3 G Cellular Network

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ABSTRACT

Keywords: 3G, CDMA2000, UMTS, QoS

This report provides the essential information about the background for the 3G cellular networks for CDMA2000 packet data networks a new data call admission i.e. multi layer call admission has been introduced and technical similarities between CDMA2000 Vs UMTS. Further, we discussed about QoS work and problem issue regarding CDMA2000 and UMTS.

In further we discussed about routing loops. Why we issue regarding loops etc. In more, we talk about 3G protocol layers, structure, mobility and handover on different quality of service parameters.

We discuss all aspects of 3G cellular network and we gone through different stages to integrate all these work in one platform.
DEDICATIONS

To our respectable parents, who prayed for our success and supported us morally and financially.
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1.1 Background

CDMA2000 is a hybrid 2.5G and 3G protocol and a multiple access scheme for digital radio, to send voice data and signaling data between cell phones and cell sites. CDMA2000 is a considered 2.5G protocol in 1XRTT and a 3G protocol in EDVO [1].

Code division multiple access transmits bits of information through wideband, spread spectrum radio interface. IS-95 is transmission protocol that employs CDMA and evolution form IS-95A to IS-95B to CDMA2000. The general trend is CDMA IS-95 A is work on GSM, IS-95 B is work on GPRS and 1XRTT/3XRt CDMA2000 work on W-CDMA and technology works behind all these standards is TDMA, EDGE and UWC-136.

CDMA (code division multiple access) is a mobile digital radio technology where channel are defined with codes. CDMA permits many simultaneous transmitters on the same frequency channel.

CDMA2000 has a very long technical history and remains compatible with older CDMA telephone methods like cdmaOne. A commercial company Qualcomm initially develops it.

The world’s first 3G commercial system was launched by SK Telecom (South Korea) in October 2000 using CDMA2000 1X. In generally assumed more than 430 million 3G users across all over the world. [23]

1.2 CDMA2000 Technical Specification

CDMA2000 is a radio transmission technology for the evolution of narrow band cdmaOne/IS-95 to 3rd generation adding up multiple carries.

CDMA2000 has also known as IS-2000. A 3G technology can deploy in several phases support an average of 144kbps packet data. It can support data rate up to 2 Mbps on a dedicated data carrier and the final phase support even higher peak rates. It also manages voice and high-speed data as well as QoS mechanism.

Important factor of CDMA2000 is to support and full fill demands of advanced 3G service such as IP-based and multimedia services.

1.3 CDMA2000 Model

CDMA2000 architecture consists of three most important parts Mobile station (MS), radio access network (RAN), core network (CN) and further core network is separated in two parts. Public switched telephone network (PSTN) interfacing to external networks and secondly is interfacing to internet protocol network or internet.

![CDMA2000 Architecture](image)

**Fig 1.2 [3]**

1.3.1 Station Mobile

After power up than it starts different processes like initialization, synchronization, idle state call origination, access state, traffic state and end of call. It terminates the radio path on the user side of the network and enables the user to access network service over the Um interface without UIM MS and it known as ME.

TE2 is an external device as we have laptop computer, for voice and application whereas TE2 refer to phone .TE2 is unnecessary and MT2 is sufficient.
1.3.2 Radio Access Network (RAN)

CDMA network provides consists of different components like, mobile station (MS), Radio base station (RBS), Base station controller (BSC), mobile switching center (MSC), Public switch telephone network packet data serving node (PDSN) and Internet protocol (IP) gateway. It also provides the radio bearers between the Core Network (CN) and Mobile Station (MS) for transport of user data and non-access stream signaling, so it enables the MS to access the service offered by PSTN or internet. It mainly works on maintenance establishment for transmission of radio channels and Radio Resource Management (RRM). It consists of Base Station (BS) and Packet Control Function (PCF). The BS is further separate into BTS as radio-terminating equipment and the BSC.

1.3.3 Core Network

Basic core network works as a backbone of whole network. Core network includes circuit switching and packet switching. Both switching techniques work on different manners in their environments. In circuit-switching network interface with radio access network via MSC, this provides the wire-line interface to the PSTN. While packet switching network interworks with radio access network via packet router and this term known as packet data serving node (PDSN). The packet core function (PCF) at the core network side. PCF controls the packet radio resource and buffer incoming data from the packet network when the radio resource is not in an active condition.

In generally it used a mesh topology and it provides connection between devices on the network, while the internet considered as a core network. It really consists of many service providers that run and perform their own core network. Those core networks inter-connected with each other.

MSC home location register (HLR) or any visitor location register (VLR), authentication centre (AC), message center (MC) and short message entity (SME) are entities that all belongs to core network.

1.3.3.1 Um Reference Point

Um interface upper layer consists of user services such as, packet data service, voice over IP (VoIP), circuit switch, voice and data. Is2000 supports mobility management, resource management, establishment and maintenance. It is also make connection between mobile station and radio access network (RAN).

1.3.3.2 Rm Reference Point

TE2 used for packet data service such as, support for point-to-point protocol (PPP) and its function locally connected to the router. There is link between MT2 and TE2 and they implement their function through point-to-point or serial link IP (SLIP).

1.3.3.3 ABIS Reference Point (A7/A3)

ABIS interface point used for exchange data between the BSC and BTS A7 id for signaling traffic between source and target BSC. It is use to control allocation and release of radio resource on the target BSC. The A3 interface carries signaling and user traffic. A3 signaling is to establish and remove A3 traffic connection and for all call specific operation procedure.
1.3.3.4 A8/A9 Reference Points

BSC is connected to PCF through this reference point by one to many relationships and exists between BSC and PCF. A8 interface server is use user data and A9 interface carry signaling.

1.3.3.5 A1/A2/A5 Reference Points

Reference point between MSC and BSC is implementing with three different major interfaces A1, A2, and A5. A1 is for signaling base station application layer (BSAP) and it called application service layer. BSAP further separated into two portions. Also known as direct transfer application part (DTAP). Base station management application part (BSMAP) messages are those that processed by the BSC. DTAP messages are page through MSC or mobile stations are not processes by MSC or mobile station. [3]

1.4 CDMA2000 Call Setup and Processing

- Call processing is the complete process in which the mobile phone initiates the call and ends the call. Given steps should be follow during the call processing
- When call processing is starts, it should be follow, initiating, routing and termination telephone call
- The cdmaOne always pass through four important ways before call are connected
- Mobile station starts as, MS Initialization, MS Idle state, System access state and MS Traffic State
- Mobile station controls the traffic and channel state

These four points play important role in call setup and call processing. It is almost the same process as IS-95, the IS-2000 standard pre define the states and the sub states for the mobile station. It is sure whatever function and process occurs in the base station, they should work within per define or specified mobile states and sub states.

1.5 Mobile Station Idle State

The Mobile station executes paging channel and monitoring procedures. The paging channel further separated into 200-ms and it called “paging channel slots”. Paging and control messages for a mobile station functioning in the non-slotted mode and it can be receive an array of paging channel slots. Mobile station operation needs the mobile station to monitor all slots. Mobile station can manage the length of the slot cycle. Mobile station will manage all active registration timers. CDMA system upholds nine different forms of registration.

- Power-up: Mobile station registers when it power on.
- Power-down: Mobile station registers when it power off.
- Timer-based: Mobile station registers when a timer deads.
• Distance-based: Mobile station registers when the distance between the current base station and in which last register go beyond the limit of a threshold.
• Zone-based: Mobile station registers when it insert in new zone.
• Parameter-change: Mobile station registers when inescapable parameters change.
• Ordered: Mobile station registers when the base station needs it.
• Implicit: Mobile station successfully sends an origination or page response message.
• Traffic Channel: Whenever the base station has confirm the registration information for a mobile station that has been given to traffic channel, the base station always make sure that mobile station is registered. [1]

1.6 System Access State

Whenever the mobile station transmits the messages to the base station on the access channel side, it receives messages from the base station. Now on the paging channel side the whole process of transmitting one message and receiving the acknowledgment for that message and it is called access attempt. Each transmission in the access attempt is called an access probe.

1.7 Mobile Terminated Call Setup

It is almost same to the mobile initiate the call setup except that it starts by mobile switching center in order to access channel.

1.8 Handoff in CDMA2000

Different Types of Handoffs

The mobile station uphold has four handoff types:
• Soft handoff
• Hard handoff
• Analog handoff
• Softer handoff

1.8.1 Soft Handoff

Mobile station starts communication with a new base station without disturbing communication with old base station and this process known as soft handoff. Typical soft handoff means a same frequency assignment between the old base station and new base station.

1.8.2 Hard Handoff

Mobile station transmits information between two base stations with different frequency assignment.

1.8.3 Analog Handoff

Mobile station is straight away from a forward traffic channel to an analog voice channel with a dissimilar frequency assignment.
1.8.4 Softer Handoff

Handoff between sectors within a cell called softer handoff.

1.9 Channels of CDMA 2000

Mobile station and base station exchange or interchange information by means of physical channel that are transmitted over a given frequency assignment. These channels can hold either user information or control information and both. The collection of these sets called CDMA channels. It consists of forward and reverse CDMA channel, which consist of multiple physical channels.

1.9.1 Forward Channels of CDMA 2000

Forward CDMA channel have one or more code channels.

1.9.1.1 Code Channel

It is a sub channel of CDMA2000 forward channel and it contains 64 code channels. Specific code channel is assign to different logic channels.

Code channel zero is also called Pilot channel. Code channel 1 through 7, may be paging channels or traffic channels. Code channel 32, a traffic channel or synchronization channel and other than all rest code, channels are traffic channels.

1.9.1.2 Forward Pilot Channel (F-PICH)

The information transmitted all time from the base station. It used for channel phase and gain, cell acquisition, handoff and channel structure. It supports smart antenna applications and it allows transmits difference. It provides the competency for soft handoff and coherent detection. Handoff is a procedure in which mobile with an on-going call changes BS or channel under the network.

1.9.1.3 Forward transmit diversity pilot channel (F-TDPICH)

It is used to support forward link transmit verity. The pilot channel and TDPICH provide phase reference of transmit diversity. In this channel, we use antenna beam forming and beam steering techniques to extend the coverage.

1.9.1.4 Forward Auxiliary Pilot Channel (F-APICH)

It uses antenna beam forming application to generate spot beam. We shared among multiple mobiles in the same spot beam. It is also used for transmit diversity.

1.9.1.5 Forward Auxiliary Transmit Diversity Pilot Channel (F-ATDPICH)

It is also processes in same way as; we have F-TDPICH but it can be combining with F-APICH.
1.9.1.6 Forward Sync Channel (F-SYNC)

It uses by mobile station operating within the coverage area of the base station to acquire initial time synchronization. Usually bit rate for the sync channel is 1200 bps.

1.9.1.7 Forward paging channel (F-PCH)

It uses to send information and control, paging message from the base station to mobile station.

1.9.1.8 Forward Traffic Channel or Fundamental Channel (F-FCH)

It uses for the transmission for user and signaling information to a specific mobile station during a call [3]. Fundamental channel also use as data scrambling.

1.9.1.9 Supplemental Channel (F-SCH)

It uses to support of high speed packet and circuit data. In this channel, base station may support flexible data rate and scrambling [3]. There are may be more than one F-SCH is use at a given time and optimal FER and data is different for voice.

1.9.1.10 Dedicated control channel (F-DCCH)

It uses for mobile specific control information and use for the transmission of user signaling information to a specific mobile station during a call. Reduce impact on voice due to high rate MAC signaling. All forward traffic channels may have one forward dedicated control channel.

1.9.1.11 Forward Quick Paging Channel (F-QPCH)

It is used to monitors the F-QPCH and when the flag is set. Mobile station looks for the paging messages.

1.9.1.12 Forward Common Control Channel (F-CCCH)

It is use for communication of layer 3 and MAC message from base station to mobile station.

1.9.1.13 Forward Common Power Control Channel (F-CPCCH)

It is use to transmit power and control bits to multiple mobiles.

1.9.1.14 Forward common Assignment Channel (F-CACH)

It is design to provide fast response reverse link channel assignments.

1.9.1.15 Forward packet Data Channel (F-PDCH)

In this base station, it can support up to two channels and the mobile station receives at most one in any time. Packet data user is sharing it.
1.9.1.16 Forward packet Data Control Channel (F-PDCCH)

In this channel, base station can support up to two F-PDCCHs. It is use to send the scheduled user’s channel id, encoder packet size.

