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NFV Service Federation: enabling Multi-Provider eHealth Emergency Services

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***Abstract*—One of the key challenges in developing 5G/6G is to offer improved vertical service support providing enlarged service flexibility, coverage and connectivity while enhancing the business relations among different stakeholders. To address this challenge, Network Service Federation (NSF) is a required feature to enable the deployment and the management of vertical services that may span multiple provider domains owned by different operators and/or service providers. In this demonstration, we show our proposed NSF solution to dynamically deploy an eHealth network service across multiple provider domains at different locations.**

I. Introduction

The next generation of mobile networks is aimed to support diverse vertical industries over a shared infrastructure. Verticals may set up a business relationship with a single service provider and expect all network service-related deployment requirements to be covered by its service provider in a transparent way. This may entail deploying parts of network services (NSs) in other administrative domains (ADs) owned by other providers due to business (e.g., cost) or technical reasons (e.g., service availability and coverage, lack of resources). In general, these NSs may consist of multiple nested NSs, each composed of multiple virtual network functions (VNFs), to form a composite NS in the context of ETSI NFV [1]. To address this challenge, Network Service Federation (NSF) is a key feature to enable the deployment of a composite NS (consisting of multiple nested NSs) across different ADs and stitch them together to provide the E2E network service. This feature provides enlarged service coverage and connectivity, seamless service continuity, and flexibility to providers (and, by extension, to their vertical customers), also opening the door to new business models between involved players.

So far, most related work is focused on optimization algorithms on how to decompose NSs and evaluated with simulations, but not much work has been done on the implementation of the NSF operation for deployment of a composite NS across different ADs including multiple NFVI-PoPs in a real system. In light of this, the 5G-TRANSFORMER (5GT) project [2] developed an NSF solution including the design of a functional workflow and the development of related entities and interfaces in an SDN/NFV-based 5G mobile transport platform, which is used in follow-up projects as 5Growth [3].

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This demonstration showcases the developed 5GT NSF solution that we apply to satisfy the requirements of an *eHealth* vertical use case. This use case requires the deployment of a composite NS at different locations in two different ADs. First, the monitoring back-end service (Monitoring NS) is deployed in the cloud of service provider 1 (AD1) and, second, an Emergency Service, triggered by a detected anomaly (e.g., upon losing vital signs of the monitored patient), needs to be dynamically deployed at the edge in the premises of service provider 2 (AD2), which is close to the patient. In particular, we will demonstrate the developed NSF procedure to (*i*) deploy a federated composite network service in different ADs for the defined *eHealth* use case, and (*ii*) dynamic initiation (and stitching with a previously running NFV NS) of the emergency service at NS run-time. In addition to this, other relevant features of the 5GT platform are included in this demo: (*i*) interworking of 5GT service orchestrators (5GT-SO) embedding two different open source Management and Orchestration (MANO) platforms, and (*ii*) deployment of NSs in multiple Points of Presence (PoPs). To the best of our knowledge, this is the first operational demonstration of NSF to deploy a vertical service consisting of a composite NS across two different ADs at different sites.

II. Testbed Architecture

Fig. 1 presents the setup under demonstration, where each AD (e.g., representing different service providers) runs its own 5GT platform (5GT-VS, 5GT-SO, 5GT-MTP and 5GT-MON). This setup is split between two sites: the CTTC 5G Lab (Castelldefels, Spain) and the 5TONIC Lab (Madrid, Spain). The 5GT-VS receives vertical service requests, which are mapped to network service (NS) requests for the 5GT-SO. The 5GT-SO manages the E2E orchestration of the NS based on the available resources (compute, storage and network) exposed by the underlying 5GT-MTP. NSF is performed when the 5GT-SO requires to instantiate part of a composite NS in another AD/s. In that case, the 5GT-SO communicates with peering 5GT-SO/s to coordinate the composite NS instantiation process through the *So-So* interface, which is traversing over a VPN tunnel in this setup. Another demonstrated feature of the 5GT-SO is the integration on its workflows of multiple MANO platforms, as explained in [4]. Specifically, the 5GT-SO of AD1 embeds Open Source MANO (OSM) Release 6 and that of AD2, Cloudify v19.01.24 community.

