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HUAWEI TECHNOLOGIES CO.,LTD.
Huawei Industrial Base
Bantian Longgang
Shenzhen 518129,P.R.China
Tel: +86 755 28780808

www.huawei.com

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TestCraft

Testing as a Service to Accelerate SDN/NFV Service Deployment

Contents

1. Executive Summary

Operators are expecting more from SDN/NFV technology to achieve greater agility, potential revenue opportunities and higher resource efficiency for potential cost savings. However, the transformation is proving to be rather a long journey where the full benefits can only be achievable after solving operational, performance and availability uncertainties caused by the multi-layer nature of an SDN/NFV architecture.

The Testing as a Service (TaaS) solution provides alternatives to address the critical challenges by adopting a methodology model for multiple dimensional testing supporting the various purposes of SDN/NFV in different life cycle phases of the system development, testing, implementation and operations. This whitepaper introduces what capabilities and innovations the TaaS solution provides and how it will contribute to the efficiency and agility during the Operator transformation to SDN/NFV.

2. Challenges in Today's Testing Environment

SDN/NFV technology introduces not only the benefits like flexibility and scalability but also the disadvantage of complexity and uncertainty, especially during implementation and operations. Those imperfections could unfortunately lead to the opposite of the Operator's distinguishing characters like high reliability and low latency. To make sure the service quality is kept consistent, SDN/NFV system introduction requires mandatorily a thorough validation approach.

However for Operators it appears the situation is more likely going from bad to worse since the testing activities today consume more than 40% of their time and efforts bringing new services on-line. This entire network life cycle becomes unthinkable for the required deployment velocity and scope of SDN/NFV resulting in increased testing complexity that should have never been underestimated. To achieve both velocity and quality, the testing method and processes need a radical revolution to the new production model.

Operators have to consider the continuous changes or even operational challenges brought on by the introduction of SDN/NFV:

- Extended test scope

✓ Testing on multi-vendors, multi-layers separate functional modules
✓ Unpredictable interoperability testing results on increasing SDN/NFV combinations
✓ Postponed E2E KPI tests from vendors' manufactory to operators test bed
✓ Extended availability and security tests on SDN/NFV systems
✓ Tests towards cloud-based features (e.g.: resource allocation, elasticity, life-cycle management automation, multi-tenancy, etc.)

- Increased test complexity

√ "Carrier Grade" service quality must be persisted on the architecture built with multi-vendors decomposed functional modules
√ Uncertainty of test objects caused by multi-vendors, shared resource, elasticity, and automated orchestration capabilities
√ New SDN/NFV test designs to support the hybrid architecture
√ SDN/NFV system test result evaluation methodology for qualified and consistent reports

- Higher test frequency for SDN/NFV service production

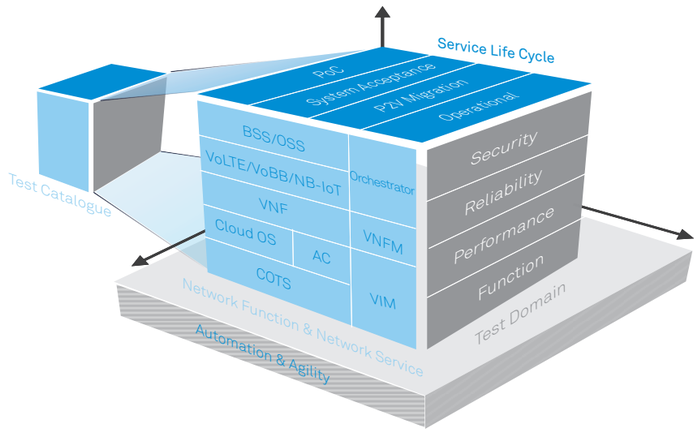
√ Operators' expectation on the potential accelerated new service development and integration with the "fail fast" abilities related to cloud native operations
√ More frequent releases or patches from separate SDN/NFV system components
√ Refreshing test methodology and processes when new updates frequently exist to SDN/NFV architecture

3. Testing as a Service Solution

Testing is ubiquitous and accompanies the whole SDN/NFV life cycle from concept, integration, launch, operation and retirement. TaaS solution is created and required to confront the multi-dimensional challenges, to provide persistent service quality even when test scope complexity changes and to achieve the cloud native agility requested by highly frequent validation.

