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Research Article

A Location Context Aware Service Discovery Model and Algorithm to Support Mobile Service Personalization

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Abstract: Along with the rapid development of mobile Internet, more and more services have emerged on the mobile platform. In this study, it proposes the model of location context aware service discovery oriented to mobile Internet. Firstly, it introduces the Location-Based Service (LBS), users' behavior preference expression and the process of content filtering. Secondly, it puts forward the model of Location Context-based Service Discovery (LCMSD) by acquiring the data of users' behavior and gaining their requirements. Thus it keeps track of users' behavior preference and updates their preference according to the location context. Thirdly, the algorithm of location-based service discovery is brought forward, which focuses on the model of location context and describing users' preference and location-based service in detail. So it solves the problem that users can't discover the required services in the current location context timely. Finally we design a simulation experiment of mobile service which computes the similarity of mobile service and users' behavior preference through mining users' preference. The result shows that it can support mobile service personalization.

Keywords: Algorithm, Location-Based Service (LBS), location context, Location Context aware Service Discovery Model (LCMSD), service discovery

INTRODUCTION

With the development of wireless network and mobile communication technologies, more and more services begin to emerge on the Internet. Location-Based Service (LBS) becomes one of the most typical applications of mobile Internet and nowadays it's more and more popular. Among all kinds of VAS (Value-added Services), mobile service is the most promising prospect and it's a general trend when network technology developpes widely and users' commands turn more and more complex. Now location based service has emerged to serve for users who have the special request everywhere at any time. So how to find users' required mobile services has proved to be an important issue that must be solved, especially the services which satisfy users' behavior preference (Xu and Cui, 2006). In addition, with the development of information society and enhancement of life, users tend to save time and improve efficiency significantly. This trend increases users' pursue of finding their personalized information, therefore in this study it comes up with mobile service discovery based on web service discovery (Wu *et al*., 2005).

LBS discovery gains the information of mobile terminal through location technique (Retscher, 2006) and provides some mobile services with users. The location technique generally used in the current system by users is Google's GIS. At present, the major mobile Internet Service Provider (ISP) are all spreading and deploying LBS such as Genie, IntelliWhere Genie, J-Navi, Webraska Personal Navigation and so on. Mobile terminal users can obtain their current location conveniently and use the terminal to inquire or collect the message nearby. In the process of location, the sensor obtains the location information of mobile terminal through mobile Internet and this technique has high efficiency. For instance, the housewives can receive the discount commodity information in the supermarket every day and users also can inquire the particular walk or riding information with their mobile phones if they're lost in an unfamiliar area. Users hope that they can get the necessary information through the mobile terminal only when they want to get the service. And they have strong demand of service contents and expression. How to meet users' special needs is the bottleneck hindering the development of mobile services. Consequently it builds prototype framework of users' behavior preference and it presents the algorithm of mobile service discovery (Yanxiang *et al*., 2005).

Our research is content filtering of information based on location context (Bill *et al*., 1994) and users' behavior preference in this study. It proposes mobile service discovery and it combines the information of location context with users' behavior preference. When

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users launch an inquiry, the system selects their interesting services through screening and computing the similarity of users' preference and mobile services. Furthermore it builds a dynamic update model of users' preference. When the location context is changed, the required services can be discovered automatically according to users' preference. What's the most important, Internet perceives the users' needs actively instead of receiving the request passively and it realizes mobile service discovery for users. The purpose of mobile service discovery in this study is to find some interesting services for users, so that they can solve the problem of finding really useful services in numbers of mobile services. It's just to support the service discovery personalization and meet users' need (Eija, 2003).

MATERIALS AND METHODS

The definition of location-based service: As long as the services which are provided to users are related to the current location context, we can call them location-based service. Location-based service is a kind of new service which obtains users' information through the mobile terminal and offers users their interesting services. Mobile services describe the attributes information of mobile service exactly mainly including its properties, input or output parameter, processing procedure, effect and service function. Furthermore, the description is almost based on the semantic concept.

Definition 1: LBS are defined as a vector of service attributes:

$$LBS =< SP, Is/Os, P, E, QoS > \quad (1)$$

According to definition 1 we can extract the important information of location-based service and do an abstract of service vector (Li and Li, 2006) such as precondition, service effect and QoS (Li and Jiang, 2007). Among it the meaning of every element is:

SP Represents service properties, including the common properties and proprietary properties. Among it, the common properties include service ID, service provider ID, service name, service provider name, service function, service category, contact and so on. The proprietary property means the special attributes which service has.

