UMTS Long Term Evolution

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Who should attend this course?

This course is suitable for engineers who need to understand the long-term evolution (LTE) of the UMTS air interface, and the design and implementation of the evolved packet system (EPS).

The course lasts for 3 days.

Course objectives

By the end of this course, the participants will:

- Have a system-level understanding of the UMTS evolved packet system (EPS) and its two main components, the evolved UMTS terrestrial radio access network (E-UTRAN) and the evolved packet core (EPC).
- Understand the protocols that are used for radio transmission and reception on the air interface, including the techniques of OFDMA, SC-FDMA and MIMO antennas.
- Understand the signalling protocols and procedures that the EPS uses to control the mobile and the network.

Pre-requisites

A basic understanding of mobile telecommunications, UMTS and high-speed packet access would be useful for this course. They are not essential, however, as the trainer can adapt the delivery to account for the previous experience of the participants.

Notes on the content

The material is based on release 8 of the 3GPP specifications for UMTS. The course is a technical one, but it has been written in a way that gives participants several important things that are missing from the specifications themselves:

- It delivers a system-level understanding of the hardware and software components of the evolved packet system, and of how they interact.
- It explains why the system has been designed in the way it has.
- It is clearly written and delivered, in plain English.

The outline below describes the material that will be delivered on a typical course. The UMTS release 8 specifications are, however, still evolving, and this will inevitably lead to changes in the course content as time goes on. We can also write customised courses to meet the requirements of individual customers, and adapt the delivery to meet the wishes and needs of the participants.

About the trainer

The courses will be delivered by Dr Chris Cox. Chris has a degree in Physics and a PhD in Radio Astronomy from the University of Cambridge, and ten years experience in 3G mobile telecommunications. He is an accomplished trainer and presenter, and twice winner of national public speaking competitions. He is the author of *"Essentials of UMTS"*, which was published by Cambridge University Press in 2008. Chris' unusual mix of technical and communication skills makes him ideally qualified to present these courses.

Day 1

1 Introduction

The first section lays out the historical and technical context of the evolved packet system and of the long-term evolution of the UMTS air interface.

- Lists of books, specifications and abbreviations
- History of mobile telecommunications and UMTS
- Requirements of the evolved packet system
- The ITU process for 4G mobile telecommunication systems

2 System architecture

This section describes the hardware and software architecture of the EPS. As such, it serves as a framework to which the later, more detailed parts of the course can be related.

- High-level hardware architecture of the EPS
- Architecture and capabilities of the UE
- Architecture of the E-UTRAN, and functions of the eNodeB
- Architecture of the EPC, and functions of the MME, SGW, PGW and PCRF
- System interfaces and protocol stacks
- Bearers, channels and example information flows
- Signalling connection management, including the RRC, EMM and ECM state diagrams
- Numbering and addressing schemes
- Services supported by the EPS, including GPRS, MBMS and voice

Day 2

3 Principles of OFDMA, SC-FDMA, MIMO antennas and hybrid ARQ

This section describes the techniques used in the LTE air interface: orthogonal frequency division multiple access (OFDMA), single carrier frequency division multiple access (SC-FDMA), multiple input multiple output (MIMO) antennas, and hybrid automatic repeat request (hybrid ARQ).

- Communication techniques for fading multipath channels
- Principles of OFDMA, including FFT processing and cyclic prefix insertion
- Use of SC-FDMA for the LTE uplink, to reduce the variation in transmit power
- Multiple antenna techniques, including transmit & receive diversity and MIMO antennas
- Use of hybrid ARQ for error correction

4 Introduction to the air interface physical layer

This section describes how the above techniques are implemented. It concentrates on the uplink and downlink shared channels (UL-SCH and DL-SCH), because these channels carry most of the information that is of interest to the user.

- Internal structure of the physical layer
- Error correction, error detection, rate matching and interleaving
- Frame and slot structure, and the use of the resource grid
- Scrambling, and its use for interference management
- Layer mapping and precoding, and their relationship to multiple antenna techniques
- Mapping of the UL-SCH and DL-SCH to resource elements
- Introduction to analogue processing

Day 3

5 Higher-layer protocols

In this section, we introduce the protocols in layers 2 and 3 of the air interface.

- MAC protocol, including its architecture and its use for channel mapping and scheduling
- RLC protocol, including transparent, unacknowledged and acknowledged modes
- PDCP, including header compression, security functions and recovery from handover
- RRC protocol, including system information broadcast and RRC connection management
- NAS protocols, including the procedures for EPS mobility and session management

6 System and network operation

The final section brings the preceding material together, by illustrating how the mobile and the network interact with each other, and how the system as a whole behaves.

- Power-on procedures, including cell selection and the attach procedure
- Security procedures, notably the procedure for authentication and key agreement
- Procedures in RRC Idle state, including cell reselection and service requests
- Procedures in RRC Connected state, including bearer management and handover