

OVNES: Demonstrating 5G Network Slicing Overbooking on Real Deployments

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Abstract—The network slicing paradigm provides the necessary means to allow vertical segments to seamlessly share the same network infrastructure, while delivering the expected service level agreements (SLAs) to their own customers. However, the concurrent access at shared resources and the huge disparity among different verticals' service requirements opens up new technical challenges that must be addressed. With this demonstration, we showcase the benefits that centralized orchestration operations, such as slice brokerage and resources allocation, can bring to tackle these issues. Our testbed, namely *OVNES*, implements the network slicing paradigm on real network equipments and discloses the novel concept of *5G Network Slice Broker* as an entity in charge of mediating between vertical network slice requests and physical network resources availability.

I. INTRODUCTION

Network virtualization and programmability have been identified as the main key-enablers for the upcoming business model revolution: vertical segments are willing to pay for obtaining a dedicated “*slice*” of the mobile network in order to deliver added-value services to their customers. In this context, the *Network Slicing* concept [1] has emerged as technological solution able to significantly increase the revenues of infrastructure providers in the 5G network landscape. Practically, network operators can offer multiple (virtualized) slices of the physical infrastructure to vertical industries (e.g., automotive, e-health, etc.) or Over-The-Top (OTT) service providers leveraging on new sources of revenue, but, at the same time, they need to cope with the seamless provision of shared network resources to meet the service level agreements (SLAs) of each instantiated network slice [2]. Therefore, an automatic network orchestration solution is needed to continuously monitor the overall network conditions and map the upcoming network slice requests into physical network resources.

Fig. 1 provides an overview of the network orchestration process across different network domains. Network slices are installed and inter-connected through cloud data centers, the core domain (where the evolved packet core, namely EPC, is operating), edge data centers (supporting mobile edge computing services [3]), fronthaul and backhaul links, and the (radio) access network, i.e., (R)AN. When an end-to-end network slice orchestration is in place, two main operations can be identified: *i*) brokering phase, *ii*) network and computational resources management. Both are handled by a network slice broker, envisioned as an automated solution that collects network statistics and provisions network slices in real-time pursuing the overall revenue maximization for e.g. by means of machine-learning techniques. A preliminary 5G network slice broker supporting network slices instantiation only on the Radio Access Network (RAN) has been fully studied and devised in [4]. However, enlarging the scope of brokering operations over all the network domains implies novel challenges

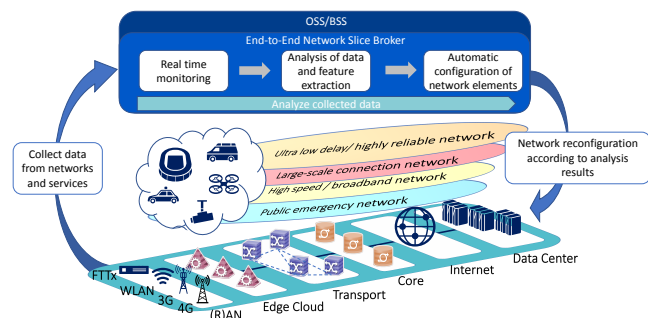


Fig. 1: End-to-end Network Slicing Orchestration

to be addressed, such as cross-domain latency, throughput performance guarantees and logical isolation among slices tailored to specific service templates [2].

In our demo, we designed and deployed an Overbooking Network Slices (OVNES) solution in charge of *i*) collecting network statistics, *ii*) predicting traffic behaviors exploiting machine-learning approaches, *iii*) applying admission control policies to optimally select network slice requests by pursuing the overall network efficiency, *iv*) scheduling physical resources based on different service requirements. Our demo is also equipped with a user-friendly dashboard to explore achievable gains.

II. OVNES IMPLEMENTATION

Due to the lack of commercial 5G radio access nodes, we build our demonstration using commercial LTE eNodeB (eNBs), leveraging on the network sharing concept. This implies that each slice is physically implemented as a different mobile virtual network operator (MVNO) and assigned with a specific public land mobile network (PLMN) identifier that shares the same RAN infrastructure. Thus, we have implemented a dedicated core network per slice.

The demonstration setup is depicted in Fig. 2. We have considered three different verticals asking a network slice with heterogeneous traffic requirements: *i*) Public Safety critical communications, *ii*) enhanced Mobile BroadBand (eMBB) GBR (mostly for VoIP calls), and *iii*) enhanced Mobile BroadBand (eMBB) best-effort (mostly for general-purpose data transmissions). Network slices requests are randomly generated based on proper service requirements, dubbed as *slice templates*. The demo consists of the following components:

- three virtualized Evolved-Packet-Core (EPC) using OpenEPC 7 [5] (one per slice);
- two NEC LTE eNBs;
- a number of LTE devices generating traffic with different service requirements, such as mobile phones, surveillance cameras and LTE USB dongles;

