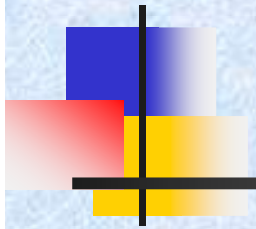
Study of Wireless Data Services in UMTS



A Literature Survey project done as the requirement of course # COE 543

Syed Mohammed Shamsul Islam

Student# 220572

Department of COE

King Fahd University of Petroleum & Minerals

Outline of Presentation

- **Introduction to UMTS**
- **Services supported by UMTS networks**
- **Overview of UMTS networks**
- **Functionality in the radio access Network**
- **Channels and Channel specifications**
- **Comparative Study**

Introduction to UMTS

What is UMTS?

- **Universal Mobile Telecommunications System (UMTS) is a member of the International Telecommunications Union IMT-2000 vision of a global 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.**

Introduction to UMTS (Contd.)

Objectives of UMTS

- **Integration of residential, office and cellular services into a single system and one user equipment.**
- **Speech and service quality at least comparable to current fixed network, including uncompromised security in mobile use.**
- **Service capability up to multimedia**
- **Separation of service provision and network or service provider**
- **UMTS user number independent of network and service provider**
- **Capacity and capability to serve the whole population, up to 100% penetration**
- **Seamless and global radio coverage achievable**
- **Radio bearer capabilities up to 144 kbps and further to 2 Mbps**

Source: [3]

Introduction to UMTS (Contd.)

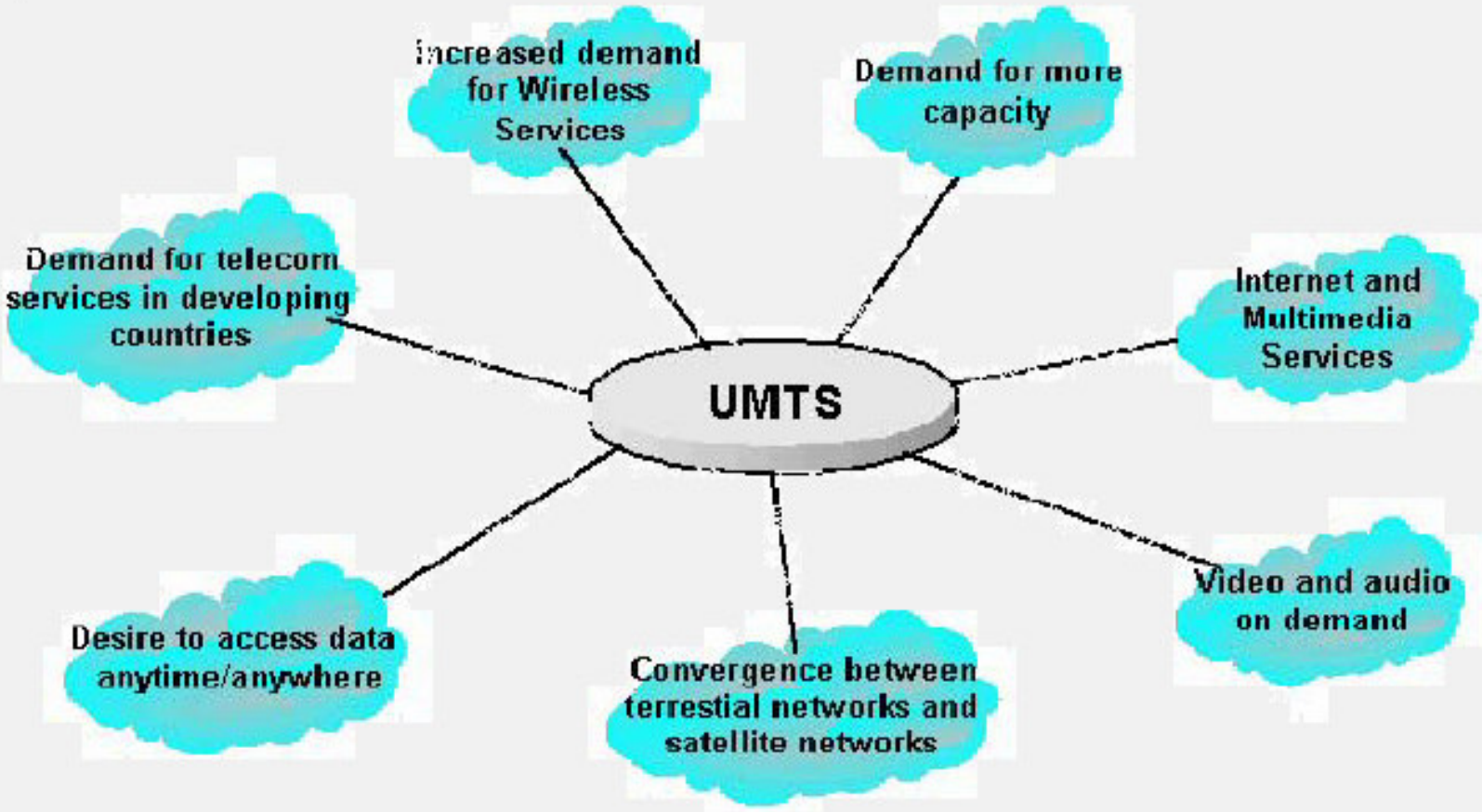
Objectives of UMTS (Contd.)

