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

01.

How to validate softwarized Network Functions?

02.

How to trust third-party developed VNFs?

03.

How to ensure the reliability of a softwarized Network Function?

Several Research Projects addressed these questions

Although

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

Goals

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 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
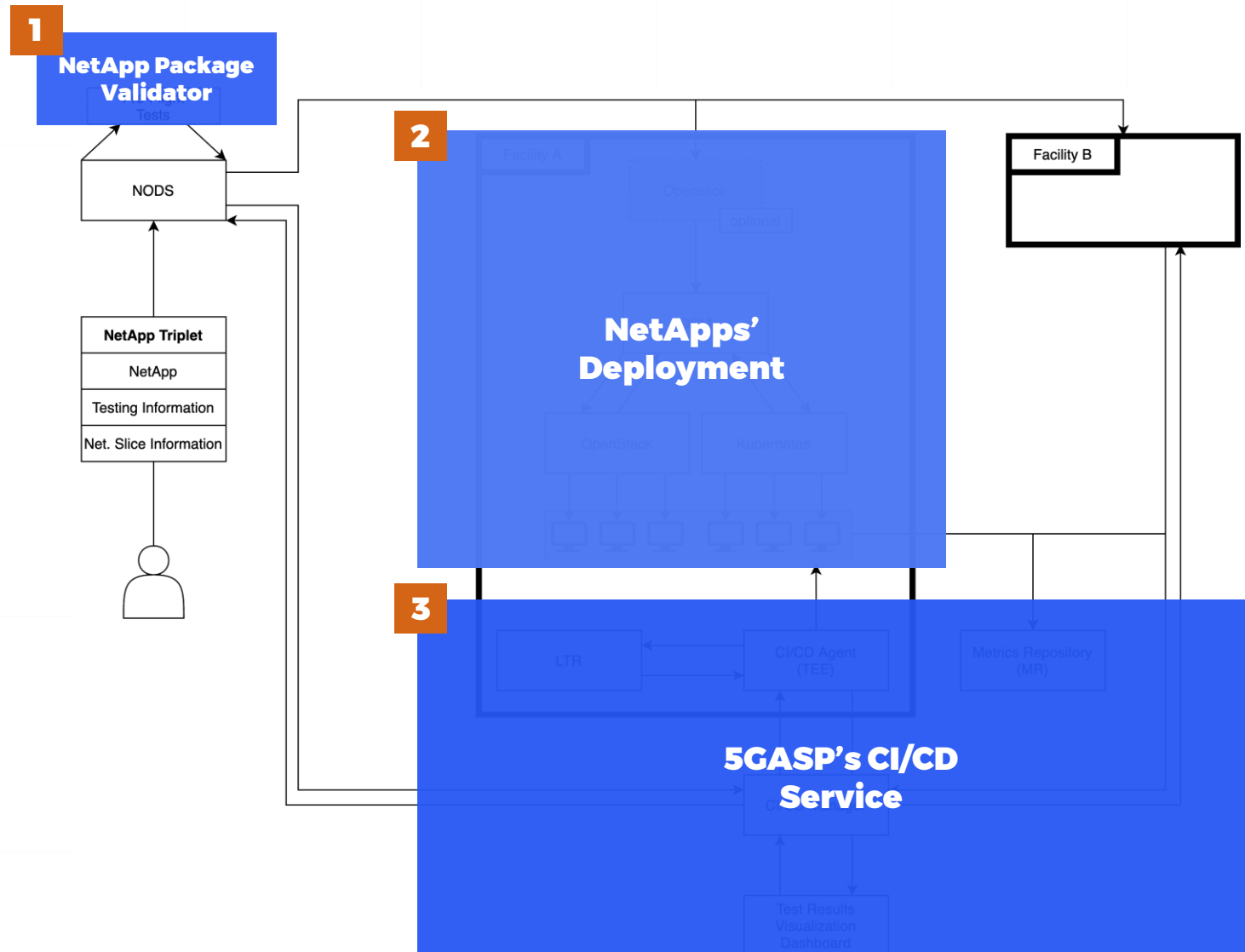
5GASP's Architecture

