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## **Issues and Optimization of UMTS Handover**

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## **ABSTRACT**

UMTS is an emerging cell phone technology and it is basically another name for 3G mobile communication systems. It provides an enhanced range of multimedia services like video conferencing and high speed internet access.

Sometimes UMTS is marketed as 3GSM emphasizing the both 3G nature and GSM standards which it was designed to succeed. UMTS is also European term for wireless systems based on the IMT-2000 standards. To utilize various merits in mobile telecommunication system which consist of various radio access networks, UMTS as Third Generation wireless technology utilizes a wideband CDMA or TD/CDMA transceiver and also cover large area. Handover is basically a function which continues the communication between users without any gaps when the hardware goes to a place where it finds no network coverage. When we talk in terms of cellular communications systems, handover is a process which is referred to the transfer of a connection from one cell to another. Handover time is generally between 200 and 1,200 milliseconds (ms), which accounts for the delay. In this thesis we are going to find the reasons for these factors which affect the Quality of service of handover.

The main focus of this research is to study the some factors which really affect the handover phenomenon in UMTS that basically affect the overall quality of mobile network. For this we intend to find the solution for problems which born during the handover. Handover provides the mobility to users which are the main theme of wireless technology and it is also make the interoperability between different network technologies.

## LIST OF ABBREVIATIONS

3G	3rd Generations
3GPP	3rd Generation Partnership Project
AAL	ATM Adaptation Layer
ATM	Asynchronous Transfer Mode
BCH	Broadcasting Channel
BER	Bit Error Rate
BLER	Block Error Rate
BSC	Base Station Controller
BTS	Base Transceiver Station
CDMA	Code Division Multiple Access
CRC	Cyclic Redundancy Check
CRNC	Controlling RNC
DL	Downlink
DPCCH	Dedicated Physical Control Channel
DPDCH	Dedicated Physical Data Channel
DRNC	Drift RNC
DRX	Discontinuous Reception
DS	Direct Sequence
DSSS	Direct Sequence Spread Spectrum
FDMA	Frequency Division Multiple Access
FEC	Forward Error Correction
FH	Frequency Hopping
GGSN	Gateway GPRS Support Node
GSM	Global System for Mobile telecommunications
HLR	Home Location Register
HSS	Home Subscriber Server
IMS	IP Multimedia System
IMT-2000	International Mobile Telecommunications 2000
IP	Internet Packet
ITU	International Telecommunication Union
ME	Mobile Equipment (Domain)
MGW	Media Gateway
MRC	Maximum Ratio Combining
MS	Mobile Station
MT	Mobile Termination/Terminal
OVSF	Orthogonal Variable Spreading Factor
PDF	Probability Density Function
PN	Pseudo-Noise
QoS	Quality of Service
RNC	Radio Network Controller
RNS	Radio Network Subsystem
RRC	Radio Resource Control
RSCP	Received Signal Code Power
RSSI	Received Signal Strength Indicator

SF	Spreading Factor
SGSN	Serving GPRS Support Node
SIP	Session Initiation Protocol
SIR	Signal to Interference Ratio
SRNC	Serving RNC
SS7	Signaling System no.7
STD	State Transition Diagram
TDMA	Time Division Multiple Access
TE	Terminal Equipment
TPC	Transmission Power Control
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
UTRAN	UMTS Terrestrial Radio Access Network
URA	UTRAN Registration Area
USIM	UMTS Subscriber Identity Module
VoIP	Voice over IP
W-CDMA	Wideband - Code Division Multiple Access

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# **CHAPTER 1: INTRODUCTION**

## **1.1 Introduction**

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.

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].

## **1.2 Cellular Networks**

The latest and more valuable form for human communication is the wireless communication. Wireless network means that every network which is wireless comes in this category. The cellular system is essentially designed such that to use the raise of frequency spectrum proficiently. The cellular architecture is designed such that at low power used a more numbers of transmitters, thus it becomes easy to reuse the frequencies, this is totally different from old communication system, because in old system of communication only one transmitter was used at very high power at a limited channels. In this system re use of frequencies was complicated [1].

In wireless communication GSM technology is playing very important role. GSM used the narrow band TDMA which allows eight calls at the same radio frequency in digital cellular system. To achieve speedy web contact and good quality of videos and images and high data rate services, Third Generation Mobile systems are used.(2). 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 and it works at 2GHz. Soft 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 [1, 2].

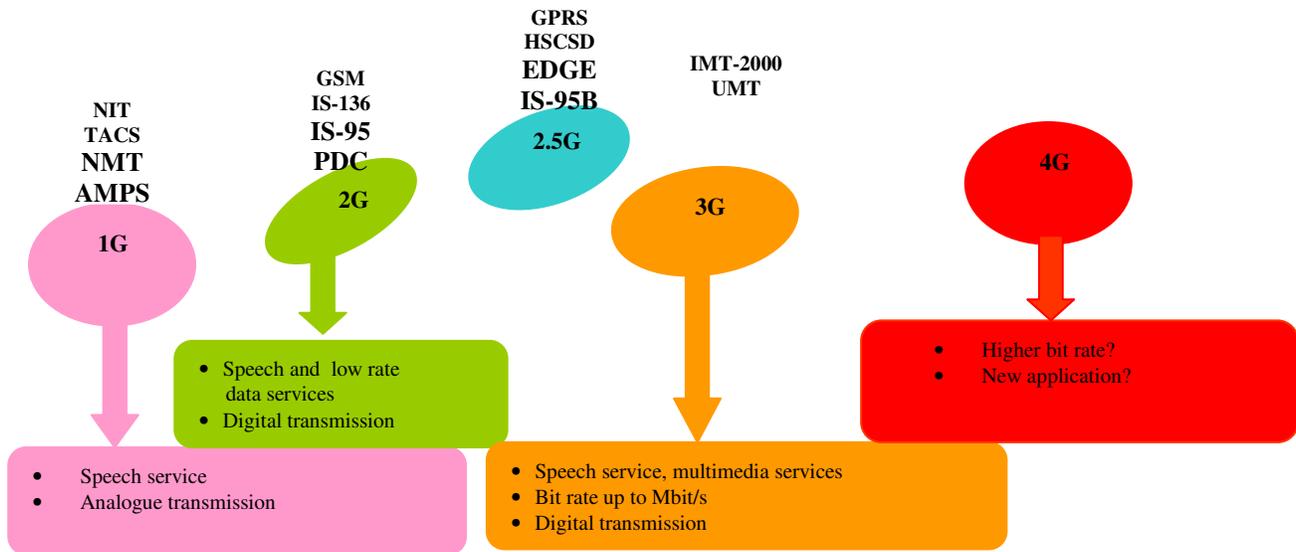


FIGURE 1.1 Evolutions of Cellular Networks

### 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

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.

#### 1.2.2.1 2G-Mobile Networks' Capacity

It uses digital technology between the Mobile station (handsets) and the tower 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.

### **1.2.2.2 Some Primary Advantages**

Following are advantages of digital system due to most consumers like it.

- Lower powered digital radio signals needs less battery power due to phones last much longer and batteries can be smaller in size.
- Digital voice encoding system allowed handling digital error checking which could boost-up sound quality by reducing the noise in transmission system.
- The lower power consumption helped to meet health standards.
- Digital systems introduced digital data services, such as SMS, GPRS, EDGE, MMS and Email.
- Digital system is most secure and reliable for consumer to handle calls according to their desires.
- We can trace and locate very easily any person through his mobile number. This is one of major advantage of Digital systems.

### **1.2.2.3 Drawbacks**

The typical disadvantages of digital systems are:

- In less populated areas, the weaker digital signal may not be enough to reach a mobile cell tower. But this is a very rare problem as 2G is deployed on very high frequency & low power.

As digital calls are tend to be free of stagnant and background noise, the poor compression used by the codec takes a toll due to which the range of the sound that they can convey is reduced. You'll hear less of the tonality of someone's voice talking on a digital cell phone, but you will hear it more clearly.

## **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. [3]

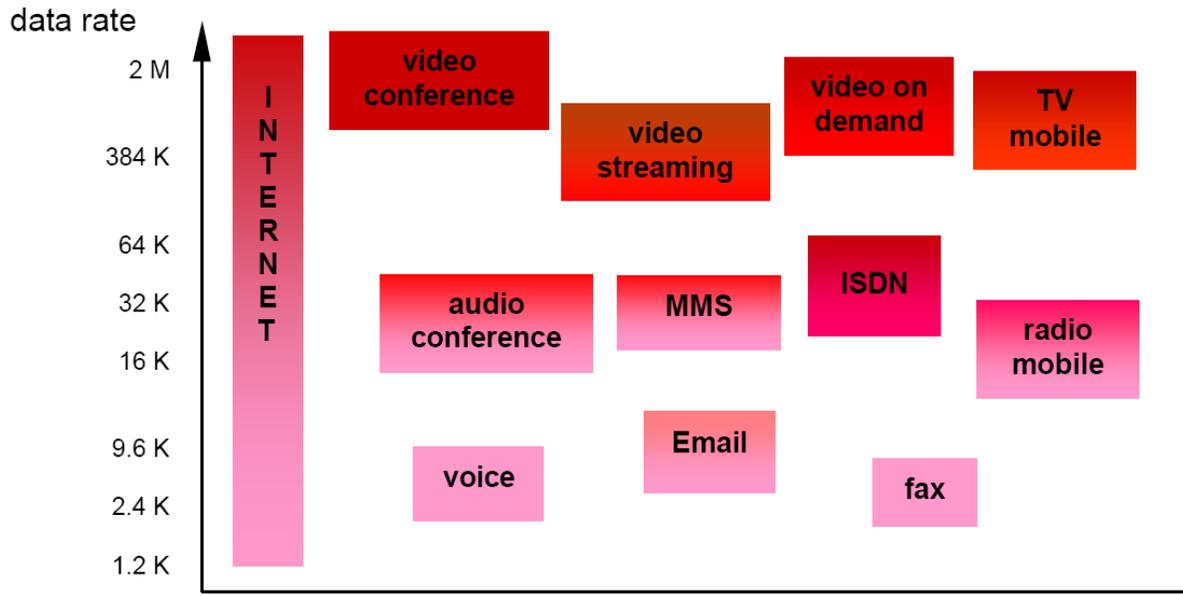


FIGURE 1.2 Bit Rate Requirements for the Highlighted 3G Applications

## CHAPTER 2: UMTS ARCHITECTURE AND FUNCTIONALITY

### 2.1 CDMA Technology

CDMA protocol is widely used in UMTS system. CDMA (Code Division Multiple Access) is the higher speed transmission protocol. CDMA technology is the type of 3G cellular network.

