An Introduction to UMTS Technology

An Introduction to UMTS Technology: Testing, Specifications and Standard Bodies for Engineers and Managers

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Dedication

To my late father and mother—

"My Lord! Have mercy on them both as they did care for me when I was little." May God bless their souls in heaven.

Table of Content

Chapter One – Introduction **1**

INTRODUCTION TO UMTS TECHNOLOGY **1**
Principles of W-CDMA **1**
Spread Spectrum **1**
Protocols and Channels **2**
Protocol Architecture **2**
Layer 1 (L1) or Physical Layer **2**
Layer 2 (L2) or Data Link Layer **2**
Layer 3 (L3) or Network Layer **3**
Transport channels **4**
Downlink Common and Dedicated **4**
Uplink Common and Dedicated **4**
Logical Channels **5**
Control Channels **7**
Traffic Channels **7**
Physical Channels **8**
UL Channels **8**
DL Channels **8**
Radio Bearers **9**
HANDOVER **9**
Soft Handover **9**
Hard Handover **10**
Inter-Frequency HHO **10**
Intra-Frequency HHO **10**
Inter-System HHO **10**
Compressed mode **11**
UTRAN to GSM handover **13**
GSM to UTRAN handover **13**
Inter RAT cell re-selection **13**

Inter RAT cell change **19**
Conclusions **20**
HSDPA **20**
Technical motivation **21**
High speed channels **21**
Adaptive modulation and coding schemes in HSDPA **23**
Fast packet scheduling function **23**
Fast hybrid-ARQ with soft combining or incremental redundancy **23**
HSUPA **24**
New HSUPA Channels **24**
DL L1 Channels **24**
UL L1 Channels **25**
HSUPA Capability **25**
Key Features of HSUPA **27**
Uplink Scheduling **27**
Hybrid Automatic Repeat Request (HARQ) **27**
Reduction of Transmission Time Interval **27**
Impact on Radio Access Network Architecture **27**
MBMS **28**
The new M-Channels **30**
Logical channels **30**
Physical and indication channel **30**
MAC **31**
Transport channel **31**
Layer 1 **31**
MBMS Session Walkthrough **31**
INTRODUCTION TO TESTING **33**

Chapter Two – UMTS Conformance Protocol Testing – Part One 35

PROTOCOL CONFORMANCE TESTING **35**
UE PROTOCOL TESTING **36**
UE in Idle mode (Single Radio Access Technology) **36**
Public Land UE Network Selection **36**
Cell Selection and Re-Selection **38**
Idle Mode UE and dual RAT **39**
PLMN and RAT Selection **39**
Cell Selection and Reselection **40**
Test of Measurement Report **41**
Test of Classmark **41**
DTM **42**
Measurement reports and Cell change order procedures **42**

Handover to UTRAN while in DTM 43
Inter-System Hard Handover from GSM to UTRAN 43
Layer 2 – Medium Access Control (MAC) 45
Testing of Logical – Transport Channels Mapping 45
High Speed - DSCH Layer 2 / MAC-hs 46
Enhanced-DCH Layer 2 / MAC-es/e 47
Radio Link Control (RLC) 48
MBMS 53
Packet Data Convergence Protocol (PDCP) 53
PDCP Robust Header Compression (RoHC) 56
Broadcast Multicast Control (BMC) 56
Radio Resource Control RRC 57
RRC Connection Management Procedure 57
RRC Radio Bearer Control Procedures 65
RRC connection mobility procedure 86
RRC Measurement Control and Report 99
REFERENCES 107

Chapter Two – UMTS Conformance Protocol Testing – Part Two 109

MORE UE PROTOCOL TESTS 109
MBMS 110
Mobility Management 111
CS Call Control 117
Outgoing Call 117
Establishment of an incoming call / Initial conditions 122
In call functions 125
Session Management 126
PDP context activation 126
PDP context modification procedure 127
PDP context deactivation procedures 127
MBMS Context Activation 128
MBMS Context deactivation 128
PS attach procedure 128
PS detach procedure 131
Routing area updating procedure 132
P-TMSI reallocation 134
PS authentication 135
Identification procedure 135
GMM READY timer handling 135
Service Request procedure (UMTS Only) 135
Emergency Call 137