The TaaS solution contains not only the test tools and platform, but also the methodology, processes, openness and industry-wide cooperation that consolidate and facilitate the transformation of SDN/NFV testing.

3.1 Multi-Dimensional Testing Model



TaaS solution methodology and processes are built from the multi-dimensional testing model. This model has consolidated into the context of requirements from both technology and operational perspective and is well extendable to address more future potential challenges along with the whole cloud transformation.

The key consideration of TaaS is presented from four dimensions as depicted in the aforementioned model:

- Full-scale Network Functions & Network Services coverage: A complete TaaS should support testing towards network modules, network functions (including both physical and virtual) and network services.
- Multiple test domains for Carrier Grade: Carrier Grade characteristics must be able to be validated by specified multiple domains testing.
- Service life cycle support: TaaS should be seamlessly integrated into service life cycle processes which facilitate validation activities through life cycle management.
- Automation & Agility: Test execution runtime and artifacts build the fourth dimension of TaaS. As one of the differentiators from classic testing service, test execution must be automated, and processes must be optimized for agility.

Based on this model, TaaS contains multiple test catalogues, one **Test Catalogue** is defined as one executable testing use-case that has the characters defined from four dimensions, consisting of:

√ "Network Function & Network Service", "Test domain" and "Service lifecycle" dimensions that together specify the test object and context of the test catalogue.
√ "Automation & Agility" dimension specifies for this test catalogue the correlated executable test artifacts and runtimes which support the testing automation process.

TaaS maintains a repository of test catalogues identified from a global knowledgebase and best practices, shielding the technology complexity existing in either the test object or test context, enabling the fast execution of the specific validation tasks.

3.2 Full Network Function & Network Service Coverage

TaaS supports various levels of Systems Under Test (SUT), as listed in the following table. The SUT could be classic Telco service, specific network functions which compose the service, or dedicated functional blocks that defined in the 3GPP or ETSI standards:

SUT	Service level	Function level	Functional block
New	NFVI	Hardware	Server
			Lanswitch
			Acceleration cards
		Software	Host OS
			Hypervisor
			SDN controller
	MANO	Application	VNFM
			NFVO
		Infrastructure	VIM

Classic Telco services with new architecture	VoLTE VoBB NBIOT VAS VPN	EPC	S/P GW
			MME
		IMS	P/S/I CSCF
			MGCF/BGCF
		SBC	A/I SBC
		AS	MMTEL/SCC AS
		UPCC	PCRF
		DRA	STP/Diameter
		HSS	HLR/SAE-IMS HSS
		CPE	CPE FW/CPE LB

It's worthy to mention that both test scope and complexity were increased by SDN/NFV technology due to the reason that its decomposed functional blocks have brought unlimited possibilities from combination of multiple technologies, multiple modules and multiple vendors. As the result, SUT could differ largely from one test-bed to another although it has the same name, like "VoLTE testing". The name "VoLTE testing" in the past could today be broken down further to "VoLTE on OpenStack Cloud", "VoLTE on Supplier's Cloud", "VoLTE on OpenStack Cloud with SRIOV", "VoLTE orchestrated by Orchestrator", etc.

TaaS has to possess the capability to quickly adapt to and support the flexible combination of various levels, various network functions and various network functional blocks. For this purpose the on-demand simulation of service traffic and interfaces is a key enabling capability.

3.3 Multiple Test Domains for Carrier Grade

To ensure the same Carrier Grade quality of service is being achieved, TaaS should perform the quality assurance in all the aspects requested by Telco services. It was commonly acknowledged that the quality should be reflected in the aspects including functional perspective, performance, availability and security. Dedicated test domains were set for the validation purpose on those dedicated aspects.

