Chapter one
Introduction

1.1 Background History

Mobile telephones became very popular in the late nineties and are today an important tool for many people. Our way of life demands more and more mobility and availability.

One of the most important technologies used for mobile telephone networks today is the Global System for Mobile communication (GSM) technology. The first GSM networks were rolled out during the early nineties and therefore are quite old today. Several newer and far more advanced technologies have been invented since then and some are almost ready to be rolled out. It is very unlikely that modern mobile telephone networks are going to replace GSM completely within the next decade.

A long period of interoperability must be expected. The cost of rolling out a new network is enormous; this requires the new technologies to be able to cooperate with the existing GSM networks in order to achieve an acceptable coverage.

The functionality to ensure acceptable quality of a call, when the person using the mobile phone, is called handover. Handover transfers the call transparently from one stationary antenna to another during the call, when the quality of the transmitted data decreases.

Our work is focused on handovers within GSM networks. We started with a joint project on designing a handover mechanism between GSM and a different radio based network. To be able to design such a handover, we started out with an investigation of handover within GSM networks. This investigation turned out to be far more complex than expected, and we decided to limit our research to GSM exclusively.

Because the GSM equipment required to perform a real handover, is huge and expensive, and because gaining access to real operators' networks is impossible, we have decided to base our research on a model of a GSM network. Through simulations and analysis of the model, we will be able to investigate the behaviour of a GSM handover. The model has the advantage of being as abstract as we need compared to real system. This allows us to concentrate our work on the actual handover and not spend our time on mangling with the bits of a real system.

1.2 Problems Definition

The old system of mobile has been used in limited channels to use by limited customers and when the customer get out of the cellular coverage area range and inter another one the call is dropped this action increased the blocking probability.

The handover is a mechanism that transfers an ongoing call from one cell to another as the user move through the coverage area of cellular system, without dropping the call.

Also the reused of frequency increases the number of channels in the system and decreases the blocking probability.

1.3 Objectives

The specific objectives of the project are to conduct a practical work:

❖ This project aims to study and analyze the internal and external handover in real data case.

❖ Planning algorithms by flowchart and execute it by a computer program to simulate handover algorithm.

❖ Evaluate the performance of the handling process

1.4 Paging

An antenna or satellite broadcasts short messages to subscribers. Receivers are usually devices such as beepers, which display messages on a small screen. Transmission of data is one-way. Paging systems are designed to provide reliable communication to subscribers wherever they are. This necessitates high-powered transmitters and low data rates for maximum coverage of each transmitter's designated area

It is a process of broadcasting a message which alerts a specific mobile to take some action, for example if there is an incoming call to be received? If the system does not know the precise cell in which a mobile is located it must perform paging in a number of cells

1.5 Roaming

Roaming is a general term that refers to the extending of connectivity service in a location that is different from the home location where the service was registered. Roaming ensures that the wireless device keeps connected to the network, without losing the connection. The term "roaming" originates from the GSM , the term "roaming" can also be applied to the CDMA technology, see CDMA Roaming. Traditional GSM Roaming is defined as the ability for a cellular 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 done by using a communication terminal or else just by using the subscriber identity in the visited network. Roaming is technically supported by mobility management, authentication, authorization and billing procedures.

1.6 Handover

The Handover procedure is probably the most important procedure to ensure the mobility of the MS during calls. The purpose of the procedure is to preserve ongoing calls, when moving from one cell to another. The presence of an ongoing call gives rise to time criticality of the processing.

The decision whether to perform the handover, is made by the serving BSC, which has no direct knowledge of the radio quality. In order to decide whether to initiate a handover, the BSC receives information about the radio link quality from the BTS and the MS. During a call, the MS periodically sends measurement results to the BTS. The measurement results contain measurements of the radio signal quality of the downlink (from the BTS to the MS) of the call and up to five neighbouring cells. The serving BTS measures the uplink (from the MS to the BTS) radio signal quality of the call and forwards the measurement result from the MS, together with its own measurements, to the BSC in a measurement report. From the information in the measurement reports, the BSC is able to decide whether a handover to another cell is needed. The algorithm to decide whether to perform a handover or not is not specified in the recommendations — it is considered to be operator dependant. This algorithm is not investigated in our work, because our work starts when the decision has been made.

There are different kinds of handovers, which involves different parts of the network. Changing cells within the same BTS is not as complex as changing cells belonging to different MSCs. In the following sections the different kinds of handover are discussed. They are listed in increasing complexity: Intra-cell/BTS, Intra-BSC, Intra-MSC and finally Inter-MSC.

1.7 Thesis structure

The thesis is structured in the following way:

Chapter 1: Introduction introduces the project, we present in this master's thesis. It contains Introduction, Technology Development Background, problems statements, and objectives.

Chapter 2: cellular system, and its generation. And Deals with the structure of the cellular system

Chapter 3: GSM Introduction describes the basics of the GSM networks. The chapter introduces the general concepts of the network: Its functionality, logical, and physical architecture.

Chapter 4: Discusses the process of handover and its types.

Chapter 5: Handover algorithms handling in mobile communication systems with

an explanation of these algorithms and analysis, planning, implementation and test results.

Chapter 6: Discusses the research, conclusion, make some limitations and recommendations

Chapter tow

Cellular System

2.1 Cellular Networks

Cellular technology has acquired over three generations since 1979, when the first national Cellular network was congenital in Japan. Each generation uses spectrum more competently, therefore adding more subscribers who can generate more cash flow for a carrier,(see figure 2.1).

The first generation (1G) cellular was only analog and used completely for voice calls. The second generation (2G) is a digital network and also provides some data services. The third generation (3G) cellular network allows high-speed data with voice. One generation doesn't clean off the previous generation; somewhat, a 2G tower operates next to a 1G tower operating at an altered part of the spectrum. But it takes time to install new hardware, cellular devices has been made to fall back to use the old generation network.

The service features in almost all networks include air interface standards, and spectrum allocated. However, 3G network features involve packet switched data, transparent roaming services, broadcast quality sound/video. [1]

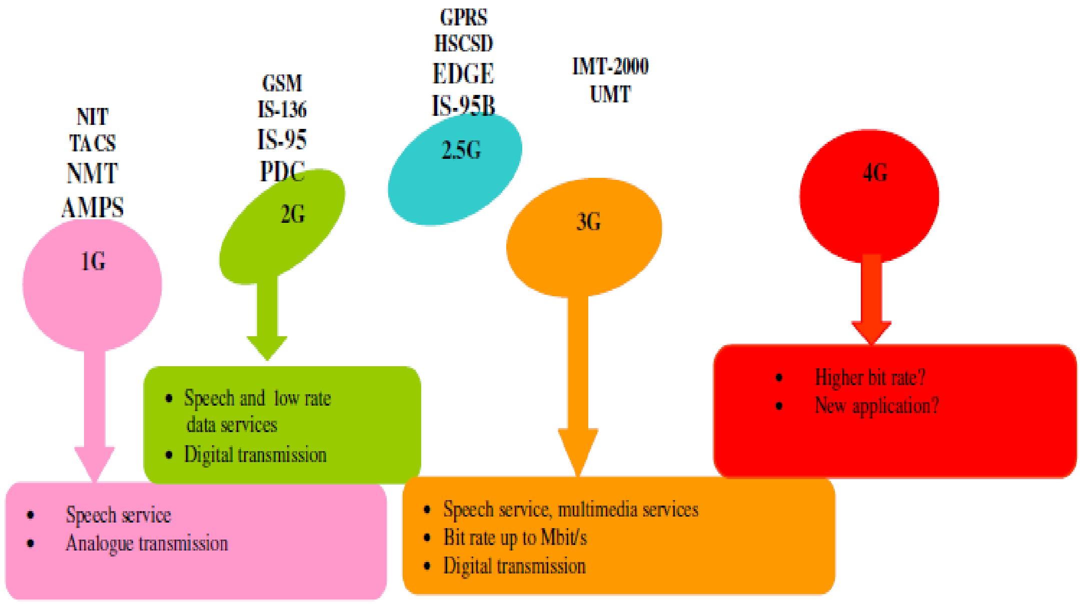

Figure 2.1 Generation Mobile Networks

2.1.1 First Generation Mobile Networks

AMPS (Analog mobile phone system) are the 1st generation for this technology; this technology was found on analog signals. These analog signals travel like a waveform. These waves are generated by mobile device from transmitting ends in mobile networks which means from one base station where it proceeds to decide the next target of the signal. At the last when the signal has reached its final target then base station again restore the signal, most likely try to reconstruct in its original shape for further proceeding.

2.1.2 Second Generation Mobile Networks

The main Advantages of 2G (2nd Generation) Mobile networks over their previous sections were:

- Mobile phone conversations were digitally encrypted
- 2G mobile systems were more reliable & efficient on the spectrum allowing for far greater mobile phone penetration levels & signals.
- 2G also introduced Value added services & data services for mobile to make a start with SMS text messages.

2.1.3 Third Generation Mobile Networks

Past communication was mostly depending only on 2G but as technology is going to be advance, there was an introduction of latest technology such as Wireless Internet access (Wi-Fi and video telephony which require universal standards at higher user bit rates. Diagram shows the bit rate requirements for some of the function that are predicated for 3G networks. Most of the new services require bit rates up to 2 M bit/s.

2.2 Cellular Concept

A cellular network is a radio network made up of a number of radio cells (or just cells) each served by at least one fixed-location transceiver known as a cell site or base station. These cells cover different land areas to provide radio coverage over a wider area than the area of one cell, so that a variable number of portable transceivers can be used in any one cell and moved through more than one cell during transmission.

Cellular networks offer a number of advantages over alternative solutions:

- increased capacity
- reduced power usage
- larger coverage area
- reduced interference from other signals

Cellular systems are widely used today and cellular technology needs to offer very efficient use of the available frequency spectrum. With billions of mobile phones in use around the globe today, it is necessary to re-use the available frequencies many times over without mutual interference of one cell phone to another.

2.3 Cellular System Architecture

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 on 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 kilometres as they are limited 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 from the covering area of an operator. Frequencies used in a cell using the same frequency must be sufficient to avoid interference. The frequency reuse will increase considerably the capacity in number of users.

2.3.1 Cells

A cell is the basic geographic unit of a cellular system. The term cellular comes from the honeycomb shape of the areas into which a coverage region is divided. Cells are base stations transmitting over small geographic areas that are represented as hexagons. Each cell size varies depending on the landscape. Because of constraints imposed by natural terrain and man-made structures, the true shape of cells is not a perfect hexagon. Basic service area that can be efficiently managed by the network, cell boundaries are defined by BS signal strength.

Possible cell shape representation (see figure 2.2);

❖ Circles
❖ Equilateral triangles.
❖ Squares
❖ Hexagon

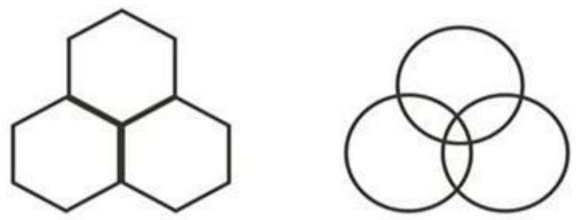

Figure 2.2 Cell shape

2.3.2 Cell size

Even though the number of cells in a cluster in a cellular system can help govern the number of users that can be accommodated, by making all the cells smaller it is possible to increase the overall capacity of the cellular system. However a greater number of transmitter receiver or base stations are required if cells are made smaller and this increases the cost to the operator.

The different types of cells are given different names according to their size and function:

- **Macro cells**: Macro cells are large cells that are usually used for remote or sparsely populated areas. These may be 10 km or possibly more in diameter.
- **Micro cells**: Micro cells are those that are normally found in densely populated areas which may have a diameter of around 1 km.
- **Pico cells**: Pico cells are generally used for covering very small areas such as particular areas of buildings, or possibly tunnels where coverage from a larger cell in the cellular system is not possible. Obviously for the small cells, the power levels used by the base stations are much lower and the antennas are not position to cover wide areas.
- **Selective cells**: Sometimes cells termed selective cells may be used where full 360 degree coverage is not required. They may be used to fill in a hole in the coverage in the cellular system, or to address a problem such as the entrance to a tunnel etc.
- **Umbrella cells**: Another type of cells known as an umbrella cell is sometimes used in instances such as those where a heavily used road crosses an area where there are micro cells. Under normal circumstances this would result in a large number of handovers as people driving along the road would quickly cross the micro cells. An umbrella cell would take in the coverage of the micro cells (but use different channels to those allocated to the micro cells).

2.3.3 Cell clusters

A cluster is the group of adjacent cells using the complete set of available frequencies. Cluster size N: is the number of cell in a cell cluster.

It is necessary to limit the interference between cells having the same frequency. The topology of the cell configuration has a large impact on this. The larger the number of cells in the cluster, the greater the distance between cells sharing the same frequencies.

In the ideal world it might be good to choose a large number of cells to be in each cluster. Unfortunately there are only a limited number of channels available. This means that the larger the number of cells in a cluster, the smaller the number available to each cell, and this reduces the capacity. [2]

Often these clusters contain seven cells, but other configurations are also possible. Seven is a convenient number, but there are a number of conflicting requirements that need to be balanced when choosing the number of cells in a cluster for a cellular system, (see figure 2.3).

- Limiting interference levels
- Number of channels that can be allocated to each cell site

No channels are reused within a cluster.

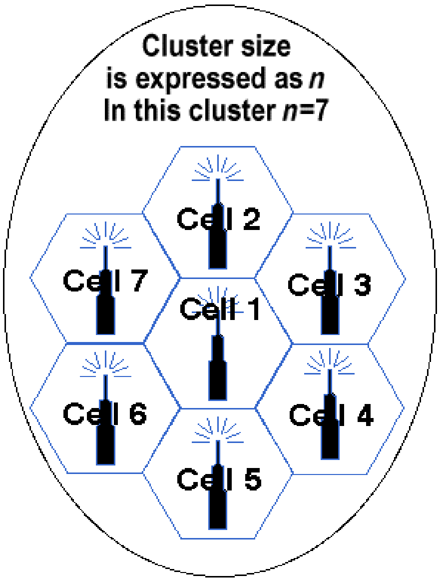

Figure 2.3 illustrates a seven-Cell Cluster

2.3.4 Cell Splitting

Cell splitting is the process of dividing the radio coverage of a cell site in a wireless telephone system into two or more new cell sites. Cell splitting may be performed to provide additional capacity within the region of the original cell site, (see figure 2.4).

Unfortunately, economic considerations made the concept of creating full systems with many small areas impractical. To overcome this difficulty, system operators developed the idea of cell splitting. As a service area becomes full of users, this approach is used to split a single area into smaller ones.

In this way, urban centres can be split into as many areas as necessary in order to provide acceptable service levels in heavy-traffic regions, while larger, less expensive cells can be used to cover remote rural regions. [2]

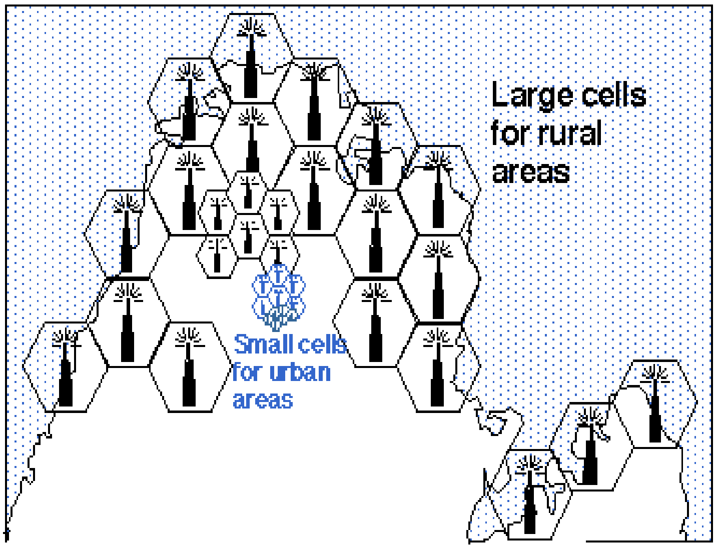

Figure 2. 4: Cell Splitting

2.3.5 Frequency Reuse

Because only a small number of radio channel frequencies were available for mobile systems, engineers had to find a way to reuse radio channels in order to carry more than one conversation at a time. The solution the industry adopted was called frequency planning or frequency reuse. Frequency reuse was implemented by restructuring the mobile telephone system architecture into the cellular concept.

The concept of frequency reuse is based on assigning to each cell a group of radio channels used within a small geographic area. Cells are assigned a group of channels that is completely different from neighbouring cells. The coverage areas of cells are called the footprint. This footprint is limited by a boundary so that the same group of channels can be used in different cells that are far enough away from each other so that their frequencies do not interfere (see Figure 2.5). [2]

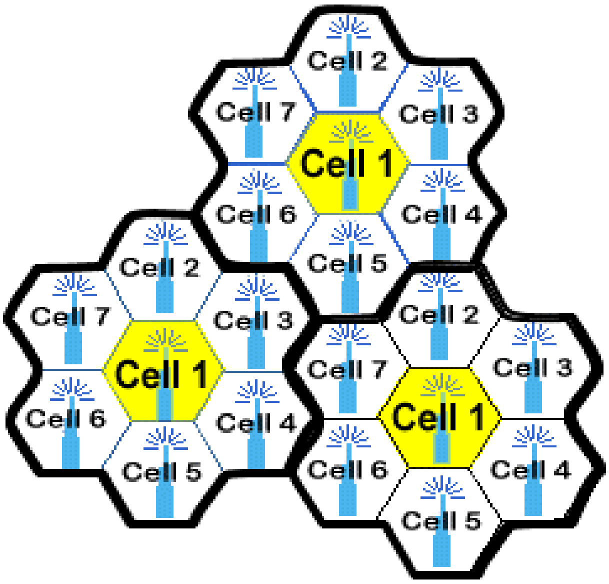

Figure 2.5: Frequency Reuse

Cells with the same number have the same set of frequencies. Here, because the number of available frequencies is 7, the frequency reuse factor is 1/7. That is, each cell is using 1/7 of available cellular channels.

Relation between K and D/R by this equation

$$D/R = \sqrt{3K}$$

In the example K=7 then D/R =4.6

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Chapter Three

GLOBALE SYSTEM FOR MOBILE COMMUNICATION

3.1 Inlet

Global System for Mobile communication (GSM) is developed in the working groups associated to European Telecommunications Standards Institute (ETSI). In the following chapter we give an introduction to the general concepts in GSM networks. The first topic is an informal overview of the functionality of a GSM network. The next topic is the logical architecture of the network. This is a description of the components in the network and their respective roles. Finally, we look into the physical aspects of the network, which includes a discussion of the individual entities' knowledge of the GSM network.

3.2 GSM overview

Throughout the evolution of cellular telecommunications, various systems have been developed without the benefit of standardized specifications. This presented many problems directly related to compatibility, especially with the development of digital radio technology. The GSM standard is intended to address these problems.

From 1982 to 1985 discussions were held to decide between building an analog or digital system. After multiple field tests, a digital system was adopted for GSM. The next task was to decide between a narrow or broadband solution. In May 1987, the narrowband time division multiple access (TDMA) solution was chosen.

3.3 Functional view of GSM

The primary goal of a mobile telephone network like GSM is that a subscriber having a mobile telephone can make and receive calls anywhere. To achieve this goal, some major functions are required, e.g. call management and call processing, radio management, mobility management, charging, and security. In the following sections each of these functions is described.

3.3.1 Call management and call processing

When a subscriber dials a number on his phone, he expects a response from the network; if a connection to the called subscriber could be established he would expect a dial tone and otherwise an error tone. What implements this behaviour is call management and call processing. Call management deals with setting up and terminating calls. This includes finding a route through the network from the calling party to the called party. Call processing is everything between setting up the call and terminating it, e.g. traffic switching, error handling, and re-routing. [3]

3.3.2 Radio management

The wireless communication path in GSM was achieved by radio communication. To be able to communicate by radio, both parties need to know which frequency the other party uses; this is decided by the antennas throughout the countryside. When the MS needs to communicate with an antenna it scans the frequencies in order to find the needed one. All matters related to controlling the radio is called radio management.

3.3.3 Mobility management

In order to allow a subscriber to receive calls anywhere, the network needs to know something about the location of the mobile phone. To avoid unnecessary network load in areas far away from the phone, the mobile phone notifies the network with its current location, when moved around; when the phone needs to be contacted by the network, only the nearby antennas try to reach it. Another situation is powering the phone on and off; the network is notified when this happens. All procedures regarding the mobility of the mobile phone are called mobility management.

3.3.4 Charging

Charging is the registration and billing of the subscribers' use of the mobile phone. Different charging is done depending on the time and the location of the mobile phone. Usually, network operators have reduced prices during off peak hours compared to peak hours. Also, calls outside the operators network is typically charged at a higher rate than calls within the operator's network.

3.3.5 Security

When communication is performed by radio waves, everyone with a radio receiver is able to listen to the communication. In order to preserve privacy, encryption of the communication is needed. This is just one security function in the mobile network. Another example is authentication; to be able to charge the correct subscriber, authentication against the network is needed. This is also needed to prevent fraud. Equipment (e.g. mobile phones) is also checked to ensure that e.g. stolen phones cannot be used.

3.4 Logical Architecture

The GSM networks are divided into two logical parts: Network Switching Sub- system (NSS) and Base Station Subsystem (BSS). The NSS is responsible for call processing, mobility management, and subscriber related functions such as charging and security. The BSS performs the radio related functions towards the Mobile Stations (MS), e.g. a mobile phone.

The following sections describe each part of the network in greater detail. The MS is not a part of the fixed network and is therefore covered in its own section (section 2.2.3). Finally we summarise the logical architecture and show the interconnection of all the entities .The following (figure3.1) depicts a typical GSM network (called, Public Land Mobile Network or PLMN) infrastructure

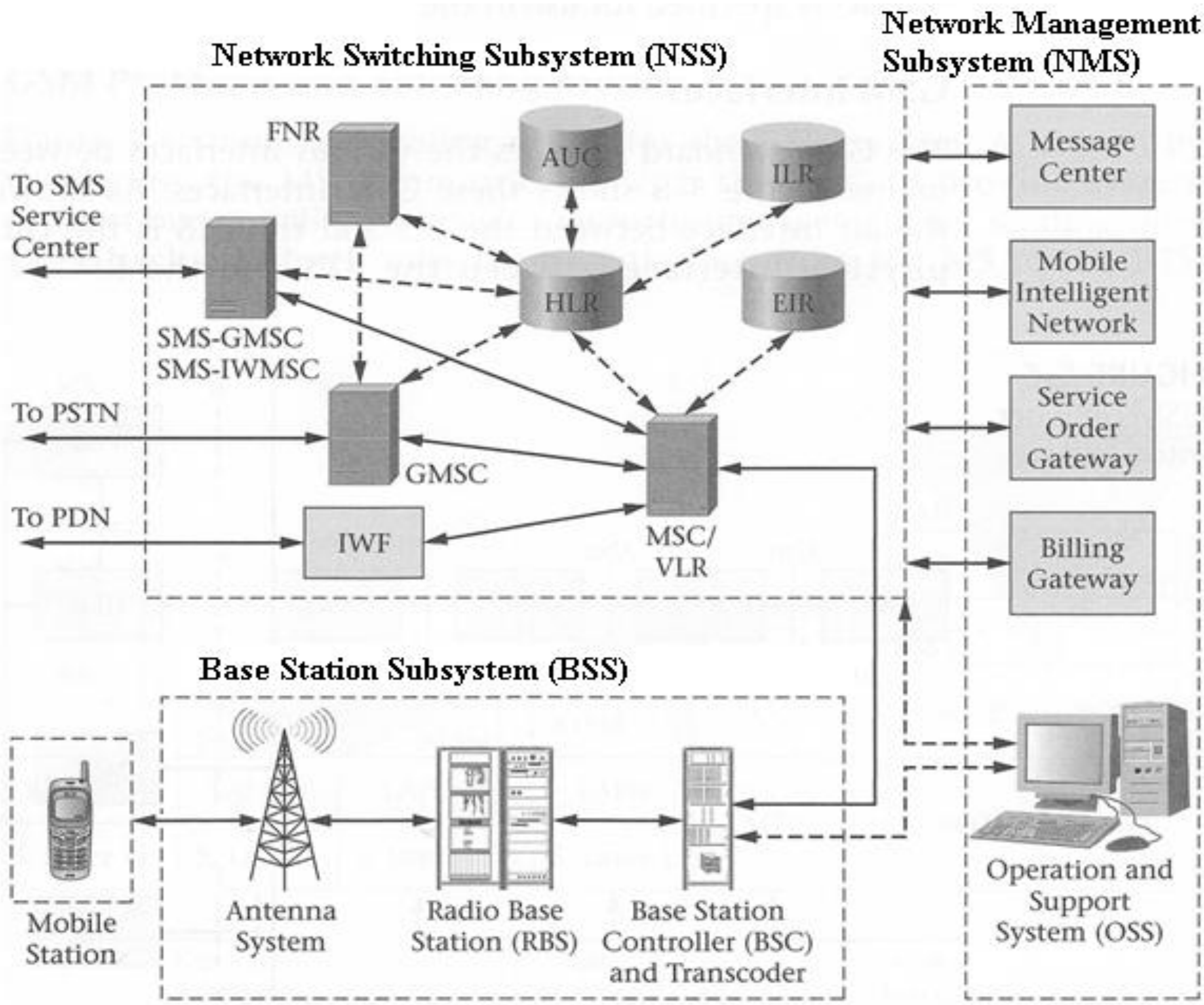

Figure 3.1: GSM network infrastructure

3.4.1 Mobile Station

The MS (Mobile station) is a combination of terminal equipment and subscriber data .The terminal equipment as such is called ME (Mobile Equipment) and the subscriber's data is stored in separate module called SIM (Subscriber Identity Module) (see figure 3.2)

Therefore, ME+SIM=MS

Figure 3.2 Mobile Station

The mobile station (MS) consists of the mobile equipment (the terminal) and a smart card called the Subscriber Identity Module (SIM). The SIM provides personal mobility, so that the user can have access to subscribed services irrespective of a specific terminal. By inserting the SIM card into another GSM terminal, the user is able to receive calls at that terminal, make calls from that terminal, and receive other subscribed services. [4]

A mobile station (MS) is a portable data and/or voice communications station which acts as a normal telephone whilst being able to move over in a wide area. A mobile station is typically made up of an antenna, amplifier, receiver, transmitter, similar hardware and software for sending and receiving signals and converting between RF waves and audio signals.. Mobile stations have found many uses in today's world.

