MOBILITY MANAGEMENT IN CELLULAR

JAWAHARLAL NEHRU UNIVERSITY

A
Dissertation submitted to
JAWAHARLAL NEHRU UNIVERSITY
in partial fulfillment of the requirements for
the award of the degree of

Master of Technology

In

Computer Science & Technology

by
SANJAY KUMAR

SCHOOL OF COMPUTER & SYSTEMS SCIENCES
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI – 110 067

JANUARY, 2001

जवाहरलाल नेहरू विश्वविद्यालय
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI-110067 (INDIA)
SCHOOL OF COMPUTER & SYSTEMS SCIENCES

CERTIFICATE

This is to certify that the dissertation entitled "MOBILTY MANAGEMENT IN CELLULAR SYSTEMS" which is being submitted by ***Mr. Sanjay Kumar*** to the School of Computer & Systems Sciences, JAWAHARLAL NEHRU UNIVERSITY for the award of ***Master of Technology*** in ***Computer Science & Technology*** is a bonafide work carried out by him under our supervision.

This is original and has not been submitted in part or full to any university or institution for the award of any degree.

PROF. C.P.KATTI
Dean
SC&SS

PROF. P.C SAXENA
SUPERVISOR
SC&SS

DR. S. GUPTA
SUPERVISOR
SC&SS

Dedicated

To

My beloved parents

ACKNOWLEDGEMENTS

I would like to pay obeisance at the feet of my beloved parents for their blessings are always with me in all my aspirations including my academics.

I wish to convey my heartful gratitude and sincere acknowledgements to my supervisor Prof. P.C. Saxena for his constant encouragement, guidance and affection throughout my work. I am grateful to him for providing me enough infrastructures through Data Communication and Distributed Computing Group (DCDCG) laboratory to carry out my work. It is a great honour for me for being a member of DCDC Group and I am thankful to all the members for their cooperation and understanding.

I would like to record my sincere thanks to my dean Prof. C.P. Katti, School of Computer and Systems Sciences, JNU for providing the necessary facilities in the centre for successful completion of this project.

I would take this opportunity to thank all my faculty members for their help and suggestions during the course of my course work.

I am particularly thankful to Debesh, Manish, Uday, Radha Kishan, Devendra, Ajeet, Lata for their constructive criticism and for endless discussions at various stages of work. And finally, I thank all my classmates in my M.Tech class, friends in Roorkee University, Roorkee.

Sanjay Kumar

Abstract

Cellular systems are going wide spread popularity day by day because it offers subscribers location independent access to a variety of telephone services. In a cellular network a mobile stations connects to a mobile switching center via a radio base station since mobile subscriber are not static, mobility management in the key issue in cellular network(i.e. to locate subscribers and maintain cells during movement).

This dissertation presents the basic concepts of mobility management in cellular network and discuss the key issue like location updating, handover techniques. First of all architecture of cellular systems is discussed which comprises type of cells, frequency reuse and different components of the cellular systems. Then a reference model for cellular systems is given with channel selection, location management. Location management discuss location updating, database used for the purpose with an example of GSM (global system for mobile communication). Handovers are then discussed which includes cell to cell handovers, domain to domain handover and subnet to subnet handover. Three handovers schemes are suggested for effective and efficient handovers.

CONTENTS

CHAPTER 1

INTRODUCTION

1.1 The Evolution of Cellular Systems

Cellular is one of the fastest growing and most demanding telecommunications applications. Today, it represents a continuously increasing percentage of all new telephone subscriptions around the world. Currently there are more than 45 million cellular subscribers worldwide, and nearly 50 percent of those subscribers are located in the United States. It is forecasted that cellular systems using a digital technology will become the universal method of telecommunications. By the year 2005, forecasters predict that there will be more than 100 million cellular subscribers worldwide. It has even been estimated that some countries may have more mobile phones than fixed phones by the year 2000.

The concept of cellular service is the use of low-power transmitters where frequencies can be reused within a geographic area. The idea of cell-based mobile radio service was formulated in the United States at Bell Labs in the early 1970s. However, the Nordic countries were the first to introduce cellular services for commercial use with the introduction of the Nordic Mobile Telephone (NMT) in 1981.

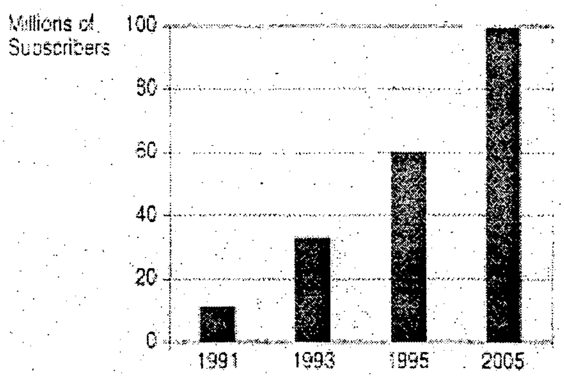


Figure 1.1 Cellular Subscriber Growth Worldwide

Cellular systems began in the United States with the release of the advanced mobile phone service (AMPS) system in 1983. The AMPS standard was adopted by Asia, Latin America , and Oceanic countries, creating the largest potential market in the world for cellular.

In the early 1980s, most mobile telephone systems were analog rather than digital. like today's newer systems. One challenge facing analog systems was the inability to handle the growing capacity needs in a cost-efficient manner. As a result, digital technology was welcomed. The advantages of digital systems over analog systems include ease of signaling, lower levels of interference, integration of transmission and switching, and increased ability to meet capacity demands. Table 1 charts the worldwide development of mobile telephone systems.

Table 1. The Development of Mobile Telephone Systems

Year	Mobile System
1981	Nordic Mobile Telephone (NMT) 450
1983	American Mobile Phone System (AMPS)
1985	Total Access Communication System (TACS)
1986	Nordic Mobile Telephony (NMT) 900
1991	American Digital Cellular (ADC)
1991	Global System for Mobile Communication (GSM)
1992	Digital Cellular System (DCS) 1800
1994	Personal Digital Cellular (PDC)
1995	PCS 1900—Canada
1996	PCS—United States

1.2 Cellular System Basics

1.2.1 Cellular Structure

In a cellular system, the covering area of an operator is divided into cells. A cell corresponds to the covering area of one transmitter or a small collection of transmitters. The size of a cell is determined by the transmitter's power.

The concept of cellular systems is the use of low power transmitters in order to enable the efficient reuse of the frequencies. In fact, if the transmitters used are very powerful, the frequencies can not be reused for hundred of kilometers as they are limited to the covering area of the transmitter.

The frequency band allocated to a cellular mobile radio system is distributed over a group of cells and this distribution is repeated in all the covering area of an operator. The whole number of radio channels available can then be used in each group of cells that form the covering area of an operator. Frequencies used in a cell will be reused several cells away. The distance between the cells using the same frequency must be sufficient to avoid interference. The frequency reuse will increase considerably the capacity in number of users.

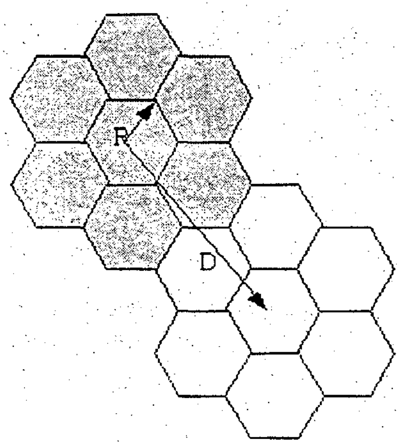


Figure 1.2 Frequency Reuse in a Cellular System

In order to work properly, a cellular system must verify the following two main conditions:

- The power level of a transmitter within a single cell must be limited in order to reduce the interference with the transmitters of neighboring cells. The interference will not produce any damage to the system if a distance of about 2.5 to 3 times the diameter of a cell is reserved between transmitters. The receiver filters must also be very preferment.

- Neighboring cells can not share the same channels. In order to reduce the interference, the frequencies must be reused only within a certain pattern.

In order to exchange the information needed to maintain the communication links within the cellular network, several radio channels are reserved for the signaling information.

1.2.2Cluster

The cells are grouped into clusters. The number of cells in a cluster must be determined so that the cluster can be repeated continuously within the covering area of an operator. The typical clusters contain 4, 7, 12 or 21 cells. The number of cells in each cluster is very important. The smaller the number of cells per cluster is, the bigger the number of channels per cell will be. The capacity of each cell will be therefore increased. However a balance must be found in order to avoid the interference that could occur between neighboring clusters. This interference is produced by the small size of the clusters (the size of the cluster is defined by the number of cells per cluster). The total number of channels per cell depends on the number of available channels and the type of cluster used.

1.2.3 Types of cells

The density of population in a country is so varied that different types of cells are used:

- Macrocells
- Microcells
- Selective cells
- Umbrella cells

1.2.3.1 Macrocells

The macrocells are large cells for remote and sparsely populated areas.

1.2.3.2 Microcells

These cells are used for densely populated areas. By splitting the existing areas into smaller cells, the number of channels available is increased as well as the capacity of the cells. The power level of the transmitters used in these cells is then decreased, reducing the possibility of interference between neighboring cells.

1.2.3.3 Selective cells

It is not always useful to define a cell with a full coverage of 360 degrees. In some cases, cells with a particular shape and coverage are needed. These cells are called selective cells. A typical example of selective cells are the cells that may be located at the entrances of tunnels where a coverage of 360 degrees is not needed. In this case, a selective cell with a coverage of 120 degrees is used.

1.2.3.4 Umbrella cells

A freeway crossing very small cells produces an important number of handovers among the different small neighboring cells. In order to solve this problem, the concept of umbrella cells is introduced. An umbrella cell covers several microcells. The power level inside an umbrella cell is increased comparing to the power levels used in the microcells that form the umbrella cell. When the speed of the mobile is too high, the mobile is handed off to the umbrella cell. The mobile will then stay longer in the same cell (in this case the umbrella cell). This will reduce the number of handovers and the work of the network.

A too important number of handovers demands and the propagation characteristics of a mobile can help to detect its high speed.

1.3 Cellular Network Elements

Subscriber Station (SS): The subscriber station is the terminal unit that performs the function of a conventional telephone. Unlike a conventional telephone, however, the subscriber station includes a full duplex radio subsystem that provides for a full duplex voice channel plus the necessary signaling between the subscriber station and the radio base station.

