A Location-Aware System Prototype for Touring in Campus

Yi-Min Chiang[1] and Jung-Hong Hong[2]
[1]Graduate Student, Intelligent Geographic Information System Lab (IGIS Lab),
Department of Geomatics, National Cheng Kung University
No.1, University Road, Tainan City 701, Taiwan; TEL: +886-6-2757575
E-mail: cs94276@gmail.com

[2]Associate Professor, Intelligent Geographic Information System Lab (IGIS Lab),
Department of Geomatics, National Cheng Kung University
No.1, University Road, Tainan City 701, Taiwan; TEL: +886-6-2757575
E-mail: junghong@mail.ncku.edu.tw

KEY WORDS: GIS; LBS; Location aware service

ABSTRACT: With rapid growth of mobile devices and wireless internet technology, current LBS-based applications can effectively use information dynamically collected from the internet. While most applications are based on “pull” service, where the required information are retrieved from remote servers upon users’ requests, the technology of Location Aware Service (LAS) instead uses “push” service to automatically feed customized information to users according to their status. The “push service” offers an obvious advantage for service providers to actively reach possible clients and offer their services. To avoid annoying or even garbage information, the service must be intelligent enough to automatically select contents that best fit users’ needs from the abundant available data. A LAS prototype system for touring in campus was proposed and discussed in this paper. Developed on the Android platform, this system is designed to be able to select and offer customized information to users according to such constraints as location, tasks, time, etc. As users move in the campus, customized information is automatically sent to users’ mobile devices for further reference. Especially for users who are not familiar with the operations of mobile devices, LAS-based applications appear to be a better approach as far as the time and efforts of training is concerned.

1. INTRODUCTION

The rapid growth of mobile devices and wireless internet technology has revolutionized the way people communicate with each other. Users nowadays can surf the internet for desired information whenever and wherever they want. With the development of Web API and social network, it also becomes much easier to “publish” information to the internet and share information with others. The progress of GPS technology enables the acquisition of location information. By submitting their locations, users can easily retrieve information about nearby point of interests via on-line systems, e.g., Google Map and Bing Map. Especially after GPS chips become a built-in component of mobile devices, the services that change their service content according to users’ location, well-known as Location Based Services (LBS), quickly becomes a hot topic in the internet-based business. Typical LBS widely available to the general public nowadays include weather, car navigation, dining suggestion, etc. Dependent on the applications, the definitions of LBS may vary from one field to another. A general definition can be found in (Virrantaus, 2001), who defined LBS as “*information services accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the mobile device.*” From a GIS perspective, Koeppel (2000) defined LBS as “*any service or application that extends spatial information processing, or GIS capabilities, to end users via the Internet or wireless network*”. Regardless if the term “GIS” is included in the definition, the operations of LBS are mainly based on the interacting relationship between users’ location and the available service content. GIS technology can thus contribute to the successful development of LBS.

The development of LBS is based on three types of technology: GIS/spatial database, internet and mobile devices (Brimicombe, 2002). The success of GIS in the past decades has accumulated a huge volume of geospatial data that can be readily used in LBS applications. With internet technology, users can access data located at remote servers. This advantage enables the possibility to acquire update-to-date information and reduce the storage and management loading for clients. It is, however, not until the success of mobile devices that the dream of ubiquitous service finally comes true. With its easier portability, the restriction of desktop GIS is removed and users can take their portable GIS to anywhere they like. As long as users can access to wireless internet, information can be dynamically retrieved upon requests. Even if internet connection is not available, users can still download data to mobile devices beforehand for off-line operations. The successful integration of these three types of technology has given a strong boost to the recent development of LBS.

There have been two major approaches about how information is communicated between clients and servers in LBS applications: "pull service" and "push service" (Steiniger, 2007). Except the static reference maps that are automatically updated according to users' location, most current LBS applications are based on "pull" service, where the required information is retrieved from remote servers upon users' requests. Location Aware Service (LAS), on the other hand, uses "push" service to automatically feed information to users according to their status. The greatest challenge for push services is to develop a mechanism that can intelligently select information useful to users and avoid useless and even garbage information. In addition to the consideration of "location", such decisions may need to further consider factors like time, users' profile, speed, condition, the property of landmarks and facilities, etc. The developed database must be able to offer all the required data and the server itself must be intelligent enough to automatically select data that best meets users' application demands. With a LAS-based system, providers can actively reach possible clients and offer their customized services. If the content can be carefully designed to precisely meet users' needs in a convenient way, the business potential the LBS technology can bring is absolutely remarkable. The remaining of the paper is organized as follows: section 2 introduces the system architecture of the LAS prototype system, section 3 discusses how database and selection knowledge is developed, section 4 demonstrates some tests of our developed system. Finally, section 5 concludes our major finding and suggests directions for future research.

