COE 543: Mobile and Wireless Networks

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Project Report

Title of the Project

"Study of Wireless Data Services in UMTS"

Type of the Project
"Tutorial"

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Chapter 1

Introduction

1.1 Title of the Project:

Study of Wireless Data Services in UMTS.

1.2 Background:

It is well-known that Internet growth has been linked together with data services. These services have been largely developed through years, and currently there is a huge amount of applications that use data services. Parallel to this, mobile systems expansion has produced a new added value to the communications market: the availability to connect with anyone, from anywhere and at any time. It is foreseeable that next phase includes the fusion of these two giants. In fact, the support of Internet applications over mobile systems will offer connection to anyone, from anywhere, at any time and to any information. This gives a wide range of facilities to the users, and some technological challenges to the engineers, as it could be the use of data services on third generation mobile systems. In this study this challenge will be focused in the context of the Universal Mobile Telecommunication System (UMTS), the European standard for third generation mobile systems. An extensive survey detailing the procedures and mechanisms within UMTS that are designed for wireless mobile data services will be made in this study.

1.3 Project Objectives:

i) To identify the wireless data services in UMTS.

ii) To analyze the procedures and mechanisms for wireless data services within UMTS.

1.4 Organization of the Report:

After a short introduction of UMTS with its objectives and evolution in chaptere 1 a detailed description is on UMTS services and network is given in the successive chapter. In Chapter 2 various services of UMTS are described with a emphasis on data services. In Chapter 3 a overall view of UMTS network and how a call is establish in the network are explained with proper illustrations. Chapter 4 drills with physical layer of UMTS network and describes various channel with their configuration. A comparative study of UMTS network with second and other third generation mobile communication systems is made using number of tables.

Chapter 2

Introduction to UMTS

2.1 What is UMTS?

Universal Mobile Telecommunications System (UMTS) is a member of International Mobile Telecommunications 2000 (IMT-2000) family of third generation (3G) mobile communication systems. It is standardized by European Telecommunications Standards Institute (ETSI) within the framework of the International Telecommunications Union (ITU) and based on the evolving GSM/GPRS core Network. Five main standardization areas of UMTS as specified by Third Generation Partnership Project (3GPP) are Radio Access Network, Core Network, Terminals, Services and System Aspects and GERAN.[23] Frequency band of 1885 - 2025 and 2110 - 2200 MHz is allocated for UMTS by World Radio Conference in 1992 [3]. It is to be a system for a wide range of mobile services provided in different service environments, thereby supporting many mobile telecommunication applications [2]. It is predicted in [1] that UMTS will play key role in creating the future mass market for high-quality wireless multimedia communications that will approach 2 billion users worldwide by the year 2010.

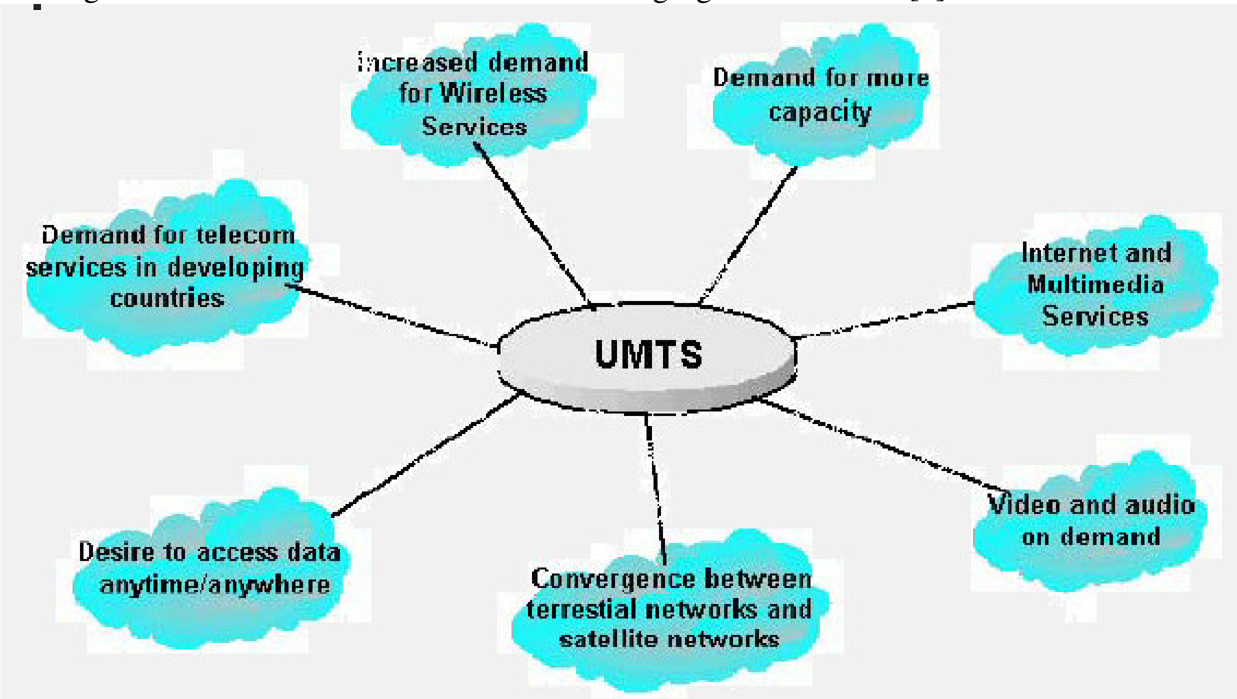
2.2 Objectives of UMTS:

Objectives of UMTS as mentioned in [3] are given below:

- i) Integration of residential, office and cellular services into a single system and one user equipment.
- ii) Speech and service quality at least comparable to current fixed network, including uncompromised security in mobile use.
- iii) Service capability up to multimedia
- iv) Separation of service provision and network or service provider
- v) UMTS user number independent of network and service provider
- vi) Capacity and capability to serve the whole population, up to 100% penetration
- vii) Seamless and global radio coverage achievable
- viii) Radio bearer capabilities up to 144 kbps and further to 2 Mbps
- ix) Radio resource flexibility to multiple networks and traffic types within a frequency band
- x) High frequency spectrum efficiency
- xi) Creation of direct satellite access for a mass user base
- xii) Use of WARC-92 frequency band(1885-2005 and 2110-200MHz)
- xiii) Low cost of services and terminals
- xiv) Flexible personalization, ease of use
- xv) Flexibility for the introduction of new services and technical capabilities
- xvi) Applicability to different needs: public, private, basic telephony, for starting telecoms; broadband multimedia for advanced telecoms.