- **Radio resource flexibility to multiple networks and traffic types within a frequency band**
- **High frequency spectrum efficiency**
- **Creation of direct satellite access for a mass user base**
- **Use of WARC-92 frequency band(1885-2005 and 2110-200MHz)**
- **Low cost of services and terminals**
- **Flexible personalization, ease of use**
- **Flexibility for the introduction of new services and technical capabilities**

Source: [3]

Introduction to UMTS (Contd.)

What is Driving UMTS?

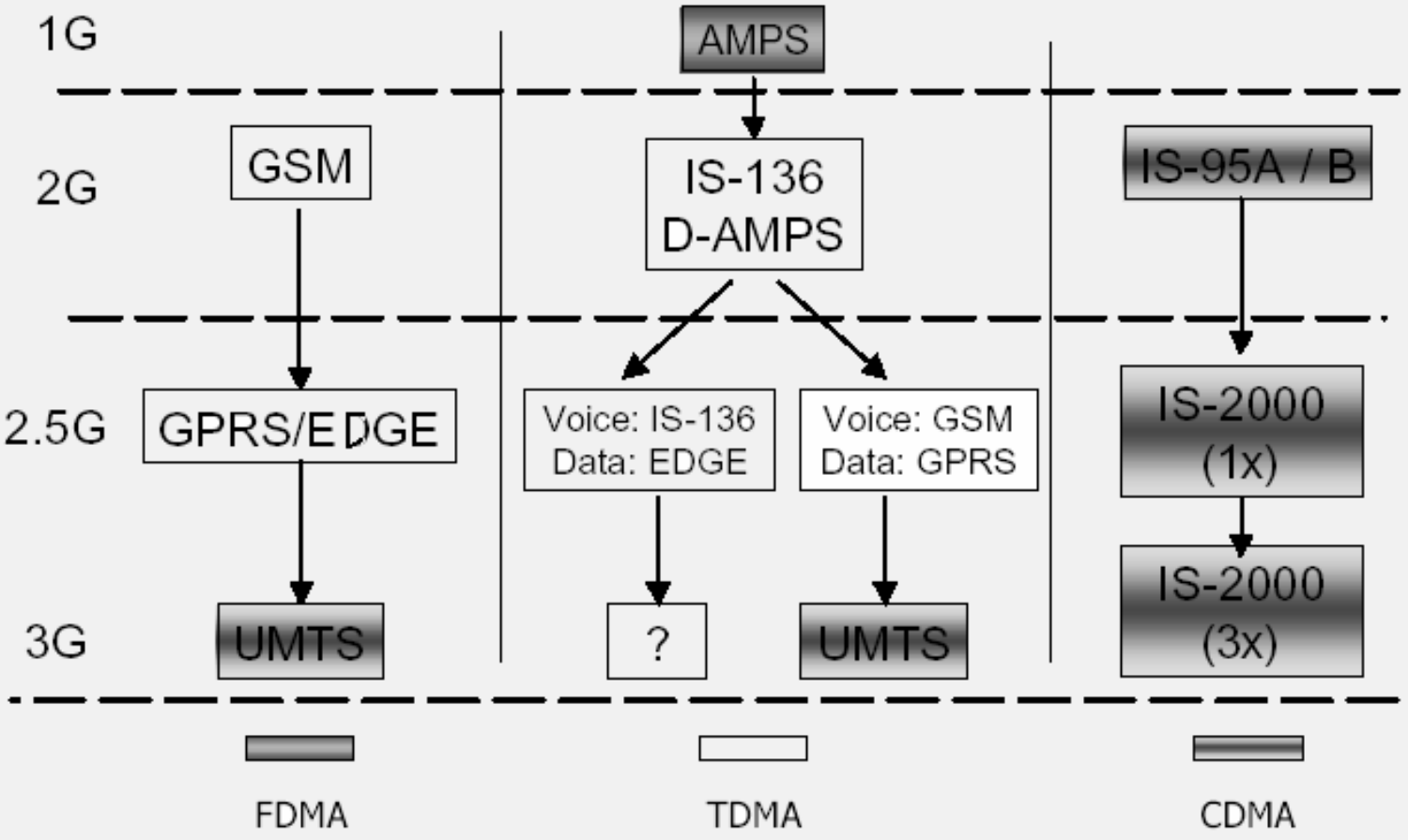


Source: [1]

Introduction to UMTS (Contd.)

Evolution of UMTS

Evolution of UMTS can be understood from the following figure:



Source: [4]

Introduction to UMTS (Contd.)

Evolution of UMTS (Contd.)

Major milestones of UMTS evolution:

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**
- **December 1996 The UMTS Forum was established at the inaugural meeting, held in Zurich, Switzerland.**
- **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).**
- **March 2001 in Palm Springs 3GPP approves UMTS Release 4 specification (spec version 4.y.z).**

Source: [9]

Introduction to UMTS (Contd.)

Evolution of UMTS (Contd.)

Milestones (contd.)

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 (?).**

Source: [9]

Services supported by UMTS networks

- **Attributes of UMTS Services**

The 5 M's:

- **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)

Source: [7]

Services supported by UMTS networks (Contd.)

Categorization of Services for UMTS

A.