1.9.2 Reverse Channels of CDMA 2000

1.9.2.1 Reverse Pilot Channel (R-PICH)

It is use for initial acquisition and time tracking. It is also use to assist the base station in detecting a mobile station transmission. The reverse channel is transmitting when the EACH, RCCCH or RTCH is active.

1.9.2.2 Reverse Access Channel (R-ACH)

In this channel, the mobile station transmission on the ACH at a fixed rate 4.8 kbps and it is also use by mobile station to start communication with BS and respond to PCH messages. The reverse channel may have up to 32 access channels per supported PCH. An access probe consists of an access preamble followed by access channel frame. It is use to initiate the calls.

1.9.2.3 Reverse Enhanced Access Channel (R-EACH)

It is used MS to starts communication with the BS and transmits short messages then start responding to pages. This channel is use in two different modes and that is, basic access mode and reverse access mode.

1.9.2.4 Reverse Common Control Channel (R-CCCH)

In a channel MS transmit during intervals specified by the base station and it may contains up to 32 reverse common control channels. Each R-CCCH is associated with a single F-CCCH. This mode initiates calls in reservation access mode.

1.9.2.5 Reverse Dedicated Control Channel (R-DCCH)

It is used to carry upper layer signaling, MAC messages and R-TCH may contain up to one R-DCCH. Also, use to reduce impact on voice due to high rate MAC signaling.

1.9.2.6 Reverse Fundamental Channel (R-FCH)

This channel is use for the transmission of user and signaling information to a specific MS during a call. It supports variable rate transmission.

1.9.2.7 Reverse Supplemental Channel (R-SCH)

It is use as optional channel and reverses supplemental channel (R-SCH) carrying data traffic as well.

1.9.2.8 Reverse Traffic Channel (R-TCH)

It almost work same as we forward traffic channel and it may combine with several reverse supplement channel, dedicated control channel and Pilot channel. [3]
Chapter 2: UMTS

2.1 Introduction

As we all know that technology has been change day by day and that changes coming and growing very fast, so for this changes comes rapidly for regarding this we have Universal mobile telecommunication system (UMTS) and the goal of third generation (3G) is to deliver the multimedia services to the users. This requires the provision of user data rates and that are much higher than previously provided by second-generation (2G) network. In global system for mobile communications, the data rate is available 9.6 kbps currently supported until yet. If we compare to this situation in case of UMTS user will provide with higher data rates up to 144 kbps and if we change our environments like, if I talk about macro cellular environments up to 384 kbps and 2 Mbps in indoor for Pico cellular environments. For meet, this and increasing demands of all kind of data transfer wireless technology placed. Wireless technology has gone through many steps in order to improve QoS and try to overcome the limitation of pervious systems. Now we have successfully passed three generations in history of cellular domains.

First generation
Second generation
Third generation

2.1.1 First Generation

In this generation generally analog techniques is used. Gradually it was felt that certain limitation have been raised small problems and the main issue is long call setup time, take full efficient use of bandwidth and insecure transmission. This is pure analog systems and offering mainly voice services, NMT 450/900, Convik450, AMPS and TACS.

2.1.2 Second Generation

In this generation, cellular system brought digital modulation techniques, due to this digital technique major changes come in the field of cellular domain and caused the considerable improvement in the efficient bandwidth usage, much better secure quality and advance mobility management. Importantly it starts encryption mechanism. This is digital systems offering voice, data services: GSM 900/1800/1900, DAMPS, IS-54, IS-136, TDMA, CDMA/IS-95 (cdmaOne) and PDC. In this generation mainly enforced by internet success and it is also offers HSCSD (circuit-switched data) bundling of traffic channels, GPRS (packet-switched data) in this addition of packet-data a network core, EDGE (efficient modulation schema, 8-PSk, increase system capacity (bit rate per user).

2.1.3 Third Generation

In this generation, we get everything in quite better way and regarding our requirements. Although second-generation present better QoS but the data rate was quite low as we need today’s. Luckily in third generation system is tend to provide all kinds of service for example, data rate, audio, video etc. On the other hand, we get much smaller call setup delay and it is user friendly. Open System Architecture (OSA) is promising to provide such API’s which will perform authentication and authorization of user secure and independent of vendor specific solution and
independent of programming languages. Services and application offers in 3G system are following as:

A Multimedia service provides high quality image, video, telephone etc. Internet services provide web browsing, file download, streaming audio and video. Service multiplexing provides different requirements share same logical connection; web browsing and voice call in parallel. Increased bit rates and minimum 144 kbps rural outdoors, maximum 500 km/h and minimum 384 kbps, suburban outdoors, maximum 120 km/h. Bandwidth offers different bit rates and its depending upon user and service requirements. QoS supports to decrease delay, jitter and BER. Asymmetrical/symmetrical connections provide data voice.

2.2 Basic Concept of UMTS

The abbreviation of UMTS is Universal Mobile Telecommunication System and worldwide industry dialogues that favor UMTS idea that goes beyond IMT-2000. In this technology, fundamental elements form the internet with the IMT-2000 radio core network and it will use internet-based protocol according to IPv4/IPv6 throughout the network. UMTS is a wideband, circuit, packet based transmission system for text, digital voice, video and multimedia with data rates up to 2Mbps. UMTS has become the dominating 3G standards and even before it starts their service in 2001 or 2002. If UMTS is completely implement than computer, phone users can be frequently attached to the internet and no matter either you are traveling or roaming have almost same set of capabilities or functionalities. When UMTS is fully accomplished, users can have multimedia devices that switch to the available technologies such as, GSM 900, GSM 1800 and GSM 1900 etc. The new air interface using WCDMA will offer better-quality performance in relation to GSM in terms of higher data rates and higher capacity. Uniquely feature in difference to GSM is IP-based network architecture, which supports both voice, data services via packet transport and switching. UMTS allows transparent wireless internet access and it will bring internet developments in a new direction characterized by mobility, location dependency and high bit rate access.

2.3 UMTS Architecture

UMTS network consist of three interface domains and their names are following as:

- Core Network (CN)
- Terrestrial Radio Access Network (UTRAN)
- User Equipment (UE)

2.3.1 Core Network

Core network of UMTS provides us transport service for various applications like packet switching and circuit switching. Generally backbone of network of UMTS is interconnected UTRAN with public networks. This network provides various kinds of function and procedures like, we have call management, security, mobility management and billing. It is using databases, SS7, IWU. Asynchronous transfer Mode (ATM) is defining for UMTS core transmission [4].The architecture of the core network may modify when new features and services are introduce.
2.3.1.1 Circuit Switch

The circuit switching service offers voice calls, video conference and standard of GSM network elements like, mobile service switching center (MSC), gateway MSC and visitor location register (VLR).

2.3.1.2 Packet Switch

Packet switch service provides regular data application, browsing, GPRS network element, IP SGSN and GGSN.

2.3.1.3 User Equipment

UMTS usually does not restrict the functionality of the user equipment. It can operate in three modes involving packet switched and circuit switched. [6]

2.3.1.4 Packet Switch/Circuit Switch Mode of Operation

In this mode, mobile station attaches with packet and circuit switch. It operates both packet and circuits switch services. [6]

2.3.1.5 Packet Switch Mode of Operation

User equipment attached with packet switch and it operates the packet switch service only.

2.3.1.6 Circuit Switch Mode of Operation

In this mode, the mobile station attached to circuit switch and it operates circuit switch service only.

2.3.2 UTRAN

The UTRAN plays very important role to make establishment and connection between user equipment and rest of the network. Radio network controller (RNC) is connect to one or more base transceiver station (BTS) and the function of RNC is to control radio resource. The RNC is belonging to access network and it connected with core network. Which consist of MSC, SGSN and MPE. The interface point between RNC and a node is IUB; UE accesses the UTRAN through base station.
Radio network subsystem consisting of RNC link with nodes and connects to the core network at a reference point. The exception of multimedia processing equipment, the core network of 3G is almost same to core network of a GSM with GPRS abilities. MPE offers such kind of function, as code conversion between audio coding, video coding, control signaling and that may be use in a completely general network to provide interoperability amongst different multimedia nodes used in the system.

### 2.3.3 USIM and Smart Cards

After technology moved forward in mobile domain, this was the introduction of subscriber identity module, which uses generic smart card technology. It provided the possibility of security and extent of uses customization to the mobile terminal.

In October 1999, exchangeability of SIMs in UMTS and GSM chosen as result come it is required to able to personalize both. It might be possible to inset a GSM SIM into a UMTS terminal and we can access a UMTS system.

Smart card industry will be able to offer cards with large memory, good CPU performance, contactless operation and it is capability for encryption. These forward steps in this technology will permit the USIM to add to the UMTS service package by allowing portable high security data storage. It is not only use to install software for the operation of any UMTS, but we can save personal files, fingerprint, images and signature data, download or upload from the card.

Contactless cards will offer much easier to use than today’s cards, like if we see this example, this would allow the smart card to be use for financial and management
process. It is quite sure that all fixed and mobile network will adopt the same low layer standards for their subscriber identity cards to enable USIM roaming on all networks and universal user access to all services.

2.4 CALL Setup in UMTS

All the three cellular systems have their call setup procedure instead of that the UMTS call setup is already to be a transition in GPRS call setup. Here we describe the UMTS call setup procedure given below:

There are four basic step of UMTS call setup.

- Idle phase
- Call setup phase
- Measurement phase
- Call release phase

2.4.1 Idle Phase

Idle phase consists of the idle state of UE and in this phase node; B has a link with UE and provides system information. This phase contains dynamic resource allocation and control procedure information. This channel is performing the function BCCH/BCH.

![Fig 2.2](6)

2.4.2 Call Setup

Call setup contain different phases and their names are such as:

- Call setup start
- Signaling connection Establishment
- Connection management
- Radio Bearer Establishment
- Ringing
- Call connected

2.4.2.1 Call Setup Start

In this phase call; setup sends RRC connection request, which contains UE identity capability establishment and in this channel is performing the function CCCH/RACH.
RACH. After receiving the RRC request, it forwards RRC connection setup, which contains the transport channel information signaling radio bearer. After that, call setup sends RRC connection complete acknowledgement.

### 2.4.2.2 Signaling Connection Establishment

This signaling connection establishment occurs when the UE because initially direct transfer to the node then connection management service request to propagate. In this response to node B and generates channel management service. It allows this, the channel including this service is DCCH and it is cause the authentication, etc.

**Fig 2.2 [6]**

### 2.4.2.3 Radio Bearer Phase

The main function starts just now that is ringing. Node B makes alerts UE and channel within it. In turn, UE gives connection acknowledgment. This phase also contains radio bearer information.

### 2.4.3 Measurement Phase

This is continuous process after the call connection. Node B calls UE for measurement control and in turn, UE give the result in the form of measurement report. The DCCH ability to perform the function of setup modifies measurement, traffic and QoS etc.
2.4.3.1 Handover Phase

In this phase Node B sends active set, update to UE and in turn UE response active setup completion. The output of this phase is adding or removing connection.

![Handover Phase Diagram](image)

Fig 2.3 [6]

2.4.4 Call Release Phase

In this phase process just reverse as the node, B calls UE for RRC connection release. UE complete the RRC connection release. This is phase is also contains DCCH.

In the end, again, it goes to idle mode and this is all about the call setup of UMTS.

2.5 Channels of GSM

There are two types of GSM logical channel.

- Traffic channel
- Control channel

2.5.1 GSM Traffic Channel

GSM traffic channel is may further divided into two different parts.

- Full rate
- Half rate

2.5.1.1 Full Rate Traffic Channel

Full rate speech channel contain 22.8 kbps and it means user data uses within in one time slot.

- Full rate channel TCH/FS
- Full rate data channels

2.5.1.2 Half Rate

In this, user data is map on the same time slot but it sent in alternate frames and half rate contains 11.4 kbps.
- Half rate speech channel
- Half rate data channel

2.5.2 GSM Control Channel

There are three common control channels in GSM domain.

- Broadcast channel (BCH)
- Common control channel (CCH)
- Dedicated control channel (DCCH)

2.5.2.1 Broadcast channels (BCH)

This channel divided into two more sub channels.

- Frequency correction channel (FCCH)
- Synchronization channel (SCH)

2.5.2.2 Common Control Channel (CCH)

This channel divided into three more sub channels:

- Paging channel (PCH)
- Random access (RACH)
- Access grant (AGCH)

2.5.2.3 Dedicated Channel (DCH)

This channel divided into 3 more sub channels:

- Stand alone control channel (SDCCH)
- Slow associated control channel (SACCH)
- Fast associated control channel (FACCH)

These are the channels of GSM system but our focus here is on UMTS. UMTS channels structure described below.

