CHAPTER 1: INTRODUCTION

1.1 Overview

Cellular technology has evolved over three generations from 1G to 3G and approaching even beyond that. Each generation uses spectrum more capably, therefore adding more subscribers. The first generation (1G) cellular was basically only analog and used completely for voice calls. The second generation (2G) has a prime motive of digital network and also provides some data services. The third generation (3G) cellular network allows high-speed data with voice. New generation doesn't overpower the previous generation i.e., a 2G Network operates parallel to a 1G tower operating at an altered part of the spectrum. But it always consume time to install new hardware, cellular devices has been made to fall back to use the superannuated generation network. The service features in almost all networks include air interface principles, and spectrum allocated. However, 3G network features engross packet switched data, transparent roaming services, broadcast quality sound/video [16].

1.2 Cellular Networks

The wireless communication became the vital mode for communication now a days. The cellular Networks was fundamentally designed to bring up the use of frequency spectrum competently. The cellular architecture is designed in such a way that at low power it can use numbers of transmitters, thus it becomes easy to reuse the frequencies, this is totally different from previous wireless communication system, because in previous system of communication only one transmitter was used at very high power at restricted channels. In this system re use of frequencies was complex [16].

In wireless communication GSM technology has very significant role. GSM used the narrow band TDMA which allows eight calls at the same radio frequency in digital cellular system. To realize speedy web connection and good quality of videos and images and high data rate services, Third Generation Mobile systems are used [17]. This research will focus on UMTS (Universal Mobile Telecommunications Network) thus 3rd generation networks are considered as UMTS. WCDMA (wide band code division multiple access) is the most important air interface which is being used in third generation. Soft handover and Hard

Handover have been applied with WCDMA air interface to get the high quality of services and high data rate and it also provides the flexibility in the network. This thesis will concentrate on the problems faced by the network and user during handover [16, 17].

1.2.1 First Generation Mobile Networks

AMPS (Analog mobile phone system) are the 1st generation 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.

1.2.2 Second Generation Mobile Networks

2G (or 2-G) is short for second-generation wireless telephone technology. Second generation 2G cellular telecom networks were commercially launched on the GSM standard in Finland in 1991.

Three primary benefits of 2G networks over their predecessors were:

- Phone conversations were digitally encrypted;
- 2G systems were significantly more efficient on the spectrum allowing for far greater mobile phone penetration levels;
- 2G introduced data services for mobile, starting with SMS text messages.

2G has been superseded by newer technologies such as 2.5G, 2.75G, 3G, and 4G; however, 2G networks are still used in many parts of the world.

1.2.2.1 2G-Mobile Networks' Capacity

It uses digital technology between the Mobile station (handsets) and the Base Station to bust-up the system capacity & performance in two ways:

- Digital signal & voice data can be multiplexed, encrypted & compressed much more effectively than analog voice data; it allows more calls to be handled in the same radio bandwidth.
- Digital systems were designed in such a way to consume less radio power from the MS,
  which means cells could be smaller in size.

1.2.3 Third Generation Mobile Networks

Precedent 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 [15].

International Mobile Telecommunications-2000 (IMT—2000), better known as **3G** or **3rd Generation**, is a generation of standards for mobile phones and mobile telecommunications services fulfilling specifications by the International Telecommunication Union. Application services include wide-area wireless voice telephone, mobile Internet access, video calls and mobile TV, all in a mobile environment. Compared to the older 2G and 2.5G standards, a 3G system must allow simultaneous use of speech and data services, and provide peak data rates of at least 200 kbit/s according to the IMT-2000 specification. Recent 3G releases often denoted 3.5G and 3.75G, also provide mobile broadband access of several Mbit/s to laptop computers and smart phones.

The following standards are typically branded 3G:

• The UMTS system, first offered in 2001, standardized by 3GPP, used primarily in Europe, Japan, China (however with a different radio interface) and other regions predominated by GSM 2G system infrastructure. The cell phones are typically UMTS and GSM hybrids. Several radio interfaces are offered, sharing the same infrastructure:

• The original and most widespread radio interface is called W-CDMA.

• The latest UMTS release, HSPA+, can provide peak data rates up to 56 Mbit/s in the downlink in theory (28 Mbit/s in existing services) and 22 Mbit/s in the uplink.

• The CDMA2000 system, first offered in 2002, standardized by 3GPP2, used especially in North America and South Korea, sharing infrastructure with the IS-95 2G standard. The cell phones are typically CDMA2000 and IS-95 hybrids. The latest release EVDO Rev B offers peak rates of 14.7 Mbit/s downstreams.

ITU IMT-2000	common name(s)		bandwidth of data	pre-4G	duplex	channel	description	geographical areas
TDMA Single-Carrier (IMT-SC)	EDGE (UWT-136)		EDGE Evolution	*none*	FDD	TDMA	evolutionary upgrade to GSM/GPRS	worldwide, except Japan and South Korea
CDMA Multi-Carrier (IMT-MC)	CDMA2000		EV-DO	UMB		CDMA	evolutionary upgrade to cdmaOne	Americas, Asia, some others
CDMA Direct Spread (IMT-DS)	UMTS	W-CDMA	HSPA	LTE			family of revolutionary standards.	worldwide
CDMA TDD (IMT-TC)		TD-CDMA			TDD			Europe
		TD-SCDMA						China
FDMA/TDMA (IMT-FT)	DECT		*none*			FDMA/TDMA	short-range; standard for cordless phones	Europe, USA
IP-OFDMA			WiMAX (IEEE 802.16)			OFDMA		worldwide

Figure 1: Overview of 3G/IMT-2000 standards

1.3 Organization Of Thesis

In this chapter, we have highlighted the various technology in cellular networks which serves as the motivation for the work reported in this thesis. Furthermore we have also outlined the specific objective of our research and related research work that has occurred in the past. *Chapter 2* provides an overview of UMTS Networks and introduces handover in UMTS network and discusses some of the tasks carried out with respect to the objective outlined. It also includes the limitation of earlier approach towards. *Chapter 3* presents the concepts of Mobility management and its importance and related work. *Chapter 4* discuss our proposed methodology and algorithms and presents proposed system framework. *Chapter 5* gives introduction of OPNET modeler used for modeling the UMTS network and represents the simulation and acquired results. Finally *Chapter 6* concludes the thesis and gives some suggestions for future work.

CHAPTER 2: CONCEPT AND BACKGROUND

2.1 UMTS Network Architecture

Universal Mobile Telecommunications System (UMTS) is a Third Generation (3G) wireless protocol that is part of the International Telecommunications Union's IMT-2000 vision of a global family of 3G mobile communications systems. UMTS is expected to deliver low-cost, high-capacity mobile communications, offering data rates up to 2-Mbps. The UMTS model suite allows you to model UMTS networks to evaluate end-to-end service quality, throughput, drop rate, end-to-end delay, and delay jitter through the radio access network and core packet network. It can also be used to evaluate the feasibility of offering a mix of service classes given quality of service requirements.

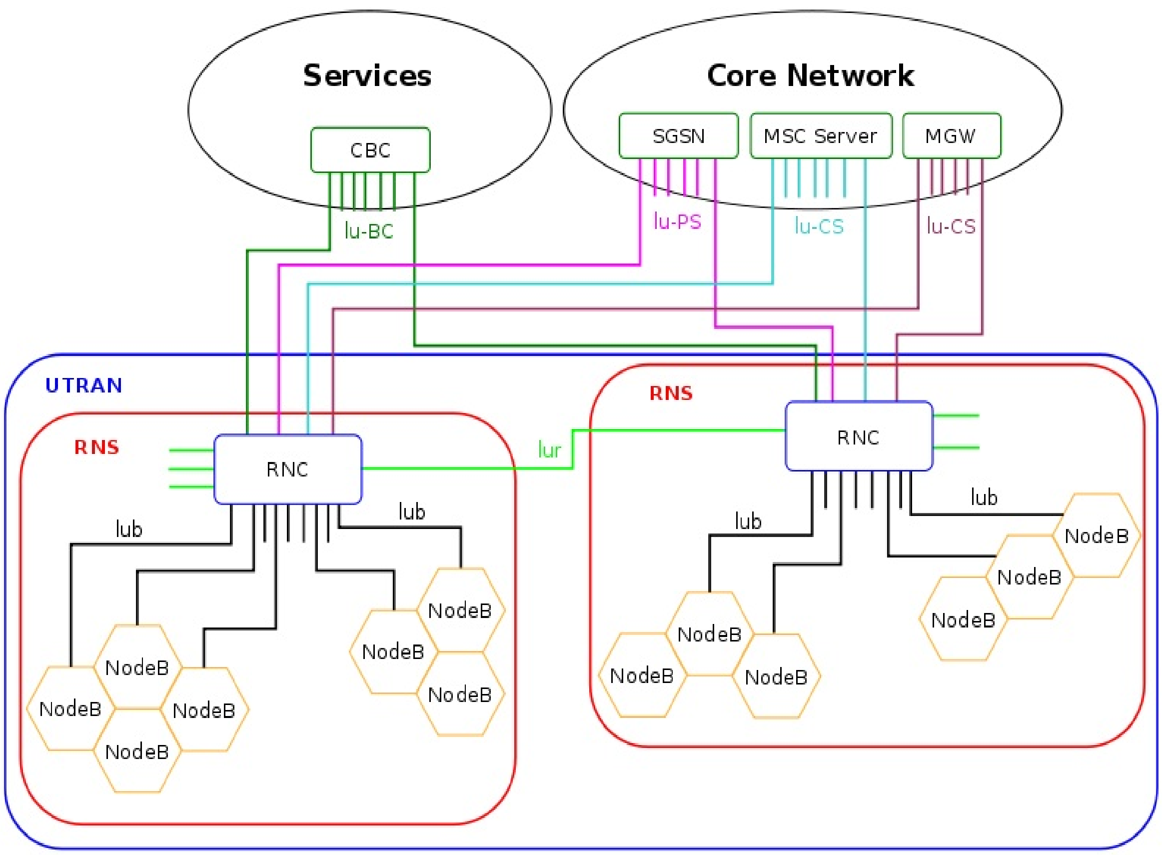


Figure 2: UMTS Network Architecture

The UMTS model of the packet wireless network is based on 3rd Generation Partnership Project (3GPP) Release-5 standards [18]. The network architecture of this release is divided into the radio access network (RAN) and the core network as shown in Figure 2. The UMTS module models the UMTS RAN and the UMTS functionality of the core network (see highlighted elements in Figure 3). The radio access network for UMTS contains the User Equipment (UE), which includes the Terminal Equipment (TE) and Mobile Terminal (MT), and the UMTS Terrestrial Radio Access Network (UTRAN), which includes the Node-B and Radio Network Controller (RNC).

UMTS uses Wideband Code Division Multiple Access (W-CDMA) access scheme. This version of W-CDMA uses direct spread with a chip rate of 3.84 Mcps and a nominal bandwidth of 5 MHz. The model supports one of W-CDMA's two duplex modes: Frequency Division Duplex (FDD). Time Division Duplex (TDD) is not supported. In FDD mode, uplink and downlink transmissions use different frequency bands. The radio frame has a length of 10 ms and is divided into 15 slots. Spreading factors vary from 256 to 4 for an FDD uplink and from 512 to 4 for an FDD downlink. With these spreading factors, data rates of up to 2 Mbps are attainable.

The packet domain core network includes two types of network nodes: serving GPRS support nodes (SGSNs) and the gateway GPRS support node (GGSN). The GPRS support nodes (GSNs) include all GPRS functionality needed to support GSM and UMTS packet services. SGSNs monitor user location and perform security functions and access control. The GGSN contains routing information for packet-switched (PS) attached users and provides interworking with external PS networks such as the packet data network (PDN). The model's CN nodes include both SGSN and GGSN functionality.

The circuit switched (CS) core network, which is not currently modeled, includes the mobile switching center/visitor location register (MSC/VLR). The MSC/VLR is used in the packet domain architecture to efficiently coordinate PS and CS services and functionality. The Home Location Register (HLR) contains GSM and UMTS subscriber information. The Charging Gateway Functionality (CGF) collects charging records from the SGSN(s) and GGSN. The Equipment Identity Register (EIR) stores information about user equipment identity. The HLR, CGF, and EIR are included in this description for completeness, but are not currently modeled.

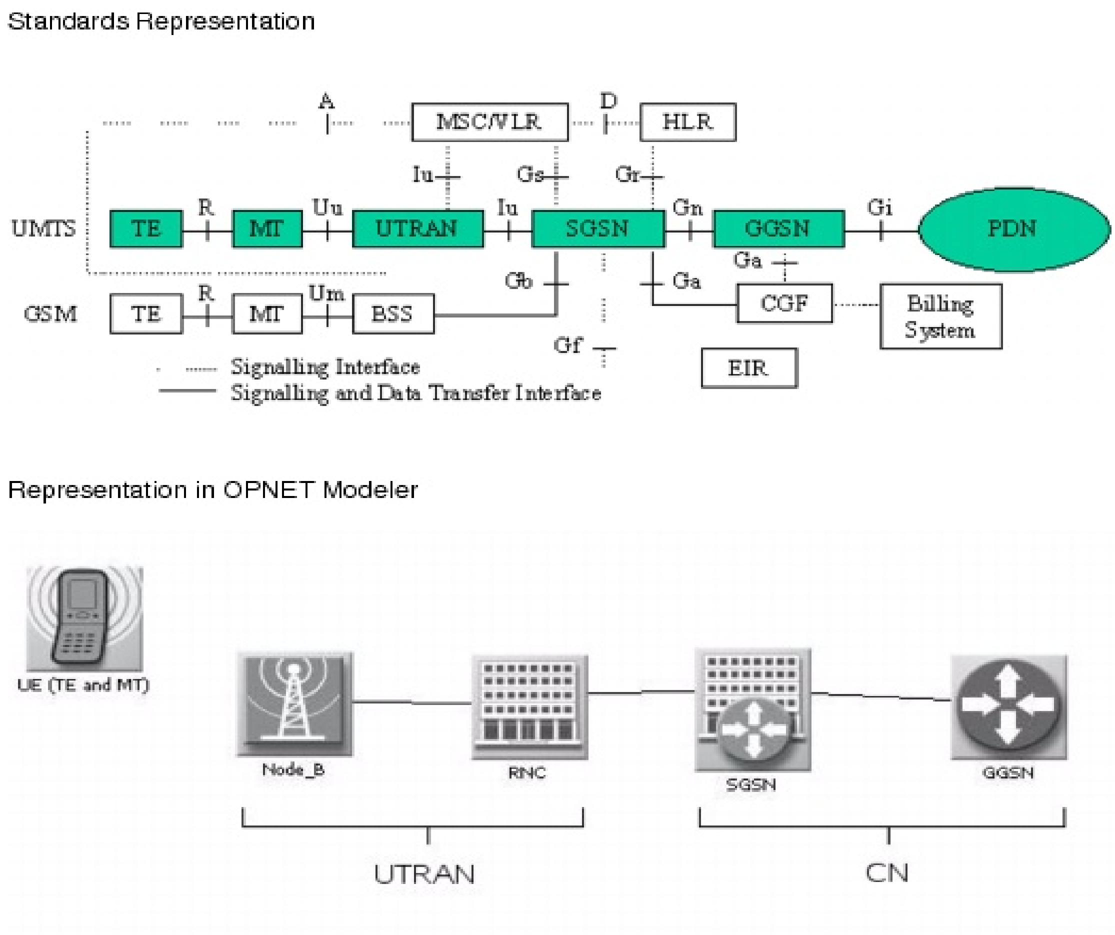


Figure 3: Overview of Packet Domain Architecture

In UMTS, the system architecture is subdivided into domains. These domains include user equipment domain which contains the USIM domain. The USIM domain in turn contains the SIM for UMTS. The end device belongs to the mobile equipment domain while the infrastructure domain consists of the access network domain. The access network domain contains the radio access network (RAN), and the core network domain. The user equipment domain is assigned to a single user. Its function is to grant access to UMTS services to users. The

USIM domain contains the subscriber identification module (SIM) for UMTS. The SIM performs encryption and authentication of users, and stores all the necessary user-related data for UMTS. Mobile equipment domain is where the end device is categorized. Functions for radio transmission as well as user interfaces are found in the mobile equipment domain.

All users share the infrastructure domain. The domain offers UMTS services to all accepted users. The core network is further divided into three domains with specific tasks. This includes the serving network domain, the home network domain and the transit network domain. Figure 4 shows the UMTS domains and interfaces.
The architecture of the UMTS consists of two main domains [19].

• The User Equipment Domain

• The Infrastructure Domain

The domains are shown in the following Figure 4.

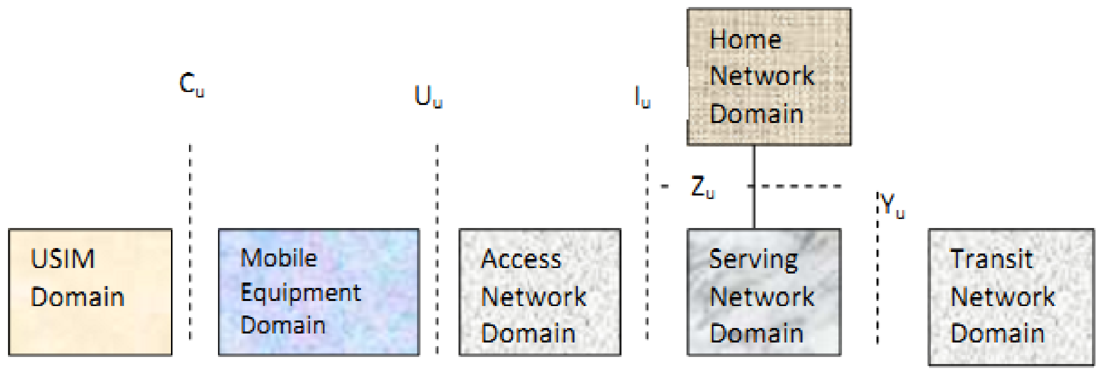


Figure 4: UMTS Domains Divisions [19].