3.4.2 Base Station Subsystem (BSS)

The Base Station Subsystem is responsible for managing the radio network, and is controlled by an MSC. Typically, one MSC contains several BSSs. A BSS itself may cover a considerably large geographical area consisting of many cells (a cell refers to an area covered by one or more frequency resources). The BSS consists of the following elements as (figure 3.3) show.

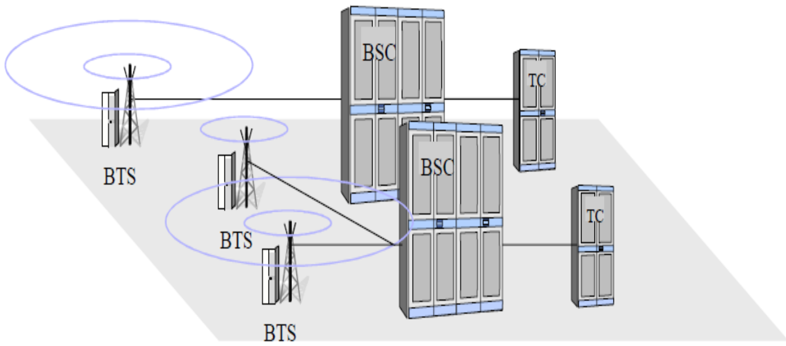

Figure 3.3 Base Station Subsystems (BSS)

3.4.2.1 Base Transceiver Station

A Base Station Transceiver (BTS) is a radio transceivers station that communicates with the mobile stations. Its backend is connected to the BSC. More detail about BTS will be covered later. A BTS is usually placed at the center of a cell. Its transmitting power defines the size of a cell. There are more on this later. [15]

3.4.2.2: Base Station Controller

A Base Station Controller (BSC) is a high-capacity switch with radio communication and mobility control capabilities. The functions of a BSC include radio channel allocation, location update, handover, timing advance, power control and paging. [15]

3.4.3 Network Switching Subsystem (NSS)

The network switching Subsystem (NSS) contains the network element MSC, VLR, HLR, AC and EIR , Fundamentally, the network and switching subsystems (NSS) are responsible for call connection, supervision and release operations between calling and called stations, where one or both of them are mobile stations (MS). (See figure 3.4)

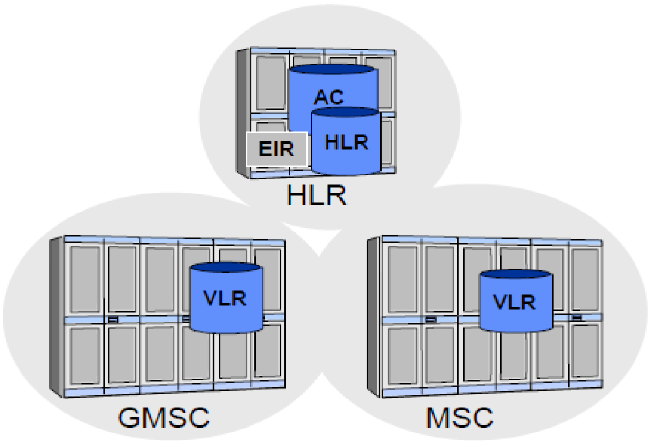

Figure 3.4: The Network Switching Subsystem (NSS)

3.4.3.1 Mobile services Switching Centre (MSC)

The MSC is responsible for controlling calls in the mobile network. It identifies the origin and destination of a call (mobile station or fixed telephone). As well as the type of call, an MSC acting as abridge between a mobile network and a fixed network which called a Gateway MSC.

3.4.3.2: Home Location Register (HLR)

The home location register (HLR) is a database used for storing and managing subscriptions. Generally a PLMN (Public Land Mobile Network) consists of several HLRs. The first two digits of the mobile directory number (e.g. 0171 2620757) are the number of the HLR where the mobile subscriber is stored. The data includes permanent data on subscribers (such as subscriber's service profile) as well as dynamic data (such as current location and activity status). When an individual buys subscription from one of the GSM operators, he or she is registered in the HLR of that operator. HLR maintains a permanent register of the subscriber's identity numbers and the subscribed services . [4]

3.4.3.3 Visitor Location Register (VLR)

Is a database - part of the GSM mobile phone system - which stores information about all the mobiles that is currently under the jurisdiction of the MSC (Mobile Switching Center) which is under it service. Of all the information it stores about each MS (Mobile Station), the most important is the current LAI (Location Area Identity). LAI identifies under which BSC (Base Station Controller) the MS is currently present.

3.4.3.4 Authentication Center (AUC)

The authentication center (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, also provides security information to the network, so that we can verify the SIM cards (authentication between the mobile station and the VLR, and cipher the information transmitted in the air interface (between the MS and the Base Transceiver Station). [15]

3.4.3.5 Equipment Identity Register (EIR)

The equipment identity register (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 can be implemented as stand-alone nodes or as a combined AUC/EIR node, as for AC.

3.4.4 Network Management Subsystem (NMS)

Network Management Subsystem (NMS) includes network management center (NMC), operations and maintenance center (OMC) and a variety of other functions (see the network infrastructure diagram at the beginning of this document). A telecommunications network requires some kind of NMS. A part of NMS is generic for any telecom system.

3.4.4.1 Operation and Support System (OSS)

The operation support system (OSS) is to do a variety of operation and maintenance works such as commissioning and integrating new network elements to the existing system, software upgrade, collecting network performance statistics, reconfiguring network dimension and frequency planning.

3.4.4.2: Message Center (MXE)

The MXE, also called Short Message Service Center (SMSC), is a node that provides integrated voice, fax, and data messaging. Specifically, the MXE handles short message service, cell broadcast, voice mail, fax mail, e-mail, and notification.

3.5 Channel structure

A channel corresponds to the recurrence of one burst every frame. It is defined by its frequency and the position of its corresponding burst within a TDMD frame. In GSM there are two types of channels.

- The traffic channels used to transport speech and data information.
- The control channels used for network management messages and some channel maintenance tasks.

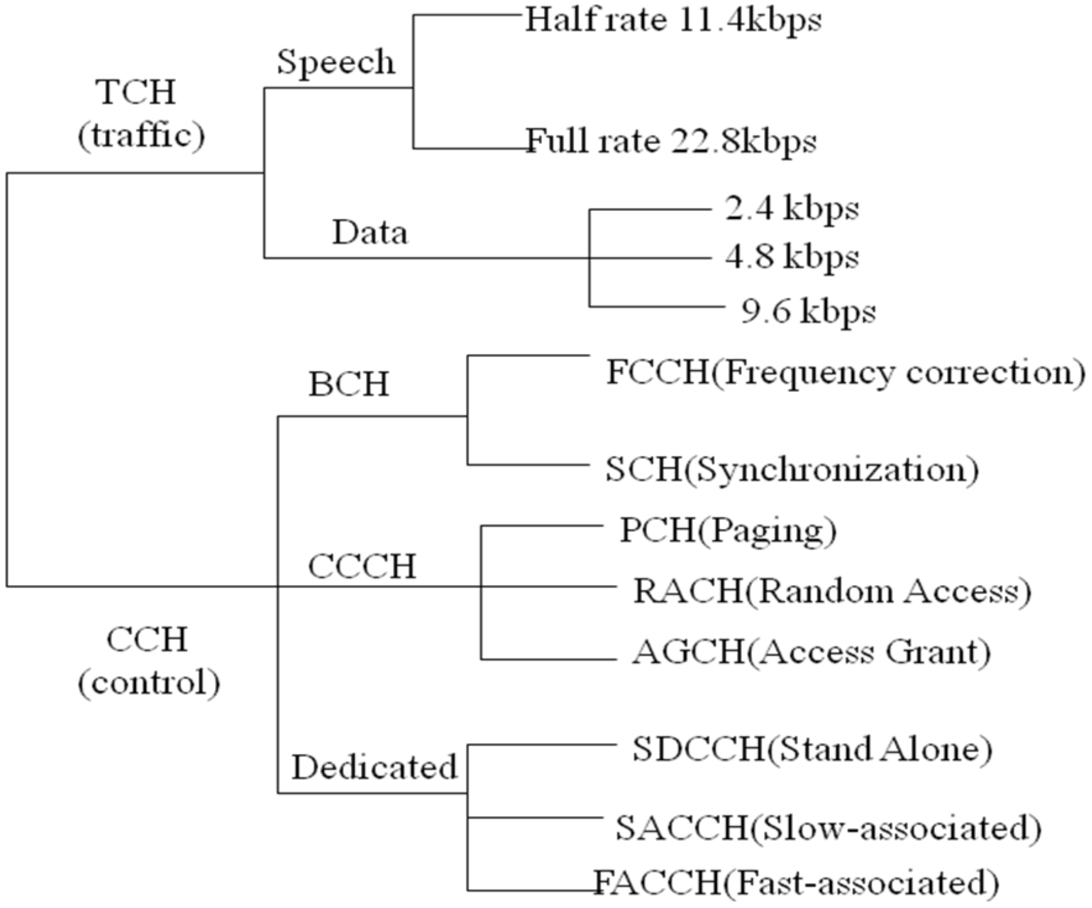

Figure 3.5 Channel structure

3.5.1: Traffic channels

A traffic channel (TCH) is used to carry speech and data traffic. Traffic channels are defined using a 26-frame multiframe, or group of 26 TDMA frames. The length of a 26-frame multiframe is 120 ms, which is how the length of a burst period is defined (120 ms divided by 26 frames divided by 8 burst periods per frame). Out of the 26 frames, 24 are used for traffic, 1 is used for the Slow Associated Control Channel (SACCH) and 1 is currently unused (see Figure 2). TCHs for the uplink and downlink are separated in time by 3 burst periods, so that the mobile station does not have to transmit and receive simultaneously, thus simplifying the electronics.

.In addition to these full-rate TCHs, there are also half-rate TCHs defined, although they are not yet implemented. Half-rate TCHs will effectively double the capacity of a system once half-rate speech coders are specified (i.e., speech coding at around 7 kbps, instead of 13 kbps). Eighth-rate TCHs are also specified, and are used for signalling. In the recommendations, they are called Stand-alone Dedicated Control Channels (SDCCH).

3.5.2: Control channels

Common channels can be accessed both by idle mode and dedicated mode mobiles. The common channels are used by idle mode mobiles to exchange the signalling information required to change to dedicated mode. Mobiles already in dedicated mode monitor the surrounding base stations for handover and other information. The common channels are defined within a 51-frame multiform, so that dedicated mobiles using the 26-frame multiform TCH structure can still monitor control channels.

The common channels include:

- Broadcast Control Channel (BCCH)

It is Broadcast downlink (Base station to mobile), continually broadcasts, on the downlink, information including base station identity, frequency allocations, and frequency-hopping sequences.

- Random Access Channel (RACH)

Is Common uplink (Mobile to base station), Slotted Aloha channel used by the mobile to request access to the network.

- Frequency Correction Channel (FCCH) and synchronization Channel (SCH)

Is Broadcast downlink, Used to synchronies the mobile to the time slot structure of a cell by defining the boundaries of burst periods, and the time slot numbering. Every cell in a GSM network broadcasts exactly one FCCH and one SCH, which are by definition on time slot number 0 (within a TDMA frame).

- Paging Channel (PCH)

Common downlink (Base station to mobile), Used to alert the mobile station of an incoming call.

- Access Grant Channel (AGCH)

Broadcast downlink, Used to allocate an SDCCH to a mobile for signalling (in order to obtain a dedicated channel), following a request on the RACH.

- Slow Associated Control Channel (SACCH)

Uplink and downlink, in every traffic channel. Used for low rate, non critical signalling.

- Fast Associated Control Channel (FACCH)

Uplink and downlink, a high rate signalling channel, used during call establishment, subscriber authentication, and for handover commands

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CHAPTER FOUR
HANDOVER

4.1 Handover concept

The Handover procedure is probably the most important procedure to ensure the mobility of the MS during calls. The purpose of the procedure is to preserve ongoing calls, when moving from one cell to another. The presence of an ongoing call gives rise to time criticality of the processing.

The decision whether to perform the handover, is made by the serving BSC, which has no direct knowledge of the radio quality. In order to decide whether to initiate a handover, the BSC receives information about the radio link quality from the BTS and the MS. During a call, the MS periodically sends measurement results to the BTS. The measurement results contain measurements of the radio signal quality of the downlink (from the BTS to the MS) of the call and up to five neighbouring cells. The serving BTS measures the uplink (from the MS to the BTS) radio signal quality of the call and forwards the measurement result from the MS, together with its own measurements, to the BSC in a measurement report. From the information in the measurement reports, the BSC is able to decide whether a handover to another cell is needed.

Most handovers take place when an active mobile changes cells. The BSC makes the decision to change cells based on the results calculated in the locating algorithm.

There are different types of handovers. The type of handover performed depends on the relationship between the cell handing over the call and the cell intercepting the call. Changing cells within the same BTS is not as complex as changing cells belonging to different MSCs. In the following sections the different kinds of handover are discussed. They are listed in increasing complexity: Intra-cell/BTS, Intra-BSC, Intra-MSC and finally Inter-MSC. Types of handovers are discussed in this chapter .[14]

In telecommunications there may be different reasons why a handoff (handover) might be conducted:

- when the phone is moving away from the area covered by one cell and entering the area covered by another cell the call is transferred to the second cell in order to avoid call termination when the phone gets outside the range of the first cell;
- when the capacity for connecting new calls of a given cell is used up and an existing or new call from a phone, which is located in an area overlapped by another cell, is transferred to that cell in order to free-up some capacity in the first cell for other users, who can only be connected to that cell;
- In non-CDMA networks when the channel used by the phone becomes interfered by another phone using the same channel in a different cell, the call is transferred to a different channel in the same cell or to a different channel in another cell in order to avoid the interference.

4.2 Measurements of Handover

To perform a fast handover procedure the BSC is provided with all the necessary information about the serving and neighbouring cells beforehand. Measurements are done by the BTS and MS during the call and will be reported to the BSC every 480 ms. The BTS will measure signal strength and bit error rate on the uplink while the MS will measure the same parameters on the downlink. In addition the MS will measure signal strength on the BCCH-carriers of the neighbouring cells. The MS will send its reports on SACCH.

During each SACCH multi frame the MS measures the following parameter.

1. RXQUAL, quality of reception
2. RXLEV , received power level from home BTS
3. Received power from neighbour cells defined on home BCCH
4. BTS carries out similar measurement in uplink in addition to MS to BTS distance

4.3 Movement from cell to cell and handover

In a primitive taxi system, when the taxi moved away from a first tower and closer to a second tower, the taxi driver manually switched from one frequency to another as needed. If a communication was interrupted due to a loss of a signal, the taxi driver asked the base station operator to repeat the message on a different frequency.

In a cellular system, as the distributed mobile transceivers move from cell to cell during an ongoing continuous communication, switching from one cell frequency to a different cell frequency is done electronically without interruption and without a base station operator or manual switching. This is called the handover or handoff. Typically, a new channel is automatically selected for the mobile unit on the new base station which will serve it. The mobile unit then automatically switches from the current channel to the new channel and communication continues.

The exact details of the mobile system's that move from one base station to the other vary considerably from system to system. For example, in all GSM handovers and W-CDMA inter-frequency handovers the mobile station will test the reserved channel before changing channels. Once the channel is confirmed okay, the network will command the mobile unit to switch to the new channel and at the same time start bi-directional communication on the new channel. In CDMA2000 and W-CDMA same-frequency handovers, both channels will actually be in use at the same time (this is called a soft handover or soft handoff). In IS-95 inter-frequency handovers and older analog systems such as NMT it will typically be impossible to test the target channel directly while communicating. In this case other techniques have to be used such as pilot beacons in IS-95. This means that there is almost always a brief break in the communication while searching for the new channel followed by the risk of an unexpected return to the old channel.

If there is no ongoing communication or the communication can be interrupted, it is possible for the mobile unit to spontaneously move from one cell to another and then notify the base station with the strongest signal.

4.4 Traffic handover

Occurs when the traffic capacity of a cell has reached its maximum or is approaching it the UE near the edges of the cell with high load may be handed over to neighbouring cells with less traffic load. The system load can be distributed more uniformly. [11]

The number of handovers depends on the degree of mobility. It is obvious that the faster the mobile node (MN) is moving, the more handovers it causes to the Network. To avoid undesirable handovers the MN with high motion speed may be handed over from micro-cells to macro-cells. On the other hand, if the MN moving slowly or not at all, it can be handed over from macro-cells to micro-cells to improve the radio signal strength and avoid consuming its battery. Figure (4.1) show mobility and handover.

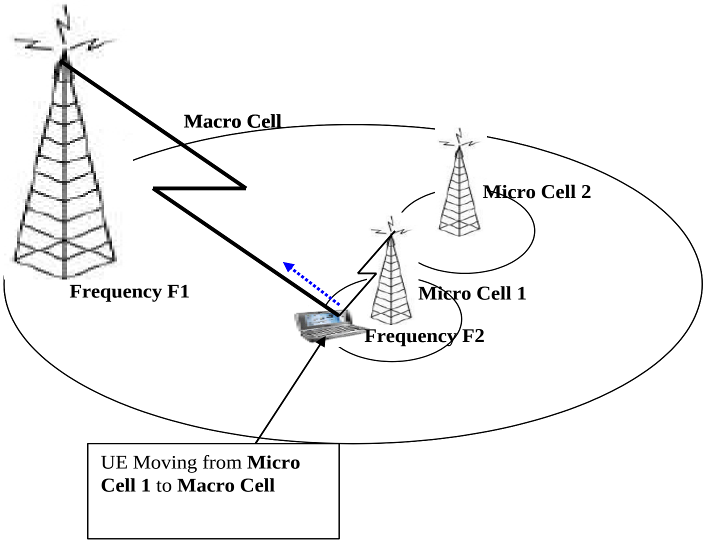


Figure 4.1Mobility and Handover

4.5 Types of handover / handoff

With the advent of CDMA systems where the same channels can be used by several mobiles and where it is possible to adjacent cells or cell sectors to use the same frequency channel there are a number of different types of handover that can be performed:

4.5.1 Hard handover

The definition of a hard handover or handoff is one where an existing connection must be broken before the new one is established. One example of hard handover is when frequencies are changed. As the mobile will normally only be able to transmit on one frequency at a time, the connection must be broken before it can move to the new channel where the connection is re-established. This is often termed and inter-frequency hard handover.(see figure 4.2)

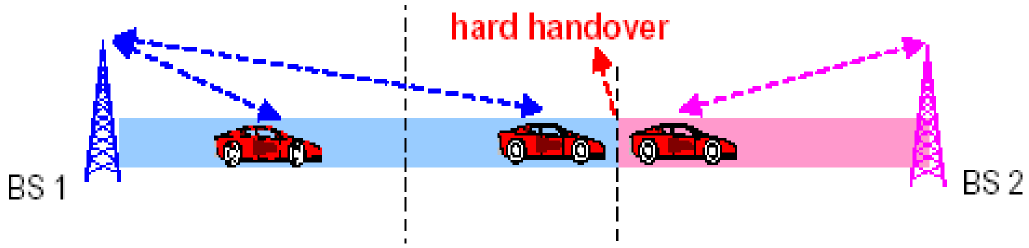


Figure 4.2 Hard Handover Examples

4.5.2 Soft handover

The new 3G technologies use CDMA where it is possible to have neighboring cells on the same frequency and this opens the possibility of having a form of handover or handoff where it is not necessary to break the connection. This is called soft handover or soft handoff, and it is defined as a handover where a new connection is established before the old one is released.(see figure 4.3) (5)

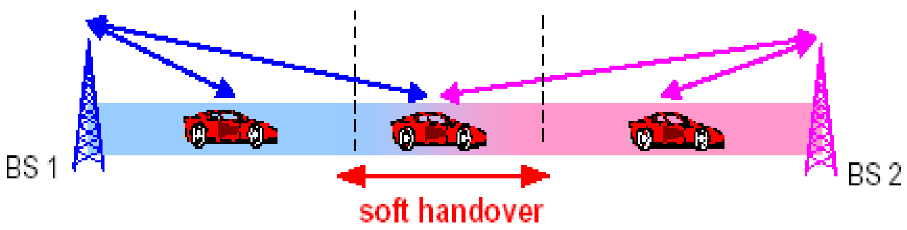


Figure 4.3 Soft Handover Examples

4.5.3 Softer handover

The third type of hand over is termed a softer handover, or handoff. In this instance a new signal is either added to or deleted from the active set of signals. It may also occur when a signal is replaced by a stronger signal from a different sector under the same base station. (see figure 4.4)

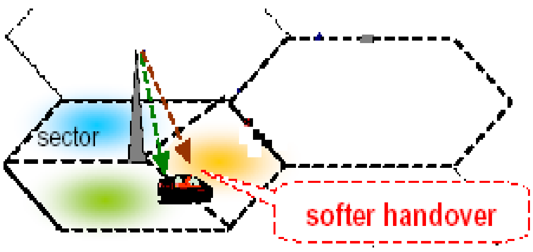


Figure 3.4Softer Handover Examples

4.6 Handover Algorithm

Types of handover algorithm can be distinguished depending on the network structure as seen in the figure below (see figure 4.5)

- **Intra-Cell/BTS**
- **Intra-BSC Handover**
- **Inter-BSC Handover**
- **Inter-MSC Handover**

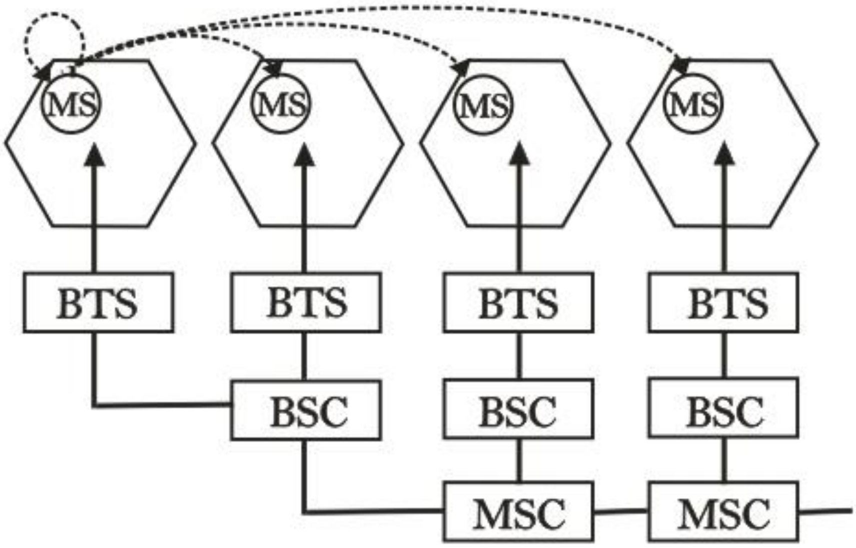


Figure 4.5: Handover between BTS, BSC and MSC

4.6.1 Intra-cell/BTS

The terms intra-cell and intra-BTS handover are both used in the literature to describe the same situation of a frequency change. Because a BTS can control several cells, the intra-BTS handover is a little more advanced (logically) than the intra-cell handover. The reason they are considered the same is that frequency reuse within the same BTS is impossible.

