OCCI and TTCN-3

Towards a Standardized Cloud Quality Assessment Framework

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Abstract: Impacting basically all types of IT infrastructures The Cloud is one of the most important evolving IT paradigms. A standard-based Cloud quality and compliance assessment framework will be therefore of utmost importance. Bringing together the Open Cloud Computing Interface OCCI and the ETSI standardized test specification language TTCN-3 and related test methodologies this paper is going to demonstrate initial steps towards such a framework. Taking into account the diversity of Cloud infrastructures, of service providers, and related architectural, harmonization and standardization effort this approach is mainly motivated by studying Cloud-related effort of the NIST Cloud Computing Program and the ETSI Cloud Standards Coordination (CSC). Reflecting the "Cloudiness" of the Software Defined Network (SDN) and ETSI Network Functions Virtualization (NFV) this paper is considering these initiatives as necessary elements of the scope of every future standardized Cloud quality assessment framework as well.

1 INTRODUCTION

Impacting basically all types of IT infrastructures "The Cloud" is one of the most important evolving IT paradigms. A standard-based Cloud quality and compliance assessment framework will be therefore of utmost importance. Bringing together the Open Cloud Computing Interface OCCI and the ETSI standardized test specification language TTCN-3 and related test methodologies this paper is going to demonstrate initial steps towards such a framework. Taking into account the diversity of Cloud infrastructures, of service providers, and related architectural, harmonization and standardization effort our approach is motivated by studying Cloud-related effort of the NIST Cloud Computing Program, NIST CC, the ETSI Cloud Standards Coordination (CSC). Reflecting the "Cloudiness" of the Software Defined Network (SDN) and ETSI Network Functions Virtualization (NFV) this paper is considering theses initiatives as necessary elements of the scope of every future standardized Cloud quality assessment framework.

The rest of the paper is organized as follows: Chapter 2 is introducing pertinent work of NIST CC and ETSI CSC– here the role of the OCCI standard becomes already visible. The methodological look at NIST/ETSI will follow the triple "use cases – standards – testing" and corresponding mappings.

Chapter 3 describes how, following the virtualization paradigm, the "Software Defined Network", SDN, and ETSI NFV have met the Cloud. It will be noticed that the NFV use case "IMS as a Service" (IMSaaS) has in its original 3GPP and ETSI context an elaborated TTCN-3 framework.

Chapter 4 introduces the OGF OCCI standard. Chapter 5 decribes some OCCI related effort of relevance in the given context.

Chapter 6 introduces TTCN-3, the "Testing and Test Control Notation Version 3" the test specification language standardized by ETSI. Chapter 7 describes relevant TTCN-3 effort.

Chapter 8 describes "TTCN-3 on top of OCCI" for both a subset of the ETSI Interoperability test cases and for BonFIRE – a large European Multi-Cloud project.

Chapter 9 resumes the paper and gives an outlook on future work.

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2 TOWARD A STANDARDIZED CLOUD QUALITY ASSESSMENT FRAMEWORK

Influenced by and possibly influencing the evolution of Cloud ecosystems potential Cloud adopters have developed related use cases of different abstraction level above the basic technologies in question. At the same time and in a similar interdependency relation in numerous bodies Cloud standards have evolved and are still evolving. In such a situation mapping use cases to compatible or even "integrated" standards is one of the natural important steps to happen next. Eventually, addressing different test types such as conformance, performance etc. test cases will be specified. Being a simplified one, this process is nevertheless a typical and necessary element in the evolution towards a quality assessment framework.

Following this process and given the sheer weight of the US Government as a Cloud adopter and the important role of ETSI concerning high-quality standards and formal testing methodologies we are going to use the NIST Cloud Computing Program and the ETSI Cloud Standard Coordination effort in order to argue for a TTCN-3- and OCCI-oriented, standardized Cloud quality assessment framework.

2.1 NIST CC Program

The NIST (National Institute of Standards and Technology) designed its Cloud Computing Program, CC, "to support accelerated US government adoption, as well as leverage the strengths and resources of government, industry, academia, and standards organization stakeholders to support cloud computing technology innovation" (NIST, 2014). The cited document "US Government Cloud Computing Technology Roadmap" comprising the Volume I "High-Priority Requirements to Further USG Agency Cloud Computing Adoption" and Volume II "Useful Information for Cloud Adopters" summarizes the results of now the finalized Phase I and defines and relates ten "high-level requirements" to the different NIST CC working groups for Phase II.