2.3 Driving forces of UMTS

Driving forces of UMTS are shown in the following figure taken from [1]:



2.4 Evolution of UMTS

Evolution of UMTS can be understood from the following figure:

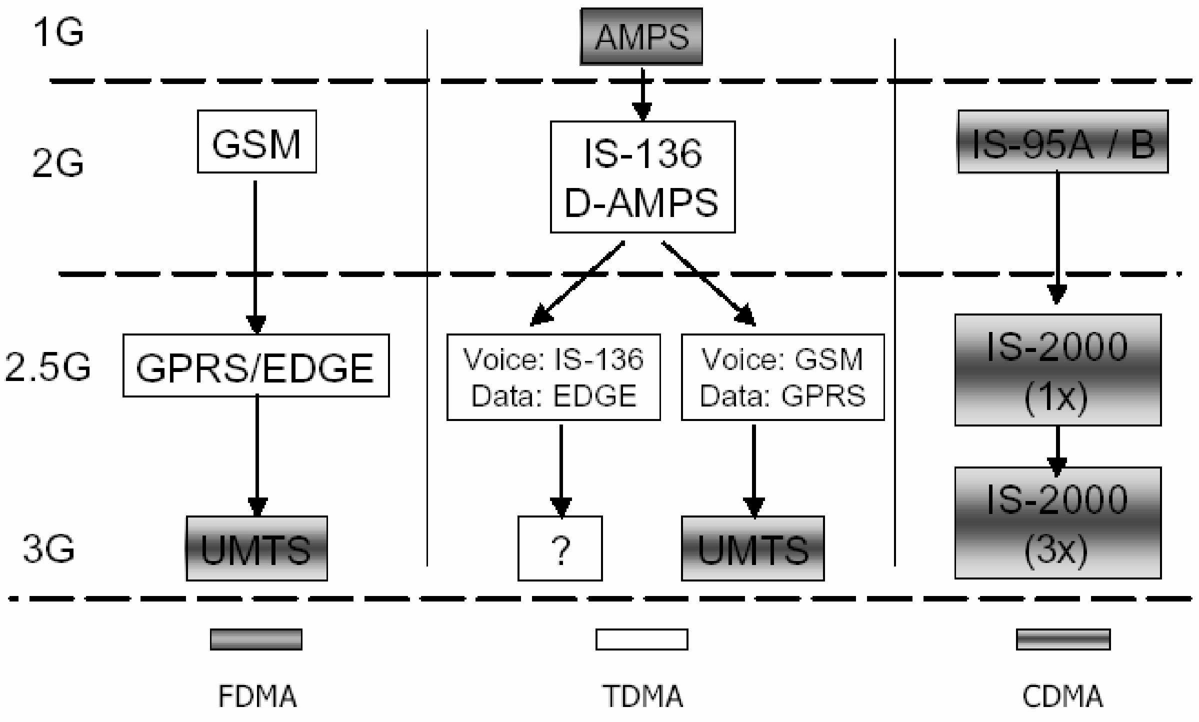


Figure 2.1 Evolution of UMTS and other 3G system [4]

Milestones: Major milestones of UMTS evolution as listed in [9] are mentioned below:

The Analog Cellular Age

- 1985 IMT 2000 study began with the establishment of Interim Working Party 8/13 (IWP 8/13) by Decision 69 and work continued in Task Group 8/1.

- 1987 - Early 1990s one UMTS research project in RACE 1, seven projects in RACE2 and fourteen projects in the ACTS Program.

- 1988 ETSI formed in Europe.

The Digital Cellular Age

- 1991 - 1995 two CEC funded research projects called CODIT and ATDMA were carried out. which was later continued in the FRAMES project and became the basis of the further ETSI UMTS work until decisions were taken in 1998.

- February 1992 World Radio Conference in Malaga (WRC-92) allocated frequencies for future UMTS use. Frequencies 1885 - 2025 and 2110 - 2200 MHz were identified for IMT2000 use.

- 1992 All major European operators start commercial operation of GSM networks

- February 1995 The UMTS Task Force was established, "The Road to UMTS" report.

- December 1996 The UMTS Forum was established at the inaugural meeting, held in Zurich, Switzerland.

- June 1997 the UMTS Forum produced its first report entitled "A regulatory Framework for UMTS".

- October 1997 ERC decided on UMTS core band.

- January 1998 ETSI SMG meeting in Paris both W-CDMA and TD-CDMA proposals were combined to UMTS air interface specification.

- June 1998 Terrestrial air interface proposals (UTRAN, WCDMA(s), CDMA2000(s), EDGE, EP-DECT, TD-SCDMA) were handed into ITU-R

- December 14 1998 The decision of the European Parliament and Council of Ministers requires that Member States take all necessary measures to allow the coordinated and progressive introduction of UMTS services by 1st January 2002 at the latest

- December 1999 in Nice ETSI Standardization finished for UMTS Release 1999 specifications both for FDD and TDD (spec version 3.y.z).

• April 2000 World Radio Conference (WRC-2000) was supposed to finalize the extension of the UMTS/IMT-2000 band.

• March 2001 in Palm Springs 3GPP approves UMTS Release 4 specification (spec version 4.y.z).

The High Speed Cellular Age

• December 1, 2001 Telenor launched in Norway the first commercial UMTS network. UMTS terminals were expected to be available 3Q 2002.

• December 19, 2001 Nortel Networks and Vodafone in Spain (formerly Airtel Movil) completed first live international UMTS 3GPP standard roaming calls.

• March 2002 (Freeze date) UMTS Release 5 (the initial target date was December 2001)

• September 25, 2002 Mobilkom Austria launches "Europe's First UMTS-Network" .

• September 26, 2002 Nokia introduces the "world’s first handset [6650] for WCDMA [UMTS] and GSM networks".

• October 1, 2002 Qualcomm announces world's first Bluetooth WCDMA (UMTS)

• June 2003 is a target date for UMTS Release 6

• 2005 (original target) UMTS service will be world wide (?).

Chapter 3

Services supported by a UMTS network

The best known new feature of UMTS is higher user bit rates: on circuit –switched connections 384 kbps, and on packet-switched connections up to 2 Mbps, can be reached. [10, Page-9] Higher bit rates naturally facilitate thousands [7, Page-187] of new services. In this chapter these services are classified with a highlight on data services.

3.1 Attributes of UMTS Services:

Various attributes of UMTS services are defined as 5 M's in [7, p-51. The meaning of 5 M's are given below:

- **Movement**-escaping place(local, global, home-based, mobile)
- **Moment**-expanding time(multitask, plan, postpone, stretch, fill, catch up, real-time)
- **Me** – extending me(personal, relevant, customized, community, multi-session)
- **Money** – expending financial resources (m-commerce, m-banking, micro-payment)
- **Machines** – empowering devices(telematics, robots, monitoring cameras, metering devices etc)

3.2 Categorization of Services for UMTS:

A. Based on who communicates with whom, what level of security may be needed, how is money handled and how immediate do the services need to be, the UMTS services are split into four groups in [7, p-197-98]:

i) ***Inter-Personal Communication:*** Content generated by the customer and Connectedness like MMS (Multimedia Messaging Service), Voice, Text-to-voice, location based service(s).

ii)***Infotainment:*** Information and Entertainment such as games, music, jokes, community services, news, sports, fashion and even adult entertainment.

iii)***Corporate services:*** Mobile access to intranets and extranets and information sharing & control. It includes email, access to the corporate phone book and CRM(Customer Relationship Management.

iv)***Consumer Enterprise:*** Mobile purchase, Mobile banking and Financial services.

B. Based on the nature the UMTS services are divided into mainly two categories in [9], [8] & [2]. These are:

xvii) Teleservices
xviii) Bearer services

Teleservices:

Examples of possible teleservices are telephony, voice messaging, program sound, telefax, data messaging, video telephony, videotext and paging as mentioned in [2].