2.1.1 The User Equipment Domain

In this domain the services of the UMTS are acquired by the users of the UMTS. This domain further consists of the following parts.

- USIM Domain

- Mobile Equipment Domain

2.1.1.1 USIM Domain

It is the smart card which is given to each UMTS user. Thus the sim card comes in the USIM Domain [19].

2.1.1.2 Mobile Equipment Domain

The terminal features and functions come in this domain. It consists of the functions which the UMTS users need to access the network [19].

2.1.2 The Infrastructure Domain

This domain is the main part of the architecture of the UMTS. This domain is further divided in to two parts.

• Access Network Domain

• Core Network Domain

2.1.2.1 The Access Network Domain

The function of the radio access network and all the nodes are in the access network domain.

2.1.2.2 The Core Network Domain

This domain is further divided in to three sub domains which are exactly alike in some cases [20].

• Serving Network Domain

• Transit Network Domain

• Home Network Domain

2.1.3 Universal Terrestrial Radio Access Network UTRAN

UTRAN comes in the access domain. Between the core network and the user equipment it maintains it makes and keeps the Radio Access bearers among the above entities. It is responsible to make a connection between the core network and the mobile equipment. UTRAN consists of the following two main parts. The UTRAN works in the UTRAN-TDD and UTRAN-FDD modes.

• Radio Network Controller

• Node-B

The main UMTS access network is known as Universal Terrestrial Radio Access Network (UTRAN). It consists of Radio Network Subsystems (RNS). The nodes in the core networks connect to UTRAN via the Iu interface. UTRAN also provides the interface Uu, through which the mobile stations connect to it. It provides management function and related functionality.

Figure 3 and Figure 5 shows the basic architecture of the UTRA network. Comparable to BSC control to BTS in GSM, RNC controls each radio network subsystems (RNS) in UMTS.

Components in the RNS include node B, which are comparable to BTS in GSM. One or more antennas are controlled by each Node B. Similarly, one mobile station can connect to one or more antennas which make up a radio cell. Each RNC is connected with the core network over the interface Iu and also connects with the node B over the interface Iub. The interface Iur has no counterpart in GSM. This interface connects two RNCs and is part of handover mechanism in UMTS.

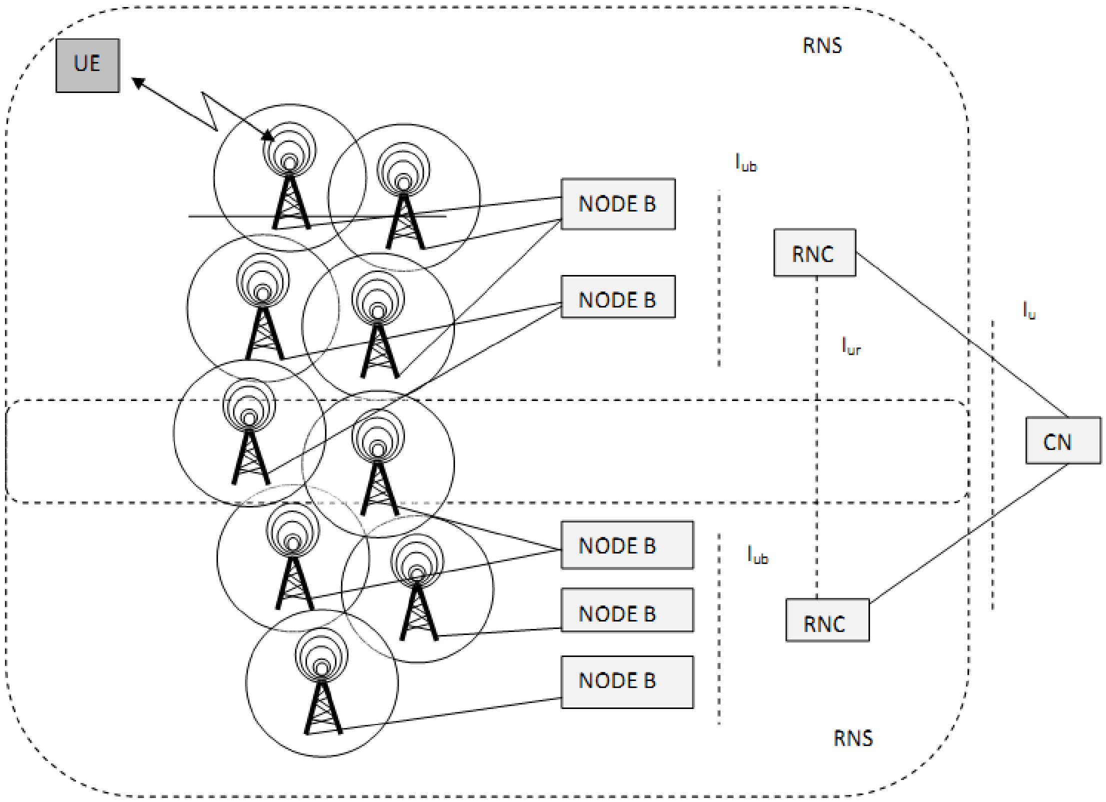


Figure 5: Basic architecture of the UTRA network.

The RNC and Node-B's comes in the radio access network and these forms a UTRAN which is shown below in Figure 3 and Figure 5.

2.1.4 Radio Network Controller RNC

In the radio access network the RNC is the main node. Between the mobile equipment and the radio access network a number of the protocols are applied in the radio network controller through the lur interface with the other RNC's of the core network. The function of the RNC is same as the function of the BSC in the GSM network. The radio resource management is controlled in more than one Node-B by the RNC. The following are tasks of the RNC [19].

• Through the radio interface it performs all the data transmission tasks.

• The radio resources are managed by this entity.

• The connection and the replacement of the radio bearers.

• The admission of the call control through the *Call admission control.*

• The allocation of the code is also the duty of this entity.

• The control of power.

• Helps in handovers and the scheduling of the packet.

• The relocation of the SRNS and the conversion of the protocol.

• The data coming from other networks are ciphered in the RNC's.

• To enable the transformation of the various entities RNC can connect and switch to ATM connection.

There are three types of RNC's.

• ***Serving RNC***: This RNC serves the user equipment because the user equipment is connected to this RNC. That is why this RNC is called as the serving RNC.

• ***Controlling RNC***: It works with reference to the Node – B.

• ***Drift RNC***: It works in the process of handover

2.1.5 Node- B

The Node-B manages the network's air interface for UEs in the same sector as the Node-B. There are both ATM and IP-enabled Node-Bs. The model suite includes a single-sector Node-B, a three-sector Node-B, and a six-sector Node-B. An RNC connects to one or more Node-Bs to communicate with the UEs of the network and to manage multiple calls. Its functions are similar to the BTS in the GSM network. The Node-B's are also called as the radio network controller. The following are functions of the Node-B.

• Many cells are managed by the Node-B.

• The tasks which are attached to the radio interface is manage in the Node-B.

• The data splitting and the combination is also the duty of this entity.

• It helps in the process of handovers too.

• It uses the mechanism for power control known as the inner loop power control.

2.2 Entities of the core network

The following are the different parts of the core network which have different functionalities [21].

2.2.1 Mobile Switching Center MSC

It is the switching entity. It supports the circuit switched connection. It also supports the mobility of the users. The current location of the user is known to the Msc. It also works in authentication and the user data encryption [21].

2.2.2 Visitor Location Register

It is the data base and it stores the copy data from HLR. The VLR stores the dynamic data. The VLR Update the information when users change its area.

2.2.3 Home Location Register

It is also the database same as the VLR. All the data of the users are stored in this database. Its main responsibly is the mobile user's mobility.

2.2.4 Gateway Mobile Switching Center

The circuit switch network between the outside network and the core network is provided by the GMsc.

2.2.5 Serving GPRS Support Node

The user's current location is stored in SGSN. It performs the functionality of the routing. Authentication and the copy of information of the user are stored in SGSN.

2.2.6 Gateway GPRS Support Node

The internet is connected to this node. It is the gate way to other packet networks. Usually firewall is containing in this entity.

2.2.7 GPRS register

It is the data base that is part of HLR. The packet switch transmission information is stored in this register.

2.3 Types of Switching in the UMTS Core Network

There are two types of switching done in the UMTS core network.

2.3.1 Circuit Switching

Its function is t o get the support of the traffic control. It maintains the information of the user location. The switching functions perform for circuit switching by the core network is done by MSC, HLR, VLR, and the GMSC.

2.3.2 Packet Switching

The packet switching tasks are performed by the serving GPRS support node and gate way GPR support node. The management of the mobility and the session is also done in this domain.

2.5 UE Architecture

Three types of UEs are supported in the UMTS model: simple mobile stations (umts_station), advanced workstations (umts_wkstn), and advanced servers (umts_server). You can model your UE nodes as either fixed (fix) or mobile (mob). Use the mobile node when the UE you are modeling moves during the simulation. You can reduce simulation run times by using the fixed nodes to model UEs that do not move during simulation.

2.5.1 UE Node Model Architecture

The UMTS station model shown in Figure 6 includes an application layer that feeds directly into the GMM layer. It also includes the RLC/MAC layer, a radio transmitter and receiver, and one antenna.

The advanced workstation and server (Figure 6) include the full TCP (UDP)/IP protocol stack between the application layer and GMM layer.

The GMM layer contains functions from the GMM, GSM, and RRC layers. It has mobility management functions (such as GPRS attach), session management functions (such as PDP context activation), and radio resource control functions (such establishment and release of radio bearers). The RLC/MAC layer contains the RLC and MAC layers. It includes priority handling of data flows, the three types of RLC modes, and segmentation and reassembly of higher-layer packets.

The links between the radio transmitter and the RLC/MAC layer and between the radio receiver and the RLC/MAC layer represent transport channels. On the uplink, there can be one random access channel (RACH), one common packet channel (CPCH), and one dedicated channel (DCH) where signaling and data traffic converges. Each transport channel in the dedicated channel has a unique spread code that distinguishes it from other transport channels. On the downlink, there can be one forward access channel (FACH), one downlink shared channel (DSCH), one acquisition indicator channel (AICH), and one dedicated signaling channel per user, and up to four data channels. The number of signaling and data channels on the downlink is equal to the number of signaling and data channels on the uplink; the exception to this is the DSCH, which has one extra channel. Each channel is assigned a different spread code and traffic on all channels can be sent simultaneously.

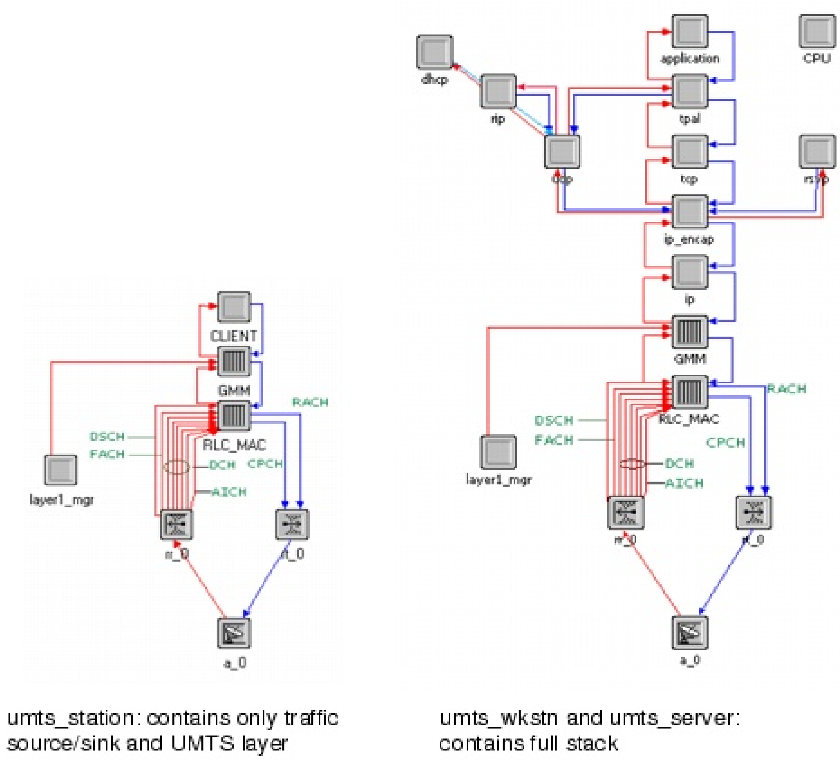


Figure 6: Simple and Full-Protocol Stack UE Node Models

2.5.2 UE Process Model Architecture

The process models for the application layer of the UE station node model are shown in Figure 7 (umts_client_mgr) and Figure 8 (umts_client_child). When the umts_client_mgr process model is invoked—either at the start of a new session for a particular QoS class or when triggered by another user (passive session)—it spawns the umts_client_child process. The child process is killed when the session ends. There are as many simultaneous child processes opened, as there are simultaneous sessions active at the UE [18].

When peer-to-peer communication is enabled at the caller side, transfer is done in both directions. In this case, the application layer at the originating UE, referred to as the mobile origination, first starts an active session. To set up a channel, the mobile origination (MO) sends a SETUP message to the mobile termination (MT). Once a channel is set up, the mobile termination sends a CONNECT message to the MO and starts sending data to MO. When the MO receives the CONNECT, it also starts sending data packets to MT. When peer-to-peer communication is not enabled, transfer occurs only in one direction. When a channel is setup on the mobile origination side, packets are sent directly to the mobile termination. No initial message sent to set up the channel on both sides as in peer-to-peer communication [18]. Therefore, data packets are queued at the termination side until a channel is set up with the mobile termination.

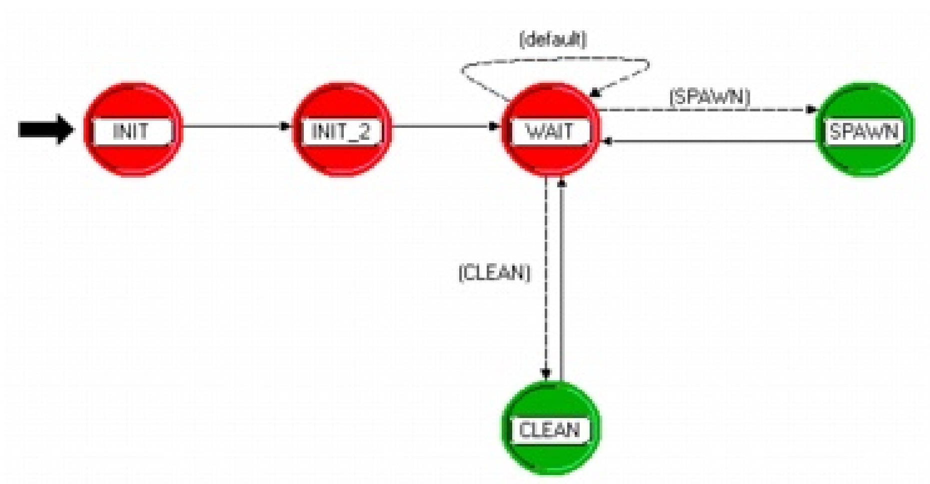


Figure 7: umts_client_mgr—Application Manager Process for the UE Station Node [18]

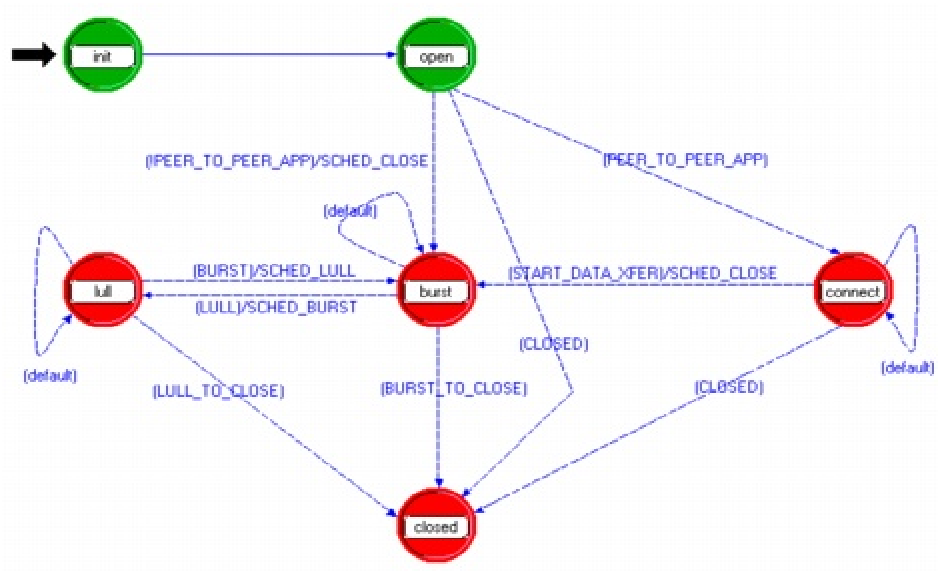


Figure 8: umts_client_child—Application Child Process for the UE Station Node [18]

Figure 9 shows the process model for the UE's GMM layer. Upon completion of GPRS attach, the UE waits in the CONNECTED state. As soon as the GMM layer receives packets from higher layers for a new QoS class, it sends a request to the SGSN to activate the PDP context. Once the PDP context is activated and a channel is set up, the UE can send packets to their destination. Modification of active PDP context is also supported. If the GMM layer receives packets from higher layers in the CONNECTED state when the PDP context is already activated but no radio bearer is set up, the UE sends a service request to SGSN. A channel is then set up and the UE can start sending packets to its destination. The radio bearer release and reconfiguration is also modeled in this process model. If the PS connection is released, the user moves to the IDLE state. The IDLE state and the RAU (Routing Area Update) state are not modeled in the current release [18].