Figure: 5GASP's High-Level Architecture

Descriptors Validator Service - Specifications

- The Descriptors Validator Service should address, at least, <u>2 Information Models</u>:
    - YANG Information Models (OSM)
    - TOSCA Information Models (ONAP)

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

- To enable an Information Model agnostic validation, 2 options arise:
    - <u>Different validator for each Information Model</u>
    - <u>Map the information to a singular structure and use it to validate the descriptors</u>

Increased modularity and decoupling

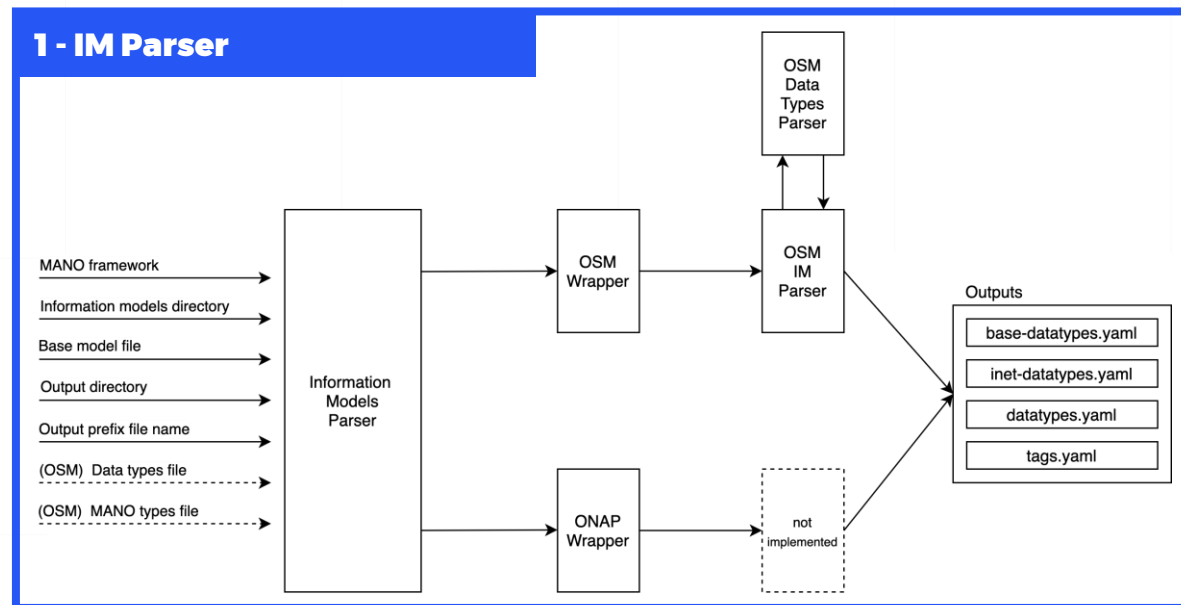# Descriptors Validator Service - Architecture and Implementation

