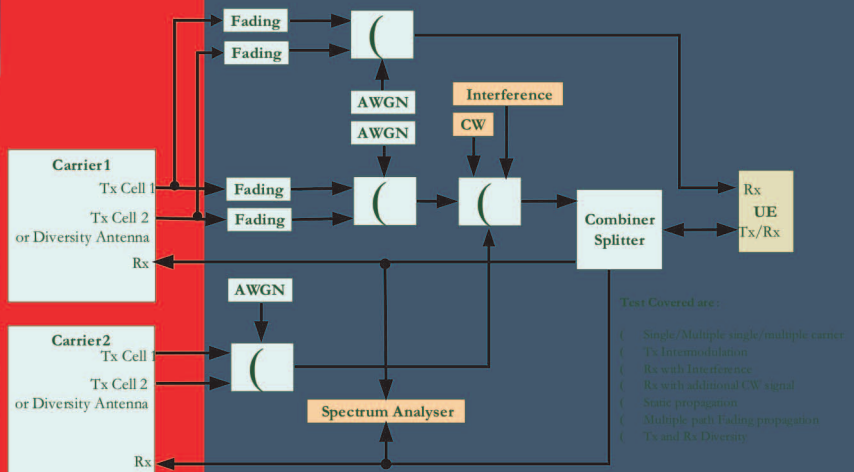


# An Introduction to UMTS Technology

Testing,  
Specifications  
and Standard Bodies  
for Engineers and Managers



Faris Muhammad

# **An Introduction to UMTS Technology**



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UMTS Technology:  
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Standard Bodies for Engineers and  
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**Dr. Faris Muhammad**

BrownWalker Press  
Boca Raton, Florida

*An Introduction to UMTS Technology:  
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## Dedication

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*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.*



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# Preface

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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 thoroughly 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 standardisation 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.

# Acknowledgments

---

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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 be 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 wide-band 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.