#### 2.1.1 CDMA Technical Features

- Two types of duplex mode supported by CDMA technology, 1<sup>st</sup> is frequency division and 2<sup>nd</sup> one is time division. For Time division UMTS uses fifteen slots per radio frame. Frequency division is uses by current system. In frequency division one frequency is use for up link and one frequency is use for down link.
- Radio channels has a bandwidth of 5MHz
- It supports inter-cell asynchronous operation.
- Chip rate is 3.84 Mbps and this technology has multi code transmission.
- Adaptive power control which depends on SIR (Signal-to-Interference Ratio).
- CDMA also supports multiple handover between hard handoff soft handoff, softer handoff.
- To enhance the capacity and coverage smart and multi user detection antennas are used [4].

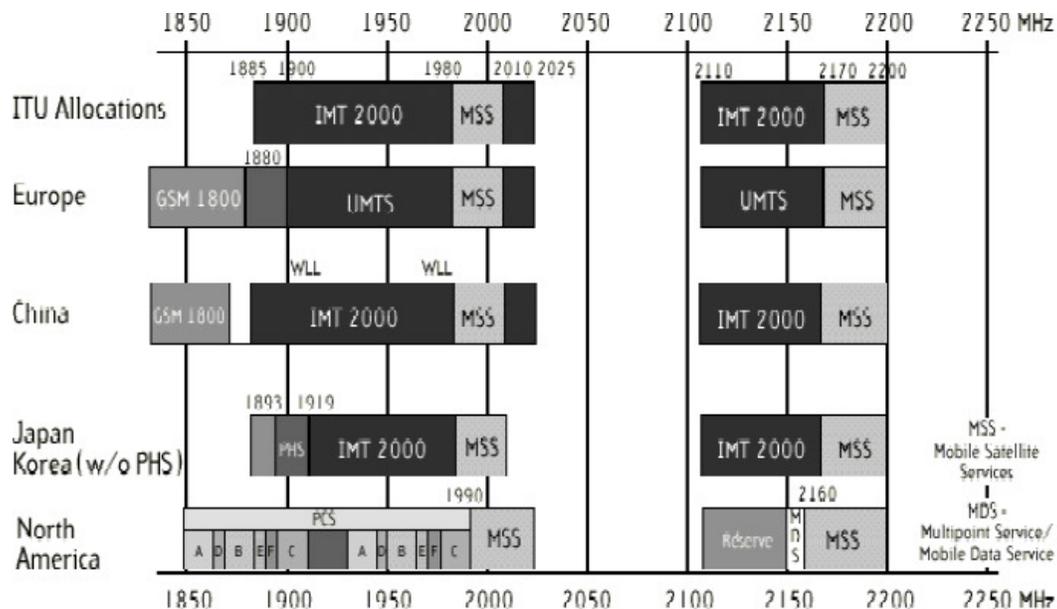


FIGURE 2.1 Models Adopted for 3G Applications

### 2.2 CDMA and WCDMA

Users are separated by single codes in Code Division Multiple Access Technology, its mean that all users can use the same frequency and for transmission as well. With the latest progress in signal processing for wireless communication it is very suitable to use the technology that is also referred as WCDMA. Wide radio signal of 5MHz in WCDMA is multiplied by pseudo-noise code sequence (Spreading signal) with a higher rate than the data rate of the message. If the proposed recipient has the right code then resulting signal appears as apparently random. The original signal is extracted in the reverse of this process. Same frequency is repeated in all cells by using unique codes, which is commonly known as a frequency re-use of 1. WCDMA chip rate is 3.84 Mcps.

The advantages of a wideband carrier with a higher chip rate are:

- Support for higher bit rates
- Higher spectrum efficiency credit to better trunking efficiency means that statistical averaging will be better.
- Higher QoS (Quality of Service) corresponds. [5].

Furthermore, from experience of second-generation systems like GSM has enabled improvements to be included in WCDMA. The main focus has been put on WCDMA operators investments for ensuring more possibilities of the reuse of GSM equipment. Re-use and evolution of the core network and the focus on co-sitting and the support of GSM handover are the examples. The subscribers need dual mode handset for the use of GSM handover.

### **2.3 Features of WCDMA**

UMTS uses WCDMA technology due to its terrestrial radio access (UTRA). Here characteristics of WCDMA which differs from GSM are described.

- WCDMA is wide band CDMA system with 5 MHz frequency band width using spreading codes and decoding at the receiver end.[6]
- The Chip rate of 3.84 Mcps is used up to 5 MHz band width where as in GSM it is only 200 KHz. Therefore wide carrier band width of WCDMA supports high data rate.
- FDD (Frequency Division Duplex) and TDD (Time Division Duplex) are used in WCDMA for uplink and downlink.
- WCDMA uses Asynchronous Mode for base station instead of synchronous mode as in GSM
- The coherent uplink and downlink detection based on pilot symbol is employed in WCDMA
- The WCDMA air interface is designed according to advanced CDMA concepts e.g. multiuser detection ,network capacity increase option , smart adaptive antenna coverage.[7]
- WCDMA is designed for GSM and WCDMA hand over support.

### **2.4 UMTS Complete Architecture and System Overview**

According to IMT-2000 standardization, UMTS (Universal Mobile Telecommunication System) is capable to fulfill the 3 G services requirements in wide range of European and future users. Here we explain some technical needs of UMTS system, overview of handover process and some features air interface.

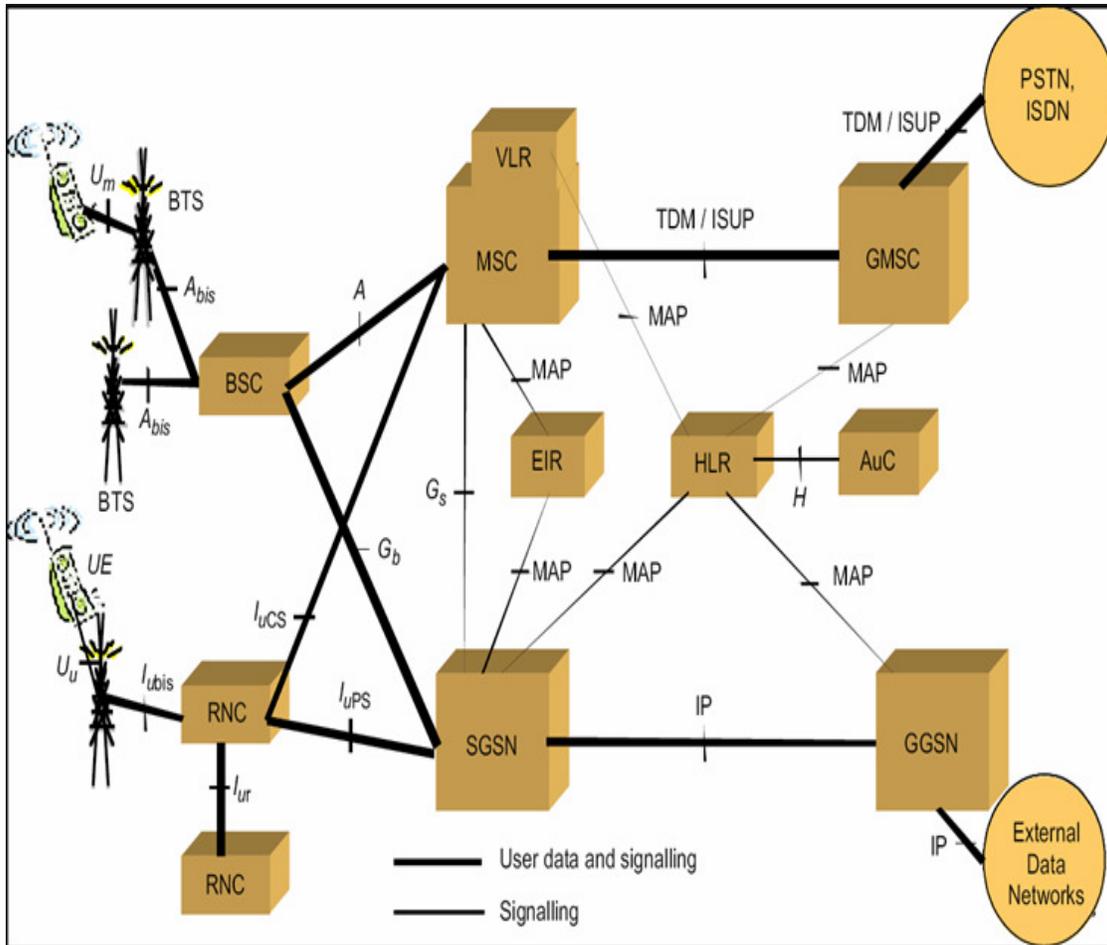


FIGURE 2.2 UMTS R99 Architecture

According to the requirement that offer to user's higher flexibilities, UMTS network architecture is precised.

The empirical architecture of UMTS is described by the FIGURE below. It consists of three major parts

1. UE (User Equipment)
2. UTRAN (Universal terrestrial Radio Access Network)
3. Core Network [8]



FIGURE 2.3 UMTS Main Reference Architecture

The second demand is the chance to accommodate for various traffic types.

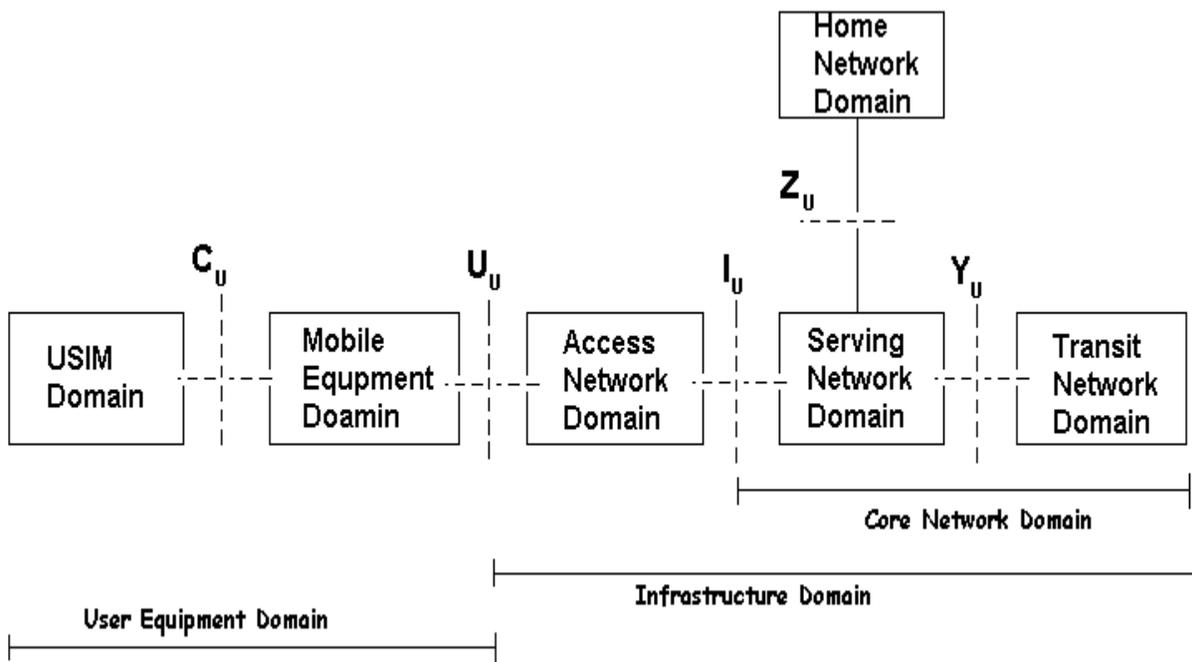


FIGURE 2.4 UMTS Domains and Interfaces

### 2.4.1 User Equipment (UE)/Cell Phone

The UE consists of two parts ME (Mobile Equipment). ME is further subdivided in to two components MT (Mobile Terminal) which performs radio transmission and related functions the second one is TE (Terminal Equipment) which ensures the end to end applications.

