Multi-Administrative Domain Service Onboarding in a ZSM-Based Orchestration Architecture

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***Abstract*—The automation and flexibility introduced in the management and orchestration of B5G/6G mobile networks are allowing the creation of innovative vertical use cases considering the coordination of multiple provider domains owned by different operators and/or service providers. The first step to enable this automation is the onboarding of network service artefacts prior to enabling its instantiation in such challenging scenarios. This demonstration focuses on the automatic onboarding operation in a multi-administrative domain scenario. We propose a cloud-native solution deployed at each administrative domain made of an artefact registry management system coupled with an Integration Fabric element following ETSI ZSM guidelines. These elements synchronize between them autonomously and with the associated ETSI NFV management and orchestration stacks ensuring a consistent catalogue of vertical services at the different administrative domains.**

***Index Terms*—Multi-administrative domain, Service Onboarding, ZSM, NFV, Cloud-Native, Management and Orchestration**

I. Introduction

Next generation of mobile networks is pushing for the automation of its management and orchestration (MANO) procedures. Therefore, the architecture can adapt to the requirements and needs of dynamically deployed cloud-native networks services (NSs) consisting of virtualised network functions (VNFs) to implement vertical use cases (UCs). This flexibility can be exploited towards the development of more complex and innovative UCs enhancing the business relations among different stakeholders, e.g., network operators. Among such scenarios, we envisage those requiring the ability to seamlessly coordinate the lifecycle management (LCM) of NSs across independent administrative domains (ADs).

One of such LCM operations is the onboarding of the different artefacts required by a NS. In this work, the required artefacts for cloud-native NSs are docker container images, Helm chart definitions, and NS and VNF descriptor packages. The onboarding operation is an essential pre-condition to perform the instantiation of an NS and its artefacts need to be present in each of the MANO stack belonging to different ADs. However, this onboarding operation is not covered in detail in the limited set of practical related works considering multi-AD scenarios. In [1], [2], [3], the authors considered a multi-AD scenario based on ETSI NFV architecture where the onboarding of NS artefacts is done following an offline and manual procedure at each AD. Recent approaches [4] are starting to demonstrate novel trends in orchestration operations like those proposed by ETSI ZSM working groups [5]. However, the work in [4] focuses on the instantiation of the different segments of a 5G network in a single AD, which is the scope of ETSI ZSM specifications. Furthermore, the work in [4] is not dealing with vertical application NSs and, like as with the previous references, it does not cover the procedures to achieve an automated onboarding of required artefacts.

The demonstration described in this work presents the cloud-native solution proposed in the 5G-ROUTES project [6] to perform the automated onboarding of vertical application NSs in the context of Connected and Automated Mobility (CAM) UCs targeting cross-border scenarios. In such scenarios, multiple ADs owned by different operators need to have available the NS artefacts to be able to offer the seamless relocation of CAM NSs triggered by vehicle's positions. To handle this automated onboarding across ADs, the proposed solution combines an artefact registry management system, named CAM Repository, coupled with the ETSI ZSM architectural element called Integration Fabric (IF) available at each AD. The implemented IF in this work goes beyond the scope of ETSI ZSM specification by offering cross-administrative domain communications. Thus, the CAM Repository instances available at each AD can synchronize and onboard the required artefacts needed at the ETSI NFV MANO stacks to enable the NS instantiation in each AD. To the best of our knowledge, this is the first practical system combining ETSI NFV and ETSI ZSM guidelines offering an automated procedure to onboard the NS artefacts of vertical applications in a multi-AD scenario.