- **Inter-Personal Communication**
  - Content generated by the customer
  - Connectedness
- **Infotainment**
  - Information
  - Entertainment
- **Corporate services**
  - Mobile access to Intranets
  - Information sharing & control
- **Consumer Enterprise**
  - Mobile purchase
  - Mobile banking
  - Financial services

Source: [7]

Attributes of UMTS Services (Contd.)

- **Categorization of Services for UMTS** (Contd.)

B.

- **Teleservices**

  telephony, voice messaging, program sound, telefax, data messaging, video telephony, videotext, paging etc

- **Bearer services**
  - Negotiation
  - Renegotiation

Source: [2], [8]

Services supported by UMTS networks (Contd.)

Quality of Service (QoS)

QoS classes for four types of traffic:

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

Source: [10]

Services supported by UMTS networks (Contd.)

- **Quality of Service (Contd.)**

QoS for teleservices:

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

QoS for bearer services: Offered data rate targets are:

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

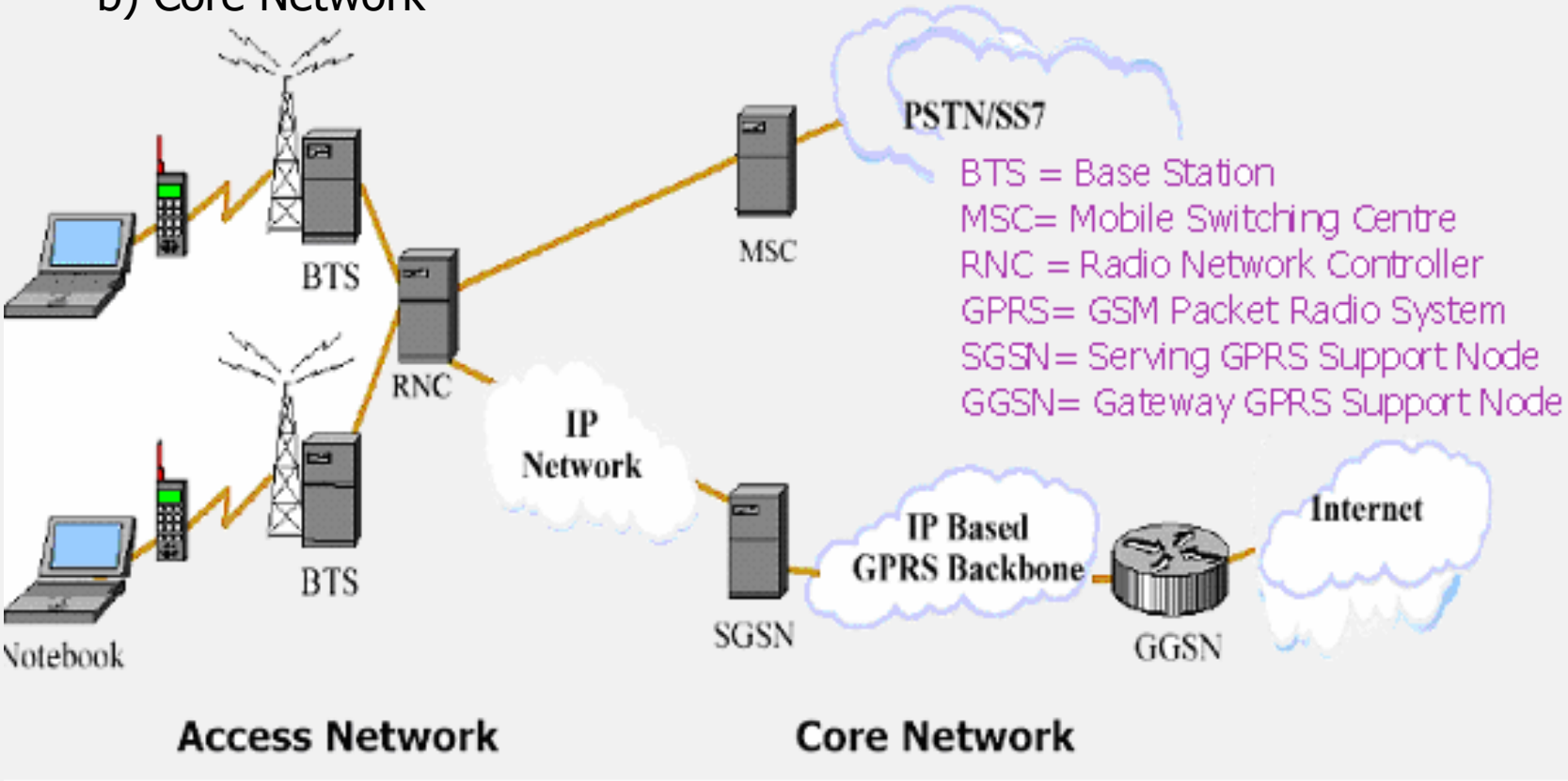
Source: [3]

Overview of UMTS network

UMTS network consists of:

a) Access Network: i) UE ii) UTRAN

b) Core Network



Source: [1]

Overview of UMTS network (Contd.)

