A Simple System Providing Location-Based Service on Urban Area

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Abstract: - This paper proposes a simple location-based service which can be used to learn places people visit in their everyday lives. Unlike the similar services provided by mobile operators which typically use trilateration calculation to derive location from multiple based stations, our proposal relies on a location server to store the location information of subscribed users. Therefore, it can be easily implemented and maintained without the involvement of mobile network operators.

Key-Words: - location-based service, GSM localization, mobile positioning, mobile network, communication systems

1 Introduction

Location-based Services (LBSs) are information services accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the mobile device, as defined in [1]. In other words, the position of a mobile terminal can be exploited in various kinds of applications.

There are two main approaches of implementing LBS, device positioning and network positioning approaches, as illustrated in Fig. 1. In the device-based approach, the most common solution is based on Global Positioning System (GPS). The GPS-enabled device sends signal to three of more satellites to calculate its current location. The major advantage of using GPS is the wide coverage of satellites that allows users to access the service any place in the world. Another advantage is that users do not need to pay any company for accessing the service (they just need to buy a GPS-enabled device). However, this service performs not so well in urban area because skyscrapers block the line of sight to satellite and cause inaccuracy results [2].

Network-positioning approach requires the network to provide the location of a mobile device. The most common solution is based on GSM mobile network [3]. Since a mobile device is receiving signal from more than one mobile base stations, based on the strength of the signals, the location of the device can be identified. This identification process relies on the trilateration or multilateration calculation, a mathematical method. Since mobile stations are widely installed in urban area, this kind of service using network-positioning approach is more effective than that using device-positioning approach.

However, the trilateration calculation requires parameters such as Round-Trip Time (RTT) and Timing Advances (TA) to complete. As only mobile operators have the privilege to obtain those parameters, it makes others hardly provides this kind service.

In summary, the location service using network-positioning approach provides better performance in urban area. However, the common solution based on the signal strength from base stations requires complex trilateration calculation. In this paper, a simple system providing location-based service is proposed. Since the proposed solution does not rely on the signal strength from base station, this service can be implemented and launched without the cooperation of mobile operations. The proposal mainly requires a server (called location server) connected to the Internet. It makes the implementation and deployment much simpler. However, these advantages scarify the location precision. That is, the proposed solution provides approximation location of a mobile device. The precision is not as better as the solutions based on the signal strength from base stations.

As a matter of fact that, in our daily life, there are many applications that only require approximate location. Our proposed solution can be used to track whereabouts of the users' children, elderly, or the people they concern with. For example, when one's son has finished school for a long time but has not arrived home yet, he/she could use this system to learn his current location, or even the full path he has traveled within the whole day.

The following of this paper is organized as follows: section 2 discusses about the design and components of our proposal. Section 3 presents our prototype. Section 4 shows how the prototype achieves the design. Section 5 discusses potential privacy concerns of the proposed system.

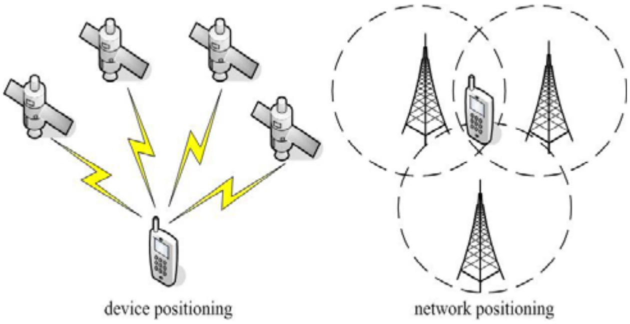

Fig. 1 topical examples of device positioning method and network positioning method of LBS.

2 Design and operations

Location-based service requires known and non-repeating positions to identify where the Mobile User locates. Since each mobile base station have a unique cell ID and each mobile device has to associate to one base station, cell ID can be used to identify the location of mobile devices.

Fig. 2 shows the components of our proposed system. The operation mainly relies on the location server to store the current locations of mobile devices. Since it is not required to access the system parameters used in the mobile base stations, it makes the implementation easy.

In this paper, we assume that all mobile base stations being discussed are GSM radio stations. The communication method between mobile users and the server is in GPRS.