2.6 UMTS Channel Structure

- Logical channels
- Physical channels
- Transport channels

2.6.1 Logical Channels

2.6.1.1 Dedicated Control Channel (DCCH)

It is used for control information for transmission of user and signaling information to a specific mobile station during a call. It handles power control for the corresponding dedicated traffic channel DTCH and there is one DCCH for each user.
2.6.1.2 Dedicated Traffic Channel (DTCH)

The dedicated user traffic in downlink sends through dedicated traffic channel (DTCH) [6]. It is also use to carry information between user and network.

2.6.1.3 Broadcast Control Channel (BCCH)

The network informs the UE about the radio environment and the information provided through the broadcast control channel (BCCH).

2.6.1.4 Forward Access Channel (FACH)

This channel is uses for transmission of relatively small amount of data and it also used by the system to reply any mobile starts connected to others. [6]

2.6.1.5 Paging Channel (PCH)

Paging control channel is the downlink transport channel in UMTS and it carries the paging control channel, PCH is transport in the secondary common control physical channel. It uses when the cell receives a call and it has almost same function to the FACH. [6]

2.6.1.6 Common Control Channel (CCCH)

It requires establishing a dedicated link with the network and usually these types of channels added with RACH, PCH within in GSM. Many user of CCCH may use the CCH and they recognize by U-RNTI. [6]

2.6.2 Physical Channels

2.6.2.1 Dedicated Physical Data Channel (DPDCH)

It functions same as forward dedicated control channel in CDMA2000, which transports the mobile control information. It is also use to carry transport channel through the air interface.

2.6.2.2 Common Control Physical Channel (CCPCH)

There are two common control physical channels.
- Primary common control physical channel (PCCPCH)
- Secondary common control physical channel (SCCPCH)

2.6.2.3 Primary Common Control Physical Channel (PCCPCH)

This channel maps the broadcast channel. This channel detected by the cell phone due to fixed channelization code and it is relate to the synchronization channel. This replaces the first 2 bit of PCCPCH in every slot. Paging does through this channel (PCCPCH).

2.6.2.4 Secondary Common Control Physical Channel (SCCPCH)

This channel transmits the information contents to two transport channels PCH and FCH. It transmits alternatively slot by slot. [6]
2.6.2.5 Synchronization Channel (SCH)

This channel is used for cell search. Further divided into two synchronization channels such as:

- Primary synchronization channel
- Secondary synchronization channel

2.6.2.6 Primary Synchronization Channel

This channel is used for transmitting a modulated code and it is called “primary synchronization code”. Every cell in a UTRAN uses the same primary synchronization code.

2.6.2.7 Secondary Synchronization Channel

This channel is constructed by repeating an order of modulated codes of 256 and transmitted simultaneously with the primary synchronization channel. It is a different physical channel at the same time.

2.6.3 Transport Channels

2.6.3.1 Dedicated Transport Channel (DTCH)

The dedicated transport channels (DCH) are different to each user and common transport channels are common for all users in a cell. DCH explains both uplinks and downlinks are available in both FDD and TDD modes. It holds higher layer data and control information like, voice, video, handoff and signal measurements.

2.6.3.2 Dedicated Channel (DCH)

It is bidirectional direction and it carries user data and control.

2.6.3.3 Broadcast Channel (BCH)

It is a downlink channel and broadcasts system information and cell specific parameters.

2.6.3.4 Paging Channel

It is used for transmitting and paging messages and use for downlink channel as well. It allows the efficient UE sleep mode procedure.

2.6.3.5 Forward Access Channel

It is a downlink channel and it carries control information and short data packets.

2.6.3.6 Random Access Channel (RACH)

It is an uplink channel and it is used to transmit, signaling messages and short data packets. Transmission is subject to conflict.
2.6.3.7 Common Packet Channel (CPCH)

It is an uplink channel and it carries user data packets. The procedure performs the same way as the random access channel. Downlink dedicated channel provides power control and control command of this channel.

2.6.3.8 Downlink Shared Channel (DSCH)

It is a downlink channel and it carries user data, control information. It is share with several UEs. Physical layer may transmit the information in whole cell or part of a cell.

2.6.3.9 Uplink Shared Channel (USCH)

These channels are only use in the TDD mode and carry both control information and user data information.

2.6.3.10 Fast Uplink Signaling Channel (FAUSCH)

It carries signaling information when allocating dedicated channels and these channels are in used conjunction with an FACH.
Chapter 3: CDMA2000 and UMTS QoS

3.1 Quality of Service (QoS) factor with CDMA2000

As we already discussed about CDMA2000 in our previous chapter, now we discuss about Quality of Service (QoS) regarding CDMA2000 in this chapter.

If future networks need to fix their place in market then it should be fulfill all the demands and challenges we are facing until today. For this, we must think about the complete and proper definition of QoS. Commercial companies and subscribers always expect best QoS from network. QoS work is done by establishing QoS handling function for end-to-end delivery for multimedia services over 3G networks.

3.2 Main idea of QoS

All network traffic should be treated equally and this is main concept of QoS. The term Quality of Service (QoS) is used to verify different things and make sure to provide best quality of service to the subscriber. QoS also provides high standard and mechanism for high quality performance applications. By utilizing QoS mechanism, network provider or network administrators can use existing services efficiently and provide good quality of service. When we talk about QoS model than we have some specific applications and users as well which have more importance so some applications are much critical. In the basis of this we consider that some traffic needs priorities base treatment.

3.2.1 QoS Goal

The goal of QoS is to make sure to provide preferential delivery service for the applications, by utilizing sufficient bandwidth, controlling latency and make sure to control reducing data loss.

3.2.2 QoS mechanism

There are two types of mechanisms in QoS.

- Admission control
- Traffic control

3.2.2.1 Admission control

In this, mechanism determines which user is allowed to use network resources or applications.

3.2.2.2 Traffic control

In this, mechanism keeps apart traffic into classes and controls delivery to the network.

3.2.3 Use of QoS

Network administrators use QoS to manage the applications, such as multimedia applications.
So that they have the required bandwidth even in times of network congestion and put aside the network system to crash.

### 3.2.4 QoS provides the following benefits to improve Network:

- Improve user experience.
- It provides administrator control over network resources.
- Reduces cost by utilizing resources efficiently and reducing the need for extension or upgrades.
- Allow other applications to access the network.

### 3.2.5 Why we need to implement QoS?

In future the base of everything will be IP and similarly IP will be on everything so more applications, access and core network are combined together to IP based services and their architecture.

### 3.2.6 QoS application criteria

There are four types of parameters relating to QoS application criteria, which play a key role in any application these are such as:

- **Target throughput**
- **Delay/Latency**
- **Jitter**
- **Reliability**

#### 3.2.6.1 Target throughput (Kbps)

It is used to minimum data rate at which usable data can be delivering over the communication path from start to end.

#### 3.2.6.2 Delay/Latency (ms)

It is use to provide the maximum delay between sending packets from origin and deliver to destination point.

#### 3.2.6.3 Jitter

It is used to allow inter arrival delay between 2 consecutive packets are received within the same IP.

#### 3.2.6.4 Reliability

It is use to inform that how many numbers of packets are in error out of total number of packets being transmitted. It is in percentage.

### 3.2.7 QoS achieved!

QoS gains good results by applying these strategies:

- **Link Efficiency**
- **Packet Classification**
• Admission Control
• Queue Management
• Congestion Management
• Traffic shaping and policing

Applications supported by QoS

• VOIP
• Push to talk
• Packet Switched Video telephony
• Video streaming
• Low latency games

3.3 CDMA2000 QoS

As we know, that cdma2000 is backward compatible with cdmaOne. The quality available depends on the generation of equipment involved. From data user’s aspects, the most important QoS factor is likely to be the data rate. QoS level is derived from requirements by communication applications and generally has very small guidelines in wire lines and Asynchronous transfer mode network systems.

In general, information about QoS can be conveying in a variable length QoS information in messages on the signaling channels. This contains subscription data either the service is secure or non-secure. Service option contains the traffic channel type, reliability and rate. QoS in the wire-lines world utilizing 2 different approaches: qualitative and quantitative. The qualitative approach is stand on differentiated services, which is reservation less model. Quantitative approach is stand on integrated service that provides end-to-end QoS by reserving resources for data traffic. Resource reservation protocol (RSVP) signaling is a protocol that reserves resources. Integrated service is independent of the original mechanism used to provide the reservation. Originally integrated services specify traffic and path characterization for transmission. As we know, that CDMA2000 is a proposed standard for packet-based communication. CDMA2000 supports for direct spread and multi carrier and it is used only for forward link: frequency division duplex configuration is used for full support for packet and circuit data service up to 2 Mbps. As we know that, many contracts are based on signal quality and bandwidth availability because customers always want high-speed data transmission. The main idea behind supporting cdma2000 QoS is to manage a single class of Link access control layer (LAC) and Medium access control layer (MAC) because both provide procedures for handling different QoS requirements. QoS flexibility is limited. Efficiency being affected with the need to switch between resource management systems when different QoS level needed. [19]

3.4 CDMA2000 QoS Implementation

QoS is an end-to-end issue that requires the management in a proper manner. For this, we have different kind of architecture for different application and subscriber as well. If we talk about a wireless network, it should be proficient to handle different kind of applications with varying QoS objectives while optimizing the utilization of system resources. Generally, we classified our data application into 2 types.
3.4.1 Real time application

Real time applications are characterized by strict requirements to avoid and control minimum data rates, limits on delay between packet reached to destination and packet loss rates. For example, audio conferencing, video conferencing, VOIP etc. Each application should be handle uniquely because the requirements on data rate, delays and packet loss rate may differ from application to application.

3.4.2 Non- real time application

It is more typical of the generally used internet application are executed in the background. These kinds of application have no burden or strict rules on packet date rates, error rates and delays. For example, web browsing, interactive chat etc.

However, it does not matter whether we are using real time application or non real time application. We must provide subscriber differentiation in terms of providing preference to a certain user in resource contentious channel environment. For fulfill all these kinds of requirements regarding provide priority differentiation between users for both types of services, CDMA2000 explains two modes of QoS.

- Assured mode QoS
- Non-Assured mode of QoS

3.4.2.1 Non-Assured mode QoS

In this the application mode is mainly focused on delivery of packets by means of best effort schedulers and the only parameter that is specified for QoS is “Priority”. There is no specific requirement on packet transfer delays and data rates.

3.4.2.2 Assured mode QoS

In this mode, QoS accepted to specify limits on parameters such as packet transfer delays and allowed data rates. QoS characterized following parameters in this mode such as:

1. Priority:
   - It is similar to non-assured mode packet data service.

2. Data Rate
   - Mobile station can specify a preferred rate and the minimum acceptable data rate.

3. Data loss Rate
   - Mobile station can specify a requested data loss rate or the acceptable data loss rate.

4. Maximum delay
   - Mobile station can strict how long data octets can saved in the transmit buffer.

[21]
3.5 QoS carries for Multimedia Service in cdma2000

The future requirements of multimedia services are being included higher capacities, increased spectral efficiency and differentiated services. It is extended to support for multiple simultaneous services and much more than the services. It is also providing much higher data rate and multimedia QoS ability to carry multiple voice, packet data, circuit data and connections with QoS requirements. The MAC layer of cdma2000 provides system, which is handling to extensive enhancements to negotiate multimedia connections, operates multiple services and manages QoS trades between multiple active services. Layer 1 of the cdma2000 protocol stack does delivery of these multiple coexisting data streams over the radio interface. [20]. It is also supported multiple supplementary channels that can be operated with varying QoS characteristics to the individual services requirements.

3.6 UMTS QoS Introduction

Presently we are using many applications on internet like email, http, telephony, video conferencing, teleconferencing, E-commerce, voice over IP (VoIP), online gaming, video streaming etc. Normally Best effort service model is used in Internet to manage these facilities. For some applications like email, web etc. the best effort service model is suitable but for some high level applications like video streaming, video conferencing, teleconferencing we need better QoS. The user decides whether he is satisfied with the QoS or not.