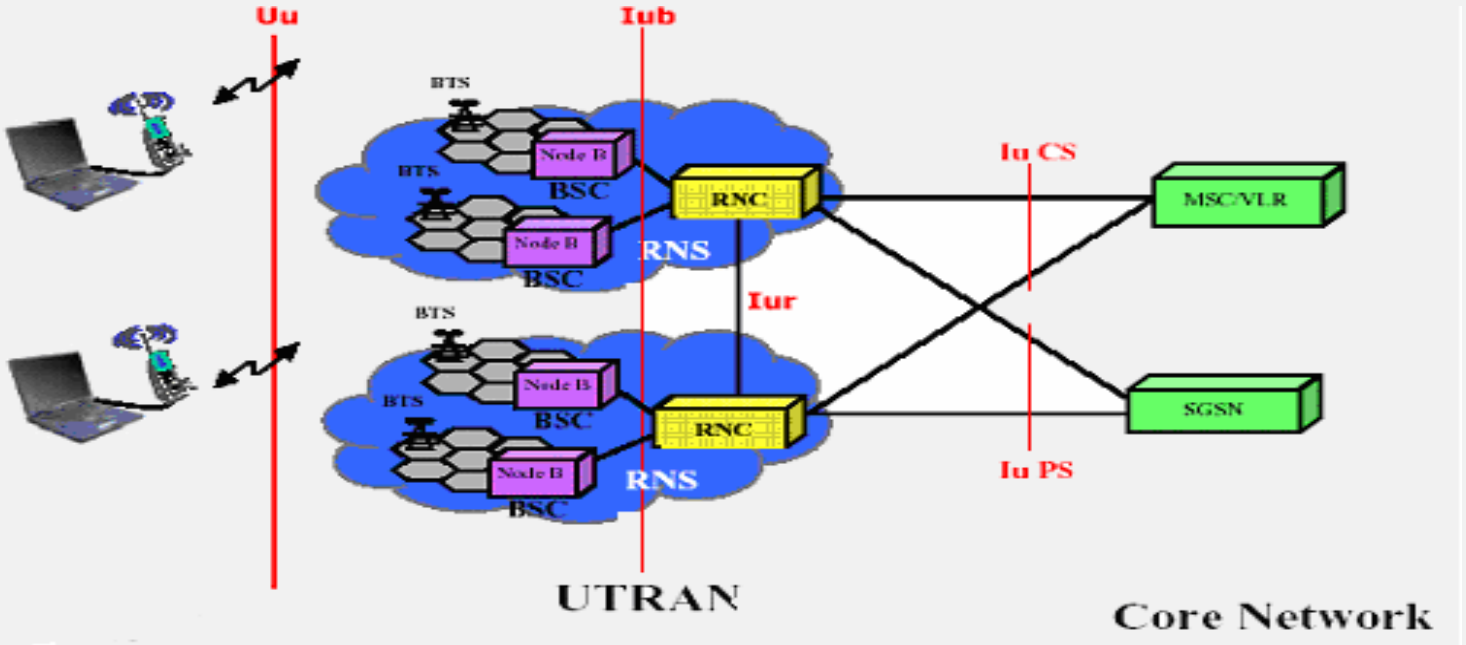
User Equipment (UE):

UMTS user equipment consists of two parts [10]:

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

b) ***UMTS Subscriber Identity Module(USIM):*** It is a smartcard that holds the subscriber identity.

UTRAN: [1]



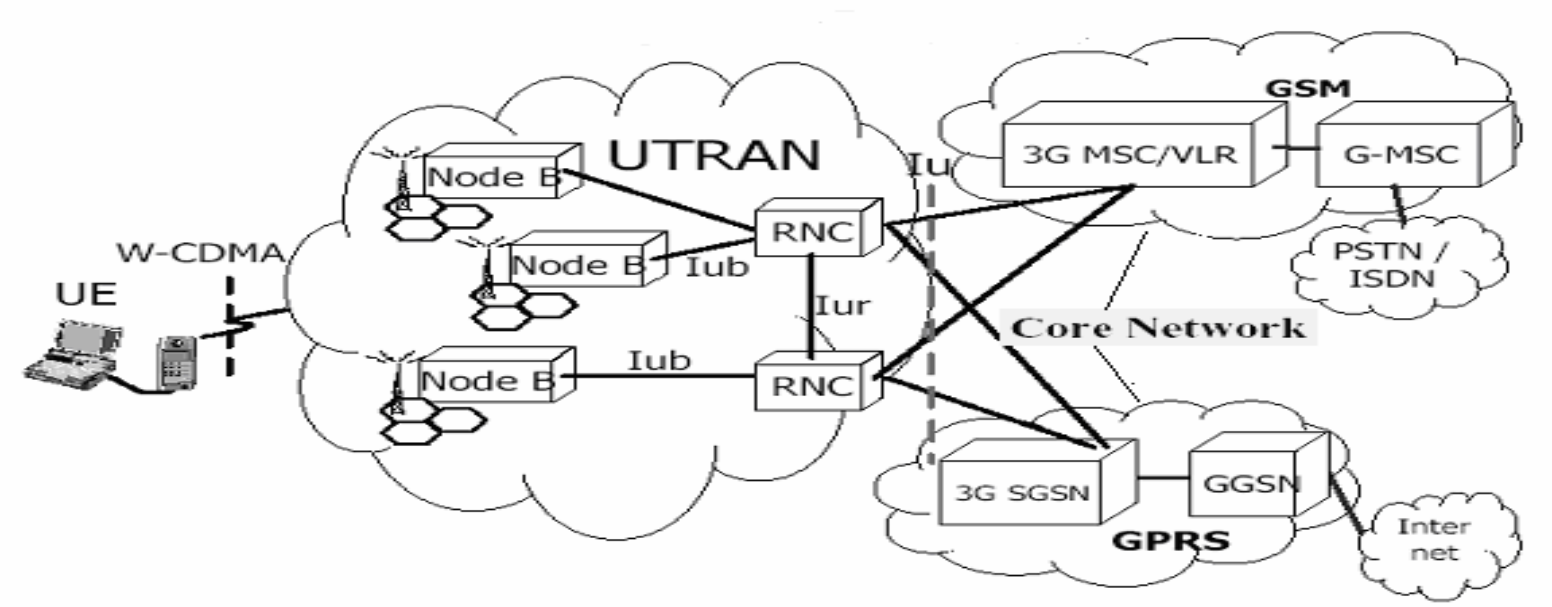
Overview of UMTS network (Contd.)

