Course Description

Course name	**#096 - 5G Network Protocol & Signaling Procedures**
Duration	**5 days**
Format	**Public classroom, Inhouse events and Online**

Overview

Dr. Spiros Louvros, PhD in Wireless Communications, Radio Access Network (RAN) Telecom Engineer, 3GPP technical recommendation group member, Greece.

The 5G network architecture is a significant evolution from the 4G LTE EPC, consisting of specific requirements (3GPP TS 22.261) and comprising three individual steps for network architectures enhancement. The first one is the well-known Non-Stand-Alone (NSA) deployment, compliant with 3GPP release 15 phase 1 (3GPP TS 23.501), with LTE RAN and NR RAN both connected to a 5G upgraded EPC core. This is the most common nowadays approach for smooth migration towards 5G. The second step is the Hybrid Non-Stand-Alone deployment, compliant again with 3GPP release 15 phase 1 and both LTE RAN and NR RAN migrated towards a preliminary 5Gcore (5GC). This is the next evolution step before full 5G deployment. The last step comprises a Stand Alone (SA) deployment, compliant with 3GPP release 15 phase 2 and Rel.16 (3GPP TS 23.502), with only NR connected to NG 5GC. In the last two steps the introduction of Network Virtualization (NFV) is the key technology for the 5G Digital Transformation. Moreover, Multi-Access Edge Computing (MEC) and Network Slicing are new abilities that enable the operator to improve the network to meet specific applications' requirements. 5G Core network provides enhanced Quality of Service for new services like Enhanced Mobile Broadband (eMBB), Massive Machine Type (mMTC) Communications and Ultra-Reliable and Low Latency Communications (URLLC). Service providers prepare their networks to accommodate a proper network convergence step hosted on a common infrastructure, which in most of the cases is Vendor specific with vendor proprietary platforms and node functionalities.

This course is split into two separate flows, offers a complete approach to 5G network signaling from both RAN as well as Core perspective. It emphasizes individually the RAN and Core protocols, signaling messages and signaling flows, offering at the end a proper binding to provide participants with a solid understanding of the E2E network signaling procedures. It starts with the first flow comprising 5G network overview and RAN protocols to be fully explained, together with the most common procedures related to NAS, layer 3, layer 2 and finally layer 1. Then continues with the second flow comprising EPC core signaling review and procedures for the NSA architecture of 3GPP Rel 15 and NG 5GC architecture starting from the Functional Entities and the 5GC interfaces and moving towards the 3GPP supported 5GC signaling messages, procedures and signaling flows.

The course can be offered in two separate ways. Option 1 contains only the first flow (sections 1-4) for a duration of 4 days, offering a proper 5G RAN Protocol & Signaling Procedures course. Option 2 contains both flows (sections 1-5) for a duration of 5 days, presenting the overall 5G Network Protocol & Signaling Procedures course.

In order for the attendant to better understand the content of this topic and to gain further insight into this course content, it is also recommended to have prior attended the 5G Network Overview

and have relevant and adequate knowledge on LTE signaling. Course customization is possible based on customer requests and demands.

Technical Focus

5G requirements have proposed advanced 5G use cases which, thanks to ultra-low network latency and very high throughputs, will revolutionize businesses and the day-to-day lives of consumers. But none of those will be possible without a proper enhanced EPC or even better a proper 5G Core (5GC). Alongside 5G new radio (NR), 5G Core is the ultimate deployment goal and a fundamental cornerstone of 5G networks. 3GPP has standardized most of the functions, protocols and interfaces for the proper digital transformation of 5G NR and 5GC. Currently, the vast majority of commercial 5G deployments are based on NR non-standalone (NSA) technology which re-uses existing LTE radio access for signaling between devices and the network together with the Enhanced Evolved Packet Core (EPC) networks as anchors to support 5G NSA. NSA is a quick solution allowing new 5G services to be introduced quickly while maximizing the reuse of existing 4G networks. However, to unlock 5G's full potential NR standalone (SA) and 5G Core (5GC) is needed. The core is the heart of the mobile network where ultra-connectivity translates into service differentiation and business flexibility and 5G NR is the radio access domain implementing the front-end solution. Both establish reliable and secure connectivity to the network and access to its services, determine the E2E quality of service and enforce it through policy allowing services differentiation.