3.3.1 Functional Tests

Category	Object	Test Description
Feature Test	COTS	CPU, NIC, Memory, Storage, specification for virtualization.
	Hypervisor	Tenant based virtualized resource management.
	MANO	NF&NS lifecycle management from on boarding to terminating.
	Network Functions	3GPP defined network function features.
	Network Services	3GPP defined Telco services.
	O&M	FCAPS features.
Inter-operability Test (IOT)	3GPP Framework	Inter-operability for 3GPP protocols
	ETSI Framework	Inter-operability for NFV architecture

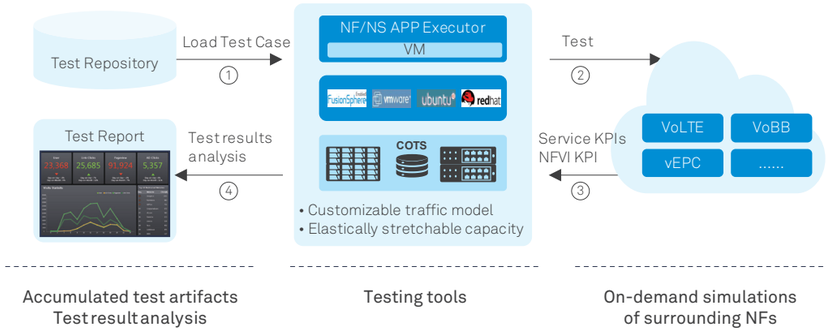
Functional test includes the feature test for different level of SUTs and the interoperability test for the interfaces between SUTs. Both feature test and interoperability test must comply with ETSI-NFV and 3GPP standards.

3.3.2 Performance Tests

Performance test makes sense as the proof of judgment for service quality and SLA. There are 3 typical scenarios supported by performance tests:

- Stability test: Validating the performance of SUT in terms of long-time operational simulation running with specified traffic model
- Benchmark test: Validating the offered specification of target SUT
- Robustness test: Validating the robustness of SUT by simulating destructive overloading traffic

Based on the combination of different traffic models and different simulations, much more possibilities can be supported for various purposes from the base of performance test. This enables operators the possibility to achieve the best balancing between investment and user experience.



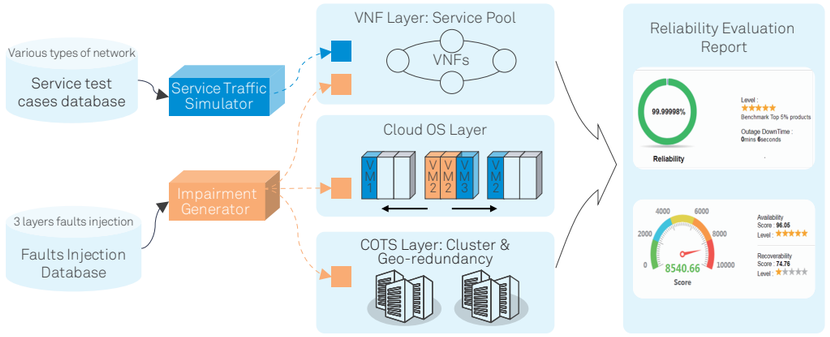
The above figure shows the generic mechanism of performance testing. The service traffic is simulated on the interfaces exactly as defined in the ETSI-NFV and 3GPP standard protocols and injected to SDN/NFV system. Measurements are then collected from the target SUT to get the performance result. The key competencies constructed in a TaaS performance test:

- Test repository enriched by accumulated test artifacts, supporting on-demand simulation of various interfaces and protocols, surrounding network functions and user behaviors.
- Software-centric test tools and platform in order to achieve effective use of test resources, supporting scalability that it can be deployed on virtual machines as required and the resource can be released when not required.
- Orchestration of traffic simulation to support the flexible customization as per the traffic profile and service profile specified by a live network, to ensure the test result more practical to live expectations.
- Automatic test result analytics based on a knowledge base collected in test repository and data caught by TaaS tools to offer the professional evaluation on the target SUT.
- End-to-end (E2E) analysis supporting the accuracy of the results based on big data and performance evaluation model developed from global experiences and best practices.

