v 2.211

SAE / EPC from A-Z

Course Duration:

- 2 days

Course Description:

- This course describes in detail the network architecture of the evolved packet core network (EPC) and it discusses migration strategies and implementation options.
- Starting out with an assessment of why an architecture evolution is necessary in the first place, the course outlines the most important targets of a system architecture evolution from the perspective of the 3GPP.
- The course continues with the detailed evaluation and description of the different new network elements like the MME, S-GW, PDN-GW and ePDG.
- This includes the detailed discussion of such important implementation aspects like S1Flex and how it can be applied under different circumstances.
- The following part provides an overview over all kinds of EPC-related scenarios like attachment from 3GPP- and non-3GPP-specific radio access technologies, host and network based mobility and call setup under different conditions.
- Another section deals with the network layout and introduces new concepts like the tracking area and the new types of TMSI's-
- In great detail the course describes such important aspects like the QoS-architecture of Rel. 8 and how it blends into the EPC.
- One complete chapter has been dedicated to the introductory description of the various protocols that are used within the EPC-environment. This includes all EPC- and E-UTRAN-specific protocols like RRC or S1-AP but it also includes introductions into DIAMETER, IPv6, QoS in IP or SCTP.
- The final chapter has been dedicated to the presentation of the important EPC-related procedures like attachment from E-UTRAN, tracking area updating and dedicated EPS-bearer establishment.

As in all INACON courses we integrated several interactive exercises for a perfect learning experience.

Prerequisites:

- The student must possess a thorough understanding in mobile communication before coming to this course.
- At the least we recommend our webinars or web based training courses on SAE and LTE to be taken beforehand.

Course Target:

- The student is enabled to develop, test and integrate EPC-related networks.

Some of your Questions that will be answered:

- Why is there a system architecture evolution in the first place?
- Which improvements does SAE yield?
- What are the requirements according to 3GPP?
- How will the protocol architecture of a typical UE look like within the SAE-environment?
- Which potential improvements have not been covered yet by the SAE?
- How do the network access and attachment work for the different RAT's?
- How does the UE prioritize different available access networks and access network types?
- How does a UE which is attached to the EPC, establish a voice call?
- How does inter-RAT mobility work while the UE is attached to the EPC?
- What are the most important differences between host and network based mobility?
- What are tracking areas and what is their relationship to location areas and routing areas?
- Which new identifiers are used within the evolved core network environment to identify users?
- How does the QoS-architecture look like in the evolved network?
- What is S1-Flex and how does it operate?
- How do the e2e-protocol stacks look like within the SAE-environment?
- Which tasks do EMM and ESM take care of and how do EMM and ESM compare and relate to GMM and SM?
- How does a UE attach to the EPC through E-UTRAN and how does it establish the default EPS-bearer and how are dedicated EPS-bearers established?
- How is handover performed in E-UTRAN?

Who should attend this Course:

- Test engineers who need to understand the EPS-architecture and its new concepts in detail.
- Design staff of EPC network elements who require a deep inside view of the new architecture and protocols.
- Everybody who shall be able to respond to sophisticated EPS-related questions.

Table of Content:

Assessment & Top Level View

- **Why is an Architecture Evolution necessary?**
  Integration of E-UTRAN with its new Concepts, Integration of Non-3GPP RAT's is sub-optimum in Rel. 7 because ..., Therefore, legacy operators of Non-3GPP-RAT's cannot adopt the existing 3GPP-CN-Architecture

- **Important Requirements on SAE according to 3GPP**
  Coexistence, Service Continuation, Better Performance, Support of any Radio Access Technology (RAT), Circuit-switched fallback (CSFB), Management of Access Networks

  ⇒ Comprehension Check & Exercise:
  Reasons of a System Architecture Evolution?