Key documents of Phase I are concerning Cloud taxonomy and vocabulary, reference architecture, standards and security; for references see (NIST, 2014).

The NIST projects and working groups apply a use case methodology to define business and technical operational scenarios and requirements. The NIST-chaired public Cloud Computing Business Use Case Working Group (CCBUCWG) has produced use cases at the functional mission level. Those "business use case are decomposed into a list of high-level requirements, then into successively more detailed requirements, until they can ultimately be mapped to technical requirements that are required to identify and executed" as "technical use cases". Dealt with by the group "Standards Acceleration to Jumpstart the Adoption of Cloud Computing" (SAJACC) the latter use cases are "designed to facilitate the qualitative testing of standards through the use of third-party APIs implemented in adherence to candidate specifications and emerging standards". SAJACC use cases represent single activities, such as the "deletion of data, and the actions needed to successfully execute that activity (receive the request, respond to the request, execute the request, etc.)".

Without any ambition towards formalization in terms of possible map-ability and automated processing, for the description of use cases two types of templates have been developed.

A particular set of standards in relation to a use cases was termed "compatible standards" – no specific exercise was undertaken to consider the "integration" of those specific standards in question – e.g. CDMI and OCCI; see also below (Edmonds, 2011) However, concerning the "current state of conformity assessment in Cloud Computing", (NIST, 2014), section 6.2.4 states: In some cases, such as the CDMI, OCCI, OVF, and CIMI standards… industry-sponsored testing events and "plug-fests" are being advertised and conducted with participation from a variety of vendors and open source projects and community-based developers. In other cases, either the standards are not yet mature enough to permit such testing, or the participants have not yet exposed the conformity assessment processes to public view. – In this spirit NIST representatives gave presentations at the "First Cloud Interoperability Week" (Sill, 2013); see also (Liang, 2013a). Finally, in order to cope with questions like "is the proposed quality assessment framework not overkill?" - it should be mentioned that the NIST is considering Cloud ecosystems as eventually big, complex and potentially endangered by "catastrophes" comparable to the famous Internet or global power grid breakdowns. Accordingly – with participation of the OGF Research Group on Grid Reliability and Robustness - NIST has started the "Complex Information Measurement Project - Koala" (NIST, 2015).

It should be noticed that so far NIST doesn't deal with SDN or NFV issues, see below.

2.2 ETSI CSC

Being part of the European Commission's Cloud related strategy the so-called key action "Cutting through the jungle of standards" was assigned by DG Connect to the specifically created ETSI working group "Cloud Standards Coordination", CSC. The latter in its mission's final step 3 created three "Specification identification gap analysis" working groups: SLAs – Security & Privacy – and – Interoperability, Data port, Reversibility. Launched in December 2012, the CSC provided a final report (ETSI, 2013). This report stated that "the Cloud Standards landscape is complex but not chaotic and by no means a 'jungle' ".

In this report ETSI CSC introduces vocabulary and taxonomies applicable to Cloud Actors and their Roles within Use Cases. The analysis of Use Cases comprises the following dimensions: "Phases and Activities", "Perspectives" (SLAs, Interoperability, Security), generic domains (e.g. "Applications in the Cloud", "Cloud Bursting" etc.), and "Phases and Activities". This schema is then used in a mapping of use cases to standards.

Gaps related to SLAs, security and privacy are dealt with in the final report. Interoperability is specifically covered by the Technical Specification "CLOUD; Test Descriptions for Cloud Interoperability" (ETSI, 2013b). The standards dealt with herein are OCCI, see below, and CDMI, CAMP, OVF and CIMI. In Chapter 8 below we are going to demonstrate some initial work related to the OCCI-related test cases.

It should be mentioned that also ETSI CSC expresses a positive view concerning OCCI (together with CDMI and OVF): "OCCI as the universal and extensible interface description for the provisioning of virtualised computing resources."

