# 4G LTE E-UTRAN Architecture, Signaling & Air Interface Certification Course

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## Course Highlights

- Introduction to Evolved-Universal Terrestrial Radio Access Network (E-UTRAN)
- E-UTRA Architecture
- E-UTRA Features and Interfaces
- OFDMA/SCDMA Basic Principles
- E-UTRA Physical Layer Structures
- LTE Network Architecture
- LTE Radio Interface Signaling
- E-UTRA Air Interface Protocols
- Physical Channels
- Operational Procedures
- Resource Allocation
- E-UTRA Air Interface Mobility
- E-UTRA and LTE Security
- Relays in LTE Advance
- Self-Organizing Network (SON)

## Key Benefits for Participants

- Understand LTE E-UTRA architecture, air interface, signaling & access methods
- Understand E-UTRA physical layer structures, channels & operational procedures

## Who Should Attend?

- LTE System Engineers & Operators
- Researchers, Technicians
- Business Managers, Sales Persons
- Telecom Operators & Regulators

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**Course Overview**

With fast growing mobile broadband, more than 7.7 billion mobile broadband subscriptions are expected by 2020 worldwide and majority of these subscriptions will be served by LTE and HSPA networks. LTE is continuously being developed to make sure that future requirements and scenarios are being met and prepared for in the best way. People are already utilizing LTE/HSPA technology for internet browsing, sending and receiving e-mails, and audio/video streaming via LTE enabled notebooks, modems, and smartphones. LTE provides several benefits to users including downlink peak rates of at least 100Mbps, and speeds of over 300Mbps in first stage deployment, while Ericson demonstrated to enhance LTE peak rates up to 1 Gbps. Moreover, LTE supports flexible carrier bandwidths from 1.4MHz up to 20MHz. These features have enhanced user experience for various applications including interactive TV, mobile video blogging, and professional services.

This course provides in-depth to LTE air interface and signaling, E-UTRAN and LTE Evolved packet core (EPC). The course provides an analysis of the LTE system architecture and protocol structure in the context of radio interface operations. This course will cover detailed insight to LTE protocols including PDCP, RRC, RLC and MAC, the inter-eNodeB protocol X2 and the S1 protocol for LTE. This course covers the issues related to spectrum and deployment of LTE systems and an in depth study of physical layer and physical channel characteristics of LTE. The operation of OFDMA and SC-FDMA techniques is explained and the technologies used for LTE physical layer is covered.

## Key Benefits for Participants

This course will provide the following key benefits to the attendees:

- Deep understanding of Evolved-Universal Terrestrial Radio Access Network (E-UTRAN) features and access methods
- Understand LTE Radio Interface Signaling and Non Access Stratum Signaling
- Be aware of MAC Procedures, Radio Link Control (RLC), Radio Resource Control (RRC) and Packet Data Convergence Protocol (PDCP)
- Be able to follow message sequences on the S1 and X2 interfaces
- Understanding the use of OFDM, OFDMA, SCFDMA and multiple antenna techniques in LTE
- Understand the LTE networks physical layer structures, physical channels and operational

procedures
- Understanding the challenges and security risks and countermeasures
- Insight to LTE-Advanced Relays and Self-Organizing Networks (SON)

## Course Objectives

This course has the following major objectives:

- Provide comprehensive knowledge about LTE E-UTRA Architecture, air interface and signaling
- Deliver insights about LTE Multiple Access Techniques, Radio and Network Identities and E-UTRAN Protocols
- Provide detailed insight to NAS Signaling, MAC Procedures, RLC Procedures, PDCP Procedures and RRC Procedures
- Detailed insights to S1 Handover Signaling, X2 Application Protocol Handover and Global procedures and Evolved GTP Path and Mobility Management
- Comprehensive knowledge about OFDM, OFDMA, SC-FDMA and Frequency hopping in LTE
- Provide deep understanding of LTE Air Interface Mobility and Operational Procedures
- Provide comprehensive overview of LTE-Advanced Relays and Self-Organizing Networks (SON) for LTE and LTE-Advanced Networks

## Course Outline

In "4G LTE E-UTRAN Architecture, Signaling & Air Interface Certification Course (Overview)", we cover the fundamentals of the LTE, LTE Signalling and Air Interface, while in "4G LTE E-UTRAN Architecture, Signaling & Air Interface Certification Course (Comprehensive)" we cover the following course contents:

### Evolved-Universal Terrestrial Radio Access Network (E-UTRAN)

- E-UTRA Features and Interfaces
- LTE Multiple Access

### OFDM, OFDMA and SC-FDMA Basic Principles

- Inter Symbol Interference
- OFDM Problems
- SC-FDMA
- Frequency Hopping

- Proposed use in LTE
- The FEC:- Turbo Coding Refresher
- Modulation in LTE

## LTE Radio Network Architecture

- Physical Channels
- Bearers
- Radio and Network Identities
- UE Context

## LTE Radio Interface Signaling

- E-UTRAN Protocols
    - NAS, RRC, PDCP, RLC, MAC, S1AP, X2AP and Transport.
    - UE Capabilities
- UE Transmitter Characteristics
- UE Receiver Characteristics
    - eNB and HeNB Capabilities.
    - HetNet and Relays.
    - CoMP - Coordinated Multi-Point Transmission and Reception

## E-UTRA Physical Layer Structures

- LTE Generic Frame Structure:
    - Type 1 Radio Frames.
    - Slots and Subframes.
    - Type 2 Radio Frames.
    - Slots and Subframes.
    - Frequency Bands.

- Carrier Frequencies and EARFCN.
- Resource Allocation:
    - Resource Grid.
    - Resource Blocks.
    - Downlink PRB Parameters.
    - Uplink PRB Parameters.
    - VRB, DVRB and mapping.
- The LTE Downlink Physical Channels:
    - PBCH, PCFICH, PDCCH, EPDCCH, PHICH.
    - REG (Resource Element Groups).
    - Mapping of RE and RS.

    - CCE (Control Channel Element).
    - PDCCH search spaces, role of CFI.

- The Control Region:
    - REG (Resource Element Groups).
    - Mapping of RE and RS.
    - CCE (Control Channel Element).
    - PDCCH search spaces, role of CFI.

- Downlink Synchronization Signals:
    - PSS & SSS, Structure.
    - Mapping to Resource Grid.
    - Timing Acquisition, Cell Search.
    - Cell Identities.
    - Cell Identity Group.
    - Identity within the Group.
    - Mapping To Cell Search Procedure.

- The LTE Uplink Physical Channels:
    - PRACH, PUCCH, PUSCH.
    - Uplink Data Transmission.
    - Uplink Reference Signals.
    - Demodulation Reference Signals and Sounding Reference Signals.

- Downlink and Uplink Timing:
    - Timing Relationship and Timing Advance calculations.

- HARQ Operation
    - Coding.
    - MCS Selection and Retransmission.

- Layer 1 Processing:
    - Scrambling.
    - Modulation Mapping.
    - Pre-coding.
    - RE Mapping.

- Carrier Aggregation Operation:
    - Backward Compatibility.
    - Downlink and Uplink Operation.
    - Transmission Modes, Transmit Diversity, MIMO Modes, SU-MIMO, MU-MIMO, Spatial Multiplexing.

- Advanced MIMO:
    - MU-MIMO.
    - Measures, Switching and Resource Allocation.
    - Co-operative MIMO.
    - Beamforming and Dual Streams.
    - Multi Antenna Options.
    - Activity: Examine RRC Messages Configuring MIMO options.

## Air Interface Protocols

- Defined the use of NAS, IP, RRC, PDCP, RLC and MAC.
- The E-UTRA Interface:
    - Stratums
    - NAS Control Plane
    - NAS User Plane
    - NAS Messages
    - EMM Messages
    - ESM Messages.
- The E-UTRA Protocols:
    - Radio Resource Control
    - RRC Messages
    - RRC States
    - Establishment of an RRC Connection.
- Non-Access Stratum - NAS Signalling
    - NAS Protocol States and Transitions
    - NAS Security
    - Integrity Protection
    - Non Access Stratum Protocols
        - EMM
        - ESM
    - Mobility Management across EMM States
    - EMM Procedures
- Medium Access Control - MAC Protocol
    - MAC Architecture
    - Mapping of Logical Channels to Transport Channels
    - MAC Procedures
        - Random Access
        - Uplink Time Alignment
        - Downlink Data Transfer
        - Uplink Data Transfer
        - PDUs and Formats
- ROHC and Lossless Mobility.

