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LTE Air Interface Operation

Course Description

With the introduction of LTE came the development of a new radio technology based on OFDMA / SC-FDMA. This course focuses on the LTE Air interface and provides a detailed analysis of the structure and features of the physical layer, as well as the layer 2 and 3 protocols, before explaining how these are used in the operation of the radio link from initial attach, through service delivery and mobility. Finally, the concept and operation of LTE-M and NB-IoT are detailed.

Prerequisites: LTE System Engineering, or equivalent knowledge.

12	12	
Hours Learning (OnlineAnytime)	**CPD Learning Credits**	**Level: 3 (Advanced)**

This course will contain the following sections:

1. LTE Air Interface

Topic areas covered include:

- Frequency Bands.

- 3GPP Spectrum Bands.

- EARFCN.

- E-UTRA Protocols:
    - Uu Interface:
        - RRC, PDCP, RLC and MAC.
    - S1-MME Interface:
        - S1AP and SCTP.
    - S1-U Interface:
        - GTP-U.
    - X2 Interface:
        - X2AP.

- UE and eNB Capabilities:
    - eNB Capabilities.

- Home Evolved Node B.

- UE Capabilities.

- Air Interface Identities:
    - UE Identities:
        - IMSI, C-RNTI, GUTI, S-TMSI, IMEI and IP Address.
    - E-UTRAN Identities:
        - eNB ID, E-CGI, PCI and TAI.
    - EPC Identities:
        - GUTI, IP Addresses and FQDN.

- LTE-Advanced Features:
    - LTE Releases.
    - LTE-Advanced.

2. LTE Physical Layer Structure

Topic areas covered include:

- LTE Frame Structure:
    - LTE FFT Sizes.
    - Subcarriers and Reference Signals.
    - Combating Interference in the Time Domain.
    - Cyclic Prefix.
    - Frame Structure:
        - Ts (Time Unit).
    - Type 1 Radio Frames, Slots and Subframes.
    - Type 2 Radio Frames, Slots and Subframes.

- Resource Grid and Resource Blocks:
    - Downlink PRB Parameters:
        - RB and RE.
    - Uplink PRB Parameters.

- Downlink Channel for Initial Access:
    - Downlink Synchronization Signals (FDD):
        - PSS and SSS.

- Downlink Reference Signals:
    - Cell Specific Reference Signals:
        - CRS-RS vs CSI-RS.
    - UE Specific Reference Signals.

- The LTE Downlink Physical Channels:
    - Broadcast Information.
    - PCFICH.
    - PDCCH.
    - Enhanced PDCCH.
    - PHICH.
    - PDSCH.
    - PMCH.

12
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LTE Physical Layer Structure (cont.)

- LTE Uplink Physical Channels:

    - Multiplexing of Control Signalling and UL-SCH Data.
    - Uplink Data Transmission.
    - PUCCH (Physical Uplink Control Channel).
    - PRACH:
        - Preamble Codes.

- Uplink Reference Signals:

    - Demodulation Reference Signal:
        - DRS.
    - Sounding Reference Signal:
        - SRS.

- FDD/TDD Timing:

    - FDD Operation.
    - TDD Operation.

3. LTE Physical Layer Features

Topic areas covered include:

- Transmission Modes;

    - Transmission Options.
    - Transmit Diversity.
    - MIMO.
    - MU-MIMO.

- HARQ Operation:

    - ARQ Operation.
    - HARQ Operation.
    - FDD Downlink HARQ.
    - FDD Uplink HARQ.
    - TDD HARQ.

- Feedback Mechanisms:

    - Feedback Options in LTE.
    - CQI (Channel Quality Indicator).
    - PMI (Precoding Matrix Indicator).
    - RI (Rank Indication).

- Carrier Aggregation:

    - Carrier Aggregation in 3GPP.
    - Carrier Aggregation Terminology.
    - Carrier Aggregation Scheduling.

4. LTE Air Interface Protocols

Topic areas covered include:

- The E-UTRA Protocol Stack.

LTE Air Interface Protocols (cont.)

- E-UTRA Signalling:

    - Stratums.
    - NAS Messages.

- EMM and ECM States:

    - EPS Mobility Management States.
    - EPS Connection Management States.

- Radio Resource Control:

    - RRC Messages.
    - RRC States.
    - RRC Connection.

- E-UTRA Radio Bearers:

    - Signalling Radio Bearers.
    - Dedicated Radio Bearers.