Radio Base Station (RBS): The radio base station has the necessary radio, control, and multiplexing functionality to maintain full-duplex radio connections to multiple subscriber stations, set up and tear down connections to subscriber stations, track signal strength and other parameters associated with specific subscriber stations, and provide trunking to the mobile switching center. A single radio base station serves a well-defined geographic area surrounding the base station. The size of the area its serves depends on many factors, but in contemporary cellular systems the area may range from as small as one square mile to as large as 200 square miles.

Mobile Switching Center (MSC) : Its performs the switching function and many control functions for the cellular serving area, which typically consists of tens or hundreds of radio base stations spread over an extended metropolitan or rural area. Unlike a switching end-office in the PSTN, whose primary role in the network is switching calls, the MSC has a significant processing burden in managing mobility, In addition to its ordinary switching function. At a minimum, the mobility management function requires the switch

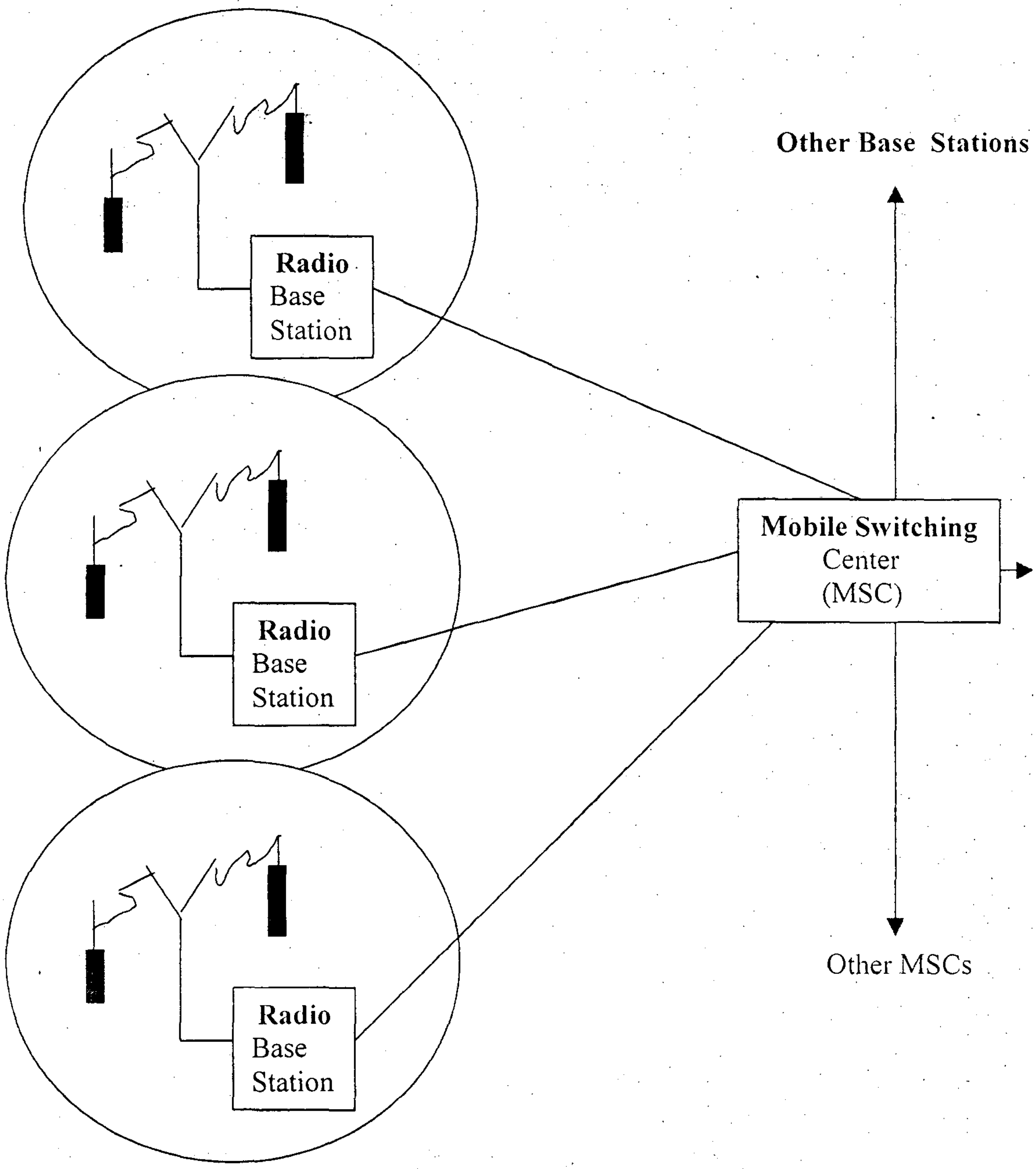


Figure 1.3 Basic Cellular Network Elements

to locate subscriber stations to which incoming calls are directed, managed the assignment of radio resources in all of the base stations as calls are originated, and track the motion of subscriber stations as they move between the serving areas of individual radio base stations to ensure continuous and uninterrupted service.

CHAPTER 2

Mobility Management In Cellular Systems

In offering the promise of making telephone service available to subscriber stations independent of their location. Cellular systems create a multifaced problem known as mobility management. The Mobility Management function is in charge of all the aspects related with the mobility of the user, specially the location management and the authentication and security. This scheme covers all aspects of the problem of locating and tracking subscriber stations as they move about in their home service area, or outside where they may be visiting and desire to obtain service.

Before we discuss the various aspects of mobility management in cellular systems, we need a more general network model because additional network elements are required to manage mobility. Also, to understand the operation of mobility, we need to define three parameters that are stored in the subscriber station and give it a unique identity. These are:

- *Home system Identity (SID)* 15-bit system identity indicator that is set to the SID of the subscriber station's home system. The FCC has defined a set of *cellular geographic serving areas* (CGSAs), and potentially two cellular systems provide service in each CGSA. Each of these systems has a unique SID. The SID of the system in which the subscriber station subscribes for service is the Home SID.

- *Mobile identification number (MIN)* 10-digit directory number of each subscriber station is encoded in to a 34-bit value called the MIN.
- *Electronic serial number (ESN)* 32-bit value that uniquely identifies the subscriber station. This number consists of an 8-bit manufacturer code, an 18-bit serial number, and 6 reserved bits.

The network elements shown in this model are

- *Subscriber station (SS)*
- *Radio base Station (RBS)*
- *Mobile switching center (MSC)*
- *Public switching telephone network (PSTN) and integrated services digital network (ISDN)* These are external networks with which the MSC will be interconnected.
- *Home location register (HLR)* The HLR is a database used for storage and management of subscriptions. The HLR is considered the most important database, as it stores permanent data about MIN, ESC, current (last reported) location , service profile , and information associated with authentication of users. The HLR may be an integral part of the MSC, or it may be a physically separate entity providing HLR services to one or more MSCs.
- *Visitor location register (VLR)* The VLR is a database that contains temporary information about subscribers that is needed by the MSC in order to service visiting subscribers. The VLR is always integrated with the MSC. When a mobile station roams into a new MSC area, the VLR connected to that MSC will request data about the mobile station from the HLR. Later, if the mobile

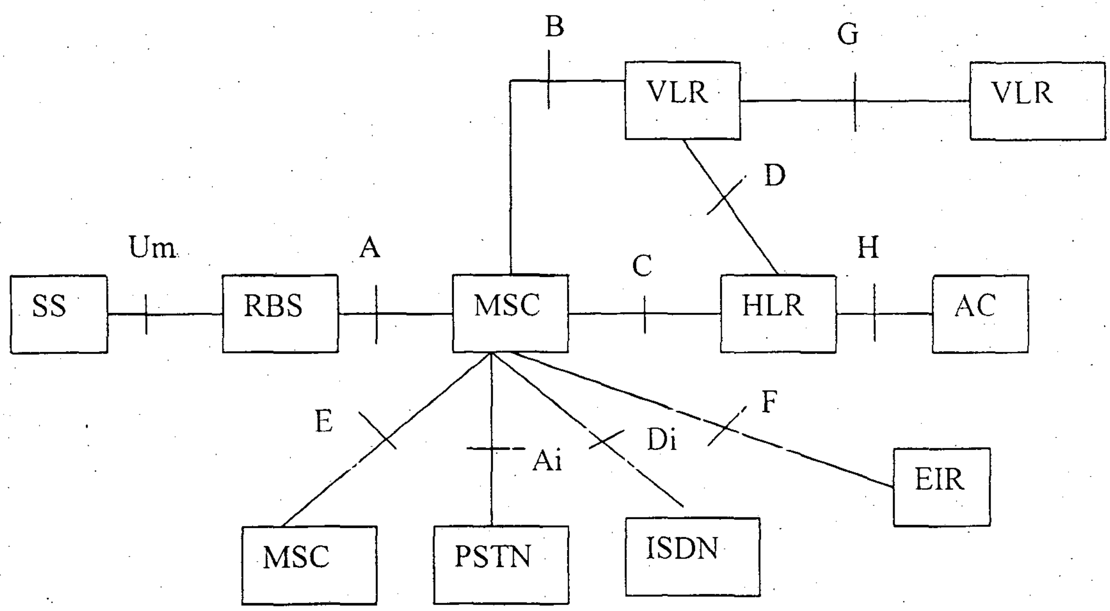


Figure 2.1 TIA Cellular-Network Reference Model

station makes a call, the VLR will have the information needed for call setup without having to interrogate the HLR each time.

- *Authentication center (AC)* A unit called the AUC provides authentication and encryption parameters that verify the user's identity and ensure the confidentiality of each call. The AUC protects network operators from different types of fraud found in today's cellular world. Again, the AC may or not be an integral part of the MSC.
- *Equipment identity register (EIR)* The EIR is a database that contains information about the identity of mobile equipment that prevents calls from stolen, unauthorized, or defective mobile stations. The AUC and EIR are implemented as stand-alone nodes or as a combined AUC/EIR node. The EIR may or may not be an integral part of the MSC.

2.1 Access and Signaling Channel Selection

When a subscriber station is first powered up, it executes a procedure for determining the radio base station that will provide it the best service, and obtains other information required to operate properly on the system to which the serving radio base station belongs. The subscriber station starts by determining its preferred system status, which is information stored in the subscriber station .The subscriber station then measures the power on the 21 dedicated control channels that belong to its preferred system (313-333 for system A, 334-354 for system B), and chooses the channel with the greatest power. It then attempts to receive a *system parameter overhead message* on this channel. If it cannot successfully receive this message, it tries on the second strongest channel. If it can't receive a system overhead message on either of these channels, it can change serving systems and try again.