3.3.3 Reliability Tests

An Operator's network has always been representative of high reliability and best quality of service. For that purpose, various redundancy and load balance solutions are designed for a telecom network on each level (hardware/signaling link/service, etc.). In a SDN/NFV network, the introduction of COTS hardware, open source operating systems (OS) and / or multi-vendor components can cause possible uncertainty which makes reliability of the services risky and critical.

TaaS reliability test domain provides the proactive approach to test and evaluate the service reliability in advance. The reliability test mechanism shown below is built on the Software Fault Injection Test (SFIT) model that simulates a variety of different levels faults and injects the faults into different targets, especially where there are risky points or weaknesses throughout SDN/NFV environment. At the same time the target traffic flow is simulated and injected to the designated SUT. By collecting the data from SUT under the circumstance of running with faults, the robustness of SUT can be observed and calculated.



The Carrier-Grade reliability evaluation can be used to verify the potential of the system in the case of components failure, fault detection, fault isolation, fault recovery capability and eventually calculates the service availability. To ensure more precise and accurate evaluation, TaaS should build the following three key competencies:

- SDN/NFV network is based on hierarchical model, reliability test requires a faults injection database containing sufficient faults types on all the hierarchies, crossing hardware, host OS, guest OS and telecom-applications.
- The injected faults should be orchestrated to be more practical and it should be supported to do the injection to specified test objects or in the required polling method.
- The availability evaluation model is built on the indicators including service down time, impacted user number, service quality KPIs like call drop ratio, etc. within a certain time period, where TaaS should support the collection of all those indicators and relevant context, to support the precise availability calculation.

3.3.4 Security Tests

In SDN/NFV network, key components that may have security risks include VNF instances, local network resource assigned to VNF instances, remote reference of the local VNF instances, the local, remote and switch storage for VNF instances, etc. While not a complete list in this document, questions to ask are:

- How to protect these components from illegal accesses?
- How to ensure the authorization of the VNF is not tampered with?
- How to make sure the obsolete VNF resources on local and remote are completely removed?
- How to guarantee the authorization is not abused?

All of these are the key technical challenges for SDN/NFV security field. TaaS contains the security test domain for SDN/NFV, focusing on the multiple-dimensions, including:

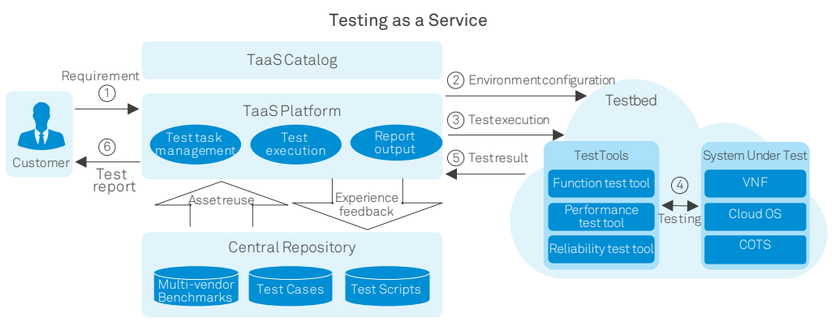
- Virtual machine security
- VNF security
- Operation monitoring of NFVI and VNF layers
- Data transmission security
- Storage security

3.4 Service Life Cycle Support

Service life cycle management is hereby defined as the supervision of the network services or applications in operators' network from initial planning through retirement. Validation activities go through the whole service life cycle, serving for different purposes in different life cycle stages. TaaS should contribute to the optimization of all validation activities and processes by leveraging the test artifacts and providing higher efficiency. TaaS supports typical use cases during life cycle management including but are not limited to:

- **Proof-of-Concept (PoC) testing:** Fast functional validation supported by functional testing block and on-demand simulators.
- **System acceptance:** Supports new installation requirement for the purpose of full functional and non-functional quality assurance and multi-vendors interoperability validation. Especially for VNF system acceptance use case, the newly designed NFVI readiness check category could facilitate the VNF planning and evaluation before VNF system introduction.
- **E2E system acceptance:** Supports E2E service validation requirements including user behavior simulators.
- **Migration testing:** Supports migration requirements for the purpose to make comprehensive guarantee tests needed for migration design, operation and after-migration service quality.
- **Change validation:** Fast regression test supports functional test block and on-demand simulators.