Typically there are two kind of services one is called real-time service and the other is called non-real time. Real time services have inflexible requirement whereas non real time services have lenient requirements so we can say that every service has different QoS level. The highest priority goes to real time application because it relates to voice applications and the lowest priority goes to non real time applications because it relates to data packets. We always use first in first out algorithm (FIFO) in the UMTS QoS classes. QoS techniques always make network more complex and complicated. Best QoS is the real dream of an end user and it will take time to implement.

3.7 Main QoS Parameters in UMTS

There are four types of parameters, which consider in the UMTS QoS. The parameters are:

- Delay
- Delay variance (Jitter)
- Throughput
- Packet loss rate

3.8 Classes of UMTS QoS

UMTS Bearer service manages UMTS QoS. Conversational and streaming classes relate to real time applications where as interactive and background classes relate to best effort service model. These classes can be classified in the basis of these factors like Guaranteed bit rate, transfer delay, traffic handling priority etc. Traditionally, there are 4 types of classes relating to UMTS QoS which are flowing as:
3.8.1 Conversational Class

Video telephony is the best example of this class. Symmetric traffic type is used in it and guaranteed bit rate is provided. We fix minimum delay in this class. There should be no buffering in this class so we can also say that it is most sensitive and high-level class.

3.8.2 Streaming Class

All multimedia services come in the streaming class. Asymmetric traffic type is used in it and guaranteed bit rate is provided. We fix minimum variable delay in this class and buffering is allowed.

3.8.3 Interactive Class

Internet is the best example of the interactive class. Asymmetric traffic type is used and buffering is allowed in this class. There is no guarantee of bit rate because it uses best effort service model. Delay factor is also like medium.

3.8.4 Background Class

Similarly, Asymmetric traffic type is used in this class and email is the best suitable example of it. Buffering is also allowed and big variable delay exists in this class. Bit rate does provide any guaranteed because it relates to best effort service model.

3.9 UMTS QoS Requirements

As we know that, we must have to follow the standard of ITU-T (international telecommunication standard) regarding UMTS QoS. Therefore, ITU-T G.114 provides limits for voice services. Normally human ear is intolerant to jitter but tolerant is allowing to some extending to error with this limit, which is 3% Frame erasure rate.

3.9.1 Real time Service Requirements

According to the ITU-T, standard preferred range is 0 to 150ms whereas less than 30ms is unnoticeable. During real time services 150 to 400ms is tolerable range but more than 400ms is unacceptabile.

3.9.2 Interactive Service Requirement

As we are using internet in this class so it requires zero loss (error) and the delay tolerance is almost 2s to 4s for web applications with the target of 0.5 seconds. Email has the same standard of delay tolerance.

3.9.3 Background Service Requirement

Generally, the background service applications expect to receive data within a specified time and the specified time limit is quite high. During use of short messaging service (SMS) or fax the delay tolerance, about 30s is allowed.
3.10 Signaling and provisioning concept in UMTS QoS

End-to-end QoS needs QoS signaling and the main thing is that all elements of network should be informing about the QoS that is to be provided. QoS signaling take place through:

- Session initiation protocol (SIP)
- Resource reservation protocol (RSVP)
- DiffServ code points (DSCP)
- PDP context
- Similarly, End-to-end QoS also needs QoS provisioning through
- Over provisioning
- DiffServ (Differentiated services)
- MPLS (Multi protocol label switching protocol)
- IntServ (Integrated services)

There is no need to be the same of signaling and provisioning mechanism in all network but internetworking is allowable here. As we know that IP networks were not design to deliver QoS, so therefore all data packets are treating equally. Similarly, no resources can be reserve for any specific users or applications. During low load conditions, we can deliver real time services in IP protocol.

QoS provisioning possibilities are mainly exist between Over-provisioning, DiffServ and MPLS. IntServ is not considering here because it is not scalable. Network operator is doing selections of these models.

Now we take a look on these techniques one by one that why and how we implemented.

3.10.1 Over-provisioning

This technique is very simple to implement and manageable and provides soft QoS guarantees. It requires sufficient network resources. Usually it is best suitable for optical fiber backbone. It is not recommend when we have to use leased-line network.

3.10.2 DiffServ (differentiated services)

This technique is been considered better than over-provisioning. It is not so much complex in management and implementation. Semi-soft QoS guarantees are provided in this technique. This technique is highly feasible when a QoS guarantee does not need be absolute.

The basic function of Differentiated Services is to offer different levels of QoS to different traffic streams for network service provider. The core function of this model is to keep the forwarding path simple, avoid assumptions regarding traffic type and push complexity to the edges. Generally, there are 3 types of differentiated services that details are following as

3.10.2.1 Premium Forwarding (PF)

This service provides the abstraction of a virtual pipe between ingress and an egress router. This service has low delay (Jitter), low loss and guaranteed bandwidth. Premium packet has low delay and it is will not dropped. [18]. User may not send
more than the size of the pipe but if he sends more than excess, than traffic delayed and dropped when the buffer is overflow.

3.10.2.2 Assured Forwarding (AF)

This service has no guarantee on delay. It has low loss and targeted bandwidth rate. It is defined in advance how much traffic to be allowed to inject into the network. There are 4 classes with each 3 different levels of drop priorities. This service provides lower loss rate than best effort. During congestion condition, best effort packets are being drop first. User cannot send more traffic than its profile. However, if he sends more than excess than traffic converts into best effort. [18]

3.10.2.3 Best Effort (BE)

It is the type of traffic, which is use in the internet so there is no QoS guarantee.

3.10.3 MPLS

The last technique regarding this is called as multi protocol label switching. This technique requires more attention and effort as well because it always requires label switch path set-up and its maintenance. Hard QoS guarantees are provides in it and the reason is that label switching path bandwidth is reserved.
Chapter 4: ROUTING LOOPS

4.1 Introduction

As we know that the growth of internet is growing day by day, routing difficulty has been increasing, and network layer instabilities are becoming more common. Routing loops are one to such instabilities and because of this service ruin and sometimes end-to-end path breakdown.

While the router starts routing process, the packets moves forwarded in the best possible direction according to the available information in the local routing table. During this process if the routing table entries on all the routers are correct then the packet choose the best optimal path from source to destination. On the other hand, if in any case, routing table entries are not corrects or any other problem occurs like, misconfiguration or through learned router, which does not properly reflect the topology of the internetwork then this phenomenon, is called the routing loops. A routing loop is a path in which through the internetwork for a network ID that loops back onto itself.

4.2 Basic Routing Loops Definition

It can be defined as, “A network problem in which packets continue to be routed in an endless circle”. It causes by a router or line failures and the notification of the downed link has not yet reached all the other routers. [9]. It also occurs over time due to normal growth or networks merge.

4.3 Transient Loops

During routing process if any of the router sends packet to the wrong router not following the original loop then it is called transient loop.
As shown in figure above R2 sends and receive packet from R1 and R3 as well, but instead of sending back to the R3, it sends to the unwanted path, it breaks the loop and this phenomena known as “transient loop”. It always needs to update its routing tables from routing protocols.

4.4 Persistent Loops

These loops may cause for different reasons, most commonly, it occurs by the miss-configuration of routers. To remove the persistent loop we need human intervention. Persistent loops are not easy to analyze because of two reasons; firstly, they are difficult to find, mostly it is very rare,secondly they occurs across in multiple number of Autonomous Systems (AS). For that reason, they need cooperation from many network operation groups to analyze that problem.

4.5 Routing Loop Detection

It based on detection algorithm.

4.5.1 Detection Algorithm

To cross the fixed-point replicas are cause by routing loops, these sets of replicas known as “replica stream”. This corresponds to multiple initiations of the packet on single link. Therefore, we are using these replica streams for detecting the routing loops. This algorithm contains three main steps such as:

- Detect Replicas
- Validate Replica Streams (Sets Of Replicas)
- Merge Replica Streams into Routing Loops

This algorithm results collection of merged replica streams. Each of these sets representing that the routing loop occurred between first and the last packet in the set.

4.5.1.1 Detecting Replicas

We detect replicas of the same packet, while crossing a link by analyzing whether two packets are replicas of looping packet. Suppose we are considering two packets, “A” and “B” and after while, in packet “B” we have any single loop packet if their headers are the same except for the TTL and IP header checksum fields. During this process, their TTL values differ by at least two and similarly their payloads are the same. Now we consider IP identification field in the IP header serves to separate packets that is looped from those that are part of the similar connection.

4.5.1.2 Validating Replica Streams

In validation replicas, streams it must full fill the two conditions, for a set of replica packets to be the evidence of a routing loop. Firstly, we will remove those having only two elements; these affects are cause to make duplicate packets interjected by the link layer. Let consider an example, suppose the sender may be unsuccessful to drain a packet in the token ring or miss-configured “SONET” protection layer can transmits packets on both of the working and protection links.

Secondly, when we will verifying that all the packets, which contain same prefix as part of the replica streams during the time of proposed routing loop. While we
merge these replicas of packets with the destination, address with 24-bit prefix into the single replica streams. [9]

As routing loops indicate, a transition in routing state due to longest prefix match may change before and after transition. If data packet with similar destination subnet as replicated packet does not itself belong to a replica stream, then other replicas observed at that time cannot be due to a routing loop. As we know that loop should distress all packets to the destination.
Chapter 5: 3G protocols layers

5.1 Protocol layers

In this chapter, we discussed to compare the functionality of UMTS layers and CDMA2000 layers.

5.1.2 Layers of CDMA2000

We have three layers in CDMA2000 and last two layers called layer 1 and layer 2. Layer 1 is physical layer, layer 2 is the link layer, and the rest of layers are used to called application. Upper layer protocol referred to layer 3 to layer 7 of OSI reference model. Later on, we divided our layers into link access control (LAC) and the Medium access control (MAC) sub layers.

5.1.3 Basic idea

CDMA2000 can be configured in a different ways and majorly depending upon the system’s requirement. CDMA2000 accepts both single carrier and multiple carrier implementations and it is proposes same as a time division duplex mode. [10]

5.2 Physical layers

Physical channels of CDMA 2000 divided into two classes.

1. Dedicated Physical channels (DPHCHs)
2. Common physical channels (CPHCHs)

5.2.1 Dedicated physical channel (DPHCH)

In this channel, we transmit the information between the base station and mobile station. We have different forwarded dedicated channels and their names are such as:

- Fundamental channel (F-FCH)
- Supplemental channel type (F-SCHT)
- Dedicated control channel (F-DCCH)
- Dedicated Auxiliary pilot channel (F_DAPICH)

We have reverse forward channels and their names are such as:

- Fundamental channel (R-FCH)
- Supplemental channel type (R-SCHT)
- Dedicated control channel (R-DDCH)
- Pilot channel (R-PICH)

5.2.2 Common physical channels (CPHCH)

Forward physical channel

1. Pilot channel (F-PICH)
2. Common Auxiliary pilot channel (F-CAPICH)
Common channel Type (F-CCHT)

1. Paging channel (F-CCHT)
2. Common control channel (F-CCCH)
3. Sync channel (F-SYNC)

Common physical channel Reverse channel

1. Access channel (R-ACH)
2. Common control channel (R-CCCH)

5.3 The link access control (LAC) sub layer

This layer is used to concern with sharing and physical connection to the network among different computer or systems. As we know that, each computer has its own unique MAC address. For this thing Ethernet is a best example of a protocol that works at the media access control layer (MAC).

LAC is mostly encouraging the reliable point-to-point transmission over air interface for circuit data service and signaling service. It provides the reliable chain delivery for packets. This reliable delivery of packets can be implements by using ARQ over wireless network. [10]. LAC can be vanishing if MAC sub layer such as sequence delivery provides a service.

Fig 5.1 [22]
5.3.1 The Medium access control (MAC) sub layer

MAC layer of cdma200 provides wide enhancement to negotiate and support current situation. It is also manages QoS tradeoffs between service is already admitted into the system. [11]. MAC layers manage the resource that are available at the physical layer and co-ordinates the usage of the channel by allocating and re-allocating the codes.

MAC sub layer and logically belong to layer 2. MAC sub layer provides the multimedia services with the capability of satisfying different QoS requirements.

The primary function of the MAC sub layer is to multiplex logical channels into different physical channel and de-multiplex physical channel into different logical channels.

MAC consists of three components and their names are as fallows.