Along with the dedicated control channels, there separate paging and access functions, which may be assigned to the same physical channels as the dedicated control channels or may be assigned to physically distinct channels. Because all channels, including the control channels come in duplex pairs, if distinct channels are assigned to the paging function and access function, these are duplex pairs of channels that carry all traffic, on both base-to-subscriber and subscriber-to-base links, associated with the paging and access functions, respectively.

As part of the system parameter overhead message, the subscriber station receives information that allows it to determine what channels to use for paging and for access. The subscriber station must proceed to scan through the set of paging channels and choose the strongest one. This paging channel is then monitored continuously, as long as the subscriber station is otherwise idle.

2.2 System Access

Once a subscriber station has powered up, and completed any initialization routines, it may try to access the system to make a call attempt, or simply await an incoming call. If the subscriber chooses to initiate a call attempt, or the subscriber station needs to respond a page, the subscriber station performs the system access function, as follows. First, the subscriber station scans all the access channels and chooses the strongest one. Then it attempts to seize the subscriber-to-base link on the access channel through a random-access procedure. Once the link is seized, the subscriber station transmits its message.

If the system access is for a call origination or a page response, the subscriber station next waits for a subsequent message designating a voice channel, then tunes to the voice channel indicated. The base station powers up the designating a voice channel and starts transmitting *supervisory audio tone* (SAT) on the channel at the same time as it transmits the voice-channel designation message. When the subscriber station tunes to the designated voice channel, it starts transponding the SAT. This transmission serves as confirmation to the radio base station that the subscriber station has received its voice-channel designation message and successfully tuned to the designated channel.

Further signaling necessary for call control occurs on the call-control channel that is embedded in the designated voice channel. If the access is a call origination, then the subscriber station goes in to conversation mode immediately on tuning to the voice channel. If the access is a page response, then the subscriber station is instructed to alert the user (ring the phone), and wait until the user answers, at which time, the subscriber station goes into conversation mode.

2.3 Paging

Paging is the function for finding the subscriber station and informing it about incoming traffic. In the other words Paging is the procedure through which a called subscriber station is located by the MSC when a caller dials the directory number of that subscriber station. In its simplest form, paging operates as follows. When a call arrives at the MSC, the MSC sends a page request to all the radio base stations in the cellular serving area. Each of these radio base stations, in turn, broadcasts the page request on its paging channel.

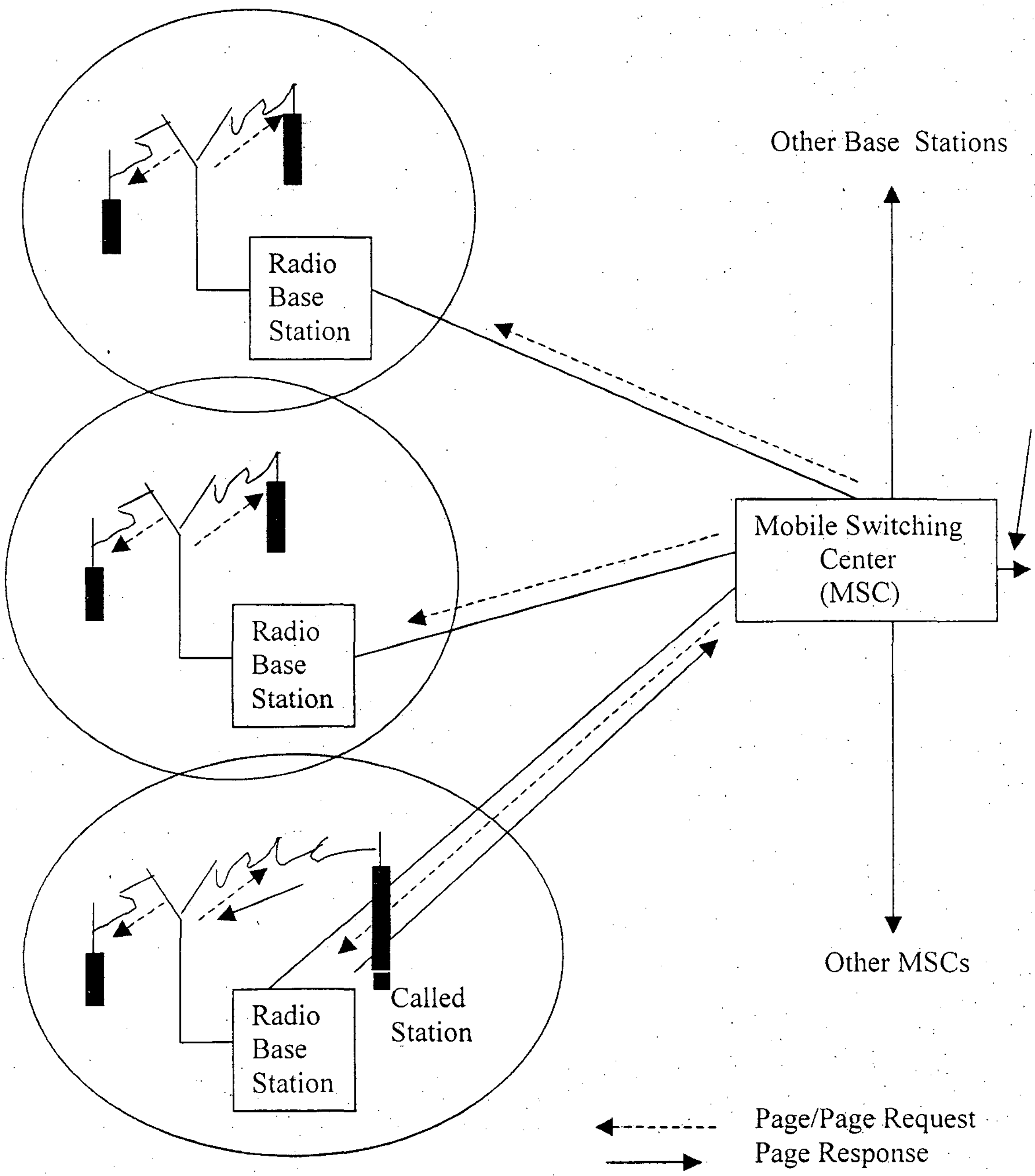


Figure 2.2 Page and page response for incoming call

All powered-up subscriber stations that are not occupied by an active call must continuously monitor the paging channel for page messages. When a page message is received, the subscriber station attempts to match the MIN (encoded directory number) contained in the page message to its programmed MIN. If the MINs don't match, the page message is ignored. If the MINs match, the subscriber station attempts to respond with a page-response message to the radio base station that issued the page message.

When the radio base station receives the page response, it returns a page response to the MSC; when the MSC gets this page response, it issues a setup order to the radio base station that results in a voice-channel designation and SAT tone transmission as in the call-setup sequence originated by the subscriber station. This step is followed by alerting (ringing) and answering if the user is present to respond to the alerting. The subscriber station then goes into conversation mode, and further signaling necessary for call control occurs on the call-control channel that is embedded in the voice channel.

If the mobile is not powered up in the serving area, or for some other reason can not successfully respond to the page, there will be no response to the page. If , after an appropriate time interval, the MSC does not receive a page response, it responds to the call attempt in some suitable manner. For example, it may use a voice message informing the caller that the subscriber is not responding to the call, or may forward the call to another landline number or voice mailbox.

2.4 Registration

For large cellular systems, the capacity of the paging channel eventually becomes an issue, because every incoming call can result in a page message being sent by every radio base station in the system.

It is possible that in a large system, the scenario above may exaggerate the paging load, because customer traffic may be only .01 or .015 Erlang per subscriber, and a fraction smaller than half of this traffic may be incoming calls. However, it is clear that paging load can become excessive if all incoming calls result in a page message being broadcast by each cell in the system. In some cases, the system operator has the option of dedicating a set of channels to carry paging traffic only, so that each radio base station has one duplex pair of channels dedicated to page and page-response message, and a separate set of channels for system access traffic. This arrangement is undesirable, however, because it uses channels that would otherwise be available for voice traffic.

Another way of controlling paging traffic is to require subscriber stations to register their presence with the system when they power up and power down. In this way the MSC knows which subscriber stations are powered up and ready to receive calls, so that it pages only subscriber stations that are present in the system. Furthermore, because the subscriber station sends its registration message to a specific radio base station, the MSC knows where the subscriber station was at power up. If the MSC then sends page requests for that subscriber station only to a group of radio base stations in the area around the radio base station where the subscriber station originally registered, the paging traffic can be cut down considerably. This improvement in paging traffic is offset by a modest amount of extra traffic on the access channels associated with the power-up and power-down registrations. Power-up registration is not a feature of the AMPS standard, and so it is not available for use with the vast majority of AMPS-compatible subscriber stations in existence today.

The simple approach relying only on power-up and power-down registration has the disadvantage that if the subscriber station moves a great distance after power requests. This limitation can be overcome with two-stage paging, where the MSC pages in the area where power-up registration occurred; if there is no response, it will page over a wider area, or over the entire system. However, this procedure increases call-setup time, as well as paging traffic. If a large percentage of customers are highly mobile, then this strategy will not help paging traffic much relative to the simple wide-area paging approach.

The registration process can also expanded to include periodic registration by subscriber stations, so that as the subscriber station moves around the system, the MSC can update its knowledge of the position of the subscriber station, and direct page requests accordingly. This method will help limit paging traffic to areas where the subscriber station is likely to be found. However, if the subscriber is not moving, the periodic registration will provide redundant information to the MSC and unnecessarily load the access channel.

2.5 Location Areas

A more general form of registration that takes care of tracking highly mobile subscriber stations while limiting access-channel traffic for slowly moving or stationary subscriber stations involves the *location area.* A location area is covered by a group of one or more radio base stations that the system operator identifies as an area where the operator considers all subscriber stations to be in a common paging area. The operator divides the service area up into a set of non overlapping location areas and assigns a number to each location area. Each radio base station includes the number of the location area to which it belongs in the overhead message train that it transmits. When a subscriber powers up, selects the strongest dedicated control channel, and reads the overhead message train, it stores the number of the location area to which the radio base station belongs, and then sends a registration message. Subsequently, when it is in idle mode, it reads the overhead message train on the paging or dedicated control channel to which it is tuned. When it reads a location-area identity that is different from the one that it has stored, it sends another registration message to inform the MSC that it has moved to a new paging area. In determining appropriate sizes for the location areas, the system operator must consider both reductions in paging traffic that are gained by decreasing the size of the location areas, and reductions in registration traffic that are achieved by increasing the size of the location areas. If each radio base station is a distinct location area, then the MSC needs to send a page request to only one radio base station to complete a call. This act, however, will result in a registration attempt by every subscriber station each time it moves out of the range of a radio base station for every incoming call. Between these two extremes is an optimal point that minimizes the load on the paging and access channels. This optimum point will vary according to the size of the system and the mobility profiles exhibited by the subscribers on the system.