2. SYSTEM ARCHITECTURE

Figure 1 depicts the basic architecture of a LAS-based application. The system architecture must include a data selection module that can automatically determine the service content according to the collected information of users and environment. We subdivide the following discussion into three major parts: client, web server and database.

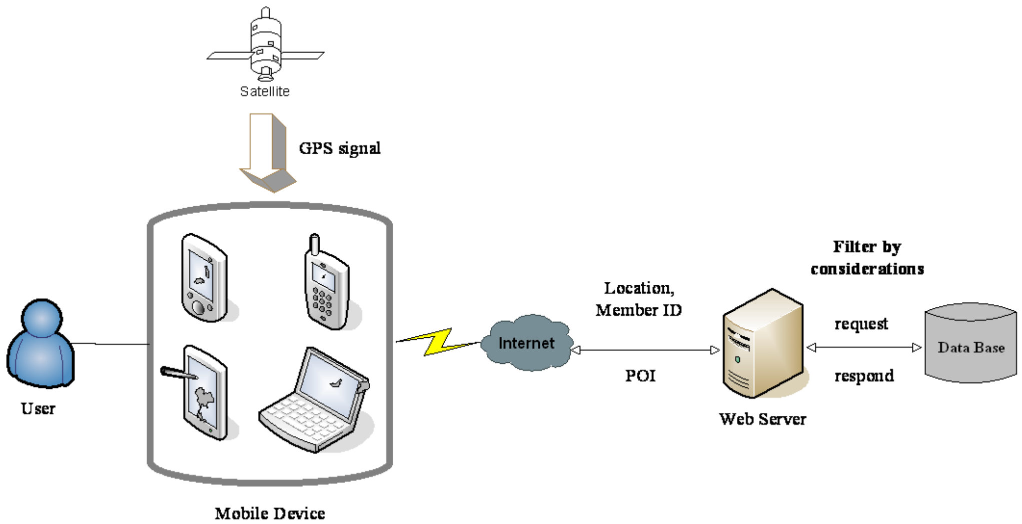


Figure 1: The System Architecture

(1) Client

Users' mobile devices, e.g. smart phone, PDA, tablet pc, PAD, must be equipped with a GPS receiver that can receive GPS signal and determine the coordinates of users' location (latitude and longitude). We select Android as the developed platform for our prototype system because its SDK provides necessary tools and libraries for developing applications on the mobile devices. The developed application programs access to Google map via its API and use the returned content as the reference map for users' decision reference. Whenever a new location of users is updated, the application programs automatically submit the coordinate to servers and wait for servers to select information about facilities or events in his or her neighborhood. The system will also use users' location as the center of the displayed map on mobile devices. The customized information from the database is transferred in JSON (JavaScript Object Notation) format from servers to the clients. After parsing their location information, the selected facilities or events are superimposed onto the reference map with pre-defined map symbols.

(2) Web Server

To meet the demands of concurrent connections from multiple clients, a web server based on http protocol is developed. We choose Apache Tomcat as our web server and develop the application program with JSP (Java Server Page) framework. The web server receives information of coordinates and ID from clients by URL parameters via wireless network, then exploits JDBC (Java Database Connectivity, a Java API that enables Java programs to execute SQL statements) driver to send SQL statement to the database. Finally, the application program on mobile devices retrieves the customized information from web page by calling the returned URL.

(3) Database
The required themes of data and their schema design are totally dependent on the applications chosen. The service content is dynamically selected from database according to users' status and tasks. The collected data in this research is stored in the PostGIS database. Based on users' status, filtering constraints are formulated in PostgreSQL. Although all data so far is stored in a single database, the fast development of service technology will further enrich the data content a LAS can offer in the future.

3. THE DEVELOPMENT OF LOCATION-AWARE SERVICE

The distinguished characteristics of LAS are its nature of continuously "tracking" users' status and automatically "pushing" customized information to users. To reduce the complexity in the following discussion, we will restrict the scope to the application of touring in campus only.

