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Location Tracking of Mobile Station using Visited Location Register

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Abstract

Mobility is part of everyday life. Most beneficial aspect of wireless networks is mobility management. A mobile user can move around the network and remain connected from anywhere of the network. The goal of mobility is that, "The user should be able to access the subscribed services anywhere (location independent), anytime (time independent), and on one single device (device independent)" (1). Location management is the one of the components of mobility management. The first stage of location management is location registration or location update. In this stage, the mobile terminal notifies network periodically about its access point and allows the network to authenticate the user and also to revise the user's profile. This paper provides location tracking of Mobile System (MS) using Visited Location Register (VLR).

Key words : HLR, VLR, BSC, BSS, BTS, MSC, MSISDN, IMSI, TMSI

1. INTRODUCTION

Currently various wireless technologies and networks are existing for satisfying different needs and requirements of mobile users. In terms of their capabilities and suitability for different applications, the different wireless networks act as complementary to each other. Integration of these networks will enable the mobile users to be always connected to the best available access network depending on their requirements (2). The size of cells must be reduced to accommodate more subscribers and to make more efficient use of the limited frequency spectrum allocation. One of the fundamental issues in cellular networks is Location Management which deals how to track subscribers on the move. In this paper, I explain the method of location tracking of mobile station using HLR in cellular networks.

2. CELLULAR NETWORKS

Communication between two moving units, called mobile stations (MSs), or between one mobile unit and one land unit is called Cellular Network. Whenever a calling is taken place, a service provider must locate and track a caller, assign a channel to the call, and transfer the channel from base station to base station as the caller moves out of range.

A service coverage area in a cellular network

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is divided into smaller areas of Hexagonal shape, named as cells. Each cell of a cellular network has a fixed base station. Using the radio transceiver, the base station is able to communicate with cellular phones. The base station is connected to a mobile switching center (MSC) which is connected to the public switched telephone network (PSTN). The following figure 1 shows the typical cellular network in which each base station is marked with a hexagonal. In the past decade, cellular communications have experienced an explosive growth due to the recent technological advances in cellular networks and manufacturing of cellular phone.

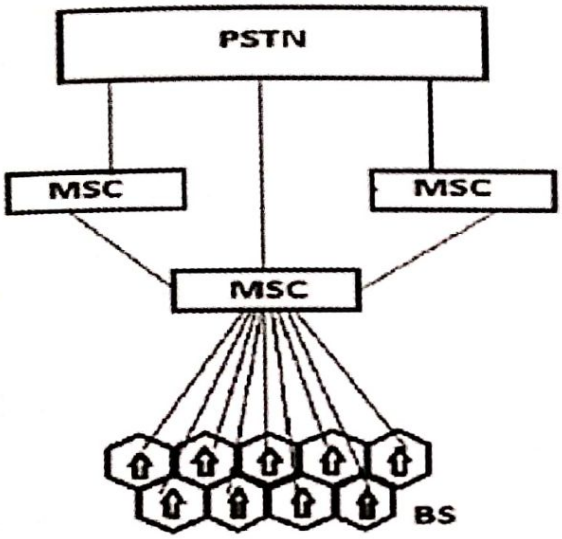

Figure 1: Typical Cellular Network

Cell size if not fixed. Depending on the population of the area, cell size can be increased or decreased. The typical radius of a cell varies from 1 to 12mi. To meet traffic demands, high-density areas require more geographically smaller cells than low-density areas. Once determined, cell size is optimized to prevent the interference of adjacent cell signals. To prevent its signal from interfering with those of other cells, the transmission power of each cell is kept low.

3. GSM ARCHITECTURE

The GSM (Global System for Mobile communication) is logically divided into two: access network and core network. The access network is called Base Station System (BSS) for GSM and Radio Network Subsystem (RNS) for UMTS. Routing, identification, authentication, subscription checking, etc. are the functionalities provided by core network. It is divided into Circuit Switched (CS) domain and Packet Switched (PS) domain. The CS domain provides the circuit switched services in a dedicated connection between the two end parties (called party and calling party) while PS domain does not provide a dedicated channel. The following figure 2 shows the architecture of GSM.