- **Seamless Mobility Options and their Characteristics**
  Intra-RAT Mobility, Inter-RAT Mobility (w/o Optimizations), Inter-RAT Mobility (with Optimizations)

- **Architecture Overview**

  ⇒ Evolved Packet Core in Context
  EPC vs. EPS, Non-3GPP Access Networks (trusted / non-trusted)

  ⇒ Zoom into the EPS
  Functional Overview of Core Network Elements within the EPC

  ⇒ Network Elements and their Functions within the EPC
  Mobility Management Entity (MME), Characteristics, Identification, Interfaces & Protocols, Tasks & Functions of the MME, NAS-Signaling towards the UE, S1-Signaling towards the eNodeB, S-GW and P-GW Selection, Other Selection Functions, Local Breakout, IMS and Local Breakout, Serving Gateway (S-GW), Characteristics, Identification, Interfaces & Protocols, Tasks & Functions of the S-GW, Packet Routing / Relaying, Legal Interception, QCI-based Packet Tagging, Accounting, PDN Gateway (P-GW or PDN-GW), Characteristics, Identification, Interfaces & Protocols, Tasks & Functions of the P-GW, UE IP Address Allocation, QCI-based Packet Tagging, Policy Enforcement, Legal Interception, Home Agent Function, Evolved Packet Data Gateway (ePDG), Characteristics, Identification, Interfaces & Protocols, Tasks & Functions of the ePDG, ESP-Tunnel Mgmt towards UE's, QoS-specific Packet Tagging in UL-Direction, Legal Interception, MAG-Function for PMIPv6, Protocol Stack Architecture on the UE-Side

  ⇒ Comprehension Check & Exercise:
  Interworking within the EPS-Architecture

Operations Overview

- **Network Access to the EPC in case of 3GPP-RAT's**

  ⇒ E-UTRAN
  Related Network Architecture, Related Network Elements, Signaling and Important State Changes (EMM, ECM, ESM)

  ⇒ GERAN / UTRAN
  Related Network Architecture, Selection of EPC vs. GGSN, Signaling Procedures (GMM/PMM, SM), Ipv4 and IPv6 for LTE, PDN connection, The EPS Bearer, The APN, Comprehension Check & Exercise:
  Relate E-UTRAN Procedures to GERAN / UTRAN Procedures

- **Network Access in case of Non-3GPP RAT's**
  - ⇒ Network Discovery and Selection
    Problem Description, Interworking with the ANDSF, Trusted vs. Non-Trusted Non-3GPP RAT's
  - ⇒ Trusted Non-3GPP RAT's
    Related Network Architecture, Signaling Procedures if EAP and PMIPv6 are used, Signaling Procedures if MIPv4 is used
  - ⇒ Non-Trusted Non-3GPP RAT's
    Related Network Architecture, Signaling Procedures if IKEv2 and PMIPv6 are used, Signaling Procedures if IKEv2 and DSMIPv6 are used
- **Voice Call Establishment**
  - ⇒ IMS-based
    Related Network Architecture, Signaling Procedure (SIP, SDP, DIAMETER)
  - ⇒ Circuit-switched Fallback
    Related Network Architecture, Signaling Procedure for MOC, Signaling Procedure for MTC, Comprehension Check & Exercise:
    Voice Call Establishment
- **Macro Mobility / Inter-RAT Roaming**
  - ⇒ Handover E-UTRAN to Trusted Non-3GPP RAT
    Related Network Architecture, Signaling Procedure (NBM / PMIPv6 on S2a), Handover E-UTRAN to Non-Trusted Non-3GPP RAT, Related Network Architecture, Signaling Procedure (NBM / PMIPv6 on S2b), Comprehension Check & Exercise:
    Inter-RAT Mobility

