Unification architecture of cross-site 5G testbed resources for PPDR verticals

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***Abstract*—A significant amount of 5G experimentation facilities and testbeds have been proposed in the scientific literature over the past five years, each characterized by its unique setup of resources and control frameworks. The 5G-EPICENTRE project focuses on the provision of a truly open, multi-site 5G experimentation facility specifically tailored to the needs of public safety solution providers, which will leverage on, and extend the capabilities of 5G testbeds developed in, or resulting out of the 5G-PPP Projects. This paper will focus on the provision of an innovative, open and interoperable platform of 5G- EPICENTRE that aims to act as both a testbed, as well as a federation of existing 5G testbeds. Through an augmentation of experimentation facilities, 5G-EPICENTRE will define the necessary information models to interconnect testbeds partaking in the federation through simplified APIs and will facilitate the orchestration of their resources to optimally service the needs and requirements of PPDR-centric applications.**

I. Introduction

Public Protection and Disaster Relief (PPDR) envelops a variety of organizations and agencies, all with a common goal of protecting the general public and the environment, particularly in cases of natural or man-made disasters [1]. PPDR operations include not only the personnel deployed on the field to administer first response to incidents, but also dispatchers and operators stationed in emergency control centers (ECC). Such facilities are equipped with several information and communications technology (ICT) systems designed for efficient communication, coordination and control between ECCs and deployed field operators. Particularly in response to disastrous events (such as earthquakes, floods, etc.), effective cross-discipline PPDR communications are crucial for PPDR agents to carry out their duties and save as many lives as possible. Given the diverse functions in which these PPDR agencies engage, along with the various environments and domains (e.g., the urban or rural area, critical facilities, etc.) in which these disciplines operate, equipment characteristics and communication needs and requirements may vary significantly. Hence, PPDR software solution providers required to conduct rigorous experimentation before their entry into the highly competitive public safety ICT market, are tasked with identifying an optimal experimentation facility. Finding a testbed that best suits their needs and application requirements can become a significantly time-consuming affair, given the many different options available.

The 5G-EPICENTRE project represents a convergence of key enabling technologies that are essential to lowering the entry barrier of the emergency and disaster management market in the foreseeable future [2]. This will be achieved by allowing newcomers and smaller players keen on penetrating the market to rapidly deploy and extensively experiment on-demand with new solutions under various network conditions, thus gaining the opportunity to improve their offerings in a timely manner and address a wider range of public safety organizations and their requirements. Furthermore, 5G-EPICENTRE aims to deliver solutions that are based on Cloud-Native microservice- oriented architectures, thus gaining a significant competitive advantage through its support of interoperability between heterogeneous experimentation components via lightweight virtualization technologies (i.e., software containers) and common orchestration tooling.

In this paper we present a services-based architecture approach for 5G-EPICENTRE to achieve the aforementioned goals, aiming at accommodating a microservice-based model through the decomposition of Virtual Network Functions (VNFs) into Containerized, or Cloud-native Network Functions (CNFs), that can be deployed on a shared Cloud infrastructure, and that are compatible with modern-era orchestration tools, like Kubernetes.

II. Experimentation Facility framework

The vision of this paper will result from the development of functional components of an E2E 5G experimentation facility framework, whose conceptual architecture is shown in Figure 1. This model accommodates a segmentation of the envisioned architecture on a vertical axis, adopting a layered design that allows facilitating the development of the various proposed solutions and functional blocks. The main technological components comprising this framework are described in the following paragraphs. Each Layer will implement all necessary security measures to deal with the larger attack surface resulting from the shift toward edge VNF containerization.

A. Front-end Layer

On the 'Front-end' Layer, the 5G-EPICENTRE facility framework will host functional components related to facilitating the interaction between the platform and targeted end-users, i.e., experimenters and network function developers. Its aim is to effectively address how these actors can utilize the front-end of the platform to build up and experiment with their solutions. Hence, this layer includes a portal, a web-based user interface where actors can define the experiment environment, migrate their applications, specify what they will need in terms of network resources (e.g., data, storage, bandwidth, etc.), and receive insights on what each of the federated testbeds can deliver. It is comprised of the Experiment Planning Interface (EPI) and Insight Tool.