MT is used for communicating Via  $U_u$  interface between UE and UTRAN.

The second part of UE is USIM (UMTS subscriber identity module is a smart card which contains user identity information and encryption keys.

## 2.4.2 Core Network (CN)

The Core network of UMTS is composed of

- CS (Circuit Switched) Domain
- PS (Packet Switched) Domain

In UMTS AAL2 (ATM Adaptation Layer 2) deals circuit switched and packet switched data where as AAL5 is responsible for data delivery. The core network architecture may subject to change according to services and features introduced. The NPDB (Number Portability Data Base) is used to provide the facility to user to change the network while keeping their old phone number.

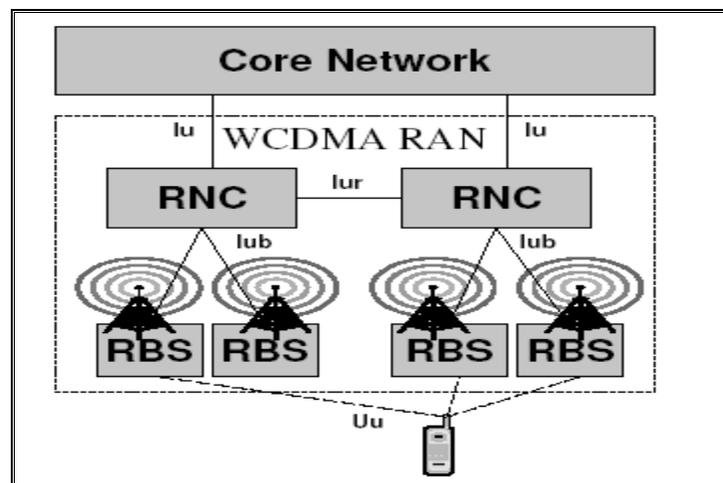


FIGURE 2.5 WCDMA Core Network

## Gateway Location Register (GLR)

The GLR (Gateway Location Register) is used to optimize subscriber handling network boundaries.

## 2.4.3 Visitor Location Register (VLR)

The combination of mobile switching centre and Visitor Location Register denoted by MSC/VLR performs switching and as a data base for circuit switched data. The MSC perform switching where as VLR keeps the copies service profile of users.

## 2.4.4 Home Location Register (HLR)

The user service profile is stored in HLR. When a new user enters to system a service profile is created as long as user subscription becomes active. The service profile consists of the information about service type and its roaming characteristics.

### 2.4.5 Mobile Switching Center and Visitor Location Register (MSC/VLR)

The combination of mobile switching centre and Visitor Location Register denoted by MSC/VLR performs switching and as a data base for circuit switched data. The MSC perform switching where as VLR keeps the copies service profile of users.

### 2.4.6 Universal Terrestrial Radio Access Network (UTRAN)

It is sub system which controls WCDMA and performs as a medium between UE and CN named as RAB (Radio access Bearers). UTRAN further contains RNS (Radio Network Subsystems) RNS is connected with CN (Core Network) via IU interfaces also UTRN connects UE via Uu interface [9].

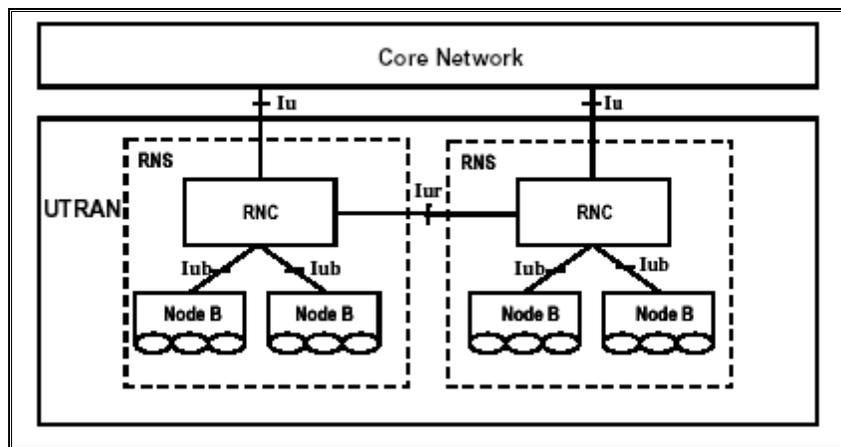


FIGURE 2.6 Core Network

### 2.4.7 Radio Access Network (RAN) Architecture

In UMTS the connection between mobile terminal and the core network is established by WCDMA RAN (Radio Access Network) besides this all other radio issues between core network and mobile terminal are handled by RAN. The WDMA RAN consists of two types of nodes.

1. RBS (Radio Base Station or Node B)
2. RNC (Radio Network controller)

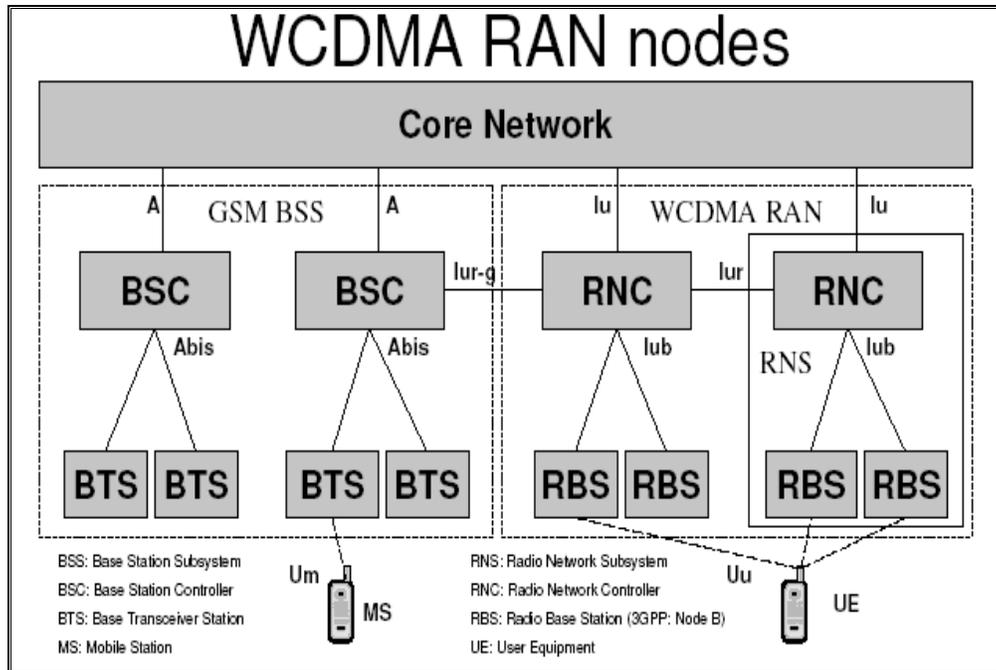


FIGURE 2.7 WCDMA Radio Access Network

### Radio Base Station (Node B)

In UMTS radio transmission and reception to mobile terminal, from mobile terminal via radio interface is done by RBS. The RNC Radio Network Controller manages RBC via Iub interface. One or more UMTS cells are covered RBS.

### Radio Network Controller (RNC)

All WCDMA radio access and network functions are handled by RAN. RAN is also responsible for the connection between WCDMA and core network using IU interface RNC performs two different roles to serve and to control in serving RNC manages overall issues of handset or mobile terminal with WCDMA including connection and termination of protocols.

In controlling RNC it manages the overall control of a specific cell and their associations. When a mobile terminal uses the resources of a cell which is not controlled by RNC then serving RNC enquire controlling RNC about these resources. The request is send via IU interface. In this case controlling RNC is also called Drift RNC. This process is done in case of soft handover.

#### 2.4.7.1 Radio Network Functionality

For optimal operation of a wireless system i.e. from handset to radio access network (RAN) numerous functions are needed to control the radio network and many handsets are using it. Except for Handover to GSM, all functions are described in this section are important and necessary for a WCDMA system.

### 2.4.7.2 Radio Access Technique in UMTS (W-CDMA)

W-CDMA is a radio access method in 3G UMTS networks. TDMA used in 2G networks while W-CDMA in 3G. WCDMA has main advantages over TDMA like higher system capacity and more stretchy use

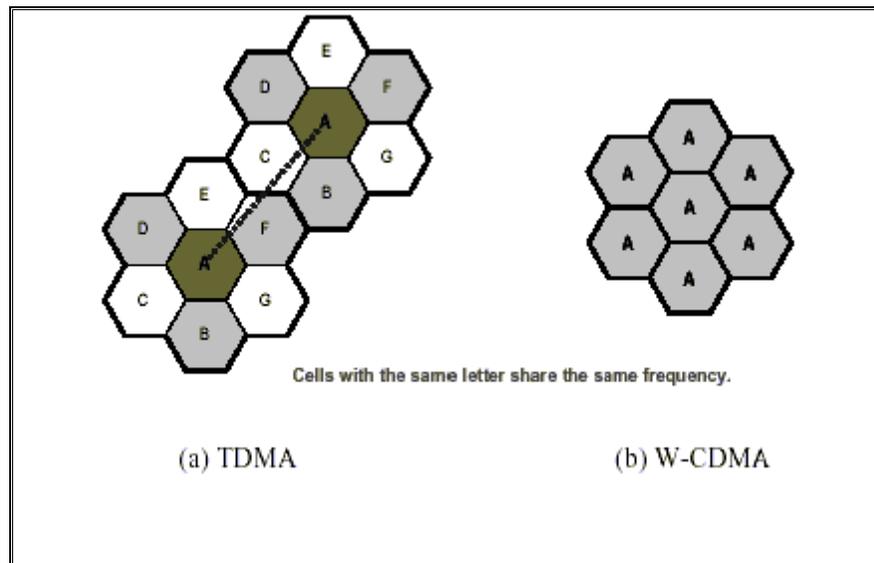


FIGURE 2.8 Frequency Reuse Comparisons between GSM & WCDMA

of the narrow radio spectrum. From the previous approaches and from simplistic point of view the available bandwidth in a cell depended not only on the total allocated bandwidth of the spectrum, but also on the frequency re-use pattern. For example, if a re-use pattern of 7 cells was used, the bandwidth available in each cell is one seventh of the total as illustrated in the FIGURE. The whole bandwidth can be reused in each cell for UMTS as W-CDMA technique is in work.