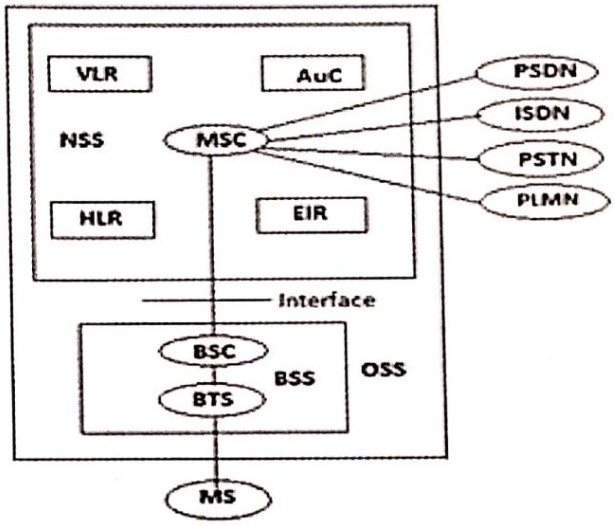

Figure 2: GSM Architecture

MS: Mobile Station

BTS: Base Transceiver Station

BSC: Base Station Controller

BSS: Base Station System

OSS: Operation Support Subsystem

HLR: Home Location Register

VLR: Visited Location Register

EIR: Equipment Identity Register

AUC: Authentication Centre

MSC: Mobile Switching Centre

NSS: Network Switching Centre

PSTN: Public Switched Telephone Network

4. GSM ENTITIES AND INTERFACES

4.1 The Base Station System (BSS)

The BSS carries out the radio-related activities. This is the link between user equipment (MS) and the network switching subsystem. BSS has one BSC and one or more BTSs. The BSS offers a Time Division Multiple Access (TDMA)-based technology to access the mobile station whereas the RMS in UMTS offers a Wideband-Code Division Multiple Access (W-CDMA)-based technology.

4.2 Base Transceiver Station (BTS)

Mobile station connects to mobile network through BTS, it handles communication using radio transmission with mobile station. As name suggests, Base transceiver station is the radio equipment which receive and transmit voice data at the same time.

4.3 Base Station Controller (BSC)

BSC controls one or more BTSs. It creates physical link between mobile MS and BTS, then manage and controls functions of it. It performs the function of high quality switch by handover the MS to next BSC and MS goes out of the current range of BTS, it helps in connecting to next in range BTS to keep the connection alive within the network.

4.4 Mobile Switching Center (MSC)

The MSC performs all the switching and signaling functions for MSs located in its area. MSC performs the functions related to call routing; handling location registration procedures and handover of calls. It's most important task is to control the calls to and from other telephones which means it controls calls from same networks and calls from other networks.

4.5 Authentication Center (AUC)

AUC is small which handles the security end of the system. Its major task is to authenticate and encrypt those parameters which verify user's identification and hence enables the confidentiality of each call made by subscriber (1). Authentication center – AUC makes sure mobile operators are safe from different most likely to happen hackers are looking for even smallest loop wholes in systems.

4.5 Home Location Register (HLR)

Primarily HLR stores the permanent data of subscriber which are type of services allowed, networks allowed, type of charging etc. and also stores some information that are frequently changed (e.g. VLR-ID refers currently serving the user).

HLR maintains all subscribers' data. For each PLMN, logically there is only one HLR. It is implemented as distributed database system with several HLRs. Multiple HLRs would manage the number of mobile subscribers regarding the capacity of the equipment and on the organization of the network. The queries to HLR need to be answered very quickly since this will affect the time required to setup the call (1). HLR acts as a directory that maintains the MSISDN number, your 12 digit mobile number, for example, 91-9846150145) and the MSC-VLR number by which this mobile (MSISDN) is being served. With the HLR, the gateway MSC checks this information and routes the call accordingly.

