

## LTE Signalling – 3 days

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### CONTENTS

The course offers a solid understanding of the layer 2 (L2) and layer 3 (L3) signalling protocols as well as the physical layer (L1) defined for the evolved radio access network (E-UTRAN). The course focuses on the radio interface and the S1-interface but includes also relevant information pertaining to the Evolved Packet Core (EPC) in order to give the student a comprehensive end-to-end view of the most important signalling scenarios.

The course uses a top-down approach starting with a high level description of the overall network architecture (nodes, areas, identity numbers, bearer concepts etc). The L3 protocols are then discussed one by one in detail in a logical scenario-based sequence. After this the L2 radio interface protocol functionality is described, focusing on scheduling and reliability issues (ARQ and HARQ). An overview of the signalling and HARQ aspects of L1 is also included to give the student a complete view of the LTE protocol stack.

### PREREQUISITES

General knowledge in earlier mobile systems (GSM/UMTS) is required. Knowledge of HSPA is useful due to the many similarities between LTE and HSPA. The course LTE/EPC System Overview is recommended.

### Introduction

- Overview of 3GPP releases
- History of the E-UTRAN/EPC standardisation work

### The Evolved Packet System

- Network elements and interfaces
- CP and UP bearers
- QoS parameters (AMBR, QCI, TFT etc.)
- Introduction to IMS: nodes, interfaces, procedures

### NAS Protocols (EMM and ESM)

- Mobility management procedures
- Session management procedures
- Pool areas and Tracking Area lists
- Dual Registration and Idle mode Signalling Reduction (ISR)
- NAS states and state transitions
- NAS message formats
- EPS security architecture, AKA, key derivation functions

### Evolved UTRAN (incl. overview of the physical layer)

- E-UTRAN channel architecture (logical, transport and physical channels)
- OFDM basics, layer 1 frames, time-frequency resource mapping
- PDCCH formats and layer 1 resource assignment

### Radio Resource Control protocol (RRC)

- System information broadcasting, paging
- RRC connection establishment, RRC states
- Default/signalled configuration of Signalling/Data Radio Bearers
- UE capabilities, Feature Group Indicators

- RRC connection reconfiguration procedure (incl. intro to ASN.1)
- Measurement control, event reporting
- RRC connection release and re-direction procedures

### **Packet Data Convergence Protocol (PDCP)**

- PDCP architecture and functions
- RoHC header compression
- PDCP reordering and retransmission during handovers
- PDCP PDU formats

### **Radio Link Control protocol (RLC)**

- RLC architecture and functions
- RLC modes: AM, UM and TM
- ARQ operation (polling, status reporting, retransmissions and re-segmentation)
- RLC PDU formats

### **Medium Access Control protocol (MAC)**

- MAC architecture and functions
- Stop-and-wait HARQ
- Scheduling on DL-SCH and UL-SCH
- CQI reporting, BSR reporting and PHR reporting
- MAC control procedures
- MAC PDU formats

### **S1 Application Protocol (S1AP)**

- S1AP procedures
- Establishment of logical S1-connection
- UE context management in eNB
- E-RAB management
- S1 handover procedures

### **Mobility and Interworking**

- X2AP procedures
- X2 handover preparation and execution
- Overview and protocols for relay eNB operation
- WiFi interworking for VoWiFi
- CS interworking (CS fallback, SR-VCC)
- ANDSF introduction

### **Signalling flows**

- Random access and RRC connection establishment
- Initial Attach and establishment of default bearer
- Dedicated bearer establishment
- X2-based handover (LTE-to-LTE)
- Inter-RAT handover (LTE-to-UTRAN)