2.6 Handover

As a subscriber station moves around in a cellular system, the radio base station that provides the best service will change. When the subscriber station is idle and monitoring only paging channel traffic, as it moves out of range of one radio base station, it will seek out another radio base station that provides the strongest signal, and continue to monitor paging traffic on the paging channel on the new radio base station.

When a call is in progress, however, a more elaborate mechanism is required for changing the radio base station that a subscriber station is communicating with as it moves away from its serving radio base station and the call quality is deteriorated by decreasing signal strength and increasing interference. Changing the radio link from one radio base station to another is called *handover*, or *handoff*. Ideally, the subscriber station will always be communicating with the radio base station that provides the best signal, and handover from one radio base station to another radio base station will be accomplished without disrupting the current call. However, many problems are associated with determining which radio base station is the best for providing service at any given time, and with coordinating the handover in a timely fashion and without disrupting the call.

2.7 Roaming

One of the most powerful features of cellular technology, however is the potential for delivering service to a subscriber regardless of location. In particular, it is highly desirable to be able to deliver service to a subscriber who is visiting a service area outside of his or her home service area. A subscriber who subscribes for service in Noida, for example, and has a directory number with the area code and Delhi exchange, should be able to go to Faridabad and receive the same service that he or she receives in Noida. A subscriber unit that is operating outside its home service area is said to be *roaming*. Strictly speaking, a subscriber station is said to be roaming when the home SID that is programmed into the subscriber station is different from the SID of the system that is providing service. This condition can happen when the subscriber station is a subscriber on the B system in a given geographic service area and is receiving service from the A system, or vice versa, as well as when the subscriber station is operating outside its home service area. A subscriber station always knows when it is roaming because the SID is always broadcast on the overhead message train, and the subscriber station compares its programmed home SID with the SID that it reads on the overhead message train. Subscriber stations are equipped with an indicator such as a light that is turned on when the subscriber station is roaming.

2.8 Location Management

Location management is concerned with the procedures that enable the system to know the current location of a powered-on mobile station so that incoming call routing can be completed. Location updating A powered-on mobile is informed of an incoming call by a paging message sent over the PAGCH channel of a cell. One extreme would be to page every cell in the network for each call, which is obviously a waste of radio bandwidth. The other extreme would be for the mobile to notify the system, via location updating messages, of its current location at the individual cell level. This would require paging messages to be sent to exactly one cell, but would be very wasteful due to the large number of location updating messages. Updating messages are required when moving between location areas, and mobile stations are paged in the cells of their current location area.

The location updating procedures, and subsequent call routing, use the MSC and two location registers: the Home Location Register (HLR) and the Visitor Location Register (VLR). When a mobile station is switched on in a new location area, or it moves to a new location area or different operator's PLMN, it must register with the network to indicate its current location. In the normal case, a location update message is sent to the new MSC/VLR, which records the location area information, and then sends the location information to the subscriber's HLR. The information sent to the HLR is normally the SS7 address of the new VLR, although it may be a routing number. The reason a routing number is not normally assigned, even though it would reduce signalling, is that there is only a limited number of routing numbers available in the new MSC/VLR and they are allocated on demand for incoming calls. If the subscriber is entitled to service, the HLR sends a subset of the subscriber information, needed for call control, to the new MSC/VLR, and sends a message to the old MSC/VLR to cancel the old registration.

For reliability reasons, Cellular systems also has a periodic location updating procedure. If an HLR or MSC/VLR fails, to have each mobile register simultaneously to bring the database up to date would cause overloading. Therefore, the database is updated as location updating events occur. The enabling of periodic updating, and the time period between periodic updates, is controlled by the operator, and is a trade-off between signalling traffic and speed of recovery. If a mobile does not register after the updating time period, it is deregistered.

A procedure related to location updating is the IMSI attach and detach. A detach lets the network know that the mobile station is unreachable, and avoids having to needlessly allocate channels and send paging messages. An attach is similar to a location update, and informs the system that the mobile is reachable again. The activation of IMSI attach/detach is up to the operator on an individual cell basis.

2.9 Authentication and Security

Since the radio medium can be accessed by anyone, authentication of users to prove that they are who they claim to be, is a very important element of a mobile network. Authentication involves two functional entities, the SIM card in the mobile, and the

Authentication Center (AuC). Each subscriber is given a secret key, one copy of which is stored in the SIM card and the other in the AuC. During authentication, the AuC generates a random number that it sends to the mobile. Both the mobile and the AuC then use the random number, in conjuction with the subscriber's secret key and a ciphering algorithm called A3, to generate a signed response (SRES) that is sent back to the AuC. If the number sent by the mobile is the same as the one calculated by the AuC, the subscriber is authenticated..

The same initial random number and subscriber key are also used to compute the ciphering key using an algorithm called A8. This ciphering key, together with the TDMA frame number, use the A5 algorithm to create a 114 bit sequence that is XORed with the 114 bits of a burst (the two 57 bit blocks). Enciphering is an option for the fairly paranoid, since the signal is already coded, interleaved, and transmitted in a TDMA manner, thus providing protection from all but the most persistent and dedicated eavesdroppers.

CHAPTER 3

Location Management

Location management schemes are essentially based on users' mobility and incoming call rate characteristics. The network mobility process has to face strong antagonism between its two basic procedures: location and paging. The location procedure allows the system to keep the user's location knowledge, more or less accurately, in order to be able to find him, in case of a coming call, for example. Location registration is also used to bring the user's service profile near its location and allows the network provide him rapidly with his services. The paging process achieved by the system consisting of sending paging messages in all cells where the mobile terminal could be located. Therefore, if the location cost is high (and thus the user location knowledge is accurate), the paging cost will be low (paging messages will be only be transmitted over a small area) and vice versa.

3.1 Present Location Management Methods

3.1.1 No Location Management

In early wide area wireless system (not yet cellular), human operators had to process the calls and the users' locations were not managed by the system. A user was able to generate a call through any base station (BS), and paging messages addressed to the called mobiles were transmitted through all BSs. The main characteristics of these systems were very large cells, and lower user population and call rates.

Small-capacity cellular systems (with a few tens of BSs serving a few thousand users) may also not use a location management method, even when the standard allows it. If subscriber number and calling rates do not require it, the location management method is not activated; resource consumption for finding users is not so important that its reduction is mandatory.

This level 0 method is therefore as simple as could be no location management is realized; the system does not track the mobiles. A search for a called user must therefore be done over complete radio coverage area and within a limited time. This method is usually referred to as flooding algorithm. It is used in paging systems because of the lack of an uplink channel allowing a mobile to inform the network of its whereabouts. It is also used in the small private mobile networks because of their small coverage area and user populations.

The main advantage of not locating the mobile terminals is obviously simplicity; in particular, there is no need to implement special databases. Unfortunately, it does not fit large networks dealing with high numbers of users and high incoming call rates.

3.1.2 Manual Registration

This method requires the user to locate himself by achieving a special procedure if he wishes to receive his incoming calls. From the network site, this method is relatively simple to manage because it just requires the management of an indicator, which stores the current location of the user. The mobile is also relatively simple; its task is just limited to scanning the channels to detect paging messages.

This method is currently used in telepoint cordless systems (such as CT2). The user has to register itself each time he moves to a new island of CT2 beacons. To page a user, the network first transmits messages through the beacon with which he registered and, if the mobile dose not answer, extends the paging to neighboring beacons.

The main drawback of this method is the constraint for a user to register each time he moves. Nevertheless, this low ergonomic can be balanced by the low equipment and management costs of the network, which allow the operator to offer users attractive fees.

3.1.3 Use of Location Areas for Automatic Location Management

Presently, the location method most widely implemented in the first- and second-generation cellular system (NMT, GSM, IS-95, etc.) makes use of location areas

(LAs) (figure 3.1). In these wide-area radio networks, location management is done automatically.

Location areas allow the system to track the mobiles during their roaming in the

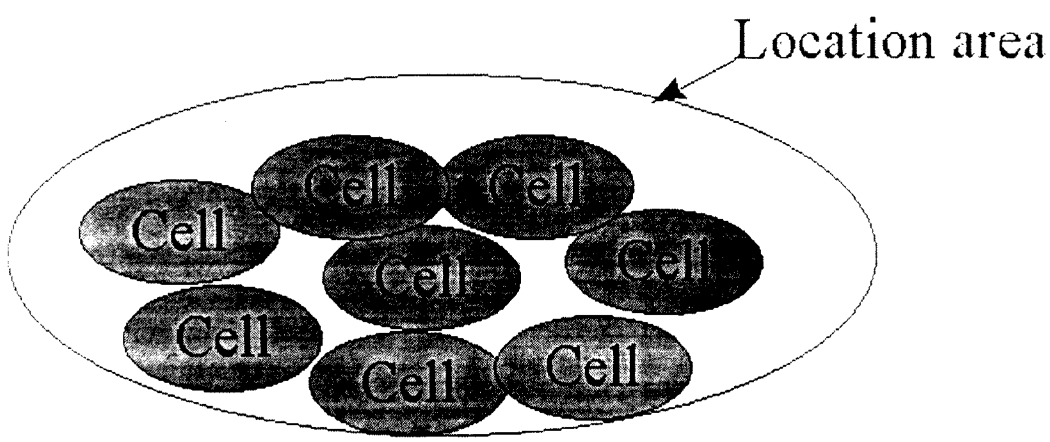


Figure 3.1 Location Area

networks: subscriber location is known if the system knows the LA in which the subscriber is located. When the system must establish a communication with the mobile, the paging only occurs in the current user LA. Thus, resource consumption is limited to this LA; paging messages are only transmitted in the cells of this particular LA.

Implementing LA-based methods requires the use of databases. Generally, a home database and several visitor databases are included in the network architecture. There are also several locations updating methods that can be implemented based on LA structuring.

3.1.3.1 Periodic location updating

This method is simplest because it just requires the mobile to periodically transmit its identity to the network. Its drawback is its resource consumption, which is user dependent and can be unnecessary if the user does not move from a LA for several hours. Generally, this method is combined with the next one.