II. System Architecture

Fig. 1 presents the experimental setup used in this demonstration. This setup is distributed between two sites: eBOS premises (Lakatamia, Cyprus) and the CTTC 5G Lab (Castelldefels, Spain). The Tenant Web Portal (TWP) runs in the first site. It is a platform to trigger the LCM operations (e.g., onboarding, instantiation, termination) of the available CAM UCs, as well as a tool designed to analyse, benchmark, and visualize the data of key performance indicators obtained from the execution of UCs. The TWP is connected to the

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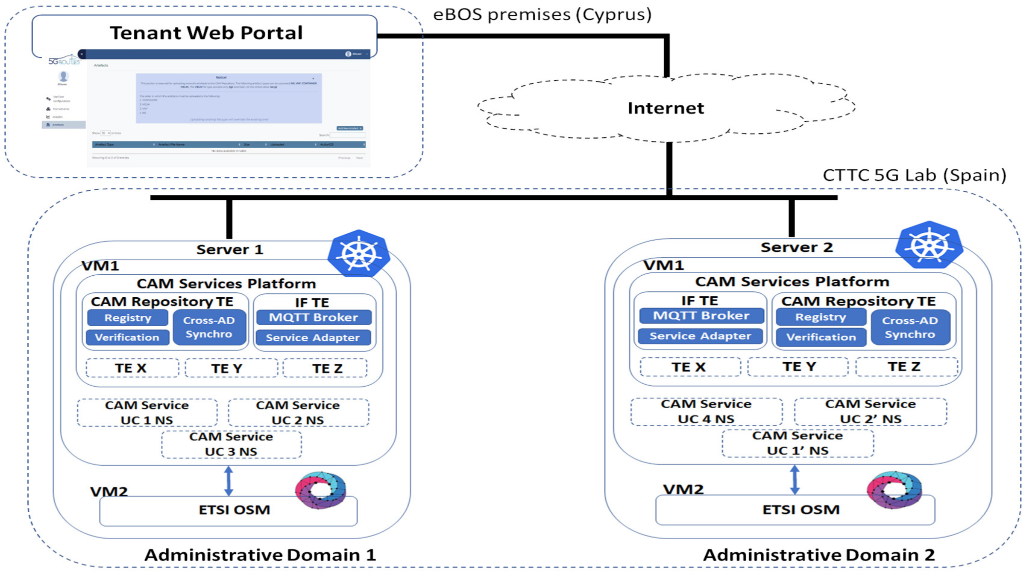

Fig. 1. Multi-administrative domain experimental setup under demonstration. The CAM Repository and the Integration Fabric enablers of each CAM Services Platform instance in each administrative domain communicate among them to perform the automated onboarding of NS artefacts

CTTC 5G Lab via a virtual private network connection. There, two different servers implement the different ADs. Each server hosts two virtual machines containing an instance of an all-in-one Kubernetes cluster acting as a Point-of-Presence and an instance of Open Source MANO (OSM) Release 13 acting as an ETSI NFV MANO stack. OSM is used not only to deploy the CAM services but also to deploy the cloud-native components of the CAM Services platform (CAM SP) defined in the 5G-ROUTES project. It is worth mentioning that the TWP does not have direct access to the ETSI NFV MANO stacks, instead it is a centralized entry-point for all the available CAM SP instances. The CAM SP is built as a combination of different technological enablers (TEs) which are connected to the mobile network infrastructure. An instance of the CAM SP is instantiated in each AD, and in conjunction with the TWP, are designed to automate the orchestration of CAM Services and to help them during run-time to enhance its functionality in cross-border scenarios involving multiple ADs.

In particular, in this demonstration, we focus on the two TEs of the CAM SP dealing with the onboarding and provisioning of the required artefacts to be able to automate the deployment of CAM services as cloud-native NSs in the available ADs. Namely, they are the IF and the CAM Repository enablers.

The IF, described in [7], follows ETSI ZSM architectural guidelines, going beyond its scope to offer multi-AD exchange of messages with other IF instances. The IF follows a microservice architecture consisting of a message passing broker based on Message Queuing Telemetry Transport (MQTT) protocol and the Service Adapter (SA) module. The MQTT broker enables asynchronous messaging following the publish/subscribe pattern. The defined topic and message structure allows the exchange of orchestration operations across multiple associated brokers in the different ADs. The SA module subscribes to the corresponding topics of the broker available in the administrative domain to receive orchestration operations and execute them by interacting with OSM. Then, the SA publishes the associated operation result in the corresponding response topic.