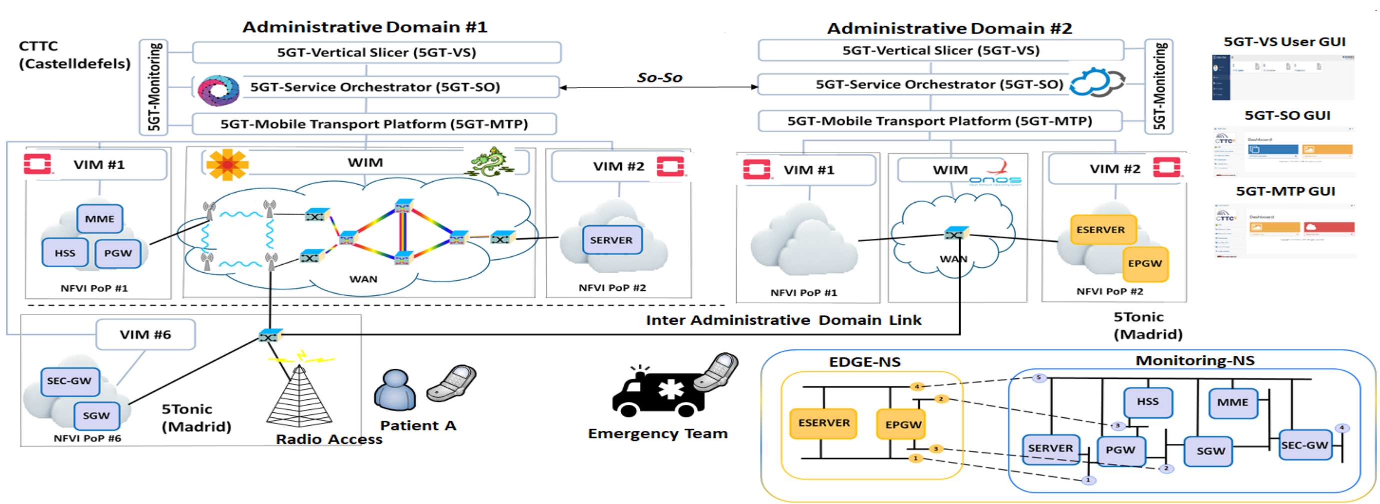

Fig. 1. Multi-administrative domain multi-technology experimental setup under demonstration

At the infrastructure level, the 5GT-MTP of AD1 coordinates three different NFVI-PoPs. Each of these NFVI-PoPs is managed by its own Virtual Infrastructure Manager (VIM) based on an OpenStack Devstack Queens Release. These NFVI-PoPs are connected through a multi-technology transport network combining a wireless mmWave/WiFi (IEEE 802.11ad/802.11ac) mesh network and a multi-layer optical network (incl. packet and optical switching). The 5GT-MTP of AD1 interacts with a parent SDN controller, following the IETF Application-Based Network Operation (ABNO) architecture, acting as Wide Area Network Infrastructure Manager (WIM). In turn, this WIM controls a hierarchy of dedicated technology-specific SDN controllers (based on the OpenDayLight and Ryu open source SDN controllers) [5]. The 5GT-MTP of AD2 manages two different NFVI-PoPs, whose VIMs are based on OpenStack Devstack Queens Release, and the WIM is based on ONOS. Finally, both ADs are connected at the data plane level by the Inter-Administrative Domain Link depicted in Fig. 1, which is implemented with a VPN tunnel.

III. Demonstration

We demonstrate the deployment of a composite NS in two different ADs for the defined eHealth use case exploiting the NSF capabilities of the 5GT platform. This composite NS has two nested NSs. First, the Monitoring NS is the back-end service performing real-time monitoring of patients' location and vital signs (e.g., heart rate). It is represented by the blue VNFs in Fig.1. In case of emergency, the Edge NS is deployed close to the patients' location in order to assist emergency teams with for instance, AR/VR services, or to provide faster access to patient's health records, thus improving on-site medical care. In Fig. 1, it is represented by the two yellow VNFs. The main steps of the demo are:

1) The Monitoring NS is deployed in AD1 as explained in [4]. The VNFs are deployed over PoP#1 (MME, PGW & HSS), PoP#2 (SERVER) and PoP#6 (SGW & SEC-GW). Once the service is deployed, the vital signs data flow between SERVER and patient A UE can traverse PGW, SGW, SEC-GW and Radio access, which is a hardware element of PoP#6.

2) An emergency event is emulated (e.g., loss of vital sign from monitored patient). Then, the SERVER VNF triggers the deployment of the composite NS at the 5GT-VS of AD1, which includes the Edge NS.

3) When processing the composite NS request, the 5GT-SO of AD1 decides to deploy the remaining nested Edge NS at AD2 due to NS availability and closeness to patient's location to satisfy the low-latency requirement imposed by the emergency situation. Then, it starts the NSF procedure to request the deployment of the Edge NS to the 5GT-SO of the AD2 through the *So-So* interface. The Edge NS will be stitched with the Monitoring NS at the AD1 to form a federated NS.

4) The Edge NS is deployed at AD2 and the required links between the different nested NSs are established through the Inter Administrative Domain Link.

5) Upon successful Edge NS deployment, the data flows from the emergency team's UE to the ESERVER through Radio access, SGW and EPGW. This enables fastest and improved medical care by on-site emergency teams thanks to the dynamic deployment of NSs at the edge.

During the demonstration, all steps are shown through the GUIs of the different building blocks of the 5GT platform at the involved ADs (e.g., visual NFV NS deployment information, VNF placement, selected network paths), as depicted in Fig 1. A demonstration video is available online[1].

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