Core Network (CN)

It is consist of

a) **Circuit switched elements(MSC, VLR, Gateway MSC)**

b) **Packet switched elements (Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN)**



External networks:[10]:

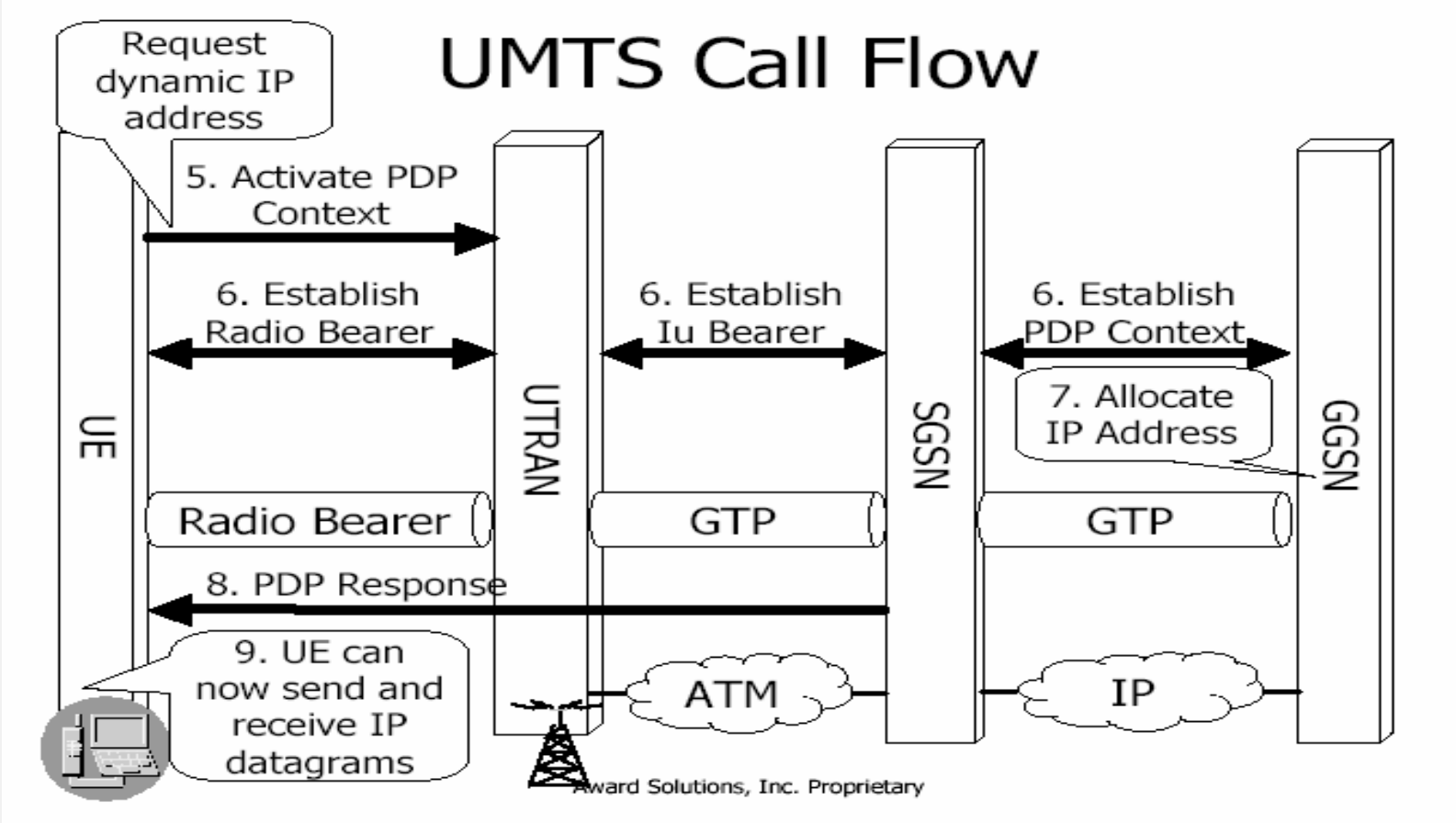
CS networks: Exp. ISDN and PSTN

PS networks: These provide connections for packet data services. Exp. the Internet

Source: Figure: [4]

Overview of UMTS network (Contd.)

- Call Flow:



Source: Figure: [4]

Functionality in the radio access network

- **System Access Control Function:**

3G subscribers get connected with UMTS network through the system access.