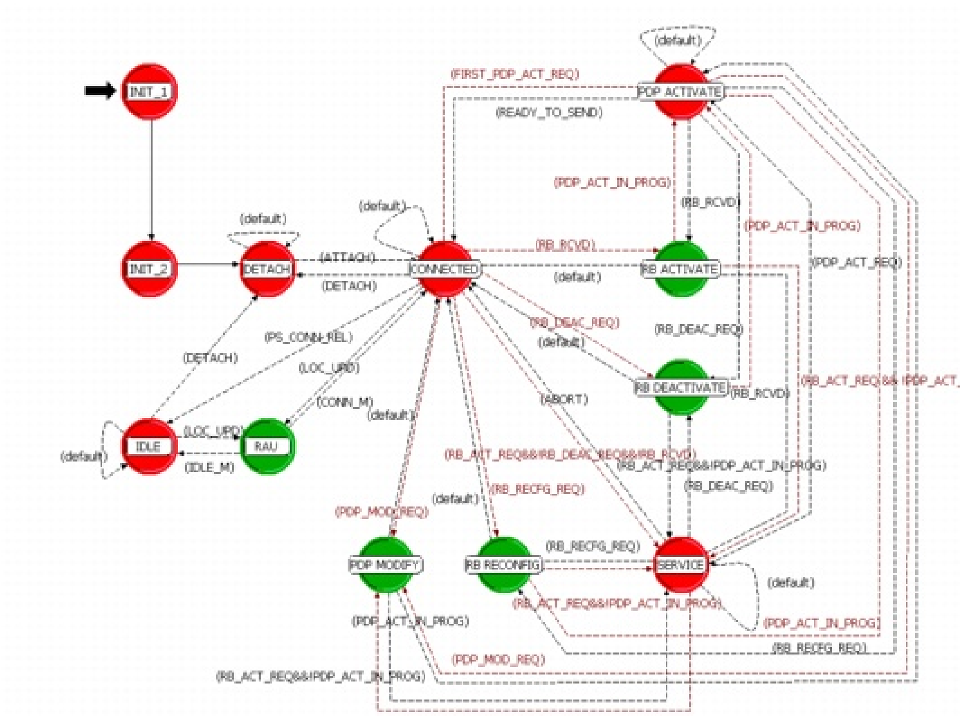


Figure 9: umts_gmm—GMM Layer Process Model on the UE [18]

Figure 10 shows the process model for the RLC/MAC layer, umts_rlc_mac. This process handles segmentation and reassembly of higher layers PDUs into and from smaller RLC PUs. It also handles transparent, unacknowledged, and acknowledged RLC modes. In unacknowledged and acknowledged RLC modes, umts_rlc_mac adds RLC and MAC headers to each PU. Packets coming from higher layers are buffered in different queues according to the channel a packet will be sent on. Packets are taken out of the buffer in each frame. If the frame boundary corresponds to the beginning of a transmission time interval (TTI) for that channel and the packet was received early enough to allow for processing time, the packet is segmented, RLC and MAC headers are added when appropriate, and the resulting packet is sent to the transmitter on the correct channel. For packets received from lower layers, packets are simply delayed by the processing time, and then forwarded to higher layers.

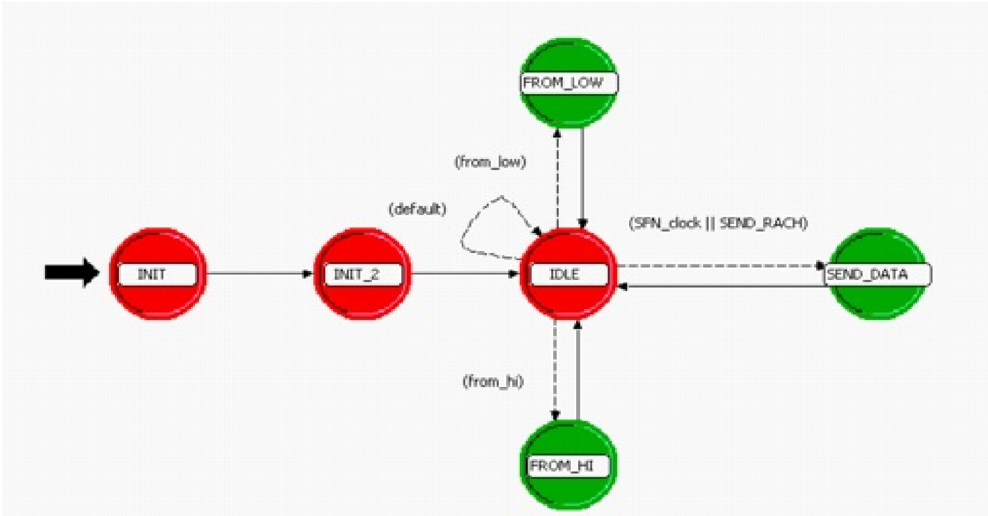


Figure 10: umts_rlc_mac Process for the UE's RLC/MAC Layer [18]

The RLC/MAC layer models all three RLC retransmission modes. For RLC Transparent Mode (TrM), Protocol Data Units (PDUs) from higher layers are segmented into smaller RLC Payload Units (PUs) and transparently transmitted to lower layers, and vice versa for reassembling PDUs from lower layers. There is no need to add RLC/MAC headers to or remove RLC/MAC headers from these packets. In RLC Unacknowledged Mode (UM), PDUs are segmented and reassembled, and RLC/MAC headers are added to each segment. Each segment is tagged with a sequence number but missing segments are not retransmitted [18].

For RLC Acknowledged Mode (AM), PDUs from higher layers are segmented into smaller RLC PUs, and RLC and MAC headers are added to each segment. Similarly, the RLC and MAC headers are removed from segments from lower layers, which are then reassembled into PDUs. As in the unacknowledged mode, each segment is tagged with a sequence number.

When the RLC/MAC layer of the receiving UE or RNC detects a missing segment, it sends a STATUS REPORT to the transmitting RNC or UE asking for the missing segment. On receipt of the STATUS REPORT from the receiver, the transmitting UE or RNC retransmits the missing segment. Retransmitted segments have higher priority than segments being transmitted for the first time. A segment can be retransmitted up to MAX_DAT times before it is discarded.

When segment is discarded after the maximum number of failed retransmissions attempts, the channel is locked and is reset. The RLC AM reset procedure can be triggered at the UE or at the RNC and is handled differently in each case.

- For RLC AM reset cases at the UE—the affected channel is blocked and all data traffic intended for that channel is discarded. Other transport channels serving different QoS classes remain active unless they also encounter a reset situation.
- For RLC AM reset cases at the RNC—the affected logical/transport channel (identified by IMSI and QoS) is blocked and the radio bearer (RB) corresponding to that channel is released. The model also considers the possibility that the RB release procedure with the UE can also fail if the UE loses communication through the signaling channel. In these cases, the RB is released after a certain number of trials.

In both reset cases, the model does not support recovery from a reset situation—a channel blocked during reset will remain blocked for the remainder of the simulation.

The transmitter and receiver also have a Transmission Window Size and a Receiver Window Size. The Maximum Send state variable (VT (MS)) is equal to the Transmission Window Size plus the sequence number of the next in-sequence PU expected to be acknowledged (VT(A)) plus the sequence number of the next PU to be transmitted for the first time (VT(S)). The Maximum acceptable Receive state variable (VR (MR)) is equal to the Receiver Window Size plus the sequence number of the next in-sequence PU expected to be received. The number of segments sent to the receiver, but awaiting acknowledgement should not exceed the Transmission Window Size. Similarly, the receiver will not accept segments exceeding the Receiver Window Size from the transmitter, and discards excess segments.

The RLC Acknowledged Mode also uses several timers. STATUS REPORT messages are sent every Timer_Status_Periodic and each time a missing segment is detected at the receiver if the Missing_PU_indicator is set to TRUE. Every time a STATUS REPORT is sent, another timer Timer_Status_Prohibit is started. The receiver cannot send a STATUS REPORT while the Timer_Status_Prohibit is active. On expiry of Timer_Status_Prohibit, a STATUS REPORT is sent if Timer_Status_Periodic expired or missing segments were detected while Timer_Status_Prohibit was active.

Every segment sent by the transmitter for the first time is copied and saved in a retransmission buffer. When the transmitter receives an acknowledgement from the receiver, it removes the acknowledged segments from the retransmission buffer. If a segment stays in the retransmission buffer longer than Timer_Discard, it is discarded. This prevents build-up of buffer length at the transmitter when there are frequent retransmissions.

When the UE is in the CELL_FACH state, the RACH (random access channel) is used to transmit data in the uplink direction. When packets are buffered at the RLC/MAC layer, the RLC/MAC spawns the umts_rach process, which models the random access channel. The umts_rach process model, shown in Figure 11, follows the slotted aloha contention algorithm. The process uses the preamble ramp-up procedure to begin sending preambles. Once it receives an acknowledge from the node B, umts_rach notifies the RLC/MAC so that data messages can be sent.

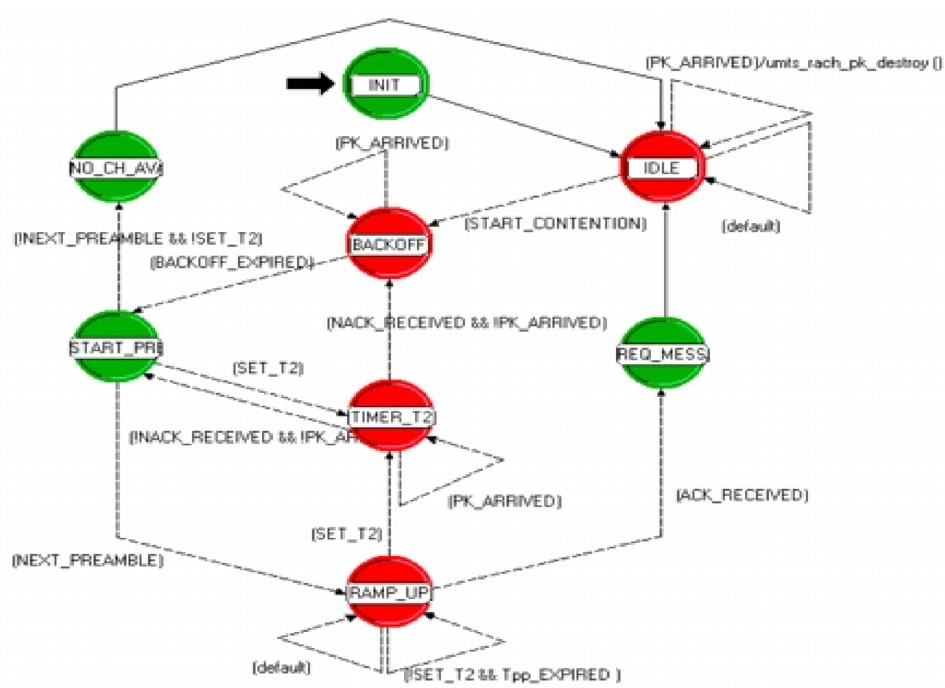


Figure 11: umts_rach Process Model on the UE

2.6 UMTS Handover Concept

In mobile communication handovers is refer to the transformation of an ongoing call or data from one channel to another which are connected to the core network. It enables the users of cellular technology to receive their calls anywhere and at any time so this process provides the mobility to the users, making it possible to the users to roam seamlessly from one cell to another cell. It is performed when the link quality between the base station and the mobile station on the move is decreasing from certain level of threshold.

In this process the existing link or the connection is tear down and the link is replaced by the cell to which the cellular user is handed on the cell to which the user is handed over is the target cell in this case. The network controller decides from the measurement reports about the link quality that the hand over process is needed to another cell or not. The inability of the network to make a new connection to the target cell is the handover failure. It occurs only when there are no resources or the quality of the radio link is very less from some threshold value in the target cell.

The request of the handover is same as the new call, the utilization of the resource should be optimized which is severe in order to make less the call dropping and blocking probabilities.

But it is admitted that force dropping of present call is more worthy then the new call blocking.

Now due to low data rate of second generation telecommunications systems there is a need of high data rate so one can enjoy the multimedia services like quality video streaming and high speed internet on his mobile phone so the third generation mobile systems are needed to replace the old telecommunication systems. Here in this report the UMTS (Universal Mobile Telecommunications System) taken as the 3rd generation networks and the most common form of UMTS as air interface is the WCDMA (Wideband Code Division Multiple Access). Handover is a process when a user switches to another channel without any interruption and when we talk about 3rd generation networks we use soft handover because in soft handover mobile phone connects to another channel before leaving first. [22].

2.7 Requirements of handovers

The handover process is required when the following events occurs.

• When the motion of the user equipment is very fast.

• The movement of the user’s equipment from one cell to another during an ongoing session.
• The experience of interference phenomena by the user’s equipment from the near cell.

2.8 Handovers Aim

The main aim of the handover process is to allow the mobile users to roam freely from one mobile network to another either the network are same or different. To achieve the load balancing in the different cell handover is also required and Also to maintain the good radio quality of the link between the mobile users and the serving base station and to minimize the interference level.

2.9 UMTS Handovers

An effectual process of the handover is necessary in the UMTS network which assures effective mobility, providing of the maintaining of ongoing session and quality of services. In addition the freedom to move within same or different network, the balancing of load and minimization of the interference level by allowing a good connectivity of the radio link to the base stations is main results of the UMTS handovers.

2.9.1 Handovers Types in UMTS

The following are the different handovers types in UMTS.
• Horizontal Handovers
• Vertical Handovers
• Soft Handovers
• Hard Handovers
• Softer Handovers
• Intra System Handover
• Inter System Handover

2.9.2 Horizontal Handovers

The transformation of an ongoing session from one cell to another cell having the same access technology is called the Horizontal Handover. For example if user equipment is connected with the radio ink with the GSM network the horizontal handover must be from GSM to GSM. Similarly the handovers between two UMTS network is the horizontal handover. Horizontal handover is the opposite to the vertical handover it is basically the handover between the same technologies like if the user is connected with the UMTS the horizontal handover must be from UMTS to UMTS. In other word it would be explained that the transferring of call from one channel to another of the same core network.

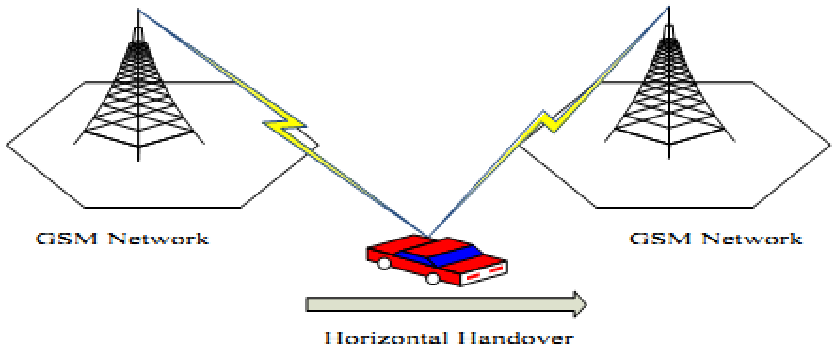


Figure 12: Horizontal Handover

2.9.3 Vertical Handovers

The transformation of an ongoing session or call from one cell to another cell having different access technologies is called vertical Handover. For example when a mobile user is moving from GSM based network to the UMTS network, here the access technologies are changed so the handover in this case is the vertical handover.

The vertical handover is the transfer of data session or a call from one access technology to another access technology or technique for example from WLAN to UMTS or vice versa. Vertical handover is normally used where the network service issues happen when the user using UMTS access technology and he would reach closed building area during data session then it would be entertain with WLAN access technology.

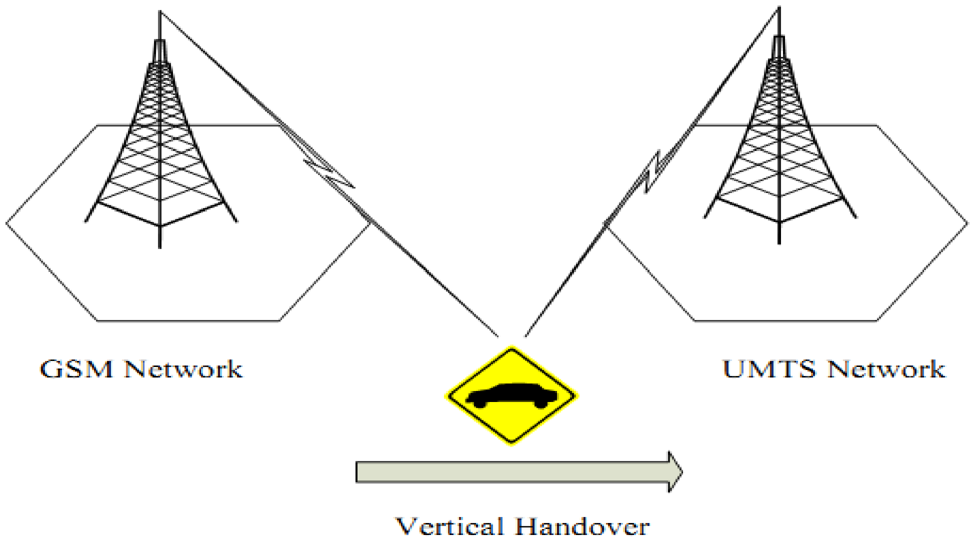


Figure 13: Vertical Handover

Loose coupling and tight coupling are the two architectures' used in the vertical handovers between UMTS and WLAN.

2.9.4 Hard Handovers

In Hard handover all the old radio links in the UE are removed before the new radio links are connected. Hard handover could be seamless or non-seamless. Seamless hard handover means that the handover is not effectible to the user. Normally a handover that requires a change of the carrier frequency (inter-frequency handover) is always similar as hard handover. From real-time bearer it means a short disconnection of the bearer and for non-real-time bearers hard handover is lossless. Hard handover can take place as intra or inter-frequency handover.

Hard handover is also called the conventional handover it has some advantages like the user can

not hold more than one channel at all time and mobile doesn't need complex hard ware to receive two channel at the same time. Hard handover is firstly introduced in GSS technology; On the other hand hard handover has some disadvantage also like there are many chances of call drop during hard handover which increase the call drop probability [23].