EPI will be able to create and run their experiments leveraging the 5G EPICENTRE infrastructure. It also provides: i) services for easily creating new experiments and choosing when and where to run them (Experiment Composer); ii) user authentication and management; iii) an AppStore-like browsing experience for the VNFs and

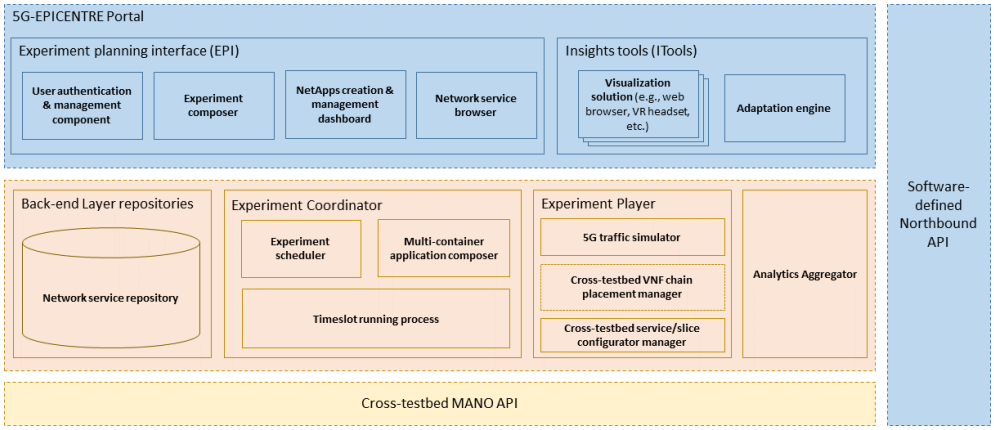

Fig. 1 5G-EPICENTRE experimentation facility framework. Blue components correspond to 'Front-end Layer' elements. Orange components correspond to 'Back-end Layer' elements. Yellow components finally correspond to the 'Federation Layer'.

NetApps hosted on the platform's open repositories; and iv) a graphical NFV prototyping & composition platform (NetApps' creation & management dashboard) supporting the definition of novel NetApps using the available VNFs and orchestration of the experimental environment using the underlying testbed resources.

The Insights Tool, an analytics visualization dashboard to determine the success of a range of network services, providing both beyond-desktop visualization features along with an adaptation rule-based engine for meaningfully personalizing the visual output with a dual emphasis on improving both the visualization process and overall system usability.

B. Back-end Layer

The 'Back-end' Layer incorporates several key functional components of the platform, implemented as a single entry point into the orchestration, with each testbed platform being treated as a point-of-presence. This layer defines the synergies that these components should implement. It further indicates the automated infrastructure management, strategic placement of NetApp chain nodes over the Cloud and edge infrastructure resources, etc. [2]. The base components comprising this layer include:

- The **Network service repository** of NetApps and micro-VNFs and CNFs, together with their northbound interface towards the catalogue browser and southbound interface towards the Cloud-Native VNF Manager constitutes a safety storage for the services.
- The **Experiment Coordinator** coordinates the life- cycle of experiments, ensuring that the required testbed(s) resources are available, and that the configuration to be sent to the orchestrator in the infrastructure is generated.
- The **Experiment Player**, which effectively runs the entire experiment and manages the entire life-cycle of the users' applications. At its core lies a cross-testbed service & slice configurator manager, which manages the orchestration of the necessary resources to optimize the NFV infrastructure for each experiment and handles all network service events. A cross-testbed VNF chain placement manager efficiently manage and monitor optimal placement of NetApp chain nodes for experiments spanning multiple testbeds, while a 5G traffic simulator handles the creation of artificial network traffic to simulate different 5G network conditions.
- An **Analytics Aggregator** aggregates the analytics data generated from the different testbeds to the front-end layer, storing the data to make them available to the Insights Tool to make them available for visualization.

C. Federation Layer

The 'Federation' Layer handles cross-testbed orchestration of network services and resources to ensure an optimal experiment environment. It implements a cross-testbed MANO API, allowing access to the facilities federated by wrapping different aspects of each individual testbed API under a unified information model. This component will define and develop a set of common and standardized interfaces that will intelligently combine the underlying testbed hardware and software components to enable the creation of new, virtual components that provide enhanced capabilities. Key objectives of these interfaces are: i) to allow testbeds to federate without losing control of their individual resources; ii) enable the calibration of individual testbed components from a singular control point; iii) allow experimenters to combine the available resources to achieve different experimentation conditions of varying scale and diversity; and iv) ensure these configurations are easily repeatable by supporting reproducible experimentation conditions.

III. CONCLUSION

This paper presented the integration of tools for cross-site network slice management, automated service function control and experiment life-cycle management, all supported through a 5G experimentation facility framework acting as a single point of control. As a testbed federator, 5G-EPICENTRE will pursue interoperability between each of its underlying testbed's diverse, multi-vendor 5G network hardware, to harmonize and align technologies and standards native to each testbed facility. Toward this end, specifically, NetApp developer interfaces for interoperability will be employed in cross-testbed service orchestration, ensuring an additional layer of interoperability is provided.

REFERENCES

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