This course will present RAN signaling, as common platform for both enhanced EPC and evolved 5GC. Moreover, a proper introduction to both enhanced EPC and 5GC signaling messages, protocols, procedures and signaling flows will be given and explained for a thorough E2E 5G signaling description.

Who Should Attend

This course presents the principles of 5G Network signaling, from 5G RAN as well as 5G core point of view. It is considered to be a useful topic for 5G System Architects who would like to have an overall picture of the 5G Network end to end. Moreover, 5G Operational & Maintenance personnel will gain a good insight into the 5G network functionality which will help them to have better understanding on their daily operational and maintenance tasks. 5G RAN optimizers will also find it quite valuable since it will contribute to a good understanding of the hidden functional and signaling procedures, leading them into better troubleshooting actions and solutions. Finally, it is also considered a good topic for researchers and Academic staff to further enhance their knowledge background and facilitate their lectures or research on 5G network aspect topics.

Course Daily Schedule

Section 1 – 5G Network Architecture
5G Next Generation (NG) Network Architecture review

- 3GPP standards
  - 3GPP rel 15 phase I and phase II overview
  - 3GPP Rel 16 overview
- 5G NG Architectures
  - Enhanced EPC
  - 5GC
- Service Based Architecture
- Reference point Architecture
- ü Non Stand Alone RAN
- ü Stand Alone RAN

5G Next Generation Network Virtualization

- Network Function Virtualization
- Software Defined Networks
- Network Slicing overview
- Context aware networks
- E2E Quality of Service in 5G NG networks

5G Core Network overview

- EPC to 5GC Evolution path
  - 3GPP Releases and phases
  - EPC enhancement on Nodes and Functions
  - 5G core Network Functions
  - Functional Entities & Functional Split
- EPC to 5GC migration phases and 3GPP options
- 3GPP vs non-3GPP Access
- Enhanced EPC interfaces
- 5GC interfaces
- Key Network Functions
- 5G Identities

5G RAN overview

- 5G RAN NSA detailed description
  - UE MR-DC Capability
  - LTE-NR Dual Connectivity
  - EN_DC (option 3x) description
  - Bearer Types
  - Vendor proprietary examples
- 5G RAN SA detailed description
- 5G RAN Network Function Virtualization
- 5G NSA gNB functional blocks and interfaces
  - Centralized units

1. CU-Control plane
2. CU-User plane

-Distributed units

- 5G RRU units
- F1/F2 Fronthaul interfaces
- EN-DC X2 Interface Software Defined Networks

5G Next Generation Quality of Service overview

- 5G Services
- E2E Quality of Service in 5G NG networks
- QoS Flow concept
  - Service Differentiation
  - 3GPP Signaling Flows
- 5G RAN Bearer concept
- 5G QoS Attributes
  - 5G QoS Identifiers
  - 5G Packet classification
- QoS Implementations
  - Pre-Authorized QoS
  - Reflective QoS
  - Packet based QoS

Section 2 – 5G Non Stand-Alone (NSA)
5G NSA Signaling Analysis

- 3GPP LTE/5G NAS signaling for (option 3x) EN_DC architecture
- 3GPP LTE/5G RRC signaling procedures and services

- LTE BCCH SIB messages
  - EN_DC cell support
  - Rel.15 parameter description for 5G cell support
- LTE Initial MN Random Access analysis
- 5G NR EN_DC Random Access analysis
- 3GPP EN_DC Master Node initial service setup signaling flow,
- 3GPP EN_DC split bearer setup signaling flow,
- 3GPP EN_DC split bearer release signaling flow
- 3GPP EN_DC split bearer suspend on VoLTE service
- 3GPP log files extract analysis

5G NSA Mobility

- 5G EN_DC Mobility overview
- Split bearer release due to LTE MN mobility
- 5G NSA re-establishment (EN_DC splitting bearer to LTE MCG bearer)
- 3GPP log files extract analysis

Section 3 – 5G NR RAN Protocols
5G NAS

- NAS Domain Selection
- NAS Functions
- 5GC Mobility Management
- 5GC Session Management