Radio Bearers Services 138
Combinations on DPCH 138
Combinations on PDSCH and DPCH 146
Combinations on SCCPCH 146
Combinations on DPCH and HS-PDSCH 148
Combinations on DPCH, HS-PDSCH and E-DPDCH 150
Short message service (SMS) 151
SMS point to point on CS mode 152
SMS point to point on PS mode 153
A-GPS 154
Signalling tests 154
Performance Tests 157
Acoustic Testing 158
USIM Testing 159
Subscription related tests 159
Security related Tests 159
PLMN related tests 162
Subscription independent tests 164
Phonebook content handling 164
USIM service handling 165
USAT Testing 166
Proactive UICC commands 166
Data Download to UICC 199
CALL CONTROL BY USIM 199
EVENT DOWNLOAD 201
MO SHORT MESSAGE CONTROL BY USIM 202
Handling of command number 202
IMS 202
P-CSCF Discovery 202
Registration 203
Authentication 205
Subscription 205
Notification 206
Call Control 206
Signalling Compression (SIGComp) 206
REFERENCES 207

Chapter Three – UMTS Conformance RF Testing 209

RF PERFORMANCE TESTING 209
UE RF Testing 210
Transmitter Characteristics 210
Output Power and Frequency 210

Output Power Dynamics in the Uplink 212
Transmit ON/OFF Power 212
Transmit Modulation. 213
Receiver Characteristics 213
Performance Tests 213
Demodulation of DCH in downlink Transmit diversity modes 214
Demodulation in Handover conditions 214
Power control in downlink 215
Downlink compressed mode 215
Blind transport format detection 215
Demodulation of Paging Channel (PCH) 215
Detection of Acquisition Indicator (AI) 215
RRM Testing 215
Idle Mode 215
UTRAN Connected Mode Mobility 216
RRC Connection Control 217
Timing and Signalling Characteristics 218
UE Measurements Procedures 218
Measurements Performance Requirements 219
Performance requirements for HSDPA 222
Demodulation of HS-DSCH (Fixed Reference Channel) 222
Reporting of Channel Quality Indicator 226
HS-SCCH Detection Performance 227
Performance requirement (E-DCH) 228
Detection of E-DCH HARQ ACK Indicator Channel (E-HICH) 228
Detection of E-DCH Relative Grant Channel (E-RGCH) 228
Demodulation of E-DCH Absolute Grant Channel (E-AGCH) 229
NODE-B RF TESTING 229
Node-B output power 229
Frequency error 229
Output power dynamics 229
Output RF spectrum emissions 230
Transmit intermodulation 231
Transmit modulation 231
Receiver Reference sensitivity level 232
Receiver Dynamic range 232
Adjacent Channel Selectivity (ACS) of the Receiver 233
Receiver Blocking characteristics 233
Receiver Intermodulation Characteristics 233
Receiver Spurious Emissions 233

Receiver Verification of the internal BER calculation **233**
Performance requirement **234**
Demodulation in static propagation conditions **234**
Demodulation of DCH in multipath fading conditions **234**
Demodulation of DCH in moving propagation conditions **235**
Demodulation of DCH in birth/death propagation conditions **235**
Verification of the internal BLER calculation **235**
Performance of signalling detection for HS-DPCCH **236**
Demodulation of E-DPDCH in multipath fading conditions **237**
Performance of signalling detection for E-DPCCH in multipath fading conditions **237**
REFERENCES **238**

Chapter Four – Testing Types and Stages 239

TESTING TYPES OF MOBILES AND BASE STATIONS **239**
Pre-acceptance testing **241**
Conformance testing **242**
Production testing **242**
Functional Testing **243**
Unit testing **243**
Functionality testing (White and Black box testing) **243**
Regression testing **244**
I&C, maintenance, live and field-trial testing **244**
Interoperability testing and plug-fests **245**
Application and end-to-end testing **246**
Network optimisation and drive testing **247**
Load and Stress Testing **247**
Non-functional testing **248**
Verification and Validation testing (VVT) **248**
General development testing **248**