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.

- **Radio Channel Ciphering and Deciphering** This computation function protects radio-transmitted data against unauthorized third parties.
- **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.

Source: Figure: [6]

Functionality in the radio access network (contd.)

- **Radio Resource Management and Control Functions**
  - **Radio Resource Configuration**
  - **Radio environment survey**
  - **Macro-diversity Control-FDD**
  - **TDD-Dynamic Channel Allocation**
  -
  - **Allocation/ De-allocation and Control of radio bearers**
  - **Radio Protocols function**
  - **RF power control**
  - **Radio Cannel Coding and Control**
  - **Radio Channel Decoding**

Source: Figure: [6]

Channels and Channel specifications (Contd.)

UTRA Transmission modes

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

Source: Figure: [6]

Channels and Channel specifications (Contd.)

Logical Channels:

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)

Transport Channels:

a) Common channels

Random Access Channel (RACH)
Common Packet Channel (CPCH)
Forward Access Channel (FACH)
Shared Channel (DSCH)
Uplink Shared Channel (USCH)
Broadcast Channel (BCH)
Paging Channel (PCH)

b) Dedicated Channels

Dedicated Channel (DCH)

Source: Figure: [6] and [9]

Channels and Channel specifications (Contd.)

Frame structure of transport channels

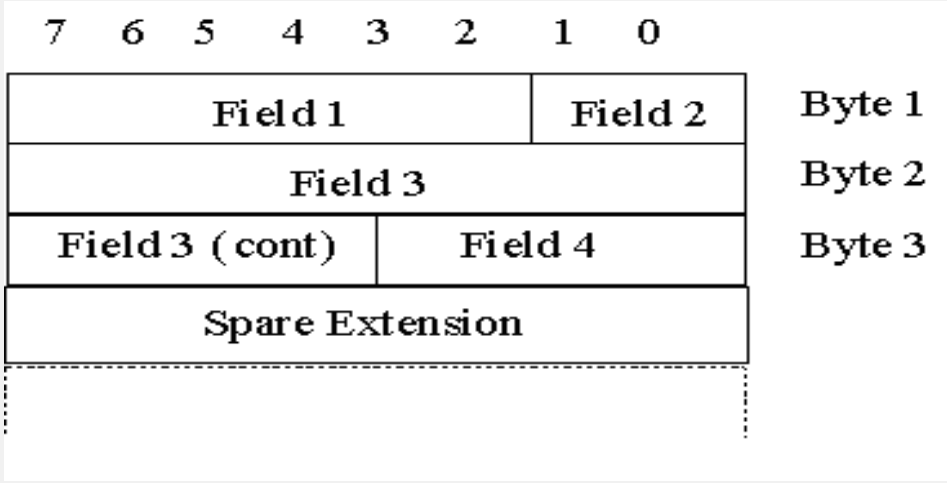
The general structure of a Common Transport Channel frame between Node B and RNC consists of a header and a payload.

Header	Payload: Data or Control Information

A) General Structure of frame:

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

- Data frame.
- Control frame.

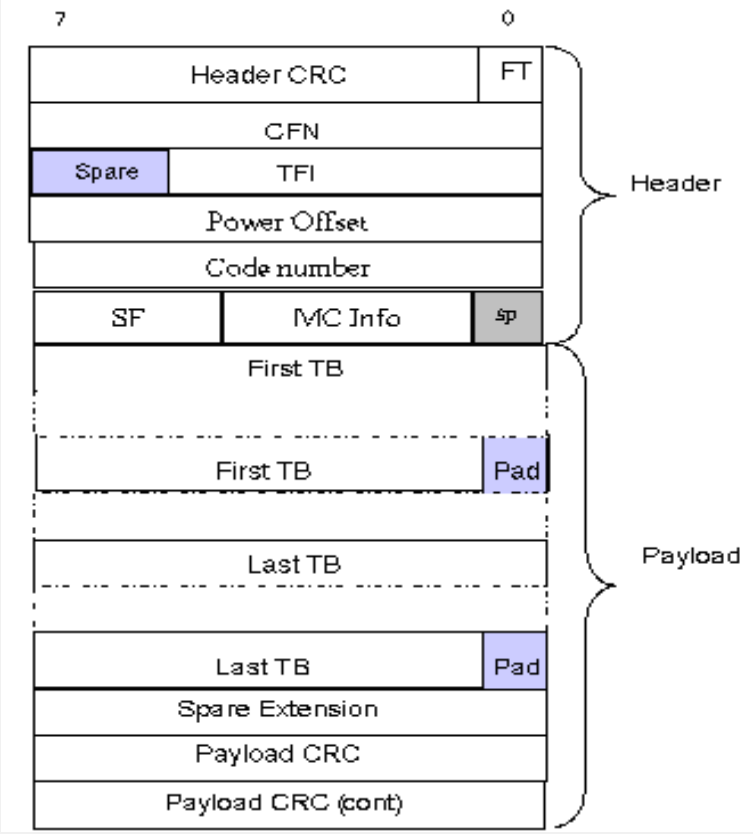


Source: Figure: [9]

Channels and Channel specifications (Contd.)

Transport Channel Frame structure (Contd.)

b) Data frame structure:



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

Source: Figure: [9]

Channels and Channel specifications (Contd.)