The intra-cell handover is actually not a “real” handover because its only purpose is to change the frequency of an ongoing call. The frequency change is performed when the quality of the link is degrading and the measurements on the neighbouring cells shows nothing better. In this case the BSC, which controls the BTS serving the MS, orders the MS and BTS to retune to another frequency, which hopefully offers better quality to the link. The link degradation is caused by interference with other calls in nearby cells using the same frequencies, and therefore the solution is to try another channel. [12]

4.6.2 Intra BSC handover

The intra-BSC handover is performed when the target cell is controlled by a BTS different from the source cell and both BTSs are controlled by the same BSC. The MSC is not involved in the handover, but is notified when the handover has taken place. If the target cell is located in another LA, the MS needs to perform the location update procedure after finishing the call; otherwise the MS is unreachable by the network.

The main steps involved in an intra BSC handover are shown in Figure 4.6 During the call, the MS measures the signal strength and quality on its own TCH and the signal strength of the neighbouring cells. The MS evaluates the average value for each of these. [12]

1. Approximately two times per second the MS sends a measurement report to the BTS with measurements from the serving cell and the best neighbouring cells.
2. The BTS adds its own measurements made on the TCH, uplink and forwards the report to the BSC. In the BSC the locating function determines if it is necessary to hand over the call to another cell because of poor quality or low signal strength in the serving cell.
3. If a handover is required, the BSC orders the BTS in the new cell to activate a TCH.
4. Once the new TCH is acknowledged the BSC sends a message to the MS via the old BTS with the information about the frequency, time slot and output power to change to.

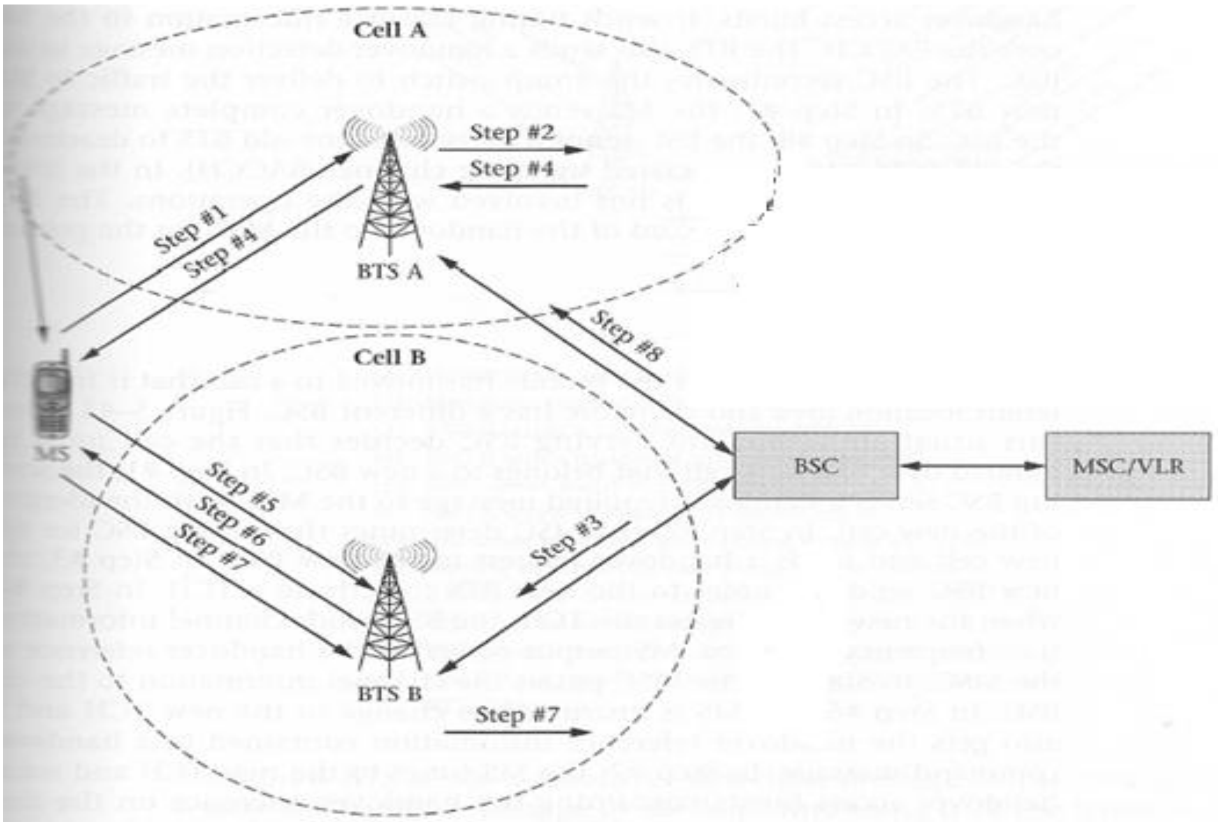
5. The MS tunes to the new frequency and sends Hand Over access (HO) bursts on the appropriate TS (FACCH). The MS does not use any timing advance. This is the reason why the HO burst is short, containing only 8 bits of information. [6]

6. When the BTS detects the HO access burst it sends physical information containing the timing advance to the MS on the FACCH. The BTS also informs the BSC by sending a HO detection message. The new path through the group switch is through connected.

7. The MS sends a Handover Complete message.

8. The old BTS is ordered to deactivate the old TCH and its associated signalling channel (SACCH).

In the intra BSC handover procedure, the BSC handles everything without any involvement from the MSC. However, to keep track of statistics the BSC informs the MSC when a handover is performed. This is shown in Figure 4.6.



(1) Ms and BTS A perform RSS measurements. **(2) Measurement report is sent to BSC.**

(3) TCH activation message is sent to BSC B. **(4) New TCH information is sent to MS over old BTS (A)**

(5) Handover access burst is sent to new BTS (B). **(6)Timing advance information is sent to MS.**

(7) Handover complete message is sent to BSC. **(8)Channel deactivation order is sent to old BTS.**

Figure 4.6 Intra BSC handover of a call.

4.6.3 Inter BSC handover

If the MS moves to an area covered by a cell belonging to another BSC and handover is required, an inter BSC handover takes place. See Figure 4.7.

The serving BSC decides from the measurement reports that the call must be handed over to a cell belonging to the new BSC. [12]

1. The serving BSC sends a Handover Required message to the MSC together with the identity of the new cell.

2. The MSC knows which BSC controls this BTS and sends a Hand over Request to the new BSC.

3. The BSC orders the BTS to activate a TCH if there is one idle.

4. When the new BTS activates the TCH, the BSC sends information about the output power, TS, frequency and handover reference to the MSC.

5. The MSC passes this information to the old BSC.

6. The MS is told to change to the new TCH and also gets the handover reference in a Handover Command message.

7. The MS tunes to the new frequency and sends HO bursts, containing the handover reference, on the FACCH (new).

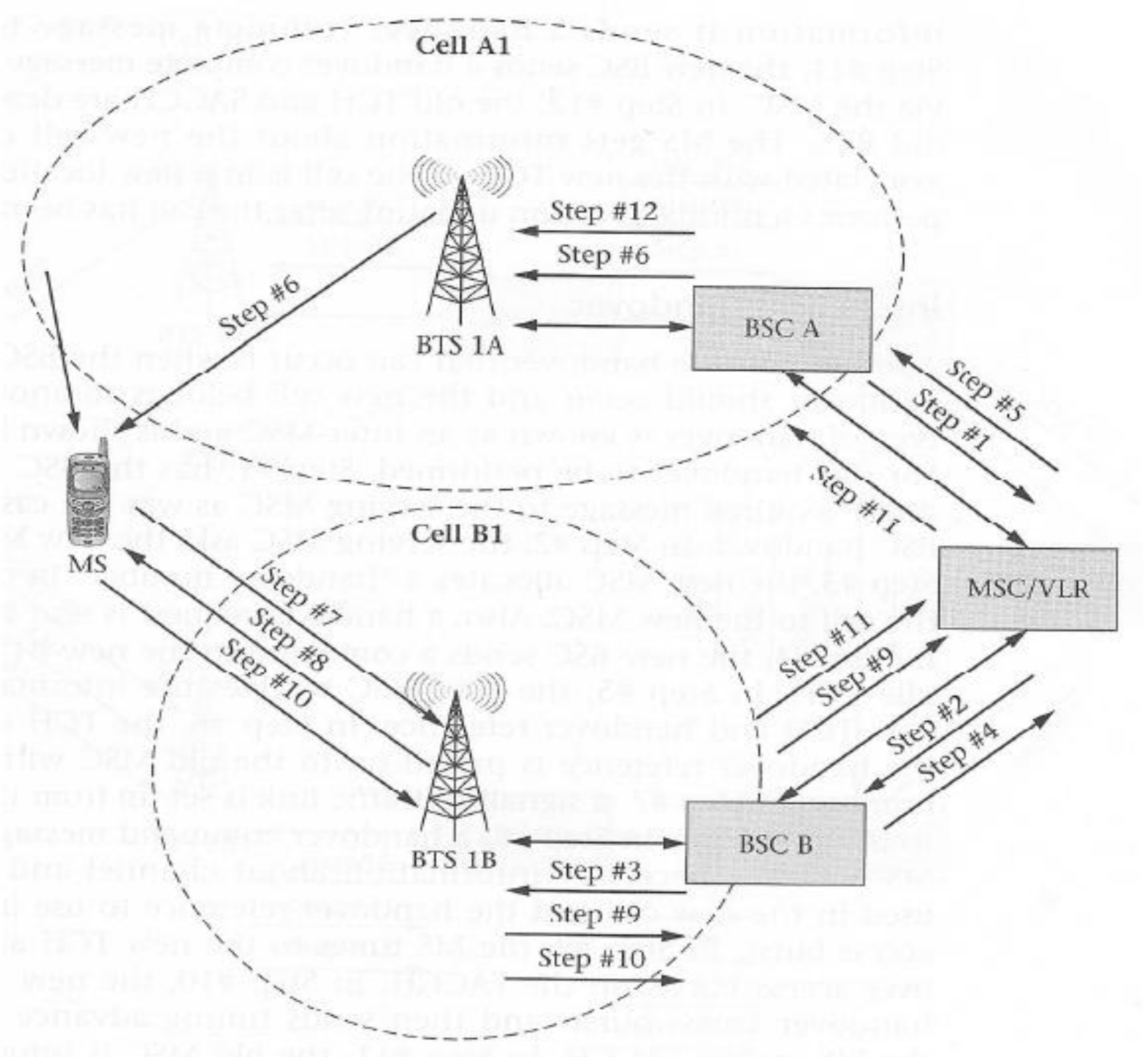
8. When the new BTS detects the HO access burst it sends physical information containing timing advance to the MS on the FACCH.

9. The new BTS also informs the new BSC by sending a HO detection message. The new BSC in turn informs the MSC. The new path through the group switch in the MSC is set up.

10. When the MS receives the physical information it sends a HO complete message.

11. The new BSC passes the HO complete information to the old BSC, via the MSC.

12. The old TCH and SACCH are deactivated by the BTS. The MS gets information about the new cell on the SACCH associated with the new TCH. If the cell belongs to a new LA the MS performs a normal location updating after the call is released.



(1) Handover request is sent by BSC to MSC . (2) Handover request is sent by MSC to new BSC (B).
(3) BSC (B) sends activation order to BTS. (4)BSC (B) sends handover information to MSC.
(5)MSC sends handover information to BSC. (6)BSC (A)sends MS new TCH information.
(7)MS sends handover access burst to new BTS (IB) . (8)Timing advance information is sent to the MS.
(9)BTS IB sends handover detection message to BSC (B). (10) MS sends handover complete message to BSC (B).
BSC B sends handover complete message to the old BSC (A).
Old BSC (A) sends channel deactivation message to old BTS(I A).

Figure 4.7 Inter BSC handover of a call.

4.6.4 Inter MSC handover

If, during a call, the serving BSC decides to perform a handover and the new cell belongs to another MSC, the traffic case becomes more complicated, compared to previously discussed handover cases. This is shown in Figure 4.8.

1. The serving BSC sends Handover Required to the MSC as in the inter BSC handover case.

2. The old MSC asks the new MSC for help.

3. The new MSC allocates a handover number (ordinary telephone number) in order to reroute the call. A Handover Request is sent to the new BSC.

4. The new BSC, in cases where there is an idle TCH in the target cell, tells the new BTS to activate a TCH.

5. The new MSC receives the information about the new TCH and handover reference.

6. The TCH description and handover reference is passed on to the old MSC together with the handover number.

7. A link is set up from the old MSC to the new MSC.

8. A Handover Command message is sent to the MS with information about which frequency and time slot to use in the new cell and what handover reference to use in the HO access burst.

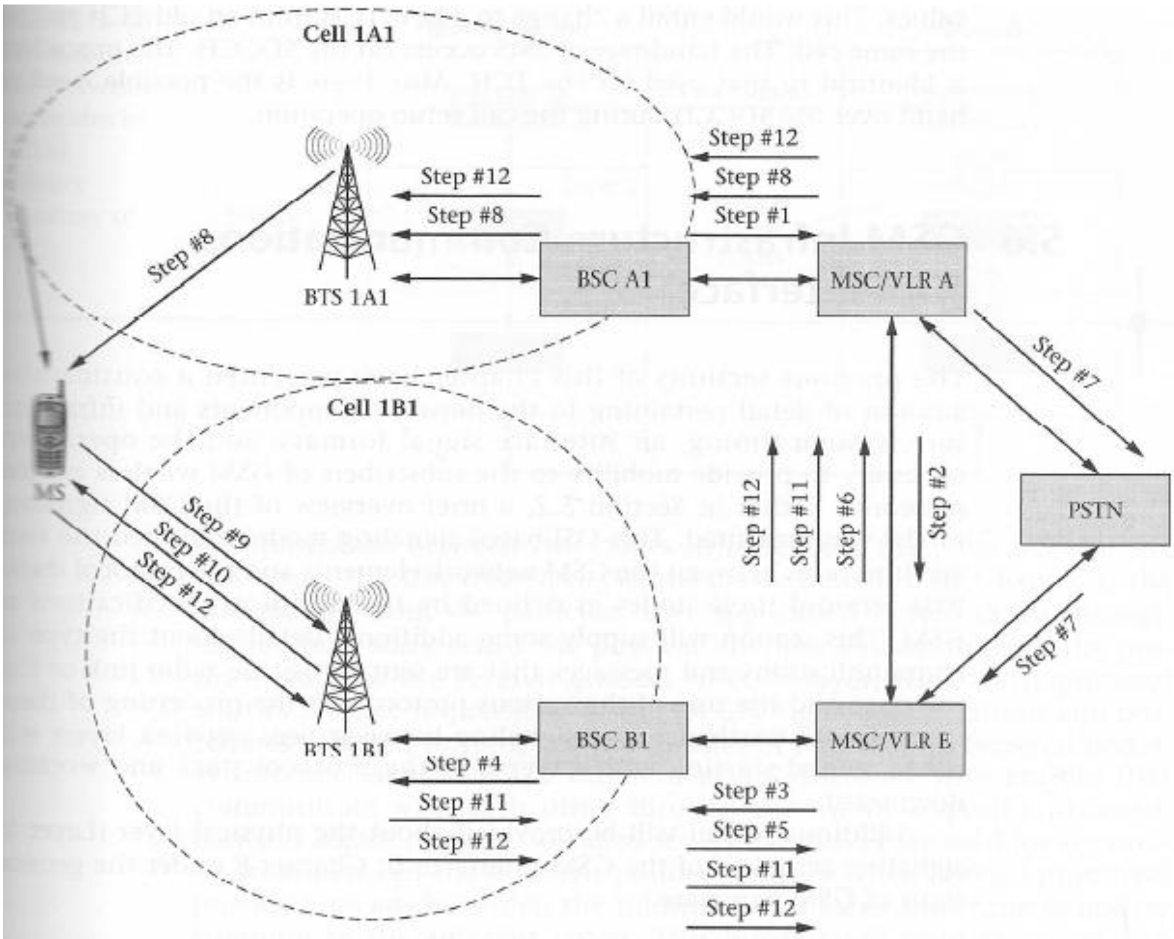
9a. The MS tunes to the new frequency and sends HO access bursts on the FACCH.

9b. When the new BTS detects the HO access burst it sends physical information containing timing advance to the MS on the FACCH. [12]

10. The old MSC is informed (via, the new BSC and the new MSC) about the detection of HO bursts. The new path through the group switch in the old MSC is set-up.

11. A Handover Complete message is sent from the MS. The new BSC and MSC inform the old MSC. The old MSC informs the old BSC and the old TCH is released.

The originating MSC retains the main control of the call until it is cleared. This MSC is called the anchor MSC.



(1) Handover request is sent by serving BSC(A I)

(2)MSC Are quests assistance from MSC B.

(3) MSC B provides MSC A with handover number and sends new BSC (BI) a handover request a.

(4) New BSC (BI) sends handover activation order to new BTS(IBI).

(5)BSC sends handover information to new MSC .

(6) Handover information is send to old MSC .

(7)A signaling /traffic link is set up between the tow MSCs.

(8) Handover message is sent to Ms.

(9)MS sends handover access burst to new BTS.

(10) New BTS sends timing advance information to MS.

(11)Old MSC is sent handover complete message to new BSC.

(12) MS sends handover complete message to the old BSC.

Figure 4.8 Inter MSC handover of a call

4.7 Handoff Procedures

4.7.1 Brief Flow of Handoff

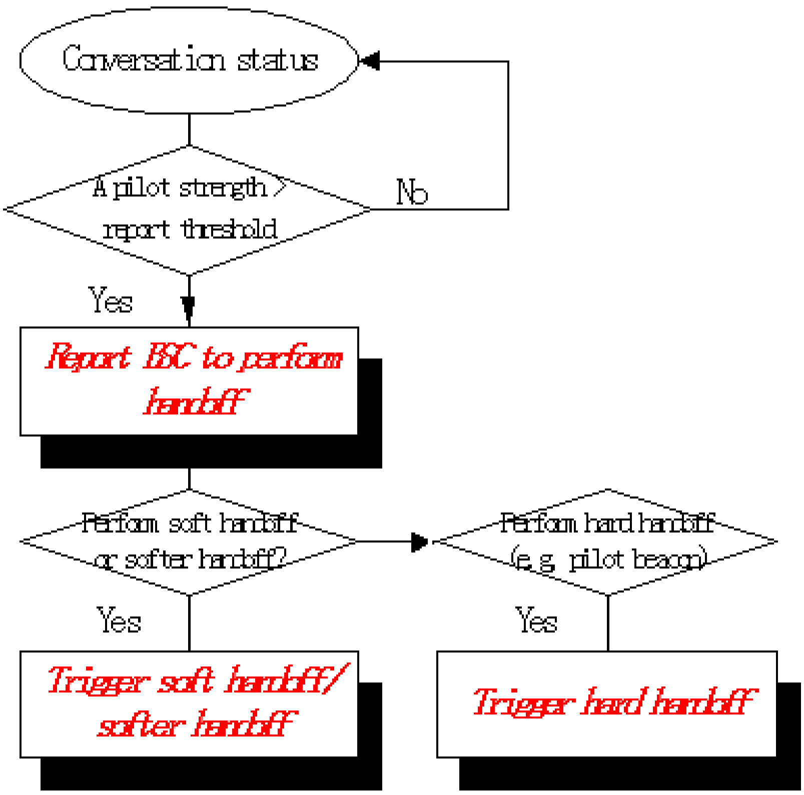


Figure 4.9 flow of handoff

When the MS triggers the handoff in the conversation, the flow is as follow;

See figure 4.5 [13]

1) When the pilot signal is more than T_ADD, the MS reports MM, and add the pilot to candidate set.

2) BS: Extended Handoff Direction Message.

3) MS: add the pilot to active set, and send Handoff Completion Message.

4) MS: when pilot signal is lower than T_DROP, start HO DROP counting.

5) MS: counter is time up, send MM.

6) BS: send Extend Handoff Direction Message

7) MS: throw the pilot from active set into neighbour set, and send Completion Message

4.7.2 Classification of pilot sets

- **Pilot set:** It is the set of the pilots corresponding to the service frequencies of current MS. That is, Pilot set can be divided into active set, candidate set, neighbour set, and remnant pilot set.

- **Active set:** It is the set of the pilots corresponding to the service channels in which the MS keeps connection.

- **Candidate set:** When the pilot signal is strong enough, the MS can be successfully demodulated and can access at any time.

- **Neighbor set:** It is the set of the pilots that are currently not in active set or candidate set but may enter candidate set.

- **Remnant set**: refer to the set of all of the remaining pilots. [7].

4.7.3 Pilot set update

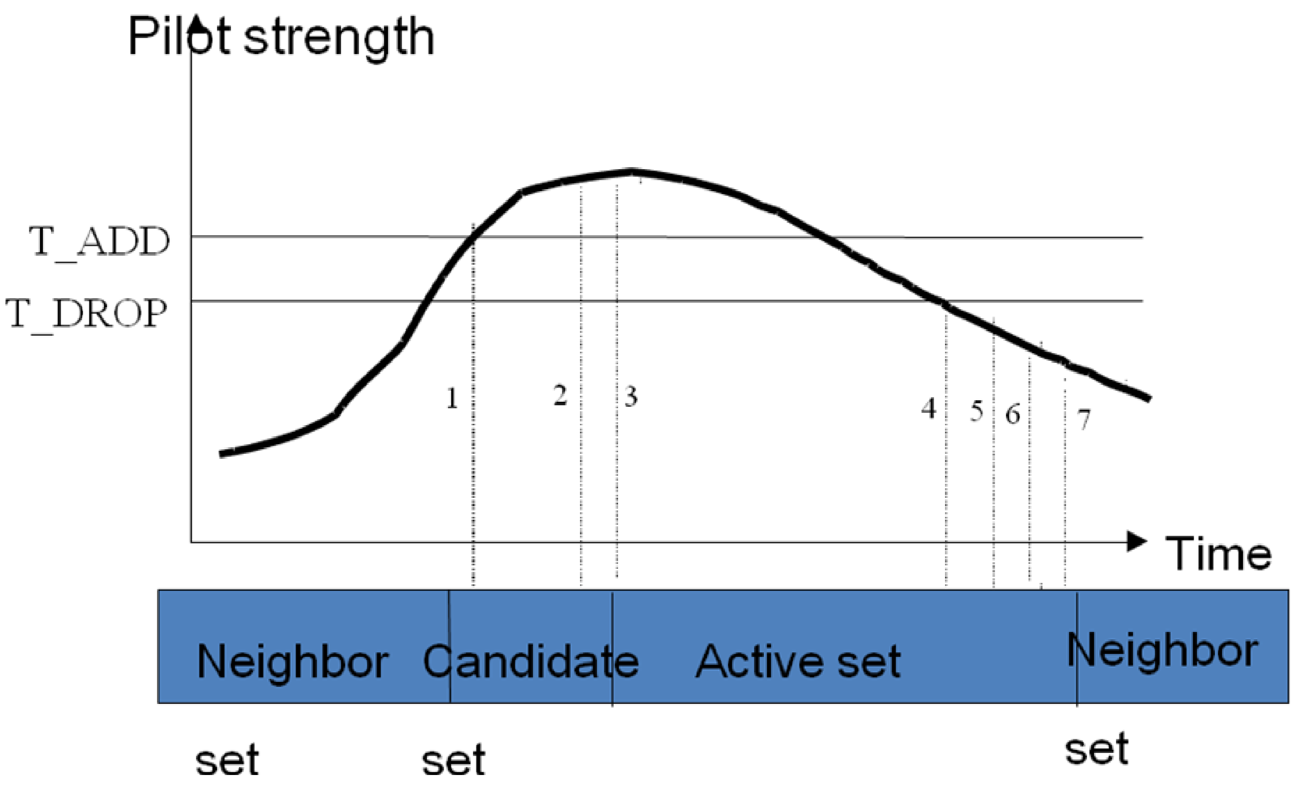


Figure 4.10 pilot set

- Soft handoff procession

1. If pilot strength is higher than T_ADD, then MS sends PSMM and add this pilot into candidate set;

2. BSC sends EHDM to request MS to add this pilot into active set;

3. MS add this pilot into active set and send handoff complete message;

4. If pilot strength is lower then T_DROP, then MS triggers drop counter TT_DROP;

5. If drop counter TT_DROP is overtime, MS sends PSMM to inform BSC;

6. BSC sends EHDM

7. MS deletes this pilot from active set and sends handoff complete message;

- **T_ADD**: pilot measurement threshold

When Ec/Io>T_ADD, the MS sends pilot strength measurement message and add the pilot to candidate set from neighbour set.