- Radio Link Control - RLC
    - RLC Structure
        - Transparent Mode Entity
        - Unacknowledged Mode Entity
        - Acknowledged Mode Entity
    - Functions
    - Procedures
        - Data Transfer
        - ARQ Procedures
        - Formats
- Packet Data Convergence Protocol - PDCP
    - PDCP Structure & Entities
    - Functions
    - PDCP Procedures
    - Data Transfer
    - Re-establishment
    - Status Report

- Radio Resource Control - RRC
    - RRC States & State Transitions
    - RRC Procedures
        - System Information
        - Connection Control
        - Inter-RAT Mobility
        - Measurements
    - PDU Formats
- S1 Application Protocol
    - S1AP Services
    - S1AP Functions
    - S1AP Procedures
        - E-RAB Management
        - Context Management
        - Handover Signalling
- X2 Application Protocol
    - X2AP Services
    - X2AP Functions
    - X2AP Procedures
        - Handover
        - Global Procedures: Load and Error Indication

- Evolved GTP: GTPv2-C
    - GTP Stack

- GTP Format
- Messages
    - Path Management
    - Tunnel Management
    - Mobility Management

## Physical Channels

- Logical Channels -BCCH, PCCH, CCCH, DCCH, DTCH.
- Transport Channels - BCH, DL-SCH, PCH, UL-SCH, RACH.
- Mapping Logical Channels into Transport Channels
- Control Channels
- Data Channels
- Uplink Data Transfer
- Downlink Channels
- Overview of the Downlink
- Physical Multicast Channel
- Physical Broadcast Channel
- Physical control format indicator channel - Uplink Channels
- Physical Uplink Shared Channel
- Physical Uplink Control Channel
- RNTI Identities.
- Random Access Process
- Contention and Non-Contention based Random Access Procedure.

## Operational Procedures

- Contents of RRC MIB and SIB messages, Scheduling Options.
- PLMN selection and Initial Cell Selection algorithms, Optimization of Parameters.
- LTE initial procedures, RRC Connection, Signalling Radio Bearers.
- Attach, PDN Connectivity and Default and Dedicated Bearer Establishment.
- Paging and ECM Idle DRX.
- ISR (Idle Signalling Reduction).
- RRC UE Capability and Security.
- RRC Messages in Operation:
    - Measurement Configuration.
    - Mobility Control Information.
    - Radio Resource Configuration.
- E-UTRA and LTE Security
    - Security Architecture
    - Implications
    - Attack Possibilities

    - User to Network Security
    - eNodeB Security
    - eNodeB Threats
    - Countermeasures
- MAC Scheduling:
    - Scheduling Uplink and Downlink Users.
    - Scheduling Methods.
    - VoLTE Scheduling, SPS (Semi Persistent Scheduling).
    - ECM Connected DTX and DRX.
    - End to End Downlink and Uplink IP Data Flow.

## Air Interface Mobility

- LTE mobility, LTE cell planning, capacity and coverage planning, frequency deployment options.
- Mobility functional architecture, role of the eNB and MME, Tracking Areas.
- E-UTRA Measurements, RSSI, RSRP, RSRQ.
- Idle Mode Procedures, LTE Idle Mode monitoring requirements.
- Cell Reselection, Priority based Reselection, Intra-Frequency measurements, Inter-Frequency and inter-RAT measurements, High and Medium
- Mobility States, Ranking of Cells, Tracking Area Update.
- Configuring Periodic and Event based Reporting:
- Timers and Thresholds.
- Mobility in ECM Connected State, Measurements, Gap Configurations, Event Triggers, Timing, the Handover Process.
- Carrier Aggregation and CA Mobility.
- Inter-RAT Mobility.

## E-UTRA and LTE Security

- Security Architecture
- Implications
- Attack Possibilities
- User to Network Security
- eNodeB Security
- eNodeB Threats
- Countermeasures

## Relays in LTE-Advanced

- Relay Classification.
- LTE-Advanced Relay Protocols:

- Sub-frame Configuration, Backhaul and HARQ.
- Relay Operational Procedures.
- Performance.
- Activity: Examine S1AP/RRC messages related to LTE-Advanced Relay.

## Self Oragnizing Network (SON)

- LTE SON vs LTE-Advanced SON.
- SON Architecture.
- Automatic Neighbour Relationship Procedures.
- Self Healing.

## Delivery Options

- Online
- Onsite

## Who Should Attend

- Technical managers who require in depth understanding of areas of LTE's (Long Term Evolution) Evolved UMTS Terrestrial Radio Access Network (EUTRAN)
- Technical managers and engineers who are specifically interested in the knowledge of the Physical and MAC layers in LTE.