

5G Core Network Architecture – 3 days

CONTENTS:

This course presents the 5G System (5GS) as defined by 3GPP, focusing on the functionalities of the 5G core (5GC) network. The relevant basics of NG-RAN are also covered. Roles of the Network Functions (NFs) as specified in the 3GPP standards are discussed, including the interactions both within the 5GC and between the 5GC and the NG-RAN, the 5GC and the external AF for Service Influencing and the 5GC and the EPC for 4G ↔ 5G Interworking.

The course explains the challenges the 5GS faces from the huge variety of services it is expected to cater to, and presents the new network features that enable the 5GS to satisfy the various service requirements in an optimal and cost-efficient way: Service Based Architecture approach with specialized NFs, Network Slicing, PDU Sessions with multiple PDU Session Anchors, hosting services closer to the user, traffic influencing from external AFs, and the 5G PCC model used to enforce service-specific subscription and traffic handling rules. The course presents how the 5GC handles the access to services by different types of UEs. It covers the 5G Registration and PDU Session Establishment traffic cases, User Plane resources definitions and handling, UE mobility handling, and the five basic 5G use cases (eMBB – including Vo5G, MIoT/mMTC, URLLC, V2X and HMTc).

PREREQUISITES:

Technical knowledge of the EPS system is crucial – the 5G features are discussed in relation to the existing 4G ones. To facilitate following the course we also recommend Apis' "5G System Overview" for introductory knowledge on 5G.

5G System overview

- Rationale behind the 5G definitions: support for various services and applications
- Requirements for the 5GS
- Service Based Architecture model for the 5GC
- Introduction of the 5GC NFs: AMF, SMF, UPF, UDR, UDM, AUSF, NEF, PCF, NSSF, NRF, UCMF, BSF, NSSAAF, NSACF, UPF and other 5GC network elements: SCP, SEPP
- 5GS Reference Points, including roaming scenarios (LBO and HR options)
- UE identities in 5G: SUPI, SUCI, GPSI, PEI, etc.

Service Based Architecture (SBA)

- Definitions of Service Based Interface, Network Function (NF), NF Service, Service Producer and Service Consumer
- NF Registration, Discovery and Selection procedures
- Inter-operator interconnect border functionalities: SEPP, IPUPS
- SBA Security: Access Tokens and the role of the NRF
- Protocol on the SBI: http/2

Network Slicing

- Definition of a Network Slice
- Identifiers of Network Slices: NSI Id, NSSAI, S-NSSAI
- NFV as a tool to implement Network Slicing
- Rules and mechanisms for allocating a Network Slice for a UE: slice-specific information used at 5G Registration and PDU Session Setup
- Main 5G use cases (eMBB, MIoT, URLLC, V2X, HMTc) realized as separate Network Slices
- Network Slice as a product: Private Networks

5G Registration procedure

- Definition of types of Registration procedures: Initial, Mobility Update, Periodic Update
- Definition of a UE Registration Area
- Signalling flow with basic parameters for Access and Mobility enforcement, AF selection, Network Slice selection and creation of relevant UE contexts
- Negotiation of service-specific features and capabilities at Registration: MICO mode, LADN, UE Reachability, Mobility Patterns, Mobility Restrictions
- Access and Mobility NAS Protocol on N1: 5GMM

Policy and Charging Control (PCC) overview

- Definition of PCC
- 5G requirements on PCC
- Comparison of the PCF vs the 4G PCRF
- Access and Mobility handling for a UE using AM Policy Associations
- QoS handling for PDU Sessions using SM Policy Associations and N4 Sessions
- Policy influencing from external AFs

User Plane resources in 5G

- Definition of a PDU Session
- Signalling flow with basic parameters for AF selection, session QoS and routing enforcement and creation of relevant UE contexts
- Definitions of Service Data Flows, QoS Flows and their relationships to PDU Sessions, Data Radio Bearers and N3 Tunnels
- Definitions of QoS Rules, QoS Profiles, PCC Rules, SDF Templates
- Routing-specific definitions in the 5GC: PDU Session Anchors (PSAs), UPF chaining, PDU Sessions with Multiple PDU Session Anchors, User Plane splitting, Multi-Access Edge Computing (MEC), Local Area Data Networks (LADN)
- SMF control of UPF over the N4 interface
- Session Management NAS Protocol on N1: 5GSM
- Protocol on N4: PFCP
- Protocol on N3 and N9: GTP-U ver.1

5GC ↔ AF Interactions: Service Influencing

- Mechanisms for the external AFs to control access, QoS and routing of application data over 5GS
- Packet Flow Description Function (PFDF) role in defining and enforcing AF-specific traffic handling rules
- Network Exposure Function (NEF) role in the interactions between 5GC and external NFs
- IMS network elements as 5G AFs
- Vo5G as a service within the eMBB Network Slice

5GC ↔ NG-RAN Interactions

- LTE, WiFi and fixed access in the 5G ecosystem
- Introduction of the network elements of the different Access Networks to the 5GC: eNB, gNB, N3IWF, TNGF, W-AGF, 5G-RG
- Non-Standalone and Standalone deployment options
- Definition of RRC States in 5G: RRC_Idle, RRC_Connected, RRC_Inactive
- The impact of different RRC States on N2 Connection handling
- Protocol on N2: NGAP

5GC ↔ EPC Interactions

- N26 interface for MME ↔ AMF communication
- Single- and Dual-Registration modes for the UEs
- Combined EPC/5GC Network Architecture