Mobile Computing Project Description

WS 2021/2022

Important Note: in addition to this document, it is essential that the notifications and announcements posted in the corresponding Moodle course or made within the lecture are considered!

1   Introduction

This semesters Mobile Computing module consists of a project related to the topic of mobile computing. The project is introduced in this document. Students will work in groups of three students. The group arrangements and project assignments will be carried out via the E-Moodle course.

Since this semester of the Master IT is designed to take place purely online, support through a meeting in the university will not be possible. In case of questions or concerns, a corresponding E-Mail including a detailed problem description can be sent to mobilecomputing@e-technik.org . In case of major difficulties, a Zoom-Meeting might be scheduled for further explanations of the problem.

The project deals with the provisioning of network slices, which is assumed to be one of the key-enabler for the 5G concept. The network slicing must be realised and implemented within an self-emulated network environment based on the virtualisation technologies LXC and/or Docker. In the following, the general scope of the project is presented in more detail including the definition of requirements and recommendations, as well as submission and evaluation guidelines.

In the following are important dates which shall be considered:

29.11.2021 – Presentation of the Mobile Computing Project within the Mobile Computing lecture

05.12.2021 – Deadline for the arrangement of groups by the students themselves via the E-Moodle course (see "Group arrangement"). In case of a suitable group partner cannot be found, please send an E-Mail including your personal information to mobilecomputing@e-technik.org in prior to the deadline. In this case a group will be assigned randomly.

06.12.2021 – Announcement of the assigned projects. Each group will receive a randomly selected combination of a service and a network approach. The combination needs to be used during the implementation of the project (see chapter 2 for more information).

13.03.2022 – Submission of the project results according to the submission guidelines. The submission will be carried out via E-Moodle

2 Network Slicing in a Self-Emulated Network Environment

2.1 General scope of the project

The provisioning of multiple independent network slices for different tenants (also called end-users in the following sections) within the following logical network infrastructure shall be achieved. The network infrastructure (see figure 1) is composed of multiple logical sections. The core of the network is based on a transport network constructed from multiple forwarding instances (routers, switches, etc.) and data centres connected to the transport network. The datacentres have the capabilities to host and provide applications and services. Access networks connected to the transport network are providing the tenants/end-users the possibility to use the services and applications within the data centres and allow a communication among the end-users if required. In between the access network and the transport network lies the logical edge network which provides the possibility to deploy light-weight services and applications closer to the end-users.
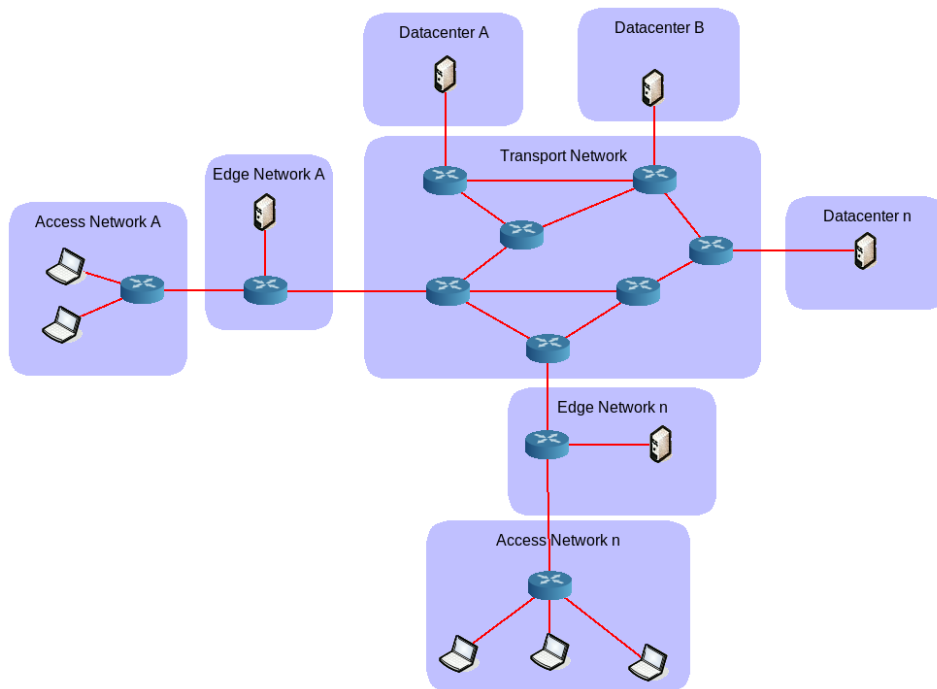

Figure 1 – Exemplary logical network infrastructure used as a basis for the provisioning of the network slices

The task of this project category consists of providing a service with a specific functionality to different tenants located in the access networks. To ensure the separation of the services and end-users, the concept of network

slicing must be utilised. The concept of network slicing is introduced in the corresponding Mobile Computing lecture of Prof. Lehmann and in various literature such as [1] (eBook available in the FRA-UAS online library).