Bearer Service:

Bearer services provide capabilities to transmit information among user network-interfaces or access points [8, p-38]. UMTS allows a user/ application to negotiate bearer characteristics that are most appropriate for carrying information. It is also possible to change bearer properties via a bearer renegotiation procedure in the course of and active connection. Bearer negotiation is initiated by an application, while renegotiation may be initiated either by the application or by the network (e.g. in handover situations). [10, p-10]

3.3 Quality of Service (QoS):

In 2.5G networks it is not possible to assign different QoS classes to individual services or packages. For example, a corporate client accessing the corporate Intranet would not get any higher priority to bandwidth that a schoolboy playing a mobile game even if the corporate customer was paying a higher access price. With UMTS, it is possible to assign QoS classes so the specific services or access packages take priority over the bandwidth resource so that higher service fees can be charged. UMTS network services have different QoS classes for four types of traffic [10, p-11]:

- ***Conversational class*** (voice, video telephony, video gaming), very delay sensative
- ***Streaming class*** (multimedia, video on demand, webcast)
- ***Interactive class*** (web browsing, network gaming, **database access**)
- ***Background class*** (email, SMS, downloading), the most delay-intensive.

The last two classes are mostly related to data services. When the end-user, either a machine or a human, in on line requesting data from remote equipment (e.g. a servers) the third class is applied. Examples of human interaction with the remote equipment are web browsing, database retrieval and server access. Examples of machine interaction with remote equipment are polling for measurement records and automatic database enquiries. For background traffic delay may be seconds, tens of second or even minutes and contents of the packets does not need to be transparently transferred. Data t be transmitted has to be received error free. The electronic postcard is one example of new applications that are gradually becoming more and more common.

Bearer services have different QoS parameters for maximum transfer delay, delay variation and bit error rate. Offered data rate targets are:[9]

- 144 kbits/s satellite and rural outdoor
- 384 kbits/s urban outdoor
- 2048 kbits/s indoor and low range outdoor

QoS of some teleservices are shown in the following table [3]:

Teleservice	Throughput (kbits/s)	Residual Error Rate	Delay (ms)
Speech telephony/terrestrial	8 - 32	10E-4	40
Voice band data	2.4 - 64	10E-6	200
Unrestricted Digital Data	64 - 1920	10E-6	100
Data Base Access	2.4 - 768	10E-6	200+
Teleshopping	2.4 - 768	10E-6/10E-7	90
Short Messages/Paging	1.2-9.6 (1.2-2.4 typ)	10E-6	100
Electronic Mail	1.2 - 64	10E-6	100
Telefax (G4)	64	10E-6	100
Broadcast./Multicast	1.2 - 9.6 (2.4 typ)	10E-6	100
Elect. Newspaper	2.4 - 2000	10E-6	200
Remote Control Services	1.2 - 9.6	10E-6	100
Location + Navigation	64	10E-6	100
Telewriting	32 - 64	10E-6	90

Chapter 4

Overview of UMTS network

4.1 UMTS Architecture

A UMTS network can be divided into two parts: Access Network and Core Network as shown in the figure below taken from [1]. Access Network consists of User Equipment (UE) and UMTS Terrestrial Radio Access Network (UTRAN). The UTRAN provides the air interface access method for User Equipment. Base Station is referred as Node-B and control equipment for Node-B's is called Radio Network Controller (RNC). The basic Core Network architecture for UMTS is based on GSM network with GPRS. All equipment has to be modified for UMTS operation and services.

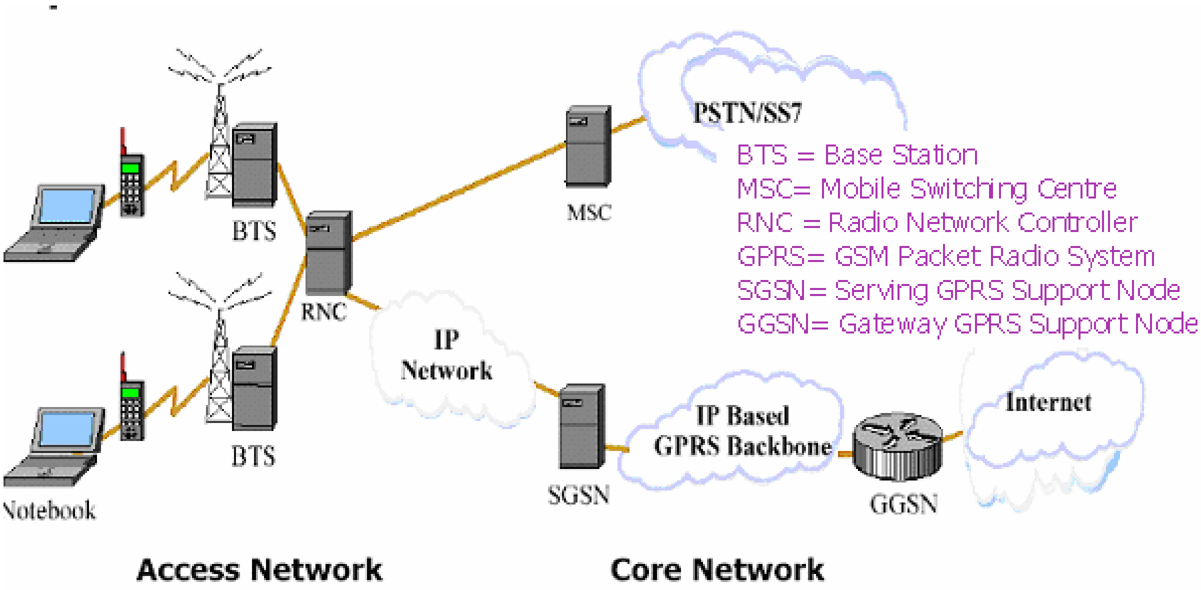


Figure 4.1 UMTS Network

It is necessary for a network to know the approximate location in order to be able to page user equipment. Here is the list of system areas from largest to smallest [9].

- UMTS systems (including satellite)
- Public Land Mobile Network (PLMN)
- MSC/VLR or SGSN
- Location Area
- Routing Area (PS domain)
- UTRAN Registration Area (PS domain)
- Cell
- Sub cell

4.2 User Equipment (UE):

UMTS user equipment consists of two parts [10]:

i) The Mobile Equipment(ME): It is the radio terminal used for radio communication over the Uu interface.

ii) UMTS Subscriber Identity Module(USIM): It is a smartcard that holds the subscriber identity. It performs authentication algorithms, and stores authentication and encryption keys and some subscriptions information that is needed at the terminal.

4.3 UTRAN:

UTRAN contains Radio Network Subsystems (RNSs) communicating with the Core Network (CN) through the Iu interface as shown in figure below collected from [1]. In turn a RNS contains a Radio Network Controller (RNC) and ore or more Node B. A Node B connects to the RNC through the Iub interface, and it can support either a FDD or TDD or combined dual mode operation.