Figure: Information Models Parser Module's Architecture

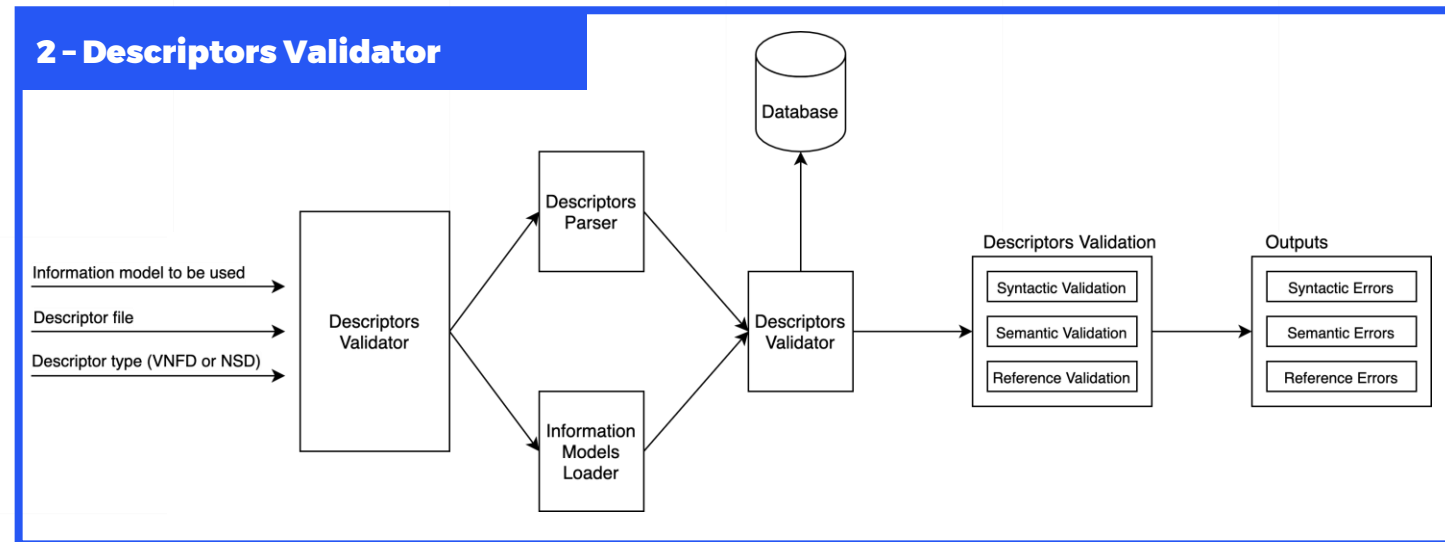# Descriptors Validator Service - Architecture and Implementation

Figure: Descriptors Validator Module's Architecture.

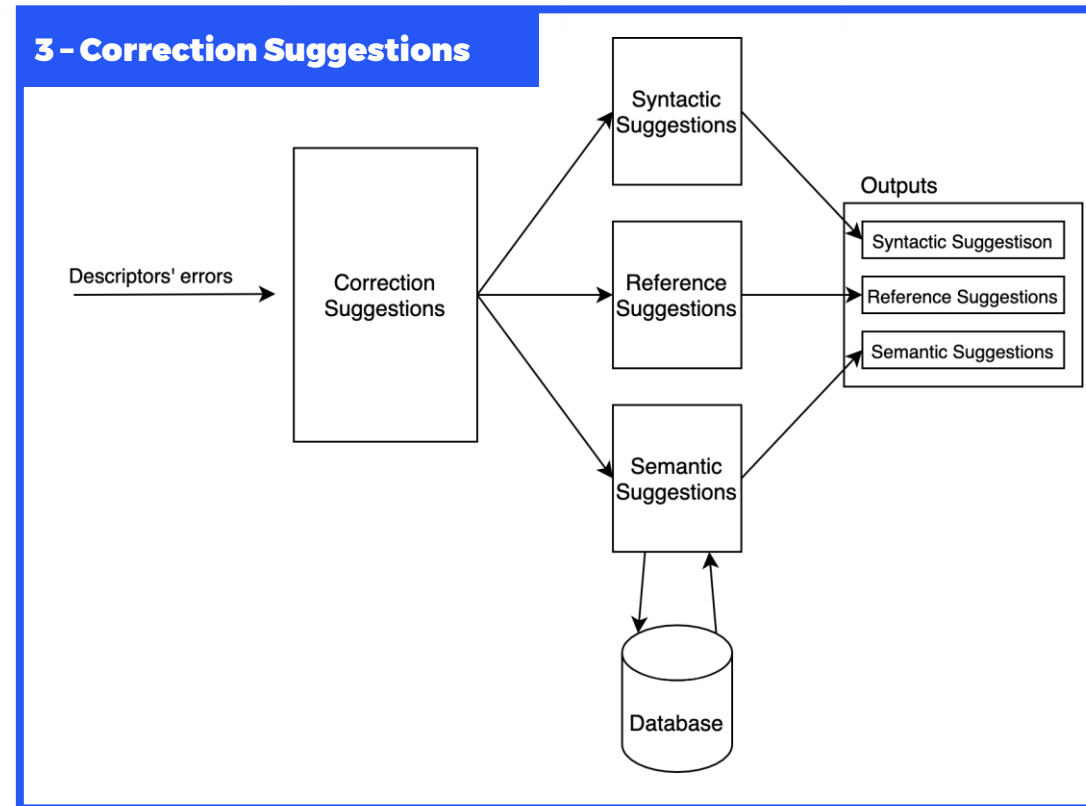# Descriptors Validator Service – Architecture and Implementation