3.1.3.2 Location updating on LA crossing

This method first requires each BS to periodically broadcast the identity of its LA. Second, the mobile is required to permanently listen to network broadcast information (on the broadcast channel) and to store the current LA identity. Of the received LA number differs from the stored one, a location update (LU) procedure is automatically triggered by the mobile.

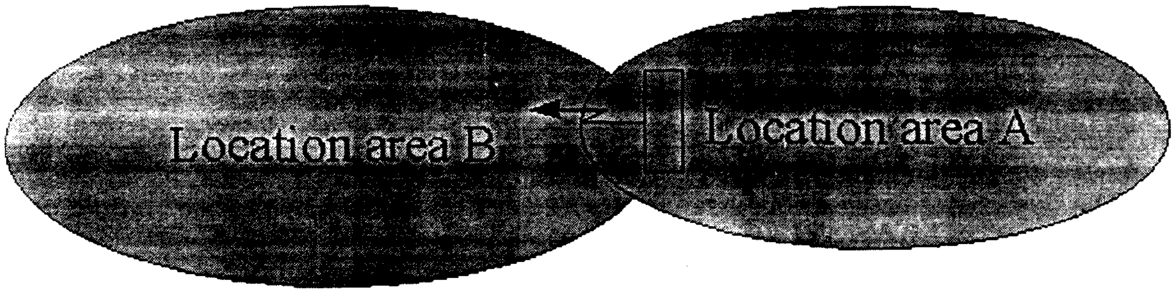


Figure 3.2 Location of Updating on LA corssing

The advantage of this method is that it only requires LUs when the mobile actually moves. A highly mobile user will generate a lot of LUs; a low mobility user will only trigger a few.

A **hybrid method** which combines the two previous ones can also be implemented. The mobile generates its LUs each time it detects a LA crossing. Nevertheless, if no communication (related to a LU or a call) has occurred between the mobile (in idle mode, i.e., powered on but not communicating) and the network for a fixed period, the mobile generates a LU. This periodic LU typically allows the system to recover user location data in case of a database failure.

3.1.4 GSM EXAMPLE

The GSM standard defines a database structure based on:

- An HLR (Home Location Register) where all subscriber related information is stored (access right, user location, etc.). Security parameters and algorithms are managed by the authentication center (AuC) which is often considered part of the HLR.
- Several VLRs. Each VLR stores part of the data regarding the users located in its related LAs.

The location management method defined in GSM combines the periodic LU method and the LU on the border crossing. The VLR stores the LA identifier, and the HLR stores the VLR identifier.

This consists of three main types of LU procedures: The intra-VLR LU, the inter_VLR LU using TMSI (temporary mobile subscriber identity), and the inter_VLR LU using IMSI (international mobile subscriber identity). A fourth one, the IMSI attach procedure, is triggered when the mobile is powered on in the LA where it was powered off.

In the following, we present the most complete LU, which is inter_VLR using MISI. This procedure mainly consists of the following steps:

- A signaling channel is allocated to the MS, and a LU is requested.
- The MS provides the network with its IMSI, which allows the new VLR (VKR2) to load authentication data from the HLR/AuC, mainly the triplets for the authentication and the ciphering procedures.

- The VLR is then able to authenticate the MS; if this step succeeds, it updates the location at the HLR. The HLR informs the old HLR (VLR1) to remove the user's data stored in VLR1.

- Ciphering may be required id available.

- A new TMSI is allocated to the MS, and . after acknowledgment of its LU request (first message sent by the MS), the channel finally released

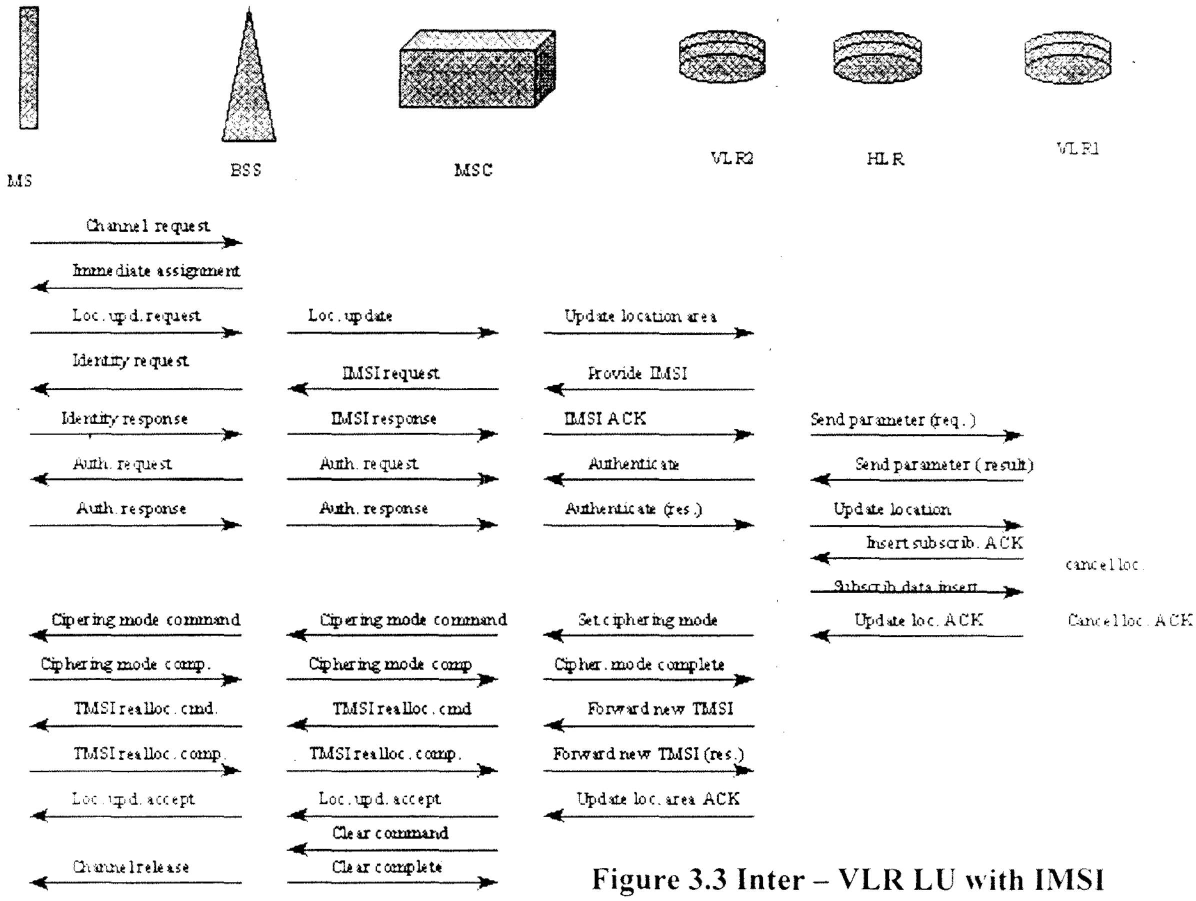


Figure 3.3 Inter – VLR LU with IMSI

3.2 Location Management methods for Cellular systems

We classifies the location management methods into two major groups (figure 5). In the first, We concludes all methods based on algorithms and network architecture, mainly on the processing capabilities of the system. The second group gathers the methods based on learning processes, which require the collection of statistics on users' mobility behavior, for instance. The second method emphasizes the information capabilities of the network.

3.2.1 Memory-less Methods

3.2.1.1 Database architecture

We divide into three cases:

- *Centralized database architecture*: presents an architecture where a unique centralized database is used. This is well suited to small and medium networks, typically based on a star topology.
- *Distributed database architecture*: uses several independent databases according to geographical proximity or service providers. It is best suited to large networks including subnetworks managed by different operators and service providers. The Cellular worldwide network, defined as the network made up of all interconnected Cellular networks in the world, can be such an example of a large network. The main drawbacks of this architecture are clearly the cost of database system acquisition, implementation, and management.
- *Hybrid database architecture*: combines the centralized and distributed architectures. In this case, a central database (HLR-like) is used to store all

user information. Other small databases (VLR-like) are distributed all over the network. These VLR databases store portions of HLR user records.

3.2.1.2 Optimizing fixed network architecture

In second-generation cellular networks and third-generation systems, signaling is managed by the intelligent network (IN). Appropriately organizing mobility functions and entities can help reduce the signaling burden at the network site. The main advantage of these propositions is that they allow us to reduce the network mobility costs independent of the radio interface and LA organization. For example, it is proposed to use different degrees of decentralization of the control functions. Thus, using adapted signaling network nodes, interconnection allows mobility costs to be reduced.

3.2.1.3 Combining location areas and paging areas

In current systems, a LA is defined as both an area in which to locate a user and an area in which to page him. LA size optimization is therefore achieved by taking into account two antagonistic procedures, locating and paging. Based on this observation, several proposals have defined location management procedures, which make use of LAs and paging areas (PAs) of different sizes. One method often considered consists of splitting an LA into several PAs.

An subscriber station registers only once, that is, when it enters the LA. It does not register when moving between different PAs of the same LA. For an incoming call, paging messages will broadcast in the PAs according to a sequence determined by different strategies. For example, the first PA of the sequence can be the one where the subscriber station was last detected by the network. The drawback of this method is the possible delay increase due to large LAs

3.2.1.4 Multilayer LAs

In present location management methods, LU traffic is mainly concentrated in the cells of the LA border. Based on this observation and to overcome this problem, Okasaka has introduced the multilayer concept. In his method, each subscriber station is assigned to a given group, and each group is assigned one or several layers of LAs

According to figure 6, it is clear that group 1 and group 2 subscriber stations will not generate Lus in the same cells, thus allowing the LU traffic load to be distributed over the cells. Nevertheless, this location updating method, although it may help channel congestion, does not help reduce the overall signaling load generated by LUs.

3.2.2 Memory – Based Methods

The design of memory-based location management methods has been motivated by the fact that systems do a lot of repetitive actions, which can be avoided if predicted. This is particularly the case for LUs. Indeed, present cellular systems achieved everyday, at the same peak hours, almost the same LU processing. Systems act as memory-less processes. Short-term and long-term memory processes can help the system avoid these repetitive actions. Some methods have thus been proposed that be based on user and system behavior observation and statistics.

3.2.2.1 Short-term observation for dynamic LA and PA size

In current systems, the size of LAs is optimized according to mean parameter values, which in practical situations vary over a wide range during the day and from one user to another.