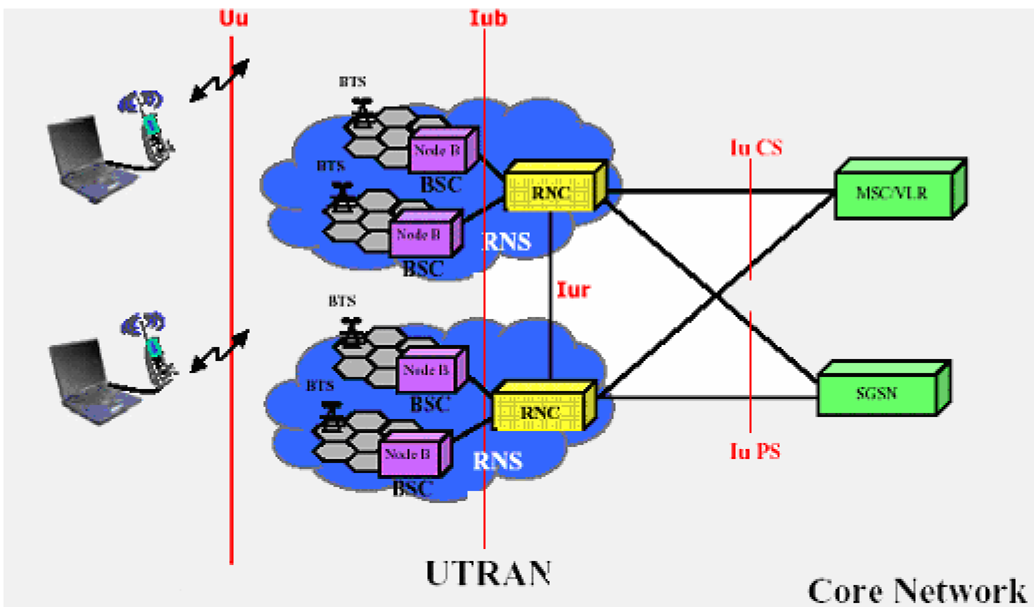


Figure 4.2 UMTS network

The RNC takes care of handover decisions requiring signaling to the UE; it comprises a combining / splitting function to support macro diversity between different Node Bs. RNCs can interconnect each other through the Iur logical interface. The latter can conveyed over a direct physical connection between RNCs or through any appropriate transport network.

All physical connections between UTRAN have a serving RNS. When service relocation demands it, a drift RNSs support the serving RNS by providing new radio resources [6, p-58-59].

4.4 Core Network (CN)

The Core Network is divided in circuit switched and packet switched domains. Circuit switched elements are Mobile services Switching Centre (MSC), Visitor location register (VLR), and Gateway MSC and packet switched elements are Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN). Some network elements, like EIR HLR and AUC, are shared by both domains.

The Asynchronous Transfer Mode (ATM) is defined for UMTS core transmission. ATM Adaptation Layer type 2 (AAL2) handles circuit switched connection and packet connection protocol AAL5 is designed for data delivery.

The architecture of the Core Network may change when new services and features are introduced. Number Portability DataBase (NPDB) will be used to enable user to change the network while keeping their old phone number. Gateway Location Register (GLR) may be used to optimize the subscriber handling between network boundaries. MSC, VLR and SGSN can merge to become a UMTS MSC. [9]

Different parts of CN connected with external networks is shown well in the following figure collected from [4]:

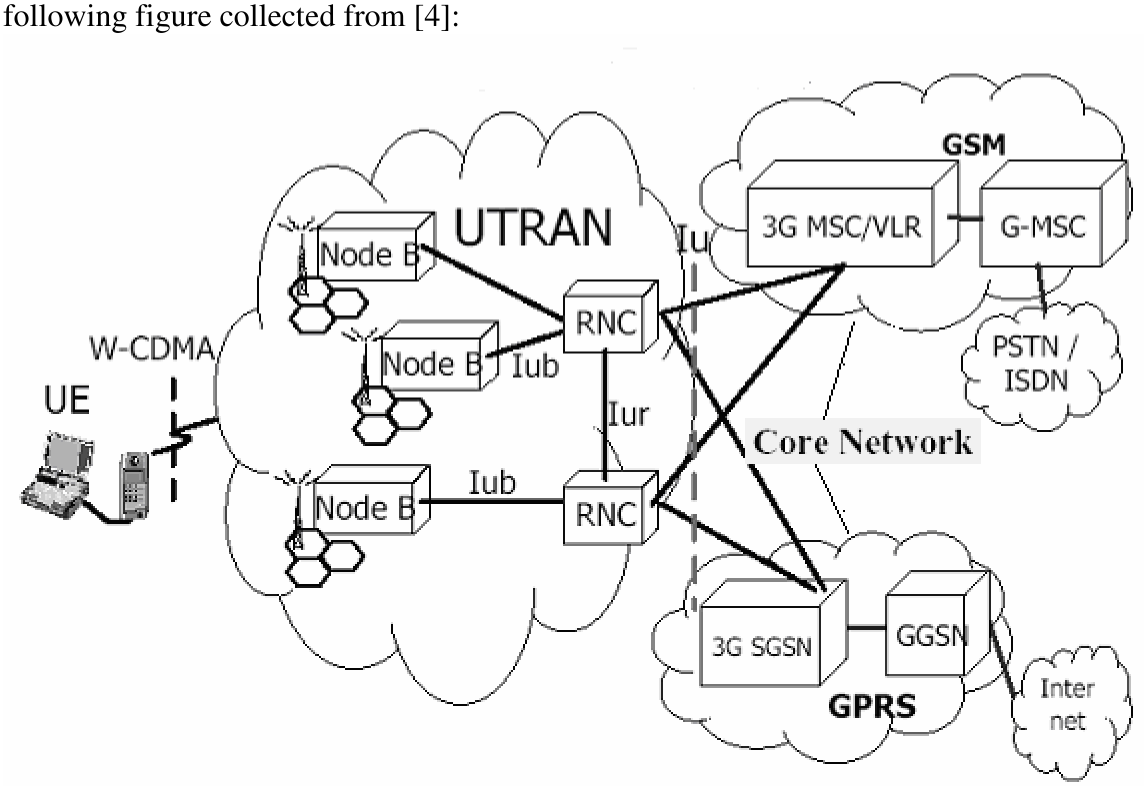


Figure 4.3 UMTS Core Network(associated with other parts)

4.5 External networks:

External networks to which CN is connected can be divided into two groups[10]:

i) CS networks: These provide circuit-switched connections, like the existing telephony service ISDN and PSTN are example of CS networks.

ii) PS networks: These provide connections for packet data services. The Internet is one example of a PS network.

4.6 Call Flow in UMTS network:

Flow of a call in UMTS network can be shown by the following figure:

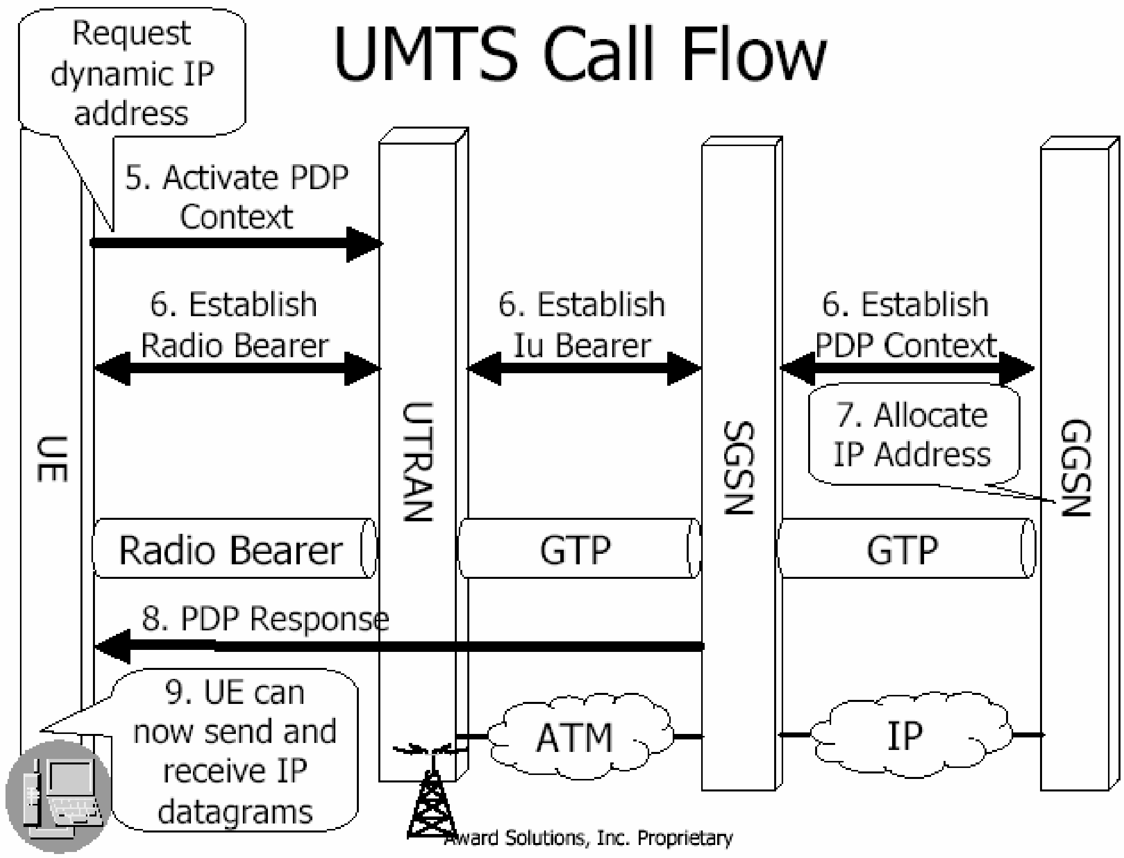


Figure 4.4 UMTS Call Flow [4]

Chapter 5
Functionality in the radio access network

UTRAN, the radio access network of UMTS performs very important tasks to render both data and voice services. In this section the functions mentioned in [6, p-60-65] will be discussed with an emphasis on those geared to data services.

5.1 System Access Control Function:

3G subscribers get connected with UMTS network through the system access. There are two key system access control functions:

i) Admission and congestion control: RNC admits or denies new users, new radio access bearer or new radio links and monitors, detects and handles situations when the system reaches near overload or and overload situation while users remain connected.

ii) System information broadcasting: This function provides the mobile station with the access stratum and non-access stratum information used by the UE for its operation within the network.

5.2 Radio Channel Ciphering and Deciphering

This computation function protects radio-transmitted data against unauthorized third parties. Ciphering and deciphering usage may depend of a session key, derived through signaling and /or session dependent information.

5.3 Mobility Functions:

a) Handover: RNC manages radio interface mobility based on radio measurement. This function may originate in the network or may come independently form the UE.

b) SRNS Relocation: This function coordinates events when a serving RNS(SRNS) role passes to another RNS. It manages the Iu interface connection mobility from one RNS to another. The serving RNC initiates this function, which finds a home in the RNC and CN.

5.4 Radio Resource Management and Control Functions:

a) Radio Resource Configuration: This function of UTRAN configures the radio network resources i.e. cells and common transport channels and takes the resources into or out of operation.

b) Radio environment survey: It performs quality estimates and measurements on radio channels like received signal strength, estimated bit error ratios, Doppler shift, interference etc from current and surrounding cells.

c) Macro-diversity Control (in FDD mode): It manages duplication/replication of data or information streams to receive/transmit the same information trough multiple physical channels (or different cells) from /towards a single mobile terminal.

d) Dynamic Channel Allocation, DCA (in TDD mode): Fast DCA implies assigning resources to the radio bearers in relation to the admission control. Slow DCA implies assigning radio resources, including time slots, to different TD cells depending on the varying cell load.

e) Allocation/ De-allocation and Control of radio bearers: The allocation/de-allocation function located in the CRNC and SRNC, translates the connection element set up requests into physical radio channel allocation according to the QoS of the radio access bearer.

Radio bearer control located both in the UE and in the RNC, manages connection element set up and release in the radio access sub-network.

f) Radio Protocols function: This function provides user data and signaling transfer capability across the UMTS radio interfaced by adapting the services to the radio transmission. This function includes multiplexing of services and multiplexing of UEs on radio bearers, segmentation and reassembly and acknowledged/unacknowledged delivery according to the radio access bearer QoS.

g) RF power control: Power control manages the transmitted power level in order to minimize interference and keep connection quality.

h) Radio Cannel Coding and Control: This function located in both UE and UTRAN brings redundancy into the data source flow, thereby increasing its rate by adding information calculated from the data source.

Channel coding control residing in both UE and URAN, generates control information required by the channel coding / decoding execution functions, e.g. channel coding type, code rate etc.

i) Radio Channel Decoding: Channel decoding residing in both UE and URAN aims to reconstruct the information source using the added redundancy by the channel coding function to detect or correct possible errors in the received data flow.

Chapter 6

Channels and Channel specifications used for data

UTRA radio interface has logical channels, which are mapped to transport channels, which are again mapped to physical channels. In this chapter at first UTRA transmission modes are defined and then various channels are described along with their classification and configuration.

6.1 UTRA Transmission modes:

Two modes are defined in UMTS i.e. Frequency Division Duplex (FDD) and Time Division Duplex (TDD)[5]. FDD is characterized by code, frequency and in the uplink by the relative phase (I/Q) and it corresponds to WCDMA operating with paired bands. TDD is additionally characterized by a time slot and it corresponds to TD/CDMA operating with unpaired bands. In the FDD mode uplink and downlink transmission use two different frequencies separated by 190MHz. [6] In the TDD uplink and downlink transmission occur over the same radio frequency by using synchronized time intervals. In 1998, the FDD and TDD modes were harmonized to have the same chip rate, frame length and number of slots per frame.[5] Table 6.1 taken from [6] illustrates the harmonized parameters of the two UTRA modes:

Table 6.1: UTA FDD and TDD Harmonized Parameter

Parameters	**UTRA TDD**	**UTRA FDD**
Multiple access	TDMA, CDMA(inherent FDMA)	CDMA(inherent FDMA)
Channel spacing and carrier chip rate	5 MHz(nominal) and 3.84 Mcps	
Time slot and frame length	15 slots/frame and 10ms	
Spreading factor	1,2,3,4,8,16 for both uplink and downlink	From 256 to 4 for uplink and from 512 to 4 for downlink
Channel allocation	Slow and fast DCA supported	No DCA required
Modulation	QPSK	
Interleaving	Inter-frame interleaving (10, 20, 40 and 80ms)	
Detection	Coherent, based on midamble	Coherent, based on pilot symbols
Intra-frequency handover	Hard handover	Soft and softer handovers
Inter-frequency handover	Hard handover	
Intra-cell interference cancellation	Support for joint detection	Support for advanced receivers at base station
Types of bursts	Traffic bursts random access and synchronization burst	DTX time mask defined, burst not applicable
Multi-rate concept	Multi-code, multi- slot and orthogonal variable spreading	Multi-code and orthogonal variable spreading

6.2 Logical Channels:

The MAC layer provides data transfer services on logical channels. In [6] these channels are classified into two groups, i.e. Control channels for control-plane information transfer and traffic channels for user-lane information transfer. Channels are given below: [9]

a) Control Channels:

Broadcast Control Channel (BCCH), Downlink (DL)
Paging Control Channel (PCCH), DL
Dedicated Control Channel (DCCH), UL/DL
Common Control Channel (CCCH), UL/DL

b) Traffic Channels:

Dedicated Traffic Channel (DTCH), UL/DL
Common Traffic Channel (CTCH), Unidirectional (one to many)

A DTCH is a point-to-point channel, dedicated to one UE, for the transfer of user information. A DTCH can exist in both uplink and downlink. Whereas a CTCH is a point-to-multipoint unidirectional channel for transfer of dedicated user information for all or a group of specified UEs.

