Mobile Location-based Information Pushing System

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Abstract: - 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.

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].

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

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[4-5]. 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[6-7].

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.

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.

Sincer 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-transparancy.

Considering the limited display screen of mobile terminals, we also propose a novel 3-dimentional Tag-Cloud model to filter the redundant tags and simlify 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 an Mobile Resturant 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 sharin. For the location-based data, we will primarily obtain from the existing network information service platforms and providers. Figure 1 gives the system's architeture 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 baded 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.

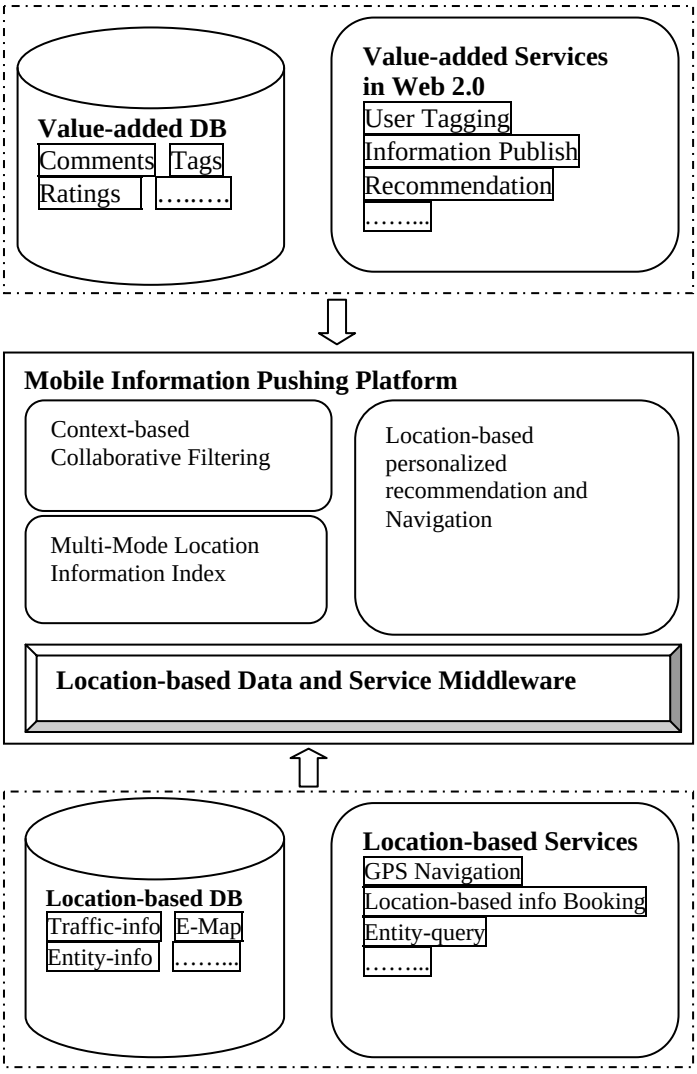

Fig 1. Architeture of the Mobile Information Pushing System

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) [9]. 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

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 Multi-Mode Location Information Index

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.

If we can effectively combine the Tagging information with Location-based Query, then we can enable the user to view other more sophisticated description made by other users, which can finally help him to find more suitable resources.

Searching and browsing are the most commonly used two types of user information retrieval approach. And the Searching mode is suitable for more precise retrieval needs (such as the exactly address of a ice cream shop). While the Browsing mode is more suitable for fuzzy query (such as arround the current location, which restuarant can be reached). Compared with desktop and laptop computers, mobile terminals have obvious deficiencies for the text input. Therefore, we research primarily based on the Browsing mode in the design of our system.

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. 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).

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 Out function, which can enable users to facilitate the choice of resources to obtain an overall understanding of certain specific resources or more detailed information.

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".

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 a 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, which was first proposed by Resnick et al. [17], 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:

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

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

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

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.

And the Pearson correlation coefficient and Vector similarity calculation are defined as Equation 3:

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

Furthermore, 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 [8].

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

Based on our platform, we cooperate with some restuarants to develop develop 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.

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.). Furthermore, we also provide a "mobile discount coupons" which can be directly used when the users show it to the restuarant.

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.

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.

Furthermore, based on the Web2.0 technologies such as User Tag-Cloud, we propose a novel dynamic 3-D Tag-Cloud model and visualization methods. It 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 as quickly as we can. The successful application of the dynamic restaurant mobile search system based on our platform do show the efficiency of our idea.

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