A Mobile Location-based Information Recommendation System Based on GPS and WEB2.0 Services

FAN YANG
Continuing Education College
Shanghai JiaoTong University
No. 1954, HuaShan Road, 20030, Shanghai
China
fyang@sjtu.edu.cn

ZHI-MEI WANG
Department of Computer
Wenzhou Vocational Technical College
Wenzhou, 325035, Zhejiang Province
CHINA
wzmfst@126.com

Abstract: - Combining the GPS location-based services and the latest Web2.0 technologies, this paper builds a scalable personalized mobile information pushing platform, which can provide user-friendly and flexible location-based service. We first propose a Location-based Data and Service Middleware based on Service-Oriented Architecture in order to implement Mobile Information Pushing System involved in a variety of formats of data integration and conversion, as well as a combination of a wide range of services. Then, we propose a novel 3-D Tag-Cloud module, so that it can visualize useful retrieval information even in the limited mobile screen. Especially, we design a multi-dimensional collaborative filtering algorithms, in order to achieve dynamic personalized recommendation and mobile information sharing. Cooperating with some restuarants, we also develop a dynamic restaurant mobile location-based recommendation and discount counpons pushing system. The successful application of the application system do show the efficiency of our ideas.

Key-Words: Mobile Information Pushing, GPS, Web2.0, Location Based Service (LBS), Tagging, Collaborative Filtering, Personalized Recommendation

1 Introduction

Global Positioning System (GPS) becomes increasingly sophisticated and popular, and began to be integrated into the user's mobile terminal units (laptop, PDA and smart mobile phone and so on).

How to provide timely and personalized information and sharing services based on the user's location information? This problem is gradually contracting wide range of concerns of different areas of the researchers, content providers and network operators. And it forms a known and independent research area named as Location Based Services (LBS) [1-2].

The new generation of multimedia mobile phone, like iPhone, has begun to integrate online LBS as Google maps is to help users access to their destinations with traffic information and road conditions.

Furthermore, the GPS chip producers, GPS maps makers, and GPS software vendors have also gradually try for mobile terminal application development. According to the current location of the user, it can provide the vicinity of restaurants, entertainment and shopping information, etc.

** This paper is partly supported by the project founded by WenZhou Science & Technology Bureau of China [Project No. H20080008], and the projec"Research and Implementation on Web2.0 Information Sharing Platform based on GPS Services"founded by Science and Technology Department of Zhejiang Province in 2009.

Looking at the existing location-based services, its information is derived from a single content providers (such as map makers or telecommunications service providers), so there are some significant limitations[3].

Different with the traditional information services, location-based services plays more emphasis on the dynamics of information and diversity[4-6]. For this new type of location-based information retrieval approach, users want to be able to obtain more real-time and targeted content services, not just the indexed information based simply on a static database[7-8].

Recently, the rise of a large number of Web2.0 applications (blog, community forums, Web Albums, Blog and Taggings, etc.) indicates that users have the very pressing requirements of direct, rapid, useful and personalized information recommendation and sharing services[9-11].

How to efficiently combine the new Web2.0 application with GPS-based LBS services, and apply to mobile phone? It should doubtless be a very important research topic, and will have a very wide market prospect.

Since there are heterogeneous data and services in various of different application platforms and service providers, we take use of the concept of Web Service technologies, and implement a location-based data and service middleware based on SOA. This interface module can repackage the heterogeneous data and service, and republic them as web service which can be used as platform-transparency.

Considering the limited display screen of mobile terminals, we also propose a novel 3-dimentional Tag-Cloud model to filter the redundant tags and simplify the information query in the mobile phone.

In order to solve the provide more precise content pusing services, we design and implement a context-based collaborative filtering algorithm, which can analyze the user value-added data obtained from many Web2.0 applications (Tagging, comments, blog, rating, etc.). Thus, we realize a dynamic and personalized mobile information pushing platform combining with the location-based services and the latest Web2.0 applications. Users can not only get the dynamic tagged object navigation, but also obtain useful recommendations matching his query.