Physical Channels:

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

a) Common Channels:

- Primary Common Control Physical Channel (PCCPCH), mapped to BC
- Secondary Common Control Physical Channel (SCCPCH), mapped to FACH, PCH
- Physical Random Access Channel (PRACH), mapped to RACH Physical
- Downlink Shared Channel (PDSCH), mapped to DSCH
- Physical Common Packet Channel (PCPCH), mapped to CPCH
- Synchronization Channel (SCH)
- Common Pilot Channel (CPICH)
- Acquisition Indicator Channel (AICH)
- Paging Indication Channel (PICH)
- CPCH Status Indication Channel (CSICH)
- Collision Detection/Channel Assignment Indication Channel (CD/CA-ICH)
-

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

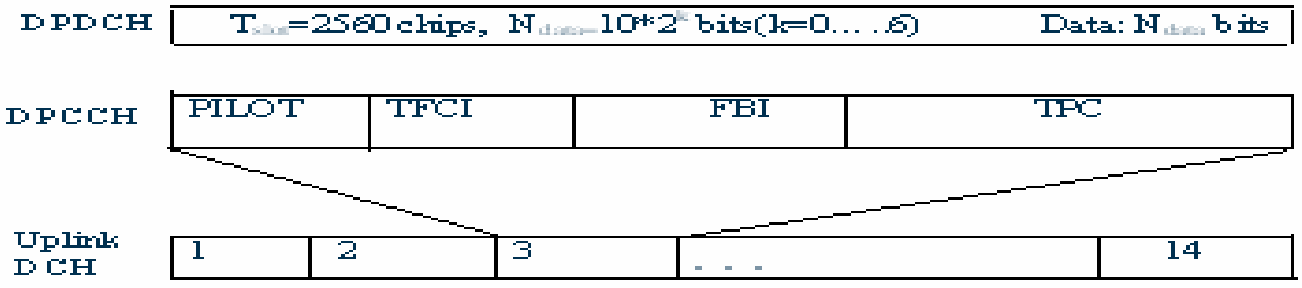
- Dedicated Physical Data Channel (DPDCH), mapped to DCH
- Dedicated Physical Control Channel (DPCCH), mapped to DCH

Channels and Channel specifications (Contd.)

- **Physical Channel structure:**

a) Configuration of FDD channels:

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[6]. An uplink dedicated frame structure and exact data rates are shown below:



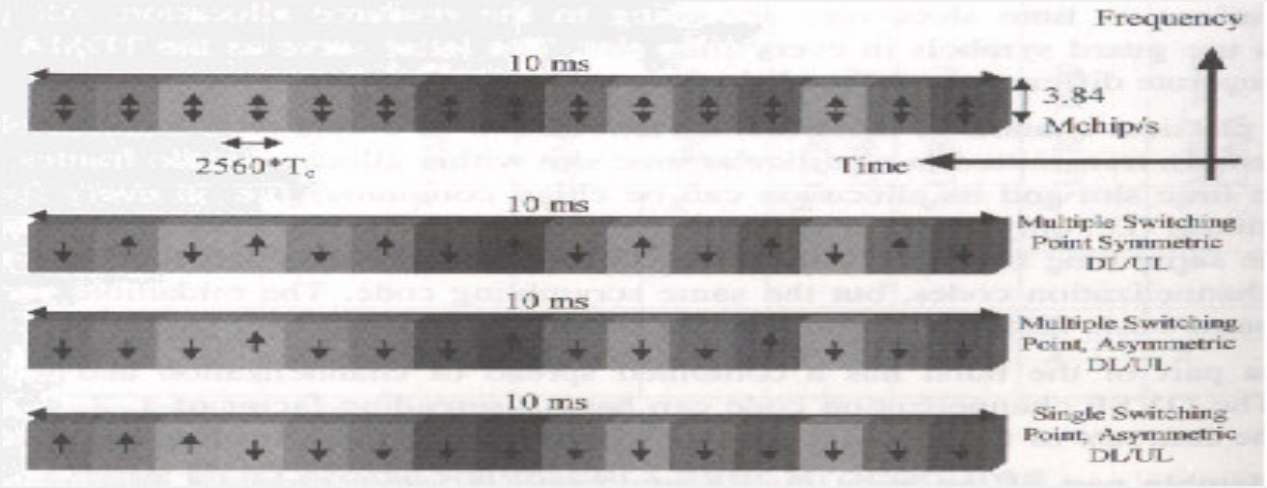
DPDCH spreading factor	DPDCH channel bit rate (kbps)	Maximum user data rate with ½-rate coding (approx.)
256	15	7.5 kbps
128	30	15 kbps
64	60	30 kbps
32	120	60 kbps
16	240	120 kbps
8	480	240 kbps
4	960	480 kbps
4, with 6 parallel codes	5740	2.3 Mbps

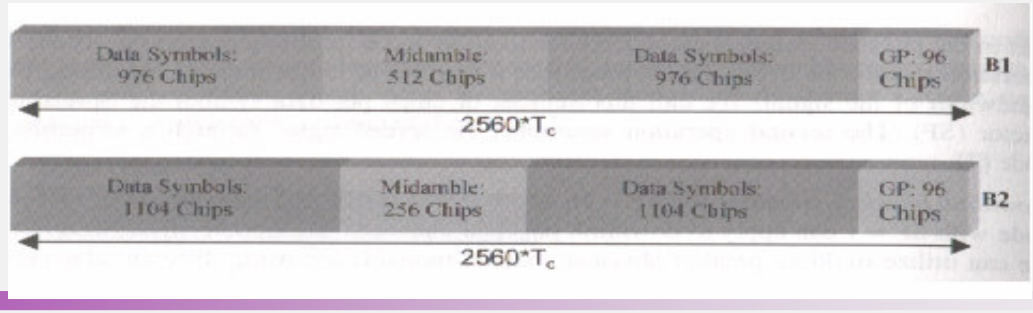
Source: Figure and table [10]

Channels and Channel specifications (Contd.)