The CAM Repository is the artefact registry management system handling and storing the NS artefacts required to perform the LCM of cloud-native CAM services. The CAM Repository follows a microservice architecture performing multiple functions: i) verification of artefact package integrity and syntax verification of descriptors versus the corresponding standard information models (e.g., ETSI SOL006); ii) internal registry/repository to host and build the unified catalogue for the uploaded container images, Helm charts, and the OSM descriptor packages; iii) provisioning of VNF and NS descriptors to OSM; and iv) cross-domain synchronization among associated CAM Repository instances in different ADs through the exchange of messages using the IF.

Functions i) and ii) allows a faster, more compact and secure procedure to pull container images and Helm charts definitions of CAM NSs rather than pulling them from repositories hosted in the internet. Additionally, they ensure self-sufficiency and independence of the ADs. Functions iii) and iv) allows automating the availability of NS artefacts in multiple ADs in a single action, which is the main outcome of this demonstration. Thanks to this, other TEs of the CAM SP can perform advanced life-cycle operations, such as service relocation operation in the presented multi-AD/cross-border scenarios.

III. Proof-of-Concept

Out of the features offered by the CAM SP, this demonstration showcases the interaction among the TWP, the mentioned TEs and OSM instances available at each AD. This interaction allows the automated synchronisation of CAM service artefacts between different ADs. Fig. 2 presents the different

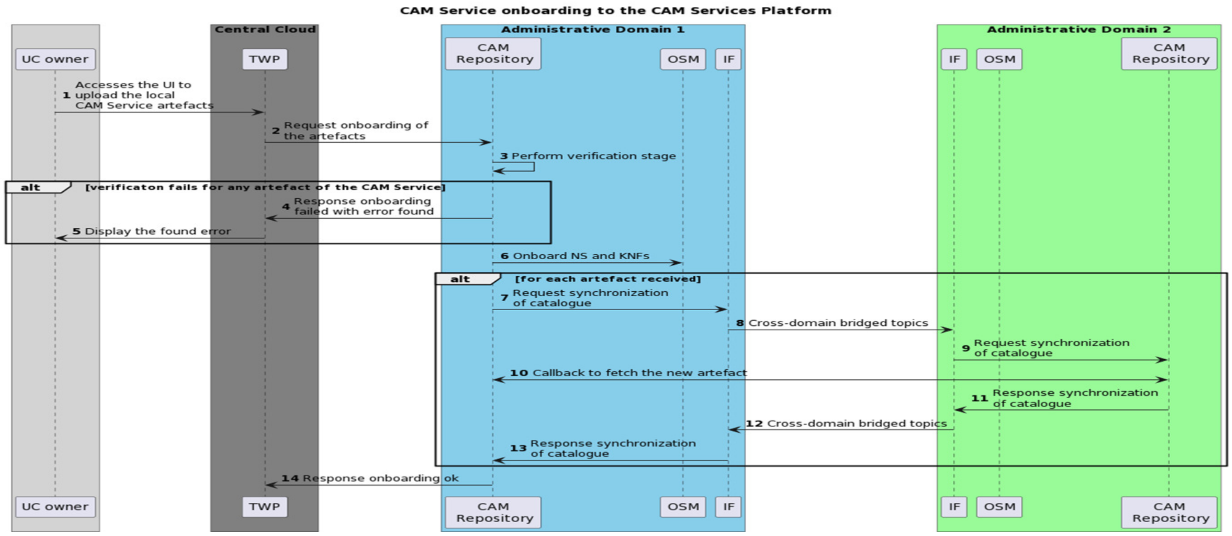

Fig. 2. CAM Service onboarding workflow in the CAM Services Platform

steps of this process, which can be summarised as follows:

1) The UC owner logs in the TWP and accesses the *Artefacts* panel. In this panel, the UC owner will start uploading the files corresponding to the UC artefacts. The order in which the artefacts are uploaded is the following: i) compressed docker container images corresponding to the atomic elements of the VNF/s, ii) Helm chart definitions describing the relation between the containers of a VNF for a Kubernetes deployment, iii) the OSM descriptor packages for each involved VNF and iv) the OSM descriptor package with the NS descriptor.