3.5 Automation & Agility



One of the four pillars of TaaS is the test automation artifacts. As diagramed in the above figure, the aforementioned test catalogue, or TaaS catalogue describes one executable testing use case which can be quickly automatically executed on defined test objects and domains for certain purposes.

TaaS catalogue, combined with the automation tools & platform, enable the automated test execution, and contribute to the agility of test process.

- Flexible selection for test scenarios and test cases

TaaS catalogue repository contains rich test use cases identified from global knowledgebase and best practices which can be further extended and customized by flexible selection of test cases from central test repository.

- Orchestration and automated execution

Orchestration should be offered by TaaS. The orchestration is applied to two aspects. One is test task orchestration, which provides the test task execution policy that the test task can be flexibly defined to carry out in serial or in parallel, by priority or by schedule. Second is the traffic orchestration, which supports the customized traffic simulation policy that generates traffic flow which can be scheduled in accordance to the required service profile and traffic profile. When starting the automatic execution from a test catalogue, all relevant test artifacts will be automatically invoked and executed without manual intervention.

- Efficient reuse of resources

The central test repository collected from global test experience and assets supports the quick replication and synergy. Software-centric testing platforms makes it possible to make use of cloud-based service environment with full scalability and elasticity, in the best cost-efficient way.

- Automatic analytics of the test results

Test result should be automatically analyzed and as the result the corresponding test report is automatically generated. The test report provides multi-dimensional test results statistics, together with the detailed test analysis and guidance.

- Optimized and agile test process

The test automation artifacts contribute to the optimization of test process to be more agile. All the test cases and execution steps should be written by a Test Driven Development (TDD) model, for the quick repeated validation of frequently released iterates so that test processes gain the higher quality benefited from frequency and agility benefited from automation.

4. Openness & Cooperation

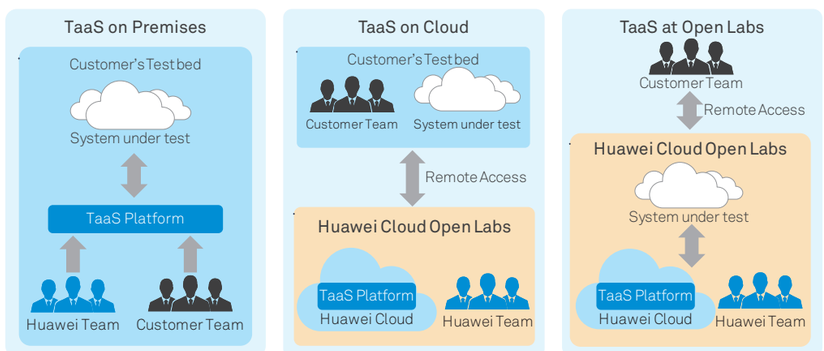
Under the opening and decoupling of the Telco network architecture, TaaS is required to provide testing from multi-dimensional perspective. Adapting to the flexible combination of multi-vendors scenarios, for this purpose, openness and SDN/NFV eco-system are the key enablers for the quick adaptation.

In other words, TaaS should be capable to provide plenty of openness, for example rich open interface APIs to quickly integrate with various possibilities from multiple vendors components and open source components, at the same time, it should also be able to quickly integrate with the existing network. Proactive Partner or Vendor involvement with TaaS APIs and capabilities with improve the outcome of the platform and its openness.

Huawei actively embraces openness and cooperation.Huawei with TaaS has completed interoperability cross-verifications / certificates with 60 partners, issued 47 technical certificates to partners, and achieved 15 third-party certificates from 3 partners in the Cloud Open Labs.. Huawei TaaS solution has integrated OPNFV community functest and yardstick projects, and is working together with 2 testing partners. These experiences are quickly accessible and can be reused in new projects.

5. Testing as a Service Delivery Mode

TaaS can be supported in 3 models: TaaS on premises, TaaS on cloud, and TaaS at Open Labs. Operators can choose a different TaaS service model to quickly and accurately match their own testing demands.