ETSI CSC has called for a 2nd Phase of work to be started in early 2015 – and in close cooperation with NIST CC.

Without any further explanation the ETSI CSC final report provides a list of the ETSI NFV specifications; see next chapter.

3 ETSI NFV, SDN AND THE CLOUD

Instrumental as a key concept and as enabler of many aspects of computing , storage and networking "Virtualization" lies at the ground of both the Cloud and concepts or initiatives such as the "Software Defined Network", SDN (ONF, 2011) and ETSI's "Network Function Virtualization", NFV (ETSI, 2012).

SDN has evolved as a potential solution to both the growing management complexity of the overly successful Internet and, in turn, the growing "ossification" of the latter. Aiming at more flexibility and dynamicity of network services through programmability of network hardware boxes such as routers, switches, firewalls etc. the OpenFlow™ protocol and API is a key element in the context. Launched in 2011 by Deutsche Telekom, Facebook, Google, Microsoft, Verizon, and Yahoo!, the Open Networking Foundation (ONF) is a non-profit organization with more than 140 members whose mission is to accelerate the adoption of open, standardized OpenFlow-based SDN.

Used as generic term "software defined networking" is also addressed by the "Network Functions Virtualization - Industry Specification Group", NFV(ISG). Initiated in 2012 within ETSI by seven telecom operators the group was joined by over 200 companies including network operators, telecoms equipment vendors. Opposed to SDN, NFV was primarily driven by concerns related to OPEX and CAPEX of typical telecom hardware appliances and service agility. NFV aims to use "advanced IT virtualization techniques" (aka Cloud plus Cloud enablers i.e. hypervisors etc.) in order to convert typical telecom appliances and service frameworks into "X as a Service" instances, the latter class being instantiated even into "IMS as a Service", IMSaaS.

SDN and NFV are highly complementary to and independent of each other.

In order to promote NFV trough OpenFlow-based SDN in March 2014 ONF and ETSI agreed on a related strategic partnership.

The NFV(ISG) has produced since five specifications covering NFV use cases, requirements, the architectural framework, and terminology. The fifth specification defines a framework for coordination and promotion of public demonstrations of Proofs of Concept, PoC (ETSI, 2014). The PoC demonstrate key aspects of NFV use cases – specifically the explicitly Cloud-related "NFV Infrastructure as a Service" (NFVIaaS), the "Virtual Network Functions as a Service" (VNFaaS), the "Service Chain Forwarding Graphs" (VNF FG), the "Virtual Network Platform as a Service" (VNPaaS) and the mobility–oriented "Virtualization of the Mobile Core Network and IMS". The first results of the NFV PoC have been showcased.

While aiming at vendor and product neutrality the Cloud "core" of the PoC was the OpenDaylight Hydrogen release of OpenStack comprising inter alia the OpenStack Neutron component as OpenFlow oriented SDN controller.
Here, in the context of this paper, it should be noticed that this whole architecture is controlled by a (super-)set of the OpenStack RESTful APIs; see below the MCN project.
Finally, it should be mentioned that ETSI NFV doesn't refer to ETSI CSC or the ETSI TC MTS, the Technical Committee Methods for Testing and Specification (ETSI, 2015); specifically, there is no hint given to the ample, standardized TTCN-3-oriented test framework (ETSI, 2015a).

4 OCCI

The Open Grid Forum's (OGF) 'Open Cloud Computing Interface' (OCCI) is a well-defined, RESTful Cloud management protocol and interface, which can be applied to and extended from its initial target IaaS to functional and non-functional aspects also of PaaS and SaaS – even in Multi-Cloud ecosystems.
The definition of OCCI comprises a "Core" and a meta-model aspect according to the following figure, see (OCCI, 2011b).
The "Core" describes the foundation of the OCCI type system – "what types of resources can be out there". This is orthogonal and complementary to the wire".
The meta-model aspect represents the descriptive part allowing for extensibility, hierarchies, dynamic runtime modifications of resource instances and tagging via Mixins, and introspection via the mandatory discovery interface (Edmonds, 2012).
Members of the OCCI specification group developed a related conformance platform in Python (OGF, 2012b and OGF, 2012a). This work was not continued after 2012; it is/was not directly targeting whole OCCI-controlled Cloud systems but the conformance of (language) specific OCCI implementations.
The OCCI Working Group of the OGF is actively pursuing the further development of the OCCI standard; a completed specification is available e.g. for JSON rendering; a "Monitoring" specification and a related "Notification" specification are almost ready, and there is work for a "Platform" (PaaS) specification; see (OGF, 2014).
At the same time the WG is present at many related Cloud events such as the Cloud Interoperability