4.6 Visitor Location Register (VLR)

VLR stores the data in the similar manner as in HLR. That is, the VLR also holds the international mobile subscriber identity (IMSI) and the mobile subscriber integrated services digital network (MSISDN), the services allowed for a particular IMSI/MSISDN pair, and authentication data, all of which correspond to a particular subscription.

The main difference between VLR and HLR is that the data stored in the VLR may changes

frequently while the data stored in HLR is permanent. Also, if a network is designed such that one VLR serves each MSC's location area, there will be fewer records in the VLR than the HLR.

As soon as a subscriber moves into an MSC's location area, the corresponding record is updated in the VLR. Subsequently, the subscriber's HLR is automatically informed of the change.

A VLR may also perform the following functions:

- Monitor the subscriber's location within the VLR's jurisdiction
- Determine whether a subscriber may access a particular service
- Allocate roaming numbers during incoming calls
- Accept information passed to it by the HLR
- Delete the records of inactive subscribers

5. MOBILITY MANAGEMENT

Mobility management is the technique which maintains uninterrupted signal connectivity, when a MS changes location from cell A to B or from a network to another network (3). There are two important points to ensure constant connectivity.

- Infrastructure management is the technique in which two or more cells or networks are connected.
- When mobile devices move from one cell to another cell, location management and registration management are handled by handoff method.The technique of mobility management is as shown in the figure 3.

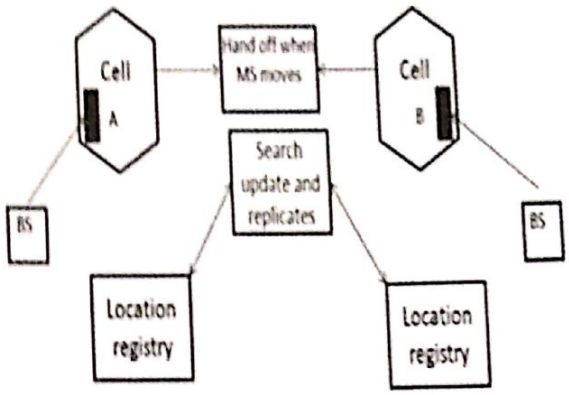

Figure 3: Mobility Management

6. HANDOFF MANAGEMENT

While a call is in progress, the process of changing the channel (frequency, time slot, spreading code, or combination of them) associated with the current connection is known as Handoff. Handoff is initiated while crossing a boundary of cell or deteriorating the quality of the signal in the current channel. Handoff is divided into two categories hard and soft handoffs.

6.1 Hard Handoff

In hard handoff, a MS only communicates with one BS. When the MS moves from one cell to another, communication must first be broken with the previous BS before communication can be established with the new BS before breaking off from the old one. A hard handoff or hard handover is generally implemented in FDMA and TDMA based cellular networks. However, it is generally fast enough that user don't feel an interruption or breakage in service. Moreover, hard handover is cheaper because it requires only one channel to operate.

6.2 Soft Handoff

New systems use a soft handoff. In this case, a MS can communicate with two base stations at the same time. This means that, before breaking off from the old one, a MS may continue with

the new BS during handoff (4). Soft handoff technology is used by Code Division Multiple Access (CDMA) systems. In CDMA, all repeaters use the same frequency channel for each MS, no matter where the MS is located. Each MS has an identity based on a code, rather than on a frequency (as in FDM) or sequence of time slots (as in TDM). The connections are almost never interrupted or dropped because there is no change in frequency or timing occurs as a MS passes from one BS to another. The figure 4 shows Handoff Management.

