End-to-end network service deployment over multiple VIMs using a disaggregated transport optical network

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ABSTRACT

5GPPP 5GTANGO project has extended SONATA NFV platform in order to be used to deploy network services over multiple Virtualization Infrastructure Managers (VIM), which are interconnected through one or multiple WAN Infrastructure Manager(s) (WIM). In this paper we present a WIM, developed in the context of 5GPPP METRO-HAUL, which is responsible for tackling the necessary connectivity services in order to interconnect the multiple NFV Infrastructure Points-of-Presence (NFVI-PoP).

In this paper, we propose to use ONF Transport API (T-API) as WIM NBI, with the purpose to control the underlying optical disaggregated network. Using this interface, SONATA NFV platform requests the necessary connectivity through its novel T-API plugin.

Keywords: NFV, WIM, disaggregated transport networks.

1. INTRODUCTION

NFV is will provide significant benefits to service providers such as higher network service deployment flexibility and faster time-to-market due to software-based network functions, lower capital expenditure, due to the usage of Commercial-Of-The-Shelf (COTS) hardware, instead of dedicated appliances, as well as lower operations expenditure, due to network automation. NFV Infrastructure Points of Presence (NFVI-PoP) support service providers' network virtualization [1] and are deployed in data centres that are interconnected through different transport networks using different technologies. Typically, NFVI-PoP allow the deployment of Network Services through the Virtualized Infrastructure Manager.

Dynamic control of transport optical networks is a requirement for NFVI-PoP interconnection. In previous papers, ONF Transport API (T-API) has been demonstrated as a possible control solution for transport networks, as it enables real-time orchestration of on-demand connectivity setup, control and monitoring across diverse multi-layer, multi-vendor, multi-carrier networks [2]. T-API 2.0 was released in April 2018. It incorporates new support for novel scenarios taking into consideration constrained connectivity, protection/restoration schemes and notification service, among others. These advanced scenarios will allow for automation and simplification of network interconnections.

T-API has been proposed for NFVI-PoP interconnection. [3] presents several use cases to support network services deployed on top of infrastructure, which is interconnected over a Wide Area Network (WAN) infrastructure. In this context, a Network Service, which is a composition of Virtual Network Functions, is instantiated by the interactions among operations support system/business support system (OSS/BSS), NFV Orchestrator (NFV-O), Virtualized Infrastructure Manager (VIM), and Network Controllers, also known as WAN Infrastructure Managers (WIM).

Disaggregated optical networks propose that network elements as transponders, reconfigurable optical add drop multiplexers (ROADMs) and optical amplifiers are provided by different vendors (i.e., white box) and coexist in the same Software Defined Networking (SDN) control within a unique transparent optical domain. In order to cope with this heterogeneity, 5GPPP Metro-haul project proposes the usage of the ONF Transport API as its SDN controller northbound interface and assumes a partial disaggregation model. Network Elements include devices modelled as OpenConfig terminal devices/Optical Platforms [4] or OpenROADM devices [5] with their component Degrees (DEG) and Shared Risk Groups (SRG, OpenROADM naming for the add/drop component).

5GPPP 5GTANGO project extends SONATA service platform [6] (which acts as an NFV orchestrator) in order to be used to control a WIM through ONF T-API, for multiple VIM interconnection. Thus, a natural relationship between the two projects exists in the sense of joining forces to contribute to network service deployment on top of multiple PoPs using SONATA service platform, which are interconnected using Metro-haul extended SDN controller.

2. END-TO-END NETWORK SERVICE DEPLOYMENT OVER MULTIPLE VIM

SONATA Service Platform is an NFV service programming, orchestration, and management framework [6]. It provides a development toolchain for virtualized network services, fully integrated with a service platform and orchestration system. It introduces a modular and flexible architecture for the Service Platform, which includes an NFV-O and a VNF Manager (VNF-M). SONATA main components and features are function- and service-specific managers that allow fine-grained service management, slicing support to facilitate multi-tenancy, recursivity for improved scalability, full-featured DevOps support and network integration with WIM support.

We have based our NFVI-PoP interconnection scenario as shown in Figure 1, where two VIM are interconnected through a disaggregated transport network, which is able to control optical ROADMs using OpenROADM models and Packet switches are based on OpenConfig model.

The T-API topology service is required to explore a set of connectivity end points (in T-API terminology service-interface-points). In order to interconnect the VNFs and to provide the network service, two or more end points given by the NFV-O are then interconnected with the T-API connectivity service including capacity and layer information, among others.