Section 2 presents a simple description of the system's overall architecture and component. Section 3 desribe the Location-based data and service middlewares Standard based on Service-Oriented Architecture. A novel Multi-Mode Location Information Index Approach based on 3-D Tag-Cloud is discussed in section 4. The Multi-Dimension Collaborative Filtering Algorithm is proposed in Section 5. This section also presents the dynamic personalized recommendation and sharing mechanism. Section 6 shows a Mobile Restaurant Location & Discount Coupons system implemented based our platform. The application data shows our system can enhance the acceptance and usage of mobile coupons which do benefit the users and companies simultaneously. The conclusion of this paper and future work overview are discussed in Section 7.

2 System Architecture

Application data information of our system can be divided into two parts: the location-based data (such as traffic and road condition data, GPS map, and entity information, etc.) and the value-added data provided by users (such as Ratings, Comments, Blog and Tags, etc.). In this paper, we will focus on value-added data information gathering, management and sharing. For the location-based data, we will primarily obtain from the existing network information service platforms and providers. Figure 1 gives the system's architecture and relative components.

Since the Internet has substantial and varied forms of data and services, we hope to be able to achieve a cross-platform mobile information-sharing platform to enable its independent of the different merchants and service providers. We first proposed a Location-based data and service middleware based on SOA, which is mainly responsible for the collection and disposal of different data type and services existing in different network information platform. Based on the pretreated information, this interface module will repackage the heterogeneous data and service, and republic them as web service. The successful design of this module is the key problem for realization of cross-platform service and data sharing.

The functional layer has three components as Multi-Mode Location Information Index, Context-based Collaborative Filtering Algorithm, and Location-based Personalized Recommendation and Navigation. We will discuss every function component in details as follows.

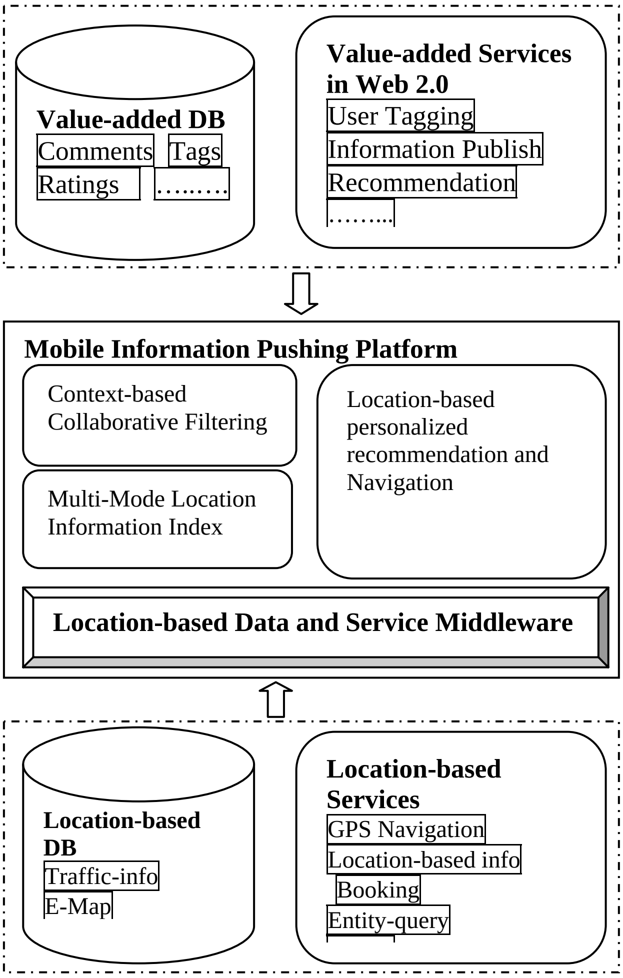

Fig 1. Architecture of the Mobile Information Pushing System

3 Location-based Data and Service Middleware based on SOA

Service-Oriented Architecture (SOA is considered as the next generation of Web services infrastructure. Its central idea is to design software applications from the perspective of integrated services, and to consider how to reuse existing services. SOA encourages the use of alternative technologies and methods (such as message mechanism). It prefers service combination rather than the preparation of new code to the framework of the application.

