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Experimental Demonstration of a 5G Network Slice Deployment Exploiting Edge or Cloud Data-Centers

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Abstract: The demo shows the 5G-TRANSFORMER architecture capability to deploy 5G network slices exploiting edge or cloud data-centers in minutes. Different slice deployments are shown to affect the performance of a dictionary mobile-app supported by them.

OCIS codes: (060.0060) Fiber optics and optical communications; (060.4250) Networks;

1. Overview

The H2020 5G-TRANSFORMER project (5GT) aims at transforming today's rigid mobile transport networks into a flexible SDN/NFV-based mobile transport and computing platform supporting different verticals (e.g., automotive, e-health, e-industry). 5GT architecture is based on the ETSI MANO architecture [1][2]. As depicted at the top of Fig. 1, it includes the 5GT vertical slicer (5GT-VS), the 5GT service orchestrator (5GT-SO), and the 5GT Mobile Transport and Computing Platform (5GT-MTP).

The 5GT-VS is the entry point for the vertical requesting a service and it handles the association of network services with slices as well as network slice management. The 5GT-SO is responsible for end-to-end orchestration of services across multiple domains and exposing them to the 5GT-VS in a unified way. The 5GT-MTP provides, manages, and abstracts the virtual and physical IT and network resources on which service components are deployed.

The demo features a software implementation of all the elements of the 5GT architecture and it exploits them for slice deployment utilizing resources related to edge or core data centers (DC). Specifically, as depicted in Fig. 1-a, one slice includes a virtualized evolved packet core (vEPC) deployed in a DC at the network core (i.e., in the ARNO testbed in Pisa) while the other slice, as depicted in Fig1-b, features the deployment of the vEPC in a DC at the network edge (i.e., at the OFC premises). The considered vertical application is a dictionary mobile app. Based on the two different deployments the mobile app will access the app server in the Internet either locally, if the vEPC (including the Packet Data Network Gateway --- PDN-GW) is deployed at edge DC, or from the ARNO testbed in Pisa, if the vEPC is deployed in the ARNO testbed core DC.

While utilizing the dictionary mobile app, visitors to the demo will experience the different latencies provided by the two different slices. Visitors will be also provided with a paper dictionary and involved in a challenge for the fastest word lookup.

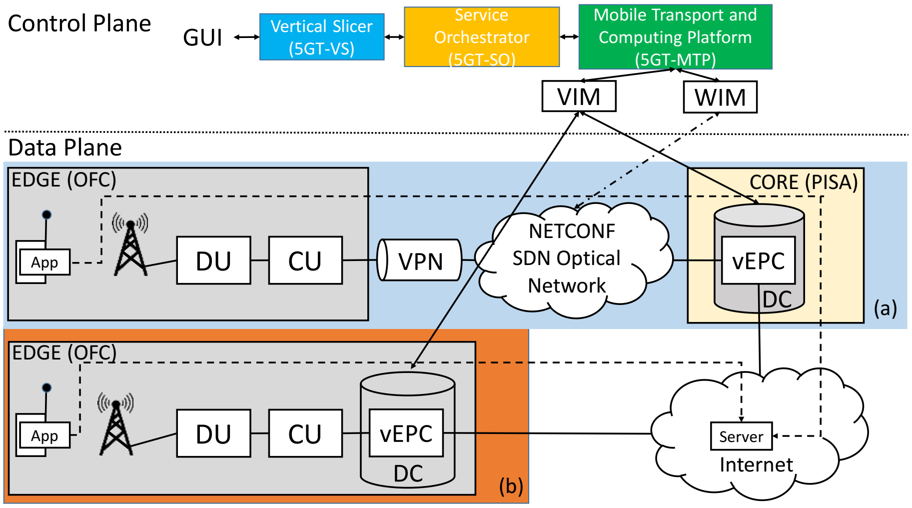

Fig. 1 Demo setup and architecture

2. Innovation

This demo will show how a novel software framework based on the 5GT architecture can deploy a mobile network slice in few minutes. Thus, the demo targets the innovations demanded by future mobile networks: slice deployment specialized to vertical requirements, latency-awareness, virtualized mobile network function set-up, flexibility and programmability enabled by SDN and NFV.

Indeed, three main factors are currently shaping future mobile networks. First, the concept of slicing has been recently introduced as a method for allowing several virtual networks to share a single physical network [3]. Furthermore, the envisioned 5G network architecture will be heavily based on virtual network function (VNF) representing “a transition from today's network of entities to a network of (virtual) functions” [4]. Finally, the design, the control, and the management of networks will be driven by the latency and capacity required by emerging 5G services (e.g., eMBB---enhanced Mobile Broadband; mMTC---massive Machine Type Communications; URLLC---Ultra-Reliable and Low Latency Communications) [5] and architectures (e.g., the Next Generation RAN --- NG-RAN) [6].

3. OFC relevance

The demo presents a multifold relevance to OFC 2019. The demo shows advances in network and service deployment in a laboratory environment toward field trials. In particular, it shows a 5G slice provisioning enabled by SDN and NFV.

The demo deals also with virtualized network function, network resource, and service orchestration (related to ETSI MANO framework) that are an emerging trend in the software-defined control for metro and core networks.

Moreover, by featuring the deployment of a 5G slice whose functions are partially virtualised and deployed in different data centers, it shows the capability of the novel developed software modules to orchestrate both services and resources in an inter-data center environment. Therefore, such deployment encompasses both packet-based and optical metro/core networks.