Chapter Five – Conformance Testing and TTCN 251

CONFORMANCE TESTING **251**
PROTOCOL CONFORMANCE TESTING **252**
Definition **252**
Purpose **252**
Black Box testing of external behaviour **252**
Implementations Testing **252**
Approach **252**
Conformance Test and Tester Architecture **253**
Conformance Testing Languages and Tools **256**

TTCN-2 **256**
TTCN-3 **261**
More Features Required **271**
Assessment of TTCN 2 and 3 **272**
VB/VC/Pearl/shell **273**
Advantages of TTCN and Conformance Testing **273**

Chapter Six – Standardisation and Validation Bodies 275

TEST CASE DEVELOPMENT **275**
Summary of Conformance Test Case Lifecycle **275**
TTCN-2 Test Cases **276**
TTCN-3 Test Cases **278**
Test Case Prose **278**
Verification **279**
TTCN-2 Test Case Life Cycle in Details **279**
Test Case Validation **281**
External validation of test cases **282**
Fundamentals of the SS Manufacturer Policy **283**
Validation Workflow **284**
Validation Reasons **285**
Validation Categories **285**
Submission Rules to GCF **285**
UE Certification **288**
Downgrade of Test Cases **288**
Multiple Test Case Paths **288**
Cut-off point for Change Requests **288**
UMTS Test Case Priority **289**
TC DEVELOPMENT AND RELEASE PROCESS **289**
Test Case SW Requirements **289**
API Functions and Runtime support for Test Cases **290**
Adaptation SW **291**
Test Cases - Testing and Regression checks **291**
Sample testing **291**
Review and Release of Test Cases **291**
Distribution and Updates of Test Cases **293**
Planning and Prioritisation **293**
Test Case Development **294**
UE Test Requirements **294**
TTCN TC Baseline handling **295**
Test System SW/HW Updates **296**
Review and Release of Test Cases **296**

APPROVAL OF TEST CASES **297**
The role of the certification bodies **297**
GCF **298**
PTCRB **299**
MCC 160 **299**
Standards Tracking **300**
OVERVIEW OF STANDARDS **300**
CR (Change Request) Management **300**
Version Control of Test Cases **301**
Interaction with External Bodies **301**
UMTS Test Cases **301**
EXTERNAL ORGANISATIONS **302**
3GPP **302**
RAN5 **303**
Test Houses **304**
CAG **304**
CDG **304**
ETSI **304**
GCF **304**
GERAN (TSG-GERAN) **305**
ETSI **305**
MCC **305**
PTCRB **306**
PVG **306**
RAN 5 **306**
UAG **306**
WG3 **307**
Testing **307**
Validation Control **307**
Reviews **307**
Release formalities **307**
Status **307**
Development **308**
Validated **308**
Approved **308**
Storage **308**
DEFINITIONS **308**
REFERENCE DOCUMENTS **310**

List of Abbreviations 311

Preface

The first Chapter of this book focuses on the basic concepts of W-CDMA technology. These principles are UMTS (CDMA) specific, and are unlikely used in other technologies; therefore some explanation may be necessary. Simplified introduction to these concepts will make reading this book easier.

Chapter 2 is divided into two parts, both covers protocol conformance testing. This type of testing is used throughout the initial stages of development to ensure the accuracy of a protocol implementation. It is also used in regression testing after initial product deployment to further verify any changes in the implementation/enhancement. Traditionally, conformance testing has been the domain of the telecommunications industry. The only way to ensure that standards are met is to test products in an effective way using the test specification. First part of chapter two mainly covers dle mode, dual RAT, RRC, RLC and MAC tests. Part two mainly concentrate on MBMS, MM, RB services, SMS, A-GPS, acoustic and IMS tests. This chapter lists all tests that are necessary to be conducted on different layers and modules of the UE under test. Further details of these tests can be found in the relevant standards.

Chapters 3 gives a unified and in-depth presentation of selections and RF conformance tests for UEs and NBs. In addition to the protocol conformance, the RF performance of the UE must also be verified. Many measurements of the transmitter and receiver performance are performed in a number of areas, e.g. out-of-band emissions. Measurements of the radio resource management (RRM) are performed to ensure that the control capability of the UE is operating according to the standards. The RRM is the component used to control the physical or RF layers in accordance with the requirements of the protocols from the upper layers. There are, for instance, very tight limits on the transmitter output power, as it is controlled to meet conditions such as variations in signal strength. This ensures that the handset only transmits sufficient power to maintain a reliable connection under the prevailing conditions.