6.3 Transport Channels:

Transport channels are defined by how and with what features data is transferred over the air interface. The generic classification of transport channels includes two groups: dedicated and common channels. The main difference between them is that a common channel is resource divided between all or a group of users in a cell, whereas a dedicated channel resource, identified by certain code on a certain frequency, is reserved for a single user only. [p-74, 10]

6.3.1 Common Channels:

Both FDD and TDD have a similar number of transport cannels; however, the FDD mode does not have and Uplink Share d Channel (USCH) and the TDD mode does not have a Common Packet Channel (CPCH). Channels are described below: [P-72 of [6]]

i) Random Access Channel (RACH): a connection based uplink channel used for transmission of relatively **small amounts of data**, e.g. for initial access or non-real-time dedicated control or traffic data.
ii) Common Packet Channel (CPCH): A contention based channel used for transmission of **bursty data traffic**. This channel only exists in FDD mode and only in the uplink direction. The common packet channel is shared by the UEs in a cell and therefore, it is a common resource. The CPCH is fast power controlled.
iii) Forward Access Channel (FACH): Common downlink channel without closed-loop power control used for transmission of relatively **small amount of data**.
iv) Downlink Shared Channel (DSCH): A downlink channel shared by several UEs carrying dedicated control or traffic data.
v) Uplink Shared Channel (USCH): An uplink channel shared by several UEs carrying dedicated **control or traffic data**, used in TDD mode only.

vi) Broadcast Channel (BCH): A downlink channel used for broadcast of system information into an entire cell.

vii) Paging Channel (PCH): A downlink channel used for broadcast of control information into an entire cell allowing efficient UE sleep mode procedures. Currently identified information types are paging and notification. Another use could be UTRAN notification of change of BCCH information.

6.3.2 Dedicated Channel:

There is primarily one transport Dedicated Cannel(DCH) for up- or downlink in the FDD and TDD modes, which is used to carry user or control information between the UTRAN and A UE. The DCH is transmitted over the entire cell or over only a part of the cell using, e.g. beam-forming antennas. [6]

6.3.3 Frame structure of transport channels:

UTRA channels user the 10ms radio frame structure. The longer period used is the system frame period. [P-78, 10] In [9] frame structure is described as below:

The general structure of a Common Transport Channel frame between Node B and RNC consists of a header and a payload.

Header	**Payload: Data or Control Information**

General Frame Structure

There are two types of frames (indicated by the Frame Type field).

- Data frame.
- Control frame.

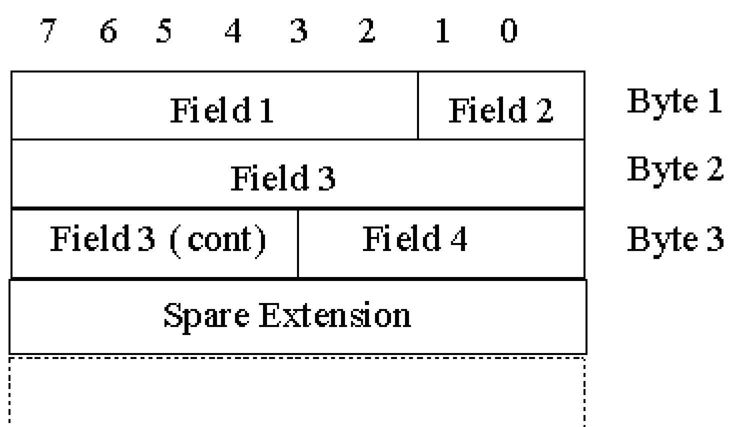
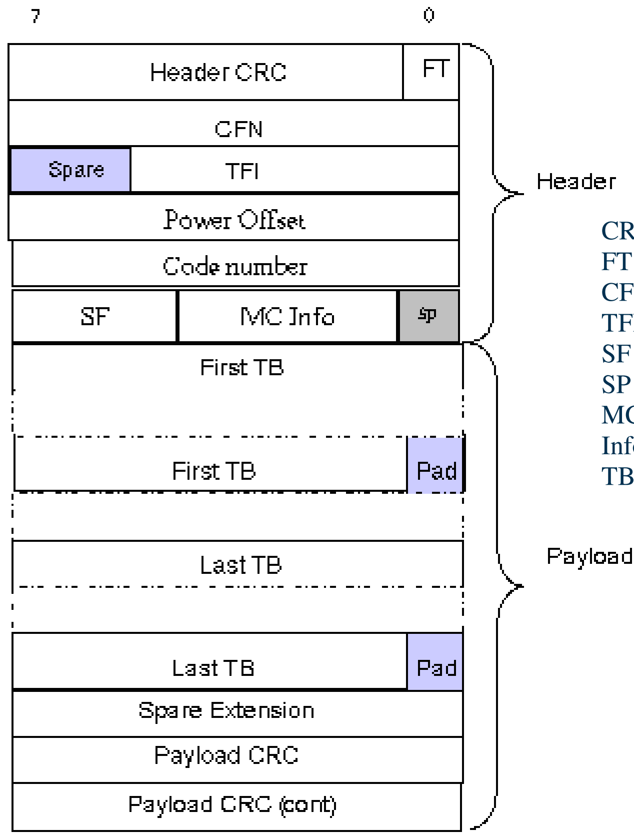


Figure 6.1 The general structure of frames

Data frame example:



CRC	Cyclic Redundancy Checksum
FT	Frame Type
CFN	Connection Frame Number
TFI	Transport Format Indicator
SF	Spreading Factor
SP	Spare
MC	Multi Code to indicate the number of parallel PDSCH codes
Info	on which the DSCH data will be carried
TB	Transport Block

Figure 6.2 DL FDD DSCH data frame structure

6.4 Physical Channels:

6.4.1 Physical channels:

Physical channels in FDD mode are as below: [9]

a) Common Channels:

i) Primary Common Control Physical Channel (PCCPCH), mapped to BC

ii) Secondary Common Control Physical Channel (SCCPCH), mapped to FACH, PCH

iii) Physical Random Access Channel (PRACH), mapped to RACH Physical

iv) Downlink Shared Channel (PDSCH), mapped to DSCH

v) Physical Common Packet Channel (PCPCH), mapped to CPCH

vi) Synchronization Channel (SCH)

vii) Common Pilot Channel (CPICH)

viii) Acquisition Indicator Channel (AICH)

ix) Paging Indication Channel (PICH)

x) CPCH Status Indication Channel (CSICH)

xi) Collision Detection/Channel Assignment Indication Channel (CD/CA-ICH)

b) Dedicated channels: [10, p-89]

i) Dedicated Physical Data Channel (DPDCH), mapped to DCH

ii) Dedicated Physical Control Channel (DPCCH), mapped to DCH

Physical channels in TDD mode are:

a) Common Physical channels:

i) Primary Common Control Physical Channel (PCCPCH), mapped to BC

ii) Secondary Common Control Physical Channel (SCCPCH), mapped to FACH, PCH

iii) Physical Random Access Channel (PRACH), mapped to RACH Physical

iv) Uplink Downlink Shared Channel (PDSCH), mapped to DSCH

v) Synchronization Channel (SCH)

vi) Paging Indication Channel (PICH)

b) Dedicated Physical Channel (DPCH)