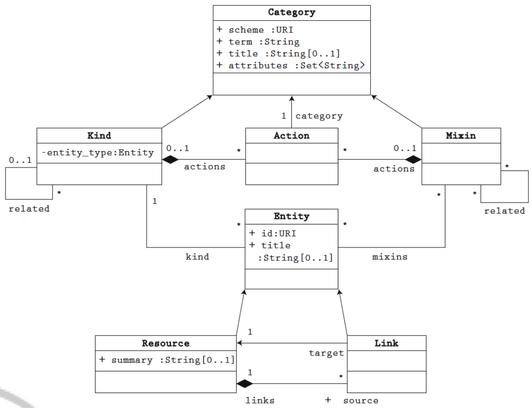

Figure 1: The OCCI "Core" Model.

Week mentioned above. Basically all WG members are also present in NIST CC or EGI (EGI, 2015) and MCN; see below.

5 OCCI-RELATED EFFORT

In order to further argue for the "robustness" of the OCCI case, in the following we are going to shortly mention effort covering technical and "market" aspects of OCCI applicability.

5.1 OCCI Technical Versatility

In (Edmonds, 2011) a standards conformant "integration scenario" of OCCI, CDMI and OVF is presented.

The "First Open Cloud Broker" developed in the CompatibleOne project and initiative is an early example for the extensibility of OCCI beyond IaaS (CompatibleOne, 2015).

The EU project MCN - Mobile Cloud – Networking, 2012-2015, "is motivated primarily by an ongoing transformation that drives the convergence between the Mobile Communications and Cloud Computing industry enabled by the Internet" (MCN, 2014). MCN's two scenarios are "Exploiting Cloud Computing for Mobile Network Operations" and "The End-To-End Mobile Cloud". While not fully concurrent with ETSI's NFV PoC architectural principles MSC is about to realize a comparable SDN/NFV framework wherein the Cloud component will be represented by OpenStack too. In contrast to ETSI's PoC non-standard set of related RESTful interfaces MCN is targeting OCCI. Referring to Core meta-model mechanisms, (MCN, 2013) section "2.4.1 OCCI Extensions" and "2.4.2 OpenStack Extensions", the project has defined necessary extensions to both OCCI and OpenStack.

Finally, among the set of MCN's XaaS to be provided we are specifically mentioning MaaS, Monitoring as a Service (see also below the BonFIRE project) and IMSaaS, IMS as a Service.

The OCCI work in MCN is well aligned with the OCCI WG.

5.2 OCCI in Large Infrastructures

"The European Grid Infrastructure (EGI) is building a federated, standards-based IaaS Cloud platform, building on its decade-long experience in delivering a reliable, federated Grid infrastructure for scientific computing and e-Research across Europe and worldwide." "Federations are enabled by a set of core services such as seamless authentication and authorization of users, gathering of accounting information, information discovery, monitoring and VM management across multiple cloud domains; see (EGI, 2015)

In the given context it is of relevance that EGI Engage, the next large project of the initiative, is targeting well defined OCCI extensions in order to increase functions and performance of its pan-European Cloud federation. This work is closely aligned with the OCCI WG.

Our tests below are using the so-called rOOCI, an OCCI implementation in ruby. The rOCCI is part of the EGI effort.