1. MAC control states
2. Radio link protocol (RLP)
3. Multiplexing and QoS control

5.3.2 MAC control states

MAC has four different states can be categorized into two groups depend on the data service which can be in active state or which can in-active state. A data service connected to the base station in the active state, control hold and suspended states but not in null state. MAC also provides the congestion control between multiple users and resolve channel access competition between multiple users. [11]

5.3.3 Radio link protocol (RLP)

This is layer 2 protocol and it is responsible for delivered the packets and bring acknowledgement after receiving packets from other side. As we know that during the transmission of the packets, some of them are receive with error so this layer try to make this process reliable transmission and best effort to delivered packets. Layer 2 entity uses one of several step or function to prevent packets error.

The mainly use of RLP for the delivery of user packet data and it is specially design for use over an air interface without the RLP layer entities such as TC/IP would be rendered useless if they interfaced directly with the error prone air interface.

The air link is inseparably error prone the RLP does not try to provide a sure delivery of packets over the air link. On the other hand, RLP provides a best effort delivery the packets up to the points and it make sure that packets delivered to the destination safely. If such a quality of service, (QoS) required, than RLP is majorly relied on the error control mechanism at higher layers to guarantee the delivery of user data.

Further reduce this problem the transmission of control packets over the air link; RLP uses negative acknowledgement (NAK), positive acknowledgment and retransmission mechanism. [13]

- Positive acknowledgment
- Negative acknowledgment
Retransmission

5.3.3.1 Positive acknowledgment

To make error free packets, the receiver sends to the transmitter an acknowledgment that packet has been received successfully. This acknowledgment is called “Positive ACK”.

5.3.3.2 Negative Acknowledgment

During the transmission packet received in error than receiver sends the acknowledgment to the transmitter, that packet has not been received successfully and called as NAK.

5.3.3.3 Retransmission

In this phase transmitter has re-transmit the packets, if transmitter did not receive any information from receipt side. Like system did not receive any error acknowledgment or any positive acknowledgment in a specific amount of time than it starts the re-transmission of the packets.

5.4 Reason of packet loss

In CDMA2000 packet data networks loss due to two main reasons that is congestion and corruption. Congestion is create due to many reason, but main cause is routing loops and buffer overflow problems. Corruption packet loss in wireless and it happened due to high bit error rate of wireless media.

5.5 OSI layer 3 to 7

Point to point protocol (PPP) layer provides a way to sum up IP datagram on a serial link. PPP itself is a combination of link protocol (LCP) and main network control protocols (NCPs). LCP is use to establish and test the data link connection. It is also allowing negotiation on various options like maximum receive unit (MRU) and authentication protocol. The PPP tunnel between packet data serving node (PDSN) and mobile station make changes in IP datagram impossible anywhere else at base station controller (BSC). NCP is use to tackle the appropriate network layer. It added the internet protocol control protocol (IPCP) that allows negotiation of IP address. DNS server address and IP compression protocol IPv6 is an NCP allows negotiation of interface PPP carried over the LAC, MAC and RP tunnels are utilize to establish connection between MS and PDSN.

User datagram protocol is another transport level protocol, which is connectionless. While UDP does not introduce any delay to establish a connection and it also use 8 bytes overhead. Only problem is that there is no assurance by receiver to receive the packets and there is no congestion control mechanism.

While TCP is, connection oriented and it has congestion control mechanism. TCP segment has 20 bytes header overhead in every segment, whereas UDP only has bytes of overhead. TCP designed to provide the reliable communication between pairs of process across the internet. It is suitable for reliable and unreliable networks.
CDMA2000 packet data networks pretend entirely different set of concerns as far as the TCP communication is concerned. We cannot make any changes unless we have required any changes in IP datagram. PDSN is the only place in the vendor network algorithm can be implement that introduce changes.

5.6 Layers of UMTS

There are several layers in UMTS, like layer 1, layer 2, link layer and the part of the layer 3, medium access control (MAC), the radio link control (RLC), broadcast/multicast control (BMC), packet data convergence protocol and all sub layer presents in layer 2. The SAPs provide the logical channel between the physical layer and link layer.

5.6.1 Physical layer

This layer is responsible to perform data or voice transmission by means of radio medium. These transforming of the frames coming from layer 2, into radio signal is the main function of this layer and after that it is responsible to translates received radio signal into logical channel.

5.6.2 The MAC sub layer

The main function of this layer is to perform the task of scheduling the radio bearers with different QoS requirements for data and voice traffic flows. It is also optimize use of the radio medium by sharing and it dynamically among users. The MAC layer works with the transport channels between physical layer, MAC layer and both control by RRC layer. On the request MAC, also provide the traffic volume and quality indication to the higher layers.

MAC has few following functions and points are such as:

1. MAC layer for each transport channel selection of suitable transport format and it depends on the instantaneous source rate.
2. Priority is handling of data by one UE.
3. Use common transport channels for identification of UEs.
4. Multiplexing or de-multiplexing of the upper layer of PDUs.
5. Used to monitor and measurements of traffic volume.
6. Ciphering for the mode transparent RLC.

If we are in the side of UE than MAC layer monitor the buffer of the uplink connection. In the same layer if we are in the UTRAN side monitoring the transmission buffer in the downlink connection.

5.6.3 The RLC sub layer and its Services

RLC is layer 2 protocol in which is used for error control, flow control or user data. Functionality of Automatic repeat request (ARQ) to realize in the RLC sub layers and the re-transmission protocol and make sure that the optimum utilization of the available radio re-sources get it without incurring excessively long delays. It performs the following tasks, which are giving below.

1. RLC channels is enough efficient to transmission and re-transmission.
2. Using error correction mechanism it controls the radio link quality and its hide a lossy radio link from upper layers like those that we have in TCP.
3. RLC is use to reduce the errors conceived by upper layer such as TCP.
The MAC control radio resource on a fast basis in this sense that given the transport format grouping of set assigned by RRC. By adjusting the high number of re-transmission, the protocol can be configuring by upper sub layer. These RRC sub layer provide the three different levels of Quality of services (QoS) and there are three types of services, which are provide by RLC to high layers.

1. Transparent mode (TM)
2. Unacknowledged mod (UM)
3. Acknowledged mode (AM)

5.6.3.1 Transparent mode (TM)

Transparent mode offers service for transmitting high layers packet data unit (PDUs) without sum up of any other protocol information. Segmentation and reassembly can or cannot be configure by upper layers. The transparent mode performs well with delay sensitive service for example; speech, audio and video are these services do not make use of re-transmission on low-level layers. Transparent mode also provides a dropping mechanism that stops delivery of already expired PDUs.

5.6.3.2 Unacknowledged mode (UM)

Unacknowledged mode offers service for transmitting without assurance of delivery to the peer RLC entity. Whenever loss of PDUs is detected higher layer got information by RLC. At the same process, duplicated or corrupted PDUs received from MAC sub layers discarded and the loss signaled.

5.6.3.3 Acknowledged Mode (AM)

This mode is certainly changes from other modes. The acknowledged mode offers service for transmitting higher layer PDUs and it gives the reliable link to the RLC peer entity with very small doubts of undetected error and low level of loss for upper layer traffic. The substitution between quality and delay of RLC can be control by RRC through setting a suitable number of allowed re-transmission provided by RLC.

5.7 Types of RLC PDUs

There are two types of RLC PDUs.

1. Acknowledged mode data PDU (AMD PDUs)
2. Status information control PDU (Status PDU)

5.7.1 Acknowledged mode data PDU (AMD PDUs)

It contains the user data and sequence number and it is grab the other possible information-polling bit is present in (AMDPDU).

It contains the status information about the transmitter and receiver window size and it is also try to get other possible information as well. It also contains the missing block information from RLC SDU discard mechanism information.
5.7.2 Status transmission mechanism

This mechanism is another way of sending status PDUs. It is motivates by the receiver as a substitute of the sender. In that case, this mechanism can allow the receiver to send status PDUs more forcefully. During this mechanism receiver, send detection of missing PDUs and trigger can make the receiver send status PDUs to request for retransmission. When the receiver detects one or more missing PDUs it sends status to PDUs. It is effective in delay, during this mechanism the status period timer trigger requests the receiver to send status PDUs back to the sender periodically.

The estimated PDU counter (EPC) mechanism makes the receiver to send status PDUs more energetically by estimating the time needed to recover the incorrect AMD PDUs. All this information include in the last message of status PDU. All triggers of the status transmission mechanism are set optionally in the RLC.

5.8 Polling Mechanism

In this mechanism, the polling sends request to the sender and when receiver gets his request and replying one or more PDUs back to the sender. The receiver for the status transmission mechanism triggers sending a status PDU. This phenomena is works or it happened when ever error or lost AMD PDUs.

5.9 Detection of missing AMD PDUs

Whenever receiver finds or detects one or more AMD PDUs than one or more PDUs will be send to the sender immediately and request of the re-transmission of missing AMD PDUs.

5.9.1 Timer based status transmission

This timer is always start when the RLC entities created and after that timer is expires than the status PDUs is transmitted. On the other hand, it will make reset the timer.

5.9.2 EPC mechanism

This mechanism provides us to reasonable limit for exchanges of status PDUs. In this mechanism, we use timers whereas timer control the period of scheduling. The transmission of status PDUs is set each time the first status PDUs is submit to the lower layer. For recovery the set of number of AMD PDUs, we used state variable V_R (EP). If in this, we did not receive any AMD PDUs request for re-transmission and it will make all V_R (EP) equal to zero. New status of PDUs is delivering by receiver. Whenever the condition during the transmission, status of report triggered while V_R (EP) if it is not equal to zero, then the status PDUs will be delay until it become less or to zero.

5.9.3 The timer prohibits the receiver

As we know that timers play important role during transmission cause of this receiver is not allow transmitting the status of PDUs before the timer expires.
5.10 SDU discards mechanism

When the number of transmission attempts or AMD PDUs does not succeed within a period than this mechanism allows the sender to discard the AMD PDUs related with a SDU from the transmission. It is also cause of reduce maximum transmission delay and buffer.

There are two kind of SDU discard mechanism and it can be configure according to the QoS demands. Their name and function as follows.

1) Time based discard with explicit signaling.
2) RLC SDU discards after MAX DAT number of transmission.

5.10.1 Time base discard with explicit signaling

The main cause of this time based discard to controls the maximum delay of each RLC SDU and make the SDU discard function indifferent variation of the channel data rate error and it may cause the SDU loss rate increase. A timer in progress for each RLC SDU received from upper layers. Whenever sender discarded the SDU, uses explicit signaling to inform the receiver of the discarded SDU.

5.10.2 RLC SDU discards after number of transmissions

RLC SDU discards the function alternatively after number of transmissions. It makes effort to keep the SDU loss rate stable. However, its delay performance is dependent on the channel condition. The sender discards all RLC SDUs holds the AMD PDU and uses explicit signaling to inform the receiver about the discarded AMD PDU by sending a status PDU.

5.11 The PDCP sub layer

Main function of this Packet data convergence protocol layer (PDCP) is transmitting and receiving of network layer data units. This protocol exists only in the user plane and only service for packet switched services. It also serves as convergence layer between the network layer and the RLC sub layer.

Functions are as follows.

- The transmitting and receiving entity respectively header compression and de-compression of IP data streams and such as, TCP/IP and UDP/IP headers for IPv4 and IPv6.
- Transfer of user data and this function is used for convergence of data between users of PDCP services.
- This services provided by the radio link control sub layer are use by PDCP.
- PDCP also provides protocol Control information compression.

5.11.1 The BMC sub layer

The broadcast/multicast control layer (BMC) and handles the messages and responsible for non-control information to user. It provides very low bit rate and there is no publication examining its performance. SMS cell broadcast service is one of the important services using this layer. This service is exists only in user plan cell.
1. Storage of cell Broadcast messages
2. Scheduling of BMC messages
3. Transmission of BMC messages to UE

### 5.12 Radio Resource Control (RRC)

It provides and controls the MAC and RLC sub layers and usually RRC covers. It also responsible for reliable connection and it is layer 3 protocol. The main function of RRC handles is the broadcasting of system information and data originated from the UTRAN and core network data.

- Configuration of the MAC, RLC
- Request for traffic volume measurements from RRC
- Controlling transmission time interval (TTI) of transport channels
- Governing data specific parameters in RLC and MAC
- Radio resource control has the following functions and it used for setting up, re-configuration and re-establish radio bearers
- Cell broadcast service (CBS) control
- Initial cell selection and cell re-selection
- Paging
- Broadcast of information
- Establishment, maintenance and release of an RRC connection between the UE and UTRAN of Radio bearers
- RRC message integrity protection
- Arbitration of radio resources on uplink DCH
- Slow dynamic channel allocation (DCA) (TDD mode)
- Timing advance (TTD mode)
- RRC connection mobility function (RNC relocation)

### 5.13 The application sub layers

The application functionalities depend upon openly or closely radio resources and it contains reconfiguration of the application. It is not control by the application itself. Therefore, we can realize functionalities that depend on not assured infrastructure like reliable communication of QoS.