6.4.2 Physical Channel structure:

a) Configuration of FDD channels: [p-89, 6]

Physical channels in FDD inherit primarily a layer structure of radio frames and time slots. A radio frame is a processing unit consisting of 15 slots with a length of 38400 chips, and slot is a unit consisting of fields containing bits with a length of 2560 chips. The slot configuration varies depending on the channel bit rate of the physical channel; thus, the number of bits per slot may be different for different physical channels and may, in some cases, vary with time. [P-89, 6] For example figure 6.3 shows frame structure of uplink dedicated physical channels, where each frame has 10ms length split into 15 slots (T_{slot}) of 2560 chips length, corresponding to one power control period. Parameter k in the figure determines the number of bits per uplink DPDCH slot. It is related to the spreading factor defined as $SF=256/2^k$, which may range from 256 down to 4. Table 6.2 illustrates the exact number of bits in the uplink DPDCH.

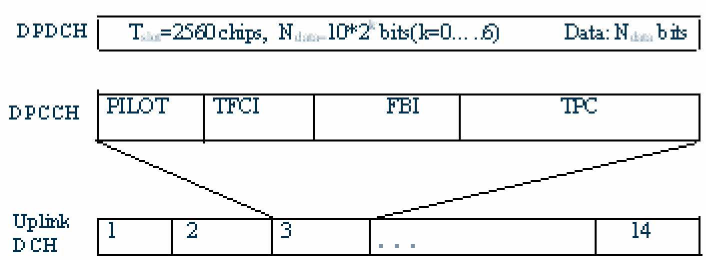


Figure 6.3 : Uplink dedicated channel structure [10, Figure 6.11]

The DPCCH uses a slot structure with 15 slots over the 10ms radio frame. Each slot has four fields to be used for pilot bits, TFCI, Transmission Power Control (TPC) bits and Feedback Information (FBI) bits.

Table 6.1 Uplink DPDCH data rates

DPDCH spreading factor	DPDCH channel bit rate (kbps)	Maximum user data rate with ½-rate coding (approx.)
256	15	7.5 kbps
128	30	15 kbps
64	60	30 kbps
32	120	60 kbps
16	240	120 kbps
8	480	240 kbps
4	960	480 kbps
4, with 6 parallel codes	5740	2.3 Mbps

b) Configuration of TDD channels:

As in the FDD mode, a UMTS frame in the TDD mode has a duration of 10ms within a sub-division into 15 time slots (TS) of 2560*T_c duration each. Hence, a TS corresponds to 2560 chips, each allocated to either uplink or the downlink as illustrated in figure 6.5. [6]

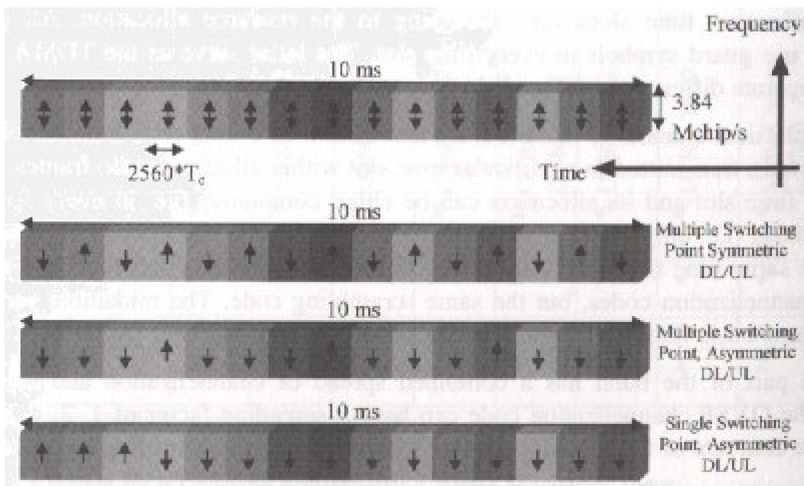


Figure 6.4 The TDD frame structure

A TDD physical channel is a burst (i.e. a combination of a data part, a midamble and a guard period), transmitted in particular time slot within allocated radio frames as shown in figure 6.6. [p-152, 6]

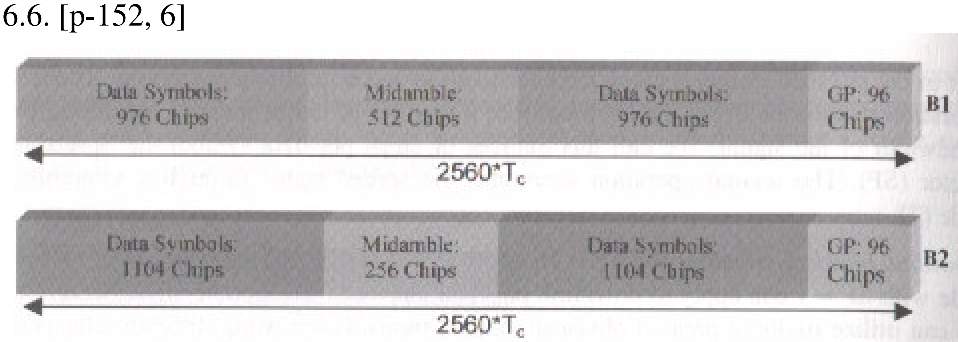


Figure 6.6 Frame structure of TDD burst types

6.5 Mapping of channels:

Logical to Transport channel conversion happens in Medium Access Control (MAC) layer, which is a lower sub-layer in Data Link Layer (Layer 2). Relationship of the physical layer (L1) and the upper layers (L2-L3) is illustrated in figure 6.1.

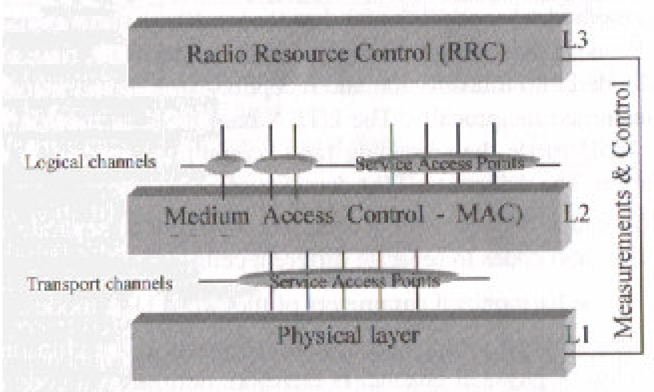


Figure 6.5 Relationship of the physical layer (L1) and the upper layers (L2-L3) [p-85, 6]

MAC layer does the mapping of channels as below:

