Course ID
5G3LECPRI
Course Duration
5 days

Course Title
5G Layers 1-3 with Emphasis on e-CPRI

Related Courses

- 5G Wireless: Technology (5GTUTE, 3 days)
- 4G LTE Evolution to 5G Wireless (5G1, 5 days)

Aimed At

This *5G Layers 1-3 with Emphasis on e-CPRI* course is for those who need to understand 5G protocols to aid their network implementation from 3GPP to oRAN.

Prerequisites

Those wishing to take *5G Layers 1-3 with Emphasis on e-CPRI* should have a good understanding of LTE/LTE-A and wireless communications.

Course in a Nutshell

5G Layers 1-3 with Emphasis on e-CPRI explores the lower layer 2, upper layer 2, and layer 3 protocols and procedures for radio technology involved in 5G RAN New Radio (NR), the e-CPRI and MIMO, and the MIMO/Beamforming techniques.

Customize It!

This duration and content of *5G Layers 1-3 with Emphasis on e-CPRI* can be customized to your participants' backgrounds and needs.

Course Outline

5G Layers 1-3 with Emphasis on e-CPRI: Day 1

- 5G Radio: An Introduction
  - 5G Spectrum & Frequency Bands
  - Sub-6GHz, cmW, mmW
  - Spectrum Management & Spectrum Sharing
  - UE 5G NR Radio Requirements
  - 5G requirements for RAN: Bandwidth, power, spectral efficiency, new technology adaptation, latency, signaling load, capacity, coverage, interference, mobility
  - 5G requirements for Core: Network topology, cloud architectures, big data analytics
  - Base Station 5G NR Radio Requirements
  - Common UE and BS Radio Requirements
  - 5G NSA and SA architectures
  - 5G core and 5G-EPC brief overview
- 5G: New Radio (NR) Physical Layer
  - How 5G will differ from 4G

- NR channel structure
- Relation to LTE
- NR time (slot) and frequency (SCS & RB) structure
- The new concept of bandwidth part (BWP) and how it is configured/controlled by operator
- Why flexible numerology?
- The L1 processing chain
- OFDM principles (basic introduction, FFT and signal generation)
- OFDM signal processing (up sampling, decimation)
- Modulation Schemes (256QAM, 64QAM, 16QAM, QPSK) and evolution from IQ modulator - IQ imbalance, phase errors, DC offset errors.
- L1 Time synchronization, frequency synchronization,
- L1 FEC and LDPC coding and decoding – analysis on decoding performance
- Code Block Group (CBG) based retransmissions
- L1 CRC coding and decoding – the BLER concept
- L1 rate matching
- The BBU modular architecture (ADC, DAC, Scheduler module, Link Adaptation module, Power control module, MIMO precoder module)
- The mMIMO antenna panel modular RF chain structure (PA, LNA)
- The RF traditional (Radio Remote Unite or RF card) chain modular structure (PA, LNA).
- BBU calibration requirements
- RRU calibration requirements
- OFDM signal processing (up sampling, decimation)

5G Layers 1-3 with Emphasis on e-CPRI: Days 2-3

- 5G 3GPP Physical Layer Channels, Signals and Procedures
  - 3GPP Physical layer procedures for control signaling
  - Synchronization signals and reference signals structure
  - Cell search procedure
  - SS/PBCH structure
  - Random access preamble formats - initial beam establishment
  - Downlink control signaling
  - Uplink control signaling
  - Overview power control
  - Overview transmit timing control
  - 3GPP Physical procedures for user data transmissions

- Reference signals (DMRS, CSI-RS, TRS, PTRS, SRS)

- 5G Layer 2 Procedures
  - Explain the L2 transport protocols SDAP, PDCP, RLC, MAC and GTP-U Protocols
  - Describe the contents of the SDAP, PDCP, RLC and MAC Packet Data Unit
  - Describe the SDAP functions in the user plane
  - Explain the PDCP functions
  - Explain the RLC functions
  - Explain RLC transparent, unacknowledged and acknowledged modes
  - Explain the MAC functions
  - MAC HARQ codebook principles
  - Scheduler functionality for UL and DL
  - Scheduler resource allocation (time-frequency grid)
  - How scheduler controls physical layer resources
  - RACH analysis
  - Scheduling requests, BSR, CQI/CSI reports
  - Beam management functions
  - P1, P2, P3 algorithm implementations
  - Explain the main functions & procedures of the transport protocol GTP-U
  - Traces and signaling examples

5G Layers 1-3 with Emphasis on e-CPRI: Days 3-4

- 5G Layer 3 Procedures
  - Explain the interaction between Radio Resource Control (RRC) and the lower layers in the control plane
  - Distinguish the RRC connected, inactive and idle UE states
  - Detail the functions and services of RRC
  - Explain the RRC signaling flow for SA service connectivity
  - Explain the RRC signaling flow for NSA service connectivity
  - Carrier aggregation
  - Emphasize on SIB contents and accessibility procedures
  - List the main functions and procedures of XnAP signaling protocol
  - List the main functions and procedures of NGAP signaling protocol
  - NAS signaling
  - NAS contents in MME/AMF

- Paging procedure
- Traces and signaling examples

- 5G Mobility
  - Explain Mobility and Dual Connectivity in 5G
  - Describe Inactive and Idle mode mobility in Standalone and Non-Standalone NR
  - SSB control and scheduling
  - UE synchronization
  - Detail the bearer type transitions (MN terminated MCG <-> SN terminated split DRB) in Non-Standalone NR
  - Describe the user plane control transitions
  - Explain Dual Connectivity mobility
  - Explain connected mode mobility in Standalone NR
  - Mobility analysis and examples

5G Layers 1-3 with Emphasis on e-CPRI: Day 5

- 5G MIMO – Beam forming
  - Massive MIMO general introduction
  - Beamforming and spatial multiplexing principles
  - MAC layer to mMIMO antenna panel interaction
  - Describe how scheduler schedule data on mMIMO antenna panel and the creation of the beams
  - MIMO/Beamforming modules
  - codebook vs non-codebook transmissions
  - The new concept of Grid of Beams (GoB)
  - Analog vs. digital beamforming
  - e-CPRI standards and description

5G Layers 1-3 with Emphasis on e-CPRI : Course Wrap-up

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