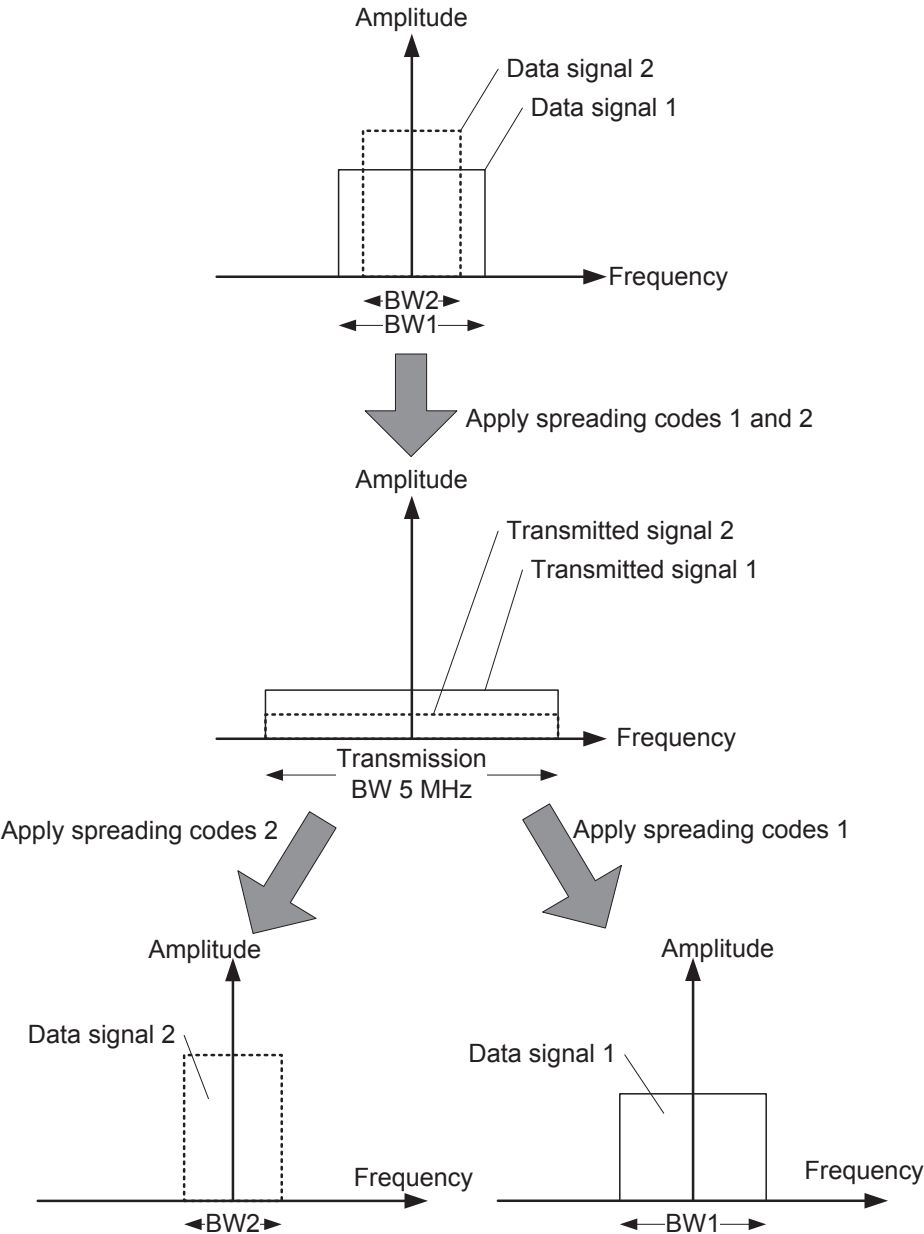


Figure 1.1 Spreading and data signal

**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 $(4 \div 256)$ 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.

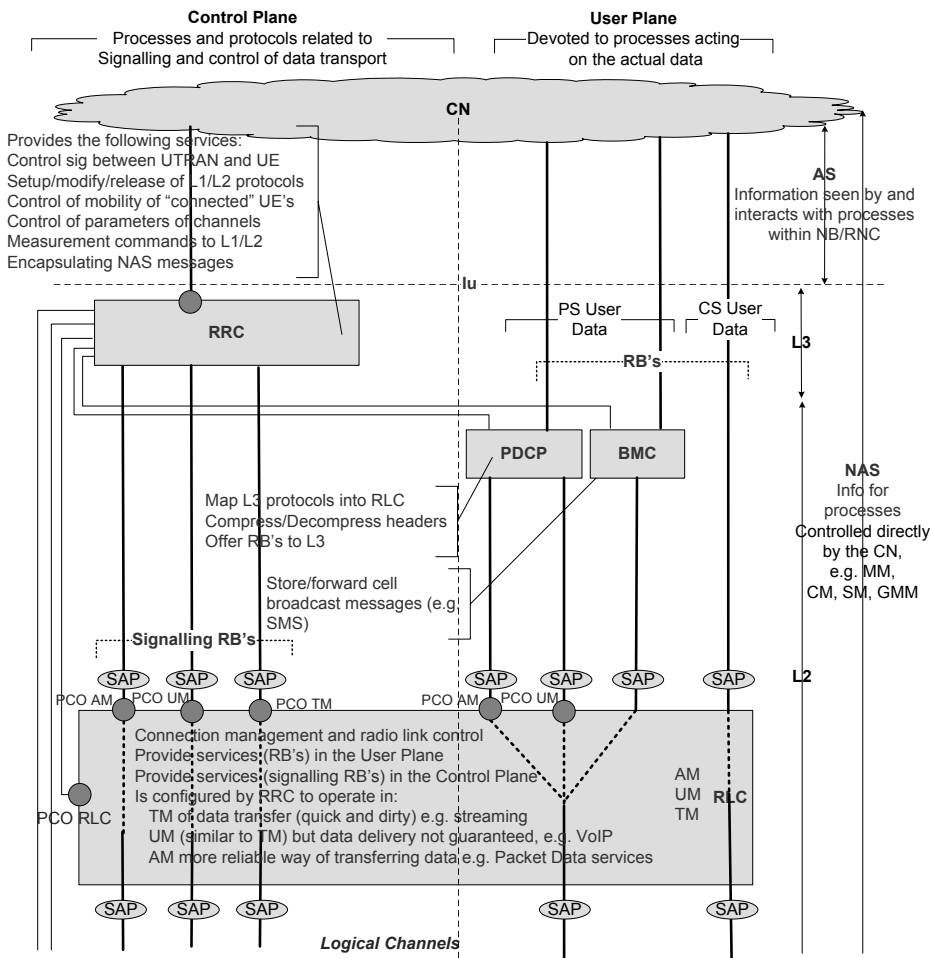
**BCH** is used for broadcasting system and cell specific information and is always transmitted over the entire cell with a low fixed bit rate.

