Towards a Fully Automated System for Testing and Validating NetApps

Rafael Direito
Instituto de Telecomunicações
Universidade de Aveiro
Aveiro, Portugal
rdireito@av.it.pt

Diogo Gomes
Instituto de Telecomunicações
Universidade de Aveiro
Aveiro, Portugal
dgomes@av.it.pt

Rui L. Aguiar
Instituto de Telecomunicações
Universidade de Aveiro
Aveiro, Portugal
ruilaa@av.it.pt

***Abstract*—5G technologies provide several advancements regarding low latency and high bandwidth network scenarios, thus enabling new vertical use cases. Nonetheless, the lack of testing and validation mechanisms for NFV-based services poses a severe challenge in reducing their time to market. In this work we showcase a service to automate the validation of 5G NetApps, thus striving towards reducing the time to market of these applications, and introducing a new layer of trust in their reliability and availability.**

***Index Terms*—5G, NFV, NetApp, 5GASP, Validation, Automation**

I. Introduction

5th generation (5G) networks have high bandwidth, reduced latency, low power consumption, and are cost-effective, thus enabling better and faster network services [1], which may support many vertical use cases, such as autonomous vehicles, smart manufacturing, and public protection and disaster relief use cases [2].

Two key enablers of these new generation networks are Software-Defined Networks and Network Function Virtualization (NFV). In the latest, services are endowed with faster and simpler upgrades, dynamic scalability, and better reliability [3], and are offered through NetApps [4] - Network Applications. Although, NFV also introduces many complex questions, mainly regarding the validation of all its involved components and the complex service function chains they form. Besides, to properly validate an NFV service, it is also needed to verify if the service meets the defined quality standards and achieves the desired Key Performance Indicators (KPIs) [2]. All these verifications heavily impact the adoption of NFV systems, thus the continuous effort to address these issues and propose novel solutions capable of tackling them.

In this work we present a novel platform to achieve the automated validation of 5G NetApps. Section II addresses a proposal for a NetApp validation system. Based on this proposal, a proof of concept system was developed in the scope of the 5GASP Horizon 2020 project. This system is presented in Section III, and its demonstration is addressed in Section IV.

II. Proposed Validation System

The validation of NetApps should address two different scopes. The first is a pre-flight validation, where the NetApp packages are validated, while the second validation occurs after the deployment of the NetApp, thus being called on-flight validation. This phase only occurs if the pre-flight validation is successful, and mainly addresses the validation of the NetApps' behavior and functionality.

During the pre-flight validation, (i) the structure of the Virtual Network Function (VNF) Descriptors and Network Service (NS) Descriptors, (ii) the VNF Juju Charms, and (iii) the VNF cloud-init files are validated. Regarding the structural validation of the descriptors we can divide it into three separate stages: (i) syntactical validation, which verifies if all the descriptors' tags are correctly defined (ii), semantical validation, which validates if all the tags' data types are according to what is described in the Information Models (IMs), and (iii) reference validation, that verifies if the internal dependencies between descriptor elements are correct.

Besides validating the behavior and functionality of a NetApp, the on-flight validation phase also ensures that the infrastructure where the NetApp is deployed can provide the resources needed for its correct behavior. Regarding the behavioral validation, it is achieved with tests developed by the NetApp developers, since they are the only ones who can validate the NetApp's functionality. These tests are called developer-defined tests and will have to be onboarded to the validation system before the validation process begins, whereas the tests already available in the validation system are referred to as pre-defined tests. These tests mainly target global NFV Key KPIs, and can be used to validate any NetApp.

Having defined the scope of the validation process, it is now needed an architecture capable of supporting it. Firstly, it is necessary to create mechanisms that allow the onboarding of tests and a Testing Descriptor alongside the NetApp. The Testing Descriptor defines the workflow of the test execution, modeling the validation process. The mechanisms just described will have to be implemented at the NetApp Orchestrator level. Secondly, a test repository will have to be deployed in order to store both the pre-defined tests and the developer-defined tests.

III. 5GASP Validation Service

A proof of concept system was implemented in the 5GASP Horizon 2020 project to demonstrate the previously presented

approach. 5GASP makes available a single entry-point for the developers to onboard their NetApps and have them deployed and validated on a 5G testbed. This entry-point is provided by the 5GASP NetApp Onboarding and Deployment Service (NODS) and allows the onboarding of a bundle composed of the following elements: (i) the NetApp to deploy, (ii) the testing information of the validation process, and (iii) information about the Network Slice where the NetApp will be deployed. To increase the interoperability of the NODS, the aforementioned bundle is onboarded under the TMF Service-Specification standard [5].