Based on this observation, it is proposed to manage user location by defining multilevel Lass in a hierarchical cellular structure. At each level the LA size is different, and a cell belongs to different LAs of different sizes. According to past and present subscriber station mobility behavior, the scheme dynamically changes the hierarchical level of the LA to which the subscriber station register. LU savings can thus be obtained.

A variant of this strategy requires from mobiles to register in the cells where they are camped on. Registrations involve a periodic timer which value has to be optimized. Thus rather than paging a mobile in all cells of a LA, the mobile will be paged only in the cells visited during the last period: these are cells the mobile camped on during its traversal of the LA.

Adapting the LA size to each user parameter values may be difficult to manage in practical situations. This led to definition of a method where the LAs sizes are dynamically adjusted for the whole population, not per user as in the previous method. Statistical information about users and mobility in the network is collected in databases and computed. Networks characteristics in function of time, place, density, and so on are thus evaluated. Results of this computation allow the network to dynamically (daily, weekly, monthly, yearly.) adjust LAs sizes. For instance, during the day, when call rates are high, it is preferable to deal with small LAs. Conversely, at night the call rate is much lower, and therefore larger LAs are better.

3.2.2.2 Individual user patterns

Observing that users show repetitive mobility patterns, the alternative strategy (AS) is defined; its main goal is to reduce the traffic related to mobility management - thus, reduce the LUs - by taking advantage of users highly predictable patterns. In AS, the system handles a profile recording the most probable mobility patterns of each user. The profile of the user can be provided and updated manually by the subscriber himself or determined automatically by monitoring the subscriber's movements over period of time.

The main savings allowed by this method are due to the non-triggered LUs when the user keeps moving inside his profile LAs. So, the more predictable the users' mobility, the lower the mobility management cost.

A variant of this method, called the Two-Location Algorithm (TLA), is proposed and studied. In this strategy, a mobile stores the two most recently visited LA addresses. The same is done at the HLR level. Obviously, the main advantage of this method relies on the reduction of LUs when a mobile goes back and forth between two LAs.

3.2.2.3 Predicting short-term movements of the subscriber

The method uses a process, which predicts the movements of the subscriber station according to its direction, velocity, and so on. Processing and prediction are made at both the subscriber station and the HLR. When actual movements of the subscriber station do not fit with those predicted, a registration is triggered by the mobile to inform the network of its actual location. Otherwise, no exchange is required, which allows savings in LU processing and signaling.

3.2.2.4 Mobility statistics

A mobility management method similar to AS is defined. It is called Statistical Paging Area Selection (SPAS) and is based on location statistics collected by each MS, which periodically reports them to the network. These statistics consist of a list of the average duration the MS had been located in each LA. A priority rule is determined to settle the sequence of LAs visited by the mobile. If this sequence id different from the last one reported to the network, the MS transmits it; otherwise, nothing is done. The paging process is achieved in the same way as in AS. When the subscriber station moves to an area that is not on the reported list, it has to process a temporary location registration to the network.

CHAPTER 4

Handover

Handover is the mechanism that transfers an ongoing call from one cell to another as a user moves through the coverage area of a cellular system. As smaller cells are deployed to meet the demands for increased capacity, the number of cell boundary crossings increases. Each handover requires network resources to reroute the call to the new base station. Minimizing the expected number of handovers minimizes the switching load. Another concern is delay. If handover does not occur quickly, the quality of service (QoS) may degenerate below an acceptable level. Minimizing delay also minimizes co-channel interference. During the handover there is a brief service interruption. As the frequency of these interruptions increases the perceived QoS is reduced. The chances of dropping a call due to factors such as the availability of channels increase with the number of handover attempts. The handover process may also involve reregistration and authentication of the terminal. Handovers can be classified as follows :

1.Soft Handover

2.Hard Handover

Soft Handover : it occurs when the mobile terminal communication is passed to the target radio port without interrupting communications with the current serving radio port. In a soft handover, the mobile terminal communicates with two radio ports simultaneously, with the signals from the radio ports to the terminal treated as multipath signals that are coherently combined at the mobile.

Hard Handover : it occurs when the communications to the mobile terminal is passed between disjoined radio systems, different frequency assignment, or different air interface characteristics or technologies. A hard handover is a "break-before-make" process at the air interface.

Whether a soft or hard handover can occur is air-interface-technology dependent. The handover process maintains the privacy of all calls in progress by a transfer of the session key from the source radio port to the target radio port. The encryption key may remain unchanged at handover.

The handover process may be network directed ,terminal assisted. or terminal directed. The handover process may be initiated by the network upon determination that the quality of the radio connection has deteriorated or for management purpose. The quality of the radio connection may be assessed either from network measurements or from measurements provided by the terminal. In addition, the terminal, making its own measurements may specifically request that a handover take place.The handover execution process requires coordination of functionally contained in various network elements. The management occurs at three relative layers.

1. Execution management of handover occurs when the resources needed for handover are all within the scope of specific elements ability to control.
2. Higher-level requests occur when the resources needed for the handover are beyond the scope of the current elements ability, and control should be passed on to an element placed higher in the network to execute the task.The handover request information is passed on to the higher-level entity, which either performs the

execution of the handover or determines that's a still higher-level functionality is required.

3. Peer-level requests occur when an element determines that management of resources is shared within the same level of the network.No special functionality is required of elements placed at a higher level in the network, but information is transferred between peer elements. The functional capability may be used in conjunction with or in place of higher-level request capability.

The handover process consists of the following steps :

1. **Initiation :** Either the mobile terminal or network identifies the need for a handover and alerts the necessary network elements.
2. **Resource reservation :** The appropriate network elements reserve the resources necessary to support the handover.
3. **Execution :** The actual handover connection of the network resources takes place.
4. **Completion :** Any unneeded network resources are freed, and access signals are exchanged following a successful handover.

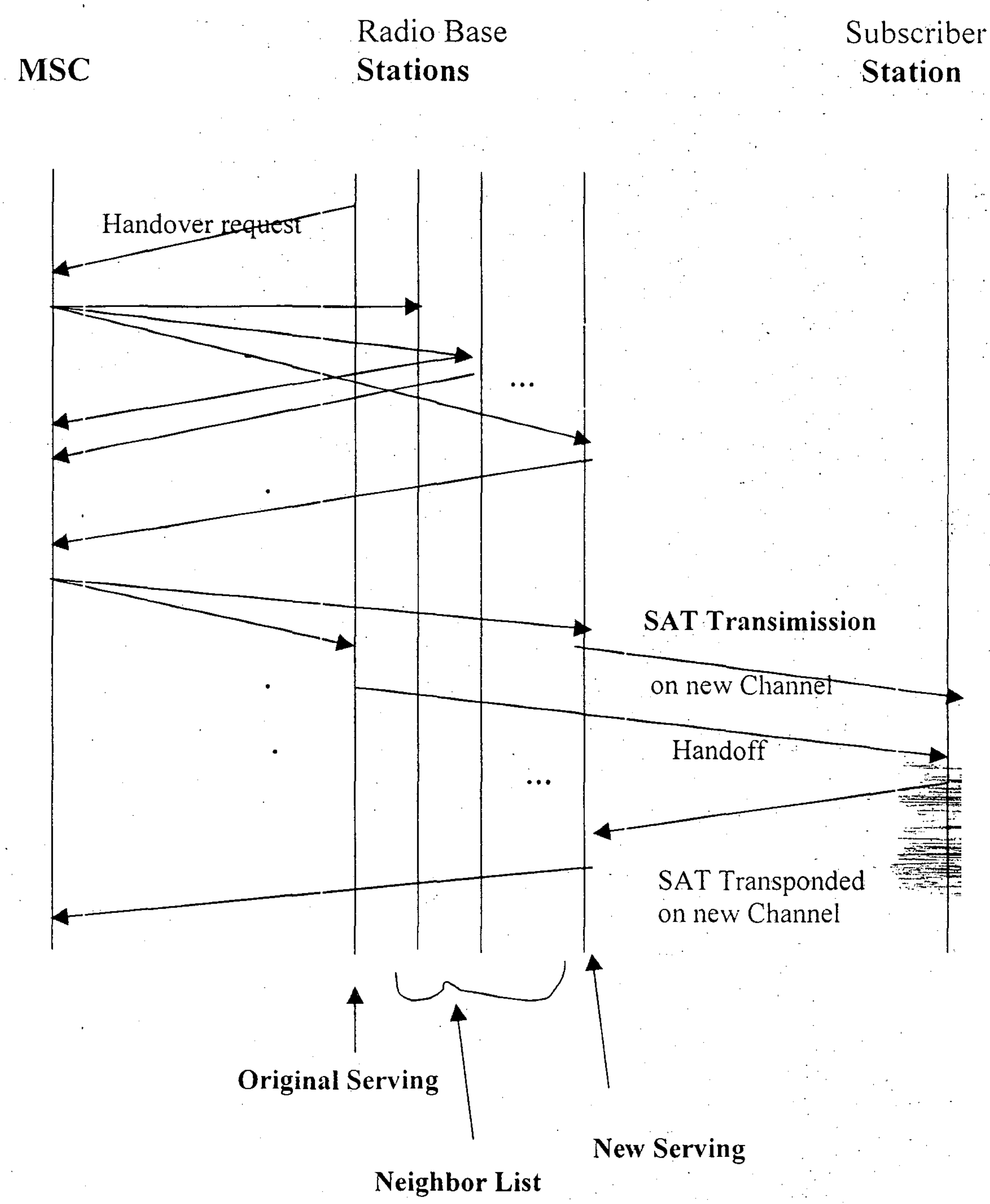
Four different types of handovers can be distinguished:

- Handover of channels in the same cell.
- Handover of cells controlled by the same BSC.
- Handover of cells belonging to the same MSC but controlled by different BSCs.
- Handover of cells controlled by different MSCs.

Handovers are mainly controlled by the MSC. However in order to avoid unnecessary signaling information, the first two types of handovers are managed by the concerned BSC (in this case, the MSC is only notified of the handover).