- **Physical Channel structure(contd.):**

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*Tc duration each. Hence, a TS corresponds to 2560 chips, each allocated to either uplink or the downlink as illustrated in 1st figure. In second figure frame structure of TDD burst types are shown.

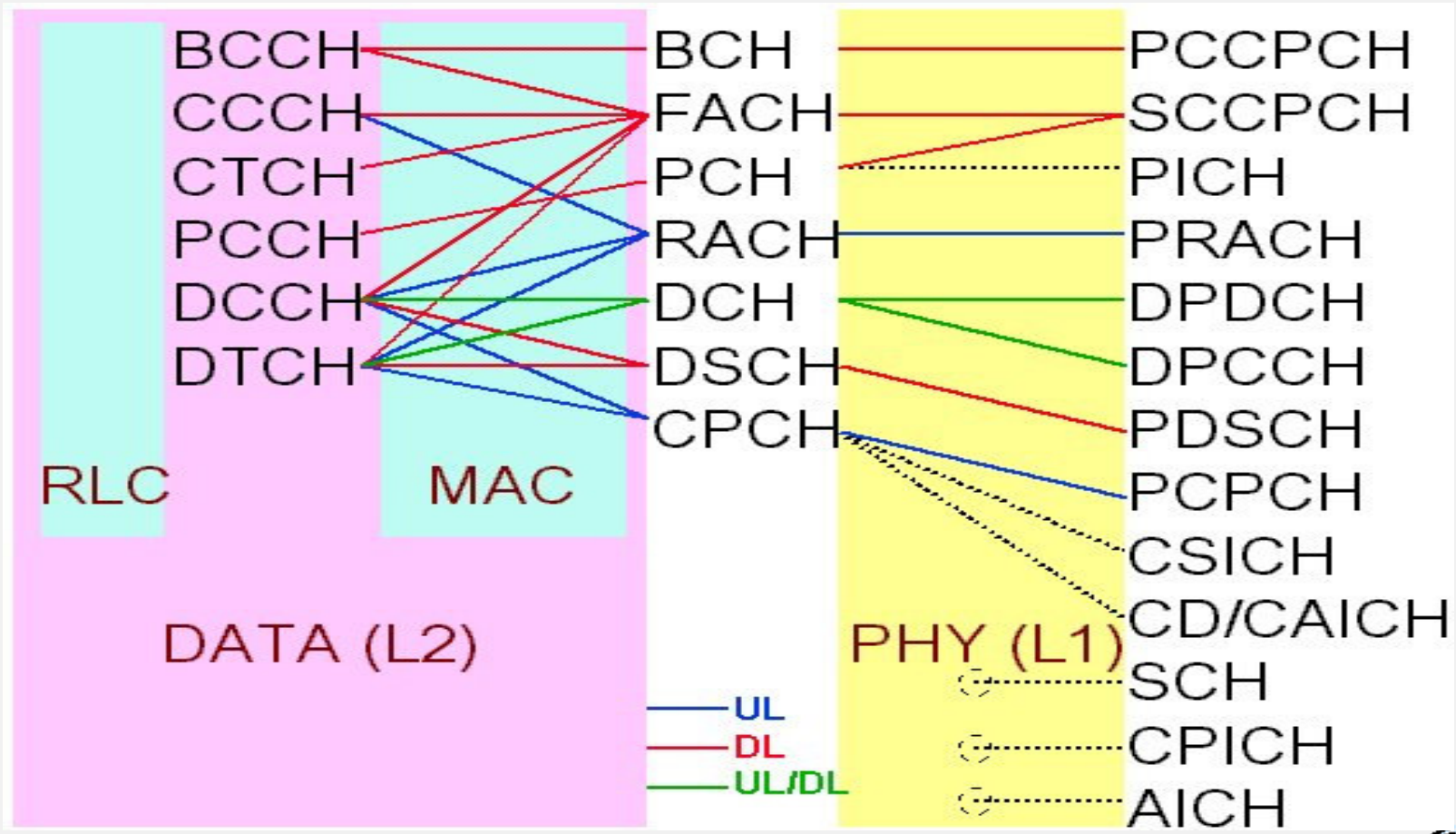




Source: Figure: [9]

Channels and Channel specifications (Contd.)

Mapping of channels



Comparative Study

- **Comparison between UMTS and 2nd generation Mobile systems:**

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

Comparative Study (Contd.)

Comparison between UMTS and CDMA2000

a) 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

b) 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)

Comparative Study (Contd.)

Comparison between UMTS and CDMA2000 (contd.)

c) 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

d) 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

References

- [1] Rivera, N. V.,"**Technical Overview of UMTS**"
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