6 TTCN-3

TTCN-3, the "Testing and Test Control Notation Version 3" is a successful Test Specification Language standardized by ETSI. Initially targeted at protocol conformance testing e.g. for IPv6, or SIP, the coverage of TTCN-3 was extended to new technical domains such as the Web, embedded and real-time systems, and new sectors such as Health, Automotive and "Intelligent Transport Systems" (ITS). Related organizations are e.g. 3GPP, OMA and AUTOSAR. The ETSI TTCN-3 standards have also been adopted by International Telecommunication Union (ITU-T) in the Z.160 series. The main characteristics of TTCN-3 are: Multi-Separation of Concerns by dividing a test system into an abstract but executable Test Specification Layer ("ATS" in Figure 2), and Concrete Codec and System-Adaptation Layers; see again Figure 2. From an effort point of view codec and adapter represent a major piece of (initial) work, paving the way towards a potential large testing framework at ATS level. This separation between concrete and abstract layer is also allowing for a high degree of reusability. Targeting testing by design TTCN-3 provides an elaborated mechanism for the construction of Templates the latter to be used as test oracles; see e.g. (Schieferdecker, 2012). A related powerful Template matching mechanism then serves to validate output from the "System under Test" (SUT) on the level of the ATS; compare this e.g. with the language dependencies in (OGF, 2012a). - Related global Verdicts are computed, possibly composed from local Verdicts.

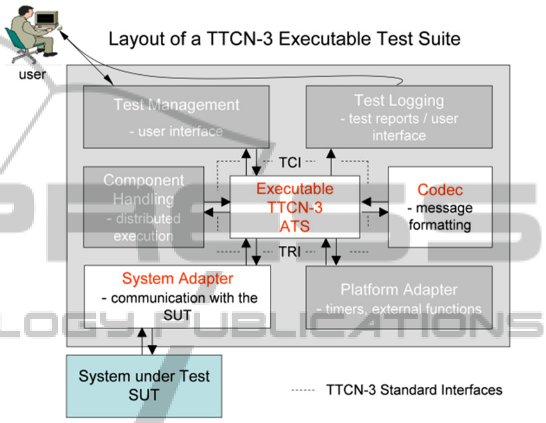

Figure 2: Layout of a TTCN-3 Executable Test Suite.

7 TTCN-3 RELATED EFFORT

In following, the first section is shortly describing effort related to TTCN-3 language developments. Section two is showing TTCN-3 as an element of ETSI's effort towards model-based testing.

7.1 TTCN-3 Development

TTCN-3 related effort is devoted to both the development of the language as such (via well- -- defined formal procedures within the ETSI); an example of relevance in context is "MTS The Testing and Test Control Notation version 3; Part 11: Using JSON with TTCN-3" - and other aspects. Such work may be carried out e.g. in cooperation with tool providers – to improve the efficiency of the coding/decoding process in a Web service environment would be an example. For a recent overview see (Stepien, 2014).

7.2 TTCN-3 in the ETSI TC MTS

TTCN-3 is not "just another standalone test specification language" but is part of an overall

effort within ETSI to further the development of methodologies in the spirit of "model-based testing" (ETSI, 2015).
Initially targeting communicating systems the ETSI MTS is addressing the formalization and mechanization/automation of a stack of processes and specifications ranging from requirements solicitation and "notation" over test and test purpose to test case specification.
Herein TTCN-3 is placed at the bottom layer.
Looking at the table format of the NIST technical and the ETSI CSC use cases the corresponding TC MTS historical effort is TPLan, ETSI ES 202 553. At present the TC MTS is pursuing with the TDL, Test Description Language, a more rigorous approach: integrating and unifying test description and test purpose specification layer above TTCN-3 TDL raises the abstraction layer of the latter and allows at the same time for down-mapping from the requirements layer; see (Makedonski, 2014).

8 TTCN-3 AND OCCI

"TTCN-3 on top of OCCI" was, to our knowledge, presented for the first time at the "Cloud Interoperability Week Workshop", (Liang, 2013a) and at the UCAAT 2013 (Liang, 2013b). This work was related to the initial version of ETSI "Test Descriptions for Cloud Interoperability" (ETSI, 2013b).
We improved and extended this effort in the following way:
- We wrote new versions of the Codec and the System Adapter allowing specifically for a complete treatment of all coding and systems requirements of the OCCI tests of (ETSI, 2013b); see Figure 2 and Figure 3 again for the positioning these components.
- Using the current version of the ETSI document, so far we carried out all the OCCI Core and Infrastructure tests against a rOCCI-based EGI Cloud test infrastructure (EGI, 2015).
- We run initial tests of the BonFIRE Multi-Cloud project "Elasticity as a Service" (for "BonFIRE and OCCI" see below), (BonFIRE, 2014).