SP is approximately composed of the service category, service name and the weight of keywords. Keys represent the collection of LBS keywords which can be expressed as a vector:

$$SP =< Category , Name , keys >$$

Is/Os is the collection of users' input and output information Is = UInput (s).

The research of LBS is aimed to let more and more users accept it and use it. The parameters adopt the common data types, just like integer, char, date and float, so we can deduce parameter type referring to parameter name. Then Is is simplified as:

$$Is =< \{Category\} \cup \{Name\} \cup \{Location\} \cup \{Time\} \cup \{Discount\} >$$

The definition of Os is as the same as Is and it contains service category, the service function and service binding interface:

$$Os =< \{Class\} \cup \{function\} \cup \{binding\ interface\} \cup \{result\} >$$

QoS is the non-function-index and it comprises the service cost, the duration time of service access, the security level of service, service usability, service reliability, service maintenance, service availability and service robustness:

$$QoS =< \{security\} \cup \{reliability\} \cup \{cost\} \cup \{maintenance\} \cup \{availability\} >$$

The collection of location-based services is made up of numbers of mobile service. On the basis of the definition, the set of location-based services is represented as ω:

$$\omega =< LBS_1, LBS_2, \ldots LBS_n >$$

Once the attributes of mobile service is know about, then the content concerned can be extracted through web content mining and content filtering. When entering the process of the content mining of mobile services, it utilizes the technology of data mining and extracting the useful patterns and important information from the related resources. It's mainly based on text information and contains web content summary, classification, clustering and association rules. Mobile service discovery is based on web content mining and filtering; only these two procedures the model of location context aware service discovery can be built precisely.

The content filtering of mobile service: Content filtering (Freddy, 2010) is the process of monitoring content on the Internet and prohibits some things from transmission. However, content filtering of LBS adopts several different service strategies according to the different users. It monitors users' behavior preference referring to the current location context and matches location-based service at the same time. It filters the information automatically on the basis of users' requirement, in the meantime the useless information is shielded out. The most important is that required service information can be provided to users through content filtering based on the current location context.

Now the filtering technology which is based on content of network analysis usually adopts the methods of matching overall features of text content. The fundament theory of content filtering in this study is scanning the web content, learning training set, getting overall features of text content, constructing the classifier and comparing it with the filter vocabularies which are obtained through machine-learning. If the web content includes specified quantity of filter vocabularies, then we conclude that it meets the need of content filtering and it can be filtered. The method of content filtering in this study overcomes these shortcomings those keywords take a part for the whole.

Content filtering mainly uses the method of matching keywords and gets rid of specific content. Content filtering of LBS is a comprehensive method and in the process of filtering it extracts relative information which meets users' requirements. Then the filter matches the input stream of the service with users' preference. The collected information is pushed to the filter and the filter checks the relative information and transmits the information to users. As a result, it helps the users solve the problem concerning amounts of information. Meanwhile users will determine whether to submit their feedback or not to the filter. Furthermore the filter can do better to furnish the useful information through self-learning and self-adjusting autonomously.

According to the process of content filtering discussed above, the characteristic words and expression of mobile services can be extracted so that we can match the LBS and users' behavior preference conveniently. Simultaneously, service function is divided into some modules through filtering and it's in favor of constructing its software architecture.

In this study it analyzes users' behavior and extracts pages users have scanned from the log library. Then it preprocesses the users' data, updates SQL inquiry, wipes out the noisy data and carrieson the correlation mining. Furthermore, it stores the action result into the database of users' behavior preference. At last, it utilizes content filtering of mobile services to match the keywords of service and users' preference.

The expression of users' behavior preference: User modeling means analyzing users' request action data and obtaining users' preference by some reasoning, artificial intelligence and machine learning. It's one kind of users' requirement description which is algorithm-oriented, specially architectural and formal. Meanwhile, user modeling is also the kernel and foundation of mobile service discovery and influences the precision of discovery result directly. So first of all, we should construct users' behavior preference as accurately as possible.

Users' behavior preference occupies an important position in the mobile service discovery, for instance, users' new registration in Internet, score on some services and the behavior of marking interesting information or buying something. These action records all demonstrate users' behavior preference. It constructs the prediction model of users' behavior preference and finds the required mobile services according to users' profiles, their interest, the behavior of transacting something and their action features in this study.

