Continuous Integration in 5GASP

Rafael Neves Direito, Diogo Gomes, Rui Aguiar – IT Aveiro
rdireito@av.it.pt, dgomes@it.av.pt, ruilaa@av.it.pt

February 4th, 2021
### The Transition to NFV raised some concerns

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>01.</strong></td>
<td>How to validate softwarized Network Functions?</td>
</tr>
<tr>
<td><strong>02.</strong></td>
<td>How to trust third-party developed VNFs?</td>
</tr>
<tr>
<td><strong>03.</strong></td>
<td>How to ensure the reliability of a softwarized Network Function?</td>
</tr>
</tbody>
</table>
Several Research Projects addressed these questions

Although

All these projects, despite providing some validation of 5G projects, are missing a fully automated and simple way to perform these validations
Goals

- Create a tool to perform a pre-flight validation of a NetApp
- Create a tool capable of performing an on-flight validation of a NetApp – validate its behavior and functionality
- Simplify the configuration of a NetApp’s validation process
- Provide a fully automated validation process
Work Proposal

NetApp Package Validator

- Aims to validate (i) the VNF and NS descriptors' structure, (ii) the VNF Juju Charms, and several security aspects of the VNF
- Although, only the descriptors validation was addressed

Descriptors Validator

- The descriptors validator should provide correction suggestions, when errors are found
- The descriptors validator should address different Information Models

On-Flight Validation Pipeline (5GASP's CI/CD Service)

- Aims to achieve an automated pipeline to validate the NetApps, which is implemented according to a Continuous Integration paradigm
- This pipeline should be triggered after all the VNFs of a NetApp are deployed
- The validation process should be configured by the developers in a straightforward manner
5GASP’s Architecture

Figure: 5GASP’s High-Level Architecture
The Descriptors Validator Service should address, at least, 2 Information Models:
  - YANG Information Models (OSM)
  - TOSCA Information Models (ONAP)

The descriptors should be validated on their:
  - Syntax - if all the tags are correctly defined
  - Semantics - if the tags' contents is correct
  - References - if all the dependencies between tags are correct

To enable an Information Model agnostic validation, 2 options arise:
  - Different validator for each Information Model
  - Map the information to a singular structure and use it to validate the descriptors
Describing the Descriptors Validator Service - Architecture and Implementation

**1 - IM Parser**

![Diagram of IM Parser Module's Architecture](image)

Figure: Information Models Parser Module's Architecture
Descriptors Validator Service – Architecture and Implementation

Figure: Descriptors Validator Module's Architecture.
Descriptors Validator Service – Architecture and Implementation

3 – Correction Suggestions

Figure: Correction Suggestions Module’s Architecture
Descriptors Validator Service – Architecture and Implementation

- **Correction Suggestions**
  - **Syntax Correction Suggestions** – Computes the Jaro distance and suggests the closest tag
  - **Semantics Correction Suggestions** – Uses the context from previous validated descriptors
  - **Reference Correction Suggestions** – Suggests the value of the referenced tag

![Descriptors Validator Database Schema](image)

**Figure:** Descriptors Validator Database Schema

```
[ERROR CORRECTION SUGGESTIONS]
---------
Error: The value '1a' on vnfd:vnfd-catalog/vnfd/vdu/vm-flavor/vcpu-count doesn't match its datatype (uint16).
Correction Suggestions: 1, 2, 4
---------
Error: The value 'vnf-cp1' on vnfd:vnfd-catalog/vnfd/vdu/interface/external-connection-point-ref doesn't match its reference (vnfd:vnfd-catalog/vnfd/connection-point/name) value of vnf-cp0
Correction Suggestions: vnf-cp0
```

**Figure:** Example of an Output of the Correction Suggestions Module
Descriptors Validator Service – Architecture and Implementation

Figure: WebUI After Validating a Descriptor
5GASP’s CI/CD Service - Specifications

- Coordinates the testing and validation of NetApps
- Triggered after the NetApps are deployed
- Deals with all the testbeds different specifications
- Addresses 2 different types of tests:
  - Pre-defined tests: available in all testbeds and are independent of the NetApp’s logic
  - Developer-defined tests: created by the developers to specifically validate the behavior of their NetApps

Figure: 5GASP Approach on DevOps Experimentation and Certification Lifecycle [11]
5GASP’s CI/CD Service - Architecture

Figure: 5GASP CI/CD Service’s High-Level Architecture
5GASP’s CI/CD Service - Implementation

- **CI/CD Manager**
  - Orchestrates the test execution in the CI/CD Agents
  - Comprises a Wrapper to interact with Jenkins (CI/CD Agent)
  - REST API which will be invoked by the NODS, implemented using FastAPI

