V1.011

LTE-A to LTE-C
Design Details & System Operation

Course Duration:

- 2 Days

Course Description:

- This course addresses the needs of technical engineering staff who work on the design, test, integration and validation of LTE-Advanced equipment, both network and UE-side.
- The course provides a thorough review of LTE-releases 8 and 9 before jumping deep into everything you need to understand about design details and system engineering in LTE-Advanced.
- Starting out with the details of carrier aggregation, the following chapters are dedicated to all LTE-Advanced features like the new MIMO-modes, HetNet-operation, the integration and operation of relay nodes, the improvements with eICIC and feICIC and a detailed description of

Pre-Requisites:

- The student should possess detailed knowledge about LTE in Rel 8 and 9, particular about the physical layer.
- We recommend to book our course LTE from A-Z beforehand.

Course Target:

- The student is enabled to design, integrate, test and validate LTE-Advanced equipment for both, the network side and the UE.
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Some of your questions that will be answered:

- Which carrier aggregation scenarios have been defined in Rel 10, 11 and 12?
- Will SRVCC in the direction from LTE to 2G / 3G become applicable and how does this compare to CSFB?
- How do remote radio heads (RRH) compare to WiFi-hotspots?
- What is the basic difference between WiFi offloading with IFOM and SIPTO?
- What is an EPDCCH and how does it operate?
- How does CoMP operate in downlink and uplink direction and which advantages does it yield for HetNet operation?
- Which new features will be coming with Rel 12 like for instance D2D or MTC?
- Which new transmission modes are introduced with LTE-Advanced and which new options do they offer for the new MIMO-modes?
- What is the relationship between SRVCC and IMS Service Centralization and Continuity (SCC)?
- Do we need to prepare for ZUC as new stream cipher?
- How does the UE convey its carrier aggregation related capabilities to the network?
- Which new procedures does feICIC yield compared to previous versions of this feature packet?
- Why is there a new PUCCH-format 3 and what does it offer compared to previously defined PUCCH-formats?

Who should attend this class ?

- The course is targeted at engineers and technicians who are involved in the design, integration and test of of LTE-Advanced equipment.

Table of Contents:

From LTE to LTE-Advanced

- **LTE / LTE-A and their Playground**
  - ⇒ Genealogy of Cellular Radio
    1st Generation, 2nd Generation, 3rd Generation, 4th Generation, 5th Generation
  - ⇒ Requirements on a 4G-compliant Radio Technology
    Detailed Description
- **History and Evolution Path of LTE**
  - ⇒ Generic LTE
  - ⇒ LTE-A
  - ⇒ LTE-B
  - ⇒ LTE-C
- **Reviewing LTE Technology**
  - ⇒ Network Architecture: The EPC in Context with Legacy
    EPC vs. EPS, Non-3GPP Access Networks (trusted / non-trusted), IMS and VoLTE, Zoom into EPS and E-UTRAN (Functional Overview of Core Network Elements within the EPC)
  - ⇒ Protocol Stack
    Control Plane, User Plane
  - ⇒ Physical Layer of LTE…
    Characteristics (OFDM , Scalable Bandwidth, Smart Antenna Technology, Extensive use of CDM, Duplex Modes), The Physical Resource: Frequency Bands for LTE (Part 1: Reserved for FDD, Part 2: Reserved for TDD), The OFDM Framework in LTE, Channels and Signals (1 Logical Channels:, Transport Channels, Physical Channels), Physical Signals (Downlink Synchronization Signals:, Downlink Reference Signals, Uplink Reference Signals), Organization of the Time-Frequency Grid (Regular Example, …with MBSFN-Subframe), Resource Allocation in LTE (Downlink, Uplink), Signal Processing Chain (The Term: "Codeword", The Term: "Layer", The Term: "Precoding"), The Transmission Modes (Transmission Modes and Antenna Ports)
  - ⇒ The UE Categories with LTE-Advanced
    Detailed Description

Carrier Aggregation

- **Types of Carrier Aggregation**
  - ⇒ Contiguous Intra-Band

- ⇒ Non-Contiguous Intra-Band
- ⇒ Inter-Band

- **Typical Application Scenarios of Carrier Aggregation**
  - ⇒ Cells are co-located and operate at similar Frequencies
  - ⇒ F2 is primarily intended to improve Cell Edge Coverage
  - ⇒ Hot Spots
- **Important Remarks about Carrier Aggregation**
  - ⇒ Meaning of a given CA-Configuration Term
    Bandwidth Class and Bandwidth Combination Set
  - ⇒ Example: CA-related UE-Radio Access Capabilities
    Details
  - ⇒ Practical Exercise: Examine SupportedBandCombination
- **Carrier Aggregation Configurations Rel 10 - Rel 12**
  - ⇒ Intra-band Contiguous
    Bandwidth Arithmetic for Contiguous Intra-Band Carrier Aggregation (Part 1: Channel Spacing between Adjacent Carriers, Part 2: Nominal Channel Spacing for Carrier Aggregation, Part 3: Minimum Channel Spacing for Carrier Aggregation)
  - ⇒ Intra-band Non-Contiguous
  - ⇒ Inter-Band
- **Resource Management with Carrier Aggregation**
  - ⇒ PCell and SCell
    Important Remarks
- **Activation of SCells**
  - ⇒ Cross-Carrier Scheduling
- **RRC-Measurement Reporting**
  - ⇒ Legacy Measurement Events during Carrier Aggregation
    Detailed Description
  - ⇒ The new Measurement Event A6
    Measurement Gaps, Detailed Description
- **Layer 1 Uplink Control Information**
  - ⇒ Overview: SR, HARQ, CSI, PUCCH/PUSCH
  - ⇒ Uplink Modulation in Rel 10
  - ⇒ Clustered SC-FDMA