In the process of scanning through mobile terminal users' input information, system log and access history are all associative with users' behavior preference. The behavior of scanning pages, dragging scroll bar and the advance or recession of pages is as the same important as users' operation. In the interaction four kinds of key data will be produced which are the track of mouse movement, the distribution of link click, the amount of page scanning and the time of page staying respectively. The description contains many fields, for example, the keywords, users' operation, selection, input/output and so on. Users' preference can be expressed as following:

Definition 2:

$$PREF =< \text{Time}, \text{Keywords}, \text{Value}, \text{SE}, \text{Input/Output}, \text{Class}, \text{Novelty}, QoS > \quad (2)$$

Time : The time while users are scanning the wanted pages

Keywords : On the half of the collection of keywords which users input to search the wanted page and it's made up of a n-dimensional vector (K1, K2, … Kn). Every dimension represents elements of the collection and keywords of every topic

Value : Users' input orientation and it reflects users' behavior indirectly:

$$SE =< Save, \text{Print}, Download, Favorites, Forwarding, \text{Recession}, ScroolBar >$$

it represents users' selection while scanning the pages,

Save, print and Download : Users save, print or download the pages on which they are keen

Favorite : Delegates the tags which users have bookmarked to express their behavior preference

Forwarding and Recession : The URL of users' advance and drawing back while they're scanning the pages

ScrollBar : The time of users' drag scroll-bar and it reflects users' behavior preference to some extent

Input/Output : Users' input or output keywords, parameters or some information related

Class : The category to which LBS belongs. It includes education page, estate page, journal and so on

Novelty : The novelty degree of pages users have scanned and it mainly determines the real-time performance of message

QoS is such information which can be sent as users' feedback and it's submitted to the filter to update

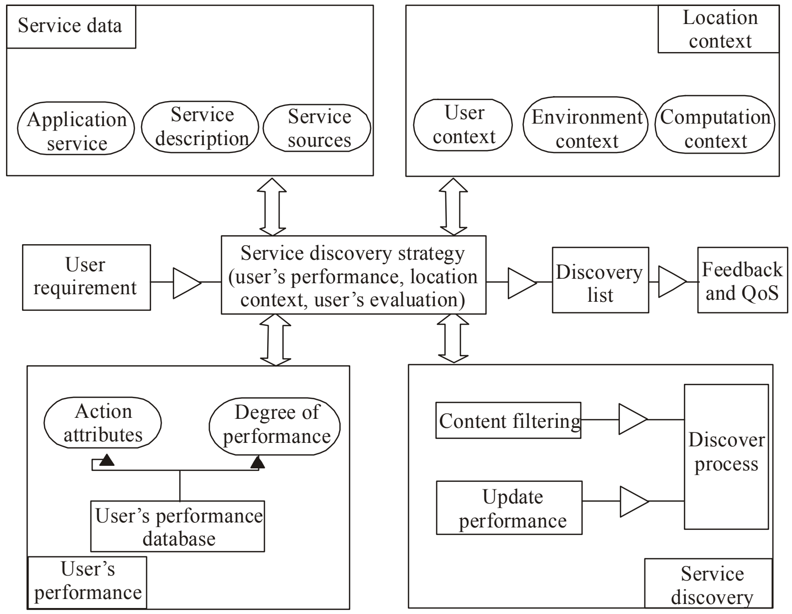

Fig. 1: The framework of service discovery

the *QoS* of LBS and users' behavior preference. We can use *QoS* to estimate the effect of service discovery. It can help us update users' behavior preference dynamically:

$$QoS = < Time, Cost, Reliability, Fidelity, Security >$$

In this study we build a *QoS* log database. In order to realize the dynamic update of *QoS* attributes, a external database is added to server which is used to store mobile service record. It makes use of *QoS* which users get in the process of service access to update *QoS* detection manager.

In short, users' online records can be tracked by server and it analyzes the records and forecasts users' preference using machine self-learning (Mladenic, 2000). Furthermore, users' requirement is obtained by human-computer interaction and their preference is deduced by mining system log (Zheng and Yan, 2010). It gains the data of users' action in implicit mode and does some related reasoning according to users' behavior. It applies the current location context as the first-level filter and users' behavior preference is updated following the change of location context. Simultaneously it makes full use of users' subjective preference tendency as the second-level filter to select LBS more accurately. Integrating these two layers of filters, it narrows down the scope of users' interesting mobile services. In a small area, the service discovery is more effective.

Service discovery is the foundation of service calling and this study includes location context with users' behavior preference to update their preference. And then it matches LBS with users' preference, computes their similarity and selects the discoverable services using *QoS*.

The model of location context-aware service discovery: Mobile service discovery is different from the former research which is based on syntactic level and this study breaks through the restriction of syntactic property. In particular it describes LBS on semantic level (Paolucci *et al*., 2002) not on syntax level. This kind of depiction is more accurate to convey properties of mobile service and in the same it adopts the method of fuzzy matching so that there is an overall and preferable result. Meanwhile, it is easy for us to match users' behavior preference and location service vector in their attributes. Then the required services are found on the basis of computing the similarity of mobile service and users' preference (Xin *et al*., 2004) and at last we sort the preliminary selection of mobile services using *QoS*.