Chapter 4 explains thouroghly all types of tests at different stages the system (whether UE or BS) need to go through throughout the lifecycle of the product. For example development testing is essential throughout the lifecycle of the product. Initial system validation of Layer 1 implementation is required at early stages of system development. Conformance testing has to cover L1/L2 protocol, Inter System Handover protocol, RRM protocol and RF performance and implementation of the system. Terminology may differ but the intended purposes of these test still widely used. Some of the tests may overlap in some cases for some products. This chapter provides good coverage of all tests at all stages.

Chapter 5 presents different languages and tools used in the conformance industry to carry out conformance testing. Standard bodies are using special languages like TTCN-2, TTCN-3 to specify the conformance test specifications but conventional languages like Basic/C/C++/Perl/Shell scripts still capture some of the market share for test suite implementation. The chapter gives more attention to TTCN-2 and TTCN-3 languages/tools.

Chapter 6 is the final chapter of this book. It covers many distinct processes apply to the provision of test cases. Test cases are written in prose, describing in detail how the test is carried out and the pass and fail criteria. To ensure that each test is a true representation of the original intent of the test, a validation and approval process has been set in place. Once the test case is verified by the supplier (3GPP), i.e. is satisfied that the test operates correctly, it is then given to an independent validation organisation to test for conformance with the original test specification and check for proper operation. When it has passed this test, it can be submitted to the relevant industry body for approval. After approval, it can be used in formal mobile terminal testing and certification. The standarisation and validation bodies and procedures are well detailed in this chapter.view of the procedure, as well as the equivalent but distinct procedures for the other systems is described in this chapter.

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Finally I would like to thank Dr Baha Hashimi for reviewing the manuscript.

Chapter One

Introduction

INTRODUCTION TO UMTS TECHNOLOGY

In this chapter basic concepts of W-CDMA are explained and discussed. These principles are UMTS (CDMA) specific, and are unlikely used in other technologies; therefore some explanation may be necessary. A simplified introduction to these concepts will make reading this book easier.

Principles of W-CDMA

Some mechanisms are required to share frequency resources in communication systems with multiple users. This mechanism is referred to as Multiple Access scheme. CDMA is a scheme where all users are transmitting on the same frequency at the same time but separated by codes.

Spread Spectrum

W-CDMA is a multiple access technique using a concept known as Spread Spectrum. In Spread Spectrum systems the information Bandwidth is spread across a wider transmission Bandwidth which is determined by a function that is independent of the transmitted information.

The original data sequence is binary multiplied with a spreading code. The bits in the spreading code are called chips and the data bits sequence are called symbols. Each user has its own spreading code. Application of the same spreading codes once again at the receiving end returns the transmitted signals to their original Bandwidths. The ratio between the transmission BW and the original BW is called the processing gain. The lower the SF the more data can by transported on the air interface. The relative strength of the desired signal and the rejection of other signals is proportionate to the number of chips over which the receiver has to integrate, which is the spreading factor. The larger the SF the larger the processing gain and hence the original signals do not need to be of high power to achieve a target quality level. The longer the symbol time the longer the integration process. This is referred to as processing gain and is directly proportional to the SF.

The spreading codes (referred to as channelization codes) are unique and have low cross-correlation with other spreading codes. This means that several wideband signals can co-exist on the same frequency without interference. When the combined signal is correlated with the particular spreading code, only the original signal with the corresponding spreading code is de-spread, while the remaining component of the signal remain spread.

The principle of correlation is used at the receiving end to recover the original signal out of the noise generated by all the other users' wideband signal. As illustrated in Figure 1.1 the original data is coded and the resulting signal is then transmitted. The received signal is multiplied by the code to recover the original data. If the receiver does not know the correct code the results will be a signal almost average to zero.

Table 1.1 illustrates the differences between the two types of codes that are used in W-CDMA and the way they are used in the downlink and the uplink.

OVSF (Orthogonal Variable Spreading Factor) are designed to allow the support of simultaneous variable data rate channels. The spreading factors are assigned so that they do not come from a parent or grandparent code on the same branch of the tree. This is to avoid code clashing.

