Showcasing 5G SA Experimentation Capabilities for Vertical Industries

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***Abstract*—The paper demonstrates the VITAL-5G platform capabilities to improve the adoption and effectiveness of 5G and beyond solutions within the Transport & Logistic domain by bridging the knowledge gap between industry stakeholders, network experts, and service developers. Therefore, in this paper, we present four distinct capabilities the VITAL-5G platform offers i) Facilitating deployment of vertical service in the 5G network, ii) Real-time monitoring of network and service performance and iii) Advanced failure diagnostics. IV) Utilization of 5G slices. To enhance the adoption and effectiveness of 5G and beyond solutions within the T&L domain, we showcase how the VITAL-5G platform hides the operational complexity from the experimenters, allowing them to express their network, application, and hardware requirements in a human-readable format, while in turn deploying complex services on the 5G SA infrastructure.**

***Index Terms*—5G SA, Edge, EdgeApp, VITAL-5G platform, VITAL-5G testbed**

I. VITAL-5G EXPERIMENTATION CAPABILITIES FOR VERTICAL INDUSTRIES

The VITAL-5G platform provides an open experimentation system tailored to vertical industries, simplifying the exploration of 5G Standalone (SA) capabilities for SMEs and researchers who are trying to solve operational inefficiency in Transport & Logistics (T&L) sector. The VITAL-5G platform offers a wide range of capabilities such as i) Facilitating deployment of vertical service in the 5G network, ii) Real-time monitoring of network and service performance, III) Advanced service and network failure diagnostics and IV) Enhanced network performance by utilizing network slicing. To enhance the adoption of 5G and beyond solutions within the T&L domain, the VITAL-5G platform is bridging the knowledge gap among industry stakeholders, network experts, and application developers through the utilization of edge applications (Edge Network Applications (EdgeApps)). The VITAL-5G platform is designed for testing and validating vertical services composed out of EdgeApps on 5G SA and beyond networks, designed to improve the efficiency of processes in vertical industries, such as the maritime vertical industries e.g., port operations for assisted and automated navigation [1,2].

A. VITAL-5G Platform Components

To facilitate the experimentation process on the 5G SA network infrastructure, the VITAL-5G platform comprises eleven software components divided under the three platform layers i.e., the Management Backend systems, the VITAL-5G Portal and the Open Online EdgeApps Repository. The VITAL-5G platform uses a 5G orchestration system, compatible with the European Telecommunications Standards Institute (ETSI) Network Function Virtualization (NFV) standard, to deploy advanced 5G EdgeApps on dedicated VITAL-5G testbeds [3]. More information on the VITAL-5G platform components can be found in the VITAL-5G deliverable 2.4 [4].

B. Vertical Services

The VITAL-5G platform can address a wide variety of vertical services across many industry verticals. A vertical service is simply a composition of EdgeApps that work together to solve a complex industrial process. An example of a vertical service is Assisted Vessel Navigation from the Antwerp VITAL-5G use case, where a group of EdgeApps work together to reduce fuel consumption and dwell times while navigating vessels across busy waterways. More details about the use case and subsequent vertical services can be found in D2.4 [4].

C. VITAL-5G tesbeds

Via southbound interface, the VITAL-5G platform is connected with three 5G SA testbeds located in Antwerp, Galati, and Athens. Each testbed supports Open Source MANO (OSM) as the Network Function Virtualization Orchestrator (NFVO) and OpenStack as the Virtualized Infrastructure Manager (VIM). Therefore, Vertical stakeholders, i.e., third-party experimenters such as Small and Medium-sized Enterprises (SMEs), companies, and research groups, will benefit such a platform, as they do not need to have expert knowledge on networking, orchestration, and performance monitoring [5,6]. The VITAL-5G platform can establish connections with a wide range of 5G testbeds, adaptable for deployment in diverse contexts to serve various vertical industries. For example, The Athens VITAL-5G testbed located in Greece hosts the Automation & remote operation of freight logistics (Warehouse logistics) use case. The Galati VITAL-5G testbeds, Romania Danube river port, hosts the 5G connectivity and data-enabled assisted navigation using Internet of Things (IoT) sensing and video cameras use case. Finally, the Antwerp VITAL-5G testbed is situated in the Port of Antwerp-Bruges, Belgium.

II. DEMONSTRATING VITAL-5G PLATFORM CAPABILITIES

The demonstration will elucidate the capabilities of the VITAL-5G platform, which are individually detailed in the subsequent sections.

A. Facilitating deployment of vertical service in the 5G network

To deploy their vertical services on the 5G SA infrastructure and start with experimentation, 3rd party experimenters need to define network requirements and hardware dependency. As shown in Figure 1, this initial step involves, i) Creation of the OpenStack/container image, ii) Defining the minimum network performance of their EdgeApp, and iii) Defining the hardware requirements of their EdgeApp. After this, all the next steps will be taken care of by the VITAL-5G project itself, thereby hiding the complexity from the experimenters. The onboarding package consists of the EdgeApp blueprint with the software image of the EdgeApp that the VITAL-5G platform leverages to define the intrinsic logic of the EdgeApp itself. After successfully onboarding all individual EdgeApps constituting the vertical services (Section I-B) third-party experimenters with support provided by the Vital-5G project, can initiate the onboarding the onboarding process for the complete vertical service.