- TaaS on premises

Service Model Description: TaaS service provider deploys the TaaS artefacts in the opertor's test bed, and then perform testing directly on operator's isolated environment together with or under the surveillance of operator.

Applicable Scenarios: Operator owns the independent isolated testing environment.

- TaaS on cloud

Service Model Description: Operator raises the testing requirements, TaaS service provider integrates TaaS cloud service with operator's test bed. After defining and choosing required test catalogues from TaaS cloud service, testing will be remotely performed towards the operator's test bed by TaaS service provider together with or under the surveillance of operator.

Applicable Scenarios: Operator could use the cloud service to finish test tasks on own test bed environment without concerning resources for testing platform / tools.

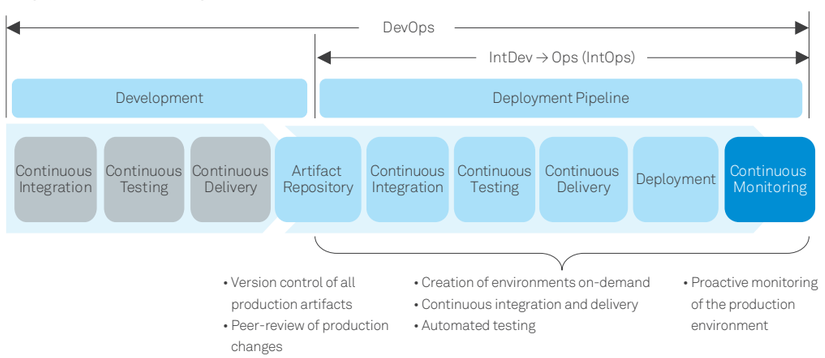
- TaaS at Open Labs

Service Model Description: TaaS service provider builds the test environment and required test platform/ tools in their Open Lab and fulfill the tests as per the requirements of operator.
Applicable Scenarios: Operator focuses on business growth. In this case they only need to give the test requirements, resource & networking requirements and test scope to TaaS service provider, then wait to get the required test result within required timeline.

6. Evolving to Telco DevOps

The DevOps model will be able to further accelerate Telco service production by introducing the concept of CI (Continuous Integration), CT (Continuous Testing) and CD (Continuous Delivery and Continuous Deployment,) although there should be a proper adaption to each other between DevOps model and the Operator's integration & operations processes.

One of the mediation approaches for Telco DevOps model is to introduce the artifact repository between suppliers' development process and Operator's integration process, where continuous testing is performed towards the artifacts update and further continuously delivered to the next stage, as shown in the figure below:



A deployment pipeline needs to be constructed on the Telco DevOps model containing the CT and the CD tools chain. The full capability set of TaaS will contribute to build the pipeline system and enable the continuous testing process. To enable the TaaS evolving to CT in Telco DevOps model, TaaS should be designed based on SOA methodology, offering the open APIs to DevOps deployment pipeline and process.

7. Conclusion

TaaS is required to address the critical challenges of adopting the SDN/NFV technology with the need to deliver a faster time to market solution on the Operator's network. In conclusion, TaaS helps operators achieve cost reduction, reduction of manual errors as well as duplicated efforts, which is a must have for any operator seeking an agile DevOps-based practice resulting in improved TCO and efficient SDN/NFV integration & operations.

For your TaaS platform requirements, Huawei has developed TestCraft. TestCraft can be deployed on premises, in a cloud and at Huawei's Cloud Open Labs. This allows Operators to choose different TaaS service models to quickly and cost effectively match their own testing demand requirements. TestCraft is designed for your SDN/ NFV deployment pipeline needs constructed from the target Telco DevOps model containing the CT and the CD tools chains used for service releases.

While testing will always be ubiquitous and accompanies the whole SDN/NFV life cycle management from concept, integration, launch, operation until retirement. TestCraft TaaS solution is created to confront the multi-dimensional challenges required in todays and future 5G networks to achieve the cloud native agility requested by our customer to be a leader in their market.