In addition, the demo focuses on the importance of latency aware service allocation. Thus, it contributes to define constraints for the network automation and intelligence algorithms utilized by the service and resource orchestrator (e.g., 5GT-SO) for service instantiation.

Finally, the demo provides software implementations of a number of ETSI specifications on network function virtualization (NFV).

4. Implemented software components and Demo description

For implementing the demo, the following components will be utilized. The open source OAI platform [7] is utilized as mobile network software. OAI provides an implementation of few NG-RAN functional splits (as defined in 3GPP TR 38.801 [6]), where, the evolved NodeB (eNB) functions are decoupled into two new network entities such as Central Unit (CU), where the base-band processing is centralized, and Distributed Unit (DU), where the RF processing is left at the antenna. In the demonstration, Option 7-1 (i.e., intra-PHY split) functional split will be utilized. The OAI core is utilized for implementing the EPC functions. OAI EPC contains the implementation of the following network elements: the Serving Gateway (S-GW), the PDN Gateway (PDN GW), the Mobile Management Entity (MME) and the Home Subscriber Server (HSS). All these OAI core elements can be deployed as individual VNF elements in a virtualized environment or can also be deployed as bundle VNF. In the demonstration, the bundle vEPC VNF is utilized. The novel 5GT-VS prototype is a Java application based on the Spring framework, exposing its functionality through a RESTful HTTP API and a web GUI. The application is disaggregated, with its several components, i.e. slice lifecycle manager, translator, arbitrator and SouthBound (SB) drivers, communicating through Simple Message Queue Protocol (SMQP). The novel 5GT-SO implementations provides the NFVO and VNFM functionality as described in [8], extended with functionality for managing PNF-containing Network Services. To do that, an additional component called Physical Network Function Manager (PNFM) is implemented, which takes care of configuring the PNFs with the necessary parameters through RESTful HTTP messages. The novel 5GT-MTP works as provider of NFV Infrastructure (NFVIaaS) using the Single logical Point of Contact concept introduced in ETSI IFA028 [9]. 5GT-MTP exposes one single interface to the 5GT-SO hiding the multi-VIM and multi-WIM complexity that is orchestrated and managed internally. According to ETSI IFA028, 5GT-MTP interfaces towards both the 5GT-SO and VIM/WIM are based on ETSI IFA005. 5GT-MTP exposes APIs to receive requests from the 5GT-SO and it utilises a REST client to interact by means of RESTful HTTP messages with both the Virtualised Infrastructure Manger (VIM) at the edge and the core data center and the Wide-area

Infrastructure Manager (WIM) controlling the SDN optical network in the Pisa ARNO testbed. The VIM is based on OpenStack (Ocata). The WIM is based on an Open Network Operating System (ONOS) controller [10], properly extended on the Northbound and on the Southbound interfaces to operate within the 5GT architecture. Specifically, on the Northbound interface the WIM is able to receive and handle connectivity requests arriving from the 5GT-MTP, using a REST API. On the Southbound interface, the ONOS-based WIM has been extended to control physical optical devices through NETCONF protocol and YANG models, as defined within the work of the ODTN (Open and Disaggregated Transport Network) project [11]. For instance, the controller is able to establish a point-to-point optical connection between two optical transponders traversing a number of ROADMs.

The tentative deployment of the demo will involve two different scenarios: in the first one, in Fig.1-a, the UEs, one Ettus B210 USPR, the DU PNF (deployed in one mini-PC), the CU PNF (deployed in one mini-PC) are deployed at the OFC premises while the vEPC, Openstack, 5GT-VS, 5GT-SO are deployed in the ARNO testbed in Pisa. The two parts of the testbed (local and remote) are connected through a VPN traversing the public Internet and an SDN disaggregated optical network, including commercial devices, controlled by the WIM, based on one instance of the extended ONOS controller, in the ARNO testbed. The second scenario, in Fig. 1-b, includes the deployment of the vEPC within OpenStack at OFC premises (in addition to what already deployed in the first scenario) and it maintains the orchestration components in Pisa. Thus, in this latter scenario, visitors can access Internet, and consequently the mobile dictionary app server, through the local gateway.

The demo starts by requesting a mobile service through the 5GT-VS GUI. The component translates the service request into a mobile-capable slice, and instantiates a Network Service implementing such a slice through the 5GT-SO. The 5GT-SO then starts the instantiation process by interacting with the 5G-MTP: at first it requests the instantiation of a vEPC VM in OpenStack. While booting, the vEPC VM the MTP creates one end of the VXLAN tunnel [12] and it starts the vEPC component processes (MME, HSS, S/PGW). The successful instantiation of the VM is notified back to the NFVO and the configuration phase starts. First the NFVO VNFM configures the vEPC (in this particular demo, no configuration needs to be applied) then it requests to the PNFM to configure the CU (which is represented in the Network Service as a PNF). The PNFM sends a message to the CU containing the IP of the vEPC, so that the CU can instantiate the other half of the VXLAN tunnel and establish the communication with the vEPC. In the scenario where the slice includes part of the SDN disaggregated optical network (i.e., Fig.1-a) the 5GT-SO interacts with the 5G-MTP also for establishing a lightpath between the VPN gateway and the vEPC. Once the slice is up the visitor will be capable of accessing the mobile dictionary app server either through the remote edge vEPC (Fig.1-a) or through the local edge vEPC (Fig.1-b), experiencing different latencies.

Acknowledgements

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