The use of spread spectrum provides sharing of the resource in W-CDMA. Each user uses spread spectrum modulation and the message signal is spread over a wide band after multiplication it with a pseudo-random spreading signal. In demodulation, the signal at receiver is cross-connected with an exact duplication of the spreading function in order to differentiate itself from other users and noise.

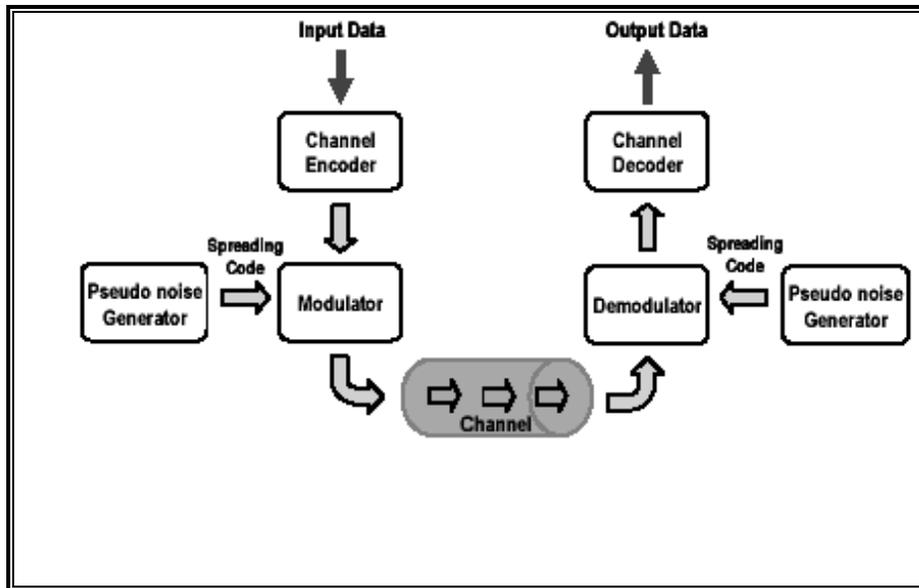


FIGURE 2.9 Process of Spread Spectrum

With a distinctive code which is being assigned to every subscriber, all the subscribers can coexist even same frequency band can be used by all users. FIGURE 2.9 show that how the signal can be modulated and then transmitted from different users in the same spectrum and at the same time and how it can be get back [10].

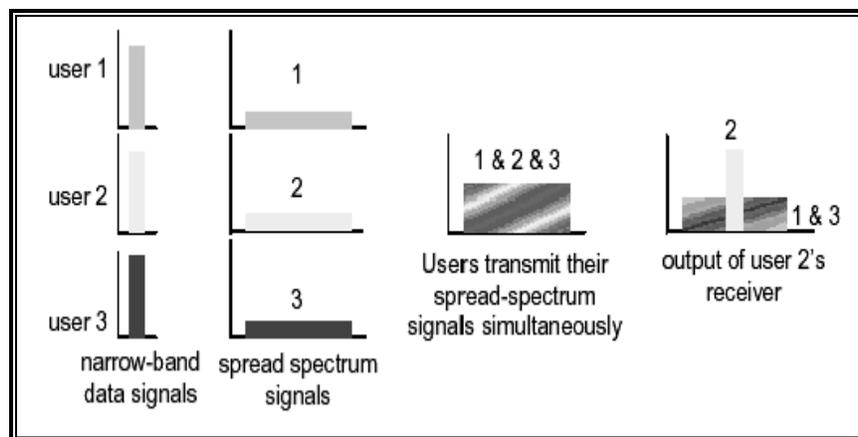


FIGURE 2.10 Principle of Spread Spectrum

Thus a result all the cells have full capacity and each cell use the same frequency, its mean there is efficiently re-use of pattern 1. From other point of view determination of the system capacity is a very complex procedure. Thus the system is measured as a soft capacity system only because of total interference occurred from others and also from noise number of subscriber are limited, and it also depends upon the geographical sharing of users, thus from this point of view the determination of the capacity is a complex concept.

$$\text{Total Interference} = \text{Intra-cell} + \text{Inter-cell interference}$$

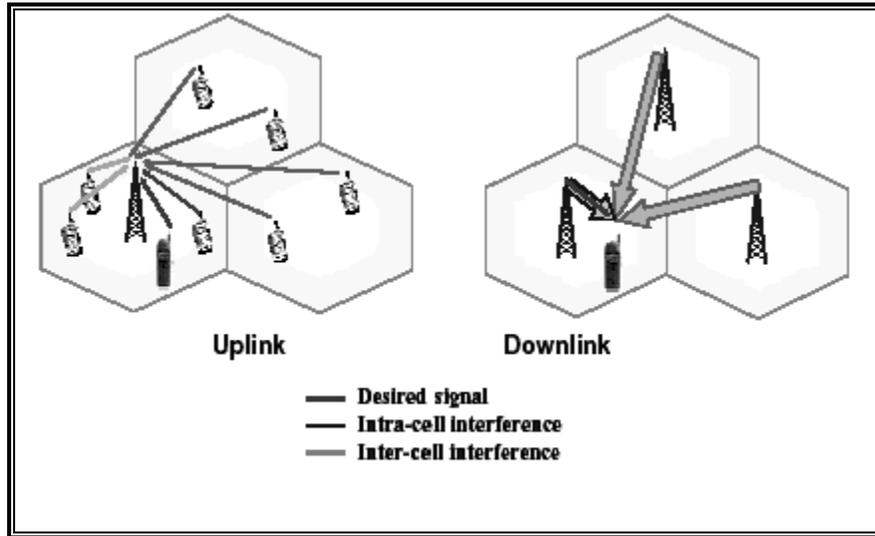


FIGURE 2.11 Interference in WCDMA

### 2.4.7.3 Radio Access Bearers

Radio Access Bearer (RAB) is the main service which is offered by WCDMA RAN. RAB is needed to begin a call connection between the handset and the base station RAB. Its characteristics are different depends upon the services or information which is being transported. Subscriber's data between core network and handset is carried by RAB; it is poised of one or more than one Radio Access Bearers between the Serving RNC and handset, and the IU bearer between the Serving RNC and core network.

The four classes are described in detail below.

**Conversational Class:** This class is used for the most delay sensitive traffic. Speech (voice) is the most common example of Conversational class. Video games and video telephony are other examples. These services should be transmitted like that real-time connections transmitted over the radio link. There will be no buffering and must require the guaranteed bit rate.

**Streaming Class:** In this class services are also transmitted same as a real-time connection. The delay is little bit variable and buffering is allowed in this class. Streaming multimedia is an example application, which is used as a rebuild technique that makes it to become visible as a steady and continuous stream. Bit rate is also guaranteed in this class.

**Interactive Class:** For data communications interactive class is used, such as interactive network games and web browsing, the delay is reasonably variable here. There is no guaranteed of the bit rate for the services in this class.

**Background Class:** This class tolerates the top delay and background. In this class downloading from internet is an example of services. Buffering is essential but there is no guarantee of the bit rate. Background traffic is one of the standard data communication schemes that are largely characterized by the fact that the destination will not expect the data within a certain amount of time. Therefore it is more or less insensitive about delivery time. There is another characteristic that the packet content does not need to be clearly transferred. Transmitted data must have to be received error-free.

The main differentiate factor between these classes is that how delay-sensitive the traffic is, as the conversational class is for, very delay-sensitive traffic, on the other hand background class is the top delay-insensitive. The note able point is that delay must concentrate for real time services, especially in the conversational class, with this Voice over IP (VoIP), is very critical. Off course there is a need for good CAC algorithms, which will give guarantee QoS and accurately use the network's resources.

RABs require an assured reservation of resources for both the Conversational and Streaming in the network, and are primarily meant for real-time services. [11]. They differ mainly in the Streaming RAB tolerates a higher delay, appropriate for one-way real-time services. The Interactive and Background RABs are so called 'best effort', i.e. no resources are reserved and the throughput depends on the load in the cell. The only difference is that the Interactive RAB provides a priority mechanism.

#### **2.4.8 Gateway MSC (GMSC)**

Gateway MSC (GMSC) connects the UMTS Public Land Mobile Network (PLMN) with the external circuit switch networks. All outgoing and incoming circuit switch connections go via the GMSC Serving GPRS Support Node (SGSN). The SGSN functionalities are same as MSC/VLR except only it handles packet switch connections. Gateway GPRS Support Node (GGSN), similarly GGSN and GMSC functionalities are same but except it handle only the packet switch connection. WCDMA has been used as air interface by Wide Code Division Multiple Access (WCDMA).

### **2.5 UMTS Features and Some Functionality**

Here are some special UMTS features and functionalities

#### **2.5.1 Power Control**

The power control standardizes the transmit power of the terminal and base station, by doing it the interference will be less and more subscribers can use the same carrier. Network can get more capacity by transmitting power regulation. In frequency re-use, to minimize the interference must have efficient power control. For every user's service the main thing is that from all handsets in the cell base station should receive the same power level despite of the distance from the base station. The quality will exceed if the power level from one handset is more than the desired level, taking an inconsistent share of the resources and creating the interference which is needless with the other users in the network.

In contrast, if the power levels are very low then the result will be in poor quality. On the other hand to keep the received power at a suitable level, WCDMA has a very fast power control which updates the power levels 1500 times each second. Then the rapidly change is handled in the radio station to make sure high performance, the power control is implemented for up-link and the downlink as well, means that base station and output handset powers are updated regularly.

### 2.5.2 Cell Breathing

Cell breathing phenomenon gets higher from power control. The cell size varies because it depends upon the traffic load. This is the exchange between coverage and capacity. Good quality can be gained though from a long distance from base station when there is low load in the cell means number of users will be less in the cell. On the other hand, when the number of users in the cell is high, the large number of subscribers generates a high interference level and subscribers have to get closer to the base station to achieve good quality. If the number of users is higher in the cell then to get the good quality the users should get closer to the base station and in case of more users, far away from base station there will involve more interference.

