

Network Function Virtualization *Details, Theory & Practice*

Course Duration:

- 2 days

Course Description:

- This course addresses the needs of technical engineering staff within telecom carriers and equipment and software vendors who are involved in the design, setup and testing of virtualized telecom network equipment and software.
- Special focus of the course is on the ETSI ISG-based reference architecture which has been accepted by the industry as baseline.
- The course starts out with an introduction to NFV (Network Function Virtualization) and how it relates especially to SDN (Software Defined Networking).
- To emphasize the meaning of SDN for NFV, we establish during the course a live virtual network using Mininet and demonstrate basic SDN and OpenFlow operation with Wireshark.
- From there the course pinpoints to cloud computing and the related business models like IaaS, SaaS, PaaS and makes the student familiar with the ideas of NFVIaaS, VNFAaaS and VNFPaaS.
- This part of the course concludes with an open discussion of the commercial and operational pros and cons of NFV.
- The following part of the course focuses on the detailed description of the ETSI-reference architecture and makes the students familiar with the different terms like MANO, NFVI and VNF, VIM, VNFM and WIM.
- We explain in detail the configuration and setup of VNFs consisting of one or more VNFCs using differently configured virtual links. This part concludes with the detailed description of the instantiation of a VNF.
- The next part of the course is dedicated to MANO-descriptors like the VNFD, VLD, NFPD and VNFFGD that are crucial for the configuration, operation and interworking of the virtualized network equipment. We depict examples and explain their meaning and potential errors step by step which is so important for testing commissioning.
- The next lecture deals with the optimization and acceleration of virtualized environments and describes which means exist for that optimization like localized memory (NUMA) and multiple core operation. This part also deals with potential performance killers like interrupts and how to mitigate their impact.
- Finally, the course presents more NFV-scenarios like Scaling In/Out and Up/Down, behavior in case of VNF-outage and setup and collection of KPIs.

Prerequisites:

- The student must be familiar with basic virtualization concepts, telecom networks and their operation and administration.
- Experience with different operating systems, esp. UBUNTU and virtualized environments on a PC are beneficial.

Course Target:

- The students are enabled to contribute during the setup, planning and testing of virtualized telecom networks.
- The students will be able to develop and interpret MANO-descriptors for VNFs etc.

Some of your questions that will be answered during the course:

- How does NFV differentiate from SDN?
- What makes NFV so appealing for telecom operators?
- Which obstacles need to be overcome to use COTS-hardware in telecom networks?
- In which steps can NFV be introduced in which parts of the telecom network?
- Which hard- and software dependencies exist for virtualized network elements in terms of hypervisors and infrastructure?
- What are MANO-descriptors and what do I need to consider when I want to create, configure and on-board them?
- What are the tasks and functions of the different blocks inside the ETSI-reference architecture like VIM, VNFM and orchestrator?

Table of Content:

Chapter 1: IT meets Telecom

- **The Ideas of NFV (Network Function Virtualization)**
COTS-Hardware / Network Elements as Software / Virtualization in-between the two
- **The Ultimate Target of NFV on the Radio Side: C-RAN**
Concept / State of Implementation / Issues
- **Network Function Virtualization in Context**
... with SDN, cloud operation and virtualization in the PC-world / NFV vs SDN (Software Defined Networking)
- **Hands in the Mud: SDN in Practice**
Mininet Virtual Network Setup on your UBUNTU-Machine / Setting up this Network in UBUNTU / Reviewing the Network Configuration / Generating HTTP-Traffic / Reaction of the vSwitch upon the HTTP-Traffic / Wireshark Logfile of the OpenFlow Traffic
- **Virtualization in the PC-World**
Virtual Machines and Hypervisors / Application of Virtualization on a PC
- **The Cloud Business**
IaaS (Infrastructure as a Service) / SaaS (Software as a Service) / PaaS (Platform as a Service)
- **Targets, Consequences and Challenges of NFV**
Commercial Targets / Other (still monetary-driven) Targets / Challenges and Consequences

Chapter 2: NFV Architecture explained

- **The ETSI-based ISG (Industry Specification Group)**
Introduction / Time Table and History
- **Example: The EPC as virtualized Network**
The VNF as basic Entity / Virtualization Layer / Hardware Resources
- **NFV Reference Architecture**
VNF-Domain / MANO-Domain / NFVI-Domain
- **More Details on the VNF-Domain**
VNF with single VNFC / VNF with multiple VNFCs / The VNF-Descriptor (VNFD) / Hardware Dependencies
- **Communication between VNFCs**
Option 1: Serial Bus / Option 2: Hardware Switch / Option 3: Vswitch / Option 4: Through (v)NICs and across Networks
- **More Details on the VNFI-Domain**
General Remarks / The Hypervisor Domain / The Compute and Storage Domains / The Network Domain / Virtual Networking Resources (not SDN) / Operation of vSwitch
- **More Details on the MANO-Domain**
Orchestrator / Repositories / VNFM (VNF Manager) / VIM / WIM / VIM: Tasks and Functions / Example: Instantiation of a VNF / Practical Exercise: Relating Messages to Interfaces

Chapter 3: Setup and Operation of virtualized Networks

- **Configuration Virtualized Network Setup (C-RAN and EPC)**
From Network Service (NS) to VNFFG and NCT
- **Introducing the Codex of NFV**
NS (Network Service) and NSD / (VNF, VNFC, PNF, VNFD VNFC, and PNFD) / Virtual Links and VLD / Connection Points (CP) / VNFFG
- **VLD-Examples**
E-TREE, E-LAN and E-LINE
- **NFPD- and VNFFGD-Examples**
Control Plane / User Plane
- **VNF Scaling and Load Balancing**
Scale Up/Down vs Scale Out/In / Auto Scaling and On-demand Scaling / Management based Scaling
- **Implementation Example**
KVM (Kernel-based Virtual Machine) / DPDK (Data Plane Development Kit) / SR-IOV and PCIe (Single Root Input/Output Virtualization / Peripheral Component Interconnect express) / OpenStack / OpenDaylight / Open vSwitch

Chapter 4: Optimization and Acceleration

- **Reviewing Interrupt Methods and their Impact on Virtualization**
Interrupt types, virtual interrupts, interrupt issues with virtualization, interrupt operation using hypervisors, ...
 - **Memory Access and NUMA**
General description of memory access and memory sharing, influence on processing speed, NUMA and the related benefits, ...
 - **Acceleration Options**
VNFD options for acceleration, typical examples like “ActiveActive”, ...
 - **MANO-Descriptors with Acceleration Descriptors**
Examples of VNFD, VDU with different acceleration descriptors
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Chapter 5: Scenarios and KPI-Measurements

- **Scaling Up/Down and Out/In Scenarios**
- **KPI-Communication between VNF and EMS**
- **SW/HW Outage VNF: Reaction of the System**