3.1 Considerations

(1) Location
Users' location information is a necessary component in any LAS-based applications. As mentioned earlier, the coordinate of users' location is by default the center of the displayed map on mobile devices. As users move, the center of the map extent must change accordingly with their new location. A series of consecutively collected locations can be used to determine the average speed of users, which serves as the basis for automatically adjusting the spatial extent of the map interface. A slow speed, e.g., strolling in the campus, shall automatically trigger the function to reduce the spatial extent being displayed in the map interface. Furthermore, users' speed may also affect the theme of data being selected. For example, if the speed of users reaches 40 km/hr, it is reasonable to assume that users are driving cars and information like parking lot or gas stations should be provided. On the other hand, if the speed is lower than 4km/hr, the supplied information should change to facilities for rest or further include small-size tourist attractions. The geometric representation and positional accuracy may be crucial in some applications. For example, a landmark with a large spatial coverage is better represented as a surface object to ensure that it would be visible in the displayed map even if only one part of it intersects with the spatial extent of the map.

(2) Time
Time is also a necessary factor for LAS because both users' actions (e.g., looking for restaurants for lunch) and service content (e.g., restaurants are only open during particular periods of time) may change with time. To intelligently determine the service content, all data with temporal characteristics must include carefully designed temporal attributes in its schema. For example, the information about when a particular facility is open to the public must be included in the application of campus touring. The comparison of the current time and the recorded temporal information determines whether a particular facility or an event is provided to users or not. Three types of data selection scenario are summarized below:

Data always displayed: This category of data denotes information that is always presented to users regardless of the temporal condition, e.g., public toilet, convenient store, ATM, etc. For a given task, these selected datasets are regarded as useful information to users all the time. It serves as the default service content for the designed applications.

Data periodically displayed: This category of data denotes information that is presented to users only during certain periods of time following fixed schedule, e.g., some buildings are only open to general public during 8:00 a.m. and 5:00 p.m. in weekdays. Typical examples include office, café, library, indoor exhibition hall, etc. Some types of data may have more than one period of time available in a day, e.g., some restaurants are open in lunch and dinner time.

Data displayed under specific conditions: This category of data denotes information that is presented to users only during a specified period of time, e.g., outdoor activities, speech, arts performing. This type of data must have a clearly specified time period about when it begins and ends.

(3) Users' profile:
In addition to users' location, the availability of users' personal information is also an important factor for LAS to generate customized service content. Users' profile must include at least one identification attribute for servers to uniquely identify an individual user. Other attributes are subdivided into general information (e.g., gender and age) and application-dependent attributes (e.g., hobby, consumer preference and specific interests). If users are willing to

share more information, e.g., the tracking of their location in everyday life, credit card bills, etc., more accurate predictions can be made with data mining technique. To avoid the issue of privacy invasion, this type of data collection method must be operated on either voluntary or agreement basis.

(4) Users' task:
Despite that users profile may act as a general reference to understand users' preference, users' task at hands may have more influence on the final selection of data. For example, the task of campus touring requires data about sites of attraction, restaurant, toilet, ATM, facilities for rest, etc. On the other hand, the task of doing business with the school may require data about individual buildings and departments. Depending on users' applications, the required data may be totally different from one task to another. This implies a mechanism that records the corresponding relationship between the types of facilities and tasks is necessary. Data can be thus selected to precisely meet users' customized demands. As the data selection process is task-dependent, all of the available tasks must be designed beforehand and prompted to users for selection at the beginning of the LAS operation.

3.2 Database Design and Selection constraints

As the research is still in the preliminary stage now, only a few selected datasets have been created at the moment. More datasets will be added in the future.

(1) Facilities:
All facilities within the test area are recorded in the same table, whose schema consists of attributes of ID, name, class, location, and tour information. From a semantic viewpoint, the class of facilities is designed to categorize facilities according to their common property, e.g., restaurants, exhibition facilities, etc.

(2) Time
The temporal information of individual facilities is recorded in another table. For any unique combination of facility ID and individual period of time, a single record is created. For example, the facility #16 is a Chinese restaurant that is open at two different periods of time, so two records will be created for this restaurant. This design allows the application to determine what restaurants are currently open. The selected results can be later joined with the facility data by common facility ID to obtain detailed information about the facilities (Figure 2).

Facility_ID	Name	Location	Class
5	小東門段城垣	Point(120.2183 22.9987)	Historic spot
16	牛伯麵店	Point(120.2155 22.9956)	Chinese restaurant

Landmark table

ID [PK]	Start_time	End_time	Facility_ID
1	11:30:00	14:00:00	16
2	17:00:00	21:00:00	16
3	08:00:00	18:00:00	5

Display time table

Figure 2: Landmark data and its corresponding temporal information.

(3) Users' profile
Users profile is created on the basis of individual member, meaning every registered member has his or her own profile. All of the users' profiles will be recorded in a single table. At this stage, users profile only includes the following attributes: member id, account, name and age. More attributes will be added in later research.

