V 1.0

FRMCS – Details of the Core Network

Course Duration:

- 2 days (onsite) or 4 x ½ days (online)

Course Description:

- This course addresses the needs of everybody who requires a detailed understanding of the cloudified core network which shall be deployed in the FRMCS environment.
- We also cover the FRMCS-specific interaction with the IMS in order to provide for mission-critical services like PTT.
- By using Open5GS we expose the students to a real-life evironment to accompany the theoretical parts.
- Another highlight of the class is how to dimension a cloudified core for the FRMCS. The understanding of this objective is particularly important for railways operators as their requirements are entirely different from those of telecom network operators.
- We integrated several hands-on parts as for example the setup of Open5GS in a Kubernetes environment or the analysis of a SIP-based PTT-call setup procedure.

Some of your questions that will be answered:

- What are the tasks and functions of the different network functions in the 5GC like AMF, SMF or UDM? What is specific for the FRMCS?
- What are microservices and how do they relate to the aforementioned network functions?
- How do the offered services change from GSM-R to FRMCS?
- What changes procedurally from GSM-R to FRMCS wrt registration to the network, authentication, call setup and mission-critical services?
- To which extent can we use the Open5GS for testing and integration of Kubernetes and cloudification prior to the real implementation of our FRMCS?
- How to dimension a 5GC for our FRMCS properly? We need to consider specific requirements like high availability, mission-critical use cases and others.
- Which role does Kubernetes play in the operation of our FRMCS core network?
- How can we get a real feeling for the operation of a cloudified network?

Table of Content:

Part 1: Warming up: FRMCS & 5G

- **Architecture of the FRMCS** / RAN, 5GC, IMS
- **Why FRMCS?** / sunset of GSM-R, spectral efficiency, softwarization …
- **From GSM-R to NR: What is new with LTE and NR?** / services, technology, example: network slicing
- **Some look into 5G radio /** OFDMA based PHY, NSA vs SA, beamforming, numerologies, enhancements compared to LTE
- **Mission Critical Services of the FRMCS (MCX)** / MCPTT, MCVideo, MCData

Part 2: Looking deeper into 5G Core Network and IMS

- **Introducing Service Based Architectures (SBA) /** service producer <=> service consumer, consequences for the 5GC
- **Definition: RESTful Communication /** what it is, how it works, why it suits cloudified operation
- **Hands On: HTTP Methods used on RESTful Interfaces**
- **The 5GC in SBA plus NW Functions /** Introducing the various network functions like UDM, UDR, AMF, SMF, AUSF …
- **Hands On: Launching Open5GS on the trainer's computer and analyzing traffic bw/ network functions**
- **Hands On: Performing UE-registration & PDU-session establishment into the Open5GS with Wireshark analysis**
- **The IMS and MC-Services /** Architecture of the IMS, MC-application servers, QoS, session management, group communications, priority call handling, emergency services

Part 3: Virtualization & Containerization

- **Introducing Virtualization** / HW-virtualization <=> SW-virtualization, virtualization in telecommunication, pros and cons of virtualization
- **Virtualization with virtual machines and containers** / virtual machines vs containers, historical view, containers, virtual machines, operating with containers and VM's, microservices, performance comparison bw/ VM and containers
- **Hands in the mud** / launching some containers and tapping the traffic between them with Wireshark

Part 4: Dimensioning of a Cloudified 5G Core for FRMCS

- **Terminology & Background** / CPU, vCPU, Core, L1-Cache, CPU-Sharing, CPU-Pinning and Hyperthreading
- **Performance of CPU's through the Ages** / introducing the *throughput*, evolution of the CPU from the Z80 to the Intel Xeon Gold, clock speed, No of bits, ...
- **FRMCS: User Categories** / mission-critical users, business-critical users, passenger services, IoT & automation
- **FRMCS: Traffic Metrics (Estimates)** / QoS-requirements, No of TAU / user / hour, No of paging events / user / hour, ...
- **Example 1: Dimensioning of the AMF in an FRMCS** / Number and types of events, scaling with the No of users => Calculation & result: CPU and memory requirements
- **Example 2: Dimensioning of the UDM in an FRMCS** / Number and types of events, scaling with the No of users => Calculation & result: CPU and memory requirements

Part 5: Cloud Native Operation & Networking

- **What does Cloud Native mean?** / deployment of containers in different types of clouds, DevOps, service mesh, CI/CD
- **Decomposing Monoliths into Microservices** / challenges, implementation freedom and options, ...
- **Example: The AMF and its microservices** / 3GPP TS 29.218, Swagger, ...
- **Introducing Kubernetes** / basics, cluster, components, worker node, pods...
- **Hands On:** Deploying and scaling *Open5GS* in a Kubernetes cluster
- **Operating the network functions of the 5GC inside a Kubernetes Cluster** / Mapping Service IP to Pod IP, Load Balancing, Readiness Probes, Alive Tests, Kill Pods, SW-Updates
- **Communication between pods and containers** / Intra-Pod, Inter-Pod / Intra-Node, Inter-Pod / Inter-Node
- **Main Security Hazards of a Cloudified 5G Core** / Virtualization and container security, risk of compromising GPDR in case of hosted solutions, phishing on data in transit, DoS attacks on different levels, zero-trust concept

Part 6: Signaling & Protocols involving 5GC and IMS

- **The 5G Protocol Stack with Focus on NAS and 5GC** / 5GMM, 5GSM, HTTP/2, JSON
- **Understanding the Essentials of HTTP/2** / why not HTTP1.1?, characteristics of HTTP/2, streams, frame types
- **Understanding PFCP** / tasks & functions, frame types, parameters, operation ...
- **Scenario: Registration Procedure** [3GPP TS 23.502 (4.2.2.2.2)]
- **Scenario: Authentication with 5G-AKA** [3GPP 33.501 (6.1.3.2)]
- **Scenario: UE-requested PDU Session Establishment** [3GPP TS 23.502 (4.3.2.2.1), 24.501 (6.4.1)]
- **Scenario: UE-initiated Deregistration**
- **Scenario:** MCPTT call setup => message flow, analysis of SIP / SDP and XCAP protocols, interaction with the 5GC and the RAN