After an appropriate design and development, the new application based on this kind of message mechanism can be simply by adjusting the original service model rather than be forced to carry out large-scale code development of new applications. Thus it can response quickly in according to the changing market conditions.

So in this system, we implement a special Data and Service Combination service similar with Middleware based on Service-Oriented Architecture. This method can solve the following two technical issues: multiple formats of data integration and conversion, as well as a combination of a wide range of services.

Despite the existing network information service platforms have already accumulated a lot of useful information, as the Public-Rating “Da Zhong Dian Ping” website (the famous and successful public facilities rating, comments and recommendation website, which has already millions of users) [12]. However, its text-based geographical information or static guiding map can not be used directly in the mobile location-based navigation. This is also very inconvenient for users, especially who is not familiar with the visiting area.

In order to solve this problem, we analyze a scenario as restaurant query based current location, and propose the possible query process.

Let us place typical query information as an example. Users want to know the restaurants' location and introduction data within 500 meters from its current location. For the query, users first through the mobile terminal to obtain a coordinate information, According to the coordinates information and then calculate the distance of their current location within 500 meters of the regional information (for example, all the street names in the target area). From the existing network information service platform, it will search all matching restaurant with the same street information.

According to personal preferences, the user continues to review the feedback restaurant list, and select the places he wishes to go. Based on this new query, the system should obtain the coordinate information of the selected restaurant and visualize the corresponding navigation information through the mobile navigation software.

In Figure 2, we abstract the above scenario for the query process of a portfolio of services. The whole scene is composed by a number of Service Components. According to every Service

Component, the user can choose the services as wish.

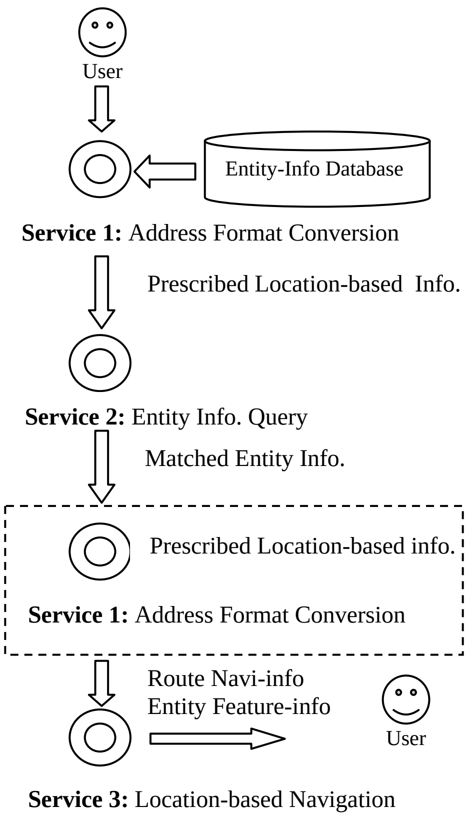

Fig 2. A Query Process Demostration based on SOA

Based on the architecture shown in Figure 2, on the one hand, the system provides users with a highly flexible, so that they can easily enjoy the use of their services.

To take navigation services as an example, according to our current market research, the various mobile phone manufacturers (such as Nokia, Dopod and Motorola, etc.) are ready to develop their own navigation software and integrated into their mobile products. Therefore, this platform is not limited to a particular user's hardware and software platform, but is devoted to enable all the navigation software can be used as a service, by adding an address format conversion services to achieve the structure of these services.

When the users select a destination, according to the in-use software platform (service), our platform can convert the location information into a prescribed format, and then give the call to provide services.