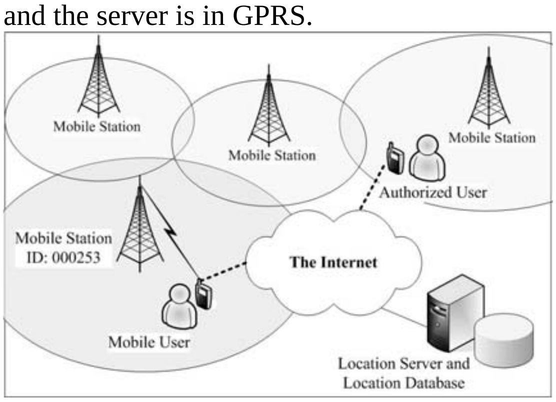

Fig. 2 Components of the proposed system

2.1 System overview

Fig. 2 shows that the system architecture which includes *mobile base station*, *mobile users*, *authorized mobile user*, *location server*, and *location database*. Their roles are described as follows:

Mobile Base Station

Each of the mobile Base Station has a unique ID for mobile base station controller on managerial purposes, is good for PTS to obtain the approximated current location of Mobile User.

Location Server

It coordinates with numerous of Mobile Users and Authorized Users, which is the backbone of PTS.

Location Database

It is a database storing location where Mobile User has traveled. Location details from the mapping of cell IDs are also provided.

Mobile User

The user being observed from the specific Authorized User, reports its location periodically.

Authorized User

The observing user having the privilege to know where the specific Mobile User locates.

2.2 System Components

This section discusses the functions of implemented components.

2.2.1 Location Database

The location database consists of three tables: the table Location storing location mappings between cell IDs and their related zone description, which helps to return comprehensive location to Authorized User.

The table Record recording the cell ID where Mobile User has traveled. A timestamp is added to each record while receiving a cell ID from a specific Mobile User since the function of Real-time Positioning and Path Tracing requires timestamps to determine which record(s) should return to Authorized User.

The table AlertWL consists of legal locations where Mobile Users can travel. The content of those areas are arranged by Authorized User.

2.2.2 Location Server
This server consists of three processes.

Location Recording Process: tt receives cell ID from Mobile Users and stores them into the table Records.

Location Reporting Process: it describes where the specific Mobile User has traveled within a specific interval.

Zone Alerting Process: it requires Location Server to alert Authorized User when Mobile User has traveled a location out of the expected locations, stored by a table AlertWL. If the location returned by Mobile User is not found in the white list, Location Server immediately alerts Authorized User by SMS. Before this function can be used, Authorized User has to input a set of locations as white list.

2.2.3 Mobile User
The application stores in mobile devices of Mobile Users. The function of Position reporting notifies Location Server where Mobile Users locates by periodically requests the closest mobile base station for cell ID and returns it to Location Server

2.2.4 Authorized User
The application stores in mobile device of Authorized User. Two functions are provided for an Authorized User to know location details of the specific Mobile User:

Real time positioning can be used to obtain the most recent record of the specific Mobile User from Location Server.

Path tracing obtaining a set of most updated location records of the specific Mobile User and plots the full path showing where the Mobile User has traveled within current period of time.

2.3 System Operations
There are three main functions PTS provides, which are Current location reporting, Path tracing, and Zone Alerting. This section discusses the components discussed in section 2.1 and 2.2 cooperate in order to provide the mentioned functions.

All the processes discuss within this section are assumed that Mobile User has already installed the application and being activated and Authorized User has installed the application in the mean time. Both users have registered at the Location Database so that the server receives locations send by Mobile User and reply requests from Authorized User monitoring the specific Mobile User with ID 151 and report its cell ID at every two minutes.

2.3.1 Current Location Reporting
Fig 3 is the flow diagram showing how the Mobile User report the cell ID to Location Server and how the Location Server reply Authorized User. When the Mobile User reports it location to Location Server, firstly it requests mobile base station to obtain the cell ID. Then, Mobile User forwards it to Location Server by the simple message ID 151 CELL 00253. The server then inserts a new record in table Record of Location with Mobile User ID 151 as well as the timestamp. This process keeps on reporting cell IDs until Mobile User terminate the application.

When Location Server receives the request from Authorized User with only the keyword REQUEST, the server then regards Authorized User desire to use Real time positioning and returns the most recent location of Mobile User to Authorized User. The represent method of location depends on the Authorized User. For text base, server directly sends the description of the location; for graphical base, server then sends the exact position where the Mobile User has located.