As a general rule, a service discovery system mainly contains three roles: users, ISP and registration center. The fundamental architecture based on location-based service is made up of four parts: user model, data center, service discovery and application interface. The framework of service discovery is described using the Fig. 1.

In service discovery, service center consists of all kinds of information sources, the fundamental service property and service function. Location context is made up of the context information provided to users and in this study we focus on user context so that it realizes serving for users in a true sense. User model is the core of service discovery and the most important part. Service discovery module includes two small modules: one is the service discovery strategy and the other is service discovery engineer. Incorporating these four parts is helpful for us to find the required mobile services.

Context is any information that is used to describe the entity object and the entity can be users, location or other objects. This information is correlated to the interaction of users and applications. Location context can be seen as an target object in the space, or the relation of this target object and other objects, involving other objects themselves and they are closely related to each other.

To be particular in this study, we construct the model of Location Context-aware Mobile Service Discovery (LCMSD). And it means the model with environment information and it's closely linked with the mobile service. In this study, it contains the circumstance context, the user context, the time context, the location context and so on. It makes location context and location-based service closely interactive and there is a crossed overlap interaction in the process of constructing the model of mobile service discovery. To users it's just the information such as location, time, causes, premise of the incident etc.

Definition 3: The model of location context:

$$ServiceContext = \{Time, Location, Runtime\} \quad (3)$$

Location context offers users the indispensable location context information which is necessary for users to find the required LBS. In the model it describes the spatial location and the time of mobile service occurrence. Simultaneously it reflects the environment change of users' behavior preference. On the whole the pages which users scan can be divided into some domains:

$$Cate = \{Cate_1, Cate_2, ..., Cate_i, ...Cate_n\}$$

D_i means Domain i and it shows the sequence number of the application domain. Catei represents the category of LBS in $Domain$ i and it can be expressed as:

$$Cate = \{(Cate_1, K_{11}, w_{11} ... K_{1i}, w_{1i} ...), ..., (Cate_i, K_{i1}, w_{i1} ... K_{ij}, w_{ij} ...) ...\}$$

K_{ij} means all the keywords and w_{ij} means all the weight of words in Domain i. The keywords and their weight are measured in Cate and they are internal connected to each other.

In this study, the model of location context-aware mobile service discovery achieves one kind of service frames which processes high changeability and expandability. LCMSD is conducted as the middle-ware of location-based service and users' behavior preference and it builds a model of the processing procedure of service data. The new services which satisfy users' needs can be added into the model. So from user's view he can make full use of the services without any alteration. To be detailed, location context information is represent as the model below by adding time, location and key weight which are related to it. On the contrary, this alteration also changes users' behavior preference.

Definition 4:

$$Context_i = \{(Cate_{i0}, Time_{i0}, W_{i0}, K_{i0}, Loca_{i0}), ..., (Cate_{ij}, Time_{ij}, W_{ij}, K_{ij}, Loca_{ij}), ...\} \quad (4)$$

$Context_i$: The current location context of $User_i$. $Cate_{ij}$ is on the behalf of $Domain_j$ for $User_i$
W_{ij} : The weight sum of all keywords in $Domain_j$ for $User_i$
$Time_{ij}$: Delegates the latest access time of $Topic_j$ for Useri
$Loca_{ij}$: The latest access location of $Topic_j$ for $User_i$
K_{ij} : All the keywords in Domain j for Useri

Location context which isn't independent always exists at the same time and intercrosses with each another. Mobile Internet and wireless network provide users with new challenges of discovering their behavior preference toward the alteration of location context. In brief, users' behavior preference can be divided into two kinds and they are context preference and personal preference separately. The most import thing is that context preference can be translated into user's individual preference under certain circumstances. The short-term preference of users is captured if we get the information of the current location context. With the change of users' short-term behavior preference and the renovation of LCMSD, the transformation of users' personal long-term behavior preference is computable and can be forecast. In other words, location context is beneficial to discover users' required mobile services in lots of services and it helps to realize mobile service discovery.

The track of users' behavior preference: Location context is very important and volatile for users when they are intended to discover required mobile services. Location context varies toward the current circumstance. Because of this kind of variability it leads to the high mobility and transfer of users' behavior preference and it also leads to the new preference production. Based on this kind of dynamic change, users' behavior preference is updated along with it. Location context can be located by the sensor. Location context searching is user-centered and it gets the satisfying solution according to time, location, input, requirement, habit and context. So we can conclude and adjust the change of users' behavior preference automatically through perceiving the location context.