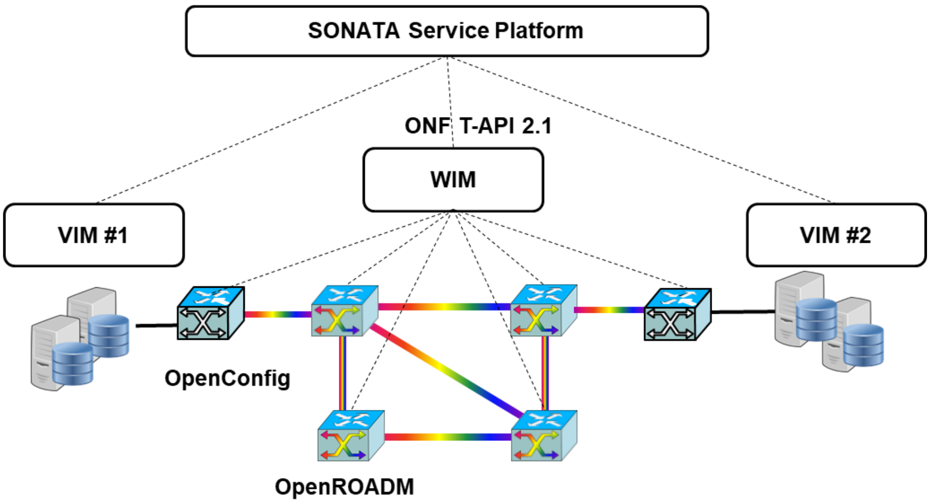


Figure 1 Proposed architecture

The Service Platform (SP) interacts with VIMs and WIMs in order to request and manage infrastructure resources, both Datacenter resources (VIMs - Virtualized Infrastructure Manager) and WAN resources WIMs (WAN Infrastructure Manager). The Infrastructure Abstraction (IA), located in the lower layer architecture of 5GTANGO Service Platform, has a southbound interface that implements the APIs needed to communicate with the VIMs and WIMs. In the case of VIMs, the IA generates HEAT templates to orchestrate the resources in OpenStack. Additionally, the IA uses neutron to handle the datacenter networking, as well as the keystone for authentication among other OpenStack APIs.

Moreover, the IA also implements an interface to the WIM in case the Service is deployed across the network. This interface is in charge of enforcing the end-to-end service connectivity between PoPs. The WIM makes uses of ONF Transport API to build that WAN connection.

Figure 2 shows the proposed workflow for deployment of an NFV Network Service, which might use two VNFs that are interconnected through a WAN. A new Network Service (NS) request is received at SONATA Service Platform. After placement has been computed, VNFA is located in VIM1 and VNFB is located in VIM2. This triggers the need to create an inter-domain link, which is executed by SONATA WIM plugin towards WIM, using ONF Transport API connectivity service request. Once the link is deployed, NS service creation is notified to user.

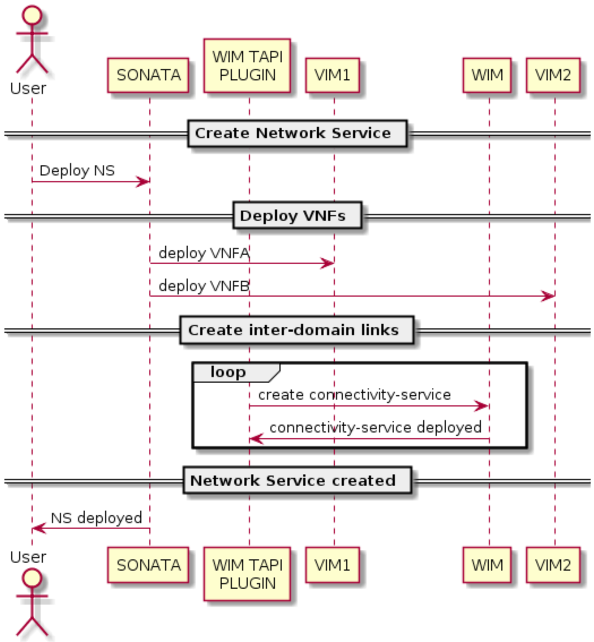
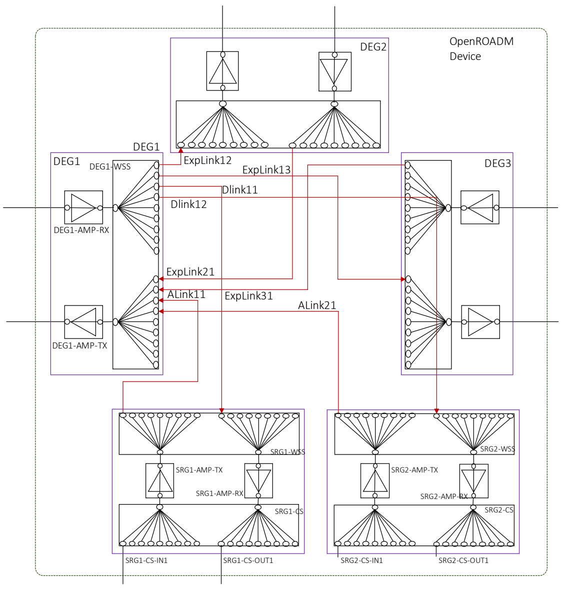