Figure: Correction Suggestions Module's Architecture

Descriptors Validator Service – Architecture and Implementation

▪ <u>Correction Suggestions</u>

　　▪ <u>Syntax Correction Suggestions</u> – Computes the Jaro distance and suggests the closest tag

　　▪ <u>Semantics Correction Suggestions</u> – Uses the context from previous validated descriptors

　　▪ <u>Reference Correction Suggestions</u> – Suggests the value of the referenced tag
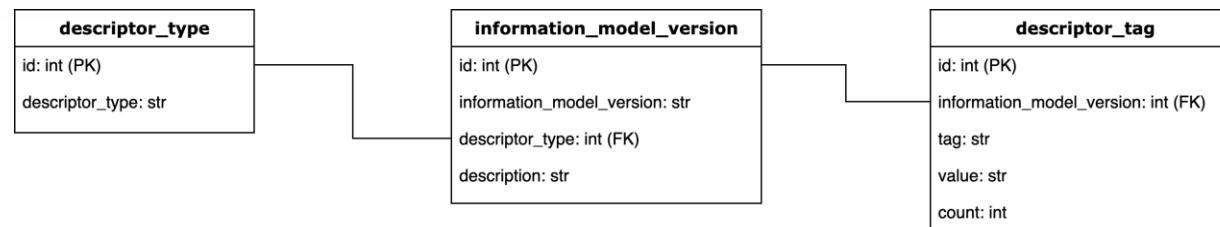
descriptor_type

id: int (PK)

descriptor_type: str

information_model_version

id: int (PK)

information_model_version: str

descriptor_type: int (FK)

description: str

descriptor_tag

id: int (PK)

information_model_version: int (FK)