On the other hand, in the data side, our architecture also ensures the biggest compatibility with the existing information service platforms.

Through the address conversion information services, multi-format data information between the address conversions can be very flexible. Users can easily finish the data exchange through coordinate information or textual address information, while neglecting the specific details of implementation. The whole data format exchange and detailed query process is transparent for the users.

4 Multiple Information Retrieval Modes

As well known, the screen of mobile terminal is far less than a laptop, so the content can be displayed in the screen for mobile terminal is much smaller and limited.

Therefore, how to utilize the limited screen display to display the most important and useful information is still a bottleneck problem of a variety of applications based on mobile phone.

In order to solve this problem we found that first step is to define what the useful and important information should be. Different searching scenario may lead to different results. Let us take the restaurant searching as an example.

When the user knows the exactly need, such as an “Ice Cream Shop” in the “Nanjing Road, Shanghai”, he/she normally prefers to simply input the constraint keywords and obtain the information of the target restaurants. So we firstly design the “Fuzzy Constrains Search Mode”.

For the restaurant, it can be described by different attributes shown as follows.

- Location Info: Address, Latitude, Longitude
- Food-Style Info:
- Recommended Meals:
- User Tags:
- Contact Info: Telephone, Fax-number, email
- Rating Info: Environment, Taste, Service
- Consumption per capita:
- Others: Parking-Possibility

We divided these attribute-domains into two categories. One is the “Search constraint-attribute domains” including “Location, Food-Style, Recommended Meals, User Tags, and Contact Info”, which are mostly used when a user input the search constraint keyword. The principle of this search engine is to be transparent for the user. That means, the user can input any keyword belong to these constraint domains separated by a space. The system will recognize the related domain for each keyword and find the matched candidate restaurants based on the constraint keywords.

The other domain category is the “Sort constraint-attribute domains” including “Rating, Consumption per capita, and others". For providing better location-based service, all the feedback candidate restaurants will be sorted by the distance. Furthermore, the user can also resort the candidate restaurants by different attributes belongs to this domain category, for example, resort by the ratings of taste in descending order, resort by the consumption per capita in ascending order, and so on.

However when the user has no idea about what kind of restaurant he/she really wants, he/she may want to browse a e-map with the restaurant information around his current location or a target location. Based on the location distance and other introduction information about the restaurant, the user can quickly find the interesting restaurant. Based on this scenario, we defined the "Location-based Browse Mode". This mode enables the user to browse the restaurants around the target location. Base on the default scenario, when the user chooses this browse mode, the system will shown the restaurants around the users' current location. The user can move the mouse to check the introduction of each restaurant, and also can browse more restaurants by the e-map zoom-out function.

Specially, when a user arrives at a new city, he may want to know the typical or popular food or restaurant in this city. Then it is very hard for him to search based on the searching or browsing mode. Fortunately, the Web2.0 application brought by one of the most important value-added data is the network of User Tagging. The Tagging data can be used not only for more accurate characterization of each resource, but also for user-characteristic similarity discovery which is helpful for achieving more accurate personalization recommend resources.

A tag is a non-hierarchical keyword or term assigned to a piece of information (such as an internet bookmark, digital image, or computer file) [13].

The use of keywords predates the internet and carried over to early websites as a way for publishers to help users find content. In 2003, the social bookmarking website Delicious provided a way for its users to add "tags" to their bookmarks (as a way to help find them later); Delicious also provided browseable aggregated views of the bookmarks of all users featuring a particular tag.[14] Flickr allowed its users to add free-form tags to each of their pictures, constructing flexible and easy metadata that made the pictures highly searchable.[15] The success of Flickr and the influence of Delicious popularized the concept, and other social software websites – such as YouTube [16] – also implemented tagging "Labels" in Gmail are similar to tags.

This kind of metadata helps to describe an item and allows it to be found again by browsing or searching. Tags are chosen informally and personally by the item's creator or by its viewer, depending on the system.