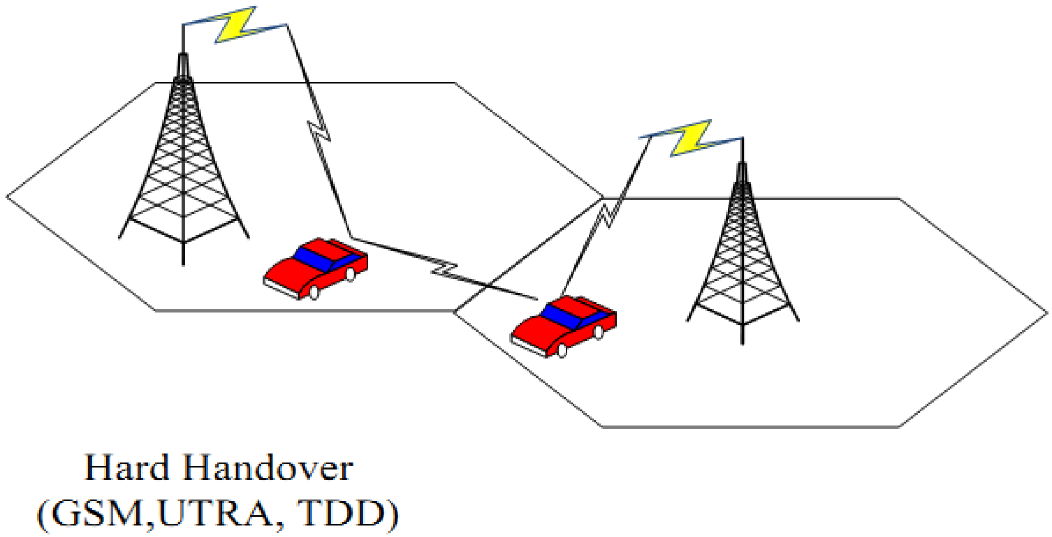


Figure 14: Hard Handovers [19]

In the UMTS to change the band of frequency between the user equipment and the UTRAN the hard handovers are used. The UMTS operator can demand for spectrum to increase the capacity so the many 5 MHZ band would used by one operator, the outcome here is the need of hard handovers between them. To change the cell that have the same frequency and when there is not the support of the micro diversity these hard handovers are used else when a user equipment is allocated a dedicated control channel, it move to the new and near cell of the UMTS network and when there is the possibilities of other handovers like soft or softer handover the hard handover is then an option and is performed [22].

Advantages of Hard Handovers

• The hard handovers are simple and economical as the cellular phone hardware is not able to make connection with the two or more channels at the same time.

• Only one channel is used at any interval of time which makes it simple and easy.

Disadvantages of Hard Handovers

• If the handover process is not successfully executed then call may be terminated or ended.

2.9.5 Soft Handovers

In this type of handovers the user equipment communicates parallel from different Node-B's with more than one sectors so the link are added and it is deleted in such a way the mobile equipment and the UTRAN always keeps a link. The technique known as micro diversity is used in this type which is known as at the same time many radio links are working and active. Soft handover was actually introduced by CDMA technology. Compared to the conventional hard handover it got few advantages. But in other hand it also has the some disadvantages. In Soft handover the UE can be connected to more than one channels at the same time, it is also known as make before break because it keep the previous channel from source until it gets the channel from source cell. Although soft handover increase the complexities but it has many advantages also like the high hand over success rate and reduction of call drop probability and elimination of inference [24].

This technique has many advantages which are shown in the bullets below [19]

- The near-far effect is reduced.
- The connections are more repellent to shadowing.
- It offers the chance to transmit data the other Node-B's and thus the communication is maintained.

The property of the CDMA is that the same frequencies are used by the all Node-B's gives an edge to the soft handover. The user equipment connected to the Node-B is called as the User Equipment Active Set [25].

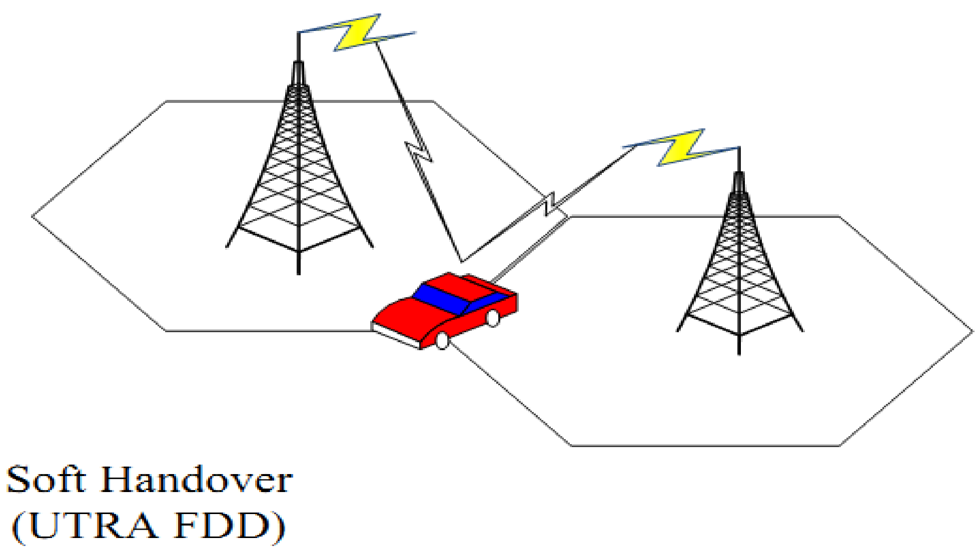


Figure 15: Soft Handovers [19].

These handovers are also called as “make before break “. It is because the connection is made first to the other Node-B and releases the older connection after making the connection to the target.

Advantage of Soft Handovers

• Sophisticated handover type in which the call dropping probabilities are low as compared to hard handovers.

• The connection to the target cell are more reliable as compared to the source connection at which the user equipment is connected first and after the handover procedure the target connection are more reliable.

Disadvantage of Soft Handovers

• More than one radio links are used so the more complex hardware is needed for it in order to cope with the existing situation.

• More than one channel is used parallel in a single call so the handover process should be done in such a way that the dropping probabilities’ should be low as possible.

2.9.6 Softer Handovers

It is the special type of the soft handover the communication moves parallel to the same Node-B’s having over its different sector [19].

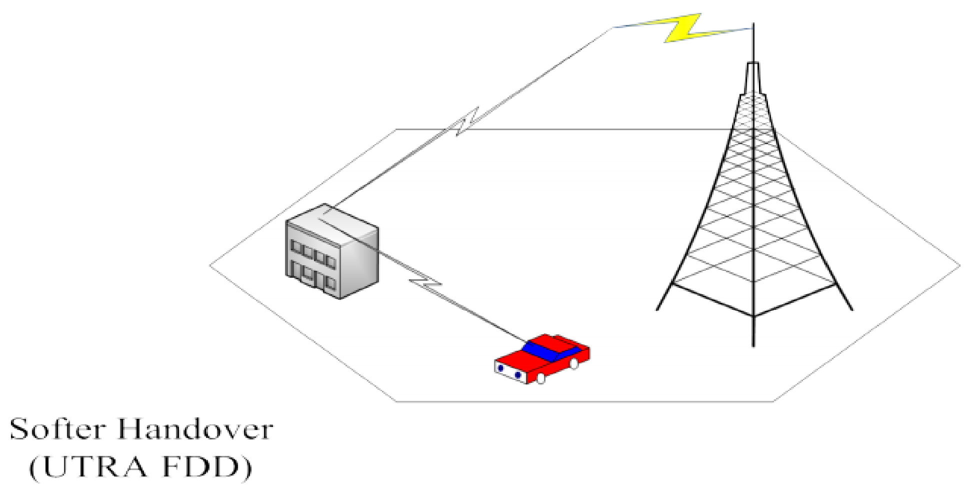


Figure 16: Softer Handover [19]

The user equipment and RNC communicates with the two different air interface channels. So two different codes are required for downlink thus the user equipments can know the signal. Rake processing used in the user equipment can receive the two signals.

2.9.6.1 Inter System Handovers

There are different radio access techniques like UMTS uses WCDMA GSM uses CDMA etc, so the inter system handovers are that type of handovers which takes place between different cells having different radio access techniques.

2.9.6.2 Intra System Handovers

Only in the single system these handovers are found. The dual mode terminal FDD-TDD these handovers can be observed. The handovers occurs from the techniques FDD to TDD.

There are two special types of the inter system handovers which are explained in the following sections.

Intra Frequency Handovers

In the WCDMA system if the intra system handover occurs with the cells having the carrier frequency same then this type of hand over is the intra frequency handovers.

Inter Frequency Handovers

In the WCDMA system if the intra system handover occurs with the cells having the carrier frequency different then this type of hand over is the inter frequency handovers.

2.10 Strategies of Handovers

The handover processes are carried out with different strategies each having its own pros and cons. The strategy is adopted and depends upon the quality of service which users require at that specific time and the cost of the network.

2.11 Role of RNC in the Handovers Process

The soft handovers are easy if the Node-B's taking part in the hand over process if the RNC's are same. It becomes difficult if the Node-B's are in control of unlike RNC's. If the problems occur in the Radio access network the core network is not permitted to be witting of the problem. Yet it is important if the communication between the RNC's is impossible directly to each other over the interface-Iur. As the Figure 17, left cell number 1 is supplied with the mobile equipment. The connection is controlled by left RNC. Thus the RNC is also called as the controlling RNC. When the user equipment shows the movement to the border of cell number 1 the soft handover is performed. Two Node-B's supplied the user equipment. The Node –B number 2 is controlled by the other RNC but the connection control is with the left RNC number 1. It serves as the serving RNC and the right RNC is controlled by the other

RNC known as the Drift RNC. SRNC receives the not processed data from the drift RNC. DRNC receives the copy of data on the downlink from the SRNC and the attach Node-B's to the user equipment receives the data. Node- B number 1 role decreases as the user equipment moves to the Node-B number 2. So the old connection is broken down to the Node-b. This handover in UMTS involves the core network in the handover process. The drift RNC becomes the controlling RNC and now it controls the connection [19].

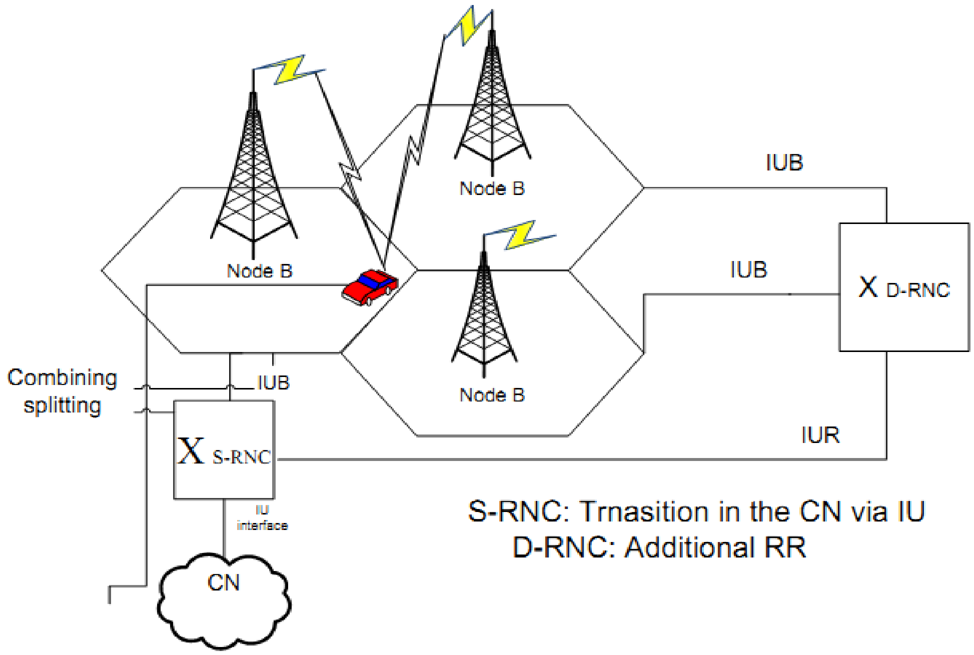


Figure 17: RNC role in the Handover Process [19]

CHAPTER 3: MOBILITY MANAGEMENT AND ITS IMPORTANCE

3.1 Market Review

Without Mobile Web facility, it is hard to imagine Modern mobile network. The competence to hand over a mobile phone within a heterogeneous wireless system, for example, is a basic prerequisite for the economic success of next Generation Mobile radio system. It is the only way to attest Mobile Users full coverage from the start. Globally, the demand for wireless data services is driving the growth of Mobile Network.

Mobile devices —PDA, Smartphone's and tablets — that had a windfall sales in recent years are fostering the change in which Mobile App based requirement are rapidly changing. Thus, remarkable data services and transmission have increased a lot. The trend is most visible throughout worldwide represented in Figure 18.

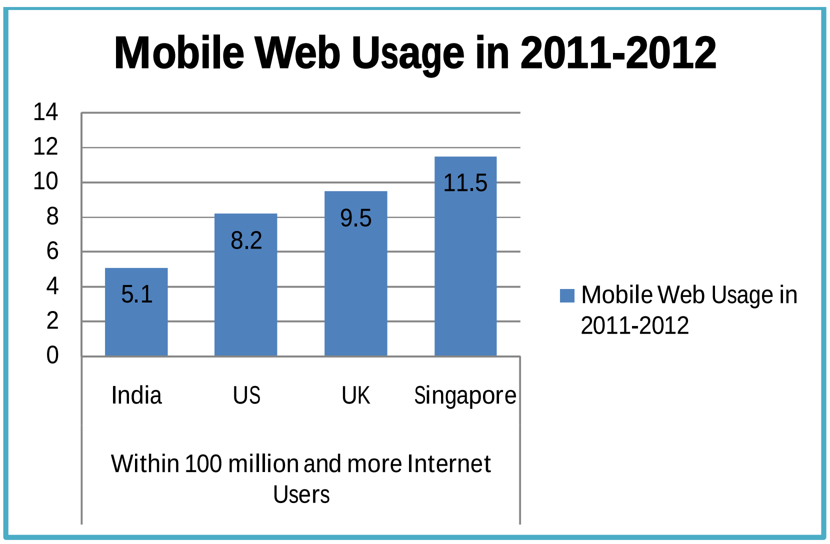


Figure 18: Percentage of the Web Traffic

With nearly large number internet users, in terms of actual numbers, India should rank as one of the biggest markets in terms of potential. Apps categories like Health apps & Access to news have highly preferred by most users worldwide.

New category of consumer reckons that network connectivity and strengths of the mobile operating system are key considerations before buying a Mobile device. Thus, this opportunity has came for all cellular operators to transform it into business & services through technological advancement which they can triumph with the integrated interface of the desktop and the mobile.

This popularity largely stems at present from them being personal, personalizable, portable, connected and increasingly multi-functional beyond their original purpose of voice communications. In addition to these factors, the advantages of mobile devices will increasingly include location awareness, one-handed operation, always on and universal alerting device. The Web can reach a much wider audience, and at all times in all situations. It has the opportunity to reach into places where wires cannot go. Finally, today, many more people have access to mobile devices than access to a desktop computer, which is shown in Figure 19 in term of subscriptions forecast.

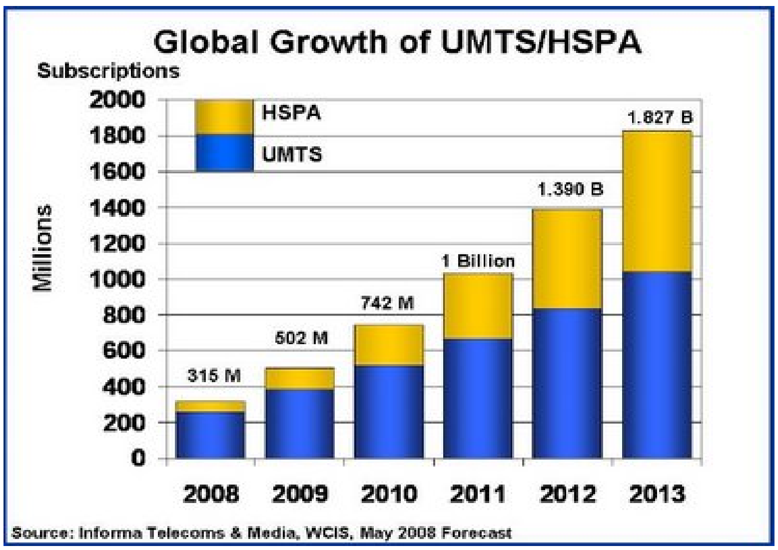


Figure 19: Statistic forecast for subscriptions in coming years

In Mobile-wireless systems, Applications are classified in to two types [7]: Horizontal application and vertical applications. Vertical applications are precise to a type of users and organization. In view of quick developments and usage with mobile devices are required to improve the software design approach for vertical applications for better outcome [7]. Such Applications desire seamless services by exploiting device capabilities to provide an enhanced user experience. While encouraging content providers to be sensitive to the needs of the users with the growing demands for wireless data and successes for a variety of wireless applications, the increasing Average Revenue per User (ARPU) for wireless services by operators worldwide.

3.1.1 Mobility Management in Mobile IP for Cellular networks

In Mobile IP of cellular, the signaling protocol in cellular network is structured into three general layers, depending on the interface.

Layer 1: *The physical layer*, which uses the channel structures over the air interface

Layer 2: *The data-link layer*

Layer 3: *The third layer* of the Cellular signaling protocol is divided into three sub layers:

Radio Resource management (RR):- (The UE to BTS Protocols) oversees the establishment of a link, both radio and fixed, between the UE and the MSC.

Mobility Management (MM):- the MM layer is built on top of the RR layer and handles the functions that arise from the mobility of the subscriber, as well as the authentication and security aspects. Location management is concerned with the procedures that enable the system to know the current location of a powered-on UE so that incoming call routing can be completed.

Connection Management (CM) is responsible for supplementary service management, and Short Message Service (SMS) management.