8.1 TTCN-3 and OCCI Mapping

The Figure 3 below shows the functional components and potential mappings of a TTCN-3 test system and those of an OCCI controlled Cloud system:

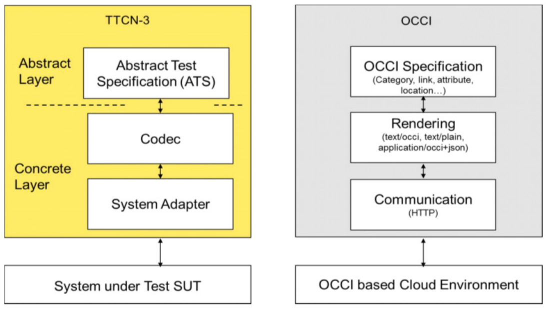

Figure 3: Mapping TTCN-3 - OCCI.

Elements formatted according to the OCCI specification can be expressed in terms of a TTCN-3 Abstract Test Specification. The rendering of the different MIME types will be accomplished by the Codec. The OCCI transport via HTTP will be provided by the System Adaptor.
For example, the OCCI "Category" can be abstracted into the following TTCN-3 Data type:

```
Category {
     charstring category,
     CategoryValue category_value
}
type set CategoryValue {
     charstring term,
     charstring scheme,
     charstring class,
     charstring title optional,
     charstring rel optional,
     charstring location optional,
     charstring attributes optional,
     charstring actions optional
}
type set of Category CategoryList;
type record Category {
     charstring category,
     CategoryValue category_value
  }

  type set CategoryValue {
     charstring term,
     charstring scheme,
     charstring class,
     charstring title optional,
     charstring rel optional,
     charstring location optional,
     charstring attributes optional,
     charstring actions optional
}
type set of Category CategoryList;
```

In order to carry out the ETSI test case "TD/OCCI/INDRA/CREATE/004: Create an OCCI Compute Resource" one has to create the following TTCN-3 request template:

```
   template OCCIReq
Req_TD_OCCI_INFRA_CREATE_004 :={
      url_req :={
      scheme := "http://",
      authority :=
"rocci.herokuapp.com",
      path := "/compute/"
   },
   category_list := {
      {
         category := "Category",
         category_value := {
            term   := "compute",
            scheme :=
"http://schemas.ogf.org/occi/infrastruc
ture#",
            class  := "kind"
         }
      },
      {
       category := "Category",
       category_value := {
           term   := "small",
           scheme :=
"http://my.occi.service/occi/infrastruc
ture/resource_tpl#",
           class  := "mixin"
       }
     },
     {
       category := "Category",
       category_value := {
           term   := "my_os",
           scheme :=
"http://my.occi.service/occi/infrastruc
ture/os_tpl#",
           class  := "mixin"
       }
       }
     },
     link_list := omit,
     x_occi_attribute_list := omit
   }
```

This template represents the test oracle, i.e. the expected response of the SUT, for this conformance test.
The related HTTP verbs GET, POST, PUT and Delete and the OCCI rendering have to be parameterized as follows:

```
   /* select HTTP verb */
   modulepar boolean Create := true;
   modulepar boolean Read := false;
   modulepar boolean Update := false;
   modulepar boolean Delete := false;

   /* select OCCI Rendering */
   modulepar charstring ContentType :=
"text/occi";
   modulepar charstring AcceptValue :=
"text/occi";
```

The annotated Figure 4 shows the corresponding result of the test:

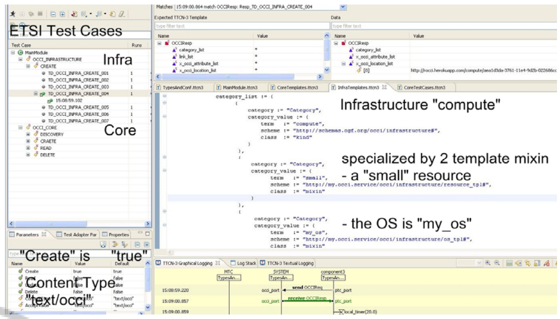

Figure 4: Creating an Infrastructure OCCI Compute resource modified by two mixins.