**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.



**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 can be used to carry a given logical channel. See channel mapping in Figure 1.3



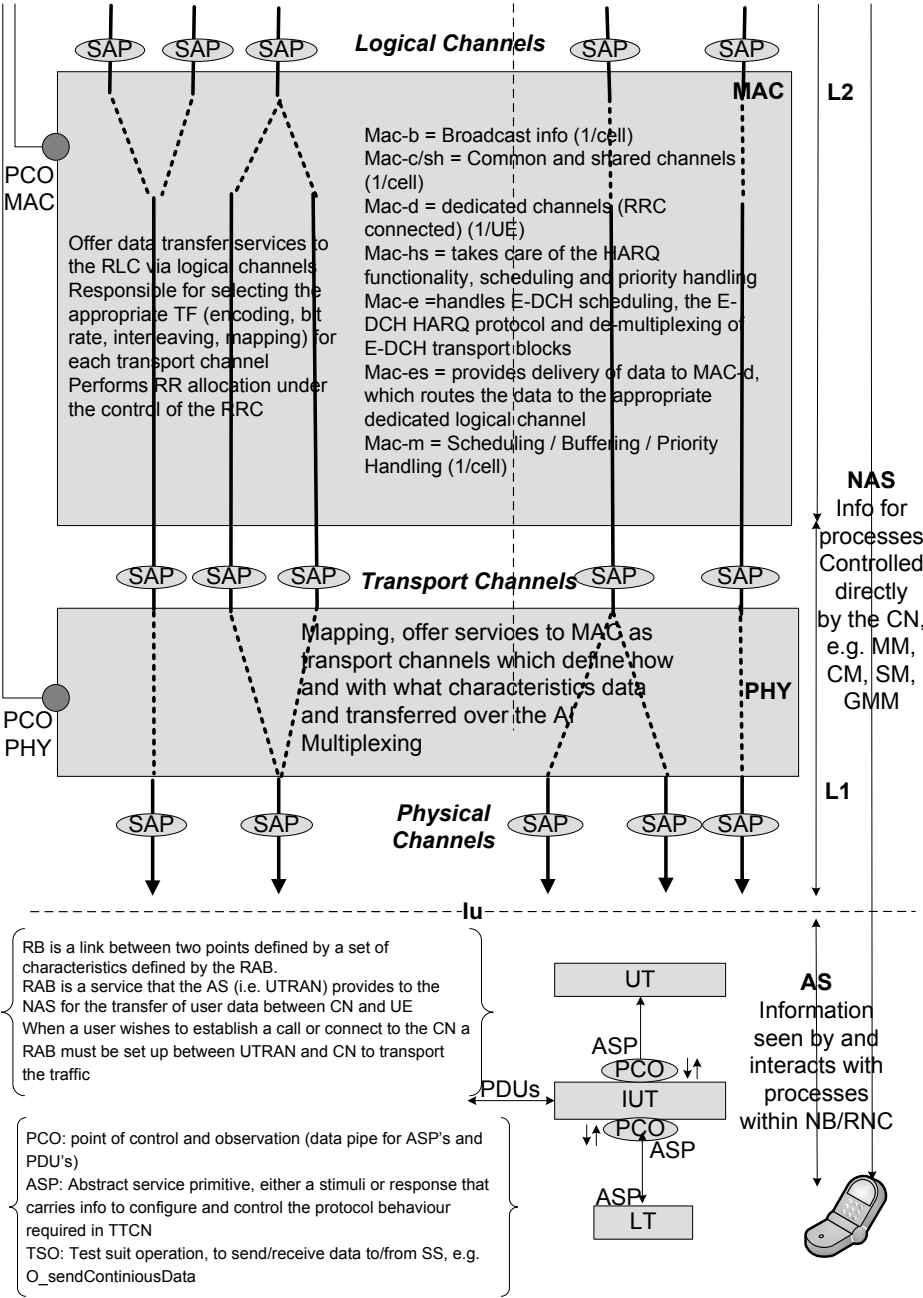


Figure 1.2b UMTS Protocols and layers