For Future mobile IP networks, Mobility Management plays a vital role for seamless services [4] that consist of two major objective Location Management (enables the serving networks to locate a mobile subscriber's point of attachment for delivering data packets) and Handover Management(maintain a mobile subscriber's connection as it continues to change its point of attachment)[3]. Operations of location management include: *Location registration*, also known as location update or Tracking information entries stored in some databases in the networks in Home Location Register & Visitors Location Register.

Location paging, also known as locating or searching (a search for the user's profile) is made usually in a local database [1]. Operations of handoff management include: *Handoff triggering*, i.e. to initiate handoff process according to some conditions [9]. *Connection re-establishing* i.e, the process to generate new connection between the mobile node and the new attachment point and/or link channel. *Packet routing*, i.e. to change the delivering route of the succeeding data to the new connection path after the new connection has been successfully established [9].

All the Handover are Classified [1][4] in following Table 1 :

Table 1: Types of Handover with mobility schemes

<table>
<tr><th colspan="3"><u>TYPES OF HANDOVER</u></th><th><u>Mobility Schemes</u></th><th><u>Advantages</u></th></tr>
<tr><td rowspan="2">Inter-cell</td><td rowspan="2">Occurs when a user moves from one cell to another cell. In this case, the user’s connection information is transferred from the old BTS to the new one.</td><td>Inter-domain / Vertical Handovers : the handovers between different domains</td><td>Macro</td><td>Flexibility, Robustness, and Scalability</td></tr>
<tr><td>Intra-domain / Horizontal Handovers:
which are handovers of the same domain.</td><td>Micro</td><td>fast, efficient, seamless mobility support</td></tr>
<tr><td>Intra-cell</td><td colspan="4">Occurs when within a cell a user experiences degradation of signal strength. This leads to a choice of new channels having better signal strength at the same Base Transceiver Station (BTS).</td></tr>
</table>

Furthermore, there are two separate mobility support protocols [3]; Firstly, Host-Based Protocols and Network Based Protocols Characterized, as shown in Table 2 & Figure 20.

Table 2 : Characteristics of Mobile Supports Protocols

<table>
<tr><th colspan="6">Characteristics of Mobile Supports Protocols</th></tr>
<tr><th colspan="2">Protocols</th><th>Location MM</th><th colspan="2">Features & Performance</th><th>Mobility</th></tr>
<tr><td rowspan="3"><u>Host-Based Mobility Management</u></td><td>MIPv6</td><td>Yes</td><td colspan="2">Tunneling of packet, reduce PLR(packet loss ratio)</td><td rowspan="2">micro</td></tr>
<tr><td>Hierarchical MIPv6 (HMIPv6)</td><td>Yes</td><td colspan="2">Routing-based, Reduce Handover latency within same domain.</td></tr>
<tr><td>Fast MIPv6 (FMIPv6)</td><td>No</td><td>Seamless Handover within different domain.</td><td>Real time application (video, voice over IP, etc...)</td><td>macro</td></tr>
<tr><td><u>Network Based Mobility Management</u></td><td>Proxy Mobile IPv6 (PMIPv6)</td><td>Yes</td><td>Seamless Handover</td><td colspan="2">Internet Enabled, reduce unnecessary signaling, and packet loss.</td></tr>
</table>

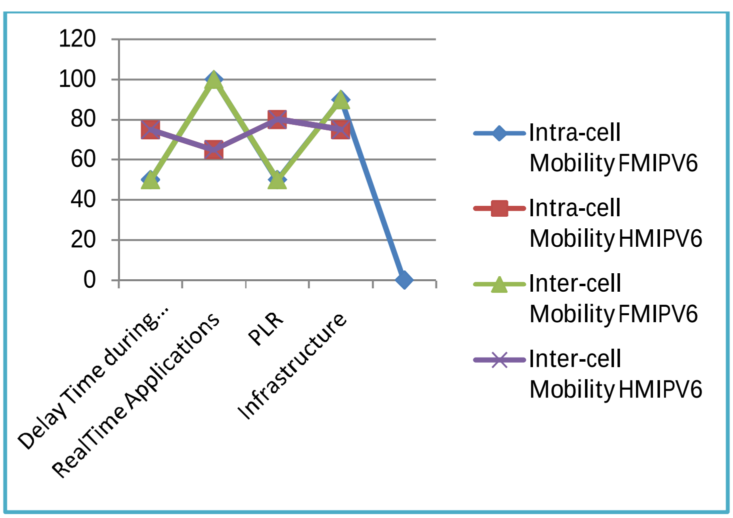


Figure 20: Comparison on basis of some parameters

3.1.2 Problem Statements

So, for the current scenario based on the market research, certain issues are drawn out in Mobility Management:-

Location identification and profiles retrieval from database of the subscribers while the subscribers are in roaming [7]. There is another problem we found, for probing the profiles from the Home Location Register and transfer to the Visitor Location Register while the subscribers are in roaming. It increases the transition between the HLR and VLR databases in mobile-wireless networks [7].

The Mobile IP protocol is implemented in several local area networks and works well. But real-time features are not supported in the protocol [1]. With the increased number of cells and smaller radius, occurrences of handovers have increased [5]. The requirement for modification of mobile nodes may cause increased complexity on them and introduce battery problem and waste of air resource. Also the tunneling that established between the Home Agent and Mobile Node increases the bandwidth constraints on the wireless link and the processing burden on the mobile node [3]. A latency-sensitive service such as real-time and multimedia applications requires persistent connectivity [3].

For real time applications based on TCP and UDP, while a handover in Host Based MIPv6 there is no packet delivery. Thus loss of packet cannot be compensated yet Layer2 supposed with intermittent losses of connectivity by retransmitting unacknowledged packets [4].

So for the Aforesaid issues a network-based mobility management protocol is being pronounce by the IETF in IP mobility management. UE is need not to take part in mobility-related signaling, it is easy deployment and low installation cost [3]. Network-based mobility management (NBMM) is to simplify the deployment, integrate with and enhance already existing solutions if suitable, to the mutual benefit of operators and mobile users. Key performance benefits of network-based mobility are identified as: removal of mobility implementations from hosts, extended capabilities for mobility, and decrease in air-link consumption [2].

Proxy MobileIPv6 more suited protocol for NBMM, as compared to host-based Mobile IP systems [2]. But still certain problem with Latency-sensitive services such as real-time and multimedia applications has to be standardized.

-In [9], horizontal handover in homogenous network and vertical handover in heterogeneous network is explained, where it is not easy to make a handover until the previous BTS connection is transferred to new one. Therefore, QoS become more vulnerable for real-time application over mobile IP network and other overheads will overwhelm QoS.

These performance measures are affected by mechanisms such as mobility management, radio resource management, call (CAC) admission control, fair scheduling, channel-dependent scheduling etc.

Besides the basic functions that implement the goal of handoff management, there are many other requirements on performance and packet-level QoS that should be carefully taken into account when trying to design or select a handoff management scheme, including[14]. Fast handoff, which is extremely important to real-time services. Seamless handoff i.e., less packet loss and low handover latency. Movement detection and prediction in which user profile will be kept for estimation of next move and decide the handover occurrence probability.

Handoff control, control through prior arrangement over soft and hard handover. Domain-based mobility management i.e. to divide the mobility into intra-domain mobility and inter-domain mobility according to whether the mobile host's movement happens within one domain or between different domains.

Mobility management includes functions to passively keep track of the location of the user's terminals and to maintain connections to the terminals belonging to the system but the data routing should not only passively reflect the change of terminal location, but also actively predict the movement of users [8].

Lastly, Issues with handover procedure which is of two types are as follows:

A hard handover is one in which the channel in the source cell is released and only then the channel in the target cell is engaged. Thus the connection to the source is broken before or 'as' the connection to the. When the mobile is between base stations, then the mobile can switch with any of the base stations, so the base stations bounce the link with the mobile back and forth. This is called ping-ponging [4][5].

A soft handover is one in which the channel in the source cell is retained and used for a while in parallel with the channel in the target cell. Soft handovers may involve using connections to more than two cells: connections to three, four or more cells can be maintained by one phone at the same time [4].

3.2 Related Works

Shein Jie, Tang Liangrui [6], proposed a algorithm for mobility support using triangle module operator and fuzzy logic based handover algorithm, considering two sets of inputs. Firstly, the RSS i.e., Received Signal Strength parameters. Secondly, the QoS parameters, like throughput, Delay, PLR (packet Loss Ratio), Security level input. These input in linguistic and crisp variable format are passed on to two different fuzzy logic based block, which will give a output of two handoff values and finally a fusion verdict is carried out by the last block for handover decision. Scenarios of this method are shown in Figure 21.

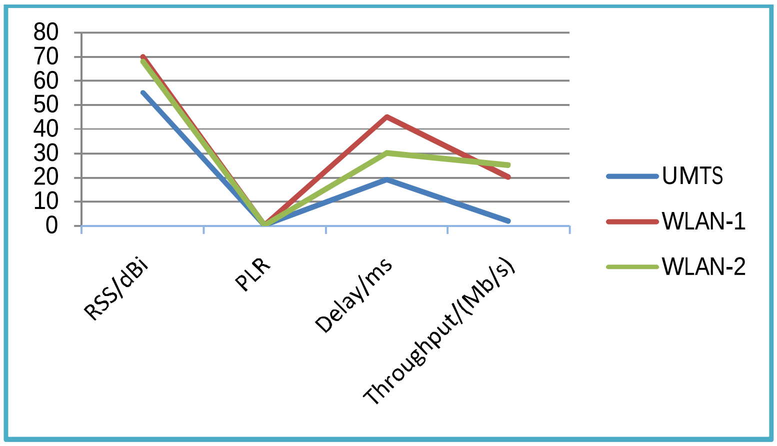


Figure 21: Variations in Vertical Wireless Technology

Trapezoidal fuzzy membership function were used for the first handover decision block, and combined triangle and trapezoidal fuzzy membership function for second handover decision block. This helped to reduce the number of switching which effectively reduce ping-pong effect.

In [5] paper, authors proposed and implemented a mixed approach for CAC and handover using Fuzzy Logic for wireless cellular networks. They evaluated the performance different scenarios as follows:

• When the user speed is slow, the prediction of the user direction becomes difficult, which results in a small percentage of the accepted calls;

• When the user angle is small, the percentage of accepted calls is higher and is decreased with the increase of the number of requesting connections;

• The proposed system keeps a higher QoS of on-going connections.

They also evaluated the performance of the proposed FL based handover systems for two scenarios: avoidance of ping-pong effect (Scenario1) and enforced handover (Scenario2)[5].
In the case of Scenario1, FBHS with an ideal behavior can avoid the ping-pong effect. For handover enforcement (Scenario2), FBHS has a good performance because in all cases has done three handovers.
In [5] paper, they considered only the priority of ongoing connections. In the future, we would like to consider also the priority of requesting connections.

CHAPTER 4: PROPOSED METHODOLOGY AND ALGORITHM

To design and control the uncertainty in cellular network, the parameters of uncertainty from the Mobile network should be properly elicit ate. Though an uncertainty arises from various sources, yet they share some common features, either in vague (fuzzy) nature or in stochastic behavior [11].

1) Vagueness - the fuzziness of data and knowledge may result from the following reasons: For example: decisions like whether user is going to move into a new cell or not. The vagueness of data comes from the low resolution of RSS, latencies while neighbor discovery.

2) Stochastic Behavior – Some time we don't know the feature and its unit, to predict some outcome. In our Scenario it is the user random movement which can't even have a vector or pattern in cell switching. For this, we used Fuzzy inference system, to deal with these uncertainties, explained in next sub-section.

Thus in context of abovementioned problem statements, if network intelligence is able to predict the "future" location of a mobile user according to the user's movement history patterns [8]. The data or services are pre-connected and pre-assigned at the new location before the user moves into the new location. Thus, the user can immediately receive service or data with virtually the same efficiency as at the previous location [8].

4.1 Fuzzy Inference System

Fuzzy inference systems (FISs) are also known as fuzzy rule-based systems, fuzzy model, fuzzy expert system, and fuzzy associative memory. The decision-making is an important part in the entire system. This is mainly based on the concepts of the fuzzy set theory, fuzzy IF–THEN rules, and fuzzy reasoning. FIS uses "IF. . . THEN... " statements, and the connectors present in the rule statement are "OR"/ max function or "AND" / min function to make the necessary decision rules. The basic FIS can take either fuzzy inputs or crisp inputs, but the outputs it produces are almost always fuzzy sets [13].

When the FIS is used as a controller, it is necessary to have a crisp output [13]. Therefore in this case defuzzification method is adopted to best extract a crisp value that best represents a fuzzy set for the selection of new Base Station or new cell [12]. This Controller will be deployed in BSC and MSC for handover control.

Construction and Working of Inference System

A FIS with five functional block described in Figure 22.

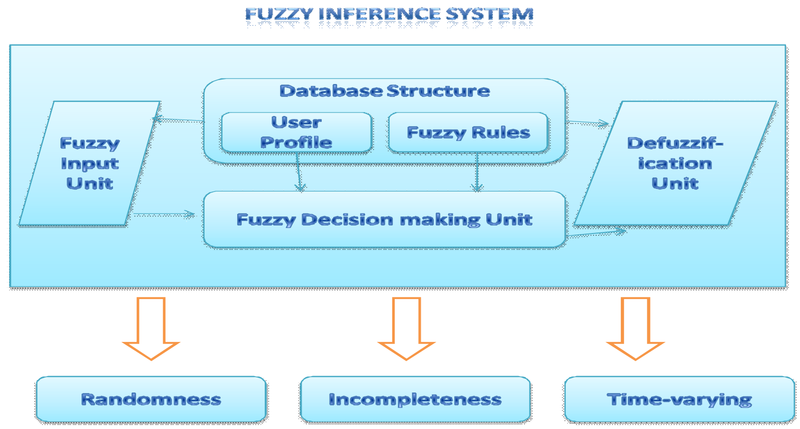


Figure 22: Functional Block Diagram of FIS

The function of each block is as follows:

A *Fuzzy rules* containing a number of fuzzy IF–THEN rules.

A *user profile* which defines the previous log of user with memberships functions;

A Fuzzy *decision-making unit* which performs the inference operations on the rules;

A *fuzzy input unit* which transforms the crisp inputs into degrees of match with linguistic values [5][6] and a *defuzzification Unit* which transforms the fuzzy results of the inference into a crisp output[5][6]. Outcomes are totally based on the randomness, Incompleteness, and Time-Varying system.

4.2 Assumptions

In our research we are considering Frequency reuse and cluster cells [12], as follows:

4.2.1 Frequency Reuse Distance and Cluster Size

The reuse of frequencies enables a cellular system to handle huge number of calls with limited numbers of channels. GSM cellular layout typically involves the frequency reuse factor which is inversely proportional to K (where K is number of cell per cluster) [12]. The value of K is 7 for TDMA system. Where R is the radius of the cell and D is the distance from the center of the cell to its neighbor using the same frequency. The minimum separation between two cells using the same frequency so that the two cells don't not interference with each other can be calculated by D/R= √3K as shown in Figure 24.

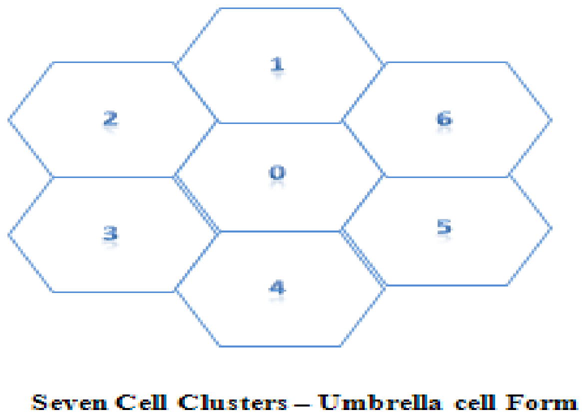


Figure 23: Cluster cell of 7 (Umbrella)

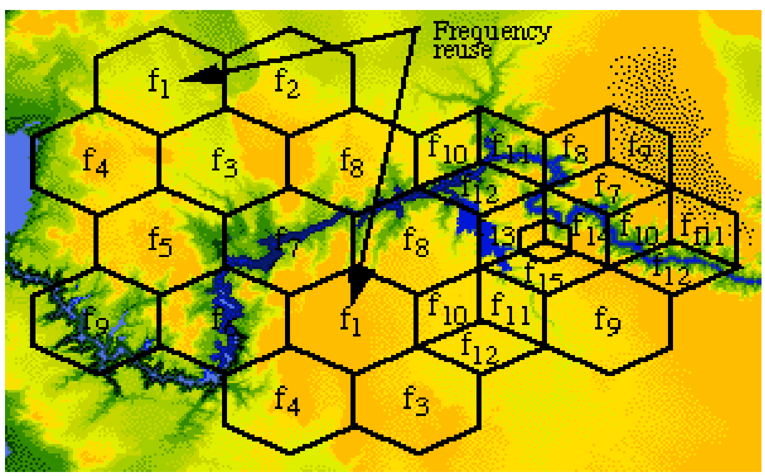


Figure 24: Frequency reuse in cellular network

4.2.2 GSM Handover Scenario

Handover is based on received signal strength (RSS) from the current base station and the neighboring base station [12]. The Figure 25 depicts a situation where a mobile node can move from one BS to another BS. This Base Station are Co-located in number of 3[12].The RSS of BS decreases as the mobile station moves away and increases as the mobile station get closer to the BS as a result of the signal propagation. It examines various approaches to handover initiation as in the forms Movement of the UE between two Adjacent BTS for Potential Handover, Relative Signal Strength, Relative Signal, and Prediction Approaches.

