Personnel Surveillance Through Mobile Phone Tracking

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Abstract

Mobile penetration in India has reached 74% with a subscriber base of 898.02 million mobile phone subscribers as of December 2013. In India, as in most other developing countries, nearly all teenagers and working-age adults carry a mobile phone. When these phones communicate with the network they reveal their location to be within the coverage area of the base station antenna that received their transmission. This location data, if it were collected, could be used to derive movement information for most of the population. Such information does not currently. Location tracking is one of the killer applications available on the mobile devices. In this paper, various location tracking techniques are compared on the basis of how difficult it is to extract location information, how frequently it is generated, and the spatial accuracy when it is used to locate a mobile handset. A new model of an indoor location tracking system has been proposed that uses the existing on campus Wi-Fi infrastructure and signal strength to determine a user's location. The model presented is cost effective; it does not require any additional hardware resources and is transparent to GSM operators in the country.

Keywords

Location Tracking, GPS, LBS, GIS, WiFi

I. Introduction

The last few years have witnessed a phenomenal growth in the wireless industry, both in terms of mobile technology and its subscribers. The number of telephone subscribers in India increased from 886 million in December 2014 according to the latest figures from the Telecom Regulatory Authority of India (TRAI), which revealed that mobile penetration reached 74% [1]. Most of mobile phone users in India are using this powerful electronic gadget for voice and Short Message Service (SMS) communication only. According to a survey half of users in their thirties access web from their mobile devices [2]. Moreover, India is following the worldwide phenomenon in using the mobile devices. Besides ubiquitous access, it is useful for getting connected to world wide information through internet and for entertainment applications. There are much powerful applications available in mobile devices that are sparingly used.

In this paper, we have proposed another model of an indoor location tracking system that uses the existing on campus Wi-Fi (Wireless Fidelity) infrastructure and signal strength to determine a user's location. The model presented is cost effective; it does not require any additional hardware resources and is transparent to GSM operator in the country. The proposed solution uses WiFi enabled mobile phones and access point in addition to web server equipped with a GSM modem. It reports to subscribers the most recent location of user as well as history of someone's previous locations within specified time window.

II. Evaluation Criteria

This section provides an overview of techniques used to track population movements. Each will be described in brief detail and evaluated using a number of criteria.

A. Spatial Accuracy

When a subject's position is measured, how closely does it match their true latitude, longitude and altitude. This is expressed as an error term, in meters.

B. Temporal Accuracy

This is a measure of the accuracy of the time stamp associated with each position measurement. Sometimes the time is known exactly, but sometimes it's approximate, which can impact the accuracy of velocity calculations.

C. Numeric Accuracy

How accurately does the technique record the number of people when taking a sample? For example, techniques that monitor vehicle movements may not generate accurate numbers of people, or a mobile phone may not always correspond to an individual.

D. Area Range

Are there limitations on the areas where this technique can be used? For example, are the subject's positions recorded at fixed points (e.g. as they pass a sensor), or can they be recorded at arbitrary locations (e.g. via GPS)? And if the points are fixed, how extensive is their coverage?

E. Sampling Rate

How often are measurements obtained? Is it periodic, on-demand, or vary with the subject's movements?

F. Demographic Info/Privacy

How much additional demographic information can be attached to the spatial and temporal measurements? Can the subjects opt in to provide more information?

G. Cost

How much does it cost to implement this technique? How does the cost scale with the number of subjects and the number of sample locations (if using fixed locations)?

H. Population Coverage

What proportion of the subjects in a region will be measured by this technique? If the proportion is small, is there any selection bias in the subjects who are recorded, and if so, does it affect the results?

III. Existing Techniques

There are many techniques for tracking the movements of a population. A number of them are described here in detail, and are evaluated against the criteria defined in this section.

A. Identifying Fixed Sensors

To compile journey information identifying fixed sensors can be used, which record a unique identifier for each subject that passes by them. Examples of these types of sensors include toll road scanners such as Melbourne CityLink's e-Tag system (Holmes 2000), public transport smart card tickets (Zhao et al. 2007), and

license plate cameras (Castilloa et al. 2008). Toll roads sensors usually either scan a license plate number (which can be linked to the vehicle's owner via a vehicle registration database) or query a transponder such as an e-Tag, which will be linked to an account in the owner's name, usually containing a billing address, credit card details, or a bank account number. This ability to link a unique identifier to an individual means that a lot of additional demographic information is theoretically available.

But, their spatial, temporal, and numerical accuracy are usually excellent, while their spatial coverage is restricted and there is little control over the rate at which samples are collected.

B. GPS Tracking Devices

Another way to collect journey information is for the subjects to carry tracking devices. These devices can either transmit their location in real time or store it in memory for later retrieval. Most devices use the Global Positioning System (GPS) to obtain their spatial coordinates, which is accurate to a few meters and works on most of the earth's surface (McNamara 2008). GPS does, however, require line-of-sight access to four satellites simultaneously, so it is often unable to determine its location while indoors or surrounded by solid obstacles. Also, because of the way GPS satellites broadcast their location data, it can take up to 30 seconds to obtain an initial reading.

GPS devices broadly fall into three categories – dedicated navigation devices, dedicated tracking devices, and programmable devices. The most common example of a navigation device is an in-car GPS unit, which guides drivers to their destination movements and the number of occupants is not recorded. Dedicated tracking devices usually combine a GPS receiver with some kind of transmitter, and are attached to an object of interest (Kucharson, 2006). On a periodic basis they transmit their location to a central computer. The most common programmable GPS devices are mobile "smart" phones with built-in GPS receivers, for example the Apple iPhone. Because of their ability to run applications, they can be programmed to periodically takes GPS readings and either store them locally or upload them to a central computer (Miluzzo et al. 2008). And since these devices tend to be carried by their owners anyway, their movements can be recorded at little or no additional cost. From the owner's perspective, the main drawbacks are the time and effort needed to install the software, the additional drain on the handset's battery due to continual use of the GPS receiver, and possibly higher data charges caused by the uploading of the location data to a central computer. However, the main factor limiting population coverage for all types of GPS devices is likely to be difficulty of convincing subjects to allow their locations to be recorded.