### 5.14 Comparison between UMTS and CDAM2000 Layers

1. In CDMA2000, we have three layers and last two layers are layer 1 and layer 2. Whereas layer 1 is physical layer, layer 2 is the link layer and the rest of layer use to called application upper layer protocol. This layer is referred to layer 3 to layer 7 of OSI reference model. Further, we divided our layers into link access control (LAC) and the Medium access control (MAC) sub layers.
2. CDMA2000 configure in a different of ways and majorly depends upon the system. Cdma2000 accepts both single carrier and multiple carrier implementations.
3. CDMA2000 link control access (LAC) is used to concern with sharing physical connection to the network among different computer or systems. It also provides segmentation and re-transmission for user and control data.
4. CDMA2000 MAC layer is resource that are available at the physical layer and co-ordinates the usage of the channel by allocating and re-allocating the codes.
5. PS domain service in UMTS supported by PDCP in the user plane and PDCP contain compression methods between MS and PDSN of CDMA2000.
6. UMTS PDP context is comparable to PPP connection, which is equivalent to packet data session in CDMA2000.
7. There is no PPP/IP connection is established between MS and SGSN in UMTS control plan.
8. UMTS signaling carries over the RRC and Iu connections.
9. UMTS user plane provides two alternatives for IP services.
10. Non-PPP lower layer protocol support IP.
11. IP supported by PPP.
12. Mobile IP introduced in UMTS. [14]
Chapter 6: 3G Channel Structure

6.1 UTRA Channels

Universal terrestrial radio access interface (UTRA) has many logical channels, which are mapped to the transport channels and further going on this process. We observe that these channels again mapped to the physical channels. All conversation between logical to transport channels is done in Medium access control (MAC) layer and we know that, it is the lowest sub-layer in the data link layer (L2).

6.2 UMTS Channels

There are 3 types of channels in UMTS which are following as:
- Logical Channels
- Transport Channels
- Physical Channels

6.3 Logical channels

There are six types of logical channels and their brief discussion is giving below.

6.3.1 Common Control Channel (CCCH)

Common control channels (CCCH) are used to support the common procedures, which are required to establish a dedicated link with the network. They reside in the same cell if the task is common for all user equipment. For example more than one user may use the control channel in common control channel (CCCH) and they called as U-RNTI (UTRAN radio network temporary identity).

6.3.2 BCCH - Broadcast Control Channel

Broadcast control channel is a downlink channel and it contains some special parameters, which are needed by a mobile. Network can be identified by it and gain access as well. Some specific information contains like, routing area code (RAC), location area code (LAC), Mobile network code (MNC) and BCCH allocation list. It is a constant power level channel. It broadcasts cell and information of system.

6.3.3 Dedicated Control Channel (DCCH)

Dedicated control channel is a point-to-point bi-directional channel. It transmits dedicated control information between user equipment (UE) and the network. It is established by the radio resource control (RRC) connection setup method. It controls the information rate and handles power control for the dedicated traffic channel (DTCH). For each user there is one dedicated control channel (DCCH). This channel is used for sending the control information. All the control information of dedicated and active connection is sent through dedicated control channel (DCCH).

6.3.4 Forward Access Channel (FACH)

Forward access channel is a transport channel and it is used for downlink signaling and small data quantities as well. It forms the downlink half of a transport channel pair
is reputed as forward access channel (FACH) or random access channel (RAC). It is simple downlink channel without closed loop power control. This channel is using by the network to reply to any mobile initiating call. It is used for transmission of very small amount of data as well.

6.3.5 Paging Channel (PCH)

It is downlink transport channel, which carries the page control channel (PCCH). It is used for notification messages in a cell and use for broadcast paging. The paging channel is used by the system to transfer control information (setup info of call) to the mobile station. When a mobile receives a call and its functionality is similar to the forward access channel (FACH).

6.3.6 Dedicated Traffic Channel (DTCH)

Dedicated traffic channel is a point-to-point channel. This channel dedication to the mobile for the transfer of information about user. It can support both uplink and downlink direction.

6.4 Transport Channels

There are 4 types of transport channels and discussion is given below.

6.4.1 Dedicated Transport Channel (DTCH)

The user equipment is identified by the physical channel i.e. frequency for TDD code and frequency for FDD time slots.

The types of dedicated transport channels are:

- Dedicated Channel (DCH)
- Broadcast Channel (BCH)

6.4.1.1 Dedicated Channel (DCH)

This channel is allocated to an individual user. It is used for both uplink and downlink.

6.4.1.2 Broadcast Channel (BCH)

Broadcast channels are used to broadcast the system information into the whole cell area. It is a downlink channel. We have single center and multiple receivers with different rate requirement in this channel.

6.4.2 Forward Access Channel (FACH)

Forward access channel (FACH) handles small quantities of data and it is downlink-signaling channel.

6.4.3 Paging Channel (PCH)

Paging channel (PCH) is always used to broadcast information over the whole cell. It is a downlink transport channel. This channel allows Sleep-mod procedure to the user equipment.
6.4.4 Random Access Channel (RACH)

Random access channel (RACH) is an uplink transport channel and it is used for transmission of small amount of data e.g. For initial access or non real time dedicated control or traffic data. Normally random access channel are received from the entire cell. This channel is transmitted using open loop power control and characterized by collision risk.

6.5 Physical Channels

There are 3 physical channels which are as follows.

6.5.1 Dedicated Physical Data Channel (DPDCH)

The dedicated physical data channel is an uplink dedicated physical channel. This channel consists of one control and one logical channel. It is same as forward dedicated control channel in CDMA2000, which transport the mobile specific control information. On each radio link there can be zero, one or many uplink dedicated physical data channel DPDCH.

6.5.2 Common Control Physical Channel (CCPCH)

There are two types of common control physical channels, which are

- Primary Common Control Physical Channel (PCCPCH)
- Secondary Common Control Physical Channel (SCCPCH)

6.5.2.1 Primary Common Control Physical Channel (PCCPCH)

Primary common control physical channel is used to broadcast information for users and for synchronization. The procedure of paging is gone through primary common control physical channel (PCCPCH). In one cell only one Primary – CCPCH can be exist. In this channel, there is not transmitting power control commands neither transmission of pilot bits nor transport formats combination indicator. This channel does not transmit during first 256 chips of each slot.

6.5.2.2 Secondary Common Control Physical Channel (SCCPCH)

The secondary common control physical channel contains the forward access channel and paging channel. Paging channels and forward access channels are transmitting alternately slot by slot in the UMTS system.

6.5.3 Synchronization Channel (SCH)

Synchronization channel allows the mobile station (MS) to synchronies with the base station (BS) with received signals, which is strongest. This is downlink-signaling channel used for cell search.

This channel consists of two sub channels, which are following as:

- Primary Sub Channel
- Secondary Sub Channel
All base station transmits the equal PN code on the primary sub channel at different time intervals. If we compare the timing interval to the expected arrival delay then we will find that it is much larger. Due to this reason, PN bursts arrive at discrete intervals of time. The 10ms radio frames of the primary sub channel and secondary sub channels divided into 15 numbers of slots and each of length 2560 chips.

### 6.6 Channels of CDMA 2000

The mobile station (MS) and base station (BS) communicate by many physical channels that are transmitted on give frequency assignment. Channels can carry either user information, control information or both as well here. The aggregate set of all these channels usually called CDMA channel. A CDMA channels consists of two kinds of channels, which are called as forward CDMA channels and reverse CDMA channels, which consists of multiple physicals channels.

#### 6.6.1 Forward Channels of CDMA2000

These are forward channels of CDMA2000 and the detail is given below:

##### 6.6.1.1 Pilot Channel (F-PICH)

Pilot channel (F-PICH) supports applications like smart antenna and similarly it transmits and permits diversity. This channel provides the capabilities for coherent detection and soft handover.

##### 6.6.1.2 Quick Paging Channel (F-QPCH)

Quick paging channel (F-QPCH) is used for longer battery lifetime and for increased standby time as well. It also improves slotted Walsh codes W80 128, W48 128, W112 128; these are reserved for quick paging channel.

##### 6.6.1.3 Common Control Channel (F-CCCH)

Common control channel is used to transmit the mobile directed messages for CDMA2000 mobile phones. This channel supports various data rates and also provides the capability for short burst data communication as well. It also provide mean for paging function.

##### 6.6.1.4 Broadcast Channel (F-BCCH)

Broadcast channel (F-BCCH) is used to broadcast transmit and overhead the messages (e.g. short messaging service). The major function of this channel is transmitting and broadcasting.

##### 6.6.1.5 Common Power Control Channel (F-CPCCH)

Common power control channel (F-CPCCH) transmits power control bits to multiple mobile phones. This channel is used together with the enhanced access channel procedure. The procedure, which are in the enhanced access channel common power control channel (F-CPCCH) are used with that procedure.
6.6.1.6 Common Assignment Channel (F-CACH)

Common assignment channel (F-CACH) facilitates quick response of reverse link channel assignment. This channel is used together with the enhanced access channel procedure.

6.6.1.7 Forward Fundamental Channel (F-FCH)

Forward fundamental channel (F-FCH) is used to transmit the user information to a specific mobile phone during a call. This channel also transmits the signaling with various data rates. Each traffic channel may contain forward fundamental channel (F-FCH).

6.6.1.8 Forward Dedicated Control Channel (F-DCCH)

Forward dedicated control channel (F-DCCH) is used to transmit the signaling information to a specific mobile phone. Each forward traffic channel may have one forward dedicated control channel (F-DCCH).

6.6.1.9 Forward Supplemental Channel (F-SCH)

Forward supplemental channel (F-SCH) is used for high data rate. This channel transmits user information to a specific mobile phone. Each traffic channel may have two forward supplemental channels (F-SCH).

6.6.1.10 Power Control Sub Channel

Power control sub-channel is used together with the forward fundamental channel (F-FCH) and forward dedicated control channel (F-DCCH) as well. [2]

6.6.1.11 Sync Channel (F-SYNC)

Synchronization channel (F-SYNC) is used for synchronization and information of the system. This channel provides the mobile station, system information and synchronization. The bit rate of the synchronization channel (F-SYNC) is 1200 bps.

6.6.1.12 Paging Channel (F-PCH)

Paging channel is used for short burst communication. This channel enables the paging functions and it is also used to send paging messages and control information from base station (BS) to the mobile station (MS).

6.6.2 Reverse Channels of CDMA2000

There are following reverse channels of CDMA2000.

6.6.2.1 Reverse Access Channel (R-ACH)

Reverse access channel (R-ACH) is used to initiate a call. Through multiple reverse access channels (R-ACH) mobile station (MS) communicate messages with the base station (BS). Clotted aloha access scheme is used in this channel.
6.6.2.2 Common Control Channel (R-CCCH)

Common control channel (R-CCCH) is used to initiate call in reservation access mode. This channel is also used to transport control information. Its functionalities are same as of reverse access channel.

6.6.2.3 Fundamental Channel (R-FCH)

Fundamental channel (R-FCH) carries voice traffic and it may carry signaling data as well. This channel is designed to transport dedicated data. Its functionalities are same as forward fundamental channel (F-FCH).

6.6.2.4 Dedicated Control Channel (R-DCCH)

Dedicated control channel (R-DCCH) is used to transport mobile specific control information. This channel carries signaling data. It is an optional channel.

6.6.2.5 Pilot Channel (R-PICH)

Pilot channel (R-PICH) provides the capabilities for coherent detection. This channel allows base station (BS) receiver to perform synchronous detection. CDMA2000 uses pilot symbols for uplink and downlink. These are the symbols, which are sent by the transmitter and after that, receivers are able to detect the phase of the signal.

6.6.2.6 Reverse Traffic Channel (R-TCH)

Reverse traffic channel (R-TCH) structure is almost same like forward traffic channel. This channel may include reverse fundamental channel (R-FCH), reverse pilot channel (R-PICH) and reverse dedicated control channel (R-DCCH) and one or many reverse supplemental channel (R-SCH).