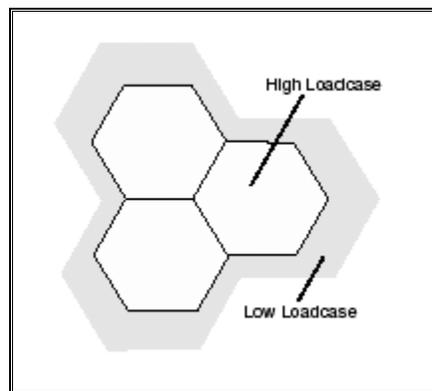


FIGURE 2.12 Call Bearing Examples

### 2.5.3 Channel Type Switching

In order to maximize the total traffic throughput, different types of channels are used to transmit the data in WCDMA. To move the subscribers between the two channels like between common channels and dedicated channels, depending upon the information that subscribers need to transmit, Channel type switching functionality will be used.

**The two most basic ones are:**

**Dedicated Channels:** When there is enough information for transmission, for example downloading, voice conversation then dedicated channel is used. Its efficiently utilizes the radio resources because it provide supports for power control and soft handover.

**Common Channels:** The common channel, in contrast, is smaller quantity spectrums efficient. As many subscribers can share the same resource, the common channel reduces the delays. This is one of the advantages of common channel. Thus for the transfer of limited information common channel is a preferable channel.

**Admission Control:** To avoid system overload and for providing planned coverage, Admission control functionality is used. This functionality is used because in WCDMA there is very clear exchange between coverage and capacity. When a new subscriber looks access to the network, the admission control functionality estimates the network load on the base of newly coming load, then subscriber is either allowed to enter in the network or being blocked. According to the services of subscriber's demand the operator can expand the network usage with in a set of network quality levels.

#### 2.5.4 Congestion Control

Overload may also occur even in case of using efficient admission control. The main cause of this is due to the movement of subscribers from one area to another one. In case of overload four different actions can be taken.

- To resolve the overload issue congestion control becomes activated and its decreases the bit rate of non real time applications.
- If overload issue is not fully solved by reducing bit rate then inter or intra frequency handover becomes active by congestion control, which moves some of the subscribers to the less loaded frequencies.
- Some subscribers are being handover to GSM
- Finally, The action of discontinue is taken to keep the quality of the remaining connections.

#### 2.5.5 Synchronization

For accurate synchronization of base stations, when WCDMA system was standardized, should not depend on external systems and this is the basic requirement for synchronization. This has achieved by a method, where the handset, when needed, measures the synchronization of offset between the different cells and then reports this to the network [12].

Moreover, there is also another option for the use of an external source, for example GPS, for node synchronization, i.e. to always give the top solution for both asynchronous and synchronous nodes are supported.

In 3G network different UTRAN synchronization are required:

- Node synchronization
- Network synchronization
- Transport channel synchronization
- Time alignment handling
- Radio interface synchronization

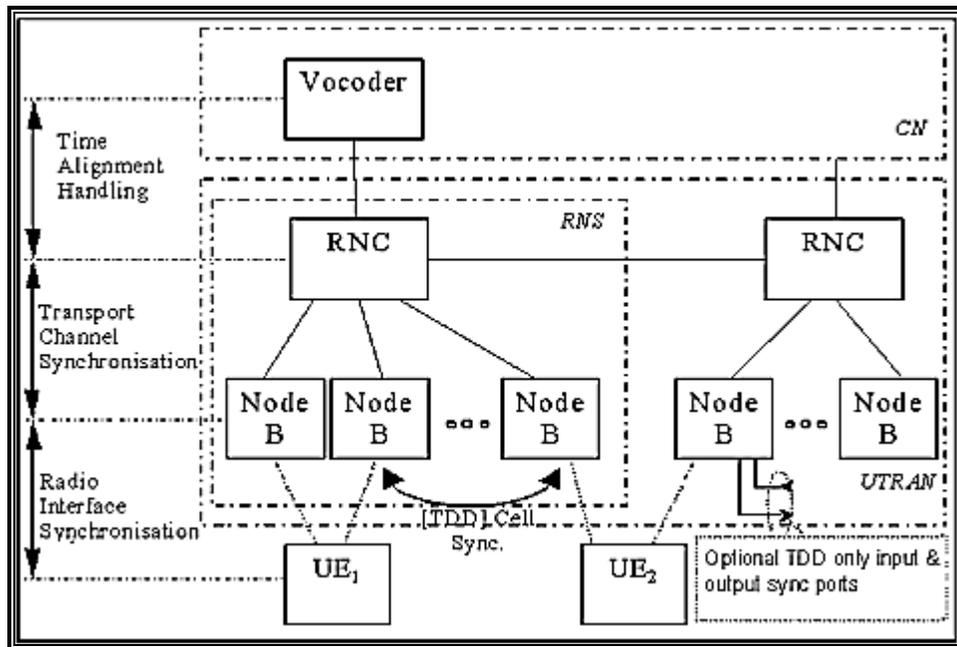


FIGURE 2.13 Synchronization Issues Model

### 2.5.5.1 Network Synchronization

It relates to the sharing of the references of synchronization to the UTRAN Nodes and the strength of the clocks in the UTRAN (and performance necessities on UTRAN internal interfaces). The distribution of an exact frequency reference to the elements of network in the UTRAN is related to many aspects. In order to generate accurate signals on the radio interface one main thing is the possibility to give a synchronization reference with frequency accuracy better than 0.05 ppm at the Node B [13].

### 2.5.5.2 Node Synchronization

Node Synchronization relates to the assessment and reward of timing differences among UTRAN nodes. FDD and TDD modes have different requirements on the accuracy of the timing difference judgment and on the necessity to pay compensation for these differences. At Node synchronization positioning or localization functions may also set the requirements.

### 2.5.5.3 The Transport Channel Synchronization

This mechanism explains synchronization of frame transport between RNC and Node B, considering the timing of radio interfaces [14].

### 2.5.5.4 The Radio Interface Synchronization

Refers to the date of transmission of Radio framework (equivalent to a downlink (FDD) or in both directions [TDD, FDD and TDD various mechanisms for determining the date of the

structure of the radio communications and various requirements of the accuracy of this timetable. Radio interface in FDD synchronization is necessary to ensure that the UE as flash Radio different cells, to minimize UE buffers.

### **2.5.6 Time Alignment Handling**

In order to reduce the buffer stoppage in SNRC, the procedure over IU relates to the control transmission timing of DL in the CN nodes. SRNC controlled this procedure [15].

## CHAPTER 3: UMTS HANDOVER

### 3.1 What is Handover?

During the last thirteen years the Internet and 2nd Generation wireless telecommunications systems like GSM (Global System Mobile) have spread themselves very fast over the free market countries. But 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). In order to get the high quality of service with faultless communication in our networks soft handovers are implemented in the networks. 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 channel and that is why soft handover is also known as Make-Before-Brake. We are going to confer in detail soft handovers in the UMTS and observe the effect of these handovers on the performance of the system [16].

### 3.2 Types of Handovers

Typically there are many types of handovers in WCDMA mobile networks. These are explained below:

#### 3.2.1 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.

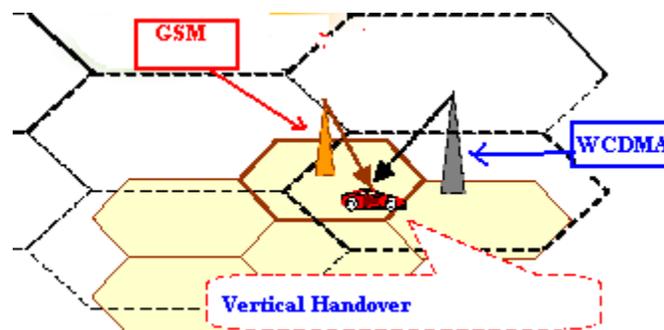


FIGURE 3.1 Vertical Handover between GSM and WCDMA

### 3.2.2 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.

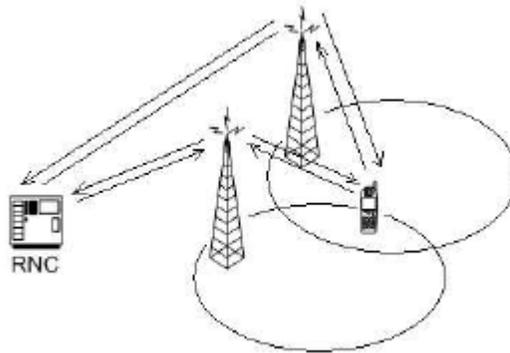


FIGURE 3.2 Horizontal Handover (UMTS Technology)

### 3.2.3 Intra-System Handover

Inter-System handover is the similar to horizontal handover it also supported when the dual mode FDD-TDD terminals may “handover” from FDD to TDD normally in it measurements mechanisms are used. Intra-system Hand Over occurs only within a single system [17]. It is further subdivided into two:

- Intra-Frequency Handover  
Intra frequency happens between cells belonging to the same WCDMA carrier frequency

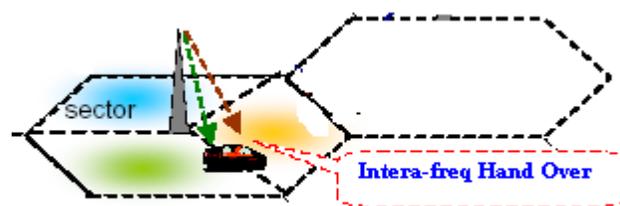


FIGURE 3.3 Intra-Frequency Handover Examples

- Inter-Frequency Handover  
On the other hand Inter frequency happens between cells operating at different WCDMA carriers.

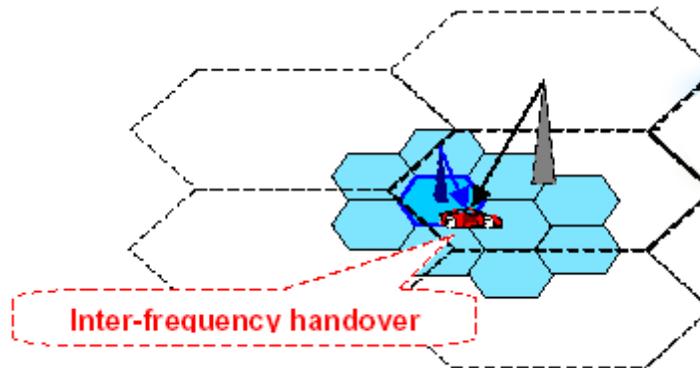
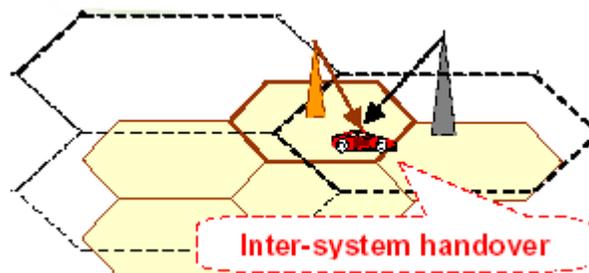


FIGURE 3.4 Inter-Frequency Handover Example

### 3.2.4 Inter-System Handover

Inter system handovers are vital to support compatibility with other system architectures. Mainly handovers between UTRAN and the GSM radio access network will be of more significance during the rollout of UMTS networks. In the preliminary operation phase of 3G networks it is very likely that rural areas will not yet been covered by the WCDMA network [18]. As a result GSM networks will still be used to provide coverage in those rural areas. But when we look that it is feasible that the additional capacity provided by WCDMA networks will be used to unload the inner-city GSM network. Inter system handover over occurs in between cells belong to two dissimilar Radio Access Technologies (RAT) or different Radio Access Modes (RAM). The majority common case for the first type is usual between WCDMA and GSM/EDGE systems. Handover between two different CDMA systems also belongs to inter system handover type. An example of inter-RAM handover is between UTRA FDD and UTRA TDD modes.



