

## **CHAPTER 3      LBS FOR TRACKING**

### **3.1 INTRODUCTION**

In this chapter we provide an overview of GSM digital cellular network as to introduce a network based solution to the vehicle tracking problem. We will discuss about operations and functionalities of the location based service (LBS) which was built on top of the GSM digital cellular network. In this chapter we will also discuss that, how it can be utilized in tracking applications.

### **3.2 GSM DIGITAL NETWORK**

The GSM mobile telephone system contains a location management component that keeps track of subscriber's locations. The primary purpose of the location management function is to help with the setup of mobile-terminating calls [Mouly and Pautet 1992]. The wider category of mobility management also includes authentication and security functions [La Porta et. al.]. The cellular network is subdivided into location areas consisting of several cells each. Each cell can have a radius between 300 meters and 25 kilometers. On the network level, location information is the address of a particular location area. To find out the exact location of a mobile unit the entire location area must be paged. Each location area has a Visitor Location Register (VLR) that contains copies of the profiles of all mobile subscribers currently registered in the location area. Typically, the VLR is co-located with a Mobile services Switching Center (MSC), and both MSC and VLR cover the same location area. Additionally, each GSM network has a logically centralized subscription database, the Home Location Register (HLR). The HLR stores the network address of the most recently used VLR for each subscriber. Location updates are necessary whenever the mobile unit enters a new location area (e.g. moves between location areas or powers up). The mobile unit listens for beacon signals of nearby cells. The best cell is chosen according to a well-defined metric. The mobile then tries to send an update message to indicate its new location. This update message is sent from the mobile unit to the MSC, which updates the VLR and HLR. The HLR informs subsequently the previous VLR to cancel the registration there. For reliability reasons, there is also a periodic update procedure, which is controlled by the operator. The location update procedure also includes authentication of the mobile unit and transfer of subscription data from the HLR to the new VLR. Location information is

only accessible to the network operator via the signaling network (typically Signaling System No. 7 – SS7) [Mouly and Pautet 1992].

### **3.3 NETWORK BASED TECHNOLOGY**

Location finding techniques are of various kinds with each technique implying impacts on requirements like accuracy, coverage, location determination, speed and ultimately, cost for the operator. Location finding techniques can be broadly divided into;

1. Network based techniques, use of smart devices at fixed locations.
2. GPS based techniques.

Network based positioning relies on various means of triangulation of the signals from cell sites serving a mobile phone. It uses various parameters and techniques to determine the location such as:

- Cell of Originating (CoO) Cell-Id
- Timing Advance (TA)
- Network Monument Result (NMR)
- Time of Arrival (TOA)
- Angle of Arrival (AOA)

The main advantage of using network based techniques is that one uses existing GSM cellular towers and base stations, therefore there are relatively low costs involved in using this existing technology. Currently, the GSM digital cellular networks have penetrated main cities to a wider extent in all over the country. Therefore, vehicle tracking system within the country could use these existing network-based infrastructures.

This cell based tracking is done making use of the cellular concept of the GSM network. When a mobile handset is switched on, it gets attached to the GSM mobile network if the network coverage is available. Normally, that handset gets signals from one serving cell and a couple of neighbor cells (theoretically six neighbour cells) that

are sited nearby. The serving cell is the primary one that, the base station connects with mobile handset. Neighbour cells are the base stations that the handset can measure. In GSM, theoretically a hand set can measure six neighboring cells while it is being attached to a one serving cell.

In cell based tracking, it only uses the serving cell to determine the location the mobile. The locations that get returned are the serving cell locations. There are no estimated locations between cells. Therefore the accuracy of positioning is almost around cell radius. But in cell based tracking with NMR it relies on serving cell and available neighbor cells information. Therefore the location can be estimated based on the NMR where it gives information of six neighbors. Therefore the accuracy of positioning is less than cell radius, which is more accurate. This is 25 % improvement of Cell ID based. This is referred to as *Enhanced Cell Global Title (ECGT)*.

### **3.4 LOCATION BASED SERVICE ARCHITECTURE**

The platform called *Location Based Service (LBS)* is used to get the current X (latitude) and Y (longitude) coordinates of tracking vehicles. This platform is built up on top of the GSM. The SIM Toolkit (STK) provides the means of positioning the mobile device. Positioning data may be as approximate as cell of origin (CoO), or more precise through additional data such as timing advance (TA) and Network Measurement Result (NMR). The STK allows for communication between the SIM and a location server (via SMS), which has the algorithms for calculating the position. The relative simplicity and platform independence of the solution allows for the rapid development and deployment of “location aware” and tracking services. Some of the chief advantages of this system are given below;