6.6.2.7 Reverse Supplemental Channel (R-SCH)

Reverse supplemental channel (R-SCH) is used for carrying the data traffic. This is a dynamically allocated channel to meet some specific data rate. It is an optional channel.

6.6.2.8 Reverse Enhanced Access Channel (R-EACH)

Reverse enhanced access channel (R-EACH) is used to initiate call more efficiently comparatively reverse access channel (R-ACH). It is an optional channel. This channel is used by the mobile station (MS) to initiate communication with the base station (BS). It transmits short messages as MAC messages and used by response to pages.

This is all about CDMA2000 channels now we compare both the channel structures.
6.7 Comparison of UMTS and CDMA2000 Channels

Synchronization channel (SCH) of UMTS has two sub-channels, which are named as primary and secondary sub-channels. These channels are similar to the forward synchronization channel (F-SYNC) in CDMA2000.

Time multiplexed common pilot channel (CPICH) of UMTS has two types of channels, which are named as primary and secondary. If we compare these channels with the CDMA2000 channels then we find that these are similar to forward common auxiliary pilot channel (F-CAPICH) and forward pilot channel (FPICH) of CDMA2000.

Paging channel (PCH) of UMTS carried by secondary common control channel (S-CCPCH). The rate ID of this channel is not same for different cells and therefore can be set to provide the required capacity for paging channel (PCH) and forward access channel (FACH) in each specific environment. If we compare this channel with the CDMA2000 channels then we can found that forward paging channel (F-PCH) is similar.

With slight differences dedicated physical control channel and data channel (DPCCH and DPDCH) in UMTS is similar to forward dedicated control channel (F-DCCH) and fundamental channel (F-FCH) in CDMA2000.

If we compare the dedicated physical control channel (DPCCH) and dedicated physical data channel (DPDCH) of UMTS is similar to the forward dedicated control channel (F-DCCH) of CDMA2000 with minor differences.

Forward access channel (FACH) of UMTS relates to forward common assignment channel (FCACH) of CDMA2000.

Dedicated physical control channel of UMTS is similar to the reverse dedicated control channel (R-DCCH) and reverse pilot channel (R-PICH) of CDMA2000 in the Uplink. Whereas dedicated physical data channel (DPDCH) of UMTS is similar to the reverse fundamental channel (R-FCH) and reverse supplemental channel (R-SCH) of CDMA2000.

Physical common packet channel (PCPCH) and Physical random access channel (PRACH) of W-CDMA is correspondent for reverse common control channel (R-CCCH) and reverse access channel (R-ACH) of CDMA2000.

In the Uplink mode, the pilot symbols transmit by the code multiplexed dedicated physical control channel (DPCCH) in the UMTS. [2]. Whereas CDMA2000 has a pilot channel (R-PICH), which consists of a fixed reference value (pilot symbol) and multiplexed forward power control (PC) information.
Chapter 7: Mobility and Handover in 3G

7.1 Introduction to Mobility

All telecommunication systems have to provide the mobility service to every subscriber in every part of the world in future. Nowadays only mobile network equipment provides this facility. A static or meshed network provider should provide mobility services to their users in order to stay in the present competition. The amount of signaling traffic will increase in obviously manners due to mobility management, in mobile networks due to high transmission demand and increasing number of subscribers and in fixed networks due to deregulation of market because of the possibility for the subscriber to change the service provider by keeping his or her personal communication number. Now we can analyze how much the difference between possible user mobility processes. Like, some of the users are seemed that they are mobile and some users are seemed almost fix but they should be capable of change their location in any scenario.

7.2 Mobility/Roaming

Subscriber can move freely all around their own network and have the ability to change the network. The main requirements of this feature, trace the network tracks and find out exact location of each subscriber in order to reliable delivery of messages and calls.

7.3 Introduction to Handover

Handover mechanism assures that whenever any mobile is moving from one base station (BS) area to another, the radio signal is handed over to the target base station (BS).

Location update procedure and paging mechanism assures that the mobile station (MS) can be reached even there is no continue radio link between the mobile and its related base station (BS).

The location procedure initiates by the mobile station (MS), whereas paging mechanism initiates by Network.

7.4 Handover

The subscriber transitions from one radio channel to another as he moves from one cell to another while engaged in a conversation.

7.5 Mobility and Handover Issues

Mobility allows the possibility for the mobile subscriber of being reachable everywhere and at every time.

Managing the mobile terminal mobility is one of the most essential parts of cellular system functionality.
In a radio communication system Paging, Location Update and Handover Operations provide the User mobility.

**7.6 Handover Control**

Handover is one of the most important terms in all the radio communication system. It provides guarantee for the user mobility in the mobile communication network.

The main concept of handover control is that when a subscriber moves from one coverage area to another coverage area then a new connection with the new target cell is established and the connection is associated with the old cell would be release.

**7.6.1 Reasons behind the Handover**

The main reason behind the handover is that air interface connection is not able to fulfill the desired criterion that is set for a standard quality of service (QoS) and therefore network initiates handover in order to maintain a well standard procedure.

A Handover criterion is being set which decides when the handover will be performed or when not performed. Some specific values and parameters are given to perform a reliable handover.

Handover can be occur due to these following reasons, which are quality of signal, user mobility, traffic distribution etc.

**7.7 UMTS Radio Access Network Architecture**

Radio Network Controller (RNC)
Radio Network Subsystem (RNS)
Node B have the ability to support FDD/TDD or both
- UTRAN comprises more than one RNSs
- Handover decisions requiring signaling to the UE is responsible by RNC
- FDD or TDD techniques are offered in the cell

### 7.8 Mobility Support in UMTS:

From and to other systems or networks (e.g. UMTS to GSM)
In the beginning, UMTS coverage facility will be poor.

- RNS controlling the connection is called as serving radio network subsystem (SRNS)
- RNS also offers some additional resources such as soft handover and it is called as Drift RNS
- End to end connections between CN and UE only via Iu at the Serving RNS

If some changing happen in SRNS then it requires some change also in Iu.

- Initiated by the Serving radio network subsystem (SRNS)
- Controlled by the both CN and RNC
7.10 Mobility Support in UTRAN Macro Diversity

- Multicasting of data through many physical channels
  - Only FDD mode
  - Enables soft handover

- Uplink
  - Continuous reception of UE data at many Node Bs
  - Data Reconstruction at Node B, DRNC, SRNC

- Downlink
  - Continuous data transmission through different cells
  - Different cells have different spreading codes
These are all issues, which are concerned about mobility and handover in the UMTS.

### 7.11 Reasons behind the Handover

Normally there are 2 reasons when handover occurs. The conditions of the handover are

- Signal Quality handover
- Traffic handover

#### 7.11.1 Signal Quality handover

Signal quality handover occurs when the strength or quality of the signal falls below some certain level which is specified in the handover criteria.

Falling of the signal is detected through constant signal measurements, which are taken by Mobile terminal (MT) and Base Station (BS).

It can be applied for both uplink and downlink radio links.

#### 7.11.2 Traffic handover

Traffic handover occurs when the traffic capacity in a cell has reached a maximum level or almost approaching near to it.

The user equipment which exists at the edge of a cell and if it has a high traffic load can be handed over to neighboring cells which has some less traffic load.

The load of a system can be distributed uniformly. How many number of handover occurs in one certain time it all depends on degree of mobility.

It is very clear that if any mobile node (MN) moves with high speed then more handovers will be occur in the network.

The mobile node (MN) with high speed may be handed over from micro-cell to macro-cell to avoid undesirable handovers.
Similarly if mobile node moves slowly then may be handover over from macro-cell to micro-cell to avoid save its battery consumption. Radio signal strength can also be improved in this way.

7.12 Handover Failure

In telecommunication field we are facing many challenges by passing everyday and handoff failure is also one of them issue. Some time it happens in our life that when a call is going on we experience to terminate the call. The numbers of cellular users are increasing by everyday all over the world. The size of cell reduced to overcome this problem. Normally we give more priority to ongoing calls rather than new incoming calls to provide better quality of service to the cellular users. When a cellular call is going on and a user moves from one coverage area to another than user expects continuity with good QoS. As we know that handoff can occur due to quality of signal, user mobility etc.

The phenomena of Handoff takes place when a cellular user reaches some specific point. The service provider sets threshold point. We can also say that these threshold values about handoff are not fixed and they can be change case to case.

7.12.1 Handoff Failure Improvement strategies

Normally there are three kinds of handoff strategies, which implement on personal communication service (PCS) networks. These strategies classify in the basis of whom initiate and who execute the handoff. The strategies are:

7.12.1.1 Mobile controlled Handoff (MCHO)

Mobile controlled handoff strategy is much desirable when it does not burden the network. When we try to implement this strategy then the complexity of mobile terminal is also enlarged so it becomes little problematic.

7.12.1.2 Network Controlled Handoff (NCHO)

During network controlled handoff strategy, Base Station (BS) monitors the signal quality from cellular mobile. After this mobile switching center (MSC) chooses the best BS and then initiates handoff. During this process mobile plays a passive role.

7.12.1.3 Mobile Assisted Handoff (MAHO)

Mobile assisted handoff (MAHO) strategy is employed by Global system for mobile communication (GSM). During this strategy, cellular mobile records signal levels from different Base stations. Base stations (BSs) generate periodic beacon for this thing. In the meanwhile cellular mobile relays power levels from various base stations (BSs) to MSC through present BS.

7.12.2 Other Handoff Strategies

There are also some handoff strategies, which relate to handoff failure problem. The selection of these strategies is also much critical because in some way it looks like a tradeoff between QoS and network operating cost. These strategies are:
7.12.2.1 Non-Prioritized Handoff Strategy

During non-prioritized handoff strategy, all new calls and handoff calls use total number of \( N \) channels, as they are idle. However, if all channels are busy at any moment and in the same time a new call arrive then the call will blocked. On other side if any handoffs call arrives at this moment then it will be forced to terminate and handoff failure occurs. This strategy mostly used in many PCS radio technologies.

7.12.2.2 Reserve Channel Strategy

During reserve channel strategy, we reserve some channels for handoff calls. It is same as like non-reserve channel except one condition, which is that if total numbers of channels \( N \) are busy at any moment and a new call arrives then it will be blocked but in the same time a handoff call arrives here then it will be attended and will not be forced to terminate. [17]

It is the Flow chart of prioritized reserve channel scheme. In this flow chart, it is described how a handoff call is treated and what are the conditions and operations apply through this procedure.

![Flowchart of Prioritized Reserve Channel Scheme (PRCS)](image)

According to this flowchart, it is obviously clear that if any handoffs call arrives than a free channel is being allocated for the continuity of call. However, if not possible because of channel availability than call will be force to terminate.

If we increase the number of reserve channels than we will observe by increasing the reserve channels gradually the probability of handover failure reduces. This phenomena is also shown in the below mentioned fig.
Furthermore if we carry out this observation if we fix 25 % as reserve channels of the total number of channels than we observe the handover failure probability decreases tremendously.

Therefore, it can be suggest here that we can fix the reserve channel up to almost 25 % of the total number of channels. Moreover, in this way we can reduce handover failure probability according to our QoS demands.

**7.12.2.3 FIFO Priority Strategy**

During first in first out priority strategy, next handoff call is selecting on a first in first out basis (FIFO).
7.12.2.4 Measurement Based Priority Strategy

This strategy uses a non-preemptive dynamic priority policy. MSC receives power level from base station of the new call and then priorities defined on this basis. The power level monitors dynamically by the network of the handoff calls in the waiting queue.

7.12.2.5 Sub-Rating Scheme (SRS) Strategy

As we know that sub-rating is a procedure in which we split temporarily an occupied full rate channel into two channels. [16] This strategy makes a new channel on a blocked BS for a handoff access attempt by sub-rating a present call.
Simulation in Mat-lab

We used Mat-lab to simulate our graphs. By using matlab, we are able to generate handover failure probability graphs. After this we analyzed graphs and made conclusions for this simulation.