So we proposed a 3D Tag-Cloud based Collaborative Sharing Mode. This mode will show the user what are the most popular and interesting tags of the food or restaurants which are added by other users who already have the experience. By choosing different tags, the user can be guided to the target restaurant and obtain the general introduction information (address, menu, pictures, user comments, etc.), the e-map and route navigation information of the restaurant.

In order to effectively realize Tagging data browsing in mobile phone, we must find a suitable visualization approach.

As well known, the screen of mobile terminal is far less than desktop or laptop computer, so the content can display in the screen for mobile terminal is much smaller and limited.

Therefore, how to utilize the limited screen display to display the most important and useful information is still a bottleneck problem of a variety of applications based on mobile phone.

Tag-cloud is recently widely used in the Web 2.0 sites as a keyword-based visualization method. Each keyword is displayed in the user interface as a tag. And the importance of each tag is shown in accordance with its corresponding font format and color. An example illustration of tag-cloud is shown as Figure 3.

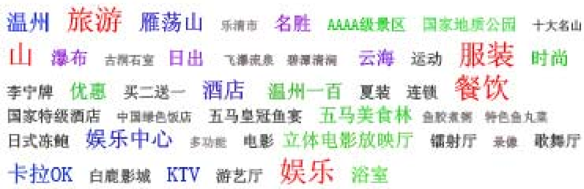

Fig 3. An example illustration of tag-cloud

The biggest advantage of Tag-cloud is that a user can have a general understanding of the entire information in a short period, which can enable the user to choose the interest content more easily.

Especially for the mobile terminal with Touch Panel, the interaction mode based on Tag-cloud is particularly convenient.

However, sometimes the current Tag-cloud visualization approaches are still efficient especially for the problem of redundant tags. Since different users may have different expression of an object, there must be a lot of redundant tags. For example, Such as "Hotel", users may tag it as "hotel", "guesthouse", “apartment”, while in fact they all have the same meaning.

To address this problem, this paper presents a novel three-dimensional Tag-cloud model. As shown in Figure 4, we first propose a SCTC (Semantic and Context based Tag Clustering) algorithm to discover the similarity among tags. All the similar tags will be grouped as a same class which is stored in the lower level. While only one tag will be displayed in the higher Tag-cloud level, which can most exactly represent the meaning of the object (normally it can be selected based on the popularity of the tags).

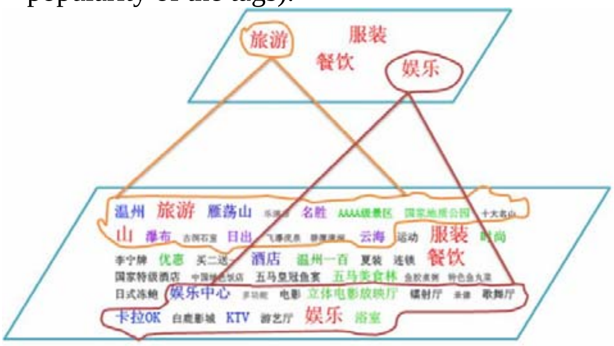

Fig 4. 3-D Tag-Cloud Framework

When a user indicates his interest in specific content by clicking a tag, the screen display will expand its related tags in accordance the corresponding level relationship. In other words, our system can realize the Tag-Cloud Zoom In and Zoom Out functions, which can enable users to facilitate the choice of resources to obtain an overall understanding of certain specific resources or more detailed information.

The user can also add some location constrains as the current location or the exactly address of the target location, which can help the system to return the feature-tag related to the constraint locations and further increase the search accuracy.

5 Context-based Personalized Recommendation

In various Web 2.0 applications, Context-based Personalized Recommendation has a very important position.

With the usage of Web 2.0 applications, the users’ value-added data (tagging, comments, etc.) will continue to grow. Unfortunately the useful data may be not necessarily increase, but bring more trash data. Therefore, for different user query, the system must effectively filter the results to ensure that users only access to those contents which may be of interest to him.