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>POST</td>
<td>/agents/new  Register new CI/CD Agent</td>
</tr>
<tr>
<td>GET</td>
<td>/agents/all   Get all CI/CD Agents</td>
</tr>
<tr>
<td>GET</td>
<td>/tests/all    Get all tests</td>
</tr>
<tr>
<td>GET</td>
<td>/tests/per-testbed Get testbed's tests</td>
</tr>
<tr>
<td>GET</td>
<td>/tests/test-status Get the status of test</td>
</tr>
<tr>
<td>POST</td>
<td>/tests/test-status Update the status of a test</td>
</tr>
<tr>
<td>POST</td>
<td>/tests/new    Create a new test</td>
</tr>
<tr>
<td>POST</td>
<td>/tests/publish-test-results Publish test results</td>
</tr>
<tr>
<td>GET</td>
<td>/testbeds/all Get all testbeds</td>
</tr>
</tbody>
</table>

**Figure**: 5GASP CI/CD Manager API Endpoints
5GASP’s CI/CD Service - Implementation

- **CI/CD Agents**
  - Until now, only Jenkins was used in the CI/CD Agents
  - Available via a cloud image, easily deployed in OpenStack
  - On boot, will inform the CI/CD Manager they are ready to receive jobs

**Stage View**

<table>
<thead>
<tr>
<th>Setup environment</th>
<th>Start monitoring</th>
<th>Obtain Tests</th>
<th>Perform Tests</th>
<th>End monitoring</th>
<th>Publish Results</th>
<th>Cleanup environment</th>
<th>End Testing Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>2s</td>
<td>1s</td>
<td>2s</td>
<td>39s</td>
<td>1s</td>
<td>1s</td>
<td>1s</td>
<td>4s</td>
</tr>
</tbody>
</table>

Average stage times:
(Average full run time: ~57s)

*Figure: CI/CD Agent’s Pipeline Stages*
5GASP’s CI/CD Service - Implementation

- **LTR**
  - Each testbed is composed of one LTR
  - The LTRs are implemented using FTP Servers
  - Store the tests which will be performed (Robot Framework Tests)

```robot
*** Settings ***
Library    PacketLoss.py

*** Test Cases ***
Testing the packet loss percentage
$(COMPARATOR)= Run Keyword If  '%(packet_loss_comparator)'' == 'more than' Set
  Variable >
  ... ELSE IF  '%(packet_loss_comparator)'' == 'more or equal than' Set Variable >=
  ... ELSE IF  '%(packet_loss_comparator)'' == 'less than' Set Variable <
  ... ELSE IF  '%(packet_loss_comparator)'' == 'less or equal than' Set Variable <=
  ... ELSE Fail 'noComparator has not been defined

$(loss_percentage)= Packet Loss

IF  '$(loss_percentage)':'' != '-1'
    Should Be True  $(loss_percentage) $(COMPARATOR) $(packet_loss_threshold)
ELSE
    FAIL  \nImpossible to compute packet loss percentage
END
```

*Figure: testPacketLoss.robot*
5GASP’s CI/CD Service - Implementation

- **Metrics Collection**
  - Enabled by TICK Stack
  - A Telegraf binary and configuration file is injected in the VNFs
  - Metrics are shipped to InfluxDB and are available via Chronograf

![Figure: Chronograf's Dashboard Example](image)
5GASP’s CI/CD Service - Implementation

- **TRVD**
  - Enables the developers to follow the stages of the validation process
  - Consumes data from the CI/CD Manager
  - Provides the test results and outcomes to the developers

### Tests Performed

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Start</th>
<th>End</th>
<th>Test Status</th>
<th>Test Description</th>
<th>Test Log</th>
<th>Test Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>bandwidth</td>
<td>2021-10-03 10:21:37</td>
<td>2021-10-03 10:22:43</td>
<td>Passed</td>
<td>Test the bandwidth between the OBU and vOBU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission_speed</td>
<td>2021-10-03 10:21:44</td>
<td>2021-10-03 10:21:49</td>
<td>Passed</td>
<td>Test the transmission speed between the OBU and vOBU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>packet_loss</td>
<td>2021-10-03 10:21:50</td>
<td>2021-10-03 10:22:30</td>
<td>Passed</td>
<td>Test the packet loss between the OBU and vOBU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>open_ports</td>
<td>2021-10-03 10:23:12</td>
<td>2021-10-03 10:22:12</td>
<td>Passed</td>
<td>Test the open ports in the OBU YNF</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Collected Metrics

To get the metrics collected during the testing and validation process, please open Chronograf’s Dashboard.