GSM Network-----WCDMA Network

FIGURE 3.5 Inter System Handover between GSM and WCDMA

There is an example is given below of signalling procedure for handing over a UMTS user to the GSM system. This example is expressive for the general procedure followed during handovers. This procedure normally consists of carrying out of measurements reserving resources and the performing the actual handover [19].

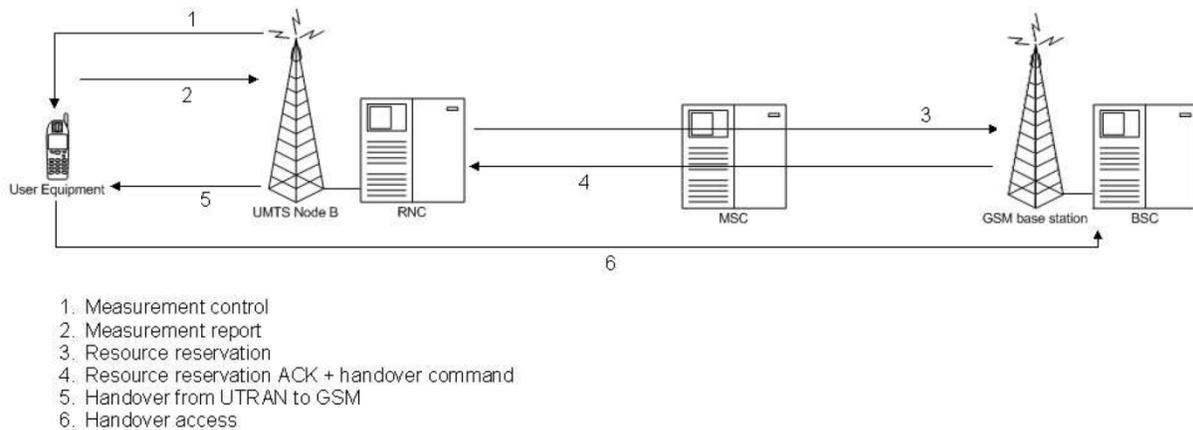


FIGURE 3.6 Inter-System Handover Procedure from UTRAN to GSM

While switching the connection to another system architecture there is need for an extent on the frequency used by the other system. When there is no full dual receiver available the transmission and reception are halted for a while to perform measurements on the other frequencies [20]. This is said to be a compressed mode.

### 3.2.5 Hard Handover

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 where 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 [21].



FIGURE 3.7 Hard Handover Examples

### 3.2.6 Soft Handover

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 know 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 [22].

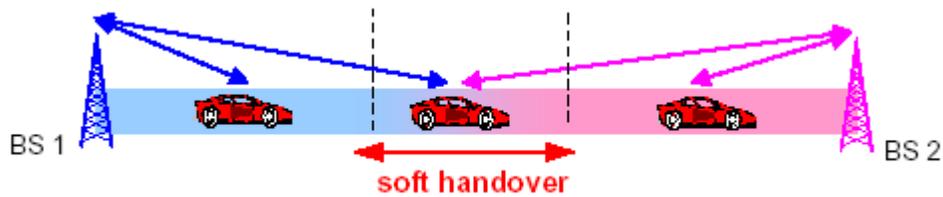


FIGURE 3.8 Soft Handover Examples

When the same BS receives two signals from a single user due to multipath this is called softer handover it uses one carrier frequency so it is an intra-frequency handover.

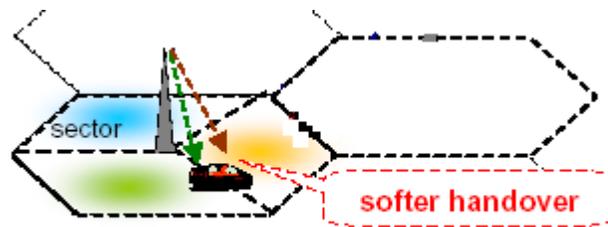


FIGURE 3.9 Softer Handover Examples

### 3.3 Basic Principle of Soft Handover

The soft handover process is different in the different transmission directions. In the uplink direction the mobile transmits the signals to the air through its Omni directional antenna. The two BSs in the active set receive the signals at the same time due to the frequency reuse factor of one in CDMA systems [23]. After that, the signals are sent forward to the RNC for selection combining. The better frame is considered and the other is discarded. As a result, in the uplink direction, there is no extra channel required to support soft handover process [24]. But In the downlink, this not the case same signals are transmitted during both BSs and the mobile can simply combine the signals from different BSs since it sees them as just additional multipath components.

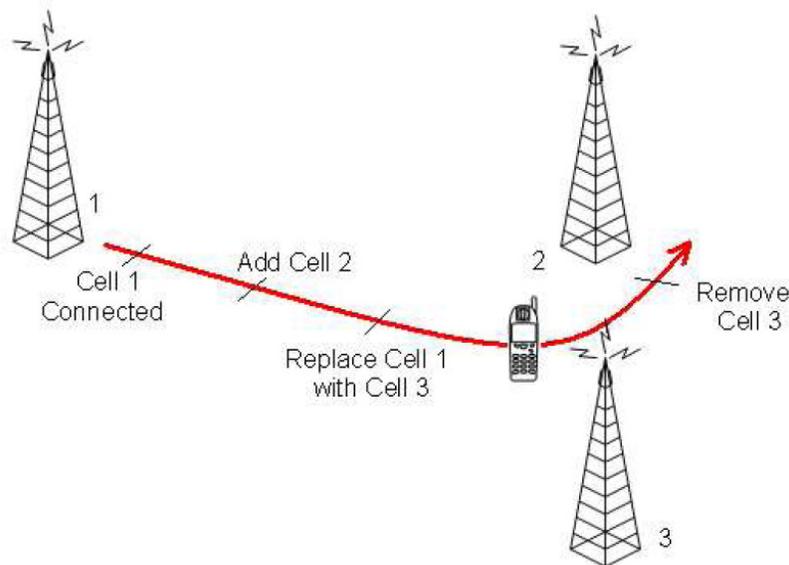


FIGURE 3.10 Soft Handover Scenarios

During soft handover, a mobile at the same time communicates with two (2-way soft Handover) or more cells belonging to different BSs of the identical RNC (intra-RNC) or different RNCs (inter-RNC).

Usually maximum ratio combining scheme is used, which provides an additional benefit called macro diversity. Due to which to support soft handover in the downlink direction, at least one extra downlink channel (2-way soft handover) is required. This extra downlink channel acts to other users acts as an additional interference in the air interface. Therefore, to support soft handover in the downlink, more resource is essential. As a result, in the downlink direction, the performance of the soft handover depends on the exchange between the macro diversity gain and the extra resource consumption [25].

### 3.4 Soft Handover Algorithm

A method and a gadget to provide a smooth algorithm improved of the handoff in a system of communication without threads for the multiple systems of the access of the division of the code of the third generation (CDMA). The method covers to establish the communication among the device without threads and at least at a low station that serves. The proper soft hand over algorithm can increase the system performance now here two conventional soft handover algorithms are shown below in the form of flow chart [26].

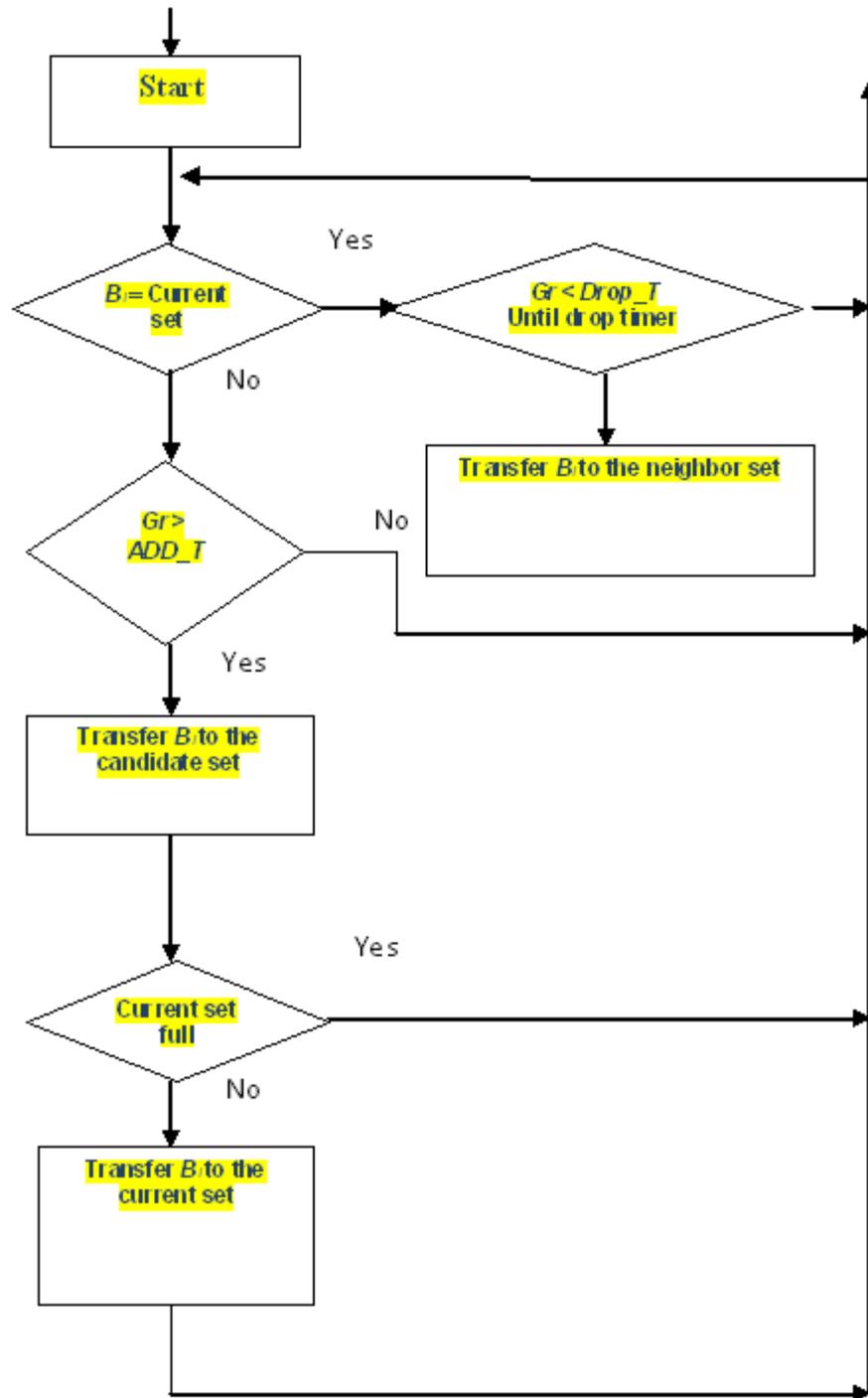


FIGURE 3.11 IS-95. Soft Handover Algorithm Flow Chart

In the above flow chart  $B_i$  is the current active BTS from where the user is getting channel and at perfect downlink power control situation, the received bit energy to interference power spectral density ratio  $E_b/S_0$  of all mobiles is kept at the target value and which is denoted by  $G_r$  here. In

these conventional algorithms absolute handover thresholds are being used.  $ADD\_T$  and  $DROP\_T$  are predetermined when dimensioning the network [27].