- **T_DROP**: pilot DROP threshold

When the pilot Ec/Io is lower than T_Drop, it will trigger counter TT_Drop.

If the pilot Ec/Io is more than T_Drop, the counter stops; when the counter is full, the pilot is wiped off from active set or candidate set to neighbour set.

- **TT_DROP:** Active or Candidate Set drop timer

If the pilot decreases time in pilot set and candidate set is more than **TT_DROP** counter, the pilot is wiped off to neighbour set.

If candidate set is full and a new pilot meets the requirements of T_ADD and needs to be added, the pilot that is the closest to TT_DROP threshold will be wiped off.

In this procedure, the MS only sends power strength measurement message to pilot cell which is in active set, and the pilot in candidate set will be directly wiped off to the neighbour set, so the MS need not send power strength measurement message. [13]

Chapter Five

Handover Algorithm & Traffic

5.1 Analysis

There are three type of handover (hard – soft – softer) they work under Internal and External algorithm. The input of the algorithm include, the measurement signal for the services cell, the neighbours cells and the fixed amusement (T-ADD = -14dBm) and (T_Drop =-16 dBm).

In this process I will compare the (Ec/Io) for the service cell and the neighbor cell if (Ec/Io > T-ADD) will send the cell to active set, and if (Ec/Io < T-Drop) will send the cell to neighbor set.

In the other hand, if the cell in active set, is it under an external or internal algorithm, as well as the availability of channels .The output classifies the cell whether it is an active , candidate or neighbor cell, and the handover whether is successful or failure handover.

The plan will be introduced under flow chart so as to be executed in a software program to simulate the handover algorithm.

5.2 Mathematical Model Analysis

Measurement of handover depends on the power of received signal which will be calculate with this equation

$$\text{Power of the received signal} = \frac{1}{(\text{distance from the phone to the antenna})2} \quad (1)$$

$$\text{Ec/Io (dBm)} = 10*\log(\text{Power of the received signal}) \quad (2)$$

$$\text{Signal –to –interference ratio} = \frac{\text{power of received signal from primary ststion}}{\text{power of received signal from secondary ststion}} \quad (3)$$

Note: In Figure 5.1 we drew the location of cell phone at the point (x,0) between the two base stations. In this case x is between 0 and 2. If the location of the cell phone is (x,0) for x less than zero, then it hasn't passed the primary base station. In this simplified model we must permit the cell phone to be either on either side of the primary base station. [12]

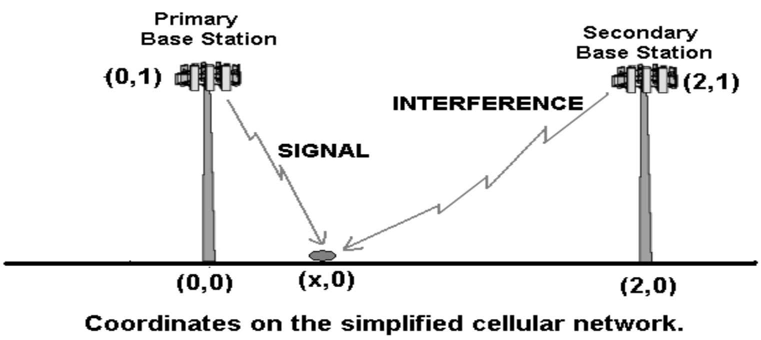


Figure 5.1 location of cell phone

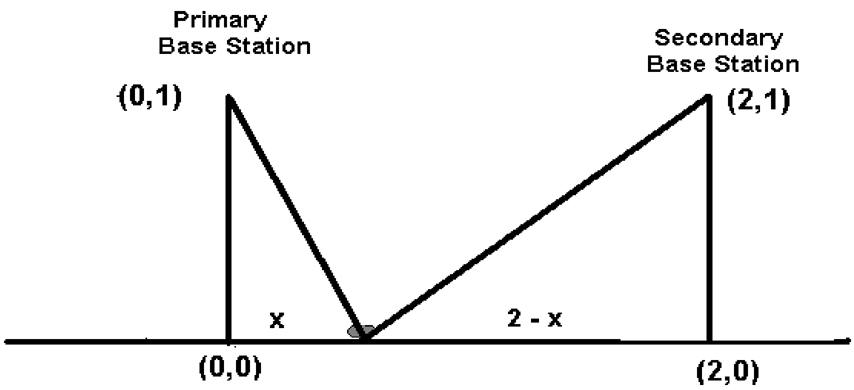


Figure 5.2. right triangles

From Figure 5.1 we see that we have two right triangles as shown in Figure 5.2. The power of the signal for each base station is the square of the length of the hypotenuse of the corresponding triangle. We have (8)

$$\text{Power of primary signal} = \frac{1}{x^2+1} \quad (4)$$

$$\text{Power of secondary signal} = \frac{1}{(x-2)^2+1} \quad (5)$$

And

$$\text{Signal-to-interference ratio} = \frac{\frac{1}{x^2+1}}{\frac{1}{(x-2)^2+1}} = \frac{(x-2)^2+1}{x^2+1} \quad (6)$$

5.3 Handoff signalling flow

In a figure5.3 we described the handover procedures.The intra-MSC handover happens when the cell to be handed over to is controlled by the same MSC, but another BSC than the one currently serving the call.

As previously described, all handovers are initiated by the serving BSC; when receiving a EAS_RES (MEASurement RESult) message indicating a handover is required, the BSC sends a HND_RQD (HaNDover ReQuireD) message to the MSC.The intra-MSC handover can be split into four phases: Decision of handover, channel allocation, handover execution, and resource deal location. We iscuss each of the four phases in the following section.

Decision of handover

The decision of whether to perform a handover is made by the serving BSC from the MEAS_RES (MEASurement RESult) messages received from the BTS.When the decision is made, the handover is initiated by sending the HND_RQD (HaNDover ReQuireD) message to the MSC. The MEAS_RES messages are sent periodically during a call, but we only look at a single one of them.

Channel allocation

The channel allocation phase of the handover is concerned with allocation of radio resources in the new BSS. The MSC requests the new BSS to allocate a channel for the call with the HND_REQ (HaNDover REQuest) message, which is acknowledged with the HND_REQ_ACK (HaNDover REQuest ACKnowledgement), when the channel has been activated. The actual allocation of the channel is done by the message CHAN_ACT (CHANnel ACTivation) and its acknowledgement CHAN_ACT_ACK (CHANnel ACTivation ACKnowledgement).

Handover execution

When the resources for the call have been allocated in the new BSS, the MS is instructed to access the new radio channel. The new BSS generates the HND_CMD (HaNDover CoMmanD) message, which contains information about the new radio channel. This message is forwarded through the old BSS to the MS (message 8_10). After reception of the HND_CMD, the MS tries to access the new channel with a HND_ACC (HaNDover ACCess) message while it is listening for aPHYS_INFO (PHYSical INFOrmation) from the new BSS, containing synchronization information for the MS. The HND_ACC messages is a special message,a so called access burst, because no signalling hannel exists. A signalling channel has been set up, when the PHYS_INFO is received by the MS. In order to set up acknowledged communication between the MS and the new BSS, the MS sends a SABM (Set Asynchronous Balance Mode) message, which is a layer 2 message.This is acknowledged by a UA (Unnumbered Acknowledgement) which also is a layer 2 message. The reason for bringing the two layer 2 messages into the discussion is, that a timer depends on them (discussed in section 4.1.3). When acknowledged mode is up, the BSC is noti_ed with an EST_IND (ESTablish INDication). When the MS has received the UA message, it informs the network, that the handover is completed. This is done by the HND_COM (HaNDover COMplete) message sent to the new BTS, which forwards it to the BSC that ends the handover with the HND_CMP (HaNDover CoMPleted) message for the MSC. At this point of time, the call is switched through the new BSS.

Resource deallocation

When the call has been switched to the new BSS, the actual handover is completed, but radio resources are still occupied in the old BSS. The MSC sends a CLR_CMD (CLeaR CoMmanD) to the old BSC, which orders the old BTS torelease the radio resources allocated for the call with the RF_CHAN_REL (RadioFrequency CHANnel RELease).

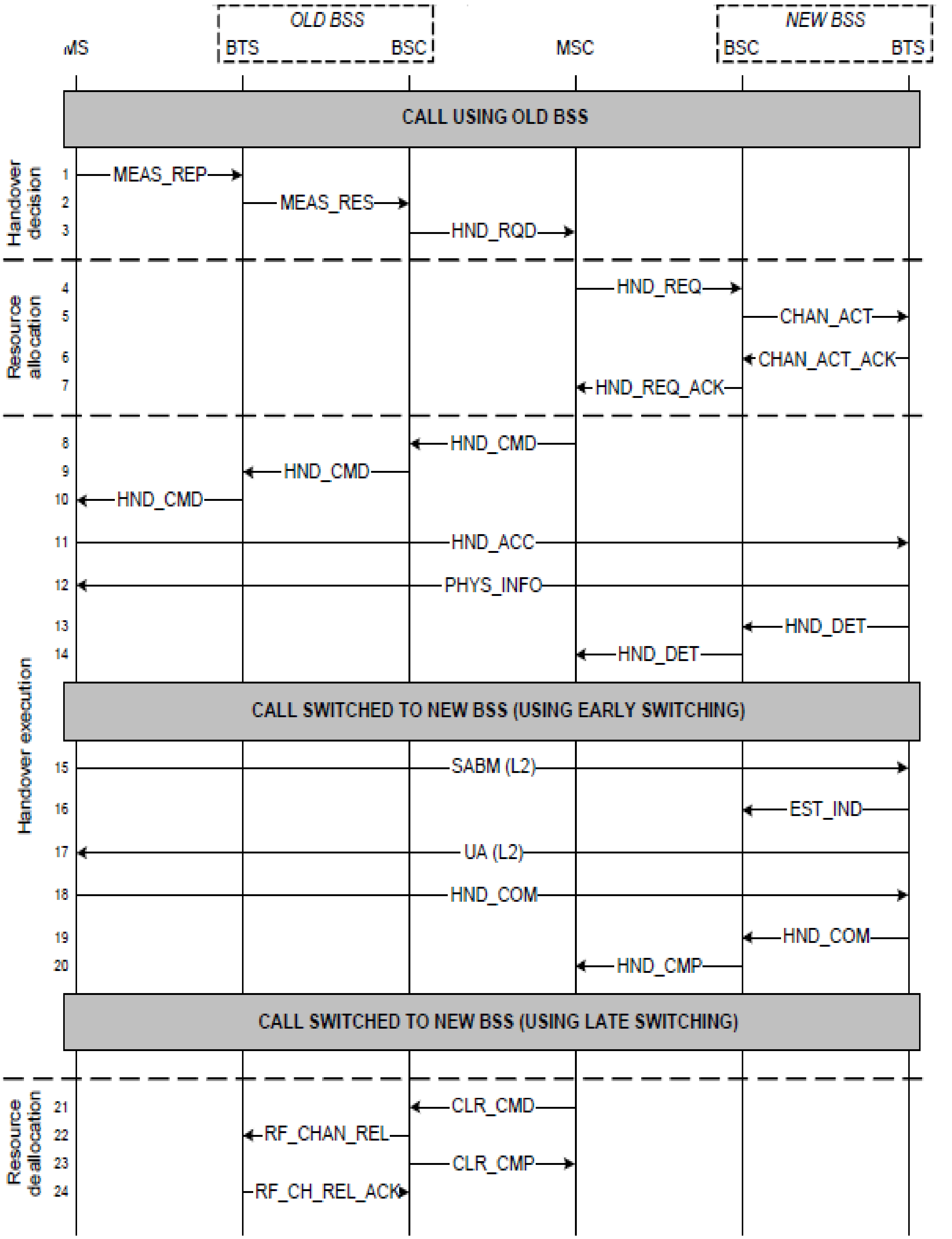


Figure 5.3 Handover signalling flow

5.4 Algorithm and planning

The plan is of the program is done to include all the steps of handover. Firstly can be input as measurement signal for service cell and neighbours cells.

Secondly the processes, is work to do a comparison for the signal strength for service cell and neighbours cells with T_ADD and T_Drop , so as to received an output as to know the classification of cell (active - neighbour –candidate) ,also the handover its success or failure,and executed as flowchart (see figure 5.4 a,b) , to implement it in software program

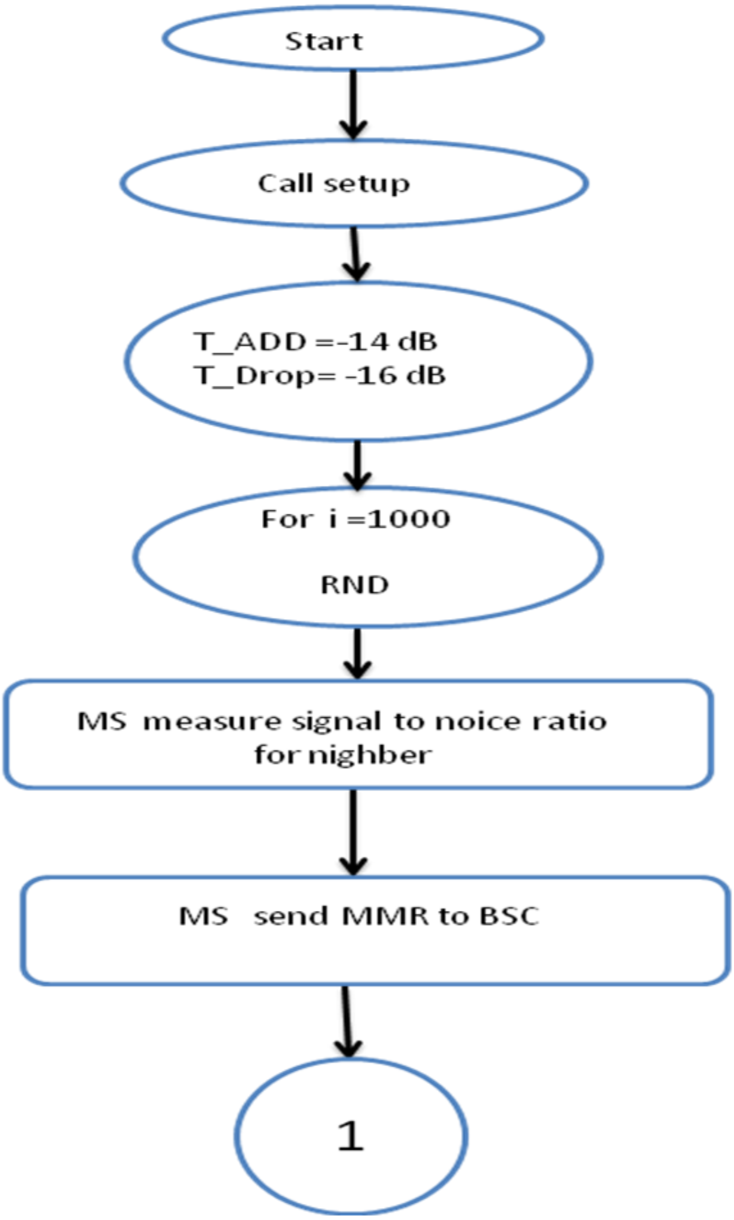


Figure 5.4 ,a handover algorithm input

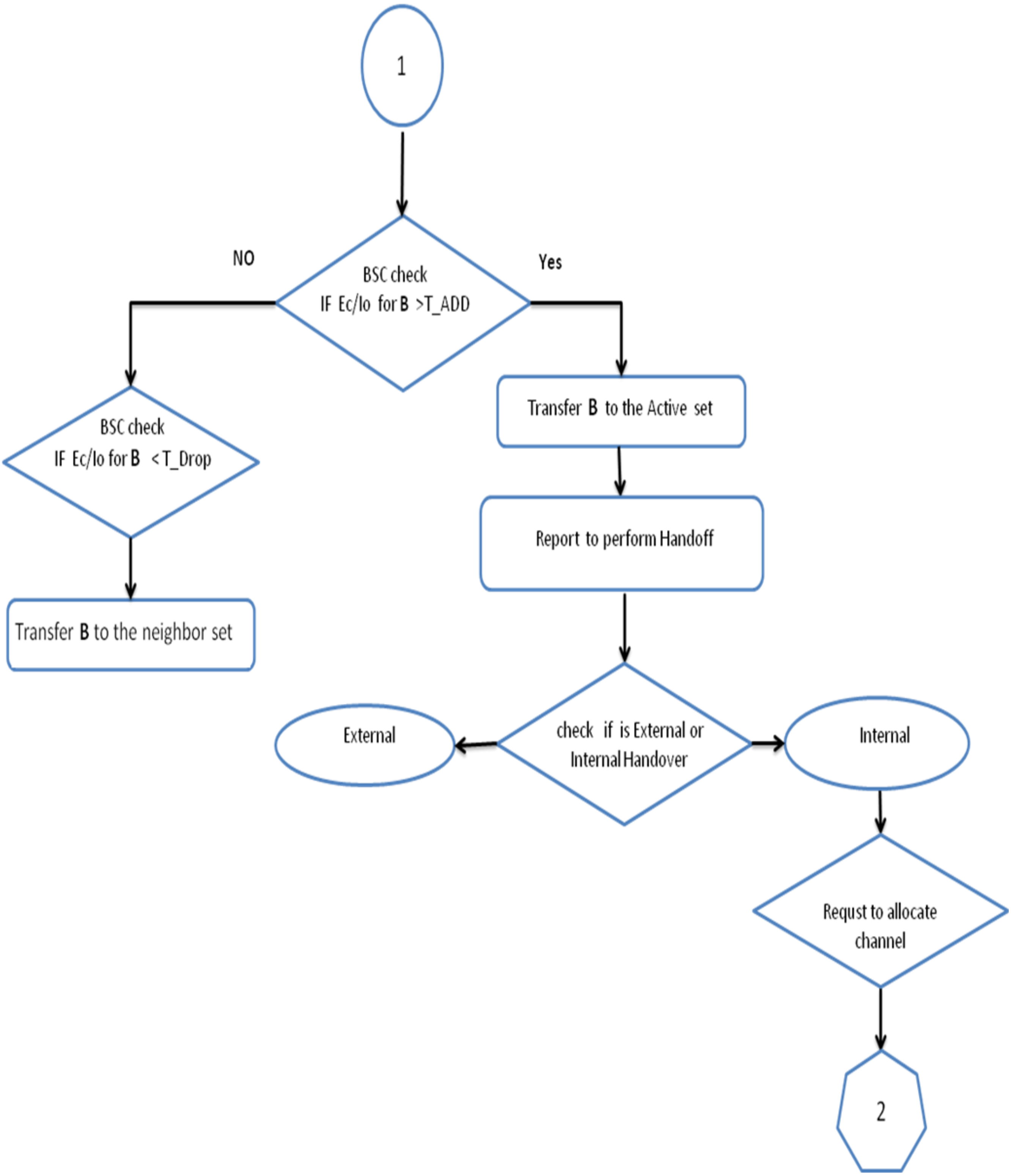


Figure 5.4 ,b handover algorithm processing

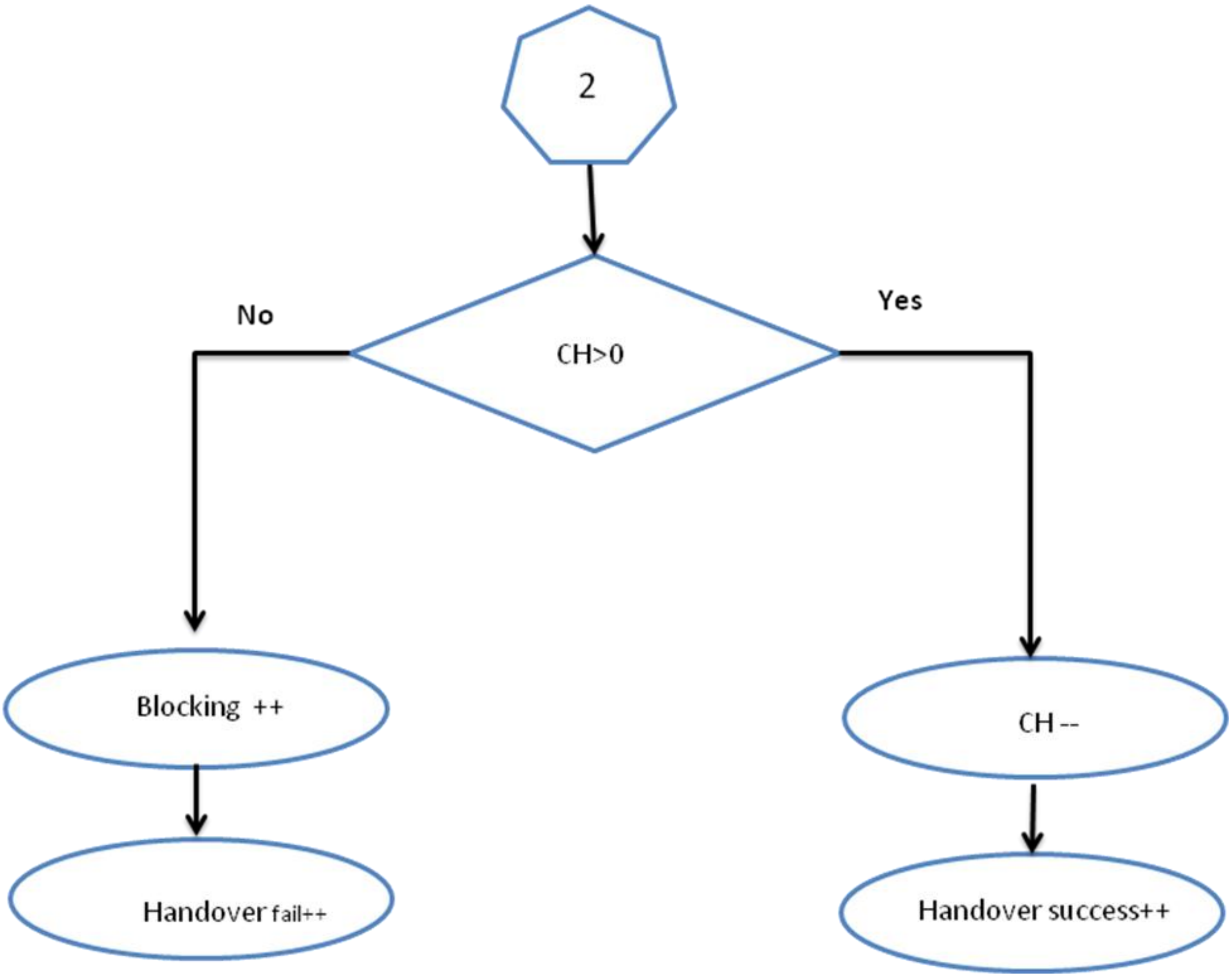


Figure 5.4 ,b handover algorithm output

5.5 Real Case Study for handover

WAD EL AMEEN Area

5.5.1 Complains Description

Customer complains that they express a bad converge situation in WAD EL AMEEN Area, with the optimization team check the complaint and made a detailed drive test to evaluate coverage status in that area.

5.5.2 Area Description

WAD EL AMEEN Area is located in Southern part of Khartoum North City, 90 Km away of center of Khartoum, near UM DWN BAN city, (Long 33.26514, Lat 5.34691), nearby village are El Hesenab, El Shawrab and El Ahamda.