The update of users' preference based on location context: Here we define a location manager to gain the current location. If the terminal location is changed, we need to call a method named on Location Changed to update the location context information. In actual operation, the location manager is supervised by two methods, on Resume and on Pause. They require

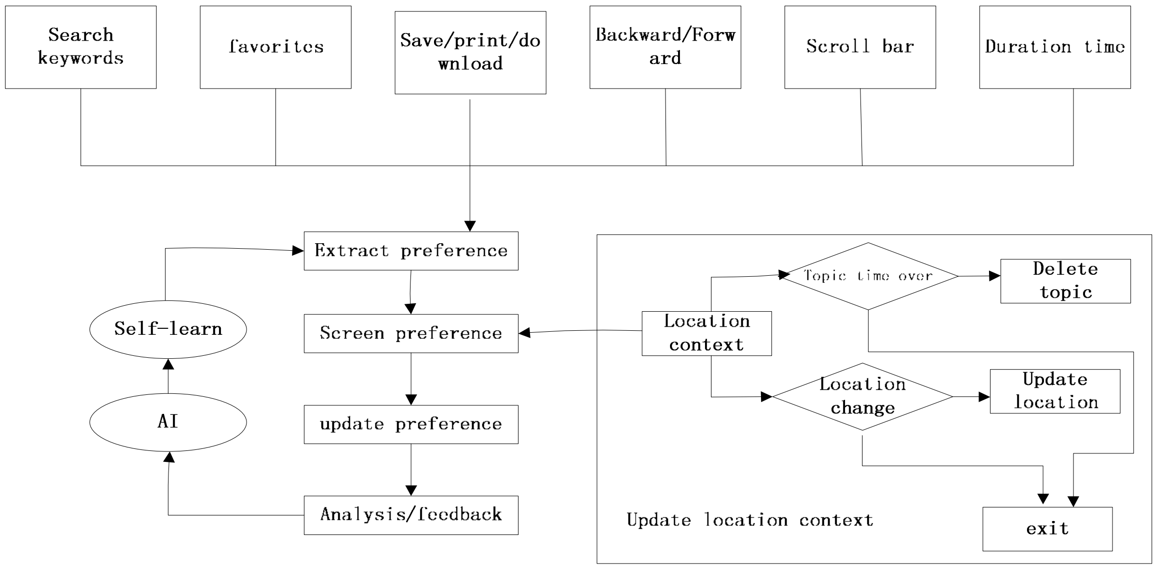

Fig. 2: The update of users' behavior preference

and remove the location context respectively. The information of users' favorites can be obtained through other users who have the similar preference or behavior in the same location context. Because the similar users almost have the same preference, other users' profiles can be adopted. Through this we can infer that it's just the location context preference and indeed it reflects users' short-term favors.

The updating process of users' preference is tied up to the location context, such as time, location, LBS topic transformation, transfer, or new preference production. Along with the alteration of the current location context, users' preference can be changed. We get the information of users' behavior preference and construct LCMSD.

In this study, it updates the information of users' behavior preference. It solves the problem that the input keywords can't describe users' preference precisely and it takes advantage of users' access behavior. It enables users' behavior preference to reflect the change of users' requirement. The update process of the model is described as Shown in Fig. 2.

In the Fig. 2, at first the system extracts users' behavior preference from their scanning action, such as their searching keywords, the URL of forward or backward, the bookmark tag, the action of saving, printing and download, the time of dragging the scroll-bar etc. And it screens users' preference through self-learning and Artificial Intelligence (AI). Then the system updates location context. If the topic is changed, then delete it. If the location is changed, then update the location information of the context. At last, it recomputes the level of users' behavior preference according to the latest location context. Simultaneously users' feedback can be used to renew users' favorites in return. Especially the whole process is circular and interactional.

The level of users' behavior preference: The level of users' preference shows how deep users are interested in services and it describes the dependency of location-based services and their requirement. LBS and users' behavior preference are both represented as vectors and their similarity is computed if location context finishes updating. The sum of all users' behavior preference is 1 and the range of everyone is between 0 and 1.