Protocols and Channels

Protocol Architecture

The diagram in Figure 1.2 illustrates in details the protocol architecture that exist across the Uu interface in a FDD UMTS system. At the lower level there is the Physical Layer (L1). This is accessed by a number of SAPs by the MAC which in turn is accessed by the RLC Layer 2 protocols.

The interconnections between different layers of protocol are defined by means of the SAPs (Service Access Points). Figure 1.2 illustrates the basic SAPs in the control and the user plane for the radio interface . Two additional SAPs are provided for the two entities (BMC and PDCP). SAPs offer a range of well defined services that will be explored further in the following sections.

Signalling messages are divided into user plane and control plane at the higher layers. RRC is a L3 entity that exists in the control plane which provide some control services to higher layers.

The air interface is layered into three protocol layers:

Layer 1 (L1) or Physical Layer

It interfaces the MAC of L2 and the RRC of L3. It offers different transport channels to the MAC.

Layer 2 (L2) or Data Link Layer

It is split into MAC, RLC, PDCP and BMC. L3 and RLC are divided into User and Control planes while BMC and PDCP exist in the User plane only.

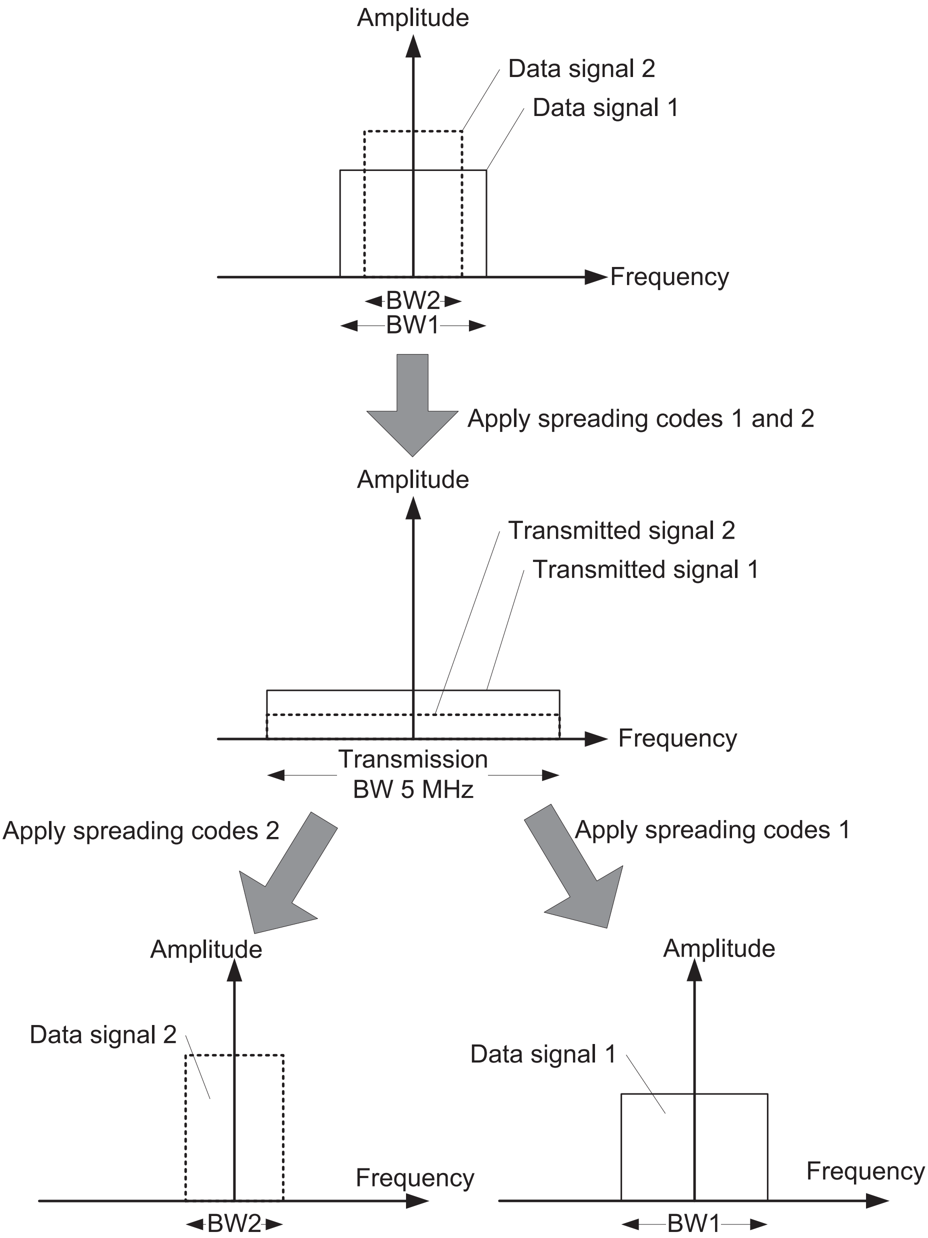

Figure 1.1 Spreading and data signal

Layer 3 (L3) or Network Layer

In the Control plane L3 is partitioned into RRC which interface with L2. The RLC provides ARQ functionality coupled with the radio transmission technique used.

Code type	UL	DL
Channelization (spreading)	4-256 Physical (user) data Control data Signalling data Form the same UE OVSF	4-512 (Release 4 onward SF range is (4 Ð 256) Control Channels Traffic Channels Different users on the same cell OVSF