(4) Users' task

As the data being selected is dependent on the task, it is necessary to record the corresponding relationship between the tasks and data themes. A single record in this table represents a corresponding relationship between an individual data theme and an individual task. This design enables the establishment of 1:N corresponding relationship between these two types of data. The data themes that corresponded to a particular task can be thus easily obtained by querying this table. This table is designed to serves as the basis for quickly filtering pre-determined data themes for a particular task.

According to users' status and the knowledge for generating customized information, different types of selection rules are formulated. Location constraints are of course a mandatory function in any LAS applications. As mentioned earlier, the location determined by GPS is used to control the displayed spatial extent of the map interface on the mobile devices. For every selected data themes, only features located within the specified buffer distance from users' current location or spatial extent of the displayed map are selected and sent to the mobile device. As far as the selected data theme is concerned, the selected themes are totally dependent on the chosen task. By combining these two types of constraints, the developed system successfully selects users' preferred class of facilities located in his or her neighborhood. By further adding the consideration of temporal constraints, the service content may be further refined. For example, to acquire the name of the facilities that are currently open, the query is specified as follows:

Select facilities.name
From facilities_time, facilities
Where current_time >facitlities_time.start_time and current_time< facilities_time.end_time
and facilities_time.facilities_ID=facilities.facilities_ID

It is clear that the more information about a user is available, the more accurate the customized information may be. By unambiguously specifying the task users have interests, the application system intelligently determines what users want to do and what type of information should be provided. This surely requires the combination of different types of constraints to generate more precise requests. For example, the suggested sites of attraction for elder and young tourists may be different. A TV idol drama was shot in NCKU several years ago, young tourists of TV fans may find it interesting to visit the sites where the famous scenes were taken. On the other hand, elder tourists may have no interests whatsoever because they are not interested in such types of TV drama. In this scenario, the age, hobby, time and location of users shall have influence on the service content.

4. TESTS OF PROTOTYPE SYSTEM

A Location-Aware Service prototype system is developed following the system architecture in Figure 1. Developed on Android platform, the software at the mobile device can read coordinates determined by GPS and automatically send the coordinate to remote service, the server automatically responds with customized information. After users login and specify their tasks, rules for selecting data are triggered according to users' location, time and task. In the following examples, the developed prototype system was tested in several scenarios of campus touring. Figure 3(a) shows the startup map interface for the developed application. After users' login, the system automatically sends users' location to the servers and adjust the displayed map according to users' location. The reference map image is obtained via Google Map API. To improve the operating efficiency, Google Map uses cache map technique by sending only the required map tiles to mobile devices. The web server responds with a UML containing the customized information for programs on mobile devices to connect. Figure 3(b) illustrates the results after adding the test data of facilities in this research. This demonstrates the outcomes by superimposing data from different resources onto the reference map. By doing so, a LAS can take full advantages of different kinds of service available in the internet and use them as an abundant information source to enrich its service content.