Definition 5:

$$pref = \{u_{pref\,(pref_1)} * p_{(pref_1)}, u_{pref\,(pref_2)} * p_{(pref_2)}, \ldots, u_{pref\,(pref_n)} * p_{(pref_n)}\} \tag{5}$$

Among it:

$$u_{pref\,(pref_i)} = [0,1],\ pref_i \in pref\ ,\ \sum_{i=1}^{n} u_{pref\,(pref_i)} = 1$$

Definition 6: Location-based service in the current location context:

$$F = \{activity_1, activity_2, \ldots activity_n\} \tag{6}$$

activity, is made up of n-dimensional vector. Among it:

$$activity = < actname, actvalue, acttype >$$

activity describes the attributes of some peripheral location-based service. Based on the current location context, this study matches LBS and users' favor and computes their similarity using the formula below:

$$Sim_{keywords, Input} = 0.5 \left(\frac{\sum_{k=1}^{n} \omega_k(keywords) \times \omega_k(actname)}{\sqrt{(\sum_{k=1}^{n} \omega_k^2(keywords))(\sum_{k=1}^{n} \omega_k^2(actname))}} + \frac{\sum_{k=1}^{n} \omega_k(Input) \times \omega_k(actname)}{\sqrt{(\sum_{k=1}^{n} \omega_k^2(Input))(\sum_{k=1}^{n} \omega_k^2(actname))}} \right) \quad (7)$$

In the Formula 7, if Sim keywords, Input >= θ, it will meet users' needs (WU *et al*., 2005) and if Sim keywords, Input <θ, it will be discarded. Then the system combines the personal factor to enter second-level filter and computes the degree $User_i$-To-$Topic_j$ namely $Interest_{ij}$:

$$Interest_{ij} = \sum_{j=1}^{N} \alpha * tf(j, N) * \log(\frac{N}{P(N_j)}) \quad (8)$$

Here α varies when the runtime of users' scanning is different. The change behavior of α is seen as following:

$$\alpha = \begin{cases} 0.5, \min < Time_{scan} < \max \\ 0, Time_{scan} < \min \\ 1, print/save/download/favor \end{cases} \quad (9)$$

Then we put the value of α into $Interest_{ij}$, recompute the level of $User_i$ to $Topic_j$ and it can be deduced as:

$$Pref_{ij} = \frac{1}{2}(Sim_{keywords, Input} + Interest_{ij}) \quad (10)$$

Finally in this study, it sorts $Pref_{ij}$ so as to find the most required LBS topic.

THE ALGORITHM OF LCMSD

This study constructs a matrix with the preference of every user according to LCMSD.

In the matrix of Fig. 3, every element delegates the level of $User_i$ to $Topic_j$. The range of q_{ij} is from 1 to 5. and the value is null if $User_i$ doesn't give an evaluation to $Topic_j$. The larger the value is, the deeper users are interested in this item. The required mobile service in the current location context can be matched with users' behavior preference. Their preference is updated by the location context and users' feedback.

In this study, it constructs a method called location based aware mobile service discovery. This algorithm requires and analyzes users' behavior preference. In the same time, it updates users' preference with location context in the current circumstance. Their preference is changing with the location context and users' feedback.

$$Q = \begin{bmatrix} q_{11} & q_{12} & \cdots & q_{1n} \\ q_{21} & q_{22} & \cdots & q_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ q_{m1} & q_{m2} & \cdots & q_{mn} \end{bmatrix}$$

Fig. 3: The matrix of users' behavior preference

The keywords similarity of LBS and users' behavior preference is calculated as Sim (Keywords pref, Key lbs):

$$Sim(\text{Keywords}_{pref}, \text{Key}_{LBS}) = \sum_{m=1}^{s}\sum_{n=1}^{t} \left[\frac{Semantic_{name}(\text{Keywords}_{pref}, \text{Key}_{lbs})*}{p\text{Keywords}_{pref\,1m} * p\text{Key}_{LBS\,2n}} \right] \quad (11)$$

Referring to this formula, we can also conclude the similarity of other attributes of service and users' preference such as Sim (SE_{pref}, $Name_{lbs}$) and Sim ($Input/Output_{pref}$, Is/Os_{lbs}):

$$Sim(SE_{pref}, Name_{lbs}) = \sum_{m=1}^{s}\sum_{n=1}^{t}[Semantic(SE_{pref}, Name_{lbs}) * pSE_{pref\,1m} * pName_{lbs\,2n}] \quad (12)$$

$$Sim(Input/Output_{pref}, Is/Os_{lbs}) = \sum_{m=1}^{s}\sum_{n=1}^{t}[Semantic(Output_{pref}, Is/Os_{lbs}) * pOutput_{pref\,1m} * pIs/Os_{lbs\,2n}] \quad (13)$$

At last, we comprehend these three similarities and compute the final similarity of mobile service and users' preference using the formula below:

$$Sim(K1, K2) = \frac{1}{3}(Sim(keywords_{pref}, Key_{lbs}) + Sim(SE_{pref}, Name_{lbs}) + Sim(Input/Output_{pref}, Is/Os_{lbs}))) \quad (14)$$

Here K1 and K2 represent the collection of users' behavior preference and mobile services separately. The modified service discovery algorithm is as shown in Fig. 4.