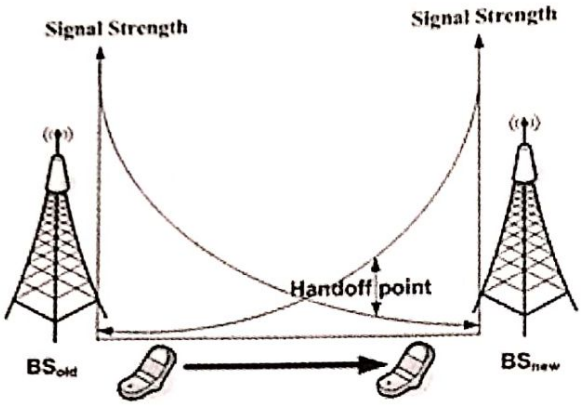

Figure 4: Handoff Management

7. LOCATION MANAGEMENT

Location management deals with how to keep track of an active mobile station within the cellular network. A mobile station is active if it is powered on. Since the exact location of a mobile station must be known to the network during a call location management usually means how to track an active mobile station between two consecutive phone calls.

To forward the incoming calls to a MS, the wireless communication system must keep the track of the users. To find out the location of a MS, the wireless network is usually divided into some location Areas (LA). It is a part of wireless network in which there is no location update. A location area consists of several cells. A MS can freely move within the LA. When it moves within on LA, it has to notify the network. The network then probes every cellsin a Location Area to locate certain MS (5). There is only low frequency location registration in a large LA. Here, large LA means more cells within it. The tradeoff between location update costs versus location finding costs is determined by the size of an LA.

As a MS moves from one cell to another, it must register its new location to enable the network to forward the calls towards the devices. It has two stages of process.

7.1 Location Update

It is the process in which MS notifies the network about its new location. The network then authenticates and stores the new location of MS.

7.2 Paging

In this process, the network sends the queries about the location of MS and the information is used to forward the incoming call towards MS. The technique of location management uses a database. The location of each MS is tracked and stored in database. During location update and paging among different network components, various signaling messages are transmitted.

Currently two levels of database schemes are used. The Home Location Register (HLR) contains the records of all users' services, in addition to location information for an entire network, while Visitor Location Registers (VLRs) download data from the HLR concerning current users within the VLR's specific service areas (5). And also each VLR is connected with multiple Mobile Switching Centers (MSC) which are used to locate the users easily.

VLR is modified by the inter-MSC movements of MS while HLR does not need any modifications. Inter-MSC movements of the LA cause VLR to be updated with the new cell

address. The inter-VLR movements cause HLR to be updated with the MSC details of new user. Update to VLR causes the modification in VLR and MSC fields.

7.3 Location Management Schemes

Location Areas

In some first generation cellular systems and in many second-generation cellular systems such as GSM, the location areas approach has been used for location management. The service coverage area is partitioned into location areas in the location areas approach. Each location area consists of several contiguous cells. The MS of each cell broadcasts the identification (ID) of location area to which the cell belongs. Therefore a mobile station knows which location area it is in. The following Figure 4 shows the different location areas.

Major functionality of a GSM or a UMTS network is Mobility Management. Whenever it moves from one location, mobile station informs the cellular network area to another (7). Mobile Station detects the location area codes. When a mobile finds that the location area code is different from its last update, it performs another update by sending to the network, a location update request, together with its previous location, and its Temporary Mobile Subscriber Identity (TMSI) as well. Thus a subscriber enjoys an uninterrupted access to the network. Roaming is the fundamental mobility management procedures of all cellular networks. Roaming is referred as the ability for a customer to automatically make and receive voice calls, send and receive data, or access other services, including home data services, when travelling outside the geographical coverage area of the home network, by means of using a visited network. This can be possible by using a communication terminal. Roaming is always technically supported by mobility management, authentication, authorization as well as billing procedures.