Scrambling	To isolate users Large number of codes Use long codes (Gold) 38400 chips length in 10 ms frame Also use short codes (Kasami)	To prevent co-channel interference from adjacent cells Long codes Limited to 512 codes

Table 1.1 Channelization and scrambling codes

Transport channels

These are the SAPs that are at the output of the MAC and at the input of L1. They define the characteristics with which data is transported over the air interface. Each transport channel has associated with it a Transport Format set, which defines the coding, interleaving and mapping onto Physical Layer. Transport channels define the interface by which the MAC communicates with the physical layer. There exist two types exist Dedicated and Common Transport channels, DCH is the only dedicated channel. Dedicated means there is a point to point link between the UE and the network while Common means point to multipoint link. In general they map to a specific physical channel. Transport channels are:

Downlink Common and Dedicated

DCH is only one channel and transmitted over the entire cell. It is characterized by the possibility of fast rate change (every 10 ms), fast power control and inherent addressing of UE's. Used for bidirectional transfer of data and control.

BCH is used for broadcasting system and cell specific information and is always transmitted over the entire cell with a low fixed bit rate.

FACH is transmitted over the entire cell. FACH uses slow (open loop) power control only. Transfer of small amount of data

PCH is transmitted over the entire cell. Broadcast of paging and notification messages while allowing for sleep mode.

Uplink Common and Dedicated

DCH is only one channel and transmitted over the entire cell. It is characterized by the possibility of fast rate change (every 10 ms), fast power control and inherent addressing of UE's. Used for bidirectional transfer of data and control.