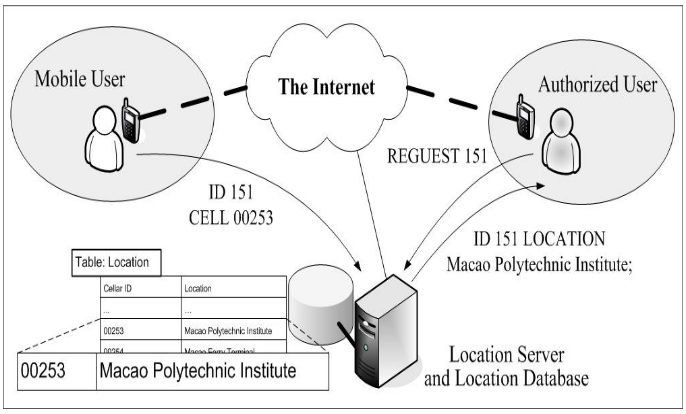

Fig. 3. Operation flow of position reporting and real-time positioning

2.3.2 Path Tracing
The keyword REGUEST has another function: if Location Server receives the request from Authorized User with timestamp parameter following ID and the keyword REGUEST. That represents that the Authorizer User is desired to use the function of Path tracing.

For Path tracing, as shown in Fig. 4, Location Server search through all possible records from the table Record and reply them to Authorized User.

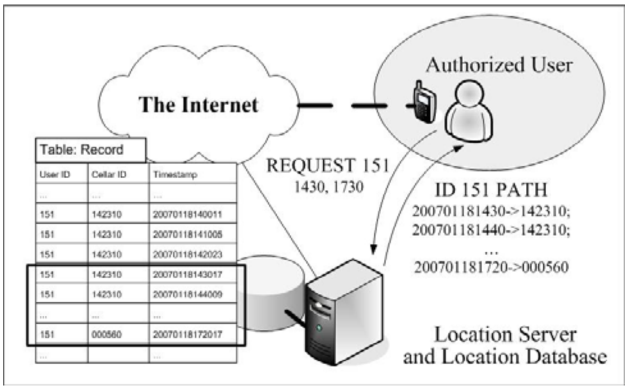

Fig. 4. Operation flows of path tracing.

2.3.3 Zone Alerting

There is also one push service provided by Location Server, Zone alerting by using the table AlertWL, which is pre-set by Authorized User.

As Fig 5 has shown, the server searches table AlertWL once any Mobile User sends a cell ID to it. If the ID is not found within the table, Location Server immediately sends an alert message to the specific Authorized User to notify it the accepted Mobile User is at an illegal location.

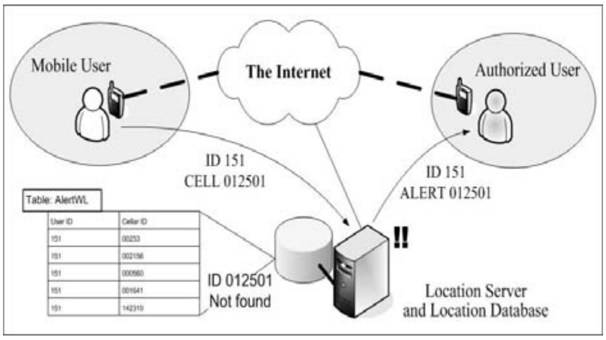

Fig. 5 flows of Zone alerting

3 Prototype

The system prototype is implemented by Python [4]. The reason of using Python is the manipulate GSM messages on mobile device by Python is simple and easy. The other reason is Python can construct a graphical user interface on mobile device within a shorter period of time. The whole prototype contains of three .py files: LServer.py, MU.py and AU.py. Location Server runs LServer.py to accept request from clients. Through the use of mxODBC module, LServer.py can links to the database Location.mdb. Mobile Users run the client application MU.py in their mobile devices, and Authorized Users run AU.py in their mobile devices. See Fig. 6 for system design which includes the user interface of the application running in mobile phones.

Before the service to be ready, the location mappings of Location Database have to be prepared. The step of preparation is using a smart phone with a simple application travel around the city to record down the cell IDs. This can be done by the use of the mobile Python method of getCellID() to request mobile base stations for it and return through the screen. After the linkages between each cell ID and its location coverage have been stored in the Location Database, the Location Server is ready to accept both request from Mobile Users and Authorized Users.

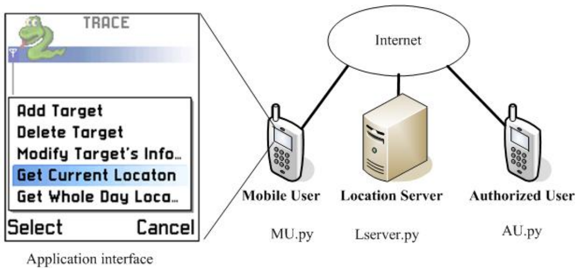

Fig. 6. Implemented system showing the application user interface.