After the bundle's onboarding to the NODS, the pre-flight validation process is triggered. This task can be delegated to an external component, the Descriptors Validator Service, which is capable of validating VNF and NS descriptors defined according multiple IMs and also offers correction suggestions for the poorly defined VNF Descriptors (VNFDs) and NS Descriptors (NSDs). After the pre-flight validation, the NetApps' orchestration and deployment take place. The NODS, made available through the Openslice Orchestrator[1], communicates with a testbed's NFV Orchestrator (NFVO) to orchestrate a NetApp's deployment phase. Once this phase is completed, the on-flight validation phase begins. This validation is enabled by 5 components, that altogether compose the 5GASP's Validation Service. These components are the following: (i) the CI/CD Manager, (ii) the Test Results Visualization Dashboard (TRVD), (iii) the Metrics Repository (MR), (iv) a pool of CI/CD Agents, and (v) a pool of Local Test Repositories (LTRs), and can be observed in Fig. 1.

The CI/CD Manager is the entry-point for the Validation Service. It is available via a REST API, implemented using FastAPI[2], and is triggered by the NODS, in order to start a new validation process.

The LTRs, implemented using FTP servers, store all the tests that can be performed in a facility and make them available for the CI/CD Agents to gather and execute them on the NetApps. These tests are implemented via a Test Automation Framework (TAF) and validate the behavior of the NetApps and their impact on the underlying infrastructure.

The CI/CD Agents are responsible for performing the tests on the NetApps. Each testbed must have a CI/CD Agent deployed on the network where NetApps will be deployed. This Agent is registered in the CI/CD Manager, enabling the communication between these two entities. The Agents receive a configuration file from the CI/CD Manager detailing the testing process and are responsible for: (i) triggering the metrics collection mechanisms in the NetApps, (ii) gathering the tests from the LTR, (iii) performing them on the NetApps, and (iv) informing the CI/CD Manager of the results of the tests.

The Metrics Repository is the entity responsible for storing VNF metrics, such as (i) CPU usage, (ii) RAM consumption, (iii) packets sent, etc. Besides providing metrics storage, this entity also provides a visualization dashboard for the developers to visualize the collected metrics.

Finally, the TRVD enables the NetApp developers to get the outcomes of the testing and validation phase. After all the tests are performed, the CI/CD Agents will store the tests' outputs in the CI/CD Manager's Results Repository. The TRVD will present these outputs and provide a URL to access the MR dashboard, so the developers can observe the validation results and metrics collected during the validation process.

Fig. 1 displays the complete architecture of the 5GASP's Validation Service.

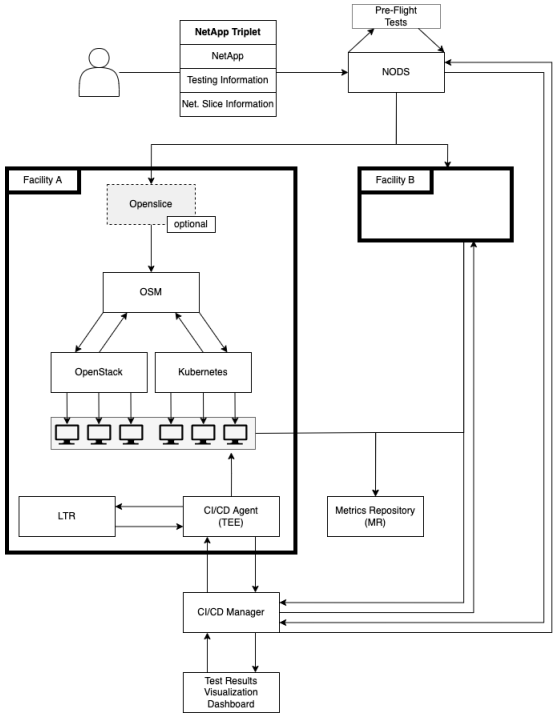

Fig. 1. 5GASP's Validation Service Architecture.

IV. Demonstration

The demonstration presented in this paper addresses the two most important workflows of the 5GASP Validation Service. Firstly, it showcases how a NetApp developer may onboard its NetApp and some developer-defined tests into NODS. Then, this demo addresses the validation process of the onboarded NetApp. Since the integration between the NODS and the Validation Service has not yet been fully achieved, the NODS Portal is mocked during this demonstration, using and API that simulates its behavior.

A. NetApp Under Test

To demonstrate how the 5GASP's Validation Service is validating and certifying NetApps, we have created a NS to provide interdomain domain connectivity [6]. This NS is composed of a VNF with a Wireguard Server, which is used to provide the tunnels between the different domains that we may choose to interconnect. During this demonstration, we deploy

[1]http://openslice.io/

[2]https://fastapi.tiangolo.com/

3 of these NSs, to simulate an interdomain scenario established via a mesh network. Then, the involved NFV components undergo a series of tests, in order to validate their behavior, thus validating the inter-domain scenario.