Figure 2 Network Service Deployment workflow

3. ONF TRANSPORT API AND DISAGGREGATED NETWORK CONTROL




```
req.post('http://' + wim_ip_port +
'/config/context/connectivity-service/' + uuid + '/',
                headers={'Content-type': 'application/json'},
json=
{
    "end-point": [
        {
            "direction": "BIDIRECTIONAL",
            "layer-protocol-name": "ETH",
            "local-id": "csep-1",
            "role": "SYMMETRIC",
            "service-interface-point":
"/restconf/config/context/service-interface-point/" +
a_cp['node_id'] + "_" + a_cp['edge_end_id']
        },
        {
            "direction": "BIDIRECTIONAL",
            "layer-protocol-name": "ETH",
            "local-id": "csep-2",
            "role": "SYMMETRIC",
            "service-interface-point":
"/restconf/config/context/service-interface-point/" +
z_cp['node_id'] + "_" + z_cp['edge_end_id']
        }
    ],
    "requested-capacity": { "total-size": { "unit": "GBPS",
"value": "1" }},
    "service-type": "POINT_TO_POINT_CONNECTIVITY",
    "uuid": uuid
}
```

Figure 3 (left) Sample OpenROADM device with 3 DEG and 2 SRGs, (right) T-API connectivity service request

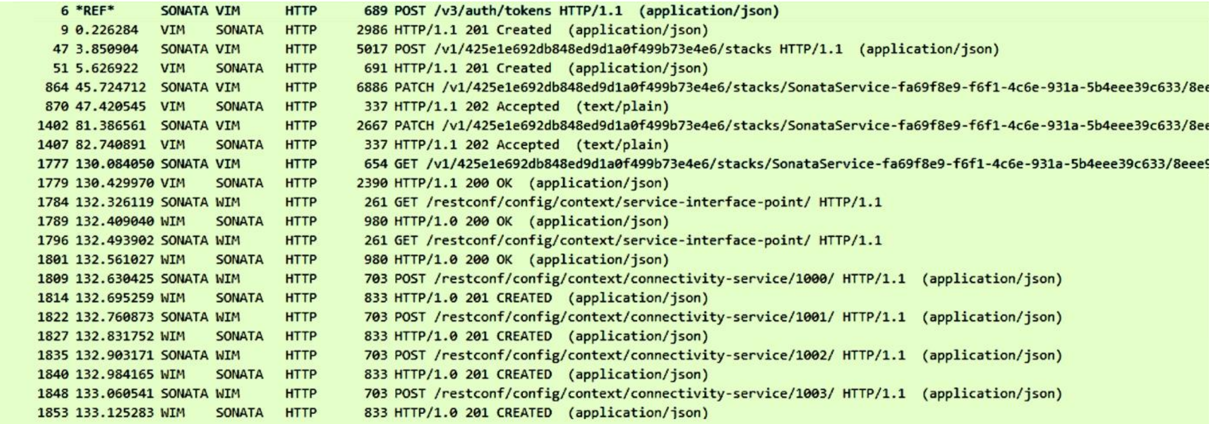
The proposed reference network is aligned with the ODTN project phase II [7], and corresponds to a partially disaggregated network [8]. In Figure 3 (left), an example of an OpenROADM device model is presented, which consist on 3 DEG and 2 SRGs.

Figure 3 (right) shows an example of connectivity service request, which includes the requested end-points (with references to service-interface-points), the requested capacity for the connectivity service and the service type. This connectivity service request, which is received by ONOS SDN controller, is translated in the necessary NETCONF operations towards OpenConfig and OpenROAMD models, as described in [8].

4. EXPERIMENTAL VALIDATION

This section focuses on demonstrating the proposed scenario in Figure 1. The objective is to validate the workflow diagrams involving the deployment of a Network Service over multiple inter-connected VIMs.

Figure 4 shows Wireshark capture between SONATA [9] and VIMs/WIM. It can be observed that once the network service request is received, SONATA requests to VIMs the deployment of heat templates, and finally it interacts with the WIM using SONATA WIM plugin [10] in order to inter-connect VNFA and VNFB. This triggers the necessary network element configuration using NETCONF and OpenConfig and OpenROADM models.