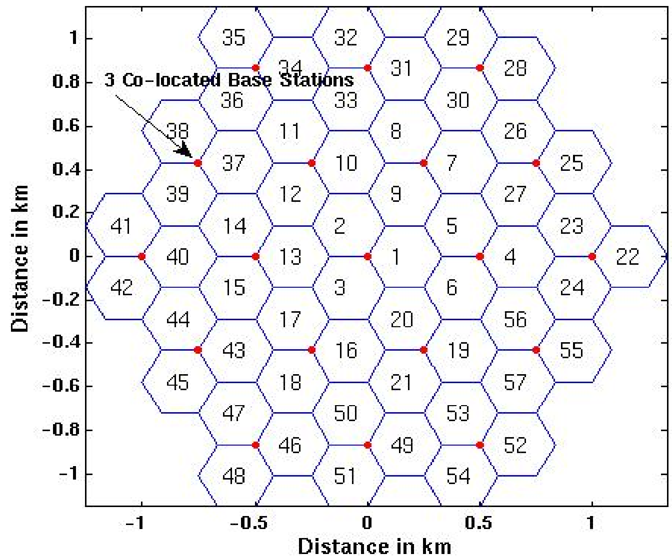


Figure 25: Placement of Base Stations n cellular Network

4.3 Proposed System Framework

In this section, an overview of the handover system framework is presented and the proposed system is explained in Figure 26. In the Layer 1, several parameters such as QoS, RSS, Timing advance, Distance, user profile etc are taken into account. In the Layer 2, we segregate the parameters according to user profiles for regular and random movement within cells. In Layer 3, Processing of these input are matched with the Fuzz Inference System (FIS) for handover decision. In Layer 4, Defuzzification is carried out for initiation of handover, respectively.

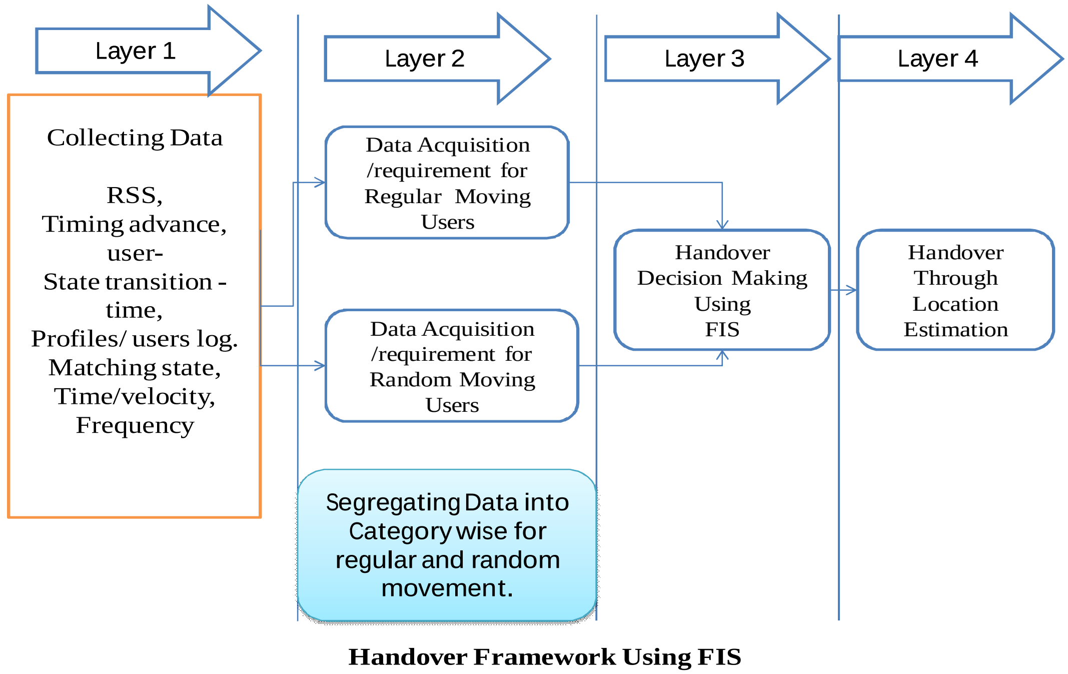


Figure 26: Proposed Handover Framework outline.

4.4 Handover Optimization using fuzzy inference system through location prediction:

4.4.1 Calculations and Formulas

4.4.1.1 Selection of Nearest Cell

In our proposed Idea, we considered the general cell structure where it have a BS and terminal at each point of attachment common to other cell in infinite order as shown in Figure 27. Each of these terminals is identified by some identification number based on Sector (Quarter) Bit Number SN (QN), Timeslot number TN, and other parameter [15]. Once the terminal is identified, we determine the sectors (or quadrant) to which it belongs out of three, shown in Figure 28.

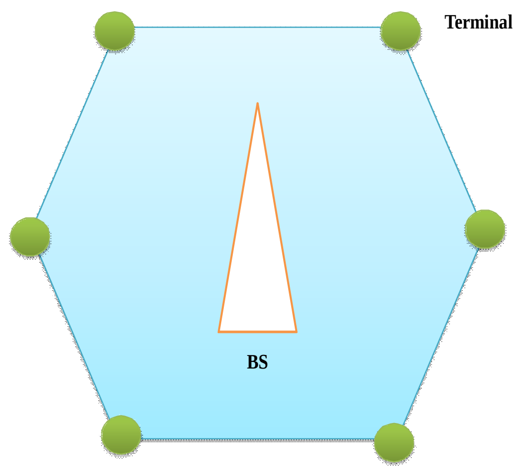


Figure 27: General Cell structure and components

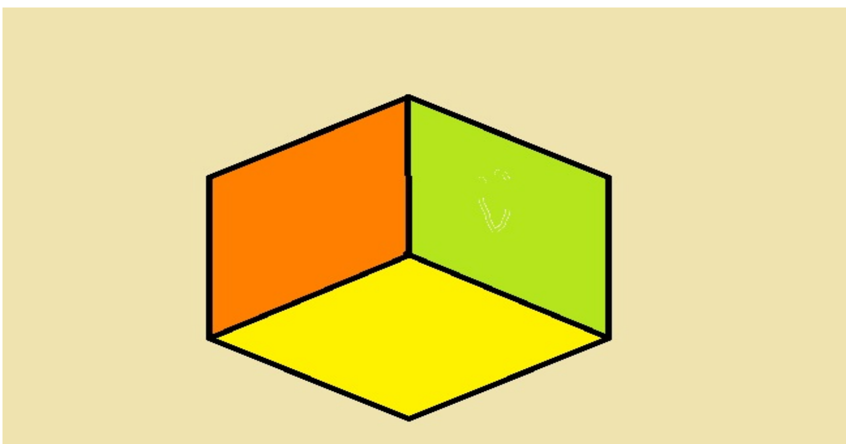


Figure 28: Cell division in three sectors (or quadrants)

Now, all this data is partitioned in to two sets to deduce several other set X and set Y as shown in Table 3.

Table 3: Membership values of X and Y.

X = set of bandwidth level RSS							
Cell c	0	1	2	3	4	5	6
T{X(c)} or μ_x							

Membership value x_i for each cell

Y = set of latencies t							
Cell c	0	1	2	3	4	5	6
T{Y(c)} or μ_y							

Membership value y_i for each cell

Membership function for this X and Y are calculated as per following formula:-

$X=\sum_{i=0}^{n} \frac{\mu_x (RSS)}{RSS}$

Similarly,

$Y =\sum_{i=0}^{n} \frac{\mu_y(t)}{t}$

Now, fuzzy partition of T{X(c)} and T{Y(c)}& the desired partition shapes of desired membership functions, as used in [6,7] i.e., triangular and trapezoidal operators. In these Networks, it does work in two side manner at layer L2 for up-downlink transmission mode. Therefore, using max-min [13]

$\|X(c) - m_{closetcell}\| = \text{max-min} (\| X(c)-m_{i(c)} \|)$ ***where*** $c \leq i \leq k$;

Where m_i is the center of membership function, k is no. of cell in participation,

For adjacent cells,

$m_{closetcell}(c+1) = m_{closetcell}(c) + \alpha(c)[X(c)- m_{closetcell(c)}]$

Else

$m_i(c+1) = m_i(c)$ ***for*** $m_i \neq m_{closetcell}$.

α(c) is the homogenous decreasing scalar learning rate. Thus, to predict the winner cell, we take m_i & $m_{closetcell}$ in constant time. Once the centers of membership functions are carried out, their widths can be determined by k- nearest neighbor heuristic. Layer 3 will optimally adjust the centers and distance through membership function of cell.

4.4.1.2 Identification of Location and Routing Area

A "location area" is a set of base stations that are grouped together to optimize signaling. The BSC handles allocation of radio channels, receives measurements from the mobile phones, and controls handovers from base station to base station.

To each location area, a unique number called a "location area code" is assigned. The location area code is broadcast by each base station, known as a "base transceiver station" BTS in GSM, or a Node B in UMTS, at regular intervals whereas routing area is a subdivision of a "location area". Routing areas are used by mobiles which are GPRS-attached also known as GSM-IP.

RSS is measured by UE and BSS over a fixed range depending upon the network domain or technology (GSM or UMTS or WLAN1) as shown in Figure 21. It has some reference sensitivity in absolute and relative accuracy (in dB). In case upper limit is below Reference Sensitivity level, the upper limit replaces the value of reference sensitivity.

Depending upon the mobility i.e., micro and macro it values rely on RF channels and frequency band. Once we acquire all the above mentioned parameters, we can now start the timestamp counter algorithm for UE and BS. [15]

Step I: Synchronize with BS -

BS send information signal to BSS so that UE can Synchronize and correct the frequency, if necessary. Then, BS sends it Timing advance (TA) to UE for adjusting the time based on Round Trip time from BS-UE-BS.

A 2-way Synchronization scheme in both UE and BS can assist the BTS and BSC for handover decision using HOFIS. Estimated time Measure (Δt) will be taken into account by BS for BSC where as UE in 2-way Synchronization scheme is supposed to measure and advertise this ETM to BSC but it is still optional for operators.

Step II:

Once this synchronization is accomplished , the time base counters is being set for different mobile and BS based on certain parameters which we discussed earlier in section 6.1.1.1.

t = Timing of transmitted signals measured by UE as time of receipt of synchronization burst to set up its time base counter.

So, whenever a handover is predicted to occur the identified Routing area, it adjust its time counters of current BS relatively to adjacent BS because different BS have different time base counter. Thus, general formula for UE in case there are two Base Station where UE is switching from BS1 to BS2 is as follows:

UE (time counter Δt) = UE (time t for current BS1) + (BS1 (t) -BS2 (t))

Step III:

BS sends the time base counter to UE for random movement when relative distance between UE and BS is zero. Therefore,

If (UE==Stationary) Then $\Delta t >> t$. Same BS will persist connection.

If (UE==moving with constant velocity) Then $\Delta t = = t$.

If (UE==moving with variable velocity) Then $\Delta t \leq t$.

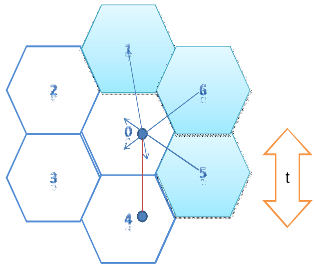
UE keep update its time-varying clock with each BTS and BSC for Timing Advance or time base counter.

Δt value 1 = TA + BTS1 time difference.

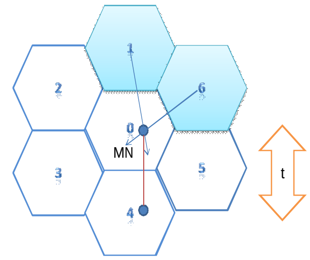
Δt value 2 = TA + BTS2 time difference.

Δt value 3 = TA + BTS3 time difference and so on.

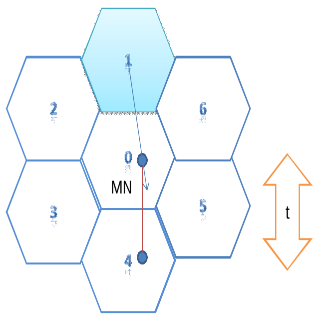
But eventually, using the quadrants for selection of cell, k = number of cell participation can be reduced to 3 for random movement and (1 or 2) for regular movement as shown in Figure 29.



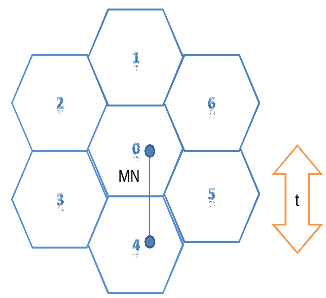
handover decision with three cell participation, with time t for movement between different cells



handover decision with two cell participation, using Profile log.



handover decision with one cell participation, for regular movement using Profile log



handover decision for stationary users.

Figure 29: Depicting the user movement with minimum cell participation

CHAPTER 5: SIMULATION AND RESULTS

5.1 Introduction to the OPNET And UMTS Module

The OPNET Modeler gives the facility of the graphical user interface in which the users can model and simulate their networks. For developing different communication structures and implementing different scenarios', different hierarchal layers are present in the environment of the modeling. Users can build a detail model according to the requirement to do the analysis of the system. The systems are designed in the object oriented way, on compilation of the model its produces a discrete event simulation in the C language. After performing the simulation, the results are analyzed with the different statistics related to the performance provided by the OPNET. The following are the different layers in the OPNET which are explain below.

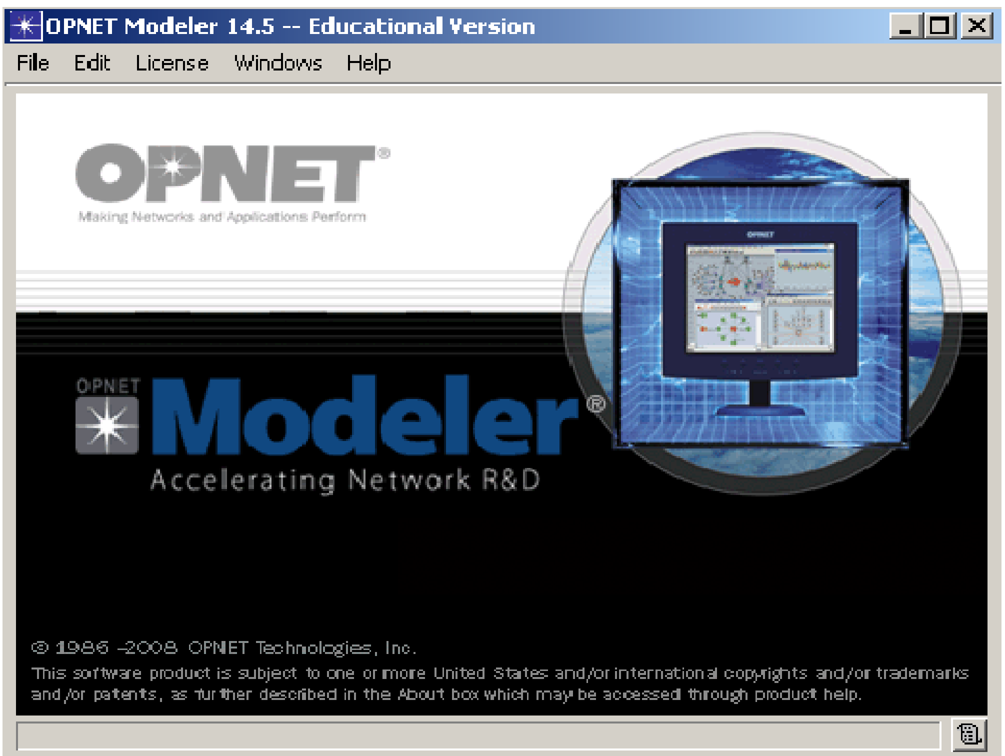


Figure 30: OPNET Modeler

5.1.1 The Network Layer

On the graphical map the network layer enables to specify the network topology. Different elements of the network can be placed on the network layer. Through different links these network elements can be connected. To perfume the mobility of the user equipment the trajectories can be created through the radio links. So it being the useful facility as the mobile UMTS users can be simulated. The sub network can be merging together in this layer. Using the network layer the network project can be built up. OPNET contains the wide library of node model having different technologies like UMTS, ETHERNET, and ATM etc.

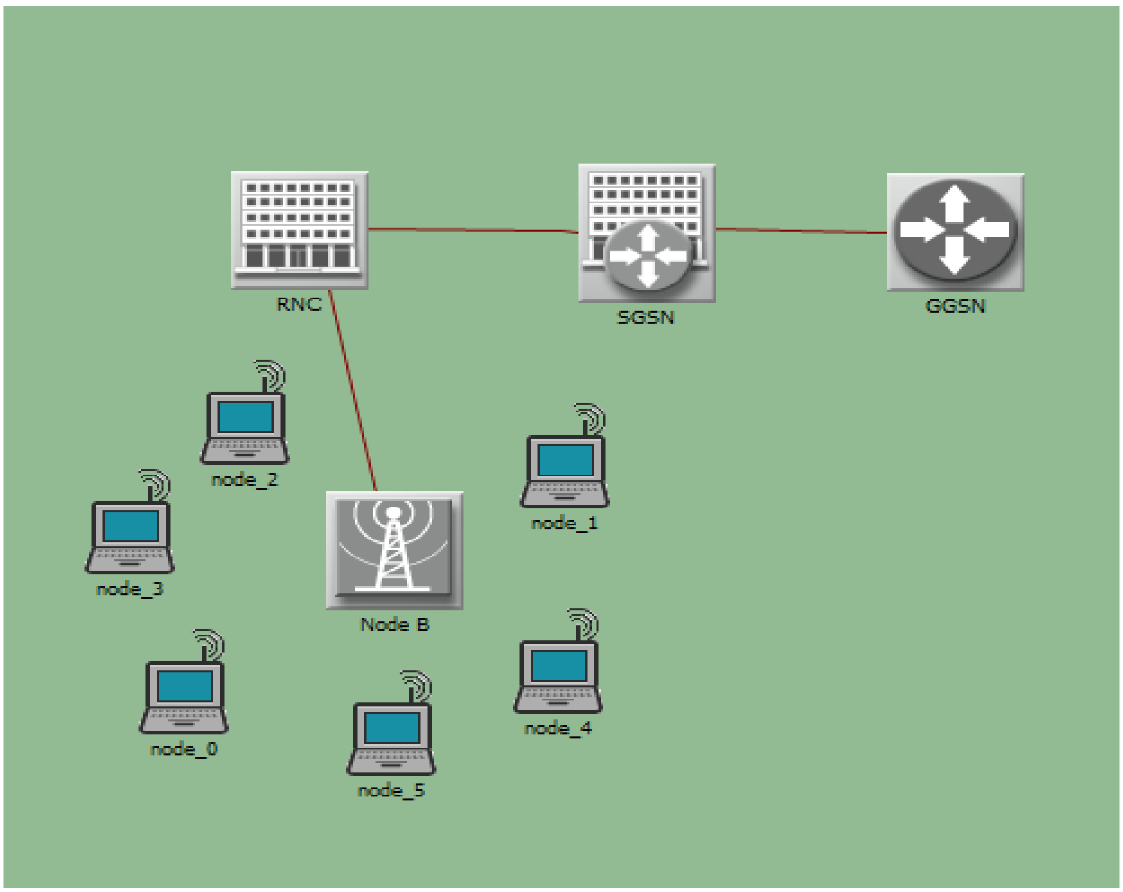


Figure 31: Network Editor Screen shot [18]

5.1.2 The Node Layer

The nodes are build up in the node layer. The nodes are made up in the node editor using different transmitter, receiver, processor etc. These blocks are called as modules. These modules allow implementing the different node specific characteristics. The Figure 32 below shows the node level implementation of the UMTS Node B.