Architectural Details of the EPS

- **Comprehension Test & Repetition:**
  Network Interfaces and Protocols
- **Network Layout and Important Identifiers**
  - ⇒ Organization of the E-UTRAN
    Tracking Areas, TAI and TAI-list, E-UTRAN Pool Areas, MME Pool's and MMEI
  - ⇒ S-GW Service Areas
  - ⇒ Identifiers of the UE
    M-TMSI and S-TMSI, GUTI
- **Bearer Concept & QoS-Architecture in SAE**
  - ⇒ SAE-Bearers, Classification and Policy Enforcement
  - ⇒ The QoS-Profile of the SAE-Bearer
    GBR - Guaranteed Bit Rate, MBR - Maximum Bit Rate, AMBR - Aggregate Maximum Bit Rate, ARP - Allocation Retention Priority, QCI-Values and their Meanings, Mapping between Rel. 8 QoS and earlier Releases, QoS-Architecture with Release 8, PCRF (Policy and Charging Rules Function), BBERF (Bearer Binding and Event Reporting Function), PCEF (Policy and Charging Enforcement Function), AF (Application

Function), SPR (Subscription Profile Repository), OCS (Online Charging System), OFCS (Offline Charging System)

⇒ Bearer Establishment & Authorization - Differences Rel. 8 vs former Releases
Dedicated Bearer, Default Bearer

⇒ Relationship and Dependency among the different Bearers

- **Security Architecture**

⇒ Overview & Introduction
Essentials, EPS-AKA, Security is performed independently in two protocol layers, Algorithms

⇒ Operation of UMTS-AKA

⇒ Key Derivation Function (KDF)
Comprehension Check & Practical Exercise:
The KDF S(10) for K(ASME), Input Parameters

⇒ EPS-AKA in Operation during Initial Attach Procedure

Protocol Suite

- **The "Mainstream" Protocol Stacks**

⇒ Control Plane / E-UTRAN - EPC

⇒ User Plane E-UTRAN – EPC (S5/S8 GTP-based)

⇒ User Plane E-UTRAN – EPC (S5/S8 PMIPv6/GRE-based)

- **Generic Protocols within the EPC-Environment**

⇒ IPv4 and IPv6 and their Differences
Headers and IP-Address Ranges, How to obtain an IP-Address, IPv4 and DHCP, IPv6 and "Stateless Autoconfiguration", IPv6 Address allocation in LTE, Fragmentation in IPv4 and IPv6

⇒ QoS in IP-Networks
DiffServ, Differentiated Services (DiffServ) architecture , Per Hop Behavior (PHB), Details of the AF(X,Y) PHB (Assured Forwarding), Details of the EF PHB (Expedited Forwarding)

⇒ SCTP
Important SCTP-Functions, Example of an SCTP-Packet

⇒ DIAMETER

- **Protocols related to E-UTRA Networks**

⇒ EPS Mobility Management (EMM)
Important EMM-Procedures, Common Procedures, Specific Procedures, Connection Management Procedures, State Machine, Relationship between EMM and ECM

⇒ EPS Session Management (ESM)
Important ESM-Procedures, MME-initiated, UE-initiated, State Machine

⇒ Radio Resource Control RRC
Overview, Transmission of broadcast information, Establish and maintain services, QoS control, Transfer of dedicated control information, State Characteristics of RRC, RRC_IDLE, RRC_CONNECTED

⇒ Packet Data Convergence Protocol (PDCP)
Overview, RoHC, Numbering of PDCP PDU's, In-sequence delivery of PDU's, Duplicate deletion, Encryption, Integrity Protection, Structure of PDCP PDU

⇒ The S1-AP Protocol

⇒ The X2AP Protocol
Protocol Stack on the X2-interface, Tasks & Functions, Mobility Management, Load Management, X2-Interface Management

Call Flows & Scenarios

- **Attachment through E-UTRAN / new MME**
- **Tracking Area Update (Inter-MME / with new S-GW)**
  Initial Conditions, Detailed Description
- **Dedicated EPS Bearer Establishment**
  ⇒ Network Initiated (IMS triggered during Call Establishment)
  Initial Conditions, Detailed Description, Detailed Description
- **Handover Procedures**
  ⇒ X2-based Handover Scenario
  Initial Conditions, Detailed Description