Here  $G_r$  represents the received  $E_b/S_0$  of CPICH from  $B_i$

In the IS-95 algorithm the handover decision is made on average received  $E_b/S_0$

### **Now observe the UTRA Handover Algorithm**

The UTRA soft handover algorithm it is also called WCDMA soft handover algorithm there is difference between IS-95A the relative thresholds are being used instead of absolute thresholds.

Some variable are given below which have been used in UTRA algorithm

$G_s$ = it is the  $E_b/S_0$  of the strongest CPICH presente in the current active set

$G_w$ = it is the  $E_b/S_0$  of the weakest CPICH presente in the current active set

The other paremetrs are already mentioned in above peragraph. In chapter# 4 an optimized handover algorithm will be shown.

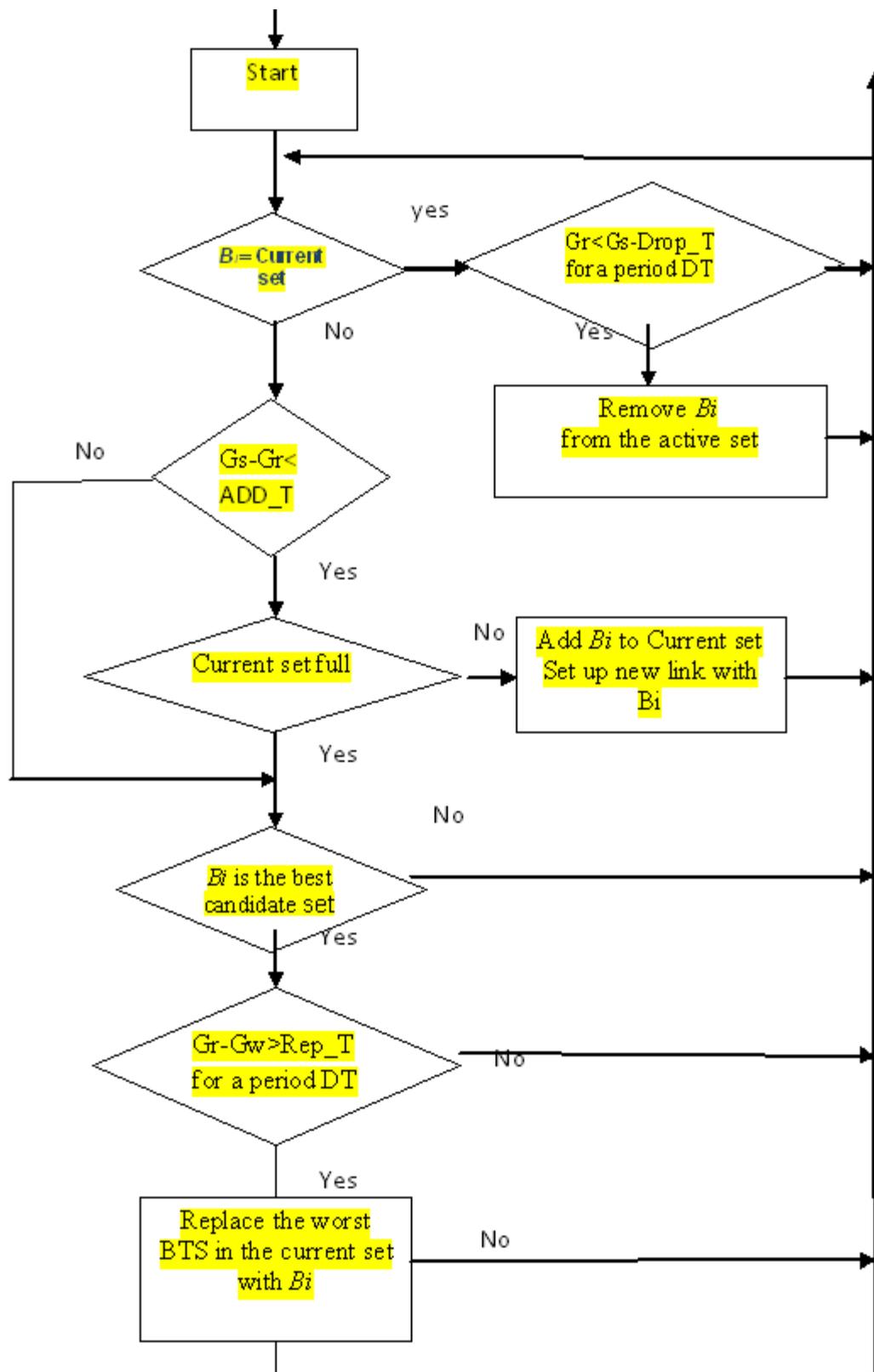


FIGURE 3.12 UTRA Soft Handover Algorithm Flow Chart

### 3.5 Feature Related to Soft Handover

The Soft Handover has many advantages when comparing to traditional handover (Hard handover etc). it improved the seamless communication and the main feature of the soft handover is that there is no break in transmission that's why it is called as a make before break while in hard handover there is a break during hand over and therefore the chances of success of handover becomes less that's why it often called break before make. Another feature includes the lower load on to the network and the soft handover process also eliminates the interference which is also a big feature of WCDMA system due to soft handover this interference elimination happens on uplink channel. There are many other features which are related to Soft handover like better communication for users, greater capacity with maintaining the same Quality of service, it gives a more time to get to the desired BS which directly effect the blocking probability and reduce it and it also reduce the call dropping probability [28].

Although there are many advantages of soft handover and it contain pretty good feature there are some disadvantages of soft handover as compared to traditional handover like it increase the complexity and also consume extra resources in downlink direction.

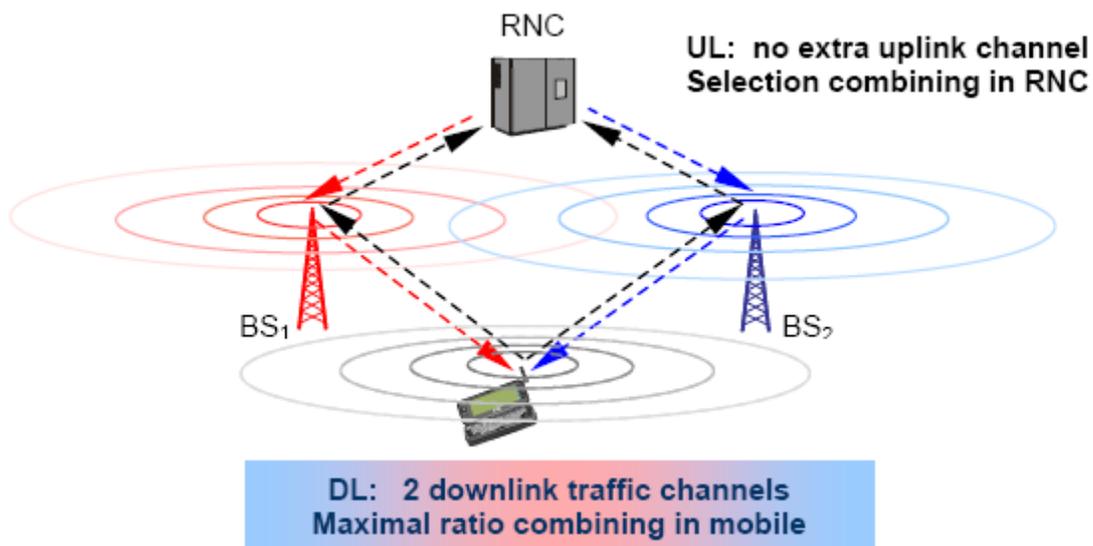


FIGURE 3.13 Downlink Traffic Channels Maximal Ratio

## **CHAPTER 4: OPTIMIZATION STRATEGIES FOR SOFT HANDOVER**

### **4.1 Introduction**

The soft hand over performance is strongly based on to the algorithm and the soft handover parameters. Hence it is very important to set proper algorithm and parameters of soft handover should be set proper in order to get better handover performance.

### **4.2 New Strategies for Soft Handover**

In this chapter we will discuss some new strategies to optimizing the soft handover issue and to get the full benefits from soft handover.

#### **4.2.1 Algorithms**

The proper algorithm will really boost the soft handover performance. Now when talking about soft handover algorithm there are two typical algorithms IS-95A and UTRAN algorithm. The IS-95A soft handover algorithm can be optimize to reduce the system down time probability and when we modify the threshold level in IS-95A algorithm according to the traffic then we can also find good response and the high rate soft handover can also be avoid with some modification. The threshold level must be set according to the acceleration of mobile users. The analysis of comparison of using different algorithm can give us maximum capacity gain [29].

#### **4.2.2 Downlink Capacity**

In UMTS the another soft hand optimization can be done by increasing the downlink capacity because the downlink capacity also effect the whole system capacity so in order to increase the downlink capacity it needs to reduce the downlink interference.

#### **4.2.3 Network Coverage**

The network coverage and increasing the capacity also can optimize the soft handover process. When capacity of the system will be increase which will automatically increase the soft handover success rate and when we talk about the network coverage it will reduce the soft handover occurrence hence it can be a good soft handover optimization strategy [30].

#### **4.2.4 Soft Handover Parameters**

Soft hand over parameters plays a big role in the optimization. The different parameters can be used with using various combinations. And then the performance can be compared after analyzing of different combination of soft handover parameters. Here the soft handover parameters are like different threshold levels.