The tool window (TTworkbench, 2015) is showing:
- the list of all the implemented ETSI tests - the currently executed is highlighted (left upper corner)
- the action “create” and the related content type “text/occi”
- a “compute” “kind” modified by the two “mixins” (large window, middle right; see Figure 1 again for terminology); (the small window, upper corner right, is showing that the compute resource was created on a server of the PaaS provider HEROKU used by EGI for testing purposes).
- the OCCI Request/Response message exchange between the System_under_Test and the Test System (graphical window right bottom; the Verdict “pass” message is just not visible;).

8.2 TTCN-3 and “BonFIRE OCCI”

BonFIRE a recent EU project has realized and is providing a multi-site testbed on top of seven Cloud infrastructures operated by seven project partners. BonFIRE IaaS offers heterogeneous compute, storage and network resources, (BonFIRE, 2014).
In the given context, the main features of the BonFIRE (BF) architecture are the following:
- BF implements an “almost” OCCI-based resource manager on top of the participating IaaS testbed sites (no Categories etc., no MIXINS).
- The rendering uses the private type “application/vnd.bonfire+xml”
- BF provides a monitoring capability at both the VM and physical level. Under user control events generated by (Zabbix) monitoring agents are transported via AMQP to an “Aggregator”. From a functional point of view, the BF monitoring fits well the “Focused Technical (security) Requirements” of (NIST, 2014) Part II, “Visibility/Control for Consumers”.

- BF provides an experimental EaaS – Elasticity as a Service - across the test bed sides.

Formally, according to the BF data model, the BF user carries out "Experiments". In a full OCCI setting "Experiments" would be defined as a Category above the participating infrastructures. Except for the description part and the fixed allocation of monitoring agents to user created VMs the monitoring architecture is close to the proposal presently discussed within the OGF OCCI WG.

The annotated Figure 5 shows:

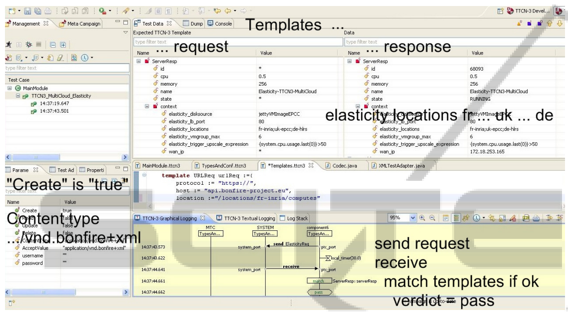

Figure 5: Creating a BonFIRE elasticity group.

- the creation of a elasticity group distributed over several BonFIRE geographical sites in France, the UK and Germany - in response to the request template (upper part right)
- the related action is (naturally) "create"
- (left below) the rendering's private type "application/vnd.bonfire+xml"
- the verdict "pass" message (graphical window part).

Not considering the only "almost" OCCI compliance of the project BonFire is a clear and working example for the potential of OCCI beyond its initial specification.

9 SUMMARY AND OUTLOOK

Using Cloud related work of NIST and ETSI we have presented standardized testing of standard-based Cloud infrastructures as a necessary element of a Cloud quality assessment framework. We have shown that OCCI is well positioned to play a pivotal role within that context.

Assuming a key role of SDN/NFV in future Cloud provisioning we have also pointed to work using OCCI in SDN/NFV settings of Cloud infrastructures.

Then we have introduced the ETSI effort towards model-based testing – comprising TTCN-3 at the lowest layer.

In summary we propose – as strategically vision behind our effort - to adopt the Cloud world as the next big application field of the well-established ETSI TTCN-3-related testing methodologies.

Finally, as a proof-of-concept we demonstrated "standardized" TTCN-3 test cases against OCCI controlled Cloud test beds.

In order to gather and solicit support for our vision future work will include true interoperability tests in the spirit of ETSI CSC and further test types such as performance tests. If SDN/NFV Cloud infrastructures such as in the OCCI-oriented MCN become available tests exploiting advanced features both of TTCN-3 and OCCI are foreseen.

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