2) For each artefact, the TWP contacts the configured CAM Repository instance to upload each of the mentioned artefacts. This request specifies the need of artefact synchronization.

3) The CAM Repository performs a verification stage for each received artefact prior to storing it. This storing operation introduces a security layer because it enables that artefacts are not directly pulled from the internet. If the artefact is an OSM VNF or NS descriptor package, the CAM Repository contacts the associated OSM instance to onboard the artefact.

4) After verifying the package, the CAM Repository triggers a catalogue synchronisation request with all CAM Repository instances connected to the cross-AD topic available in the IF. The message exchanged between IF instances informs of the type of artefact, and the callback URL to retrieve it.

5) The CAM Repository in the second AD reacts to this message, retrieves the corresponding artefact from the callback URL and processes it accordingly (i.e., step 3).

6) The CAM Repository in the second AD validates the synchronisation request to the *"first"* CAM repository and finally, the TWP receives confirmation of the correct package onboarding at all ADs.

7) The TWP can list the new NS as *"instantiable"* once all the artefacts corresponding to an NS have been correctly processed and synchronised among the different associated CAM Repository instances at each AD.

A. *Demonstration Requirements*

This demonstration is executed remotely based on the environment depicted in Fig. 1. Internet access is required to log in to the graphical user interface (GUI) of the TWP and OSM. The progress of the involved operations is visualised in the GUIs of the TWP and OSM and in the logs of the IF.

IV. Conclusion

This demonstration shows the approach proposed in the 5G-ROUTES project for the automated onboarding and provisioning of the artefacts required for the deployment of cloud-native CAM NSs in a multi-AD environment to address cross-border scenarios. This solution is triggered by a central element, the TWP, and relies on the coordination of OSM MANO stacks with the enablers of the CAM SP in each AD, namely, the CAM Repository and the IF. The former enabler is an artefact registry that uses the latter to perform the synchronization among ADs. This approach allows to cover the onboarding operation in multiple ADs with a single action and introduce a layer of security in CAM network service deployments because artefacts (i.e., docker images, Helm chart definitions) are verified and not directly pulled from the internet.

References

[1] N. Uniyal et al., "5GUK Exchange: Towards sustainable end-to-end multi-domain orchestration of softwarized 5G networks" in Elsevier Computer Networks, Sept. 2020.

[2] J. Baranda et al., "Realising the Network Service Federation vision", in IEEE Vehicular Technology Magazine, March 2020.

[3] J.S. Choi, S. J. Chun, S. Lee, "Hierarchical Distributed Overarching Architecture of Decoupled Federation and Orchestration Frameworks for Multidomain NFV MANOs", in IEEE Comm. Mag. Sept 2022.

[4] H. Baba, et al., "End-to-end 5G network slice resource management and orchestration architecture", in Procs. of IEEE Netsoft 2022, June 2022.

[5] ETSI, "ETSI GS ZSM 002, v1.1.1: Zero-touch network and Service Management (ZSM); Reference Architecture", Aug 2019.

[6] EU 5G-ROUTES Project: 5th Generation connected and automated mobility cross-border EU trials, https://https://www.5g-routes.eu/ [Accessed: May 2023].

[7] J. Baranda, L. Vettori, B. Bakhshi, J. Mangues-Bafalluy, "ZSM-based Orchestration for Inter-Administrative Domain Cross-Border Vehicular Scenarios", in Procs. of IEEE SECON 2022, Sept. 2022.