At present, the Information Filtering technologies can be divided mainly into two categories: Content-Based Filtering and Collaborative Filtering.

The Content-based Filtering technology filters information mainly based on the feature of contents. For example, when a user want to search the restaurant providing spicy food, the system will only match those restaurants of their textual "food feature".

Unlike other content-based information-filtering techniques [17-19], the key idea of CF is that a user is likely to prefer items that other users with similar interests. Owing to the different techniques used to describe and calculate the similarities between users, CF algorithms are normally categorized into two general classes [20]: memory-based and model-based algorithms and model-based algorithm. For the memory-based algorithm, it directly calculates the similarities between the active users and other users or the similarities between the active items and other items [21].

This approach usually does not consider the content of information, but other users’ historical rating and tagging information as the mainly filtering condition. This makes the collaborative filtering algorithm to receive better analysis results especially for the information which is difficult to descript and classify based on simple keywords in comparison with the content-based filtering algorithm.

Furthermore, the collaborative filtering algorithm relies on users’ ratings, which makes it much easier to combine users’ preferences and content’ quality to personalized recommendation. Accordingly, we research and propose a novel context-based collaborative filtering algorithm which can enable the personalized recommendation based on users’ application data through the Web2.0 applications (tagging, rating, comments, etc.)

Collaborative filtering algorithm usually takes a user × item-vote matrix as input. Each line is on behalf of a user records, and each row is on behalf of an item. Therefore the matrix of each line is on behalf of the user corresponding to the column corresponding to the item-vote.

Generally, the task of CF is to predict the votes of active users from a user database, which consists of a set of votes $v_{i,j}$ by i users on j items. A memory based

CF algorithm calculates this prediction as a weighted average of the votes of other users on that item using the Equation Item-vote matrix is the basis for collaborative filtering algorithm. According to the matrix, a calculation model of user preferences can be defined as Equation 1:

$$P_{a,j} = \overline{v_a} + \kappa \sum_{i=1}^{N} \varpi(a, j)(v_{i,j} - \overline{v_i}) \tag{1}$$

where $P_{a,j}$ denotes prediction of the vote by active user *a* on item *j*, and *n* is the number of users in the user database. $\overline{v_i}$ is the mean vote by user *i*, defined as Equation 2□

$$\overline{v_i} = \frac{1}{|I_i|} \sum_{j \in I_i} v_{i,j} \tag{2}$$

where I_i is the set of items on which user *i* has voted. The weights *w(a, i)* reflect the similarity between the active user and other users in the database. κ is a normalizing factor used so that the absolute values of the weights sum to unity.

Most memory-based algorithms use Equation 1 to make a prediction and are only distinguished by the ways used to calculate the weights. And the popular calculation approaches, Pearson correlation coefficient and Vector similarity calculation, are defined as Equation 3 and 4:

$$\varpi(a,i) = \frac{\sum_j (v_{a,j} - \overline{v_a})(v_{i,j} - \overline{v_i})}{\sqrt{\sum_j (v_{a,j} - \overline{v_a})^2 \sum_j (v_{i,j} - \overline{v_i})^2}} \tag{3}$$

$$\varpi(a,i) = \sum_j \frac{v_{a,j}}{\sqrt{\sum_{k \in I_a} v_{a,k}^2}} \frac{v_{i,j}}{\sqrt{\sum_{k \in I_i} v_{i,k}^2}} \tag{4}$$

From the Equation 3 and 4 we can see, the existing methods of calculating similarity are based on one-dimensional item-vote vector.

Unfortunately for many applications systems, these methods can not indicate the context of users' resource selection. For example, when users select the restaurant, they need to take into account a variety of factors (including price, taste, environment and location, etc.), these factors can not be a simple one-dimensional item-vote vector. More importantly is that users' choices are constantly changing. For example, for the same user, his may have different needs for business travel and personal travel.