tag: str

value: str

count: int

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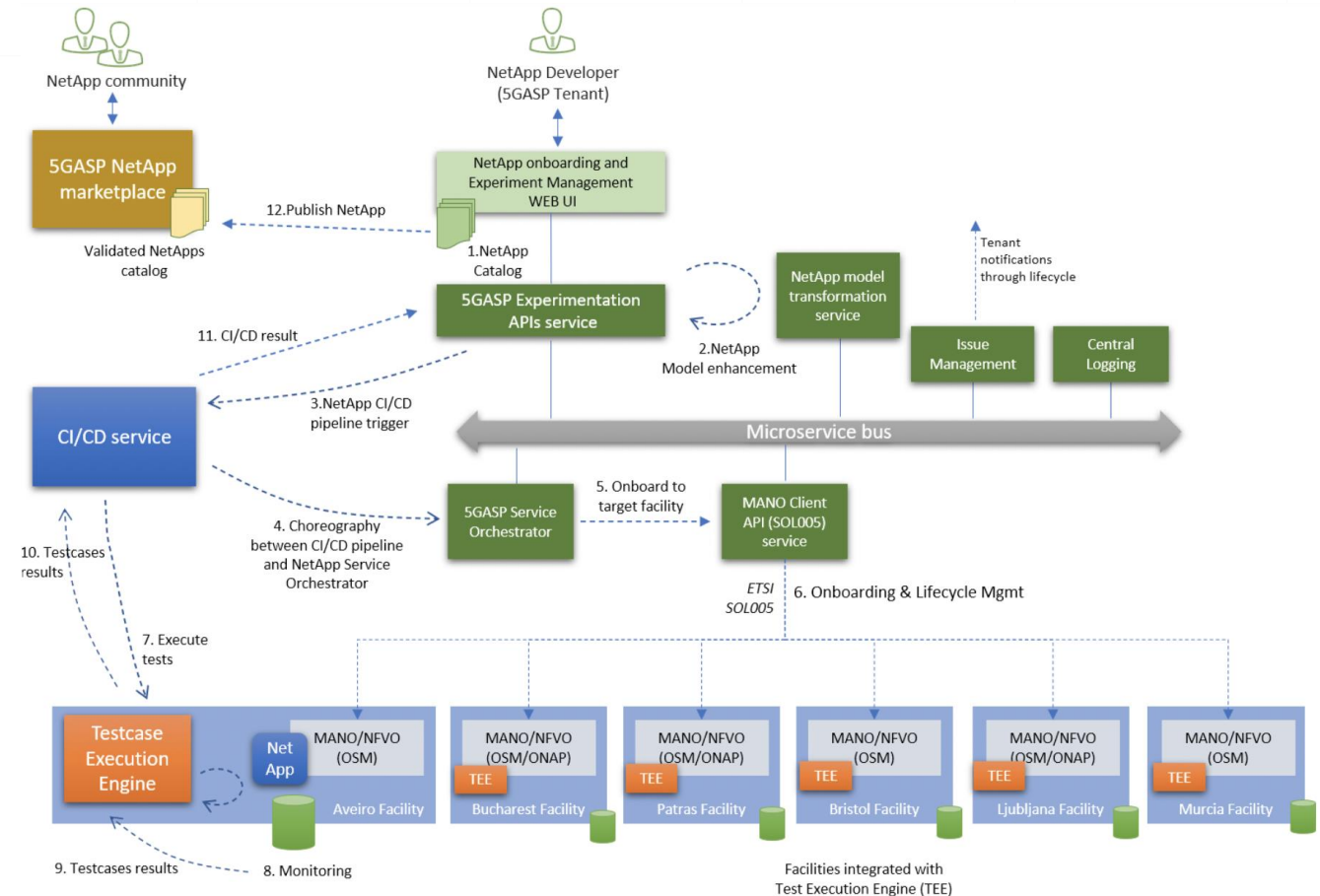
Figure: 5GASP Approach on DevOps Experimentation and Certification Lifecyle [11]
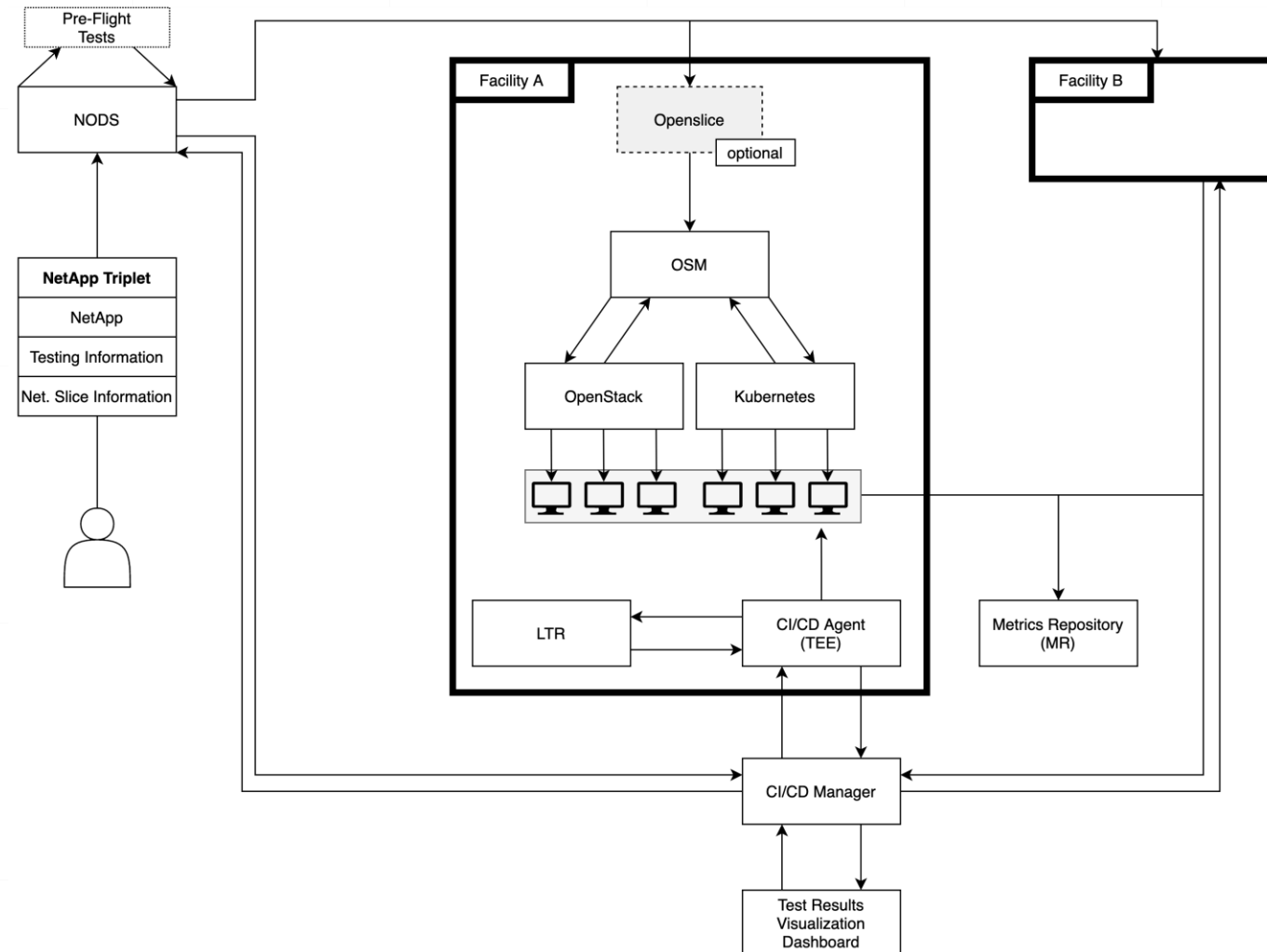
5GASP's CI/CD Service - Architecture