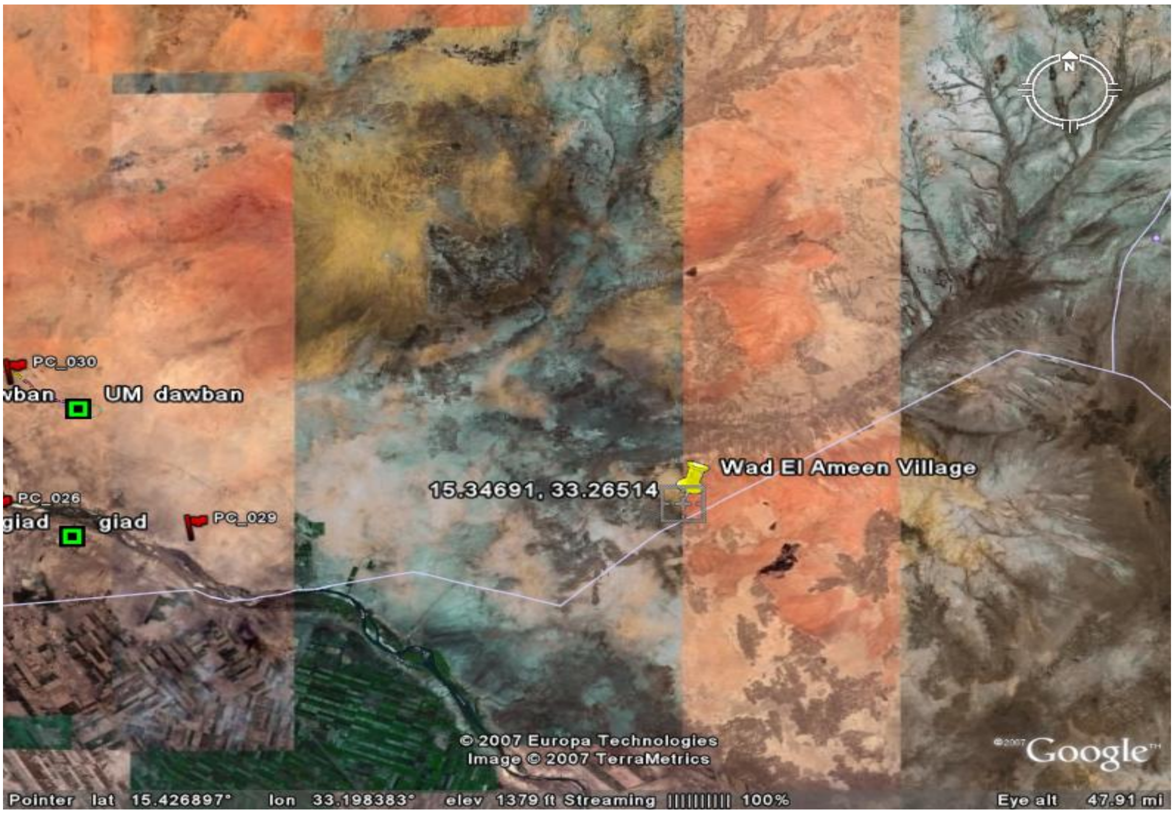


Figure 0.5 Location of WAD EL AMEEN area (Google earth)

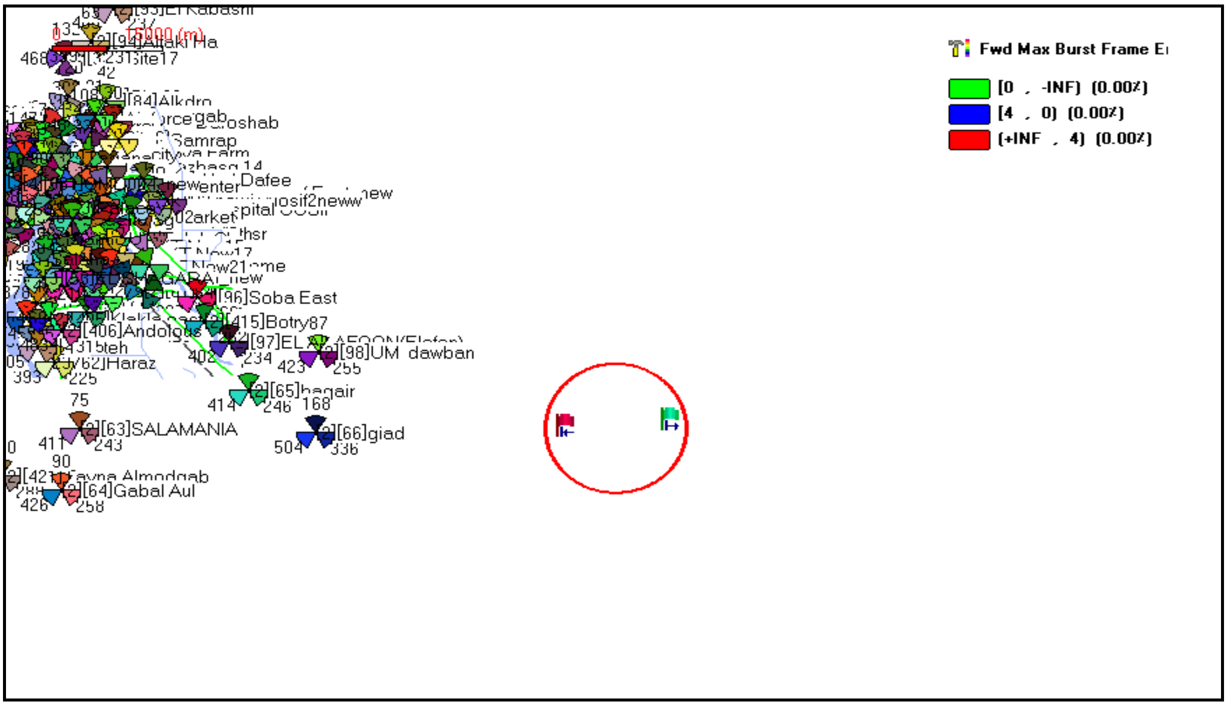


Figure 5.6 Location of WAD EL AMEEN area

5.5.3 Coverage Status

5.53.1 Forward Received Power

Rx indicates the intensity of the forward signal. The Quality of system is related to the signal intensity and the signal quality, so when measuring the system's forward coverage, it is needed to combine the Forward Received Power along with the pilot Ec/Io.see(Table 5.1 & figure 5.7)

Table 5.1 Forward Received Power

Forward Received Power Rx (dbm)	Legend Color	Description
Rx ≤ -105	Black	The coverage is very poor and the service areas can not get coverage.
-105 < Rx ≤ -95	Red	The coverage is poor and can not guarantee the outdoor coverage.
-95 < Rx ≤ -85	Yellow	The coverage is common and can not guarantee the indoor coverage.
-85 < Rx ≤ -75	Green	The coverage is relatively good and can guarantee the indoor coverage generally.
-75<Rx <-65	Blue	The coverage is good.
Rx >-65	Sky blue	The coverage is very good.

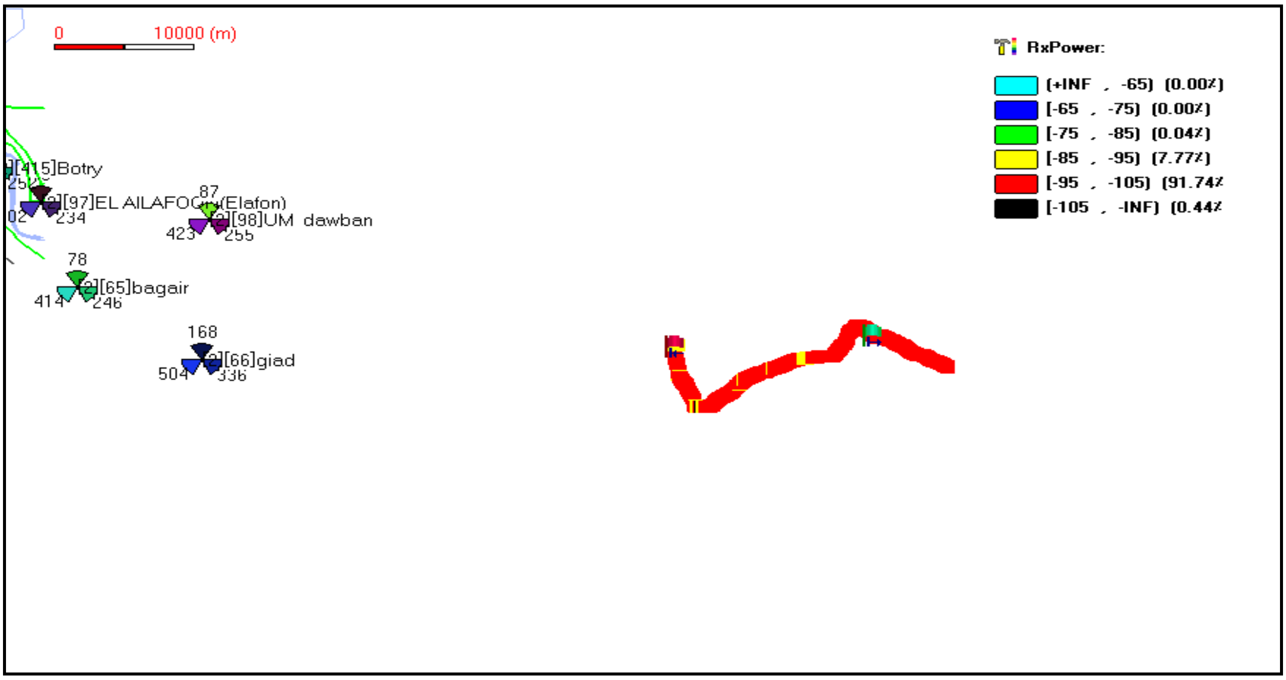


Figure 5.7 Rx Power in WAD ELAMEEN area

5.5.3.2 Reverse Transmitted Power

TX reflects the reverse coverage performance.see (Table 5.2 & figure 5.8)

Table 5.2 TX

Reverse Tx dBm	Legend color	Description
$Tx > 23$	Black	The coverage is very poor and can hardly be guaranteed.
$13 < Tx \le 23$	Red	The coverage is relatively poor, and the outdoor coverage can not be guaranteed.
$3 < Tx \le 13$	Yellow	The coverage quality is common, and the indoor coverage can not be guaranteed.
$-10 < Tx \le 3$	Green	The coverage is relatively good, and the indoor coverage can generally be guaranteed.
$-20 < Tx \le -10$	Blue	The coverage quality is good.
$Tx \le -20$	Sky Blue	The coverage quality is very good.

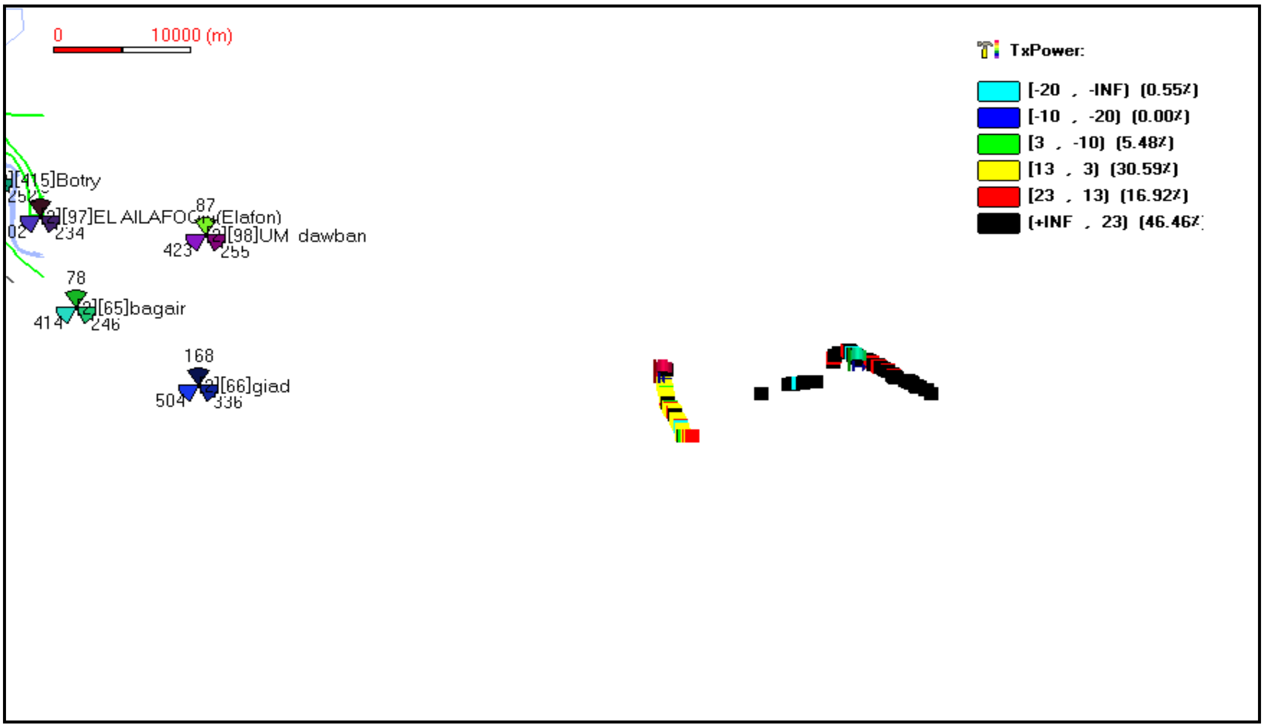


Figure 5.8 Tx Power in WAD ELAMEEN area

5.5.3.3 FER

The forward FER characterizes the quality of basic channels in voice service. see (table 5.3& figure 5.9)

Table 5.3 Legends of Forward FER

Forward FER (%)	Legend Color	Description
FFER > 5	Black	The voice quality is very poor.
3 < FFER ≤ 5	Red	The voice quality is relatively poor and subscribers can detect this easily.
2 < FFER ≤ 3	Yellow	The voice quality is common. Subscribers can detect no obvious voice defects.
1 < FFER ≤ 2	Green	The voice quality is relatively good, and subscribers can hardly feel voice defects.
FFER ≤ 1	Blue	The voice quality is good.

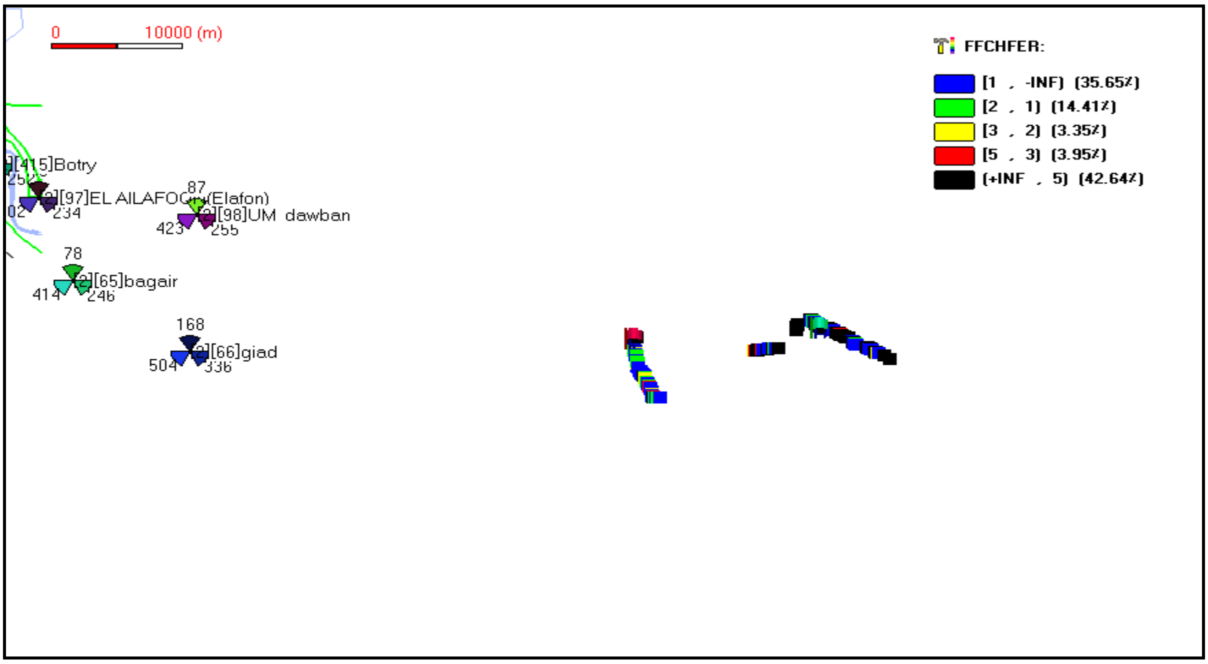


Figure 5.9 FER in WAD ELAMEEN area

5.5.3.4 Aggregate Ec/Io

Ec/Io indicates the quality of the forward signal. This parameter has great influences on voice service. see (table 5.4& figure 5.10)

Table 5.4 Legends of Forward Ec/Io

Forward Ec/Io (dB	Legend Colo	Description
Ec/Io ≤ -15	Black	The coverage is very poor and can hardly be achieved.
-15 < Ec/Io ≤ -12	Red	The coverage is relatively poor. The rate of data service is low and the quality of the conversation can not be guaranteed.
-12 < Ec/Io ≤ -10	Yellow	The coverage of voice service is common, and the rate of data service can not be guaranteed.
-10 < Ec/Io ≤ -8	Green	The coverage of the voice service is relatively good, and the data service can generally reach a relatively higher rate.
-8<Ec/Io ≤-6	Blue	The coverage is good.
Ec/Io > -6	Sky Blue	The coverage is very good.

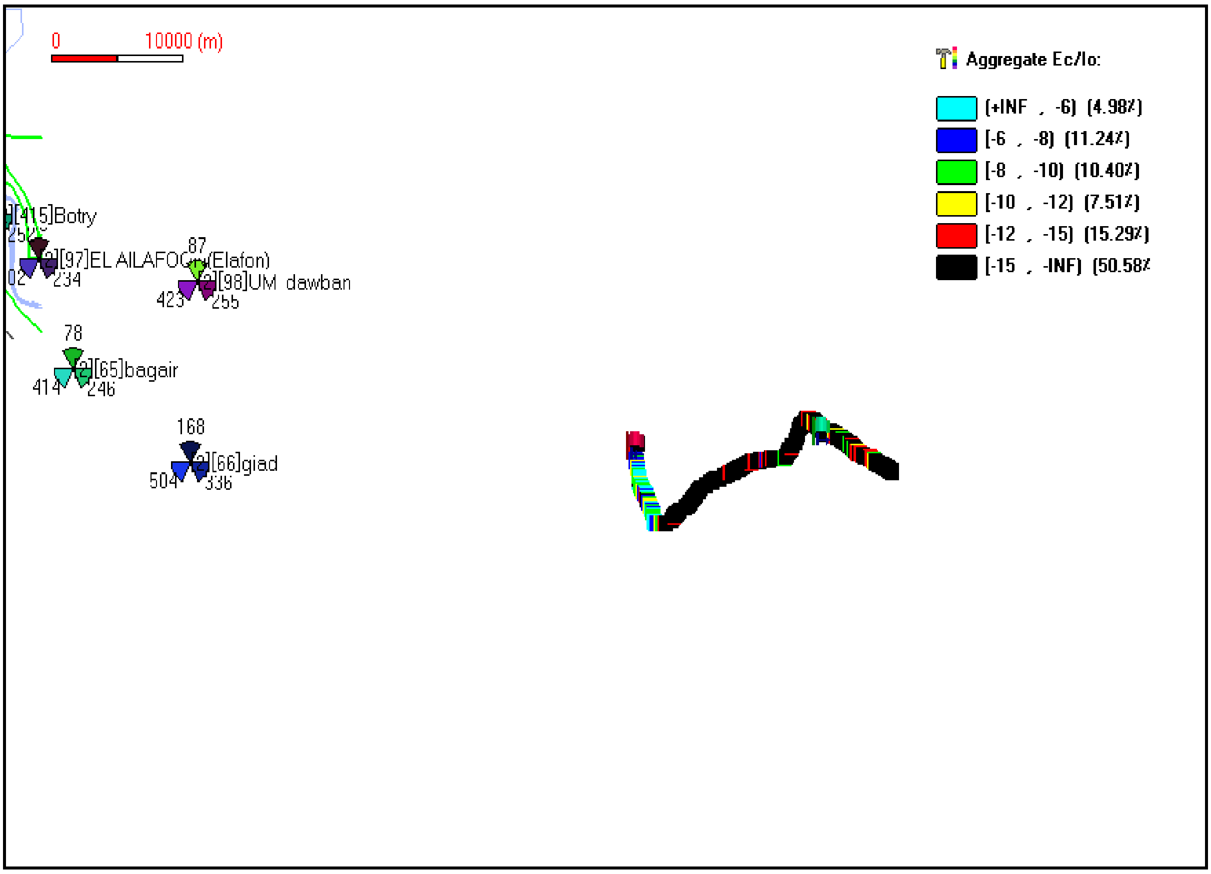


Figure 5.10 Aggregate Ec/Io in WAD ELAMEEN area

5.6 Traffic analysis performance for real data

CELL	Sector ID	Date	Hour	TCH _ TRAFFIC	Drop Rate	INTRACELL_HANDOVER _SUCCESS_RATE	INTRACELL_HANDOVER _FAILURE_RATE
Bagair	2	15/03/10	1:00:00 AM	8.51	0	99.369	0.174
Bagair	2	15/03/10	2:00:00 AM	6.35	0	99.113	0.331
Bagair	2	15/03/10	3:00:00 AM	4.45	0	84.65	0.156
Bagair	2	15/03/10	4:00:00 AM	4.06	0	99.276	0.181
Bagair	2	15/03/10	5:00:00 AM	3.29	0	99.2	0.175
Bagair	2	15/03/10	6:00:00 AM	1.41	0	99.536	0.063
Bagair	2	15/03/10	7:00:00 AM	1.65	0	90.34	9.3
Bagair	2	15/03/10	8:00:00 AM	1.9	0	99.602	0.039
Bagair	2	15/03/10	9:00:00 AM	2.89	0	98.916	0.723
Bagair	2	15/03/10	10:00:00 AM	2.91	0.38	99.115	0.369
Bagair	2	15/03/10	11:00:00 AM	2.96	0.42	93.75	0.147
Bagair	2	15/03/10	12:00:00 PM	2.95	0	89.73	7.34
Bagair	2	15/03/10	1:00:00 PM	4.54	0.15	99.342	0
Bagair	2	15/03/10	2:00:00 PM	4.21	0.19	99.674	0.033
Bagair	2	15/03/10	3:00:00 PM	4.52	0	99.817	0
Bagair	2	15/03/10	4:00:00 PM	3.39	0	98.601	1.34
Bagair	2	15/03/10	5:00:00 PM	5.38	0	99.667	0.111
Bagair	2	15/03/10	6:00:00 PM	6.26	0.18	99.758	0.04
Bagair	2	15/03/10	7:00:00 PM	8.12	0.44	99.059	0.29
Bagair	2	15/03/10	8:00:00 PM	10.23	0.18	99.023	0.383
Bagair	2	15/03/10	9:00:00 PM	8.9	0.44	99.12	0.137
Bagair	2	15/03/10	10:00:00 PM	9.11	0.18	99.324	0.119
Bagair	2	15/03/10	11:00:00 PM	8.44	0	99.071	0.304
Bagair	2	15/03/10	12:00:00 AM	6.67	0.125	99.602	4.37
avrg				5.12917	0.112	97.694	1.089
SDV				2.621	0.159	3.942	2.415
median				4.485	0	99.16	0.1745

Table 5.7 Data for Bagair cell in 24 hours

CELL	Hour	Data Average of TCH _ TRAFFIC	Average of Drop Rate
Bagair	12:00:00 PM	4.45	0
	1:00:00 AM	8.51	0
	2:00:00 AM	6.35	0
	3:00:00 AM	4.06	0
	4:00:00 AM	3.29	0
	5:00:00 AM	1.41	0
	6:00:00 AM	1.65	0
	7:00:00 AM	1.9	0
	8:00:00 AM	2.89	0
	9:00:00 AM	2.91	0.38
	10:00:00 AM	2.96	0.42
	11:00:00 AM	2.95	0
	12:00:00 PM	4.54	0.15
	1:00:00 PM	4.21	0.19
	2:00:00 PM	4.52	0
	3:00:00 PM	3.39	0
	4:00:00 PM	5.38	0
	5:00:00 PM	6.26	0.18
	6:00:00 PM	8.12	0.44
	7:00:00 PM	10.23	0.18
	8:00:00 PM	8.9	0.44
	9:00:00 PM	9.11	0.18
	10:00:00 PM	8.44	0
	11:00:00 PM	7.22	0.19
Bagair Total		5.152083333	0.114583333
Grand Total		5.152083333	0.114583333