- Packet Data Convergence Protocol:

    - PDCP Services.
    - PDCP Profiles.
    - PDCP Headers.

- Radio Link Control:

    - Transparent Mode.
    - Unacknowledged Mode.
    - Acknowledged Mode.
    - RLC PDU's.

- Medium Access Control:

    - Services expected from physical layer.
    - LTE Logical and Transport Channels.

- RNTI Identities:

    - MAC Headers.
    - Random Access Process.

5. LTE Operational Procedures

Topic areas covered include:

- Connecting to a Cell:

    - Cell Search.
- System Information.
    - PLMN Selection.
    - Cell Selection.
    - Random Access Process.
    - RRC Procedures at Initial Attach.

- Security:

    - EPS Authentication and Key Agreement.
    - Key Distribution in the EPS.
    - Security Procedures.
    - Algorithms.

LTE Operational Procedures (cont.)

- LTE Capabilities.

- Data Transfer:
    - Uplink Scheduling.
    - Downlink Scheduling.

- Discontinuous Reception (Paging).

- DRX in Active Mode.

- Timing Advance.

- Power Control.

- VoLTE Scheduling:
    - Improving Coverage with TTI Bundling.
    - Voice Scheduling and SPS.

6. LTE Air Interface Mobility

Topic areas covered include:

- Mobility Functional Architecture:
    - eNB.
    - MME.
    - Tracking Area.

- LTE Measurements:
    - RSRP (Reference Signal Received Power).
    - RSSI (Received Signal Strength Indicator).
    - RSRQ (Reference Signal Received Quality).

- LTE Idle Mode Mobility:
    - LTE Cell Reselection.
    - Priority Based Inter-RAT Cell Reselection.
    - Reselection to a Higher Priority Frequency or RAT cell.
    - Reselection to a Lower Priority Frequency or RAT cell.

- E-UTRA Measurements:
    - Measurement Configuration Options.
    - Basics of Measurement Objects.
    - Basics of Report Configuration.
    - LTE Events.
    - RRC Measurement Configuration Example.
    - Gap Configuration.
    - Timing.

- Handover Process:
    - X2 Handover Request and Response.
    - RRC Connection Reconfiguration.
    - Random Access.
    - SN Status Transfer and Status Report.

7. LTE-M

Topic areas covered include:

- Fundamentals of LTE-M:
    - LTE-M Benefits.

- LTE-M Device:
    - Handset Categories.
    - Category M1.

- LTE-M Channels:
    - PBCH.
    - MPDCCH.
    - PDSCH (SIB1-BR).
    - PDSCH.
    - PUSCH.
    - PUCCH.
    - PRACH.

- LTE-M Operation:
    - RRC Connection Establishment.
    - Session Establishment.
    - Mobility.

- Power Efficient Features:
    - Power Save Mode.
   - Extended Discontinuous Reception.

8. NB-IoT

Topic areas covered include:

- Fundamentals of NB-IoT:
    - NB-IoT Benefits.
    - Not Supported in NB-IoT.

- NB-IoT Device:
    - NB-IoT Category.
    - Power Category.

- NB-IoT Downlink Air Interface:
    - Downlink NB-IoT Channels.
    - Downlink Frame Structure.
    - NRS (Narrowband Reference Signal).
    - Narrowband Primacy Synchronization Signal.
    - Narrowband Secondary Synchronization Signal.
    - NPBCH / MIB-NB.
    - LTE-NB NPDSCH and NPDCCH Mapping.
    - LTE-NB for Guard Band / Standalone Deployment.

NB-IoT (cont.)

- NB-IoT Uplink Air Interface:

    - NB-IoT Uplink Channels.
    - NB-IoT Uplink Frame Structure.
    - NPUSCH Resource Unit.
    - NPUSCH DMRS.
    - NPRACH.

- NB-IoT Operation:

    - Scanning for NB-IoT.
    - MIB/SIB and Scheduling.
    - Cell Selection for NB-IoT.
    - NB-IoT Attach.
    - NB-IoT Access Procedure.
    - Resource Allocation.
    - Peak Data Rates.
    - Multi Carrier.

- NB-IoT Optimization Features:

    - CIoT Control Plane Delivery.
    - Power Save Mode.
    - Extended Discontinuous Reception.
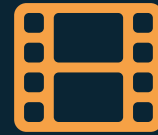
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