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.
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.
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.

- 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.

5. LTE Operational Procedures

Topic areas covered include:

- Connecting to a Cell:
  - Cell Search.

- System Information:
  - PLMN Selection.
  - Cell Selection.
  - 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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