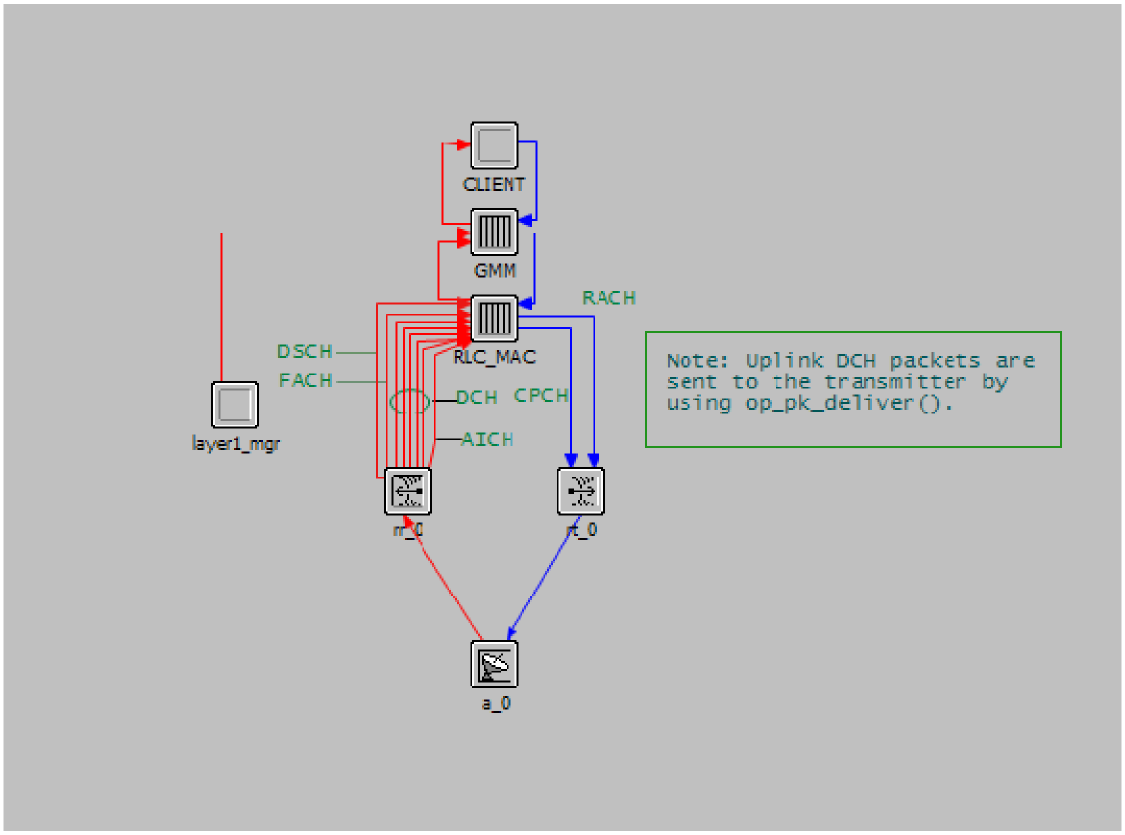


Figure 32: UMTS work station [18]

5.1.3 The Process layer

This layer makes the possibility of programming the various modules which are used in the node layer in order to design and implement various protocols or the required behavior of the node. The OPNET has a wide kernel of standard procedures that are mostly used in the communication networks but it is possible to write the C++ codes which are the user's specific function. The process editor uses *Proto-C*, which is the programming language which makes the combination of the C/C++ language and the state transition diagram.

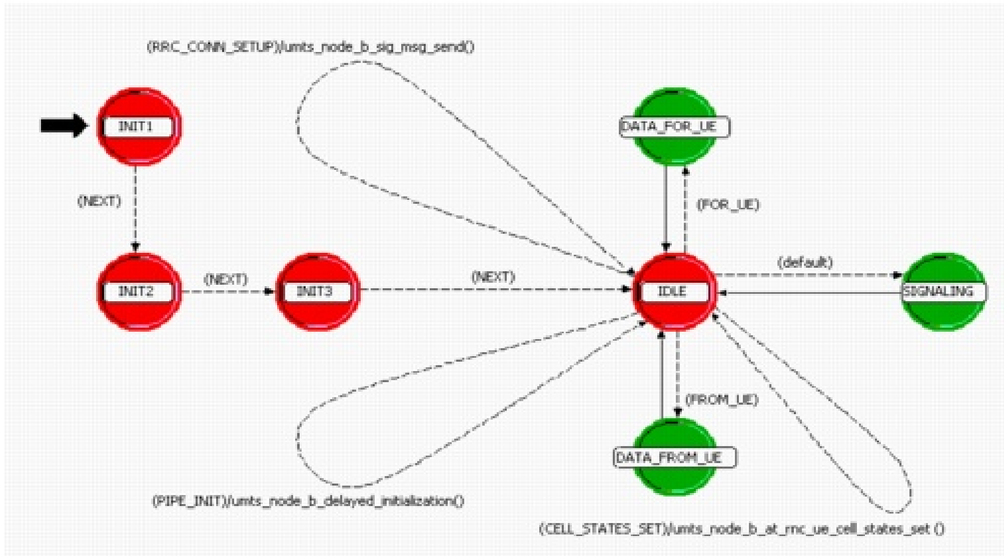


Figure 33: umts_node_b Process Model

5.1.4 OPNET UMTS Model

OPNET Modeler presents the specialized models that cover the specific needs for the simulating and modeling the networks that poured on certain technology area. UMTS is the one of those models which is based on the 3GPP specification. The model focuses on UE-UTRAN-CN architecture as shown in the Figure 34.

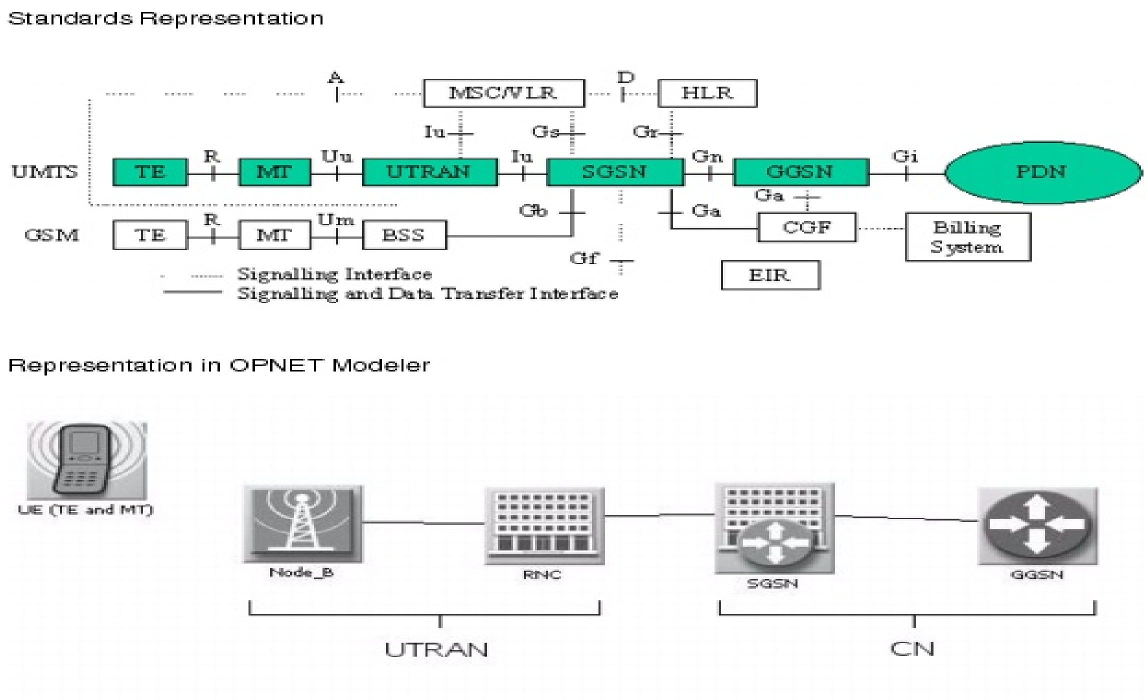


Figure 34: UMTS Architecture

The User equipment model gives the functionality of the mobile equipment. It is responsible for the radio link termination. The UTRAN model consists of the Node B and the RNC. The core network is not fully implemented. The SGSN and the GGSN are included. The UMTS model supports wide range of a feature which resembles the real network. The four different traffic classes are defined in the model which is conversation, interactive, background and streaming. Different QoS profiles are defined for each traffic class. This allows studying various effects in the network.

The overall features of the UMTS OPNET Model are shown in the bullets below [18].

• It is based on WCDMA.

• It support the four QoS classes

• It supports the user equipment UE, Node B, RNC, Repeater, GGSN and SGSN.

• It supports the hard, soft and the softer handovers.

• It supports the outer loop power control.

• It offers the facility of the set up, release and negotiation of the radio access bearers.

• It supports for the dedicated and the common control channels.

• It supports for the different modes like acknowledge, unacknowledged and the transparent RLC.

• It supports for the multiplexing of logical channel to the transport channel.

5.2 Simulation

We have used the OPNET Modeler 14.5 for the simulation of our proposed methodology in form of scenarios. It can be simulated by selecting the different Entities from object palette and dragging of different devices like RNC, Node B, SGSN, UE etc, interconnecting them with the desired links.

5.3 Handover Scenarios

I have implemented one scenario with fuzzy logic and compared it with the existing scenario in context of UMTS handover.

HOFIS_UMTS_SCENARIO (our Proposed handover methodology)

UMTS_SCENARIO (conventional handover methodology)

We have selected different network elements and configure it according to the requirement of our scenarios. The following are the entities which we have selected from the *Object Palette Tree* from the OPNET Modeler.

• Application Definition

• Profile Definition

• Umts_rnc

• UMTS_node_b

• Umts_ggsn_slip8

• Umts_sgsn

• FTP Server

• Umts_wkstn

All these network entities are configured according to scenarios which are explained in the following diagram :-

Here, we have consider two Node B(Base Station) and two UE with a random trajectory. These two Node B are connected to one common RNC and rest of the structure of network is mentioned in the Figure 35

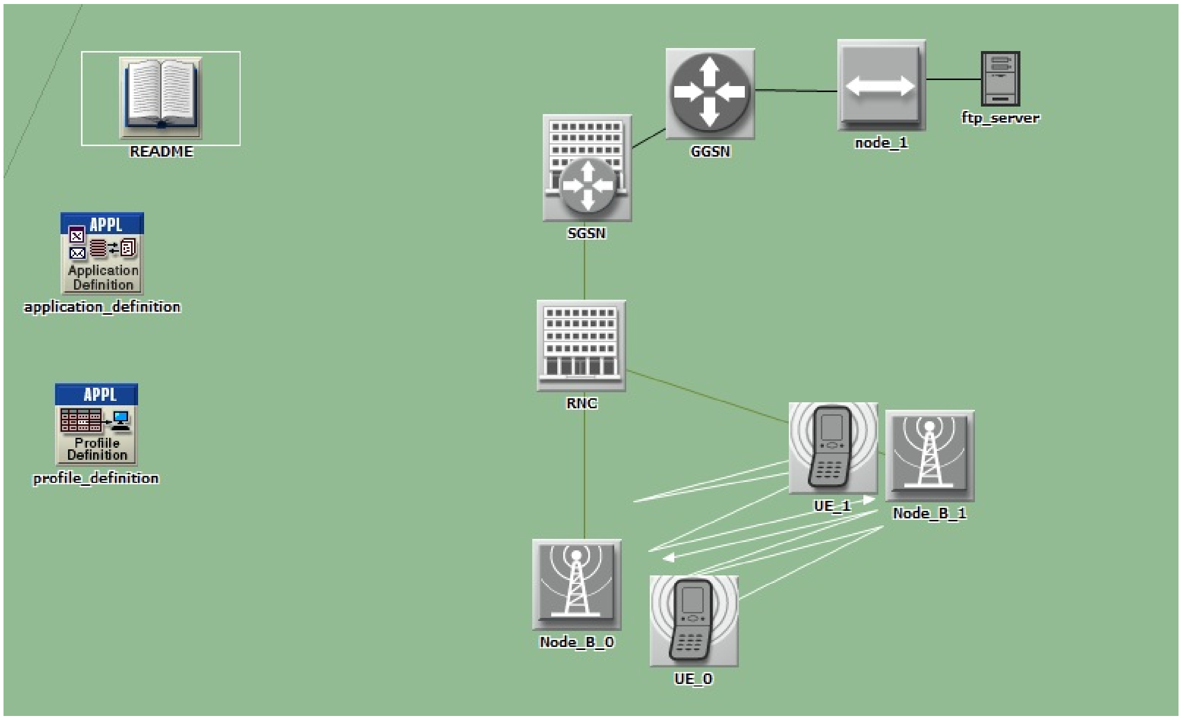


Figure 35: UMTS Network used for two scenarios

The above network structure and scenarios are taken from the model library of the UMTS from OPNET and we have modified the code of UE process model in layer 1 of UE Node Model with our proposed methodology and the other scenario we have taken from default model library.

In Figure 36 , the node model of UE is offered based on TCP/IP. I have made changes in the layer 1 node where several events and state are present

- Fixed
- Silent
- Active
- Location update
- Table Update
- Set Update
- Set Configuration

Over key Concern of area and State is location update and set update, where two function one for UMTS handover event check is there and next is event code check in terms of RSS. Thus are the major changes are made in these functions only.

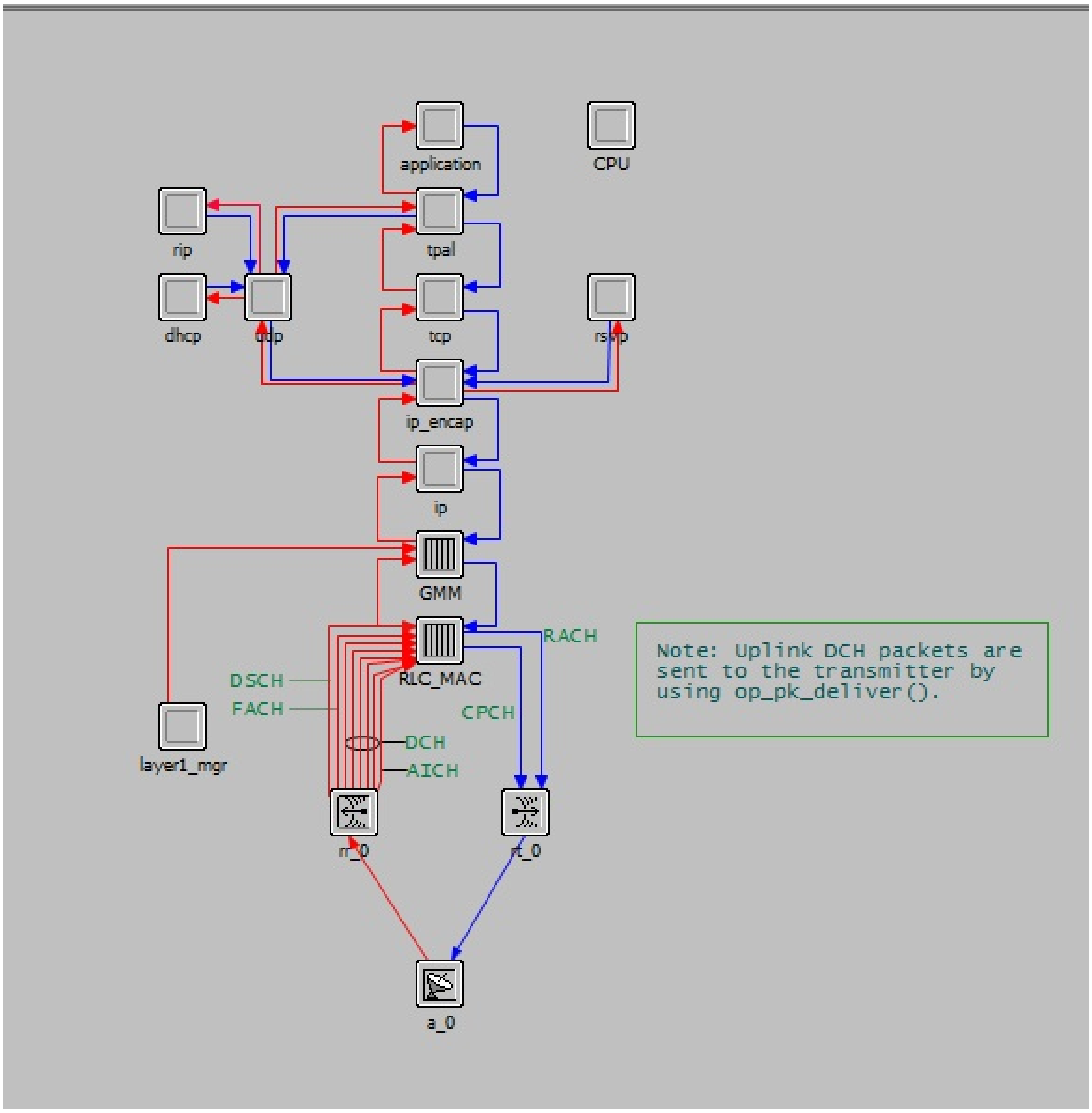


Figure 36: Node Model of UE

The Process Model of UE layer 1 in Node Model is represented in Figure 37.