Relay Nodes, HetNets, ICIC, eICIC, feICIC

- **Welcome to the "Small Cells" Family…**
  - ⇒ Overview
  - ⇒ Relay Nodes
    Types of Relay Nodes (Type 1 Relay Nodes, Type 2 Relay Nodes), Use Cases, Interfaces (Detailed Description, The Un-Interface), Inband vs Outband Operation (Detailed Description), R-PDCCH and Subframe Timing, Why are small cells that important?
- **HetNet as dominant Network Configuration**
  - ⇒ Practical Exercise: HetNet vs Hierarchical Network
  - ⇒ Range Extension
    Detailed Description
- **Inter Cell Interference Coordination (ICIC)**
  - ⇒ Interference in the Cellular Environment
    Conclusions for the LTE and LTE-A Environment
  - ⇒ ICIC Option 1: Use different Set of Resource Blocks
  - ⇒ ICIC Option 2: Fractional Frequency Reuse
    Detailed Description
  - ⇒ Practical Exercise: Liabilities of ICIC
- **enhanced Inter Cell Interference Coordination (eICIC)**
  - ⇒ HetNet with Macro Cell and multiple small cells
    Protecting the control region…
  - ⇒ The EPDCCH
    EREG and ECCE
  - ⇒ The Concept of Almost Blank Subframes (ABS)
    Detailed Description
- **further enhanced Inter Cell Interference Coordination (feICIC)**
  - ⇒ Reduced Power ABS
  - ⇒ Transmitter based Muting
  - ⇒ Receiver based Puncturing
  - ⇒ Receiver based Interference Cancellation

Advanced MIMO in LTE-A

- **Downlink Single User MIMO (SU-MIMO)**
  - ⇒ Support for TM 9 and 8 x 8 MIMO

⇒ DM-RS and CSI-RS
Precoding with TM 9

⇒ CSI-RS within the Physical Resource Block

- **Downlink Multi User MIMO (MU-MIMO)**
  - ⇒ Review: MU-MIMO in Rel 9
  - ⇒ MU-MIMO in Rel 10
- **Uplink MIMO**
  - ⇒ Detailed Description

CoMP and C-RAN

⇒ Introduction to CoMP (Coordinated Multi Point Transmission)

⇒ Operation Principles

⇒ Primary Objectives

⇒ Relationship to Soft Handover

⇒ Relationship to Smart Antenna

⇒ Terminology
Cooperating Set, Measurement Set

⇒ Categories / Operation Modes

⇒ Joint Processing (JP)
Joint Transmission (JT), Joint Reception (JR), Dynamic Point Selection (DPS)

⇒ Coordinated Scheduling / Beamforming (CS/CB)

- **Scenarios**
  - ⇒ Scenario 1: Intra eNodeB CoMP
  - ⇒ Scenario 2: Homogenous Network with central eNodeB
  - ⇒ Scenario 3 and 4: eNodeB with Small Cells (HetNet)
- **Cloud or Centralized RAN (C-RAN)**
  - ⇒ The Idea and Architecture of C-RAN

VoLTE

- **Options of Voice Support over LTE**
  - ⇒ SRVCC
  - ⇒ CSFB
  - ⇒ SVLTE

⇒ VoLGA

⇒ FEMTO / PICO Cells

⇒ Over The Top (OTT)

⇒ IMS

- **LTE Voice Architecture with IMS**
- **Operation of CSFB**

⇒ Architecture in case of Circuit Switched Fallback (CSFB)

⇒ CS Fallback Solution Overview

⇒ CSFB Procedures
, Procedure Overview, The Principle of CSFB, Handover or Redirection

⇒ Example: CSFB for MTC from eUTRAN with Packet HO

- **Operation of SRVCC and IMS-based Solutions**

⇒ Architecture in case of IMS-based Voice Services
VoLTE, ICS, SRVCC

⇒ IMS Centralized Services
UE enhanced for ICS, MSC-S enhanced for ICS

⇒ Architecture for IMS Service Centralization and Continuity
SCC AS , UE (normal or enhanced for ICS), MSC Server (normal or enhancements for ICS), IMS registration via CS access

⇒ Single Radio Voice Call Continuity (SRVCC)
SRVCC Evolution (eSRVCC, aSRVCC, rSRVCC, vSRVCC), SRVCC in Release 8, Enhanced SRVCC (eSRVCC) – Rel. 10, , Example: SRVCC from eUTRAN to GERAN with PS Bearer HO (HO Preparation:, Bearer Splitting:, PS to CS Handover Initiation, Relocation of PS Bearers, Session Transfer Initiation, Handover Execution, Session Transfer Signaling, CS Handover Completion, Deletion of the old voice bearer, PS Handover Completion, Additional Emergency Services Handling)

What else is on the Radar Screen?

- **Introduction and Overview**

⇒ Various improvements…
FDD/TDD joint operation, New Carrier Type (NCT), LTE in unlicensed spectrum, 256-QAM, Machine Type Communication (MTC)

- **3D-MIMO**
- **Carrier Aggregation with more than 2 Carriers**
- **Part-time Cells**
- **Interworking LTE <=> WiFi**

- **Device to Device Proximity Services (D2D)**
  ⇒ Use Cases
- **Mobile Relay**
- **And what about 5G?**
  ⇒ New Radio
  ⇒ Network Evolution