Each independent network slice needs to provide the service to their assigned end-users. Possible services are:

- File-Hosting/File-Sharing: allowing the end-users to upload/store files, as well as downloading and using files from other end-users of the network slice. The concept of network slicing ensures that end-users of network slice A cannot access the data of network slice B and vice versa.

- Voice-over-IP: allowing the end-users to establish a Voice-over-IP communication to other end-users within the network slice. The network slicing concept prevents the establishment of a communication between end-users of two independent slices.

- Text-based Chats: enabling the end-users to communicate with each other using text-based chats including different chat rooms. Each network slice provides independent chat rooms to its end-users and prevents a communication between the end-users of different network slices.

- Video-on-demand: providing the streaming of videos to the end-users on a video-on-demand basis. The concept of network slicing ensures a separation of available videos to the end-users.

The network slices enabling the services to the different tenants and end-users need to span the edge and transport network as well as the data centres. The network slicing in the edge and transport network needs to be achieved through the utilisation of a networking approach to ensure a suitable separation of the different tenant's data flows. The possible networking approaches are:

- Pure Software-Defined Networking (SDN)
- Virtual Extensible LAN (VXLAN)
- Generic Routing Encapsulation (GRE)
- Generic Network Virtualisation Encapsulation (GENEVE)
- Multiprotocol Label Switching (MPLS)
- Virtual Local Area Network (VLAN)

2.2   Requirements and recommendations

- Design and definition of a logical network infrastructure (see chapter 2.1) used for the implementation of the independent network slices based on the assigned service and networking approach.

- Implementation of the designed network infrastructure using the virtualisation technologies LXC [2] and/or Docker [3] (LXC is recommended). Each LXC- and/or Docker-Container is required to represent an instance of the designed network infrastructure (as an example: router, server, etc.). The connections between the containers shall represent the links within the logical network infrastructure.

- While the service implementation may consist of an individual implementation, it is highly recommended to use existing service implementations. The main scope of this project category consists of the concept of network slicing and not the development of a service.

- Depending on the assigned networking approach, to realise the network slices in the edge and transport network as well as the data centre, common Linux networking tools/configurations might be enough, while other approaches require the utilisation of Open vSwitch (OVS) [4] (including appropriate rules and configurations) or the routing protocol suite FRRouting [5]

- All configuration required for the network slices shall be achieved from within the containers. Configurations performed on the host system shall be limited to the lifecycle of the containers (such as start, stop, or configuration for achieving logical network infrastructure)

- Utilisation of container management platforms such as LXD (for LXC) and Kubernetes (for Docker) is not prohibited, but also not recommended

3   Evaluation Guidelines

The evaluation of the project is carried out based on the group's performance in three main aspects: documentation, video demonstration and continuous processing, which are explained in the following. The project submission will take place via the Mobile Computing Moodle course on the specified and announced date. Additional information dealing with the actual submission process might be announced in time.

Documentation

The documentation should consist of the following aspects:

- Description of the designed and implemented network infrastructure realised with LXC and/or Docker including the connections between the different containers
- Description of the functional components composing the service and their relation to each other
- Description of the established network slices on the network infrastructure including their configuration
- Analysis (by using Wireshark) and functional tests proving the correct behaviour and configuration of the network slices
- Guide including all steps required to put the configured emulation into operation

To allow an individual evaluation for each student within a group, it is important to highlight the work of each student within the documentation and implementation. Within the documentation, each chapter/section must be marked with the name of the corresponding author. Within the implementation, meaningful comments must be used to refer to the corresponding developer.

Video Demonstration

The project results need to be presented and demonstrated. This takes place by each group preparing a 15-minute video consisting of the presentation and demonstration. Each group member shall participate within this video. For creating the video, the platform Panopto (please see provided link in Moodle course) shall be used.

Continuous project processing

The continuous work on the project will be considered during the evaluation. For this a private GitHub-Repository for each group is prepared and access will be granted to each group member through an invitation send to the corresponding student e-mail addresses. The repository shall be used to document the progress of the group with each group member participating on it. Special focus is placed on the definition and continuous processing of project milestones.

4 References

[1]   D. Chandramouli, R. Liebhart, and J. Pirskanen, *5G for the Connected World*. Chichester, UK: John Wiley & Sons, Ltd, 2019.

[2]   "Linux Containers - LXC - Introduction." [Online]. Available: https://linuxcontainers.org/lxc/introduction/. [Accessed: 19-Nov-2021].

[3]   "Docker Documentation | Docker Documentation." [Online]. Available: https://docs.docker.com/. [Accessed: 19-Nov-2021].

[4]   "GitHub - openvswitch/ovs: Open vSwitch." [Online]. Available: https://github.com/openvswitch/ovs. [Accessed: 19-Nov-2021].

[5]   "FRRouting." [Online]. Available: https://frrouting.org/. [Accessed: 18-Oct-2021].