There are some important terms which we used in our source code. The terms are:
- S: total number of available channels
- Pb: blocking probability
- Ph: probability of handover failure
- Pft: probability of forced termination
- Pnc: probability of not completed call
- rho_o: offered traffic load in Erlang/cell

Source Code of Simulation

clc
close all
clear all

%function Z,F&B.H_FT

s = 10; my = 1/3 ;rr=1.2; rho_o=2;
eta=0.5*my;
t=60./([1:12]*eta);

for k=1:12;

[pb1(k), ph1(k), pft1(k), pnc1(k) ,p1,lam1] = handoff (s,0,my,eta*k,rho_o);
[pb2(k), ph2(k), pft2(k), pnc2(k) ,p2,lam2] = handoff (s,1,my,eta*k,rho_o);
[pb3(k), ph3(k), pft3(k), pnc3(k) ,p3,lam3] = handoff (s,2,my,eta*k,rho_o);
[pb4(k), ph4(k), pft4(k), pnc4(k) ,p4,lam4] = handoff (s,3,my,eta*k,rho_o);
[pb5(k), ph5(k), pft5(k), pnc5(k) ,p5,lam5] = handoff (s,4,my,eta*k,rho_o);
[pb6(k), ph6(k), pft6(k), pnc6(k) ,p6,lam6] = handoff (s,5,my,eta*k,rho_o);

figure(1)
semilogy(t,ph1,'linewidth',2)
hold on
semilogy(t,ph2,'r','linewidth',2)
hold on
semilogy(t,ph3,'k','linewidth',2)
hold on
semilogy(t,ph4,'y','linewidth',2)
hold on
semilogy(t,ph5,'g','linewidth',2)

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hold on
semilogy(t,ph6,'m','linewidth',2)
hold on
legend('Reserved channels0','Reserved channels l','Reserved channels2','Reserved channels3','Reserved channels4','Reserved channels5','location','southwest')
title('Handover Failure Probability for different numbers of Reserved channels')
ylabel('Handover failure Probability')

%xlabel('Iteration with the time')
grid on

s1=8;s2=12;s3=16;s4=20;
for k=1:12;
    [pb7(k), ph7(k), pft7(k), pnc7(k),lam7] = handoff (s1,2,my,eta*k,rho_o);
    [pb8(k), ph8(k), pft8(k), pnc8(k),p8,lam8] = handoff (s2,3,my,eta*k,rho_o);
    [pb9(k), ph9(k), pft9(k), pnc9(k),p9,lam9] = handoff (s3,4,my,eta*k,rho_o);
    [pb10(k), ph10(k), pft10(k), pnc10(k),p10,lam10] = handoff (s4,5,my,eta*k,rho_o);
end
figure(2)
semilogy(t,ph7,'linewidth',2)
hold on
semilogy(t,ph8,'r','linewidth',2)
hold on
semilogy(t,ph9,'k','linewidth',2)
hold on
semilogy(t,ph10,'y','linewidth',2)

legend('Total number of channels 8','Total number of channels 12','Total number of channels 16','Total number of channels 20','location','southwest')
title('Handover Failure Probability for different channels with 25% Reserved Channels')
ylabel('Handover failure Probability')

%xlabel('Iteration with the time')
grid on
3G Pros and Cons

As we know our thesis is based on 3G cellular network. We put our efforts to see 3G network with various technologies. There are many aspects of 3G and doubts whether it will be hit or miss. All technologies are developed for some specific purposes and for have unique requirements as well. Every technology is different from other for example, if we talk about things from subscriber aspect, it has different issues and different requirements and if we look things from network or operator aspect it has entirely different requirements and issues.

From subscriber aspect, the pros come using packet-oriented networks based on IP and in GSM circuit switched networks used for voice communication. For this, subscribers pay for the cost of calls or usually pay a monthly payment to the network operator. However in 3G, users are connected all the time and receive text, email, pictures, video etc. There is no time limit of receiving these text, email pictures and videos. Users do not pay for the connection time and it is only based on data being transmitted and received. The main thing is that it depends what type of service is used. As we all know that the new multimedia services that will be offered with 3G are high quality and attractive as far as user perspective concerned. Due to these services the network operators are hoping to generate high revenue in near future.

The cons from subscriber aspect are importantly focused because some services demand a large bandwidth so that's why its cost is much higher. For example, real time video streaming. Some other issues also need attention regarding the available data rates in the network. UMTS support maximum data rate of 2 Mbits and it will be only get it if users located near to the base station and indoors. The maximum data rate of 384 Kbit/s is achievable in 3G system for outdoor. The distribution of data rate in 3G system will vary a lot, where some users get data rates close to the 9.6 Kbit/s, while on other side GSM receives very high data rates reaching the upper limits of 2 Mbps. A disadvantage is that when users communicate with a base station at highest possible data rate than it took almost the full capacity of the base station. Similarly some services that demand high data rates will also have to pay some higher cost. For building a 3G network infrastructure, operators need to invest millions of dollars and it is not matter either they are in profitable or not. The capacity of the core network has to enhance to deal with the higher data traffic in 3G networks. For this, mobile manufactures also have to spend a lot of capital to enhancing the 3G terminals that can use the different services in the future.
THREATS TO 3G

We think readers might be interested to see what is happening with 2.5G, GPRS and CDMA2000 1X technologies. All developing mobile countries have multiple operators offering 2.5G and users are learning to use new advance technologies and services. Currently we are facing threats to 3G from Wireless Lan (W-LAN) or Wi-Fi is a medium range wireless technology well suited for high-speed data. For example, “use internet for surfing with laptop computers at airport terminals, hotels and conference centers etc. W-LAN is good solution for home networking for those high technology services, connectivity is also provided within many computers etc. W-LAN gradually more deployed by organizations from universities to corporate offices. W-LAN is much faster than 3G but there are many other problems with W-LAN such as, handling voice traffic, security matters, the diminishing amount of free content and access of W-LAN mimicking the diminishing amount of free content and services on the fixed internet etc, which also affect the W-LAN opportunity”. W-LAN and 3G support each other.
4th Generation 2010 & Future Work!

As we already define, that first generation was related to offer a single service and speech was the core issue in it. The core issue in second generation was related to speech and data but with low rates. The scope of third generation (presently used) is wider and it offers high quality multimedia services like multimedia messaging service, mobile internet access, mobile intranet access, video conferencing, and location based services, customized infotainment etc. The major technologies of 3G are Bluetooth, wireless LAN (IEEE 802.x standard), Wimax, WiFi etc. These technologies have many features and have the ability to provide high data services according to their environments. There are some limitations of 3G. We use CDMA technique in the 3G it cannot provide high data rates, which we need today!

Similarly, there are some limitations about spectrum and its allocation as well in 3G. It is not ideal for roaming among various services. According to the latest study, it is found that latest services of 3G are not using so much in many countries due to cost factor. So we can say that any user should have freedom and flexibility to select any desire of services with economical price and good QoS at anytime, everywhere. It is expected that 4G technology will have the ability to manage these things nicely.

The core issues and challenges relating to 4G are:

- Proper manageability of heterogeneous Network
- Handover issues (provide constant QoS level during handover)
- Adding new users
- Location and resource coordination
- All QoS issues (relating to fixed and wireless applications)
- Fully support of multicasting
- Network failure issues (backup facility!)
- Billing and pricing (cost factor)
- Create and implement knowledge based network operations
- Seamless interoperability
- Developing smart antennas

4G technology is expected to provide about 1Gbps while stationary and almost 100 Mbps while moving. It is not a defined standard or technology. It is collection of protocols and technologies aimed at creating fully packet switched networks optimized for data. So it will base only packet switching not circuit switching and we will get low latency data transmission. This technology will provide the opportunity for broadband access in the remote areas without any infrastructure to support DSL access or cable.

4G technology will cover these areas and will be able to deploy soon

- E-commerce
- Public places (airports, train station, buildings etc.)
- Business
Entertainments like, online games, videos, etc
Travel
Health care field (medicine)
Education
Vehicular

Femtocell technique is highly linked with 4G. Basically it is a small cellular base station (BS) and known as an access point BS. It is used in residential and small business environment but all indoor. It is connected to the service network provider via broadband like DSL, cable etc. Normally 2-4 active mobile phones support in a residential setting. It is also important in 3G applications as well as in 4G. The main thing of this technique which are distinguishable among others that it is cheap, self install, ‘plug n play’ access point, use mature mobile technology, use licensed spectrum, fully controlled of coverage and capacity etc.

According to one study report it has approved that most of the people use services indoor and efficiency of small cells is much better than big size cells. So we can say that the best way to increase capacity is to shrink the cells. This technique has a major contribution in voice coverage, voice capacity, data coverage and data capacity as well.

The core issue of 4G is to provide high data rate application like 100Mbps up to 1Gbps. By adopting femtocell technique in 4G we can get high data rate although this technique is best for short range and dense coverage areas.

In the result we purpose that femtocell technique is essential for 4G but it is highly recommended for indoor coverage so we need a ‘Greater Femto’ in the future age.

Some remaining Q!

Does our hardware equipment can process such high limits of data!

Battery life time is also one of issue!

Will we be able to implement 4G in 2010! (2G is still using in some countries)

Compatibility in 2G→3G→4G is still a resolvable issue!
Conclusions

Mobility and handover in 3G is still a critical issue and we try to manage it in a proper way. Different kind of strategies has been adopted to resolve this issue like MCHO, NCHO, and MAHO etc. These strategies are implemented on the basis of current situation and requirements as well. Regarding this, our main purpose is to provide best QoS to the users but sometimes the priorities change according to the situation. In the real world scenario, sometimes we give priority to the new incoming calls but not ongoing calls. Anyhow our focus is always to provide best continuity of ongoing calls and QoS as well. We need such a reliable and flexible handover strategy when we have to deal with handover in 3G.

To overcome this problem we discussed above many handover failure strategies like non-prioritized handoff strategy, reserve channel strategy, FIFO strategy, measurement based priority strategy and sub-rating scheme strategy. The selection of these strategies is also one of the resolvable issue! By analyzing these strategies we selected reserve channel strategy for further study.

Reserve channel strategy is much flexible and softer to implement rather than else strategy. In this strategy we reserve some channels for handoff calls. So if all channels are busy at any moment and a new call arrives then it will be blocked but in the same way if a handoff call arrives there, then it will not be forced to terminate and will be attended due to reserve channels.

Furthermore we observe the phenomena of handover failure calls by fixing different number of reserve channels. We observed that when we fixed less reserve channels then probability of handover failure rate was much higher but by increasing reserve channels we got less handover failure probability rate. After this we reserved 25% channels as reserved channels and experimented handover failure probability rate then we found tremendously less handover failure rate. So we can propose here that by implementing this strategy with almost 25% reserve channels we can overcome this handover failure problem.

The main advantage of this strategy is that it is dynamically selectable. We can change it easily according to the situation and requirements. When we use this strategy we have choice to change the parameters easily according to the current situation. So we can suggest that by implementing this handover strategy we can overcome the handover problems in 3G cellular area.
**Abbreviations**

3G- third generation  
CDMA-Code division multiple access  
MS-Mobile station  
RAN- radio access network  
CN- core network  
PSTN-Public switched telephone network  
TE- Terminal Equipment  
MT-Mobile Terminal  
S- Signaling  
PCF-Packet control function  
PDSN-Packet data serving node  
RBS-Radio base station  
BSC- Base station controller  
MSC- mobile switching center  
IP-Internet protocol  
RRM-Radio Resource Management  
BS-Base Station  
PCF- Packet Control Function  
BTS-base transceiver station  
HLR-home location registers  
VLR-visitor location registers  
AC- authentication centre  
MC- message center  
SME-short message entity  
VOIP-Voice over internet protocol  
PPP-point to point protocol  
BSAP-base station application layer  
BSMAP-Base station management application part  
UMTS-Universal mobile telecommunication system  
QoS-Quality of service  
GPRS-general packet radio service  
TDMA-time division multiple access  
OSA-Open System Architecture  
WCDMA-wide band code division multiple access  
UTRAN-Terrestrial Radio Access Network  
ATM-Asynchronous transfer Mode  
GSM-global system for mobile communication  
PS-packet switch  
CS-Circuit switch  
RNC-Radio network controller  
RRC-Radio resource control  
AS-Autonomous Systems  
RSVP-Resource reservation protocol  
SIP-Session initiation protocol  
DSCP-DiffServ code points  
MPLS-Multi protocol label switching protocol  
LAC-link access control  
MAC-Medium access control  
RLP-Radio link protocol  
NAK-negative acknowledgement  
MRU-maximum receive unit  
TCP-transmission control protocol
UDP-User datagram protocol
BMC-broadcast-multicast control
ARQ-Automatic repeat request
TM-Transparent mode
UM-Unacknowledged mod
AM- Acknowledged mode
CBS-Cell broadcast service
RNC-radio network controller
RNS-radio network subsystem
FIFO-first-in-first-out
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