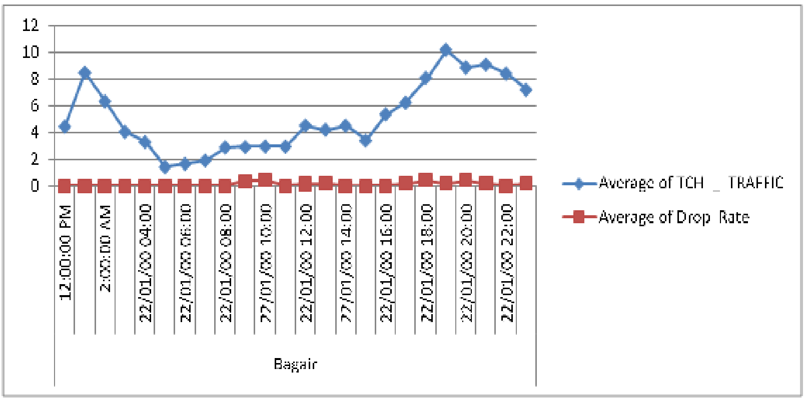


Figure 5.12 study for traffic and drop rate in 24 hours in Bagair cell

		Data	
CELL	Hour	Min of INTRACELL_HANDOVER_SUCCESS_RATE	Min of INTRACELL_HANDOVER_FAILURE_RATE
Bagair	22/01/00	99.369	0.174
	22/01/00 01:00	99.113	0.331
	22/01/00 02:00	84.65	0.156
	22/01/00 03:00	99.276	0.181
	22/01/00 04:00	99.2	0.175
	22/01/00 05:00	99.536	0.063
	22/01/00 06:00	90.34	9.3
	22/01/00 07:00	99.602	0.039
	22/01/00 08:00	98.916	0.723
	22/01/00 09:00	99.115	0.369
	22/01/00 10:00	93.75	0.147
	22/01/00 11:00	89.73	7.34
	22/01/00 12:00	99.342	0
	22/01/00 13:00	99.674	0.033
	22/01/00 14:00	99.817	0
	22/01/00 15:00	98.601	1.34
	22/01/00 16:00	99.667	0.111
	22/01/00 17:00	99.758	0.04
	22/01/00 18:00	99.059	0.29
	22/01/00 19:00	99.023	0.383
	22/01/00 20:00	99.12	0.137
	22/01/00 21:00	99.324	0.119
	22/01/00 22:00	99.071	0.304
	22/01/00 23:00	99.117	0.233
Bagair Total		84.65	0
Grand Total		84.65	0

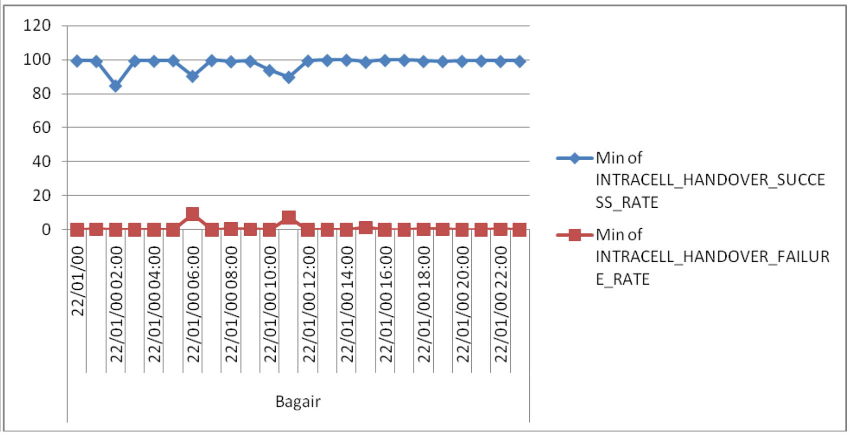


Figure 5.13 study for success and failuer handover in 24 hours in Bagair cell

CELL	Sector ID	Date	Hour	TCH _ TRAFFIC	Drop Rate	INTRACELL_HANDOVER_ SUCCESS_RATE	INTRACELL_HANDOVER_ FAILURE_RATE
UM dawban	2	17/03/10	1:00:00 AM	7.28	4.97	99.342	0.033
UM dawban	2	17/03/10	2:00:00 AM	7.46	6.32	99.059	0.147
UM dawban	2	17/03/10	3:00:00 AM	8.19	5.78	99.466	7.34
UM dawban	2	17/03/10	4:00:00 AM	13.77	7.96	98.601	0
UM dawban	2	17/03/10	5:00:00 AM	16.6	6.58	99.12	0.033
UM dawban	2	17/03/10	6:00:00 AM	27.23	6.07	99.536	0
UM dawban	2	17/03/10	7:00:00 AM	7.5	18.93	99.511	1.34
UM dawban	2	17/03/10	8:00:00 AM	6.32	6.24	99.227	0.111
UM dawban	2	17/03/10	9:00:00 AM	4.83	12.55	99.423	0.04
UM dawban	2	17/03/10	10:00:00 AM	7.14	22.01	99.758	0.29
UM dawban	2	17/03/10	11:00:00 AM	16.7	0.19	99.08	0.383
UM dawban	2	17/03/10	12:00:00 PM	6.58	0.116	99.304	0.137
UM dawban	2	17/03/10	1:00:00 PM	8.64	0.112	99.667	0.119
UM dawban	2	17/03/10	2:00:00 PM	12.74	0.235	99.117	0.304
UM dawban	2	17/03/10	3:00:00 PM	8.52	0.133	99.2	0.29
UM dawban	2	17/03/10	4:00:00 PM	9.68	0.127	99.536	0.109
UM dawban	2	17/03/10	5:00:00 PM	2.95	0.214	90.34	0.721
UM dawban	2	17/03/10	6:00:00 PM	4.54	0.101	99.602	0.137
UM dawban	2	17/03/10	7:00:00 PM	4.21	0.079	98.916	0.063
UM dawban	2	17/03/10	8:00:00 PM	4.52	0.137	99.115	0.147
UM dawban	2	17/03/10	9:00:00 PM	3.39	0.162	93.75	0.237
UM dawban	2	17/03/10	10:00:00 PM	5.38	0.181	89.73	0.128
UM dawban	2	17/03/10	11:00:00 PM	6.26	0.121	99.342	0.04
UM dawban	2	17/03/10	12:00:00 AM	8.12	0.176	99.674	0.162
avrg				8.689583	4.146	98.309	0.513
SDV				5.434	6.146	2.803	1.482
median				7.37	0.202	99.2655	0.137

Table 5.8 Data for UM dawban cell in 24 hours

		Data	
CELL	Hour	Average of Drop Rate	Average of TCH _ TRAFFIC
UM dawban	1:00:00 AM	4.97	7.28
	2:00:00 AM	6.32	7.46
	3:00:00 AM	5.78	8.19
	4:00:00 AM	7.96	13.77
	5:00:00 AM	6.58	16.6
	6:00:00 AM	6.07	27.23
	7:00:00 AM	18.93	7.5
	8:00:00 AM	6.24	6.32
	9:00:00 AM	12.55	4.83
	10:00:00 AM	22.01	7.14
	11:00:00 AM	0.19	16.7
	12:00:00 PM	0.116	6.58
	1:00:00 PM	0.112	8.64
	2:00:00 PM	0.235	12.74
	3:00:00 PM	0.133	8.52
	4:00:00 PM	0.127	9.68
	5:00:00 PM	0.214	2.95
	6:00:00 PM	0.101	4.54
	7:00:00 PM	0.079	4.21
	8:00:00 PM	0.137	4.52
	9:00:00 PM	0.162	3.39
	10:00:00 PM	0.181	5.38
	11:00:00 PM	0.121	6.26
	12:00:00 AM	0.176	8.12
UM dawban Total		4.14558333	8.689583333
Grand Total		4.14558333	8.689583333

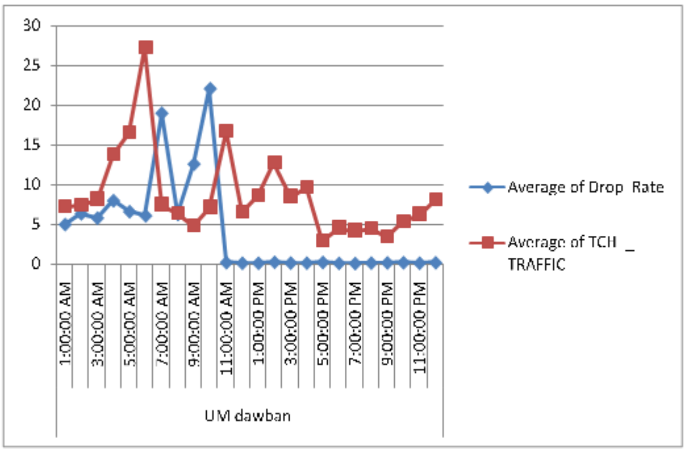


Figure 5.14 study for traffic and drop rate in 24 hours in Um dawban cell

		Data	
CELL	Hour	Min of INTRACELL_HANDOVER_SUCCESS_RA	Min of INTRACELL_HANDOVER_FAILURE_R
UM dawban	1:00:00 AM	99.342	0.033
	2:00:00 AM	99.059	0.147
	3:00:00 AM	99.466	7.34
	4:00:00 AM	98.601	0
	5:00:00 AM	99.12	0.033
	6:00:00 AM	99.536	0
	7:00:00 AM	99.511	1.34
	8:00:00 AM	99.227	0.111
	9:00:00 AM	99.423	0.04
	10:00:00 AM	99.758	0.29
	11:00:00 AM	99.08	0.383
	12:00:00 PM	99.304	0.137
	1:00:00 PM	99.667	0.119
	2:00:00 PM	99.117	0.304
	3:00:00 PM	99.2	0.29
	4:00:00 PM	99.536	0.109
	5:00:00 PM	90.34	0.721
	6:00:00 PM	99.602	0.137
	7:00:00 PM	98.916	0.063
	8:00:00 PM	99.115	0.147
	9:00:00 PM	93.75	0.237
	10:00:00 PM	89.73	0.128
	11:00:00 PM	99.342	0.04
	12:00:00 AM	99.674	0.162
UM dawban Total		89.73	0
Grand Total		89.73	0

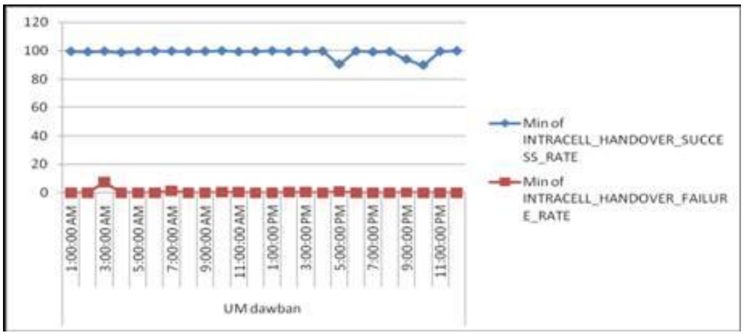


Figure 5.15 study for success and failuer handover in 24 hours in UM dawban cell

CELL	Sector ID	Date	Hour	TCH _ TRAFFIC	Drop Rate	INTRACELL HANDOVER SUCCESS_RATE	INTRACELL HANDOVER FAILURE_RATE
Giad	2	21/03/10	1:00:00 AM	27.23	0.162	98.825	0.109
Giad	2	21/03/10	2:00:00 AM	7.5	0.056	99.113	0.721
Giad	2	21/03/10	3:00:00 AM	6.32	0.116	99.674	0.137
Giad	2	21/03/10	4:00:00 AM	4.83	0.044	99.071	0.063
Giad	2	21/03/10	5:00:00 AM	7.14	0.108	99.276	0.147
Giad	2	21/03/10	6:00:00 AM	16.7	0.296	99.817	0.237
Giad	2	21/03/10	7:00:00 AM	6.58	0.199	99.081	0.128
Giad	2	21/03/10	8:00:00 AM	8.64	0.101	99.2	0.04
Giad	2	21/03/10	9:00:00 AM	12.74	0.162	99.342	0.162
Giad	2	21/03/10	10:00:00 AM	8.52	0.056	99.059	0.12
Giad	2	21/03/10	11:00:00 AM	9.68	0.116	99.117	0.111
Giad	2	21/03/10	12:00:00 PM	2.95	0.044	79.071	0.172
Giad	2	21/03/10	1:00:00 PM	4.54	0.108	99.602	0.174
Giad	2	21/03/10	2:00:00 PM	4.21	0.296	80.54	0.723
Giad	2	21/03/10	3:00:00 PM	4.52	0.199	74.98	0.198
Giad	2	21/03/10	4:00:00 PM	3.39	0.112	89.86	0.162
Giad	2	21/03/10	5:00:00 PM	5.38	0.181	8.74	0.369
Giad	2	21/03/10	6:00:00 PM	6.26	0.127	80.86	0.162
Giad	2	21/03/10	7:00:00 PM	8.12	0.079	90.75	5.53
Giad	2	21/03/10	8:00:00 PM	10.23	0.257	97.57	3.23
Giad	2	21/03/10	9:00:00 PM	8.9	0.044	99.342	6.67
Giad	2	21/03/10	10:00:00 PM	9.11	0.108	99.059	4.37
Giad	2	21/03/10	11:00:00 PM	8.44	0.296	99.117	1.68
Giad	2	21/03/10	12:00:00 AM	6.67	0.199	79.071	0.233
avrg				8.275	0.144	90.422	1.069
SDV				5.063	0.081	19.312	1.883
median				7.32	0.116	99.065	0.173

Table 5.9 Data for Gaiad cell in 24 hours

CELL	Hour	Data Max of INTRACELL_HANDOVER_SUCCESS_R	Max of INTRACELL_HANDOVER_FAILURE
Giad	1:00:00 AM	98.825	0.109
	2:00:00 AM	99.113	0.721
	3:00:00 AM	99.674	0.137
	4:00:00 AM	99.071	0.063
	5:00:00 AM	99.276	0.147
	6:00:00 AM	99.817	0.237
	7:00:00 AM	99.081	0.128
	8:00:00 AM	99.2	0.04
	9:00:00 AM	99.342	0.162
	10:00:00 AM	99.059	0.12
	11:00:00 AM	99.117	0.111
	12:00:00 PM	79.071	0.172
	1:00:00 PM	99.602	0.174
	2:00:00 PM	80.54	0.723
	3:00:00 PM	74.98	0.198
	4:00:00 PM	89.86	0.162
	5:00:00 PM	8.74	0.369
	6:00:00 PM	80.86	0.162
	7:00:00 PM	90.75	5.53
	8:00:00 PM	97.57	3.23
	9:00:00 PM	99.342	6.67
	10:00:00 PM	99.059	4.37
	11:00:00 PM	99.117	1.68
	12:00:00 AM	79.071	0.233
Giad Total		99.817	6.67
Grand Total		99.817	6.67

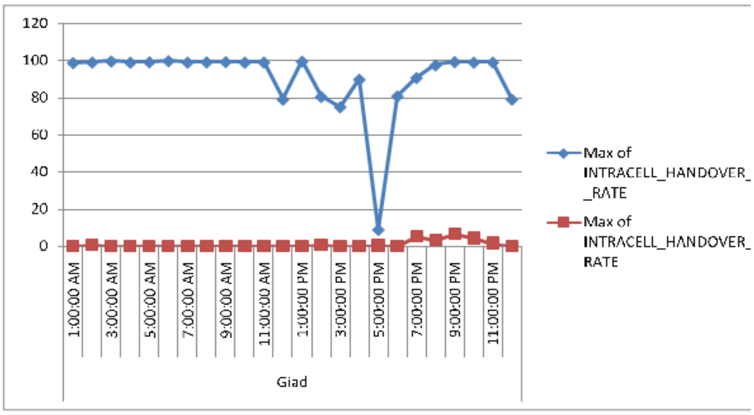


Figure 5.16 study for success and failuer handover in 24 hours in Giad cell

		Data	
CELL	Hour	Average of TCH _ TRAFFIC	Average of Drop Rate
Giad	1:00:00 AM	27.23	0.162
	2:00:00 AM	7.5	0.056
	3:00:00 AM	6.32	0.116
	4:00:00 AM	4.83	0.044
	5:00:00 AM	7.14	0.108
	6:00:00 AM	16.7	0.296
	7:00:00 AM	6.58	0.199
	8:00:00 AM	8.64	0.101
	9:00:00 AM	12.74	0.162
	10:00:00 AM	8.52	0.056
	11:00:00 AM	9.68	0.116
	12:00:00 PM	2.95	0.044
	1:00:00 PM	4.54	0.108
	2:00:00 PM	4.21	0.296
	3:00:00 PM	4.52	0.199
	4:00:00 PM	3.39	0.112
	5:00:00 PM	5.38	0.181
	6:00:00 PM	6.26	0.127
	7:00:00 PM	8.12	0.079
	8:00:00 PM	10.23	0.257
	9:00:00 PM	8.9	0.044
	10:00:00 PM	9.11	0.108
	11:00:00 PM	8.44	0.296
	12:00:00 AM	6.67	0.199
Giad Total		8.275	0.14441667
Grand Total		8.275	0.14441667

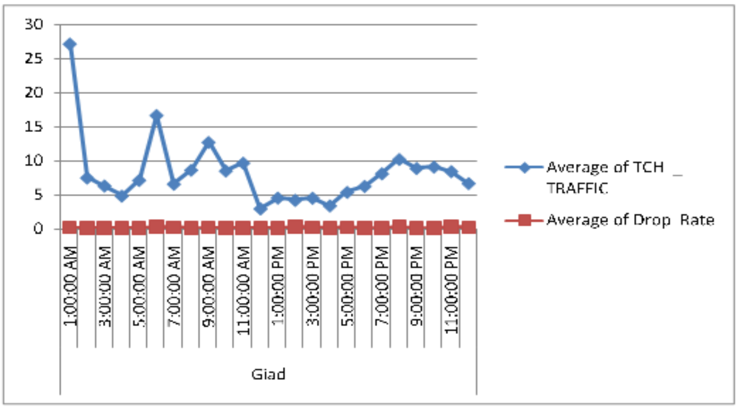


Figure 5.17 study for traffic and drop rate in 24 hours in Giad cell

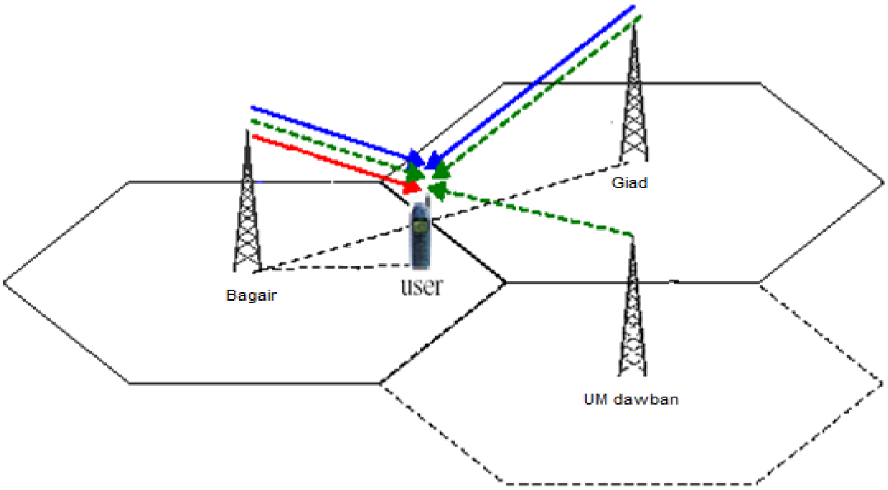


Figure 5.18 Three Cell

CELL	Sector ID	_Date	TCH_TRAFFIC	Drop Rate	INTRACELL HANDOVER SUCCESS_RATE	INTRACELL HANDOVER FAILURE_RATE
Bagair	0	15/03/10	36.45	9.53	99.181	0.162
Bagair	0	16/03/10	27.64	13.74	99.536	7.194
Bagair	0	17/03/10	29.76	4.84	90.34	0.12
Bagair	0	18/03/10	16.70	9.63	99.602	4.109
Bagair	0	19/03/10	6.58	8.63	98.916	0.266
Bagair	0	20/03/10	8.64	6.76	99.115	3.199
Bagair	0	21/03/10	12.74	0.08	93.75	0.128
UM dawba	1	15/03/10	8.52	0.127	89.73	9.723
UM dawba	1	16/03/10	9.68	0.079	99.342	0.369
UM dawba	1	17/03/10	2.95	0.257	99.674	7.147
UM dawba	1	18/03/10	4.54	0.162	99.817	0.046
UM dawba	1	19/03/10	4.21	6.67	98.601	0
UM dawba	1	20/03/10	4.52	7.17	99.667	0.033
UM dawba	1	21/03/10	3.39	5.9	99.758	0
Giad	2	15/03/10	5.38	6.07	99.059	0.162
Giad	2	16/03/10	6.26	8.93	99.023	7.162
Giad	2	17/03/10	8.12	6.24	99.12	0.172
Giad	2	18/03/10	10.23	12.55	99.324	9.366
Giad	2	19/03/10	8.9	2.01	99.071	0.258
Giad	2	20/03/10	9.11	0.19	99.602	0.29
Giad	2	21/03/10	8.44	0.116	99.663	6.383
Giad	2	10/03/10	6.67	0.112	99.324	0.137

Table 5.10 Data for three cell in aweek

Min of TCH_TRAFFIC		
CELL	_Date	Total
Bagair	15/03/10	36.45
	16/03/10	27.64
	17/03/10	29.76
	18/03/10	30.94
	19/03/10	29.79
	20/03/10	28.94
	21/03/10	29.62
Bagair Total		27.64
Giad	10/03/10	45.77
	15/03/10	33.57
	16/03/10	67.87
	17/03/10	39.39
	18/03/10	82.4
	19/03/10	42.59
	20/03/10	48.54
	21/03/10	48.4
Giad Total		33.57
UM dawban	15/03/10	21.33
	16/03/10	17.59
	17/03/10	13.85
	18/03/10	17.67
	19/03/10	17.97
	20/03/10	18.49
	21/03/10	16.04
UM dawban Total		13.85
Grand Total		13.85

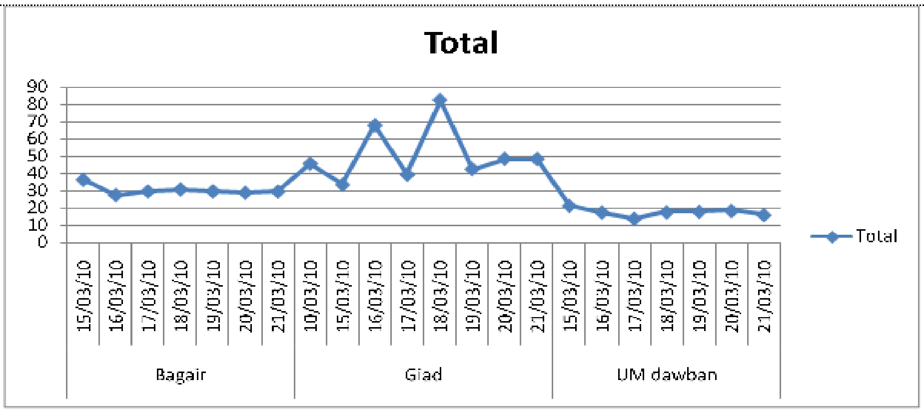


Figure 5.19 Traffic in three cell for aweek

Max of Drop Rate		
CELL	_Date	Total
Bagair	15/03/10	0.096
	16/03/10	0.08
	17/03/10	0.115
	18/03/10	0.176
	19/03/10	0.116
	20/03/10	0.067
	21/03/10	0.113
Bagair Total		0.176
Giad	10/03/10	0.131
	15/03/10	0.145
	16/03/10	0.164
	17/03/10	0.111
	18/03/10	0.235
	19/03/10	0.14
	20/03/10	0.121
	21/03/10	0.198
Giad Total		0.235
UM dawban	15/03/10	0.108
	16/03/10	0.296
	17/03/10	0.199
	18/03/10	0.112
	19/03/10	0.181
	20/03/10	0.127
	21/03/10	0.079
UM dawban Total		0.296
Grand Total		0.296

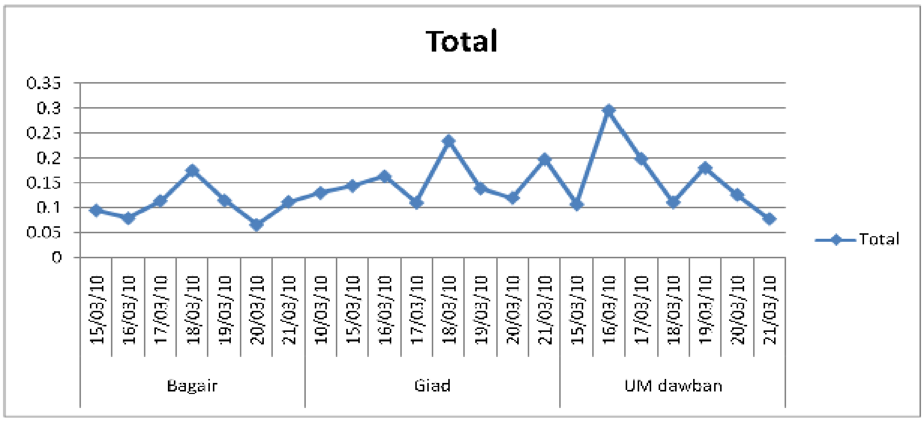


Figure 5.20 Drop rate in three cell for aweek

Average of INTRACELL_HANDOVER_SUCCESS_RATE		
CELL	_Date	Total
Bagair	15/03/10	99.181
	16/03/10	99.381
	17/03/10	99.304
	18/03/10	99.466
	19/03/10	99.292
	20/03/10	99.403
	21/03/10	99.423
Bagair Total		99.35
Giad	10/03/10	99.12
	15/03/10	99.08
	16/03/10	99.239
	17/03/10	99.2
	18/03/10	98.825
	19/03/10	99.153
	20/03/10	99.059
	21/03/10	99.023
Giad Total		99.087375
UM dawban	15/03/10	98.916
	16/03/10	99.115
	17/03/10	99.511
	18/03/10	99.769
	19/03/10	99.342
	20/03/10	99.674
	21/03/10	99.817
UM dawban Total		99.44914286
Grand Total		99.28604545

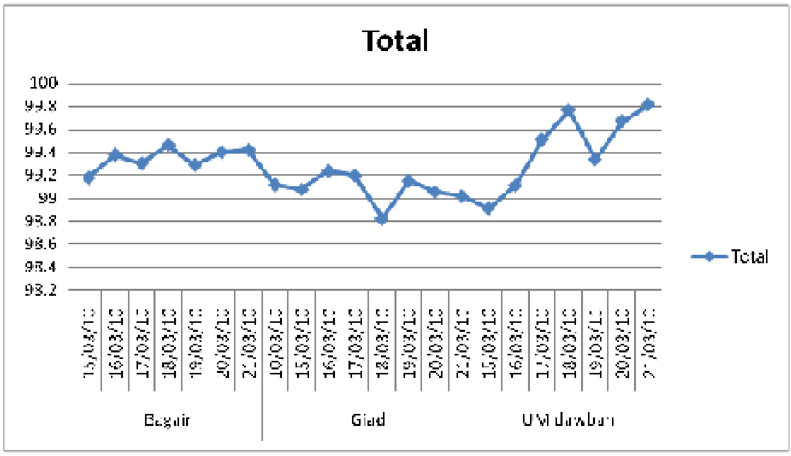


Figure 5.21 Handover cuccess in three cell for aweek

5.7 Implementations

After analysis and planning of handoff algorithm we used Java software program to implement our code , also excel package software program have been used for the statistical analysis of the traffic, call drop, .and handover success by use the real data case of three cell from the service provider (SUDANI) .