6	*REF*	SONATA	VIM	HTTP	689	POST /v3/auth/tokens HTTP/1.1 (application/json)
9	0.226284	VIM	SONATA	HTTP	2986	HTTP/1.1 201 Created (application/json)
47	3.850904	SONATA	VIM	HTTP	5017	POST /v1/425e1e692db848ed9d1a0f499b73e4e6/stacks HTTP/1.1 (application/json)
51	5.626922	VIM	SONATA	HTTP	691	HTTP/1.1 201 Created (application/json)
864	45.724712	SONATA	VIM	HTTP	6886	PATCH /v1/425e1e692db848ed9d1a0f499b73e4e6/stacks/SonataService-fa69f8e9-f6f1-4c6e-931a-5b4eee39c633/8ee
870	47.420545	VIM	SONATA	HTTP	337	HTTP/1.1 202 Accepted (text/plain)
1402	81.386561	SONATA	VIM	HTTP	2667	PATCH /v1/425e1e692db848ed9d1a0f499b73e4e6/stacks/SonataService-fa69f8e9-f6f1-4c6e-931a-5b4eee39c633/8ee
1407	82.740891	VIM	SONATA	HTTP	337	HTTP/1.1 202 Accepted (text/plain)
1777	130.084050	SONATA	VIM	HTTP	654	GET /v1/425e1e692db848ed9d1a0f499b73e4e6/stacks/SonataService-fa69f8e9-f6f1-4c6e-931a-5b4eee39c633/8eee
1779	130.429970	VIM	SONATA	HTTP	2390	HTTP/1.1 200 OK (application/json)
1784	132.326119	SONATA	WIM	HTTP	261	GET /restconf/config/context/service-interface-point/ HTTP/1.1
1789	132.409040	WIM	SONATA	HTTP	980	HTTP/1.0 200 OK (application/json)
1796	132.493902	SONATA	WIM	HTTP	261	GET /restconf/config/context/service-interface-point/ HTTP/1.1
1801	132.561027	WIM	SONATA	HTTP	980	HTTP/1.0 200 OK (application/json)
1809	132.630425	SONATA	WIM	HTTP	703	POST /restconf/config/context/connectivity-service/1000/ HTTP/1.1 (application/json)
1814	132.695259	WIM	SONATA	HTTP	833	HTTP/1.0 201 CREATED (application/json)
1822	132.760873	SONATA	WIM	HTTP	703	POST /restconf/config/context/connectivity-service/1001/ HTTP/1.1 (application/json)
1827	132.831752	WIM	SONATA	HTTP	833	HTTP/1.0 201 CREATED (application/json)
1835	132.903171	SONATA	WIM	HTTP	703	POST /restconf/config/context/connectivity-service/1002/ HTTP/1.1 (application/json)
1840	132.984165	WIM	SONATA	HTTP	833	HTTP/1.0 201 CREATED (application/json)
1848	133.060541	SONATA	WIM	HTTP	703	POST /restconf/config/context/connectivity-service/1003/ HTTP/1.1 (application/json)
1853	133.125283	WIM	SONATA	HTTP	833	HTTP/1.0 201 CREATED (application/json)

Figure 4 Wireshark capture between SONATA and VIMs/WIM

5. CONCLUSIONS

We have presented a general scenario for multi-site NFVI-PoP End-to-end network service deployment using a disaggregated transport optical network. ONF Transport API has been the selected interface for WIM plugin of the SONATA Service Platform, which has been validated on top of a disaggregated transport optical network.

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REFERENCES

[1] R Vilalta, R Muñoz, A Mayoral, R Casellas, R Martínez, V López, D López, Transport network function virtualization, Journal of Lightwave Technology 33 (8), 1557-1564.

[2] ONF Transport API (TAPI) https://www.opennetworking.org/wp-content/uploads/2017/08/TAPI-2.0-Updates-Overview.pdf

[3] Ricard Vilalta, Arturo Mayoral López-de-Lerma, Victor López, Konrad Mrówka, Rafał Szwedowski, Stephan Neidlinger, Antonio Felix, Zdravko Stevkovski, Lubo Tancevski, Ajay Singh, Ricardo Martínez, Ramon Casellas, Raul Muñoz, Transport API Extensions for the Interconnection of Multiple NFV Infrastructure Points of Presence, OFC 2019.

[4] OpenConfig project and data models http://openconfig.net and https://github.com/openconfig/public/tree/master/release/models

[5] The Open ROADM Multi-Source Agreement (MSA) http://www.openroadm.org

[6] C Parada, J Bonnet, E Fotopoulou, A Zafeiropoulos, E Kapassa, et al., 5GTANGO: A Beyond-Mano Service Platform, 2018 European Conference on Networks and Communications (EuCNC).

[7] The Open Disaggregated Transport Network project, ONF, https://www.opennetworking.org/odtn/

[8] Ramon Casellas, Alessio Giorgetti, Roberto Morro, Ricardo Martínez, Ricard Vilalta, Raül Muñoz, Enabling Network Slicing Across a Disaggregated Optical Transport Network, OFC 2019.

[9] SONATA Quick Guide, https://sonata-nfv.github.io/quickguide

[10] https://github.com/sonata-nfv/tng-sp-ia-wtapi