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

Problem
Contextualization | Related
Projects | Work
Proposal | Descriptors
Validator | CI/CD Service | Results | Conclusions | Future
Work | Contributions

5GASP's CI/CD Service - Implementation

- ▪ <u>CI/CD Manager</u>
  - ▪ 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

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

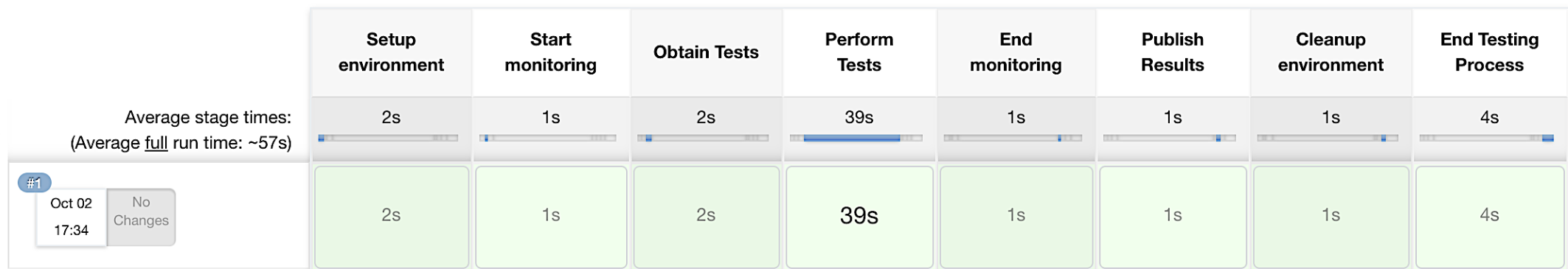|	Setup environment	Start monitoring	Obtain Tests	Perform Tests	End monitoring	Publish Results	Cleanup environment	End Testing Process
Average stage times: (Average <u>full</u> run time: ~57s)	2s	1s	2s	39s	1s	1s	1s	4s
#1 Oct 02 17:34 No Changes	2s	1s	2s	**39s**	1s	1s	1s	4s