### **4.3 Optimized Power Control Scheme during Soft Handover**

Now the power control schemes are anticipated for optimizing the power dissection between the BSc in the active position during soft handover. Power control during soft handover, Describes the principles of the proposed power control scheme. The feasibility of the new scheme is evaluated. Afterwards, the system level performance of the new scheme is investigated under UTRA soft handover algorithm by comparing to the balanced power control [31].

At some point in the power control method is more complex because there are at least two BSc involved. In the uplink path, the mobile terminal adjusts its transmit power based on the permutation of the received transmit power control (TPS) command from all BSc in the active set. Consequently, the consistency of TPC bits and the proper combining approach are fatal to the uplink power control during soft handover.

Downlink power control schemes through soft handover commonly assumed that is deviation in the transmit powers from different power stations in the active set can lead to the reduction of the macro diversity gain. A couple of technique have been planned to keep away from the power drifting, the amendment loop power control was planned to sustain the balance of the transmit power from different base station in the active set. As well as the inner closed loop power control, an amendment loop is employed for balancing the downlink power among active set cells through macro diversity. An unbalanced power allocation scheme was investigated that it can decrease the overall transmit power. In this system, the BS has a better connect with the mobile transmit signal at higher power. Site choice diversity transmits power control (STDT), which has been adopting by 3GPP as a substitute plan for soft handover. The principle of SSST is that the best BS of the active set is dynamically selected as the only transmitting site, and other BSc concerned turn down their DPDCHs (Dedicated Physical Control Channel). In this method, the interference caused by the various site transmissions is mitigated. On the other hand, SSST loses the benefits of macro diversity. In this theory, an optimized downlink power control plan is anticipated [32].

As mentioned and confirmed, CDMA systems are interference-limited. Reducing the total nosiness is one of the basic conventions for optimizing the radio resource in CDMA system. The basic rule of the new approach is to reduce the total power control approach is to reduce the total power utilization during the soft handover as lower power utilization mean less nosiness to other active users.

### **4.4 Theory of Soft Handover Optimization**

As we know that the WCDMA systems are high capacity and interference limited systems and downlink is affected by soft handover is much more complicated than the uplink affected by the soft handover.

#### **4.4.1 Extra Resource Management**

In soft handover there is no extra channel is needed for uplink which definitely saves the extra resources and hence the capacity is also increased. But this is not the case in downlink due to

extra channel the extra resources consumed by these channels which also increase the downlink interference. So to optimize this soft handover process the downlink capacity must be increased and from analysis it can be when the extra resources would be managed [33].

#### 4.4.2 Interference

In downlink during Soft handover the extra resources consume due to use of extra channels which also increases the interference level [34]. Now when the user is in soft handover situation the interference for other users, increases so in order to get an optimized soft handover an example is considered.

Observing the following FIGURE when the user has the only connection with the BS-x then the optimum power  $P_1$  is required the power  $P_{2x}$  and  $P_{2y}$  are required when the user is in soft handover process with two BTS, BS-x and BS-y

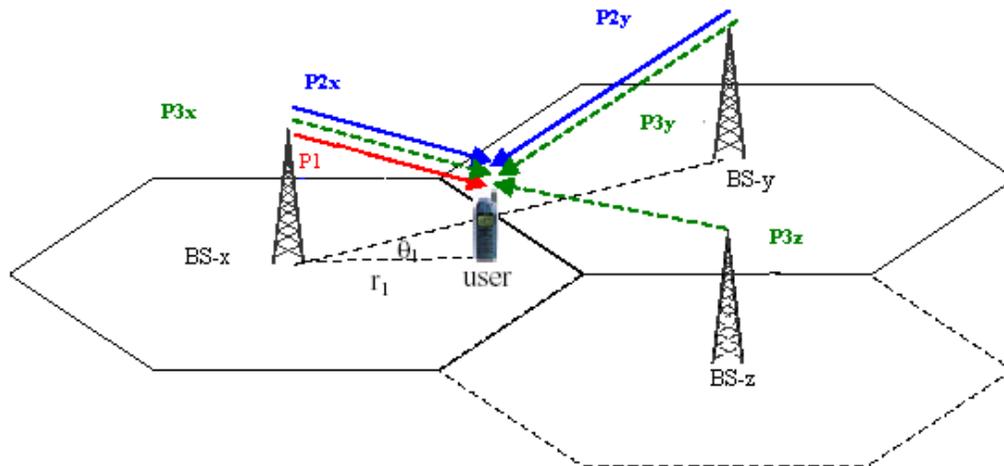


FIGURE 4.1 Optimization of Soft Handover

and when the user will face soft handover situation with three BTS, BS-x, BS-y and BS-z then the power needed from these BTSs will be  $P_{3x}$ ,  $P_{3y}$  and  $p_{3z}$  respectively. Now the total interference by this user can be calculated by adding all the channels linked with this user. Here it is assumed that the active BTS is BS-x for the user and the BS-y and BS-z are the candidate sets and the three is maximum size of the active set.

The number of active sets can be modified according to total resources to minimize the interference.

The IS-95A soft Handover algorithm optimized to reduce system down time probability the threshold level have been modified according to traffic, following is the flow chart of optimized soft handover by using the above example.

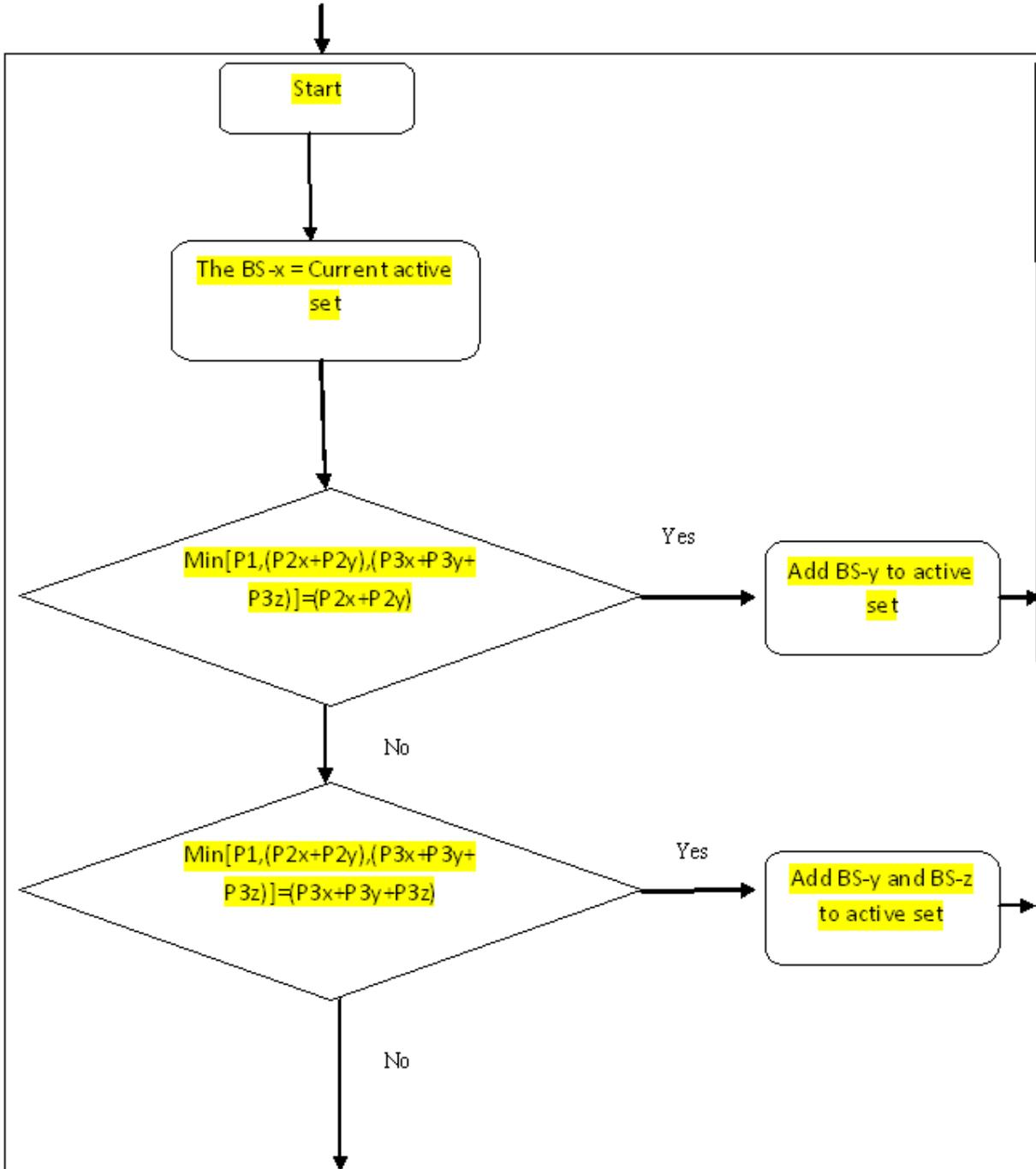


FIGURE 4.2 Optimized Soft Handover Flow Chart

## **CHAPTER 5: RESULTS AND CONCLUSIONS**

### **5.1 Results and Conclusions**

Now after discussion and research work we concluded that extra resource consumption and macro diversity have weakened the downlink power during the soft handover in WCDMA technique. The downlink capacity will be improved by getting optimum power control scheme good cell selection techniques and the by adopting the optimize radio parameters. There is an exchange between macro diversity and extra resource management to get a better system level performance since the macro diversity is directly proportional to the link level performance.

There is a need to adopt new power scheme to get the better division of power and that power scheme should be designed specially for WCDMA system rather than the old and conventional power scheme. Because the conventional power scheme causes interference and it also doesn't get full advantages from macro diversity so to obtain a system which can pass high soft handover, can handle high fading and with improved downlink performance the new power scheme must be implemented.

The Capacity gain is directly related to the handover threshold which has been obtained from the handover optimization so it has been concluded that the new power scheme and the handover optimization can really boost up the downlink capacity.

### **5.2 Future Research Work**

In this report we tried to focus the main aspect that affect the overall capacity of the network during the soft handover process in WCDMA system but there are many aspects which have not been covered in this report. When we talk about future research work then one should pay more attention on to the quality of Service of the system. The QoS is essential to offer real time service which is the vital aspect of UMTS system. When studying the End to end delay of an observed connection and the coefficient of errors of the block parameters which has been affected by the soft handover it will be found some interesting result those can be effect the UMTS system performance.

It is also important for future research to study the effect of characteristics of different channels on to the capacity of the system and there is a need to find a new power scheme to get the better division of power and that power scheme should be designed especially for WCDMA system rather than the old and conventional power scheme.

In the End the future research must be focused to get different algorithms and the new optimized power control schemes to get a better network.

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