Demo: Automated Multi-Site E2E Orchestration of Hybrid Network Services Mixing PNF, VNF and CNFs

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***Abstract*—Heterogeneity is one relevant characteristic of next generation mobile networks. This term embraces not only different kind of infrastructure resources or transmission technologies (e.g., networking vs computing, wireless vs optical), but it also applies to different ways of implementing the network functions (NFs) composing the network services (NSs). This allows the definition of hybrid NSs combining different kind of components, such as physical, virtual, and cloud-native NFs. This demonstration shows the enhancements introduced in the 5Growth platform to manage physical NFs, hence increasing the capabilities of this platform to cope with more heterogeneous hybrid NSs in multi-site scenarios. In particular, we show the deployment of an NS constituted by physical, virtual, and cloud-native NFs implementing an end-to-end service covering access, mobile core and application functionalities.**

I. Introduction

Heterogeneity is one of the main pillars over which next-generation mobile networks are built on. Multiple kind of resources (e.g., networking vs computing) and different transmission and virtualization technologies will be combined to automate the deployment of network services (NSs) implementing different vertical use cases in multi-site infrastructures. These NSs, composed by interconnected networks functions (NFs), will be deployed thanks to the development of an appropriate Management and Orchestration (MANO) plane integrating Software Defined Networking (SDN), Network Function Virtualization (NFV), and Network slicing paradigms. These NFs can present physical (PNFs), virtual (VNFs), and cloud-native (CNFs) nature, hence forming hybrid NSs. Although current trends is to move towards CNF-based NS definitions due to its smaller footprint, suitable for edge locations, not all NS components can be implemented using containers or even virtual machines (VMs), which are the basis of VNFs. Actually, although being considered part of legacy systems, PNFs are still needed. For instance, a base station PNF equipped with its own radio unit can be a hardware box whose functionality have not yet gone under virtualization due to difficulties to retain the original PNF performance or it is under prototyping (e.g., enabling ran-slicing capabilities), but they are needed to perform end-to-end (E2E) services. Hence, there is interest in developing MANO architectures able to understand the capabilities of the underlying infrastructure to seamlessly orchestrate hybrid NSs integrating all these different kinds of NFs. The orchestration of such hybrid NSs combining PNF, VNF and CNFs has not been extensively considered in the literature, being OSM, an open source MANO project, one of the limited examples. OSM tackles full hybrid NSs deploying them using multiple NS instances in a very specific infrastructure scenario considering a single NFVI-Point of Presence (NFVI-PoP), where the network connectivity is already pre-established. This work goes beyond such approach and shows, to the best of our knowledge, the first deployment of a single hybrid NS integrating NFs of all different types (i.e., PNF, VNF and CNF) in multi-site scenarios. Due to its different nature, such NFs are deployed in multiple NFVI-PoPs controlled by different infrastructure managers and they are automatically and dynamically interconnected through a configurable SDN transport network. For that, we have enhanced the 5Growth (5Gr) MANO platform [1] to allow the onboarding, instantiation, and termination of PNFs being part of hybrid NS definitions including also VNFs and CNFs.

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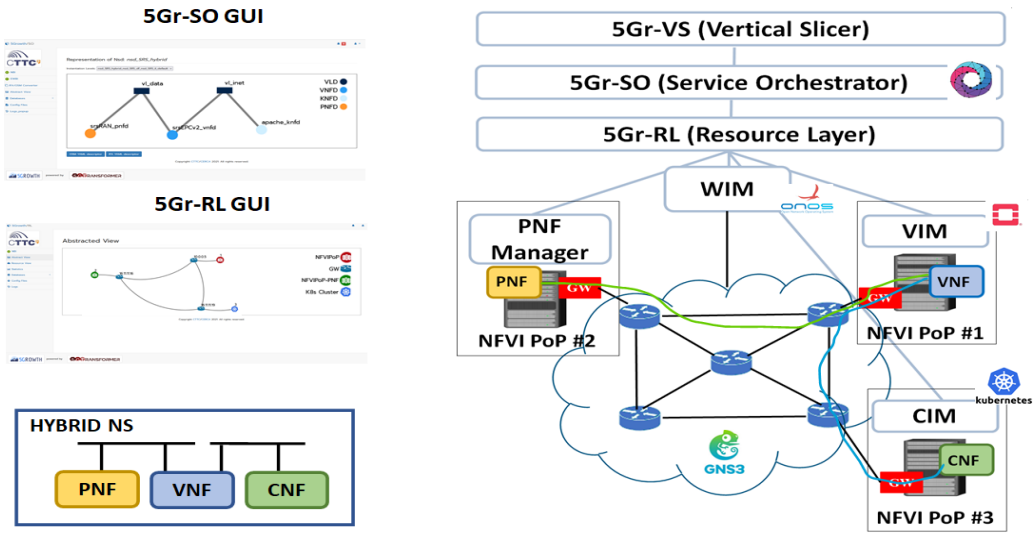