Therefore, in this system we design and implement a Constrainable Multi-Dimensional Collaborative Filtering Model. The detailed algorithm can be found in [22-23].

On the one side, the model allows users to add custom constraint condition as the pre-condition of the algorithm. For example, such as price priority, environment priorities, or various factors consideration by setting different weights.

On the other hand, the model improves the user similarity calculation model and enables it to deal with multi-dimensional user vote data, which can describe and calculate the similarity between users more accurately.

6 A dynamic restaurant mobile search system

Cooperating with some restaurants, we developed a dynamic restaurant mobile location-based recommendation and discount counpons pushing system. Based on our dynamic location-based resturant recommendation and navigation services, the user can easily find the resturant in a certain range of current location as shown in Figure 8.

Fig. 5. Restaurant Location-based Browse and Navigation

Especially, through this application platform, users can not only receive the static description of the restaurants which are suitable for their own tastes (such as size, styles, features, environment, etc.), but also can see the dynamic synergy of the community users tag information (such as ratings, comments, recommend dishes, etc.) as shown in Figure 6.

- The stars beside a restaurant name show the general ratings from other users.
- The number as “100m” shows the distance between user’s current location and the target restaurant.
- The number after the “C.C.” means the consumption per capita which is also an important condition when a user makes the decision to choose the restaurant.
- The golden coin logo here illustrates if the restaurant has promotion activity and enables the user to download the coupons into the mobile phone.

Fig. 6. Information of Candidate Restaurants

A "mobile discount coupons" is also provided in this system, which can be directly used by showing it to the restaurant after the dinner as shown in Figure 7.

On the one hand, the use of mobile coupons can help us to know users’ acceptance of our recommendations. On the other hand, through our collaborative filtering and personalized recommendation algorithms, our system can effectively improve the accuracy of recommendation which may satisfy the users and then effectively improve the acceptance of mobile coupons. The application data shows our system can enhance the acceptance and usage of mobile coupons which do benefit the users and companies simultaneously.

Fig. 7. Restaurant Coupons

In order to increase the accuracy of our algorithm, we also provide the mobile rating and commenting interface as shown in Figure 8. The evaluation data can help other user obtain the newest collaborative data from other users, and also can help us to change the recommendation mechanism and increase the restaurant recommendation accuracy.

Fig.8. Mobile Rating and Commenting

7 Conclusion

In this paper, we propose a novel mobile information pushing platform based on GPS and Web2.0 applications. Through this platform, users can easily obtain not only the Location-based Service based on the GPS, but also personalized recommendations.

First of all, we take use of the concept of Web Service technologies, and implement a location-based data and service middleware based on SOA. This interface module can repackage the heterogeneous data and service, and republic them as web service, which can enable the cross-platform application of our platform.

Considering different service requirements, this paper firstly proposes the Fuzzy Constraint Keywords based Searching Mode and Location-based E-Map Browsing Mode, which can enable the user to find the useful entity information easily.

Furthermore, this paper introduces the latest Web2.0 application technologies into our mobile information retrieval system. And it proposes a novel dynamic 3-D Tag-Cloud collaborative sharing mode which can provide users with dynamic recommendation information based on the collaborative value-added data. It also allows users to quickly find their interests even in the limited mobile phone screen.

Finally, we design a collaborative filtering and recommendation algorithm based on other users' comments and tags information, which can provide more precise recommendation.

References:

[1] Koeppel, I. What are location services? From a GIS Perspective, ESRI white paper.2000.

[2] Shiode, N., Li, C., Batty, M., Longley, P., & Maguire, D. The impact and penetration of location-based services. In H. A. Karimi & A. Hammad (Eds.), Telegeoinformatics: location-based computing and services, 2004, pp. 349–366, CRC Press.