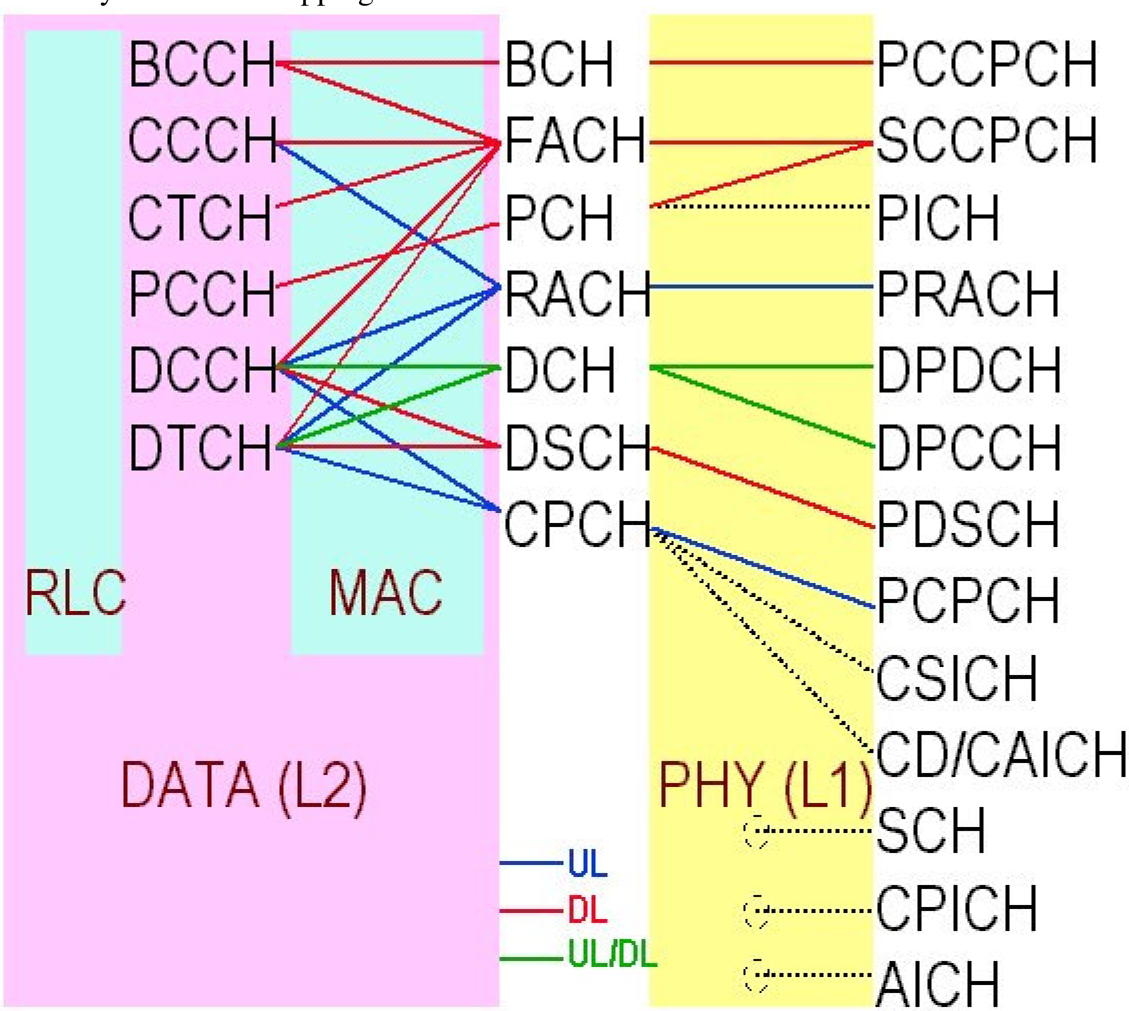


Figure 6.7 Mapping of channels [9]

Chapter 7

Comparative Study

7.1 Comparison between UMTS and 2nd generation Mobile systems:

Table 7.1 Main differences between WCDMA and GSM air interfaces[10]

Parameters	WCDMA	GSM
Carrier spacing	5MHz	200KHz
Frequency reuse factor	1	1-18
Power control frequency	1500Hz	2Hz or lower
Quality control	Radio resource management algorithms	Network planning(frequency planning)
Frequency diversity	5MHz bandwidth gives multipath diversity with Rake receiver	Frequency hopping
Packet data	Load-based packet scheduling	Time slot based scheduling with GPRS
Downlink transmit diversity	Supported for improving downlink capacity	Not supported by the standard, but can be applied

Table 7.2 Main differences between WCDMA and IS-95 air interfaces[10]

Parameters	**WCDMA**	**IS-95**
Carrier spacing	**5MHz**	**1.25MHz**
Chip rate	**3.84 Mcps**	**1.2288Mcps**
Power control frequency	**1500Hz, both uplink and downlink**	**Uplink: 800Hz, downlink: slow power control**
Base station synchronization	**Not needed**	**Yes, typically obtained via GPS**
Packet data	**Load-based packet scheduling**	**Packet data transmitted as short circuit switched calls**
Downlink transmit diversity	**Supported for improving downlink capacity**	**Not supported by the standard**

7.2 Comparison between UMTS and CDMA2000:

The main differences between UMTS and cdma2000 can be summarized as follows [8]

1. Although cdma2000 proposes multiples of 1.288Mcps chip rates to allow greater compatibility with IS-95(in particular, 3.6864Mcps is suggested), W-CDMA employs 3.84 Mcps.

2. In Is-95 and cdma2000, the BSs operate synchronously by obtaining timing from GPS. W-CDMA advocates asynchronous operation to enable deploying Pico cells within buildings where GPS is not available.

3. The frame length of WCDMA is 10ms to ensure small end-to-end delays, though it is 20ms in cdma2000.

Differences are illustrated separately with respect to bandwidth & sprading, air interface, power control and channelization & Source Identification Codes in the following tables:

Table 7.3 Difference in bandwidth and spreading [4]

	Bandwidth	**Spreading**	**Chanalization Codes**
cdma2000	1.25 MHz (1x) 3.75 MHz (3x)	1.2288 Mcps 3 * 1.2288 or 3.6864 Mcps	4-128 bits (1x) 4-256 bits (3x)
UMTS	5 MHz	3.84 Mcps	4-256 bits

Table 7.4 Difference in Air Interface[4]

	UMTS	**cdma2000**
Synchronization between cell sites	**Asynchronous**	**Synchronous**
Configuration	**Direct spread configuration**	**Direct spread (1x)** **Multi-carrier (3x forward link)**
Channel coding	**Convolutional Turbo (Parameters flexible)**	**Convolutional Turbo (Parameters fixed in the standard)**

Table 7.5 Difference in Power control[4]

	UMTS	cdma2000
Open loop Power control for System Access	√	√
Forward link Power control	**1500/sec**	**800/sec**
Reverse link Power control	**1500/sec**	**800/sec**

Table 7.6 Differences in Channelization & Source Identification Codes[4]

	UMTS	cdma 2000
Channelization codes	**Orthogonal Variable Spreading Factor (OVSF) codes from 4-256 bits**	**Walsh codes (same as OVSF) codes from 4-128 bits**
Source identification code for Sector	**512 unique scrambling codes each identifying a sector (38,400 bits)**	**One PN code (32,768 bits) 512 unique offsets are generated using PN offsets**
Source identification for mobiles	**Unique scrambling codes assigned by sector**	**One long PN code (242 bits). Unique offsets are generated based on ESN. Not assigned by sector**

Chapter 8

Conclusion

In this literature survey project a comprehensive study is made of on data services of UMTS. Although its one of the most recent development of modern mobile communication system and yet to be implemented in full suing it has become a vast area of research that is hard to cover in this type of short report. However, after reading related books, surfing web sites and consultation with the supervisor a summary of the terms and concepts of UMTS data service is tried to make in the survey.

Appendix A

References

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