Also, a drive test software been used to study real data case in (WAD ELAMEEN) area.

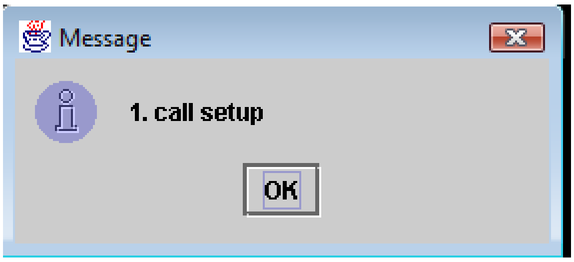
The java software is characterize by simple, secure, portable, object-oriented, high performance and dynamic

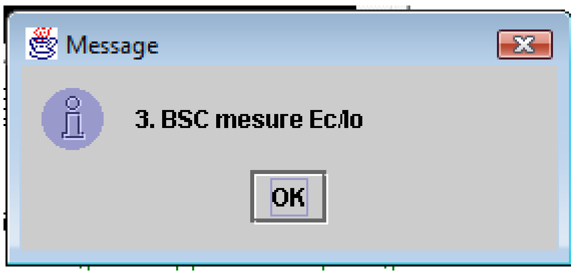
The code is shown in appendix I

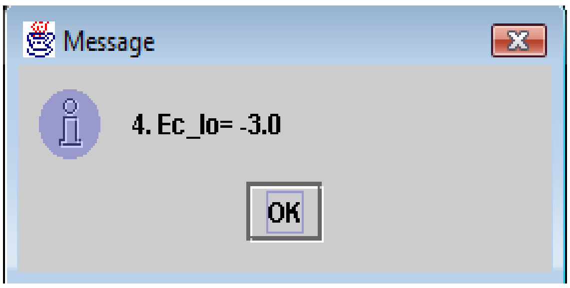
5.8 Result

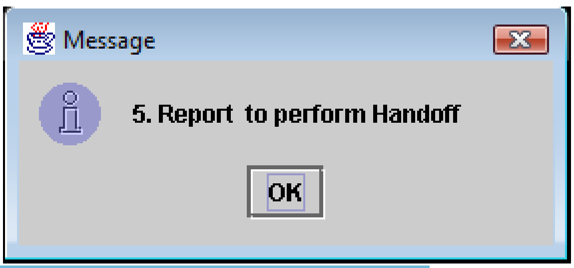
5.8.1 Results for Simulator

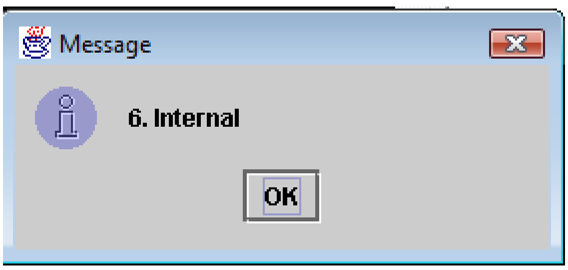
The result of simulator can be to now the type of cell as its active /candidate or neighbour cell , also to now the evaluation of handover is it success or failure according to that ,also the call drop we can see the result of simulator in the flowing windows

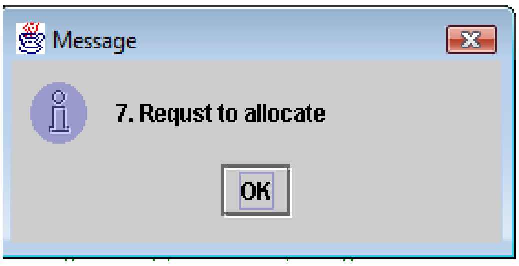


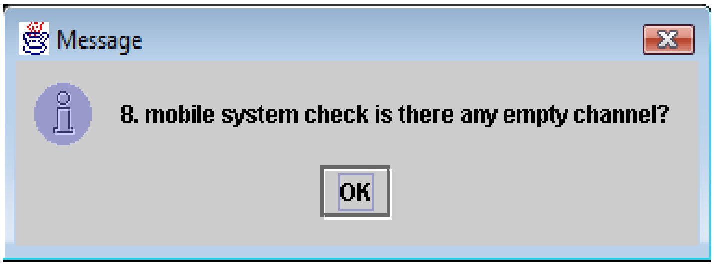




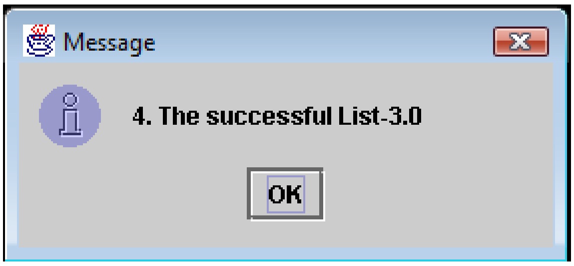


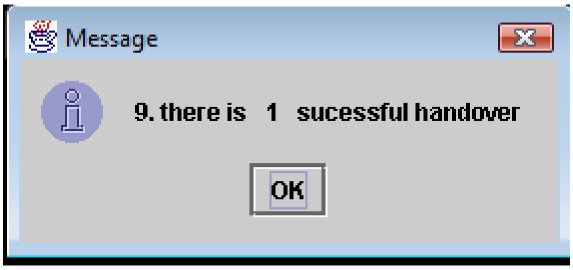


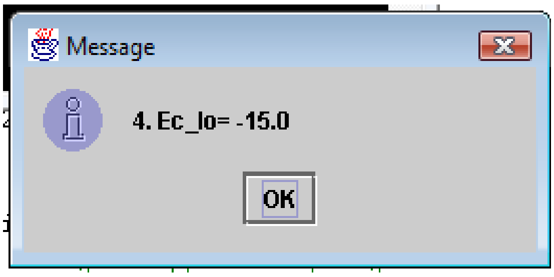

Message
7. Requst to allocate
OK

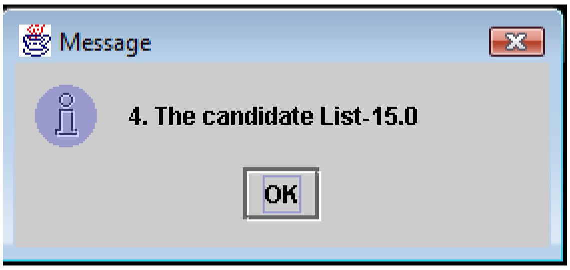

Message
8. mobile system check is there any empty channel?
OK

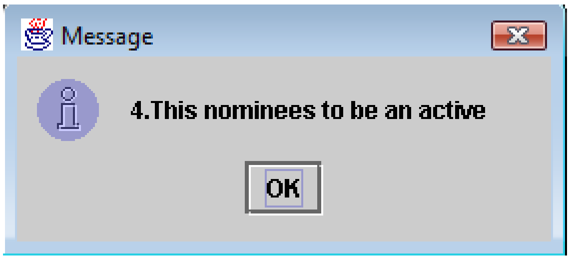

Message
9. there is 4.0 channel
OK

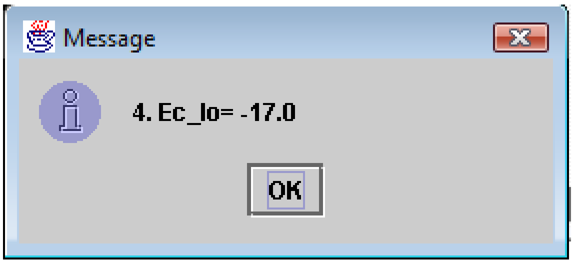

Message
4. The successful List-3.0
OK

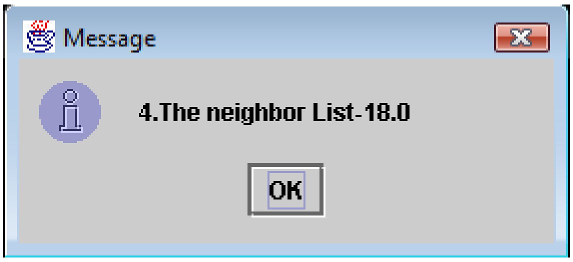

Message
9. there is 1 sucessful handover
OK


Message
4. Ec_lo= -15.0
OK

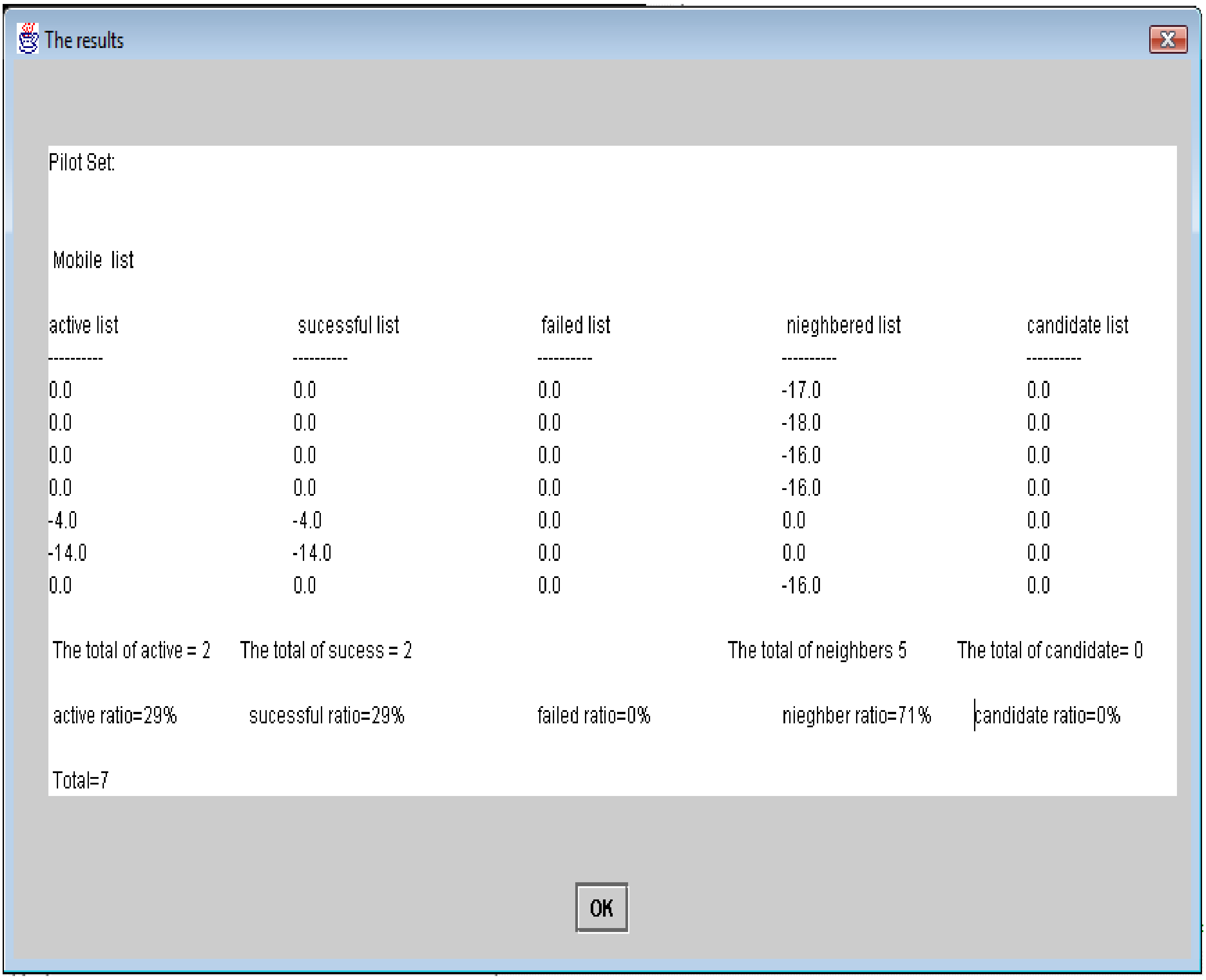

Message
4. The candidate List-15.0
OK


Message
4.This nominees to be an active
OK


Message
4. Ec_Io= -17.0
OK


Message
4.The neighbor List-18.0
OK


Message
5. handover failed
OK


The results
Pilot Set:
Mobile list
active list sucessful list failed list nieghbered list candidate list
---------- ---------- ---------- ---------- ----------
0.0 0.0 0.0 -17.0 0.0
0.0 0.0 0.0 -18.0 0.0
0.0 0.0 0.0 -16.0 0.0
0.0 0.0 0.0 -16.0 0.0
-4.0 -4.0 0.0 0.0 0.0
-14.0 -14.0 0.0 0.0 0.0
0.0 0.0 0.0 -16.0 0.0
The total of active = 2 The total of sucess = 2 The total of neighbers 5 The total of candidate= 0
active ratio=29% sucessful ratio=29% failed ratio=0% nieghber ratio=71% candidate ratio=0%
Total=7
OK

5.8.2 Result of real Data case in WAD ELAMEEN area

Figure 5-1 is shows clearly that WAD ELAMEEN area is located out side Grate Khartoum city, (in the other vendor service area), a very weak signal can be detected some times in that area but because of lack of information from other vendor, optimization team can not determine which site is serving this area.

Figure 4-1 Rx level and figure 4-4 Aggregate Ec/Io shows very poor coverage status is in the area handover failure.

For the below reason

- This area is located out side Great Khartoum.
- optimization team did their best to improve coverage in this area, but It is impossible because of the factor of distance.
- There are increasing for call drop(handover failure) duo to the distance .
- Depending on customer requirement, a new site in this area will solve the problem of poor coverage and handover failure and provide coverage for this area and near by villages which have the same problem.

The optimization Tem decided to install new site to solve problem for handover failure and poor coverage as shown in table 5.5

Site location and specification will be as follows

Table 5.5 Proposal of New suggested Site

BSC	Site Name	LAT	LON	Site type	BTS Type	Antenna Height	Azimuth	Down Tilt
KHS	WAD ELAMEEN	15.34691	33.26514	S777	I1	50	0	2
KHS	WAD ELAMEEN	15.34691	33.26514	S444	I2	50	120	2
KHS	WAD ELAMEEN	15.34691	33.26514	S222	I4	50	240	2

5.8.3 Result for data analysis for three cell (Giad ,Bagair and UM dawban)

From the table and graph above for three cell we analysis for handoff success rate, handoff see that increasing for handoff success rate in 24hours also do the same analysis for one week .

The result for data analysis seen in the below point .

- Increasing for handoff success rate due to decreasing in handoff failure rate
- Also the traffic will be good if there is less drop rate.
- Less distance between BTSs mains success handover .

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مواضيع: الاتصالات، الهاتف المحمول، هندسة البرمجيات، السودان
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المســــــــــــــتخلص

أن الهدف من هذا المشروع هو دراسة وتحليل وتخطيط وتصميم برنامج حاسوبي لمحاكاة مناولة الهاتف الخليوي من ثم دراسة حالة حقيقية عن طريق التجربة والقياس في خلية ود الامين ومن ثم تقيم المناولة لثلاث خلايا بدراسة حقيقية عن طريق تحليل حركة مرور المكالمات خلال 24 ساعة لمدة اسبوع لعوامل كثافة المرور ,احتمالية منع المكالمات , عملية نجاح المناولة وكذلك فشل عملية المناولة.

تم تنفيذ المشروع بتكوين نمازج رياضية لخوارزميات المناولة المختلفة والمتعددة ثم إستخدام برنامج حاسوبي (الجافا) لتنفيذ التخطيط لهذه الخوارزمية كما تم إجراء دراسة ميدانية لحالة فشل المناولة وتحليل الحركة بمنطقة ود الامين االكائنة شرق الخرطوم من مزودي خدمة سوداني وكنار .

بعد تنفيذ البرنامج تم الحصول علي نتائج مقبولة في شكل جداول ومخططات وذلك بقياس معدلات الحركة ومعدلات نجاح وفشل المناولة من بيانات حقيقة من مذودي شركة سوداني .

Abstract

The objectives of this project is to study , analyze, plan and design a computer program to simulate the handling of a cell phone and then study the real practical case by practical experimental measurement at the cell of WAD ALAMEEN.

Then evaluate the handover of the three cells through practical study by analyzing calls traffic during 24 hours for a period of one week for the factors of traffic intensity, call drop, handover success and Handover failure.

The project been executed by constructing samples of mathematical algorithms for a combination of various and different handovers, the computer software (Java) been used to implement the planning of this algorithm. In addition, a field study been carried out to study the handover failure and traffic analysis at WAD ELAMEEN area, east of Khartoum, serviced by SUDANI and KANAR providers.

After the program been implemented, a real data from SUDANI provider been used and acceptable results were achieved in the form of tables and graph by measuring the rates of traffic and the success and failure of the handover.

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رابط:	https://search.mandumah.com/Record/560860

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List Of Tables

Abbreviations

0-9

2G	2nd Generation
3G	3rd Generation

A

AB	Access Burst
ACCH	Associated Control Channel
ACC	Automatic Congestion Control
AuC	Authentication Centre

B

BA	BCCH Allocation
BCC	Base Transceiver Station (BTS) Colour Code
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
BER	Bit Error Ratio
BS	Base Station
BSC	Base Station Controller
BSS	Base Station Subsystem
BSSMAP	Base Station Subsystem Management Application Part
BTS	Base Transceiver Station

C

CB	Cell Broadcast
CBCH	Cell Broadcast Channel
CBR	Constant Bit Rate
CC	Call Control
CCCH	Common Control Channel
CDCH	Control-plane Dedicated CHannel
CDMA	Code Division Multiple Access
CIR	Carrier to Interference Ratio

D

DCCH	Dedicated Control Channel
DCH	Dedicated Channel
DTCH	Dedicated Traffic Channel
DTE	Data Terminal Equipment
DT	Drive Test

E

Ec/Io Ratio of energy per modulating bit to the noise spectral density

EIR Equipment Identity Centre

F

FACCH Fast Associated Control CHannel

FACCH/F Fast Associated Control Channel/Full rate

FACCH/H Fast Associated Control Channel/Half rate

FACH Forward Access Channel

FB Frequency correction Burst

FCCH Frequency Correction CHannel

FFS For Further Study

G

GMLC Gateway Mobile Location Centre

GMSC Gateway MSC

GSM Global System for Mobile communications

H

HANDO Handover

HCS Hierarchical Cell Structure

HDLC High Level Data Link Control

HHO Hard Handover

HLC High Layer Compatibility

HLR Home Location Register

HO Handover

I

I/O Input/Output

IMSI International Mobile Subscriber Identity

J

JAR file Java Archive File

K

kbps kilo-bits per second

ksps kilo-symbols per second

L

LA Location Area

LAC Link Access Control

LR Location Register

LU Location Update

M

MA Mobile Allocation

MAHO Mobile Assisted Handover

ME Mobile Equipment

MM Mobility Management

MS Mobile Station

MSC Mobile Switching Centre

MT Mobile Terminated

N

NB Normal Burst

NCELL Neighbouring (of current serving) Cell

NEHO Network evaluated handover

NMS Network Management Subsystem

NMSI National Mobile Station Identifier

NT Network Termination

O

O&M Operations & Maintenance

OMC Operation and Maintenance Centre

OML Operations and Maintenance Link

P

PACCH Packet Associated Control Channel

PAD Packet Assember/Disassembler

PBCCH Packet Broadcast Control Channel

PBP Paging Block Periodicity

PCCH Paging Control Channel

PCH Paging Channel

PCM Pulse Code Modulation

PDCH Packet Data Channel

PPCH Packet Paging Channel

PSTN Public Switched Telephone Network

Q

QoS Quality of Service

R

RF Radio Frequency

RFCH Radio Frequency Channel

RXLEV Received signal level

RXQUAL Received Signal Quality

S

SACCH Slow Associated Control Channel

SCCH Synchronisation Control Channel

SCCP Signalling Connection Control Part

SCH Synchronisation Channel

SHCCH Shared Channel Control Channel

SIM GSM Subscriber Identity Module

SMS Short Message Service

SP Service Provider

T

TC TransCoder

TCH Traffic Channel

TCH/F A full rate TCH

TMSI Temporary Mobile Subscriber Identity

U

UL Uplink (Reverse Link)

UM Unacknowledged Mode

UMS User Mobility Server

UPD Up to date

V

VLR Visitor Location Register

VMSC Visited MSC

Contents

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Post Graduate Faculty

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HANDOVER ALGORITHM & TRAFFIC

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المســــــــــــــتخلص

أن الهدف من هذا المشروع هو دراسة وتحليل وتخطيط وتصميم برنامج حاسوبي لمحاكاة مناولة الهاتف الخليوي من ثم دراسة حالة حقيقية عن طريق التجربة والقياس في خلية ود الامين ومن ثم تقيم المناولة لثلاث خلايا بدراسة حقيقية عن طريق تحليل حركة مرور المكالمات خلال 24 ساعة لمدة اسبوع لعوامل كثافة المرور ,احتمالية منع المكالمات , عملية نجاح المناولة وكذلك فشل عملية المناولة.

تم تنفيذ المشروع بتكوين نمازج رياضية لخوارزميات المناولة المختلفة والمتعددة ثم إستخدام برنامج حاسوبي (الجافا) لتنفيذ التخطيط لهذه الخوارزمية كما تم إجراء دراسة ميدانية لحالة فشل المناولة وتحليل الحركة بمنطقة ود الامين االكائنة شرق الخرطوم من مزودي خدمة سوداني وكنار .

بعد تنفيذ البرنامج تم الحصول علي نتائج مقبولة في شكل جداول ومخططات وذلك بقياس معدلات الحركة ومعدلات نجاح وفشل المناولة من بيانات حقيقة من مذودي شركة سوداني .

Abstract

The objectives of this project is to study , analyze, plan and design a computer program to simulate the handling of a cell phone and then study the real practical case by practical experimental measurement at the cell of WAD ALAMEEN.

Then evaluate the handover of the three cells through practical study by analyzing calls traffic during 24 hours for a period of one week for the factors of traffic intensity, call drop, handover success and Handover failure.