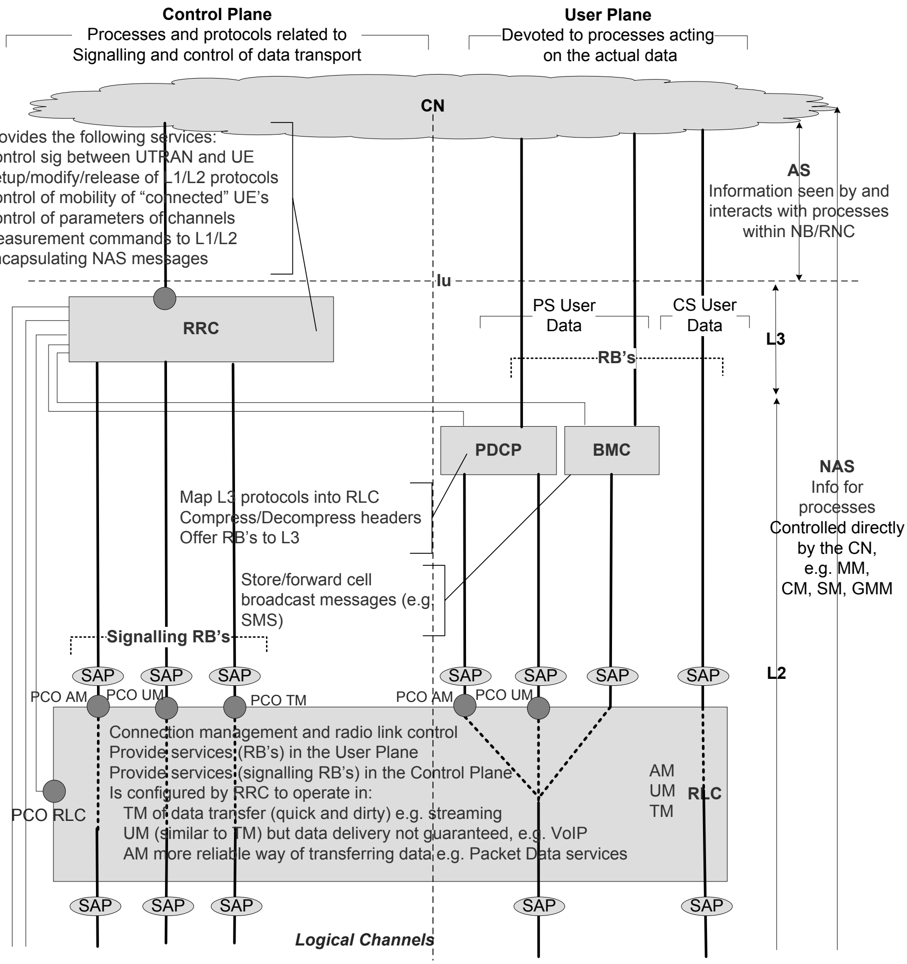

Figure 1.2a UMTS Protocols and layers

RACH is used for initial access or transfer of small amount of data. Open loop power control only.

Logical Channels

The MAC layer provides data transfer services on logical channels. Different logical channel types are defined for different kinds of data services as offered by the MAC. It is characterized by the type of information transferred. These are an information stream provided by the MAC dedicated to the transfer of a specific type of information over the radio interface. There are restrictions on the transport channel type that that can be used to carry a given logical channel. See channel mapping in Figure 1.3

