Usefulness of cell level mobile traffic information to identify mobile station movements

B.K.U.R. Nawaratne, J.L.P.R. Perera, K.D.C. Perera, W.P.R.M. Perera, W. Walpola *and* S. Perera.
University of Moratuwa

Introduction

Mobile services and applications are being replaced with new location-aware applications and services. Although mobile commerce enables access to services and applications regardless of the location of user, in many situations the specific location of the user is highly important. Map applications, weather applications, tracking applications, commerce applications heavily use geo-location information to improve user experience. Use of GPS data has been the trend for location based services; nevertheless, this has been a huge over-head on users in battery life. GPS location information requires special hardware support in the handset, which is not available on many mobile devices. These limitations made us think about less costly location information through GSM networks. There is a trade-off between location accuracy and cost of the location information.In this paper, we attempt to provide a realistic assessment on use of the mobile cell level information for identifying location and the movement of a mobile device. It will elaborate on our dataset used for experiments; advantages of using the GSM based location information, challenges in using GSM cell level data for location and movement prediction, and possibilities with more accurate GSM level information.

Methodology

GSM Location information can be categorized into five levels with increasing accuracy from 1 to 5.The Sri Lankan mobile service providers mostly use pull services that request the required user data only when necessary. Thus, it is only able to retrieve the level 1 (Cell ID) and level 2 (Cell is divided into three directions and will give the users location using one of the three directions with the cell ID) data in the current situation.The format of the level 2 data set we received from our service provider is as follows:

A Data line is formatted as IMSI number, date, time and CGI.

IMSI:The International Mobile Subscriber Identity is used to identify the user of a cellular network and is a unique identification associated with all cellular networks. In the dataset, it is anonymized by hashing the IMSI due to privacy concerns.

CGI:Cell Global Identity is a standard identifier for mobile phones cells. It geographically connects mobile phones. If a cell phone is connected to a GSM network then the position of that particular cell phone can be determined using CGI of the cell, which is covering that cell phone. For the following analysis and evaluation, we have used the above dataset.

Results and Discussion

1. Advantages of GSM Data

Gathering GSM data is not difficult as it is readily available with the subscriber. Control of manipulating or intercepting the GSM data is difficult as it is collected by the service provider.Hence, likelihood of occurring errors with the data is at a minimum level. Compared to other methods such as GPS tracking, GSM is less expensive and does not need any specialized hardware on the receiver end. To gather GPS data we need a user base with our application installed in their mobile device. GSM location information is useful when we need a larger user base initially because it takes a large time to gather sufficient user base with our application

installed. Though the accuracy is low, since the quantity is large there are number of applicable models to predict movements from the dataset. [1]

2. Challenges

2.1. Location update frequency

Location updates for a given user can happen in many various ways [2]. Updates can occur with constant time intervals, when user crosses a cell boundary, when user makes a call or any other data transition. In our dataset, location update frequency was highly unreliable and low as it updates location only when user involves in a call or transmits data. Even when the user crosses the cell boundary, Mobile Switching Centers (MSC) are not notified (it is kept in Base Station Controller (BSC) level and not notifies to MSC level to save bandwidth).

User movement prediction gets mainly affected by the low update frequency (Effect on location prediction is much lesser). Due to the location update policy of the network, most of the users only have one location update record, which is not useful in movement prediction. Even when we have more than one location update, it is extremely hard to predict the speed and direction of the movement.

2.2. Location Accuracy

Location accuracy plays a major role in predicting location as well as predicting movement [3]. We have accuracy up to cell level. Cell size can change depending on several factors. Urban areas tend to have large number of small cells and rural areas tend to have small number of large cells. The sample region we considered, mainly constructed with Micro-cells with 100m-300m radius. Cell radius tends to change with the traffic levels of each cell. Increase in the traffic level of a cell results in automatically handing over the farthest users (from cell tower) to the nearest low traffic cell.

Each cell is divided into 3 parts with 120 angles, this improve the accuracy towards 1/3 of the area of the cell. Taking the map of cell towers and the possible regions, we can further increase the location accuracy. Low accuracy is the main challenge in all applications of cell level location information.

2.3. Cell Change due to Cell Traffic Levels

Even the cellular user is static, not moving, it cannot be guaranteed that the base station it is connected is the same for the entire period. Cellular tower cells can only accommodate a finite amount of cellular traffic. The more traffic is generated; the cell should take actions to keep up its accommodating limit, without breaking down its operation. One of the methods used to keep up the limit is to make forcible handoffs of the cellular devices. Thus, the cellular device will be connected with the next closest cell with low traffic. Therefore, even the cellular device is static; it will shift its connection from cell to cell.

2.4. Difference of using 2G and 3G Cell Sites

2G and 3G Technologies are mainly used by the cellular. Thus, there are both 2G and 3G cell sites available. There are some devices which we can set 3G only mode. In that case, the device will connect to the nearest 3G cell site, though its nearest site is a different 2G cell site.

This will create challenges in identifying the cell locations. Furthermore, if we are taking the count of mobile users in a particular cell site, this will give false counts, due to count of cellular users that are not in the geographical cell area.

3. Alternative technologies

Currently, the industrial norm for location tracking uses the cell ID to track cellular devices [4]. However, the precision is not as expected, as this prediction is not always being able to locate the location to within a few meters. Other methods such as GPS, AGPS are trends in the location tracking since the smartphone usage high. Other approaches such as TOA (Time of arrival), AOA (Angle of arrival) can be used to increase the accuracy of the location in parallel to the methods suggested above.

Conclusions

As a conclusion with the experiments we did with the dataset (cell level location information), it seems that cell level location information has very few user cases where we do not need accurate location information. As an example for an application that suggest nearby food stores, cell level accuracy is adequate. Nevertheless, for an application that tries to predict the speed of the moving device, cell level accuracy is not enough. It is best to use GSM location information whenever application constrains permits.

References

Anthony, S., Marca, L., 2005. Place lab: Device positioning using radio beacons in the wild. Pervasive Computing, 116-133.

Bhattacharya, A., Sajal ,K., Sanjoy, D., Sena, K., 1999. A selective location update strategy for PCS users. ACM/Baltzer J. Wireless Networks, 5, 313--326.

Vitaletti, A., Trevisani, E., 2004. Cell-ID location technique, limits and benefits: an experimental study, in IEEE Workshop on Mobile Computing Systems and Applications, 2004.