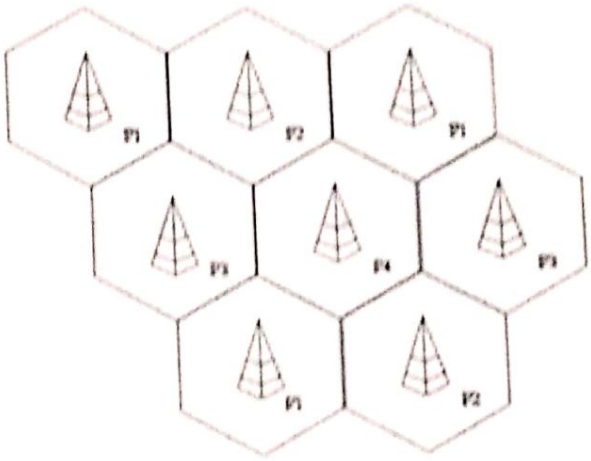

Figure 5:Location Areas

A mobile station will update its location (i.e. location area) whenever it moves into a cell which belongs to a new location area. For example, when a mobile station moves from cell F2 to cell F4 in the Figure 5, it will report its new location area because cell F2 and cell F4 is in different location areas. When an incoming call arrives for a mobile station, the cellular system will page all cells of the location area which was last reported by the mobile station (8).

GSM distinguishes explicitly between user and equipment and deals with them separately (9). Besides phone numbers and subscriber and equipment identifiers, several other identifiers have been defined; they are needed for the management of subscriber mobility and for addressing of all the remaining network elements. The most important addresses and identifiers are presented in the following.

The data stored includes:

- Mobile subscriber Roaming number (MSRN)
- Service type (services that the subscriber is allowed to access)
- Current location
- HLR address Ciphering keys
- Billing information
- International Mobile Subscriber Identity (IMSI)

- Subscribers phone number
- Access point subscribed (GPRS)
- Temporary Mobile Subscriber Identity (TMSI)

Keeping track of Mobile Station

When a MS crosses a boundary from a cell belonging to one LA into a cell belonging to another LA, it must report its new location to the network. When a MS crosses a cell boundary within a location area, it does need to report its new location to the network (6). But when a MS leaves the MSC service area, the scenario changes and updating information is increased. The VLR is always integrated with the MSC as shown in figure 4 and there is one VLR for each MSC service area. The VLR can be regarded as a distributed HLR as it holds a copy of the HLR information stored about the subscriber.

The role of a VLR in a GSM network is to act as a temporary storage location for subscription information for MSs which are within a particular MSC service area (9). Thus, there is one VLR for each MSC service area. This means that the MSC does not have to contact the HLR (which may be located in another country) every time the subscriber uses a service or changes its status. Figure 6 shows the interaction between VLR and HLR. Following occurs when MS moves into a new service area:

- The VLR checks its database to find whether or not the details of MS (based on the subscriber's IMSI).
- When the VLR does not find the record of MS, it sends a request to the HLR for a copy of the MS's subscription.
- The HLR passes the information to the VLR and updates its location information for the subscriber. The HLR instructs the old VLR to delete the information it has on the MS.
- The VLR stores its subscription information for the MS, including the latest location and status.

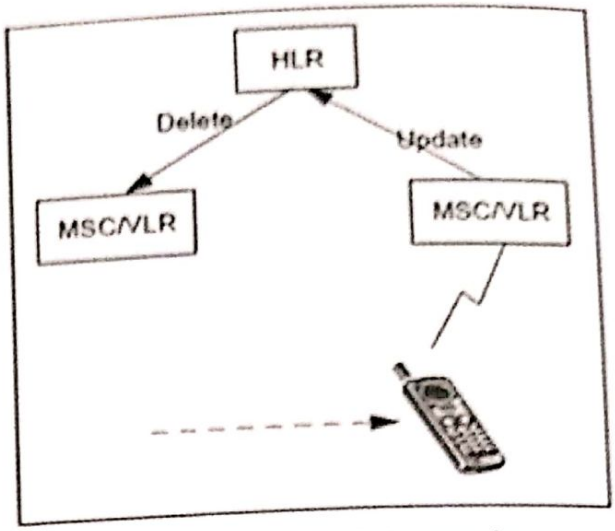

Figure 6: VLR-HLR Interaction

8. CONCLUSION

In cellular networks, mobile station moves anywhere. For making a call, location registration is needy. In this study, I noticed how these HLR and VLR reflects when mobile stations make call. When a mobile station makes a call two basic operations are performed. In this paper, I mentioned the operations of VLR and HLR when a call takes place and the location tracking of mobile station using VLR. In the future I will further research improved on location management using fuzzy logic and fuzzy databases.

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