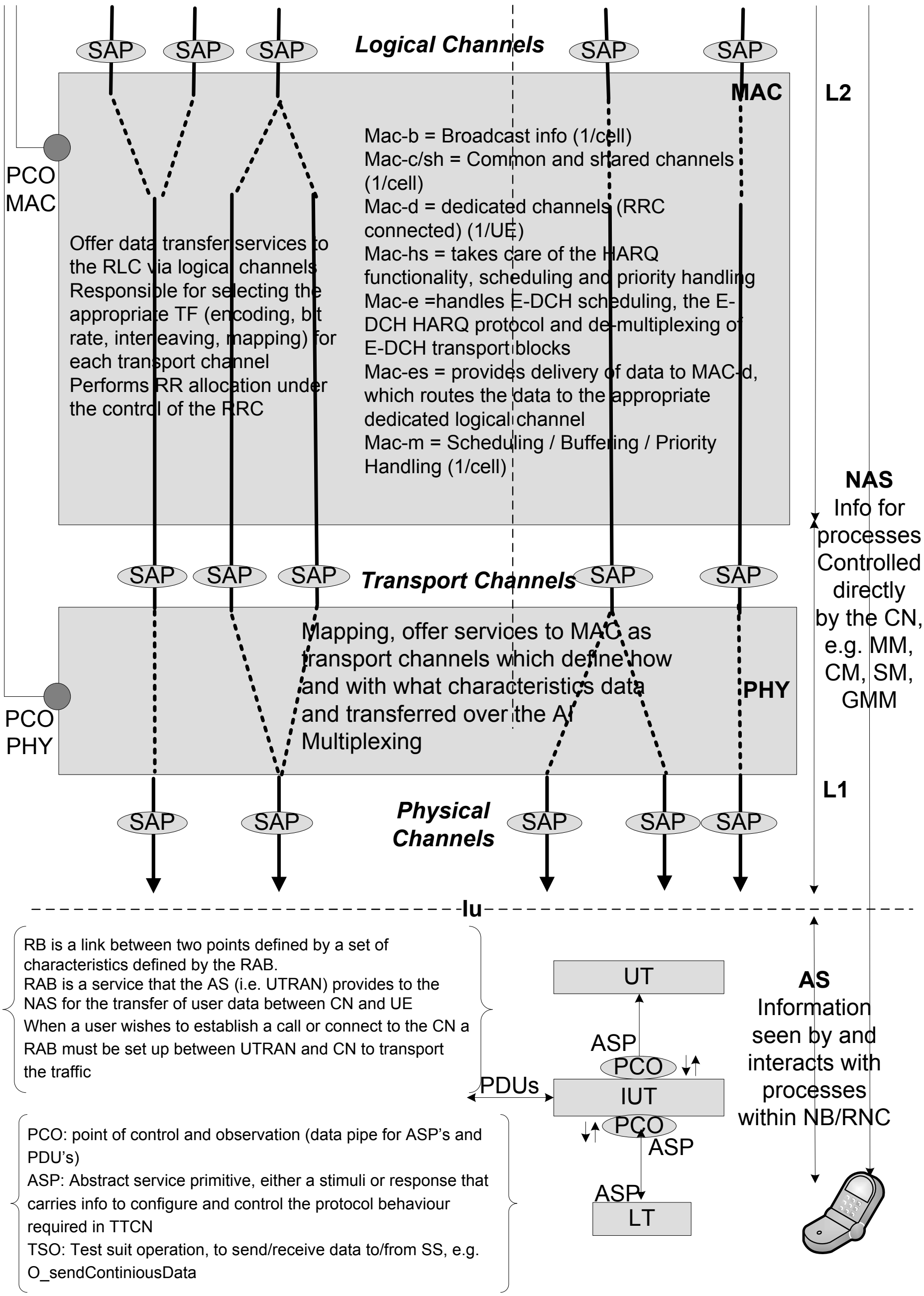

Figure 1.2b UMTS Protocols and layers

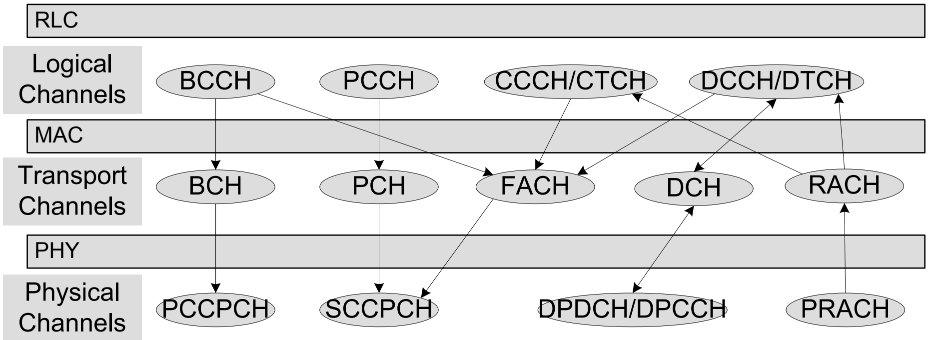

Figure 1.3 Channel mapping

Control Channels

These channels are used for control plane information

Downlink

BCCH is used to broadcast control and signalling information which is system and cell specific. Therefore it is only a downlink channel. It is carried via either the P-CCPCH or the S-CCPCH. This means that its messages can always be read by a UE, once the UE has detected a Node-B's unique scrambling code, which it does during its initial cell search.

PCCH is used to transfer paging information when the net does not know the location of the UE. Also is used when the UE is in the Cell Connected state. PCCH can be carried on PCH and it is a downlink channel only.

CCCH is a bidirectional point to multipoint channel that is used to transfer control information from the network to the UEs. It is used as part of the resource allocation procedure to carry the resource allocation procedure information. CCCH can be carried S-CCPCH.

DCCH is a point to multipoint channel that carries UE specific control information after an RRC connection is setup. DCCH can be carried on FACH or DCH (RNC to decide).

Uplink

CCCH on the uplink this is used by the UE having no RRC connection setup with the net. Also used by the UE's that are using common transport channels when accessing a new cell after cell reselection and has no resources allocated in the intended cell. CCCH can be carried on RACH.

DCCH is a control channel that can be used to transfer dedicated signalling messages from the UE to UTRAN. DCCH can be carried on RACH.

Traffic Channels

These channels are used for user plane information