B. Tests Performed

In order to validate the "NetApp" under test, we utilize 5GASP's pre-defined tests, and developer-defined tests, which are onboarded alongside the NetApp. The first tests mainly address the validation of infrastructure aspects, such as the bandwidth available in the tunnels connecting the domains, the percentage of packets lost, and the delay in the communication between different domains. On the other hand, the developer-defined tests target the behavior and the functionality of the Wireguard servers provided by the VNFs. Thus, these verify if it is possible to dynamically add new peers to a Wireguard server, or delete them, and if the traffic between the Wireguard peers is indeed being ciphered, as it is supposed to be. These tests are just for demonstration purposes, and many more can be developed, onboarded, and used to validate our interdomain tool.

C. Demonstration Steps

Our demonstration is mainly focused on the on-flight validation of the NetApp, and includes the following steps:

- Showcase of the two developer-defined tests which will be used to validate the NetApp under test;
- Development of the Testing Descriptors which will guide the validation process;
- Onboarding of a NetApp bundle (NetApp Artifacts + Testing Artifacts) to the NODS Portal, and the automated deployment of the NetApp in one of the 5GASP's testbeds;
- Automated validation of the NetApp;
- Showcase of the results of the validation process, and all the metrics collected during the validation process.

D. Results Visualization

After the demonstration is finished, we provide access to the TRVD, so it is possible to interact with the collected validation results. This dashboard presents a listing of all the executed tests and their results, and also provides a URL to access the Metrics Repository, where it is possible to visualize all the metrics collected during the validation process. Fig 2, showcases a portion of the TRVD's web interface.

V. Conclusions

This demo paper presents a demonstration of the 5GASP's Validation Service, which allows the automated validation of NetApps, thus simplifying the testing process that these NetApps would have undergone. NetApp developers will be able to freely use 5GASP's services to deploy their NetApps in one of our testbeds and validate them, through the already onboarded tests and their own developed tests. Although 5GASP's platforms and services are still embryonic, we consider some progress as already been made towards

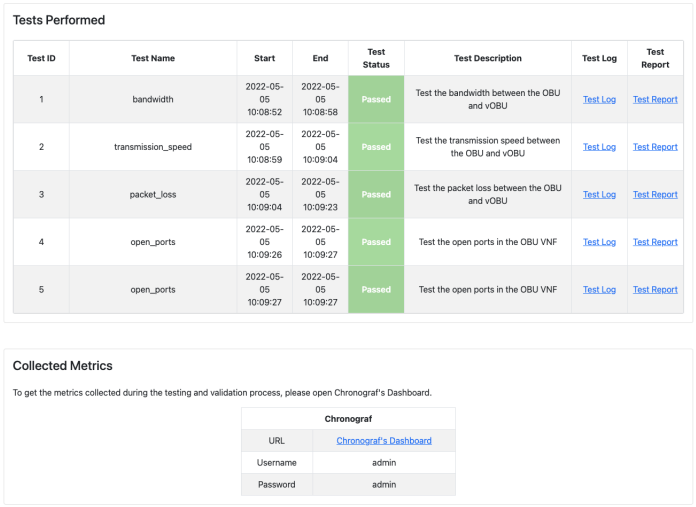

Fig. 2. TRVD's Web Graphical User Interface (GUI).

the development of a fully automated system for testing and validating NetApps, and in the future, we expect to increase the pool of tests onboarded in our Validation Service, and the scope of our validation process, in order to enable validation mechanisms on the 5G Core and Radio Access Network (RAN) levels. The code used for this demonstration is open-source and it is available on 5GASP's GitHub[3].

VI. Acknowledgment

This work was supported by the H2020 European Project 5GASP (grant agreement No. 101016448)

References

[1] D. Cotroneo *et al.*, "Network function virtualization: Challenges and directions for reliability assurance," in *2014 IEEE ISSRE Workshops*, Nov. 2014. DOI: 10.1109/issrew.2014.48.

[2] M. Peuster *et al.*, "Introducing automated verification and validation for virtualized network functions and services," *IEEE Communications Magazine*, vol. 57, no. 5, pp. 96–102, 2019. DOI: 10.1109/MCOM.2019.1800873.

[3] M. Chiosi *et al.*, "White paper: Network Functions Virtualisation - An Introduction, Benefits, Enablers, Challenges & Call for Action ," Tech. Rep. 1, October 2012.

[4] K. Trichias *et al.*, "VITAL-5G: Innovative network applications (NetApps) support over 5g connectivity for the transport and logistics vertical," in *2021 EuCNC/6G Summit*, IEEE, June 2021. DOI: 10.1109/eucnc/6gsummit51104.2021.9482437.

[5] K. Trantzas *et al.*, "An automated CI/CD process for testing and deployment of network applications over 5g infrastructure," in *2021 IEEE MeditCom*, Sept. 2021. DOI: 10.1109/meditcom49071.2021.9647628.

[6] J. Fonseca *et al.*, "Dynamic interdomain network slicing for verticals in the 5Growth project," in *2021 IEEE NFV-SDN*, pp. 154–160, 2021. DOI: 10.1109/NFV-SDN53031.2021.9665037.

[3]https://github.com/5gasp