[3] Jiang, B., Yao, X. B. Location-based services and GIS in perspective. Computers, Environment and Urban Systems,Vol.30, No.6, 2006, pp. 712-725.

[4] Kaasinen, E. User needs for location-aware mobile services. Personal and Ubiquitous Computing, Vol. 7, 2006, pp.70–79.

[5] Csinger, A. Users models for intent-based authoring. Dissertation, The University of British Columbia, 1995.

[6] Karimi, H. A. Telegeoinformatics: Current trends and future direction. In H. A. Karimi & A. Hammad (Eds.), Telegeoinformatics: location-based computing and services, 2004, CRC Press.

[7] Li, C. User preferences, information transactions and location-based services: A study of urban pedestrian way finding. Computers, Environment and Urban Systems, Vol.30, No. 6, 2004, pp.726–740.

[8] Ashbrook, D., & Starner, T. Using GPS to learn significant locations and predict movement across multiple users. Personal and Ubiquitous Computing, Vol.7, 2003, pp. 275–286.

[9] Fan Yang, Bernd Kraemer, Zhimei Wang, An Novel E-Learner Community Construction Algorithm in Point View of Learning Interests, WSEAS Transactions on Computers, Vol.5, No. 12, 2006, pp.3097-3103.

[10] Zhi-mei Wang, Ling-Ning Li, Enable collaborative learning: an improved e-learning social network exploiting approach, Proceedings of the 6th Conference on WSEAS International Conference on Applied Computer Science, Vol.6, 2007, pp.311-314.

[11] Fan Yang, Bernd Kraemer, Zhimei Wang, Peng Han, An Improved E-learner Community Construction Algorithm Based on Learning

Interest Feature Vectors, 6th WSEAS International Conference on APPLIED INFORMATICS AND COMMUNICATIONS (AIC'06), Crete Island, Greece, 2006, pp. 254-259.
[12] Public-Rating “Da Zhong Dian Ping” website http://www.dianping.com
[13] Definition for Tags from wikipedia “http://en.wikipedia.org/wiki/Tag_(metadata)#cite_note-0”
[14] Del.ici.us website, “http://del.ici.us”
[15] Flickr website, “http://www.flickr.com”
[16] Youtube website, “http://www.youtube.com”
[17] Yuki Kadoya, Masao Fuketa, Elsayed Atlam, Kazuhiro Morita, Shinkaku Kashiji, and Jun ichi Aoe. An efficient e-mail filtering using time priority measurement. Information Sciences, Vol. 166, No.1-4, 2004, pp.213–229.
[18] Bo-Yeong Kang, Dae-Won Kim, and Sang-Jo Lee. Exploiting concept clusters for content-based information retrieval. Information Sciences, Vol.170, No.2-4, 2005, pp. 443–462.
[19] D.R. Tauritz, J.N. Kok, and I.G. Sprinkhuizen-Kuyper. Adaptive information filtering using evolutionary computation. Information Sciences, Vol.122, No.2-4, 2000, pp.121–140.
[20] John S. Breese, David Heckerman, and Karl Kadie. Empirical analysis of predictive algorithms for collaborative filtering. In Proceedings of 14th Conference on Uncertainty in Artificial Intelligence, 1998, pp.43–52.
[21] Greg Linden, Brent Smith, and Jeremy York. Amazon.com recommendations item-to-item collaborative filtering. IEEE Internet Computing, Vol. 7, No.1, 2003, pp.76–80.
[22] Zhimei Wang, Peng Han, Fan Yang, E-Learner Community Exploiting Based on Collaboration Filtering, Proceedings of the 6th WSEAS International Conference on Applied Informatics and Communications, Elounda, Greece, 2006, pp.250-253.
[23] Bo Xie, Peng Han, Fan Yang, Ruimin Shen, Hua-Jun Zeng, Zheng Chen: DCFLA: A distributed collaborative-filtering neighbor-locating algorithm. Information Science, Vol.177, No.6, 2007, pp.1349-1363.