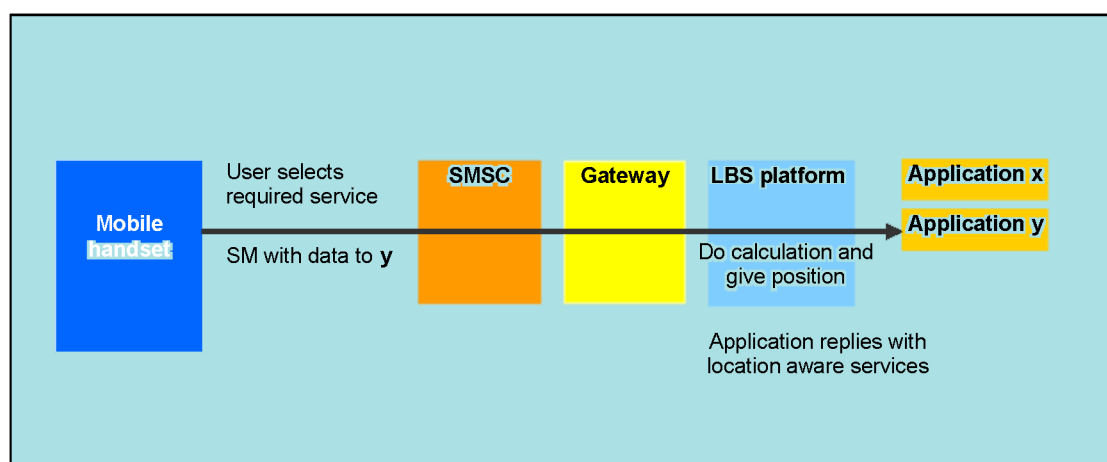
- Only requires Phase 2+ compatible phone.
- Does not require costly Network-based PDE or Handset-based PDE (Position Determination Equipment).
- Does not require interfacing with SS7 and or queries to the HLR to calculate position.
- Simple, with almost zero deployment time.
- Will work when phone is in idle state.

The system can be used in two different ways. The main difference lies in how the message is originated; however the positioning algorithm also differs slightly between the two requests. Those two functions are;

- *Mobile Originated requests*
- *Server Originated requests*

### 3.4.1 MOBILE ORIGINATED REQUEST

In this instance the mobile user navigates via a menu in the phone to the desired service. Once the user selects the service, a message containing location data is sent back to the server. The location data will include local information and may include network measurement result (NMR), channel list and timing advance (TA) if available. The server then decodes the information and predicts the position of the handset. Once the position is approximated the requested service is identified and the closest available services can be returned. This system can be called as “location aware” information on demand. Mobile originated request denotes in figure 3-1 below.



**Figure 3-1: Mobile originated request.**

### 3.4.2 SERVER ORIGINATED REQUEST

The server initiates a request by sending an envelope to the handset. The SIM then processes the envelope by replying with the accessible location data. Once the server has received the reply, the information will be decoded as in the previous method except for the fact that timing advance will be considered. This system operates without user interaction and is used primarily for fleet tracking applications. The server originated request denotes in figure 3-2 below.

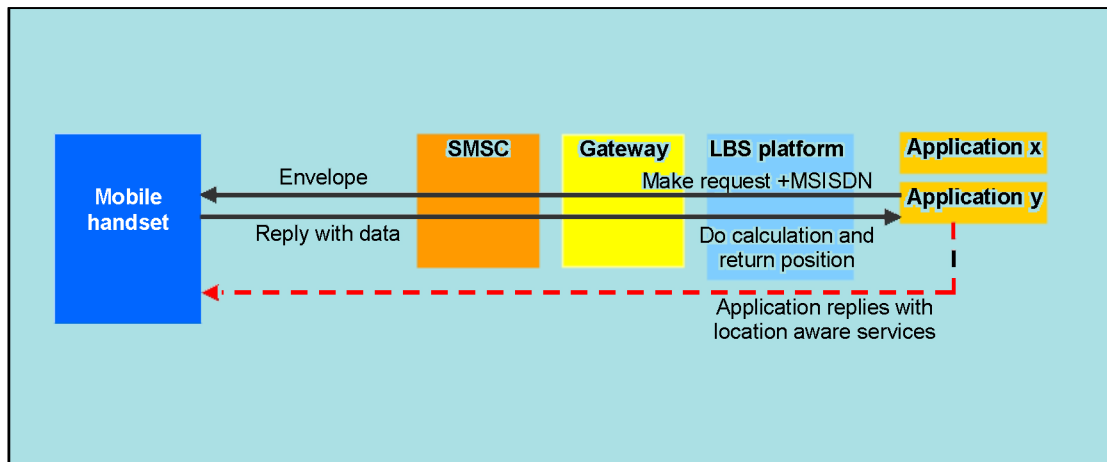


Figure 3-2: Server originated request.

### 3.4.3 POSITIONING AND ACCURACY OF LBS

Base stations and their details are maintained in a virtual grid within the location server. All position and error calculations are based on this grid. The SIM contains the application that is required to gather the information required for positioning from the phone. The calculations can be modified to suite the topology of the GSM network under consideration.

Accuracy ranges between 200m where the base station density is high (cities), to about 10km in rural areas where there may be only one base station serving a very wide area. Accuracy also depends on the data received. Additional data such as NMR allows for the narrowing down of a handset's position by reducing the approximation error. The system has been extensively tested throughout the GSM Network of Dialog Telekom Limited.

The recommended interface into the system is via HTTP. Such as posting a URL with the MSISDN and reading the data that returned. The request returns with the handset position (latitude and longitude) and error. More direct methods such as sockets and named pipes can also be accommodated for data transmission.

### **3.5 SUMMARY**

In this chapter we discussed about GSM digital cellular network as to introduce a network based solution to the problem. We discussed about the architecture of the location based service (LBS) and its mode of functions including “Mobile originated request” and “Server originated request”. The next chapter will discuss about the approach to the problem. In that chapter it will also evaluate the location based system in order to provide an alternative tracking solution in terms of low cost and decent accuracy. We will also try to identify required hardware and software components in the proposed vehicle tracking platform.