selection.

V. EXPERIMENTS

We have conducted a set of experiments to evaluate the performance of our QoS prediction method. We also have conducted experiments to verify the relation between users' (or Web services') locality and QoS similarity. More specifically, we addressed the following questions:

- Is there a correlation between location closeness and QoS similarity for either Web services or users? How strong is it?
- Do the parameters and top-K influence the prediction accuracy? The parameter determines how much the hybrid QoS prediction method relieson the user-based prediction or the service-based prediction, each contributes to the prediction accuracy.
- How does the data density affect the performance of the QoS prediction? What is the performance of our method under different data sparseness conditions?
- How much better is our approach when compared with other CF-based QoS prediction methods? We

compared our approach with several previous, well known methods, in both prediction accuracy and prediction time.

All experiments were developed with Matlab.

TOP 5 COUNTRIES WITH MOST USERS

Rank	Country Name	Number of Users	Proportion of Users
1	United States	161	47.49%
2	Germany	41	12.09%
3	Japan	16	4.72%
4	Canada	12	3.54%
5	Poland	12	3.54%

Table.2. Top 5 Countries with most Users

TOP 5 AUTONOMOUS SYSTEMS WITH MOST USERS

Rank	AS Number	Number of Users	Proportion of Users
1	AS680	31	9.14%
2	AS2500	9	2.65%
3	AS559	9	2.65%
4	AS786	9	2.65%
5	AS25	6	1.77%

Table.3. Top 5 Autonomous Systems with most Users

5.1 Dataset

During our experiments, we adopted a real-world Web service dataset, WSDream dataset 2 [36], published in www.wsdream.com. This dataset contained the QoS records of service invocations on 5825 Web services from 339 users. The dataset can be transformed into a user-service matrix. Each item of the user-service matrix is a pair of values: response time (also called Round Trip Time, RTT) and throughput (TP). Therefore, the original user service matrix can be decomposed into two simpler matrices: RTT matrix and TP matrix. We used either the RTT matrix or the TP matrix to compute both the user and the service similarities.

TOP 5 COUNTRIES WITH MOST WEB SERVICES

Rank	Country Name	Number of Web Services	Proportion of Web Services
1	United States	2389	41.01%
2	United Kingdom	510	8.76%
3	Canada	432	7.42%
4	Germany	298	5.12%
5	China	271	4.65%

Table.4. Top 5 Countries with most Web Services

TOP 5 AUTONOMOUS SYSTEMS WITH MOST WEB SERVICES

Rank	AS Number	Number of Web Services	Proportion of Web Services
1	AS271	281	4.82%
2	AS786	257	4.41%
3	AS4134	160	2.75%
4	AS26496	155	2.66%
5	AS11426	125	2.15%

Table.5. Top 5 Autonomous Systems with most Web Services

This dataset also contained both the IP addresses of all users and the URLs of all Web services. Through analysis, we found that all 339 users were distributed within 137 ASs and 31 countries. Among the 5825 Web services, 5102 Web services are distributed within 1021 ASs and 74 countries. The AS numbers and country names of the other 723 services is unknown because we either failed to transform their URLs into IP addresses or failed to obtain their AS numbers and country names. Table 3 and Table 4 show the top five countries and top five ASs respectively, of users in the dataset. Table 5 and Table 6 show the top five countries and top five ASs respectively, of Web services in the dataset.

5.2 Correlation between Location Closeness and QoS Similarity

In this subsection, we present experimental results on the relation between the location closeness and QoS similarity for both users and Web services. The QoS similarity both between users and between Web services is computed with PCC. To correctly evaluate this relationship, we developed the following two series of experiments:

1) For a user, we first identified its top K similar neighbors based on the QoS similarity measurement. We then calculated the proportion of the user's similar neighbors that are within the same AS or country of the user. A higher proportion indicates a stronger correlation between location closeness and QoS similarity with respect to users.

2) We computed the average QoS similarity between every pair of users within the same AS or country, which is referred to as Local User Similarity (LUS), denoted by either A-LUS (AS-based) or C-LUS (Country-based). On the other hand, we computed the average QoS similarity between every pair of users across different ASs or countries, which is referred to as Global User Similarity (GUS).

VI. CONCLUSION

This paper presents a personalized location-aware collaborative filtering method for QoS-based Web service recommendation. Aiming at improving the QoS prediction performance, we take into account the personal QoS characteristics of both Web services and users to compute similarity between them. We also incorporate the locations of both Web services and users into similar neighbor selection, for both Web services and users. Comprehensive experiments conducted on a real Web service dataset indicate that our method significantly outperforms previous CF-based Web service recommendation methods.

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