In Fig. 4, the modified service discovery algorithm is discussed. Firstly, it enters the process of content mining and filtering and then it analyzes system log in order to extract the important information of users' behavior preference and mobile service. Secondly, it does an abstract description of them and computes the level of $User_i$ to $Topic_j$. Thirdly, it constructs the matrix of users' behavior preference and updates users' behavior preference referring to the location context. Then it expresses the factors of current location context and computes the similarity of three parts of users' preference and mobile service. At last, it computes the average of the three similarities and uses the method of

Algorithm: Modified Service Discovery Algorithm

Input: users' scanning system log; numbers of LBS
Output: the list of services
1.do content filtering of LBS
$lbs = \{keywords, name, type, uinput(s), uoutput(s), function, qos\}$
2.extract users' scanning system log
$pref =< key, save, print, load, bookmark, forward, backward, scrollbar, I/O, class, qos >$

3.compute $Sim_{keywords,input}$ and $Interest_{ij}$
$$Interest_{ij} = \sum_{i=1}^{N} \alpha * tf(j,N) * \log(\frac{N}{P(N_i)})$$

4.compute the level of $User_i$ to $Topic_j$
$$Pref_{ij} = \frac{1}{2}(Sim_{keywords,Input} + Interest_{ij})$$

5.update users' preference according to location context
$update\ (loccontext)$
6.construct the matrix of users' preference
7.compute $Sim(keyword_{pref}, key_{lbs})$, $Sim(SE_{pref}, Name_{lbs})$ and $Sim(Input/Output_{pref}, Is/Os_{lbs})$ and sign them as $sim1$, $sim2$ and $sim3$ respectively
8.get the average value of the three similarity
$sim = 1/3(sim1 + sim2 + sim3)$
9.use quick-sort algorithm to sort
$List = quicksort\ (similarity_i)$
10.get the first n matches
$NewList = topn(List)$
11. Get the corresponding LBS on the basis of similarity.

Fig. 4: Modified service discovery algorithm

Algorithm: Update location context algorithm

1. Users input keywords to search pages.
$Keywords = \{K1, K2, ...K_i, ..., K_n\}$
2. if $K_i \notin Cate_{ij}$
  extract time and location of SC
  add $Context_i$ to K_i
 else
  update $Interest_{ij}$
3. extract the users' log record
 if $Sim_{keywords,Input} > Sim_1$
  add $Context_i$ to access topic of LBS;
 else if $Sim_{keywords,Input} > Sim_2$
  $update\ (loccontext)$
4. update time of LBS topic
 if $Time - Time_{ij} > \Delta t$ //the topic expires
  $delete(topic)$
else if
  $update\ (loccontext)$
5. $quicksort\ (lbs)$ //when updating the LBS topic.

Fig. 5: The update of location context algorithm

quick-sort to sort the selected services using QoS. Finally we get the first n matches and obtain the corresponding mobile services on the basis of similarity.

In the algorithm above, the update process is specified as Fig. 5.

In Fig. 5, it describes the update algorithm of location context. Firstly, it extracts time and location of SC and compares the similarity and the fixed threshold. Then it updates the topic through determining whether it expires or not. Considering these two methods, it obtains and does an analysis on users' preference and constructs their vectors. It updates users' preference according to the change of location context and computes their similarity of mobile service and users' preference. It helps users describe LCMSD by inputting the keywords and utilizes users' log to mine their access behavior reflecting the dynamic change of users' requirement more promptly. In brief, it integrates the current location context with users' preference and concretes mobile service from many perspectives including the attributes, properties, function, input/output, process and QoS. At lat it sorts the services using QoS to find users' most favorite mobile services and implements service discovery to support mobile service personalization.

RESULTS AND DISCUSSION

The design of experiment: The system acquires the program or scripts of the pages which users have scanned according to the change of users' preference and the current location context. Then, it analyzes plenty of fields of mobile services, such as the program, the keywords of pages and users' operation on pages. And it also optimizes the keywords and does some normalization processing. Furthermore, we take advantage of service discovery algorithm to filter the pages which are unrelated to their requirement and it builds indexes so that users can require and retrieve the related information easily.

At last, the system obtains the description documents of mobile services on the basis of location-based service. It builds the database which can help users find services and meanwhile the database of users' behavior preference can be updated adaptively according to the current location context.