4.1 Cell to Cell Handover :

To decide when it is appropriate to handover a call, is to monitor average received



Radio Base Stations

Fig. 4.1 Message Sequence for Cell to Cell Handover

signal power at the radio base station on which the call is operating, and when it falls below some predetermined threshold, initiate a handover. To perform the handover, the MSC needs to know which base station has the best signal quality for this subscriber station. It sends a measurement request to potential candidate radio base stations, which are the radio base stations that the system operator has previously determined to be neighbors of the base station that is currently supporting the call. These radio base stations have dedicated measurement receivers that respond to the measurement request by tuning to the channel that the call in question is using and measuring the average received power on that channel. These measurements are reported back to the MSC, which then decides if any of the radio base stations have sufficiently high received signal to support the call, and if so, which one has the highest signal strength. The MSC then checks to see if any channels are available in the chosen radio base station, sets up a circuit to the new radio base station, tells the new radio base station to turn on its transmitter for the channel to which the call is to be handed over, and sends a handover order to the subscriber station. The subscriber station then tunes to the new channel and proceeds to communicate with the new radio base station.

4.2 Domain to Domain Handover :

When the cellular systems determines that a handover is required in an attempt to maintain the desired signal quality of the radio link. The signal quality is constantly monitored by the cellular systems and base station subsystem and the base station may optionally forward its own measurements to the cellular systems. Domain to Domain Handover is performed as follows. The cellular system determines that a handover is required. It sends the STRN_MEAS message to the serving BSS. This message contains the signal strength measurements. The serving BSS sends a HAND_REQ message to the MSC. This message contains a rank-ordered list of the target BSSs that are qualified to receive the call. The MSC reviews the global cell identity associated with the best candidate to detemine if one of the BSSs that it controls is responsible for the cell area. In this scenario the MSC determines that the cell area is associated with the target BSS. To perform an domain to domain handover, two resources are required : a trunk between the MSC and the target BSS, and a radio traffic channel in the new cell area. The MSC reserves a trunk and sends a HAND_REQ message to the target BSS. This message includes the desired cell area for handover, the identity of the MSC-BSS trunk that was reserved, and the encryption key. The target BSS selects and reserves the appropriate resources to support the handover pending the connection execution. The target BSS sends an acknowledgment to the MSC (HAND_REQ_ACK). The message contains the new radio channel identification. The MSC sends the HAND_COMM message to the serving BSS. In this message the new radio channel identification supplied by the target BSS is included. The serving BSS forwards the HAND_COMM message to the cellular systems. The cellular systems returns to the new radio channel and sends the HAND_ACC message to the target BSS on the new radio channel. The target BSS sends the CHH_INFO message to the cellular systems. The target BSS informs the MSC when its begins detecting the mobile handingover. The target BSS and the cellular systems exchange messages to synchronize/align the cellular systems transmission in the proper time slot. On completion, the cellular systems sends the HAND_COMP message to the target BSS. At this point the MSC switches the voice path to the target BSS. Once the cellular systems and target BSS synchronize their transmission and establish a new

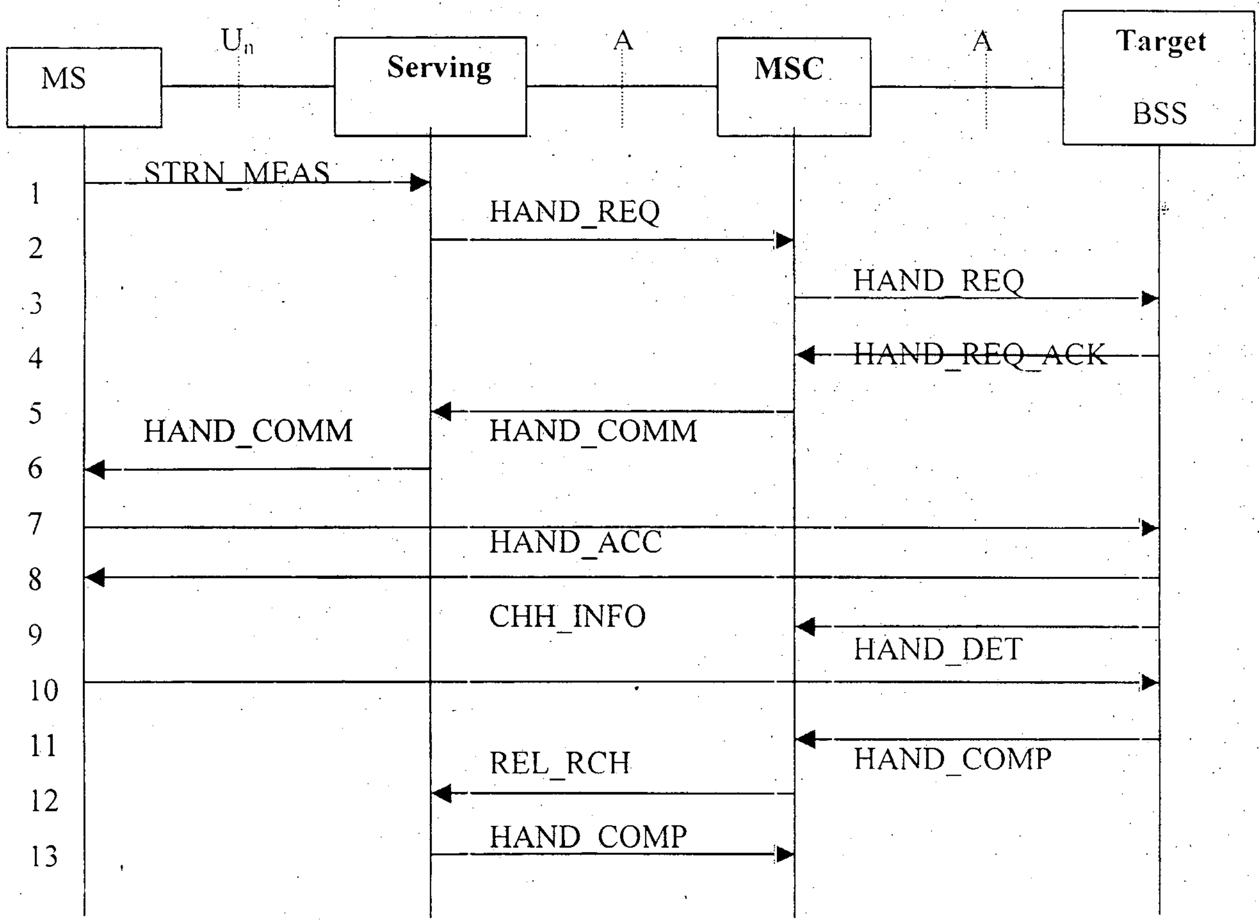


Fig 4.2 Message Sequence for Domain to Domain Handover

signaling connection, the target BSS sends the MSC the HAND_COMP message to indicate that the handover is successfully completed. The MSC sends the REL_RCH message to the serving BSS to release the old radio traffic channel. At this point the serving BSS frees up all resources with the cellular systems and sends the REL_RCH_COMP message to the MSC.

4.3 Subnet to Subnet Handover

In this scenario we assume that a call has already been established. The serving BSS is connected to the serving MSC and the target BSS to the target MSC. Subnet to Subnet handover procedure is as follows :The cellular system determines that a handover is required. It sends the STRN_MEAS message to the serving BSS. This message contains the signal strength measurements. The serving BSS sends a HANS_REQ message to the MSC. This message contains a rank-ordered list of the target BSSs that are qualified to receive the call. When a call is handed over from the serving MSC to the target MSC via PSTN, the serving MSC sets up an inter-MSC voice connection by placing a call to the directory number that belongs to the target MSC. When the serving MSC places this call, the PSTN is unaware that the call is a handover and follows the normal call routing procedures and delivers the call to the target MSC. The target MSC sends a HAND_NUM message to its VLR to assign the TMSI. The target VLR sends the TMSI in the HAND_NUM_COMP message. The MSC reviews the global cell identity associated with the best candidate to detemine if one of the BSSs that it controls is responsible for the cell area. In this scenario the MSC determines that the cell area is associated with the target BSS. To perform an domain to domain handover, two

