5G Core

from Monoliths to Cloud Native

from Diameter & GTP to HTTP2 & JSON

Course Duration:

- 3 full days or 5 x half day (course has been tailored for **online methodology**, for more information on video, please send email to gheine@inacon.de)

Course Description:

- This course addresses the needs of technical engineering staff who require a detailed understanding of the 5G core network, built inside Kubernetes (K8s) cluster using containers and cloud-native networking to host micro-services.

- This course has been designed to meet the requirements of both: engineering experts to design and test such micro-services inside K8s and operations staff to operate and maintain a container-based 5G core network.

- The course starts out with a wrap-up of general 5G-topics like a short overview of NSA vs SA, the future of RAN and QoS in 5G.

- The whole next chapter is dedicated to the detailed definition of the various new network functions inside the 5G core, e.g. AMF, SMF, UPF, NRF, SEPP, to name a few.

- In that respect, it is our target to make the students understand how these network functions are physically realized as micro-services inside a cloud-based environment.

- Of course, we also explain in detail the HTTP/2- and JSON-based communication among these network functions in a service based architecture (SBA).

- In the following chapter we highlight the differences between HW-virtualization and VM's on one hand and OS-virtualization and containers on the other hand.

- Focus in this chapter is on hands-on and life creation and setup of images and containers and their use for different purposes (e.g. Apache web server).

- Chapter 4 is dedicated to container orchestration through Kubernetes and the various specifics of Kubernetes.

- That relates in particular to the thorough analysis of the Kubernetes cluster architecture, namely the worker node(s), pods and the master node.

- Another focus is on the operation of micro-services inside a Kubernetes cluster, namely load balancing, IP-addressing and networking among pods and containers.

- Much effort is again spent on practical exercises with real-life use of a running Kubernetes cluster in our network.

- The following two chapters 5 and 6 are dedicated to the new 5G signaling procedures with focus on core network.

- Most important: These two chapters are complementing each other with chapter 5 depicting the theory part according to the standard and chapter 6 providing the peer hands-on logfiles.

- This provides students with real-life exposure to the meaning of parameters and messages in 5G.

- Chapter 6 is also referred to frequently earlier in the course to emphasize the interaction among micro-services in the 5GC.

Prerequisites:

- The students need to have *basic* understanding of 5G but *good* understanding of the EPC.

- Practical experience with LINUX CLI is beneficial as we perform quite a few life exercises.

Some of your questions that will be answered:

- How are network elements and network functions broken down into micro-services?

- Why does the 5GC require the use of HTTP/2 and JSON for the communication among the micro-services / network functions?

- What is HTTP/3 and does it currently play any role in the context of 5G?

- What is the meaning of PRINS and how does it enable secure communication among 5G core networks in case of roaming?

- Which network function in the 5GC is responsible for which tasks?

- How is the 5GC physically realized in a Kubernetes environment?

- Why does 3GPP endorse new authentication options like EAP-TLS?

- How does a UE register to the 5GC and which network functions are involved?

- How does a UE obtain its IP-address(es) from the network and which network functions are involved?

- How does Inter-RAT mobility work between LTE and NR, esp. with N26-interface deployed?

- What are the differences and specifics of HW- and OS-virtualization? What are the differences and specifics of containers and virtual machines?

- How precisely does mobile edge computing work and which requirements does it impose on the 5GC?

- What happens if the UE needs to register to a specific network slice?

- Why does 3GPP introduce the 5G-AKA authentication procedure and what are differences compared to EPS-AKA?

- How can we trace the signaling among different containers in a cloud?

- How does Kubernetes achieve load balancing among different pods?

Course Target:

- The students will gain thorough understanding of the 5GC network functions and how they are realized as micro-services.

- Through our deep dive into container and Kubernetes practice the students can put their hands in the mud and gain practical experience with cloud-native operation.

- Finally, the students will understand the signaling flows when UE, NR-RAN and 5GC interact with each other in various different scenarios.

Table of Content:

Chapter 3: Virtualization and Containerization (2.5 – 3.5 h)

- **HW-Virtualization** (What it is?, HW-Virtualization in telecommunication, ETSI-reference model, from HW-virtualization and VM's to OS-Virtualization and Containers*...)*
- **Live: Setup and observation of VM's**
- **Docker Images and Containers**
- **Docker Environment** (components, Docker hub, containerd, comparison with podman, ...)
- **Live: Building our own images and containers**
- **Live: Playing with containers** (Apache web server in a container, port mappings, traffic recording between containers with Wireshark, ...)
- **Container Orchestration: First look onto Kubernetes (K8s)**
- **Live: Understanding networking between containers**

Chapter 4: Cloud Native Networking (2.5 – 3.5 h)

- **Definition, philosophy and and principles of Cloud Native** *(according to CNCF, micro-services, DevOps culture, CI/CD, service mesh, types of clouds (public, private, hybrid))*
- **Decomposing typical silos into micro-services** (theory and practice, meaning of YAML-files, ...)
- **Example: Looking at the different Micro-services inside UDM and AMF...**
- **Deep dive into Kubernetes Architecture** (Cluster, master node, worker node, pods, kube-api server, kube-controller, kube scheduler, etcd, ...)
- **Deep dive into Kubernetes Operation** (mapping service-/cluster IP-addresses to Pod-IP addresses, load balancing in a K8s cluster, health checks, self-healing, ...)
- **Deep dive into Kubernetes Networking** (Communication between 2 containers in a single Pod, between two Pods in the same worker node, in different worker nodes)
- **Live: Operation of Kubernetes** (Basics, scaling, health checks, ...)
- **Live: Bashing into running Kubernetes Pods and invoking real-life traffic**

Chapter 5: Scenarios (Reference / Theory) (2.5 – 3.5 h)

- **Understanding HTTP/2** (stream based transmission, operation, head of line blocking, outlook to HTTP/3, frame types, scenarios)
- **Registration and TA-Update procedure** (*according to 23.502 (4.2.2.2.2) but immediate mapping to real-life messages in chapter 6*)
- **UE Requested PDU Session Establishment** (*according to 23.502 (4.3.2.2.1) but immediate mapping to real-life messages in chapter 6*)
- **5G Authentication using 5G-AKA** according to 33.501 (6.1.3.2) (detailed analysis, depicting the differences to 4G (e.g. HXRES*, K(ausf)) but immediate mapping to real-life messages in chapter 6)
- **Xn- and N2- based Handover procedure (intra NR)**
- **5GS to EPS handover using N26 interface**
- **EPS to 5GS handover using N26 interface**
- **Deregistration procedure**

Chapter 6: Scenarios (Wireshark / Practice) (2.5 – 3.5 h)

- **HTTP/2: Upgrade from HTTP/1.1 to HTTP/2**
- **HTTP/2 Session Setup between two NF's in the 5GC**
- **5GS Registration with 5G-AKA Authentication**
- **UE-requested PDU-Session Establishment Procedure**

Alternatively or in addition we may incorporate and analyze your own logfiles