The project been executed by constructing samples of mathematical algorithms for a combination of various and different handovers, the computer software (Java) been used to implement the planning of this algorithm. In addition, a field study been carried out to study the handover failure and traffic analysis at WAD ELAMEEN area, east of Khartoum, serviced by SUDANI and KANAR providers.

After the program been implemented, a real data from SUDANI provider been used and acceptable results were achieved in the form of tables and graph by measuring the rates of traffic and the success and failure of the handover.

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Abbreviations

0-9

2G 2nd Generation

3G 3rd Generation

A

AB Access Burst

ACCH Associated Control Channel

ACC Automatic Congestion Control

AuC Authentication Centre

B

BA BCCH Allocation

BCC Base Transceiver Station (BTS) Colour Code

BCCH Broadcast Control Channel

BCH Broadcast Channel

BER Bit Error Ratio

BS Base Station

BSC Base Station Controller

BSS Base Station Subsystem

BSSMAP Base Station Subsystem Management Application Part

BTS Base Transceiver Station

C

CB Cell Broadcast

CBCH Cell Broadcast Channel

CBR Constant Bit Rate

CC Call Control

CCCH Common Control Channel

CDCH Control-plane Dedicated CHannel

CDMA Code Division Multiple Access

CIR Carrier to Interference Ratio

D

DCCH Dedicated Control Channel

DCH Dedicated Channel

DTCH Dedicated Traffic Channel

DTE Data Terminal Equipment

DT Drive Test

E

Ec/Io Ratio of energy per modulating bit to the noise spectral density

EIR Equipment Identity Centre

F

FACCH Fast Associated Control CHannel

FACCH/F Fast Associated Control Channel/Full rate

FACCH/H Fast Associated Control Channel/Half rate

FACH Forward Access Channel

FB Frequency correction Burst

FCCH Frequency Correction CHannel

FFS For Further Study

G

GMLC Gateway Mobile Location Centre

GMSC Gateway MSC

GSM Global System for Mobile communications

H

HANDO Handover

HCS Hierarchical Cell Structure

HDLC High Level Data Link Control

HHO Hard Handover

HLC High Layer Compatibility

HLR Home Location Register

HO Handover

I

I/O Input/Output

IMSI International Mobile Subscriber Identity

J

JAR file Java Archive File

K

kbps kilo-bits per second

ksps kilo-symbols per second

L

LA Location Area

LAC Link Access Control

LR Location Register

LU Location Update

M

MA Mobile Allocation

MAHO Mobile Assisted Handover

ME Mobile Equipment

MM Mobility Management

MS Mobile Station

MSC Mobile Switching Centre

MT Mobile Terminated

N

NB Normal Burst

NCELL Neighbouring (of current serving) Cell

NEHO Network evaluated handover

NMS Network Management Subsystem

NMSI National Mobile Station Identifier

NT Network Termination

O

O&M Operations & Maintenance

OMC Operation and Maintenance Centre

OML Operations and Maintenance Link

P

PACCH Packet Associated Control Channel

PAD Packet Assember/Disassembler

PBCCH Packet Broadcast Control Channel

PBP Paging Block Periodicity

PCCH Paging Control Channel

PCH Paging Channel

PCM Pulse Code Modulation

PDCH Packet Data Channel

PPCH Packet Paging Channel

PSTN Public Switched Telephone Network

Q

QoS Quality of Service

R

RF Radio Frequency

RFCH Radio Frequency Channel

RXLEV Received signal level

RXQUAL Received Signal Quality

S

SACCH Slow Associated Control Channel

SCCH Synchronisation Control Channel

SCCP Signalling Connection Control Part

SCH Synchronisation Channel

SHCCH Shared Channel Control Channel

SIM GSM Subscriber Identity Module

SMS Short Message Service

SP Service Provider

T

TC TransCoder

TCH Traffic Channel

TCH/F A full rate TCH

TMSI Temporary Mobile Subscriber Identity

U

UL Uplink (Reverse Link)

UM Unacknowledged Mode

UMS User Mobility Server

UPD Up to date

V

VLR Visitor Location Register

VMSC Visited MSC

Contents

Chapter one
Introduction

1.1 Background History

Mobile telephones became very popular in the late nineties and are today an important tool for many people. Our way of life demands more and more mobility and availability.

One of the most important technologies used for mobile telephone networks today is the Global System for Mobile communication (GSM) technology. The first GSM networks were rolled out during the early nineties and therefore are quite old today. Several newer and far more advanced technologies have been invented since then and some are almost ready to be rolled out. It is very unlikely that modern mobile telephone networks are going to replace GSM completely within the next decade.

A long period of interoperability must be expected. The cost of rolling out a new network is enormous; this requires the new technologies to be able to cooperate with the existing GSM networks in order to achieve an acceptable coverage.

The functionality to ensure acceptable quality of a call, when the person using the mobile phone, is called handover. Handover transfers the call transparently from one stationary antenna to another during the call, when the quality of the transmitted data decreases.

Our work is focused on handovers within GSM networks. We started with a joint project on designing a handover mechanism between GSM and a different radio based network. To be able to design such a handover, we started out with an investigation of handover within GSM networks. This investigation turned out to be far more complex than expected, and we decided to limit our research to GSM exclusively.

Because the GSM equipment required to perform a real handover, is huge and expensive, and because gaining access to real operators' networks is impossible, we have decided to base our research on a model of a GSM network. Through simulations and analysis of the model, we will be able to investigate the behaviour of a GSM handover. The model has the advantage of being as abstract as we need compared to real system. This allows us to concentrate our work on the actual handover and not spend our time on mangling with the bits of a real system.

1.2 Problems Definition

The old system of mobile has been used in limited channels to use by limited customers and when the customer get out of the cellular coverage area range and inter another one the call is dropped this action increased the blocking probability.

The handover is a mechanism that transfers an ongoing call from one cell to another as the user move through the coverage area of cellular system, without dropping the call.

Also the reused of frequency increases the number of channels in the system and decreases the blocking probability.

1.3 Objectives

The specific objectives of the project are to conduct a practical work:

❖ This project aims to study and analyze the internal and external handover in real data case.

❖ Planning algorithms by flowchart and execute it by a computer program to simulate handover algorithm.

❖ Evaluate the performance of the handling process

1.4 Paging

An antenna or satellite broadcasts short messages to subscribers. Receivers are usually devices such as beepers, which display messages on a small screen. Transmission of data is one-way. Paging systems are designed to provide reliable communication to subscribers wherever they are. This necessitates high-powered transmitters and low data rates for maximum coverage of each transmitter's designated area

It is a process of broadcasting a message which alerts a specific mobile to take some action, for example if there is an incoming call to be received? If the system does not know the precise cell in which a mobile is located it must perform paging in a number of cells

1.5 Roaming

Roaming is a general term that refers to the extending of connectivity service in a location that is different from the home location where the service was registered. Roaming ensures that the wireless device keeps connected to the network, without losing the connection. The term "roaming" originates from the GSM , the term "roaming" can also be applied to the CDMA technology, see CDMA Roaming. Traditional GSM Roaming is defined as the ability for a cellular 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 done by using a communication terminal or else just by using the subscriber identity in the visited network. Roaming is technically supported by mobility management, authentication, authorization and billing procedures.

1.6 Handover

The Handover procedure is probably the most important procedure to ensure the mobility of the MS during calls. The purpose of the procedure is to preserve ongoing calls, when moving from one cell to another. The presence of an ongoing call gives rise to time criticality of the processing.

The decision whether to perform the handover, is made by the serving BSC, which has no direct knowledge of the radio quality. In order to decide whether to initiate a handover, the BSC receives information about the radio link quality from the BTS and the MS. During a call, the MS periodically sends measurement results to the BTS. The measurement results contain measurements of the radio signal quality of the downlink (from the BTS to the MS) of the call and up to five neighbouring cells. The serving BTS measures the uplink (from the MS to the BTS) radio signal quality of the call and forwards the measurement result from the MS, together with its own measurements, to the BSC in a measurement report. From the information in the measurement reports, the BSC is able to decide whether a handover to another cell is needed. The algorithm to decide whether to perform a handover or not is not specified in the recommendations — it is considered to be operator dependant. This algorithm is not investigated in our work, because our work starts when the decision has been made.

There are different kinds of handovers, which involves different parts of the network. Changing cells within the same BTS is not as complex as changing cells belonging to different MSCs. In the following sections the different kinds of handover are discussed. They are listed in increasing complexity: Intra-cell/BTS, Intra-BSC, Intra-MSC and finally Inter-MSC.

1.7 Thesis structure

The thesis is structured in the following way:

Chapter 1: Introduction introduces the project, we present in this master's thesis. It contains Introduction, Technology Development Background, problems statements, and objectives.

Chapter 2: cellular system, and its generation. And Deals with the structure of the cellular system

Chapter 3: GSM Introduction describes the basics of the GSM networks. The chapter introduces the general concepts of the network: Its functionality, logical, and physical architecture.

Chapter 4: Discusses the process of handover and its types.

Chapter 5: Handover algorithms handling in mobile communication systems with

an explanation of these algorithms and analysis, planning, implementation and test results.

Chapter 6: Discusses the research, conclusion, make some limitations and recommendations

Chapter tow
Cellular System

2.1 Cellular Networks

Cellular technology has acquired over three generations since 1979, when the first national Cellular network was congenital in Japan. Each generation uses spectrum more competently, therefore adding more subscribers who can generate more cash flow for a carrier,(see figure 2.1).

The first generation (1G) cellular was only analog and used completely for voice calls. The second generation (2G) is a digital network and also provides some data services. The third generation (3G) cellular network allows high-speed data with voice. One generation doesn't clean off the previous generation; somewhat, a 2G tower operates next to a 1G tower operating at an altered part of the spectrum. But it takes time to install new hardware, cellular devices has been made to fall back to use the old generation network.

The service features in almost all networks include air interface standards, and spectrum allocated. However, 3G network features involve packet switched data, transparent roaming services, broadcast quality sound/video. [1]

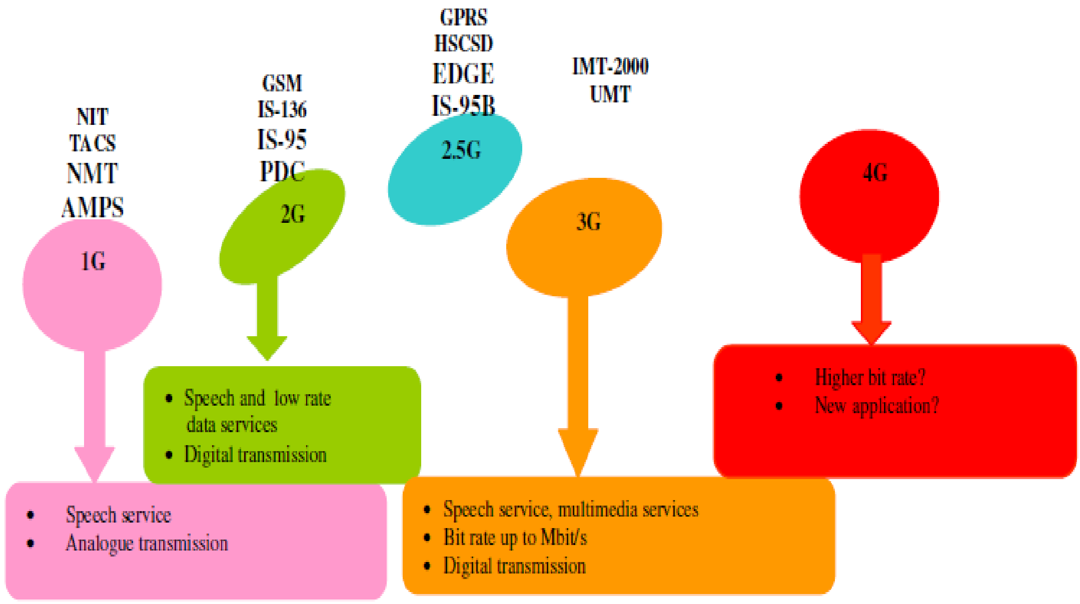

Figure 2.1 Generation Mobile Networks

2.1.1 First Generation Mobile Networks

AMPS (Analog mobile phone system) are the 1st generation for this technology; this technology was found on analog signals. These analog signals travel like a waveform. These waves are generated by mobile device from transmitting ends in mobile networks which means from one base station where it proceeds to decide the next target of the signal. At the last when the signal has reached its final target then base station again restore the signal, most likely try to reconstruct in its original shape for further proceeding.

2.1.2 Second Generation Mobile Networks

The main Advantages of 2G (2nd Generation) Mobile networks over their previous sections were:

- Mobile phone conversations were digitally encrypted
- 2G mobile systems were more reliable & efficient on the spectrum allowing for far greater mobile phone penetration levels & signals.
- 2G also introduced Value added services & data services for mobile to make a start with SMS text messages.

2.1.3 Third Generation Mobile Networks

Past communication was mostly depending only on 2G but as technology is going to be advance, there was an introduction of latest technology such as Wireless Internet access (Wi-Fi and video telephony which require universal standards at higher user bit rates. Diagram shows the bit rate requirements for some of the function that are predicated for 3G networks. Most of the new services require bit rates up to 2 M bit/s.

2.2 Cellular Concept

A cellular network is a radio network made up of a number of radio cells (or just cells) each served by at least one fixed-location transceiver known as a cell site or base station. These cells cover different land areas to provide radio coverage over a wider area than the area of one cell, so that a variable number of portable transceivers can be used in any one cell and moved through more than one cell during transmission.

Cellular networks offer a number of advantages over alternative solutions:

- increased capacity
- reduced power usage
- larger coverage area
- reduced interference from other signals

Cellular systems are widely used today and cellular technology needs to offer very efficient use of the available frequency spectrum. With billions of mobile phones in use around the globe today, it is necessary to re-use the available frequencies many times over without mutual interference of one cell phone to another.

2.3 Cellular System Architecture

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 on 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 kilometres as they are limited 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 from the covering area of an operator. Frequencies used in a cell using the same frequency must be sufficient to avoid interference. The frequency reuse will increase considerably the capacity in number of users.

2.3.1 Cells

A cell is the basic geographic unit of a cellular system. The term cellular comes from the honeycomb shape of the areas into which a coverage region is divided. Cells are base stations transmitting over small geographic areas that are represented as hexagons. Each cell size varies depending on the landscape. Because of constraints imposed by natural terrain and man-made structures, the true shape of cells is not a perfect hexagon. Basic service area that can be efficiently managed by the network, cell boundaries are defined by BS signal strength.

Possible cell shape representation (see figure 2.2);

❖ Circles

❖ Equilateral triangles.

❖ Squares

❖ Hexagon

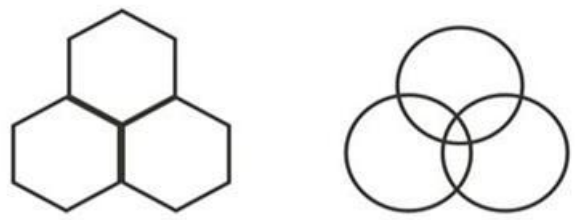

Figure 2.2 Cell shape

2.3.2 Cell size

Even though the number of cells in a cluster in a cellular system can help govern the number of users that can be accommodated, by making all the cells smaller it is possible to increase the overall capacity of the cellular system. However a greater number of transmitter receiver or base stations are required if cells are made smaller and this increases the cost to the operator.

The different types of cells are given different names according to their size and function:

- **Macro cells**: Macro cells are large cells that are usually used for remote or sparsely populated areas. These may be 10 km or possibly more in diameter.
- **Micro cells**: Micro cells are those that are normally found in densely populated areas which may have a diameter of around 1 km.
- **Pico cells**: Pico cells are generally used for covering very small areas such as particular areas of buildings, or possibly tunnels where coverage from a larger cell in the cellular system is not possible. Obviously for the small cells, the power levels used by the base stations are much lower and the antennas are not position to cover wide areas.
- **Selective cells**: Sometimes cells termed selective cells may be used where full 360 degree coverage is not required. They may be used to fill in a hole in the coverage in the cellular system, or to address a problem such as the entrance to a tunnel etc.
- **Umbrella cells**: Another type of cells known as an umbrella cell is sometimes used in instances such as those where a heavily used road crosses an area where there are micro cells. Under normal circumstances this would result in a large number of handovers as people driving along the road would quickly cross the micro cells. An umbrella cell would take in the coverage of the micro cells (but use different channels to those allocated to the micro cells).

2.3.3 Cell clusters

A cluster is the group of adjacent cells using the complete set of available frequencies. Cluster size N: is the number of cell in a cell cluster.

It is necessary to limit the interference between cells having the same frequency. The topology of the cell configuration has a large impact on this. The larger the number of cells in the cluster, the greater the distance between cells sharing the same frequencies.

In the ideal world it might be good to choose a large number of cells to be in each cluster. Unfortunately there are only a limited number of channels available. This means that the larger the number of cells in a cluster, the smaller the number available to each cell, and this reduces the capacity. [2]

Often these clusters contain seven cells, but other configurations are also possible. Seven is a convenient number, but there are a number of conflicting requirements that need to be balanced when choosing the number of cells in a cluster for a cellular system, (see figure 2.3).

- Limiting interference levels
- Number of channels that can be allocated to each cell site

No channels are reused within a cluster.

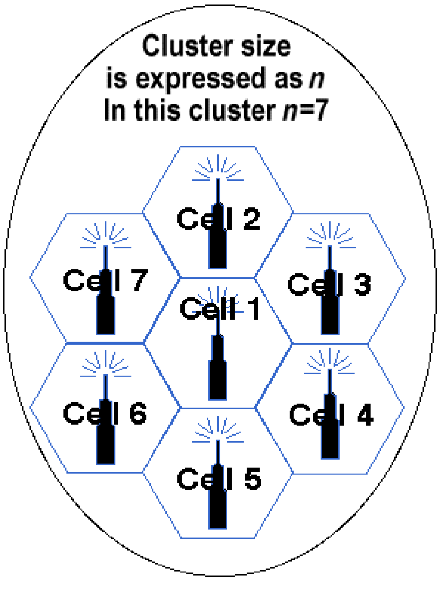

Figure 2.3 illustrates a seven-Cell Cluster

Chapter Six

Conclusions & Recommendations

6.1 Conclusion

1. First, the study and the analysis been completed and then the simulation of the handoff algorithm have been done using JAVA software program.

2. The simulation program consider the signal strength of the service cell, and the signal strength of the neighbor cell, T-AD, T-DROP which are the parameters, from the simulation we observe that results of classification of cells, handover success, handover failure and call drop.

3. Also failure handover of real data measured for WAD ALAMEEN cell have been listed and measured using drive test and calculating the forward receive power, reserved transmitted power, FER and Ec/Ro.

4. Lastly, we perform the handoff algorithm by traffic analysis of the cell of BAGAIR, GIAD AND UMDAWAN BAN by considering the traffic, drop rate, handover success rate and handover failure rate.The analysis results been shown in tables and graphs

6.2 Limitations

1. The real data used in this analysis was old because of the difficulty of obtaining an up to date data from the service providers due to the confidentiality and security between telecommunications companies as a result of competition.

2. The real data analysis and test for WAD ELAMEEN through the service provider is very expensive in order to provide a means of movements, optimization Team and the specialized tools.

3. Time for simulation to run the program will increase if the number for sample is increased which need a computer with higher specifications

6.3 Recommendation

1. The analysis consider internal handoff algorithm, we suggest that to analyze external handoff.
2. The analysis was done for soft handoff for CDMA system, the hard handoff for GSM system need to be analyzed for the sake of comparison.
3. To extend the simulation program to include all effective parameter of handoff algorithm to achieve optimization.
4. The traffic analysis consider only three cells, we suggest that the analysis should deal with at least a cluster size of seven cells to see the effect of signal interference ratio on the handoff algorithm.
5. To extend the performance of the traffic analysis of the handoff algorithm to include the pit error rate (PER) and quality of service (QOS).

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Appendix I

```
import javax.swing.*;

import javax.swing.JOptionPane;

class main

{

public static void main(String[] args)

{

  JTextArea outArea= new JTextArea();


 String title1="The results ";

 String output1="Pilot Set:\n";


  double a[]=new double[8]; //Ec_Io

  double active[]=new double[8];

  double drop[]=new double [8];

  double candidate[]=new double[8];

  double X[]=new double[8]; //distance

  double successful[]=new double[8];

  double failed[]=new double[8];


double T_ADD=-14, T_Drop=-16,x,Ec_Io,sig_power,ch,r_ac ;

int i,j,ac=0,niegh=0,cand=0,sucess=0,fail=0;

String d,c,output,output2,output3, title;

for (i=1;i<=1;i++)

{

JOptionPane.showMessageDialog(null, "1. call setup");


for (j=1;j<=7;j++) // mesure 7 nieghbers = step 2
```

```
{
x=Math.round(100*Math.random());
sig_power=1/Math.pow(x,2);
Ec_Io=Math.round( 10*Math.log(sig_power));
a[j]=Ec_Io;
X[j]=x;
}

JOptionPane.showMessageDialog(null, "2. sending MMP to BSC");
JOptionPane.showMessageDialog(null, "3. BSC mesure Ec/Io");

for (j=1;j<=7;j++)     // print 7 signal nieghbers
{

JOptionPane.showMessageDialog(null, "4. Ec_Io= "+a[j]+"\n"); //check signal to decide active and nieghbers
step 5

  if (a[j]>=T_ADD) // active
{
  ac=ac+1;
  active[j]=a[j];
  JOptionPane.showMessageDialog(null, "4. The Active List"+ active[j]);
  JOptionPane.showMessageDialog(null,"5. Report  to perform Handoff");
  if (X[j]>40) //type of handover (measure distance)    step 5.1
  {
    JOptionPane.showMessageDialog(null,"6. External");
  }
    else
    {
```

```
  JOptionPane.showMessageDialog(null,"6. Internal ");
  JOptionPane.showMessageDialog(null,"7. Requst to allocate");
  JOptionPane.showMessageDialog(null,"8. mobile system check is there any empty channel?");
  ch=Math.round(10*Math.random()); // choice number of empty channel ranodmly
  if (ch>0) // test is there empty channel    step 5.1.1
  {
  JOptionPane.showMessageDialog (null,"9. there is " +ch+ " channel ");
  successful[j]=active[j];
  JOptionPane.showMessageDialog(null, "4. The successful List"+ successful[j]);
  sucess=sucess+1;
  JOptionPane.showMessageDialog (null,"9. there is   " +sucess+ "   sucessful handover ");
 }
 else
 {
  JOptionPane.showMessageDialog (null,"9.blocking and handover fail");
  failed[j]=active[j];
  JOptionPane.showMessageDialog(null, "4. The fail List"+ failed[j]);
  fail=fail+1;
  JOptionPane.showMessageDialog (null,"9. there is   " +fail+ "   failed handover   ");
 }
 }
 }
else if (a[j]<=T_Drop) //nieghbers
{
 niegh=niegh+1;
 drop[j]=a[j];
 JOptionPane.showMessageDialog(null," 4.The neighbor List" + drop[j]);
 JOptionPane.showMessageDialog ( null, "5. handover failed ");
```

```
}
else if (a[j]<T_ADD && a[j] > T_Drop) // candidate
{
  cand=cand+1;
  candidate[j]=a[j];
  JOptionPane.showMessageDialog(null,"4. The candidate List"+ candidate[j]);
  JOptionPane.showMessageDialog(null,"4.This nominees to be an active  " );
}
}
title="\n The total of lists";
output="\n The total of active = "+ac + "\t The total of sucess = "+sucess +"\t The total of neighbers " +niegh
+ "\t The total of candidate= " +cand+"\n"
+"\n active ratio="+Math.round((double)100*ac/7)+"%"+"\tsucessful
ratio="+Math.round((double)100*sucess/7)+"%"+"\tfailed
ratio="+Math.round((double)100*fail/7)+"%"+"\t\tnieghber
ratio="+Math.round((double)100*niegh/7)+"%"+"\tcandidate ratio="+Math.round((double)100*cand/7)+"%"
+"\n\n Total="+(cand+niegh+sucess+fail);
 output1+="\n\n Mobile  list\n\n";
 output1+="active list\t\t sucessful list\t\t failed list \t\t nieghbered list \tcandidate list \n----------\t\t----------\t\t-
---------\t\t----------\t\t----------\n";
 for( j=1; j<=7; j++)
 output1+=active[j]+"\t\t"+successful[j]+"\t\t"+failed[j]+"\t\t"+drop[j]+"\t\t"+candidate[j]+"\n";
 outArea.setText(output1+output);
 JOptionPane.showMessageDialog(null, outArea, title1,JOptionPane.PLAIN_MESSAGE);
 System.exit(0);
}
}
}
```

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