COURSE OUTLINE

Introduction to EPS
- Evolution steps of the 3GPP systems, the goals for LTE
- LTE bandwidths, bit rates and UE categories

EPS Network Architecture
- E-UTRA and Evolved Packet Core network architecture
- Nodes: UE, eNB, SGW, MME, PGW, PCRF
- Interfaces: Uu, X2, S1, S11, S5, Gx, S6a, SGi, Rx
- Overview of EPS protocols: PDCP, RRC, GTP, X2AP, S1-AP, S1-MME, GTP, Diameter
- IP connectivity, user plane and control plane
- Access Stratum signaling and Non-Access Stratum signaling
- E-UTRAN protocol stack and channel architecture
- E-UTRAN L3 and L2 protocols: RRC, PDCP, RLC, MAC, PHY

Non-Access Stratum (NAS) Protocols
- NAS protocols (EMM and ESM)
- UE states and state transitions (LTE-idle, LTE-active, LTE-detached)
- Subscriber identities and their relations (IMEI, IMSI, GUTI, STMSI, RNTIs)
- Security and keys' derivation
- Integrity and Encryption - SNOW 3G, AES
- EPS Authentication and Key Agreement; Key Hierarchy
- Key distribution and mobility
- NAS message structure

Radio Resource Control (RRC) Protocol
- RRC procedures including system info broadcasting, paging, RRC connection establishment, security establishment, NAS message transport and RRC connection reconfiguration
- Types of radio bearers
- RRC States & State Transitions

Packet Data Convergence Protocol (PDCP)
- PDCP architecture
- PDCP Functions (robust header compression, ARQ at handover, status reporting ciphering and integrity protection)
- PDCP message structure for Data and Control

Radio Link Control (RLC) Protocol
- RLC architecture (Transparent Mode, Unacknowledged Mode, Acknowledged Mode)
- Functions (segmentation / concatenation, ARQ procedures)
- RLC PDU formats (RLC user plane and control PDUs)

MAC Protocol
- MAC Architecture
- MAC PDU: user plane and control plane parts
- Scheduling procedures for downlink and uplink resource assignments
- Scheduling Requests, Buffer Status Reports and Power Headroom Reports
- Hybrid-ARQ processes and HARQ operation
- Mapping of Logical Channels to Transport Channels
- MAC level identities mapping

LTE PHY Layer
- Logical, Transport and Physical channels and their relation to the radio interface protocol stack (i.e. Channel architecture)
- Adaptive Modulation and Coding, QPSK, 16-QAM, 64-QAM
- Principles of OFDM/OFDMA/SCFDMA
- Principles of MIMO
- Downlink and uplink frame structure and its elements (PRB, RE, CCE)
- L1 control information, formats and signaling
- Resource mapping to radio frame
- PHY layer related scheduling principles (including ”maximum SNIR”, ”round robin” and ”proportional fair” schedulers)

S1 Interface Procedures
- S1 CP and UP protocol stacks
- S1 Application Protocol (S1-AP)
- S1-AP identifiers
- S1-AP procedures: S1 association and SON related procedures, UE related procedures
- GTP-U protocol (including tunneling concept and TEID)

X2 Interface Procedures
- X2 CP and UP protocol stacks
- X2 Application Protocol (X2-AP)
- X2-AP identifiers
- X2-AP procedures: X2 association procedures, UE related procedures, SON related procedures

S11, S5/S8, S10 Interface Procedures
- CP and UP protocol stacks for each interface
- GTP-C (eGTP) protocol
- GTP-C message header and tunneling concept
- Functions and procedures related to each interface (UE context exchange, call establishment, bearer management, etc.)

IMS and End-to-End Signaling
- IMS architecture (S-CSCF, P-CSCF, I-CSCF, HSS, AS, etc.)
- IMS security and PCC considerations
- SIP Basics - registration, session establishment
- IMS end-to-end protocol stack
- IMS end-to-end call establishment
- Voice in LTE (CS Fallback, Voice Call Continuity, VoLGA)

Interworking with 3GPP and non-3GPP networks
- Roaming
- Inter-working with 3GPP and non-3GPP networks
- Inter-RAT handover: example of handover between LTE and UMTS

Note: the course content is subject to minor changes and adaptations to the customer needs.