5G NR RRC

- RRC Protocol
- RRC Services
- RRC Functions
- RRC messages
- RRC Procedures

5G NGAP/XnAP

- NGAP/XnAP Protocol
- NGAP/XnAP Services
- NGAP/XnAP Functions

- NGAP/XnAP messages
- NGAP/XnAP Procedures

5G NR SDAP

- SDAP Protocol
- SDAP Services
- SDAP Functions
- SDAP Procedures

5G NR PDCP

- PDCP Protocol
- PDCP Services
- PDCP Functions
- PDCP messages
- PDCP Procedures

5G NR RLC

- RLC Protocol
- RLC Services
- RLC Functions
- RLC messages
- ü RLC Procedures

5G NR MAC

- MAC Protocol
- MAC Services
- MAC Functions
- MAC messages
- MAC Procedures

Section 4 – 5G Stand-Alone (SA)
5G SA Signaling Analysis

- 5G SA idle mode behavior
- 5G SA RACH CBRA & CFRA process
- 5G Connection setup

- Signaling Flow analysis

5G SA Mobility

- 5G NR mobility overview
- 5G NR measurements
- 5G Intra-NR mobility
  - RRC IDLE
  - RRC INACTIVE
  - RRC CONNECTED
- Beam management
- Inter-RAT NR handovers
- VoLTE over 5G
  - EPS Fallback in 5G NR
- Signaling Flow analysis

Section 5 – 5G Core Signaling
5G Core Interfaces

- N1 Control Plane Interface
- N1 Protocol
- N1 Service
- N1 Procedures
- N2 Control Plane Interface
- N2 Protocol
- N2 Service
- N2 Procedures
- N3 User Plane Interface
- N4 Interface for Control & User Plane

5G Core Procedures

- Registration Procedures
  - Attach
  - Detach
  - Authentication
  - 5G key hierarchy and algorithms
  - 5G Authentication procedure (including signaling flows)
  - Security of non-3GPP access
- 5G Service request Procedures

- 5G Session Management Procedures
  - PDU Session Establishments/Release
  - QoS overview
- 5G Mobility Procedures
  - IRAT Handover 5GC to EPC
  - IRAT Handover EPC to 5GC

Instructor Biography

Dr. Spiros Louvros holds a PhD Diploma in Wireless & Mobile Communications, a Master (Msc) in RF system design for RF Engineering and Radio Communications, and a Bachelor in Applied Physics. He has an extensive working experience in both Industry and Academia for more than 25 years in many related technical fields.

Dr. Louvros is included in the list of "Who is Who" of Onalytica, as one of the Academics & Researchers influencers in the area of 5G technology and networks. For further reference please be kindly referred to Onalytica, 'Who is Who in 5G - Influencial Voices & Brands' full report https://lnkd.in/eRj3YAsG

He has worked as MW Link Planner, Mobile switching engineer, Section Manager Operational & Maintenance for well-known Mobile Operators as Siemens, Vodafone, CosmOTE Deutsche Telecom Group. He has extensive experience of more than 15 years in the Cellular Technologies starting from early GSM and extending up to LTE/LTE-A and 5G RAN technologies, working as RAN Optimizer, Planner and 3GPP Standards consultant. The last 5 years is working as LTE-A/5G system architect and Technical Consultant Leader for RAN technologies, leading research and implementation projects related to 5G NSA & SA smooth migration as well as preliminary 6G Radio technologies consultancy projects.

In the Academic sector Dr. Louvros held for 08 years the Tenure Track position of Assistant Professor in the Technical University of Western Greece in the technical field of Wireless and Mobile Communications. During his professorship he has conducted several courses in graduate and undergraduate level in the area of Mobile Communications, Satellite Communications, Optical network infrastructure and Information Theory. He was leading a laboratory for advanced Antennas and MIMO technology with emphasis in EU Research Projects and Industrial collaborations. He finally conducted several lectures in IEEE summer schools and special Academia-Industry collaborative events

Dr. Louvros offers for more than 15 years exclusive technical trainings on collaborative technologies of GSM, 3G, LTE/LTE-A (including MTC NB_IoT), 5G and preliminary 6G with reference to contemporary 3GPP standards and vendor specific features and architectures. He also conducts and provides technical report authorships and network deployment consultancy to operators and customers worldwide.

Dr. Louvros has been a member of the Continuing Education Institute-Europe faculty since 2020.