![Figure: TRVD - Tests Performed and Collected Metrics](image)
5GASP’s CI/CD Service - Implementation

- **Testing Descriptor**
  - Starting point of the validation process
  - Defined by the NetApp developers
  - Onboarded to NODS, alongside the NetApp itself
  - Augmented by the NODS
  - YAML File

```yaml
testcases:
  # Platform-specific tests
  - testcase_id: 1
    type: predefined
    scope: infrastructure
    name: infrastructure_kpi
    kpi: deployment_time

  # NetApp-specific tests
  - testcase_id: 2
    type: developer_defined
    scope: infrastructure
    name: bandwidth
    parameters:
      - key: host1_ip
        value: 10.0.0.1
      - key: host1_username
        value: root
      - key: host1_password
        value: password
      - key: host2_ip
        value: 10.0.0.2
      - key: host2_username
        value: root
      - key: host2_password
        value: password
      - key: desiredValue
        value: 100 mbps
      - key: comparator
        value: more than
  - testcase_id: 3
    type: developer_defined
    scope: operational
    name: packet_loss_ratio
    parameters:
      - key: host1_ip
        value: 10.0.0.1
      - key: host1_username
        value: root
      - key: host1_password
        value: password
      - key: desiredValue
        value: 1 %
      - key: comparator
        value: less than
```

Figure: Portion of a Testing Descriptor
Descriptors Validator Service - Results

- The Descriptors Validator was tested with a collection of descriptors gathered from OSM Hackfests
- Several OSM’s IMs were tested
- All the descriptors were correctly validated
- All correction suggestions were according what was expected

<table>
<thead>
<tr>
<th>Descriptors File Size (bytes)</th>
<th>Median of the Validation Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1000 bytes</td>
<td>1.95</td>
</tr>
<tr>
<td>Between a 1000 bytes and 1500 bytes</td>
<td>2.59</td>
</tr>
<tr>
<td>Between a 1500 bytes and 2000 bytes</td>
<td>3.46</td>
</tr>
<tr>
<td>Between a 2000 bytes and 2500 bytes</td>
<td>3.14</td>
</tr>
<tr>
<td>Between a 2500 bytes and 3000 bytes</td>
<td>8.71</td>
</tr>
</tbody>
</table>

*Figure:* Relation Between the Descriptor’s File Size and its Median Validation Time
5GASP’s CI/CD Service - Results

- The CI/CD Service was not tested in a production scenario
- 3 Testing Scenarios were created to test this service
- All the tests were correctly performed

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Start</th>
<th>End</th>
<th>Test Status</th>
<th>Test Description</th>
<th>Test Log</th>
<th>Test Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>bandwidth</td>
<td>2021-10-03</td>
<td>2021-10-03</td>
<td>Passed</td>
<td>Test the bandwidth between the OBU and vOBU</td>
<td>Test Log</td>
<td>Test Report</td>
</tr>
<tr>
<td>transmission_speed</td>
<td>2021-10-03</td>
<td>2021-10-03</td>
<td>Passed</td>
<td>Test the transmission speed between the OBU and vOBU</td>
<td>Test Log</td>
<td>Test Report</td>
</tr>
<tr>
<td>packet_loss</td>
<td>2021-10-03</td>
<td>2021-10-03</td>
<td>Passed</td>
<td>Test the packet loss between the OBU and vOBU</td>
<td>Test Log</td>
<td>Test Report</td>
</tr>
<tr>
<td>open_ports</td>
<td>2021-10-03</td>
<td>2021-10-03</td>
<td>Passed</td>
<td>Test the open ports in the OBU VNF</td>
<td>Test Log</td>
<td>Test Report</td>
</tr>
</tbody>
</table>

Figure: TRVD’s Web Interface Portraying a Successful Validation Process

Figure: Overall Validation Process Execution Time
5GASP’s CI/CD Service - Results

Figure: Execution Time for Each Individual Test

![Box Plot of Individual Test Execution Times](image)

<table>
<thead>
<tr>
<th>Test</th>
<th>Median of the Test Execution Times (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>bandwidth</td>
<td>5.311</td>
</tr>
<tr>
<td>transmission_speed</td>
<td>4.509</td>
</tr>
<tr>
<td>packet_loss</td>
<td>19.201</td>
</tr>
<tr>
<td>open_ports</td>
<td>0.055</td>
</tr>
</tbody>
</table>

Figure: Median of Each Test Execution Time
Conclusions

- The Descriptors Validator was able to correctly validate all the descriptor of the testing set.
- The time needed to validate the descriptors, via the Descriptors Validator, will not increase the SDLC.
- The CI/CD Service enables full automation when validating a NetApp.
- The CI/CD Service was able to correctly perform all the desired tests.
- The time needed to validate a NetApp, although dependent on the individual tests’ performing time, is inferior to 2 minutes.

Overall, it is possible to affirm that both developed tools provide added value in the validation of NetApps.
Future Work

- Develop modules to validate the VNF's Juju Charms and evaluate its security. This is needed to achieve a full spectrum NetApp Package Validator

- Integrate the CI/CD Service with the NODS

- Standardize the communication interfaces of the CI/CD Manager, using TMF Standards

- Increase the pool of tests of the CI/CD Service
References


If you are interested in the work we have been developing in 5GASP

www.5gasp.eu

community.5gasp.eu

@5gasp
Thank you for your attention!

Any questions?