C. Active Querying of Handsets

Because cell activity measurements only count handsets that are on a call or sending/receiving an SMS, attempts at tracking populations will be biased by frequent users. This can be overcome by the active querying of individual handsets, where the location of a handset can be polled as needed. Querying the location of a handset will at least retrieve its current cell ID, but a number of more sophisticated techniques are described in Raja et al. (2004) that can return more accurate locations. Many of these require handsets that co-operate with the network in non-standard ways, but some can be implemented with normal handsets and upgraded network infrastructure.

Another technique that can be used with standard handsets is called Angle of Arrival (AOA). If a cell is equipped with a directional antenna it can calculate the direction from which a handset's signal arrives. This information, when combined with a distance estimate derived from the round trip delay, can locate the handset to within a small arc. In practice however, this technique relies on having a line-of-sight connection between the handset and antenna, because reflected signals will provide incorrect angles (Raja et al. 2004). Since line-of-sight cannot be guaranteed in most environments, this technique is rarely used.

However, the main problem with active querying is that generates extra traffic on a mobile phone network above and beyond that used for normal operations. It should also be pointed out that active querying also drains the batteries of handsets slightly faster than normal, since they have to communicate with the network more often.

The use of active querying to calculate population numbers also faces the problem that it is necessary to know the identity of every handset that might be in the area in order to query it.

D. Passive Querying of Handsets

Finally, it should be possible to track the location of handsets on a mobile phone network with passive scanning. This involves recording details of the time, handset ID, and cell ID sent when a handset communicates with the network as part of normal operations from billing data. These messages, known as signalling data, are a superset of billing data, and by passively scanning all of them it should be possible to track the location of every handset on the network at a greater frequency than with billing data. Passive scanning would be accurate to the nearest cell ID, could track journeys, and would work wherever there is mobile phone coverage. The sampling rate would depend on handset usage, but would at least be as frequent as the network's requested periodic update rate.

IV. Objectives

The objective of this paper is to track location in indoor environments. The system uses the information built in a typical mobile such as its IMEI (International Mobile Equipment Identity), IMSI (International Mobile Subscriber Identity) and the various Wi-Fi Access Points (AP) in campus to pinpoint the users' position. A communication program installed on the web server communicates with GSM modem to provide users real time data related to a person's movement and location.

V. Methodology

The operational steps of the proposed system on the server and client side can be categorized into 5 modes as follows:

1. Server Configuration Mode: Initially, a database with the MAC addresses of the various WiFi access points (APs) on the campus is developed. Each AP is associated with a physical location description on the campus, e.g. 2nd Floor North block, as well as a graphical image of the location. The physical
2. Description of the location will be sent via SMS to the mobile that issued the request to locate an individual, whereas the graphical display of the location will be projected to the web system users.
3. Client Configuration Mode: The client installs the application on his/her mobile phone and configures the web server's IP address, the GSM Number and the Refreshment Rate about which the application will be sending data.
4. Registration Mode: The application prompts the user to enter his/her name, gender, nickname, id, age, etc, and then retrieves

MAC address of the mobile phone. Following that, it generates information that is sent to the AP specified in the configuration Mode. On the server side, the info is received by the AP after login and broken into segments, which identifies the user with his personal and mobile details and this information is stored in the server database. The mobile phone number is retrieved from the AP, which is set by the telecommunication company, to validate the user's identity. At this point, the user is registered and detailed information is retrieved to locate him/her. An additional feature of the system is that it allows users to create a public or private profile. The default public profile allows the user's location to be identified to any system user that issues a request to locate. The private profile on the other hand, allows only a set of preselected users to view the location. These selected users are specified during registration time using their usernames or mobile phone numbers.

Fig. 1: System Architecture

5. Running Mode: The inbuilt programs running on the mobiles of all the system users, periodically sends the MAC address of each mobile phone to the specified server via the WiFi access point it is connected to. The mobile phone MAC address is enough to identify the user. The server validates the 3 parameters by comparing it against the information stored in the database during the registration phase. The MAC address of the APs are used to accurately locate the user as will be explained in the next section.

6. Location Mode: The application also retrieves and sends the MAC addresses of all APs within the mobile phone coverage range, with their corresponding signal strengths .The user can locate a person either via an SMS request or online using the web. The looked-up person's identity can be specified using his/her username, name, or mobile phone number. Upon receiving the request, the server first checks if the looked-up person's profile is valid. It then checks if the looked-up person has a public or private profile.

To identify the user's location, the MAC addresses of the AP in the vicinity of the user with their corresponding signal strengths, are retrieved by the search algorithm from the database. In our current implementation, the search algorithm simply associates the looked-up person with the AP with the strongest signal strength. The pre-stored physical location of this AP is then looked up and sent to the requester as either an SMS text message or a visual plot displayed on a webpage.

VI. Conclusion

A long way in a remarkably short time has been achieved in the history of wireless mobile communication. There has been a clear shift from fixed to mobile cellular telephony, especially since the turn of the century and India is one of the world's fastest growing and biggest mobile phone markets. A Mobile Device has numerous applications but there are much powerful applications available in mobile devices that are sparingly used. In this paper, we have proposed a model of an indoor location tracking system that uses the existing on campus Wi-Fi infrastructure and signal strength to determine a user's location. The model presented is cost effective; it does not require any additional hardware resources and maintains the transparency as required by GSM operators in India.

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