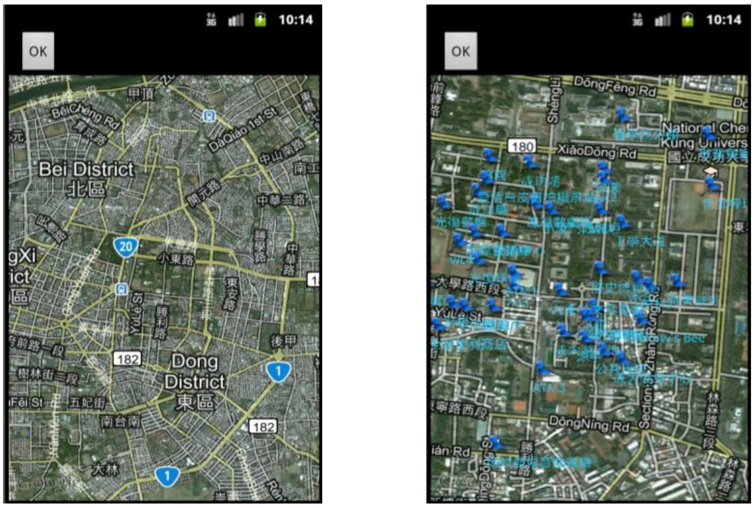
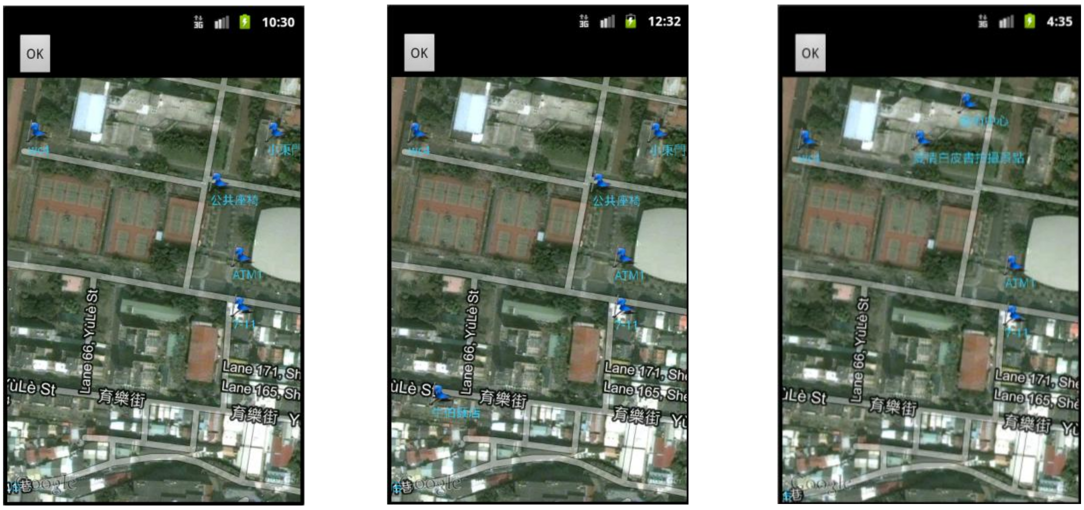


Figure 3 (a) The startup map interface; (b) the map interface after adding landmark data.

The following test involves two types of users: elder tourists and young tourists. Figure 4 (a) shows the displayed map for an elder tourist strolling in the campus at 10:30 a.m. In addition to the data themes that will be displayed all the time, e.g., ATM, public toilet, convenient store, the system further selects data of public seats and historic attractions based on the age information acquired from users' profile. Figure 4(b) shows the displayed map when the time is 12:32 p.m. The information about restaurants has been automatically added into the displayed map for users to select because it is within the specified lunch time. If users' profile further includes information about the style of food or restaurant he or she likes, it is possible to further refine the type of restaurants displayed in the maps. Figure 4(c) shows the displayed map for a young tourist at 4:35 p.m. The information about performance center and shooting sites for TV idol drama is added. The information of restaurant and public seats, however, is no longer displayed on the map. Although we are still in the very preliminary stage for developing a LAS and the variety of data and types of selection knowledge are still very limited at the moment, the progress so far has demonstrated that the development of a LAS that can dynamically adjust the service content according to users' status is feasible.



(a) **(b)** **(c)**

Figure 4 (a)Displayed map for elder tourist in the morning; (b)Displayed map for elder tourist in the lunch time; (c)Displayed map for young tourist in the afternoon.

5. Conclusion

In this paper, we extensively discuss the factors that must be considered during the design of LAS-based applications. To facilitate such a push-service, the information and knowledge about location, time, users' profile and users' task must be included in the developed mechanism. The developed prototype system successfully demonstrates the capability of dynamically changing map content according to users' status. As customized information is intelligently selected form the database and automatically sent to users' mobile devices, the loading of users' training can be largely reduced. Users are surely welcome useful information that can guide them for making better decisions, especially when they are in an unfamiliar environment. Unlike pull services, push services heavily rely on the continuously tracking of users' status and a variety of knowledge that can adapt to users' task needs. As this would require formalization of data selection knowledge, data mining is a very useful tool for expanding the required knowledge for LAS-based applications. From our viewpoint, an ideal LAS application should not only let providers to reach possible clients and offer their services, but also provide information that precisely meets users' demand in a simple and straightforward way.

References:

Brimicombe, A. J., 2002. GIS - Where are the frontiers now?. In: Proceedings GIS 2002., Bahrain, 33-45. Koeppel, I., 2000. What are Location Services? - From a GIS Perspective. Tech. rep., Sun Microsystems.

Steiniger, S., Neun, M. & Edwardes A., 2007. Foundations of Location Based Services, Lesson 1, CartouCHe – Lecture Notes on LBS, V. 1.0.

Virrantaus, K., Markkula, J., Garmash, A., Terziyan, Y.V., 2001. Developing GIS-Supported Location-Based Services. In: Proc. of WGIS'2001 – First International Workshop on Web Geographical Information Systems., Kyoto, Japan. , 423–432.