Fig. 7 the demonstration of path sketching function of from the source obtained by Path tracing.

In this prototype, two Mobile Users and an Authorized User have been participated for testing and demonstration by two weeks, from 9 am to 5 pm. Both Mobile Users report their location at every two minutes throughout the test. Authorized user requests for Real-time positioning and Path tracing trice a day with the fixed time set at 11 am, 2pm, and 5pm. Although the prototype during the test is text only, a graphical based user interface can be implemented, it depends on application. The example is show in Fig. 7 which shows the result of path tracing of where Mobile User has traveled from 14:30 to 17:30 by graphical base method.

4 Discussions

4.1 Privacy and Protection

In order to introduce PTS to the public, several security considerations are required. The concept of secrecy and availability of the system have been added, a number of protections have been added into the system.

Device password protection:
Authorized User requires passing the authentication phase before opening the Tracking Application. The file storing Mobile User list also has been protected by password.

Access right protection:
Only Authorized User is allowed to configure the setting of PTS on specific Location Application such as the time interval returning the location Mobile User, altering the content of the white list for zone alerting service and changing administration password.

Private channel protection:
Authorized User cannot obtain any information without the acceptance from Mobile User. Whenever any Mobile User accepts the request from Authorized User, it updates Tracking Application at to let the Authorized User getting location details of the Mobile User at any time. Moreover, Tracking Application shows all usernames as well as mobile numbers of the accepted Mobile Users so that Authorized User can use the function of people positioning or people tackling at any time.

4.2 Deployment Issues

The deployment of PTS is very simple and straight forward. For the server part, it mainly requires a Location Server and Location Database storing the mapping between meaning location description and mobile base station ID. The content of mapping details can be done by using a handheld device with a simple coding application to get cell IDs from mobile base stations without any help of operator.

Since almost all handheld development platforms are supporting both the methods of getting cell ID and Internet socket communications, which helps the deployment of client-side application on Authorized Users become very simple.

Unfortunately, there is a special consideration needed on Mobile Users application, since they have to report their location at specific interval, which is required to work as daemon process in order not to affect their daily user-habits on handheld devices.

As a result the Mobile User application can only be run on devices supporting daemon processes such as Nokia Symbian 60 Series OS smartphones, Motorola embedded- Linux phones, or Microsoft Mobile OS handheld devices.

4.3 Traffic Charge

The processes of testing and demonstrating the prototype discusses in Section 3 took for two weeks. Each day the Mobile User works for eight hours and report its position to Location Server by GPRS at every two minutes. In the mean time, Authorized User sends requests of both Real-time location reporting and Path tracing for testing, which be done trice a day.

The connection charge of GPRS in Macau is MOP 0.06 [9000] (around USD 0.009) for each kilobyte. The average message size of report from Mobile User is 80bytes. The Mobile User sends 30 messages to Location Server each hour. For an eight-hour testing message cost for Mobile throughout one day is:
Message Size = 0.08 * 30 * 8 = 19.2 (KB)
Message Cost = 0.06 * 19.2 = 1.152 (MOP/day)
which implies that the accumulated Mobile User Message Cost for 2 weeks is MOP 23.04, which is around USD 2.88 for 2 weeks.

Since Authorized Users involving data uploading and downloading, their average message size for the day, which includes sending requests and receiving responds, is around 6KB. The total cost for Authorized Users is:
Total Cost = 6 * 0.06 * 20 = 7.2 (MOP/2 weeks)

The result shows that the total cost for the Authorized User during the testing and demonstration period is MOP 7.2, which is less than a dollar in US.

4.4 Co-existing with multilateration positioning scheme

The advantages of PTS are its simplicity and implementation independence. However, the trade off is users only get the loose location (it depends on the coverage of a base station) of the target user. For example, in our school, it can be identify by five cell IDs. That is, we only know the target is in one of the five areas of our school. The goal of this solution is not to replace the Multilateration positioning, but provide an alternative system for the location based applications requiring loose location. In other word, our application is not to identify the exact location of the target, but to find out which area the target is located at. For example, to check whether one's child in his/her school (a area) during school time.

5 Conclusion

This paper proposed a simple system providing location-based service. It is easy to implement and require low operation overhead. The identification of locations is based on the cell ID of mobile base stations. We have implemented our prototype using Python and proved the feasibility of our system. We also discuss the issues of privacy, deployment, and operating cost of the proposed system.

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