Fig. 1. Experimental scenario under demonstration

II. System Architecture

Fig.1 presents the experimental setup deployed in the CTTC 5G Lab facilities. In this setup, the 5Gr MANO platform [1] deploys the different NFs included in the NS definition according to their requirements among the different NFVI-PoPs available at the underlying infrastructure. In total, the experimental setup under demonstration consists of three different NFVI-PoPs, interconnected by the depicted packet-switched transport network emulated with GNS3 [2]. These packet-switches are controlled by an instance of the ONOS SDN controller acting as a Wide Area Infrastructure Manager (WIM). In this setup, each NFVI-PoP presents different capabilities. More specifically, NFVI-PoP#1 is managed by an Openstack-based Virtual Infrastructure Manager (VIM) to instantiate VNFs in the form of VMs, NFVI-PoP#2 is managed by the PNF Manager we develop to configure resources in the host where PNFs run, and NFVI-PoP#3 is able to host CNFs in the form of containers thanks to its associated Kubernetes-based Container Infrastructure Manager (CIM).

In this demonstration, we show the introduced enhancements in our baseline open-source implementation of the Resource Layer (5Gr-RL)[1] and the Service Orchestrator (5Gr-SO)[2] modules of the 5Gr MANO platform to allow the lifecycle management of PNFs within the definition of hybrid NSs. For that, in addition to changes in the orchestration workflows of the mentioned modules, we required (i) the definition of a PNF abstraction model allowing the distinction of generic capabilities common to all kind of PNFs and additional configurable properties tailored to the type of PNF (e.g., a firewall or a base station) and (ii) the development of the corresponding PNF Manager able to present this description to the 5Gr-RL, the module in the 5Gr architecture handling the resource abstraction and the execution of resource allocation operations. At the 5Gr-SO, the orchestration of PNFs within a NS descriptor is based on the decoupling between this kind of NF and the rest (i.e., VNFs and CNFs) of NFs included in the NS description. During instantiation, CNFs and VNFs are instantiated first with the help of the Core MANO wrapper sub-module of the 5Gr-SO by interacting with the associated Core MANO platform, in this case OSM Release 10. Then, the resource orchestration engine (ROE) sub-module of the 5Gr-SO interacts with the 5Gr-RL to manage the creation of the required virtual interfaces at the selected PNF-capable NFVI-PoP to match the characteristics of the virtual links (e.g., CIDR and VLAN identifier) created for the communications between NFs. The policy used in the 5Gr-RL to create such interfaces ensures isolation between other virtual links of the same NS and other NS instances. The PNF Manager executes the creation of the virtual interface for the PNF and it also triggers the procedure to properly launch the *physical process* of the PNF according to the configurable properties sent by the 5Gr-RL as part of the virtual interface creation request. Finally, the ROE

[1]mobilE tranport pLatform for multi-tEChnology neTwoRk infrAstructure (ELECTRA). Available at:https://gitlab.cttc.es/cttc-cnd/ELECTRA

[2]Multi-nfvo fEderated ServiCe orchestrAtion pLatform (MESCAL). Available at: https://gitlab.cttc.es/cttc-cnd/MESCAL

has been enhanced with the required logic to determine the needed connectivities among NFVI-PoPs based on the relations between NFs described in the NS, its distribution, and its nature.

III. Demonstration

This demonstration shows the capabilities of the 5Gr platform to deploy full hybrid NSs, as the one depicted at the bottom left part of Fig. 1. This NS consists of three NFs: a PNF modelling an enodeB entity, a VNF implementing a mobile network core entity, and a CNF acting as a web server. The PNF and the VNF are built based on the srsRAN software [3], while the CNF is an Apache HTTP server available as a Helm chart in [4]. After onboarding the associated descriptors in the 5Gr platform, the main steps of the demonstration are:

1) The 5Gr-SO receives the request to deploy the described hybrid NS.

2) At the 5Gr-SO, the ROE module parses the associated NS descriptor classifying the different involved NFs. This information, together with the status and capabilities of available NFVI-PoPs is needed to determine the appropriate placement at the underlying NFVI, as depicted in Fig.1.

3) Based on the placement and the component NFs, the ROE interacts first with the Core MANO wrapper to deal with the deployment of VNFs and CNFs, as explained in [5]. Then, the ROE orchestrates with the 5Gr-RL the creation of a virtual interface to support the PNF resource in an isolated manner according to the instantiation parameters of the VNFs and CNFs. The 5Gr-RL interacts with the associated PNF Manager, which finally configures the PNF resources at the corresponding PoP (i.e., creation of a virtual interface and launching of the enodeB process).

4) After validating the deployment of NFs, the ROE determines the pairs of required connections (e.g., CNF-VNF, VNF-PNF) and composes a query to the 5Gr-RL. The 5Gr-RL interacts with the WIM to physically establish such connections between required NFVI-PoPs (green and blue lines in Fig. 1) through the depicted SDN-controlled transport network.

5) Once the connections are established, the deployed enodeB PNF attaches automatically to the mobile network core VNF. Then, we emulate a user equipment (UE) at the PNF side and we check that the UE can communicate with the deployed CNF through the mobile network VNF.

During the demonstration, all steps are shown through the GUIs of the different building blocks of the 5Gr platform (e.g., NS description, NS deployment information status, established network paths and PNF resources), and of the different infrastructure managers (e.g., Openstack, Kubernetes), as depicted in Fig. 1. A demonstration video is available online[3].

References

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