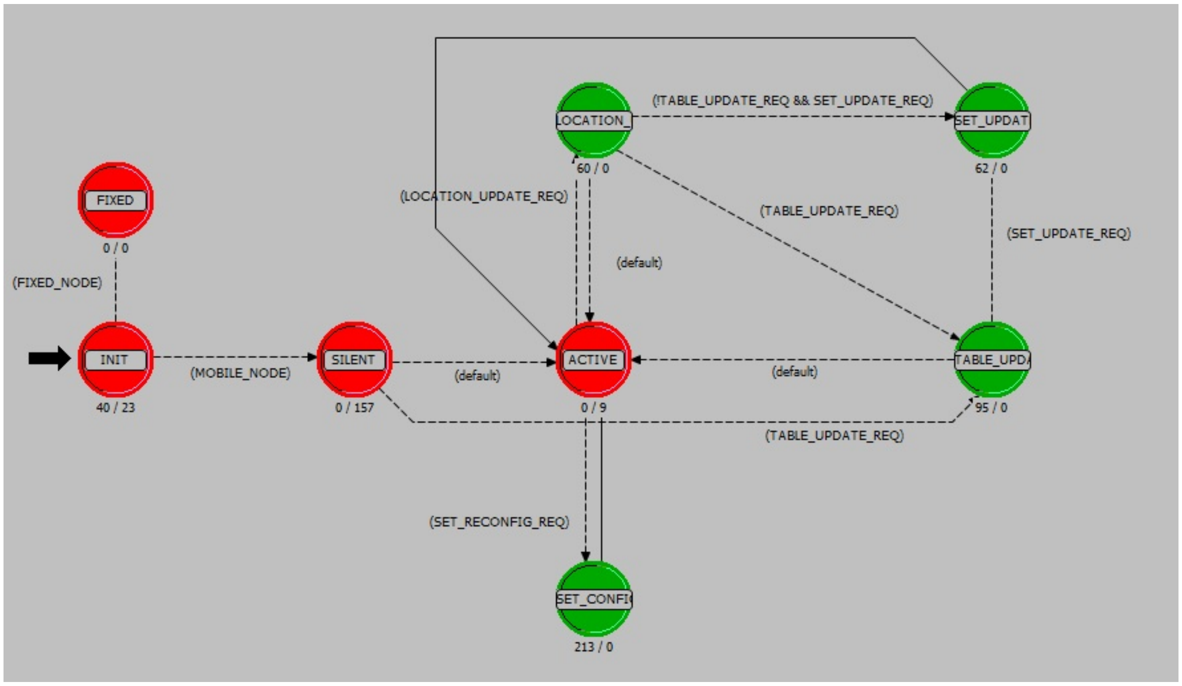


Figure 37: Process model of Layer 1 in node model

In Figure 37, it is shown how an set cells is being updated time to time depend on UE movement which is assigned here in form of trajectory. To compare results we have chosen the same network model for checking the efficiency of both scenarios which are explained in next sextion.

5.4 Results

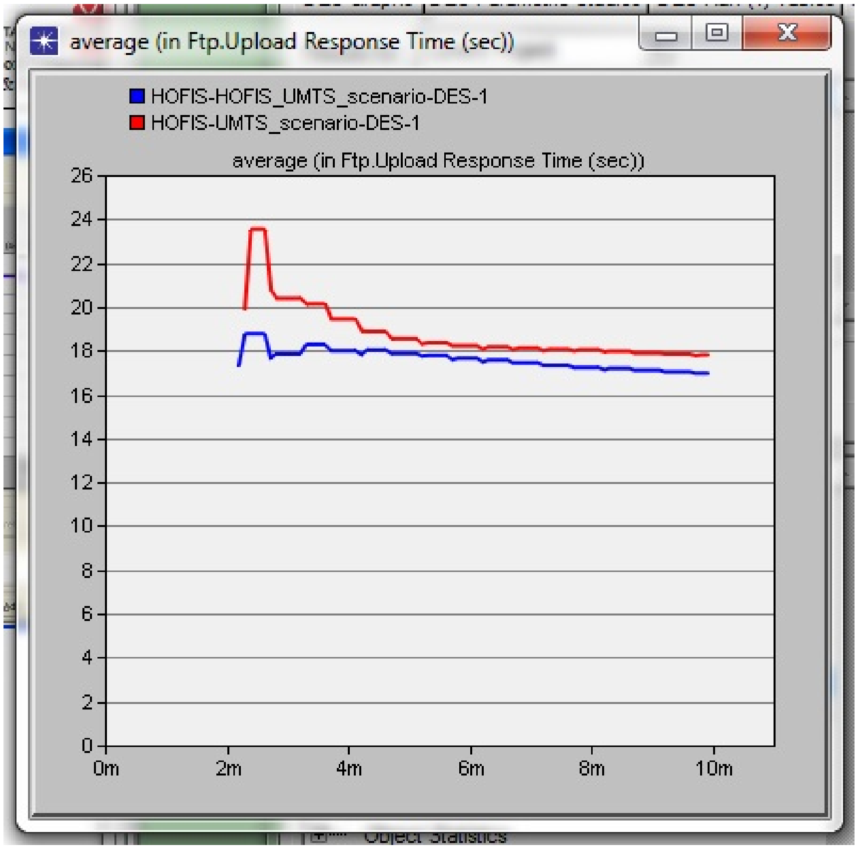


Figure 38: Ftp upload response time (sec)

In Figure 38, we can see that in global Statistics , Ftp upload response time is bit less in our approach which is 19 sec (approx) and in conventional UMTS handover it is 23 sec, thus upload response time is better in our case.

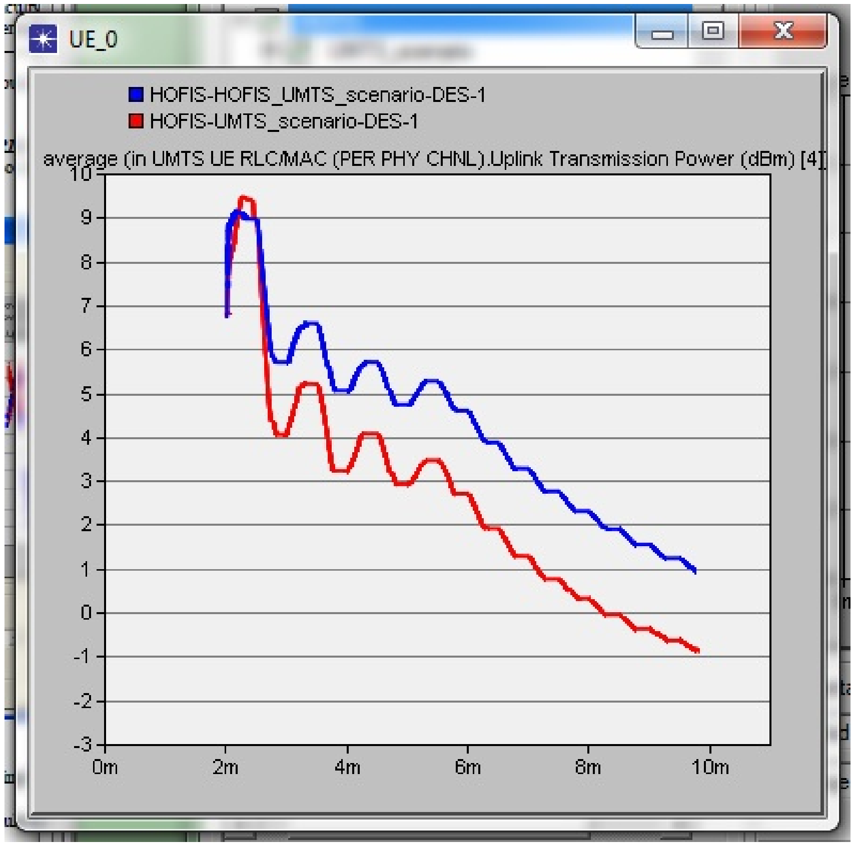


Figure 39: UE Uplink transmission power

In Figure 39, we can see that Uplink transmission power is higher in our case, which has both advantages and disadvantages as follows :

Advantages :

As uplink is better thus we can conclude that UE has better link with Node B (BS) and it has ability to estimated optimal connectivity in term of power when moving in random or regular way.

Disadvantages:

But when User is moving within the cell or stationary in regular interval it will directly affect he UE in term of power and battery loss and unnecessary calculation to be done.

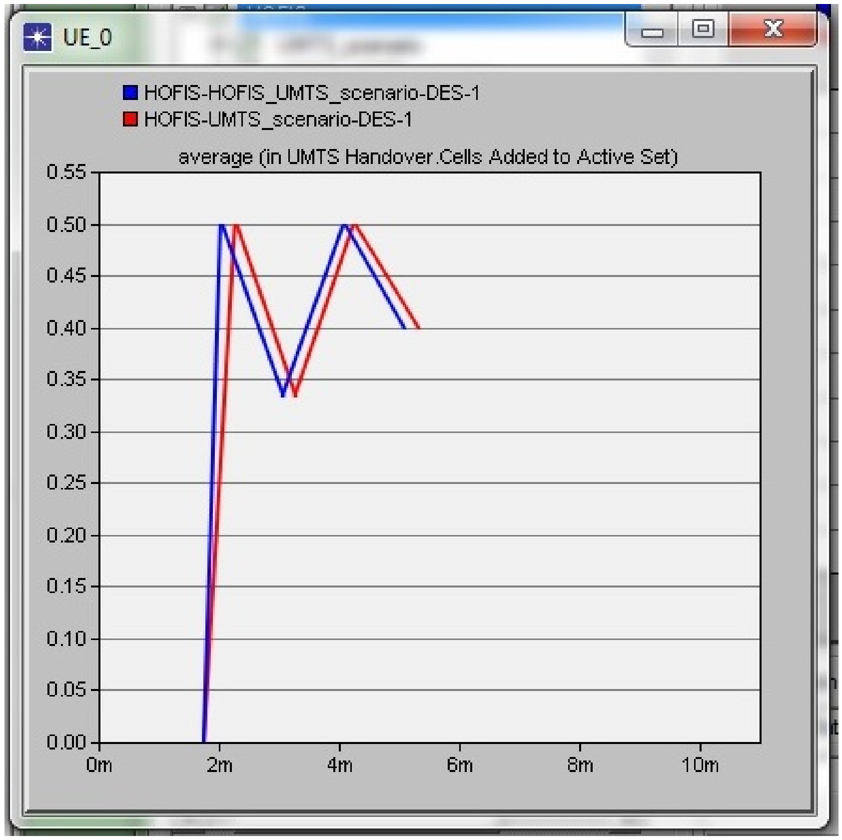


Figure 40: Cell Added to Active Set

In Figure 40, we can say that our approach is getting good result for which it is intended to do. While movement cell addition should be better when there is probability of movement thus according to simulation and trajectory assigned in the simulation we can see that between 2 minute to 4 minute it has good cell addition rate i.e., number of cell in active set with which handover event is occurred.

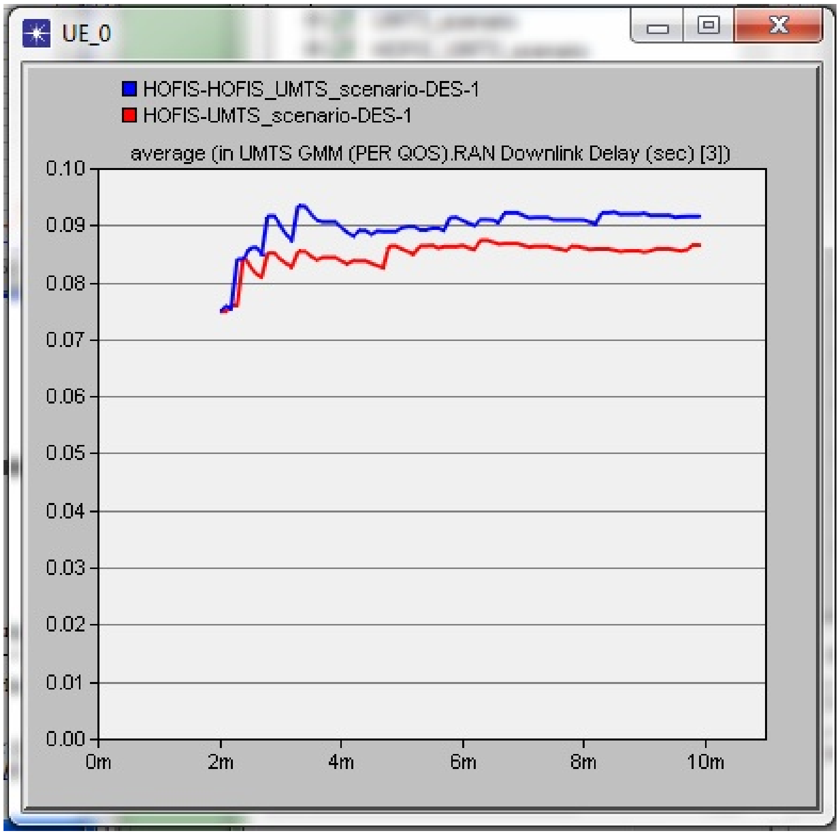


Figure 41: Downlink Delay

In Figure 41, UE downlink delay is increased in our case with respect to convention one ,which is not a tangible result but considering CAC , it is better to have downlink delay rather than packet loss.

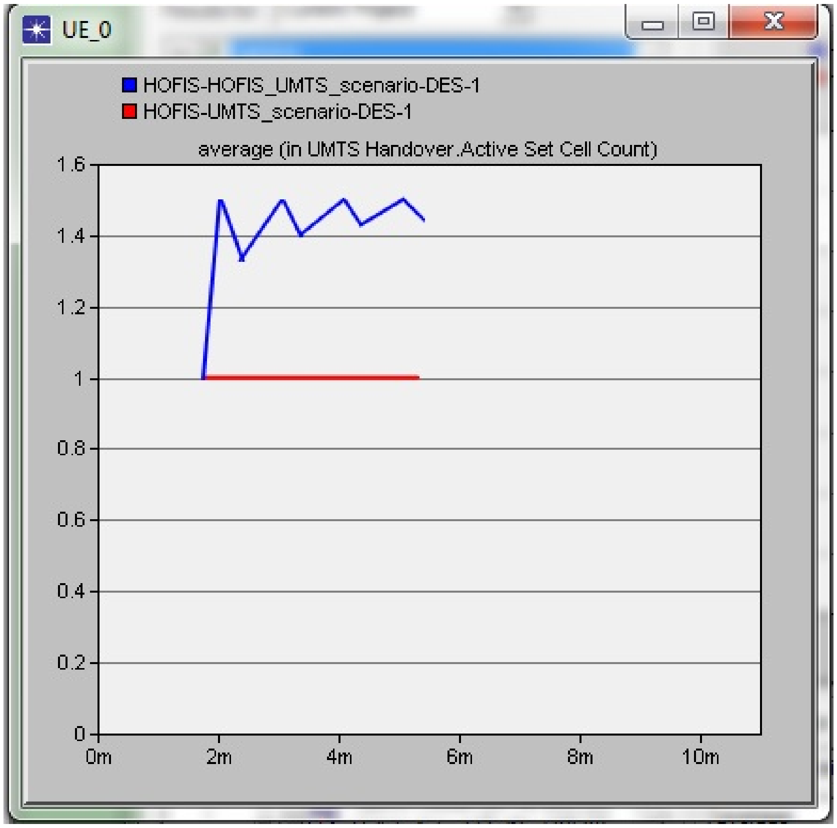


Figure 42: Active Cell Count

In Figure 42, Active cell count is varying time to time which conclude that we are keep tracking of nearest neighbors Node B (BS) which improve connectivity and less packet and path loss ratio.

Finally, thus we can conclude that in common RNC our proposed method have shown better results in most of the cases but in some scenario it may be tradeoff for UE.

CHAPTER 6: FUTURE WORK AND CONCLUSIONS

In Future we would like to optimize the handover within different RNC , and reduce the count of active set of cells.

Finally, we would like to mention some of our future research dimensions. The framework demonstrated in this paper is designed to a corporate-purpose framework. To prove the utility of the framework, we need to apply the framework to various network mobility management systems. As future prospects, simulation in NS2 (network simulator) integrated with other soft computing methodology, like Genetic Algorithm & Neural Network or Radial basis function for frequency difference measure. Based on the Movement of users [8], emphasizing over the 5 percent users with random movements, we can prioritize users according to their class of services used in mobile IP network based on profile log. GPS positioning using users state and its movement pattern can be measure accurately, however many other security problems are left open for our future work. The results which we got till now are not so tangible, thus seeking opportunity for lucrative results.

The future generation wireless mobile networks will aggregated heterogeneous wireless technologies such as WLAN, WiMAX, GPRS, Long Term Evolution (LTE) and 3G/4G Cellular wireless networks providing mobile users universal and seamless mobility for all kinds of traffic[10]. A UE may come across various different wireless networks while on the move. Along its path, it may be advantageous to transfer its connection to a different wireless network (a process referred to as the handover). The UE and BS needs to have sufficient intelligence to perform this function optimally. Firstly, after the market research, we discussed about the current technologies and mobile IP protocols for Mobility Management. Then, we felicitated and surveyed the related works. Finally, we proposed the idea on the basis of problem statement stated in current Mobile IP in cellular Network and address the possible solution for these issues.

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