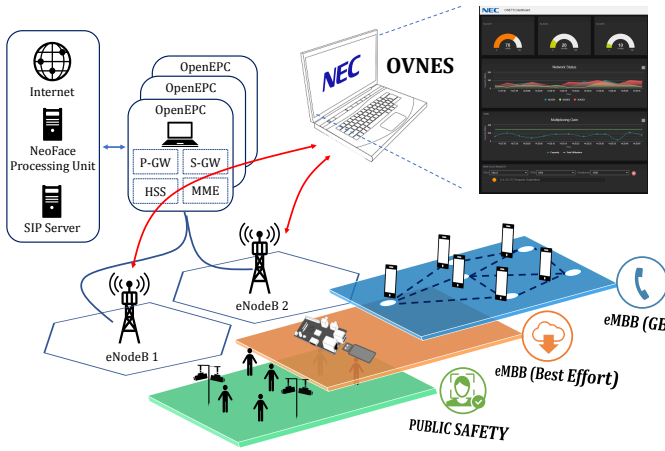


Fig. 2: Demo overview: building blocks

- OVNES solution implemented as a stand-alone software connected to NEC eNBs as well as to the cloud environment (EPCs).

NEC eNBs are provided with a Local Maintenance Terminal (LMT) for management operations. Among the others features, the LMT allows to adjust the physical network resources allocation (in terms of physical resource blocks, PRBs) of a specific PLMN, i.e., a specific network slice. The LMT is programmable by means of XML configuration files that are loaded and installed every time the network slicing configuration changes. In order to simulate tenant requests and provide dynamicity, we have developed JAVA interfaces and a user-friendly dashboard (GUI) on the OVNES framework solution (Fig. 2), implemented as a JavaScript web page running on Apache Tomcat web server.

III. EXPERIMENT LIFECYCLE

In our experimental testbed we run across all the lifecycle management steps of the network slicing scenario, as summarized in Fig. 4. In the *network slice requests generation*, slice requests are issued through the dashboard interface while specifying the proper network slice parameters such as the template, the size in terms of PRBs and the time duration. In the *network slice request management phase*, incoming slice requests are matched against the real-time monitoring information and prediction estimations within our OVNES framework. To allow OVNES to optimally allocate network resources, the admission policy is fed with a machine-learning process (feedback loop depicted as a dashed line) applied on the real tenant network resource utilization. At this point, overbooking mechanism could be enforced, which translates into increased resource utilization and additional revenues for the infrastructure provider. Once the slice request has been processed, the GUI notifies the user about the positive (or negative) outcome, while the OVNES solution automatically starts the *network slice installation procedure* instructing the LMT of involved eNBs to reserve the requested amount of PRBs.

Successful installations are notified through the dashboard. When the slice is correctly installed, different traffic source devices (see Fig. 3) are attached to the eNBs and data transmissions are activated based on the required service, e.g., cameras sending HD video or mobile phone making calls.

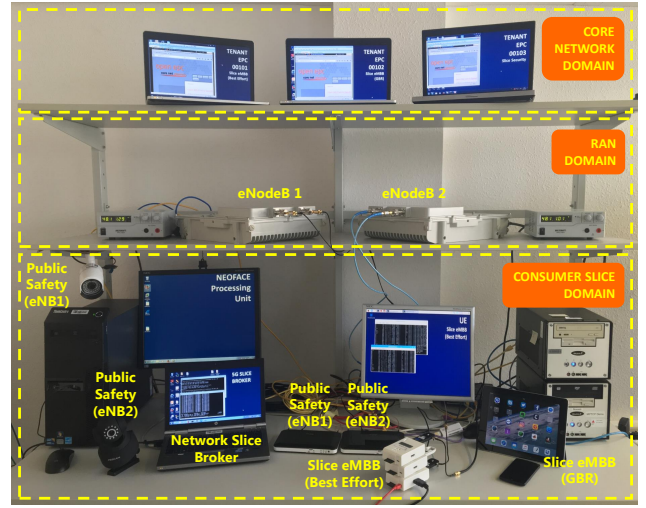


Fig. 3: Deployment setup

If the slice is not admitted, all device connections to RAN equipments are rejected by the eNBs, as no PRB reservation has been performed for that particular slice (PLMN-id). Our demonstration video is available online¹.

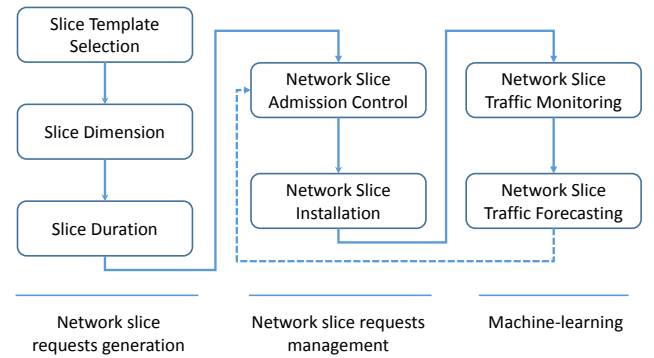


Fig. 4: Experiment phases

IV. CONCLUSIONS

The proposed demonstration proved feasibility and reliability of the Overbooking Network Slices (OVNES) solution in real cellular deployments. In particular, it showed the potential multiplexing gain obtained applying machine-learning approaches on the network slice traffic monitoring and resources management.

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¹Available at <https://www.youtube.com/watch?v=9WMZFXv2OcE>