B. Enhanced network performance by utilizing network slicing

Third-party experimenters can utilize the available slices from each VITAL-5G testbed for their vertical service. Therefore, the VITAL-5G platform accommodates the required network and service quality by reading out minimum network performance specified, as shown in step 2 of Figure 1. The technical support of VITAL-5G constructs then the blueprint of the EdgeApp where the needed slice requirements for the EdgeApp are provided. The VITAL-5G platform makes sure a slice will be created to meet the needs of the vertical services specified by experimenters.

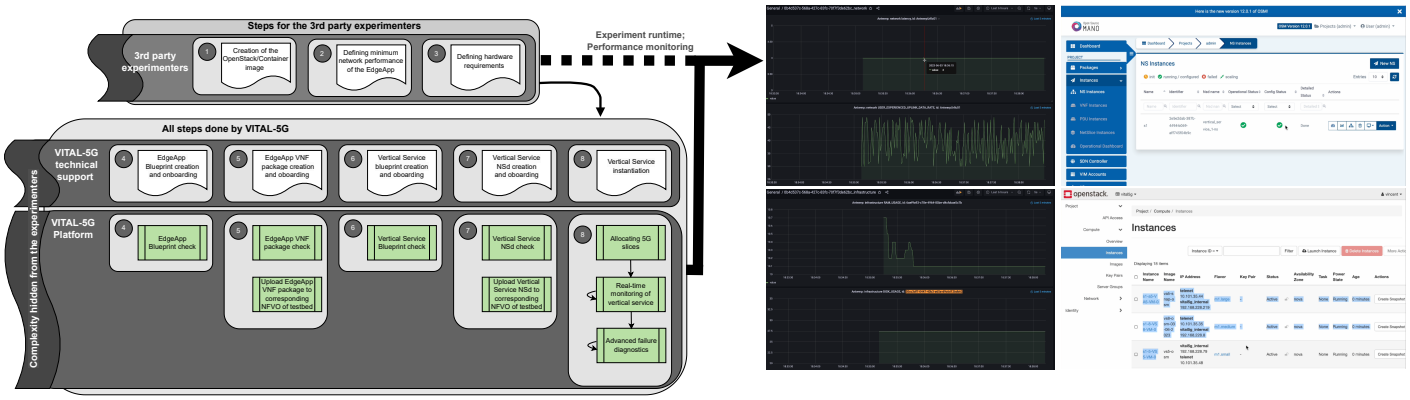

Fig. 1: Onboarding EdgeApps on the VITAL-5G platform

C. Real-time monitoring of network and service performance

Once VITAL-5G instantiated the vertical service of the experimenters it will show and collect in real-time the requested metrics specified by the third-party experimenters (Figure. 1). The VITAL-5G platform can retrieve infrastructure metrics, service metrics, network metrics and platform metrics.

D. Advanced failure diagnostics

During the run-time of a vertical service, the VITAL-5G platform has advanced AI/ML processes running to diagnose failures. Such AI/ML processes provide more insights on how the vertical service performed, after the termination of the vertical service.

III. Demonstrating the benefits of the VITAL-5G platform

The VITAL-5G platform enhances how third-party experimenters (i.e., industry stakeholders, network experts and vertical service developers) test and validate vertical services composed out of EdgeApps. The VITAL-5G project achieves this by hiding the complexity, of the network but also of deployment and orchestration procedures for vertical services, which are necessary for service deployment and later on its proper functioning during runtime, to the experimenters as shown in Figure 1.

1) The initial steps, i.e. steps 1 to 3 as shown in Figure 1, for experimenters are as follows, i) The creation of the software image that needs to run in the OpenStack or Kubernetes environment, ii) Defining together with the network experts of VITAL-5G the minimum network requirements of their EdgeApp (e.g., latency, throughput, and reliability), and iii) Defining the hardware requirements such that the EdgeApp can run in the most optimal conditions.
2) The VITAL-5G technical support team creates the EdgeApp blueprint and the EdgeApp Virtual Network Function (VNF) descriptor, denoted as steps 3 and 4 in Figure 1. These steps are based on the information supplied by the experimenters during steps 1 to 3 in Figure 1. Concurrently, the VITAL-5G platform conducts a thorough validation of the onboarded EdgeApp blueprint and proceeds to upload the EdgeApp VNF descriptor to the resource and service orchestrator of the specific testbed, as selected by the experimenter.
3) The VITAL-5G technical support team creates the vertical service blueprint and vertical service Network Service (NS) descriptor, as outlined in steps 5 and 6. These steps are based on the data provided by the experimenters during previous stages. In parallel, the VITAL-5G platform rigorously verifies the onboarded vertical service blueprint and proceeds to upload the vertical service NS descriptor to the service orchestrator of the designated testbed chosen by the experimenter.
4) After completing the aforementioned steps, the vertical service instantiation process is initiated through the VITAL-5G platform, as depicted in step 7 in Figure 1. Upon successful instantiation, the VITAL-5G platform undertakes the following tasks: I) Allocates the requisite 5G slices in accordance with the specified criteria within the EdgeApp blueprint. II) Commences real-time monitoring of the vertical service by dynamically generating monitoring panels (refer to Fig. 1). III) Activates the mechanisms for advanced failure diagnostics of the launched vertical service.

This is how the VITAL-5G platform hides the complexity by performing resource allocation, service orchestration, platform-tested integration and communication, in the background, while the experimenter only receives confirmation and monitoring dashboards to follow the progress of the experiment and service and network performance. Furthermore, the above procedure will be showcased on the example of the Assisted Vessel Navigation use case from VITAL-5G, thereby deploying two vertical services on the Antwerp testbed using the VITAL-5G platform.

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