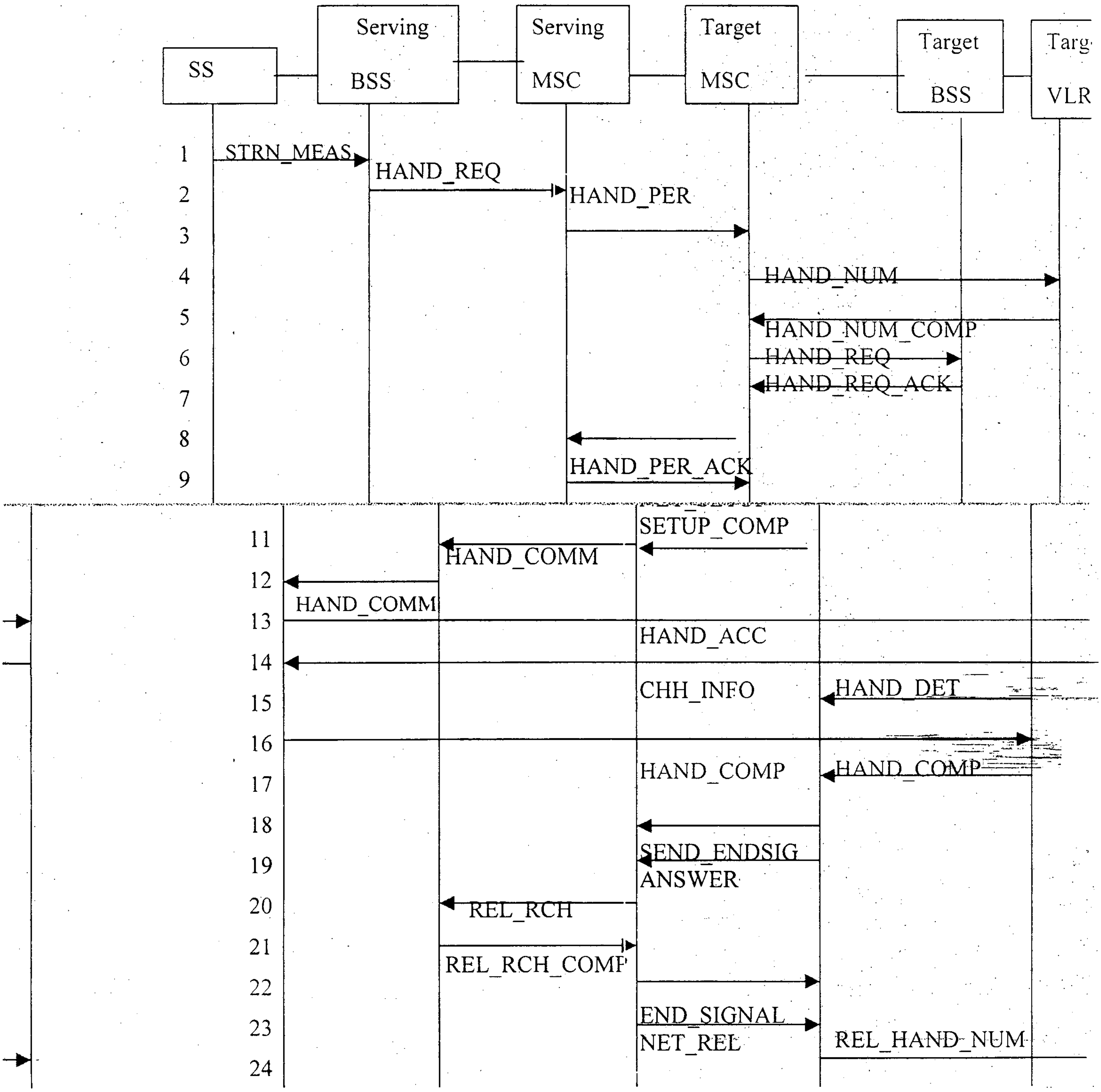


Fig. 4.3 Message Sequence for Subnet to Subnet Handover

resources are required : a trunk between the MSC and the target BSS, and a radio traffic channel in the new cell area. The MSC reserves a trunk and sends a HAND_REQ message to the target BSS. This message includes the desired cell area for handover, the identity of the MSC-BSS trunk that was reserved, and the encryption key. The target BSS selects and reserves the appropriate resources to support the handover pending the connection execution. The target BSS sends an acknowledgment to the MSC (HAND_REQ_ACK). The message contains the new radio channel identification. The target MSC sends the HAND_PER_ACK message to the serving MSC indicating that it is ready for the handover. The serving MSC sends the NET_SETUP message to the target MSC to set up for the call. The target MSC acknowledges this message with a SETUP_COMP message to the serving MSC. The MSC sends the HAND_COMM message to the serving BSS. In this message the new radio channel identification supplied by the target BSS is included. The serving BSS forwards the HAND_COMM message to the cellular systems. The cellular systems returns to the new radio channel and sends the HAND_ACC message to the target BSS on the new radio channel. The target BSS sends the CHH_INFO message to the cellular systems. The target BSS informs the MSC when its begins detecting the mobile handingover. The target BSS and the cellular systems exchange messages to synchronize/align the cellular systems transmission in the proper time slot. On completion, the cellular systems sends the HAND_COMP message to the target BSS. At this point the MSC switches the voice path to the target BSS. Once the cellular systems and target BSS synchronize their transmission and establish a new signaling connection, the target BSS sends the MSC the

HAND_COMP message to indicate that the handover is successfully completed. At this point the handover has been completed, the target MSC sends the SEND_ENDSIG message to the serving MSC. The cellular retunes to the new radio channel. A new voice path is set up between the cellular systems and the target BSS. The target MSC sends an ANSWER message to the serving MSC. The MSC sends the REL_RCH message to the serving BSS to release the old radio traffic channel. At this point the serving BSS frees up all resources with the cellular systems and sends the REL_RCH_COMP message to the MSC. The serving MSC sends the END_SIGNAL message to the target MSC. The serving MSC releases the network resources and sends the NET_REL message to the target MSC. The target MSC sends the REL_HAND_NUM message to its VLR to release the connection.

The mobile station is the active participant in these procedures. In order to perform the handover, the mobile station controls continuously its own signal strength and the signal strength of the neighboring cells. The list of cells that must be monitored by the mobile station is given by the base station. The power measurements allow to decide which is the best cell in order to maintain the quality of the communication link. Two basic algorithms are used for the handover :

- The minimum acceptable performance' algorithm gives precedence to power control over handover, so that when the signal degrades beyond a certain point, the power level of the mobile is increased. If further power increases do not improve the signal, then a handover is considered. This is the simpler and more common method, but it creates 'smeared' cell boundaries when a mobile transmitting at peak power goes some distance beyond its original cell boundaries into another cell. When the quality of the transmission decreases (i.e. the signal is deteriorated), the power level of the mobile is increased. This is done until the increase of the power level has no effect on the quality of the signal. When this happens, a handover is performed.

The `power budget' algorithm uses handover to try to maintain or improve a certain level of signal quality at the same or lower power level. It thus gives precedence to handover over power control. It avoids the 'smeared' cell boundary problem and reduces co-channel interference, but it is quite complicated. This algorithm performs a handover, instead of continuously increasing the power level, in order to obtain a good communication quality.

4.4 Suggested Handover Scheme in mobility management in cellular systems

Since the users movements can produce the need to change the channel or cell, specially when quality of the communication is decreasing. This procedure of changing the resource is called handover. Handover are mainly controlled by MSC. Subscriber stations is the active participants in the procedure. This when a subscriber station removes into the radio propagation coverage of different base station, the handover protocol will re-determine the connection route. Basically handover protocols is composed of three basic steps :-

(a) Selecting interactive switching and setting up new connection segment from interactive switching to the BSC/MSC.

(b) Mapping the data path of interactive switching into the new connection segment on the premise of no-cell-loss optimization.

(c) When subscribers stations from a new BSC/MSC.

We.can suggest here three handovers schemes for the handover.

(i) Partial path Rerouting Scheme :- The basic idea of this scheme is to delete partial existing connections, and add some new paths; moving subscribes stations. For example – if moving from one BSC/MSC to another BSC/MSC then delete partial connections from subscriber station related with first BSC/MSC and extend the remainder of connections to another BSC/MSC.

(ii) Path Splicing :- The basic idea of partial path rerouting scheme is based on BSC/MSC, not on the subscriber station. This scheme makes subscribers station send a trans-area request to the first BSC/MSC where it is, requesting the second BSC/MSC to join in the trans area operating. First BSC/MSC, using the adjacent area trans area control setup in advance, transfers this request to second BSC/MSC which first implements local calls permit control and authorizes wireless link, and, according to the quality of service parameters in the trans-area request, to splice into a new path from subscriber station to second BSC/MSC.

(iii) Path Extension Scheme - After handover operating, new route is from subscribers stations to first BSC/MSC and extend from first BSC/MSC to second BSC/MSC. This scheme needs no interactive switching search step and multiplexes the existing paths to a maximum extent.

The signaling used in handovers schemes are as follows :-

(i) Handover request / response

(ii) Handover confirm / complete

(iii) Handover join / complete.

Handover Request - The function of handover request is to select interactive exchange, set new path, let subscriber station send out handover request through existing BSC/MSC to start handover operating.

Handover Response - The function of handover response is to connect to new BSC/MSC, new subpath and marks that new path has got ready.

Handover confirm - The function of handover confirm is to notify new exchange that it may use the new path. Subscribers stations notifies existing ports to prepare to transform to new BSC/MSC. Then subscribers stations should stop cell transmission to the existing BSC/MSC and the send the cell to the interactive exchange connecting new path.

Handover Confirm/Complete - The function of handover confirm conplete is to respond to handover confirm and release old path, transmit handover confirm from interactive exchange to existing BSC/MSC, release the interactive exchange to the path segment of BSC/MSC , then to subscriber stations. It means that subscribers stations can be handed over to new BSC/MSC.

Handover Joint - The function of handover joint is to setup the new link for new BSC/MSC and complete the terminal – terminal connecting path. Once subscribers stations receive handover confirmation message for each connection, it changes to the new operating frequencies, the new BSC/MSC assigns, and then transmit handover joint the new BSC/MSC port to constitute a signaling loop.

Handover Join complete - The function of the handover join complete is to constitute data path on a subscribers channel.

Conclusion

In mobile radio networks, the nature of the radio channel and the mobility of subscribers are the dominant factors affecting routing. This dissertation presented the mobility specific functions needed in cellular systems. We have discussed the implications of these factors, and presented the general cellular system architecture. Next we concentrated on the routing problems of locating and tracking subscribers and maintaining calls during subscribers movement. The implementation of the mobility function is strongly dependent on the cellular system infrastructure. We have discussed location updating and location management and cell to cell handover, domain to domain handover and subnet to subnet handover for mobility of subscriber stations inside these and suggested three handover schemes for mobility management.

References

1 Design and analysis of low power accesss protocol for wireless and mobile networks.WIRELESS NETWORKS volume 6 (2000) No. 1, published February 2000.

2 Dimitri Bertsekas, Robert Gallager "Data Networks Prentice hall Inc." New Jersey 1987.

3 D.Comer, Internetworking with TCP/IP, Volume I: Principles,Protocols and Architecture, 2nd ed, Englewood clilff : Prentice Hall, 1991.

4 David M. Balston. The pan-European cellular technology. In R.C.V. Macario, editor, Personal and Mobile Radio Systems. Peter Peregrinus, London, 1991.

5 J. Das "Review of Digital Communication - 'state of the art' in Digital Signalling, Digital Switching and Data Networks. " Wiley Eastern Ltd. Publication 1988

6 John M. Griffiths. ISDN Explained: Worldwide Network and Applications Technology. John Wiley &Sons, Chichester, 2nd edition, 1992.

7 M. Rahnema, "Overview of the GSM System and Protocol Architecture," IEEE Communications, vol. 31, no. 4, pp. 92-100, April 1993.

8 On Demand Multicast Routing Protocol in Multihop Wireless Networks IEEE NETWORKS January 2000, Vol. 14 No. 1.

9 R. Johannesson and K. Sh. Zigangirov, Fundamentals of Convolutional Codes, IEEE Press, 1999.

10 S. Keshav "An Engineering Approach to Computer Networking" AT & T Labs Research , Addison Wesley Second Addition 2000.

11 S.Chen and K.Nahrstedt, " An Overview of quality of Service Routing for generation High Speed Networks : Problems and Solution ", IEEE NETWORK, Nov/Dec 1998.

12 Seshadri Mohan and Ravi Jain. Two user location strategies for personal communication services. IEEE Personal Communications, 1(1), 1994.

13 Vijay K. Garg, Joseph E. Wilkes, "Wireless And Personal Communications Systems "AT &T Company, Bell Labs Division, Prentice Hall Publication 1996

14 W.C.Y.Lee, “Mobile Cellular Telecommunication Systems ”, New York: McGraw-Hill, 1987.

15 W.C.Y.Lee, “Mobile Communication Engineering ”, New York: McGraw-Hill, 1987.

16 Yu – Liang Chang and Ching – Chi Hus. “ Routing in wireless / mobile ad-hoc networks; in : mobile networks and applications, Baltzer science publication (April 2000) Volume – 5.