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)

```
*** 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  \nComparator 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

Problem
Contextualization | Related
Projects | Work
Proposal | Descriptors
Validator | CI/CD Service | Results | Conclusions | Future
Work | Contributions

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

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

Figure: TRVD - Tests Performed and Collected Metrics

Figure: TRVD – Test Outputs and Results

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:
    # Pltform-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

Descriptors File Size (bytes)	Median of the Validation Time (ms)
Less than 1000 bytes	1.95
Between a 1000 bytes and 1500 bytes	2.59
Between a 1500 bytes and 2000 bytes	3.46
Between a 2000 bytes and 2500 bytes	3.14
Between a 2500 bytes and 3000 bytes	8.71

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

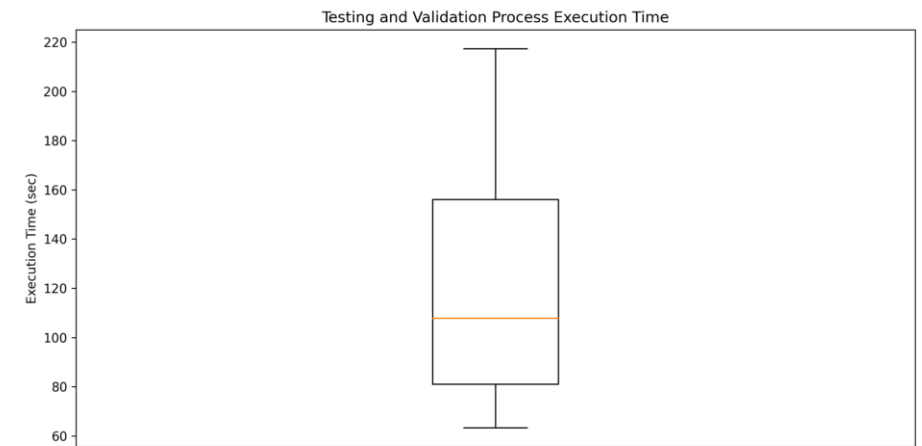**Figure:** TRVD's Web Interface Portraying a Successful Validation Process

Figure: Overall Validation Process Execution Time

5GASP's CI/CD Service - Results

Figure: Execution Time for Each Individual Test

Test	Median of the Test Execution Times (sec)
bandwidth	5.311
transmission_speed	4.509
packet_loss	19.201
open_ports	0.055

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

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

[2] C. Tipantuña and P. Yanchapaxi, "Network functions virtualization: An overview and open-source projects," in *2017 IEEE Second Ecuador Technical Chapters Meeting (ETCM)*, 2017, pp. 1–6. doi: 10.1109/ETCM.2017.8247541.

[3] R. Mijumbi, J. Serrat, J.-L. Gorricho, N. Bouten, F. De Turck, and R. Boutaba, "Network Function Virtualization: State-of-the-Art and Research Challenges," *IEEE Communications Surveys Tutorials*, vol. 18, no. 1, pp. 236–262, 2016. doi: 10.1109/COMST.2015.2477041.

[4] R. Mijumbi, J. Serrat, J.-l. Gorricho, S. Latre, M. Charalambides, and D. Lopez, "Management and orchestration challenges in network functions virtualization," *IEEE Communications Magazine*, vol. 54, no. 1, pp. 98–105, 2016. doi: 10.1109/MCOM.2016.7378433.

[5] ETSI ISG NFV, "ETSI GS NFV 002 V1.1.1: Network Function Virtualisation (NFV): Architectural Framework," Tech. Rep. 1, Oct. 2013.

[6] S. Chayapathi Rajendra and. Farrukh Hassan and P. Shah, *Network Functions Virtualizations (NFV) with a touch of SDN*. Pearson Education, Inc, 2017, isbn: 0134463056.

[7] M. Abu-Lebdeh, D. Naboulsi, R. Glitho, C. Wette, and Tchouati, "NFV Orchestrator Placement for Geo-Distributed Systems," Nov. 2017. doi: 10.1109/NCA.2017.8171391.

[8] *5GTANGO*, Accessed: 02-08-2021. [Online]. Available: https://www.5gtango.eu/.

[9] *5G EVE*, Accessed: 02-08-2021. [Online]. Available: https://www.5g-eve.eu/.

[10] *5GinFIRE*, Accessed: 02-08-2021. [Online]. Available: https://5ginfire.eu/.

[11] 5GASP Consortium, "5GASP Project Proposal," Tech. Rep., Jun. 2020.

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?