In the research process of service discovery based on the current location context, it uses two evaluation methods to assess the effect of service discovery algorithm. This experiment mainly includes three parts:

- Users' information and their preference can be mined. More, it computes the change situation of users' behavior preference with the alteration of the current location context based on service discovery.
- This study computes the similarity of LBS and users' requirement in order to find their relativity.
- It evaluates the effect of the algorithm using the precision and recall and sorts the required mobile services with QoS so as to find the most favorite mobile services.

The result of experiment: According to the goal of evaluating the performance of service discovery, we do an experiment of finding users' required services. In the library of LBS we choose 400 items as training data source, among which there are 284 restaurant services. The purpose of training is to determine the similarity threshold. At last it filters 1200 LBS to serve for the experiment and tests 300 LBS every time.

In this study it adopts two kinds of methods, just like Table 1. One is discovering LBS manually and the other is detecting the simulation using the discovery algorithm proposed above. The experiment places the relative restaurant services into the set of related services. Otherwise, it puts them into the set of unrelated services. When the test is finished, it does data training by means of putting the set of related services as training data source. Then users' preference can be updated according to the change of the current location context . The contrast of two methods is:

Table 1: Result of manual method

		Manual	
No.	Sum	Related	Unrelated
1	300	102	198
2	300	114	186
3	300	128	172
4	300	138	162

Table 2: Result of LCMSD method

		LCMSD			
		Related 1		Unrelated 1	
No.	Sum	Related 2	Unrelated 2	Related 2	Unrelated 2
1	300	142	46	50	62
2	300	160	40	42	58
3	300	171	31	35	63
4	300	180	22	24	74

Table 3: Results of evaluation performance

	Recall	Precision
1	0.7395	0.7553
2	0.7921	0.8000
3	0.8301	0.8465
4	0.8824	0.8911

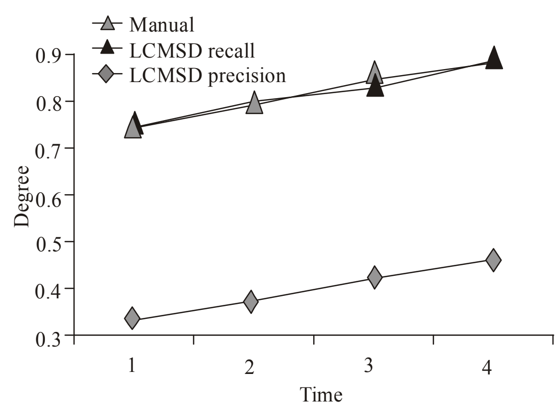

Fig. 6: The contrast of two methods

In Table 1 and 2, there is an obvious superiority of LCMSD. The recall and precision of LCMSD method is obviously high than the method of manual service discovery. And it discovers the required services which satisfies users' preference. According to the performance evaluation method, it can get the change table of the discovery capability with the change in the current location context.

According to the Table 3, we can see the change of precision. So the precision chart and recall chart of performance is shown in Fig. 6.

From the figure discussed above, it shows that the precision and recall of the algorithm proposed in this study have been improved to some extent and it has a clear superiority than the manual method. The precision is more and larger as time goes on. Because as the hours pass away, the information of users' behavior preference is more and more accurate through users' feedback and self-learning. Furthermore, the algorithm of LCMSD almost discovers the whole required mobile services and the performance of LCMSD has been increased on a certain scale. In addition, this experiment indicates that it's better to compute the similarity of location-based service and users' behavior preference by matching them and updating users' favorites with their feedback of used services. In this way LBS which meet users' demands can be found efficiently with the algorithm of Fig. 4 and 5. At last, it can support mobile service personalization.

CONCLUSION

Service discovery is the foundation of realizing the service discovery to support mobile service personalization. In this study it proposes a scheme of mobile service discovery based on users' behavior preference.

In this study, it presents two problems of location-based service in the location context: one is the match of mobile service and users' behavior preference and the other is revising the discovery result with users' personalized information. The research work and achievements what we do mainly consists of some aspects. Firstly, it builds the model of LCMSD and describes users' requirement and mobile services on the semantic level accurately. Secondly, it analyzes the process of discovery comprehensively and designs the algorithm of service discovery. It makes a systematic analysis on users' behavior preference and updates the users' behavior preference according to the alteration of the current location context and LBS topic information. Thirdly, it does an experiment of restaurant service and sorts the services using QoS threshold to find the most favorite services. The experiment supports service discovery based on location context better and shows that the precision of service discovery is improved.

In the future, we will continue to study on the perfection mechanism of users' behavior preference and the adjust mode of location-based service match. We are aimed to achieve the personalized service discovery.

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