JOINT VNF AND MULTI-LAYER RESOURCE ALLOCATION WITH AN OPEN-SOURCE OPTIMIZATION-AS-A-SERVICE INTEGRATION

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Abstract

The open-source planning tool Net2Plan provides a network Optimization-as-a-Service system to assist Open-Source MANO and WAN Infrastructure Manager(s) with the joint computation of multi-site VNF placement and multi-layer resource allocation in the deployment of a network service in a metro network.

1 Introduction

The popularization of cloud-based services is a challenging scenario for the management and planning of telco networks, in which IT and network resources coexist to offer remote services. It is crucial to optimize the usage of both IT and network infrastructure to be in compliance with the 5G KPIs [1], and novel techniques for this have been presented as an evolution of the traditional approaches. In this context, Software-Defined Networking (SDN), which decouples the control logic tasks from the data plane actions, and Network Function Virtualization (NFV), which virtualizes traditional bare-metal network functions, are essential technologies to provide "*a scalable management framework enabling fast deployment of novel applications […] with reduction of the network management OPEX by at least 20% compared to today*" [1]. Indeed, the combination of SDN and NFV enables unprecedented levels of network control and dynamism providing the flexibility and programmability [2] required in the 5G objectives and opens the door to a large number of optimization opportunities [3].

In this scenario, the Metro-Haul project [4] proposes for the metro network the interconnectivity of two different types of nodes, Access Metro Edge Nodes (AMEN) and Metro Core Edge Nodes (MCEN), both with computational resources within an infrastructure that spans SDN/NFV capabilities. Additionally, Metro-Haul provides a Control, Management and Orchestration (COM) framework to exploit SDN and NFV benefits, to provide a high-performance environment in end-to-end scalable and efficient scenarios targeted to support a 5G-aware multi-layer network infrastructure underneath of the Wide-Area Networks (WAN) context [5]. To provide the connectivity between data centers located in multiple sites, the ETSI proposes the WAN Infrastructure Manager (WIM) plugin, as part of the deployment of a network service instance in a multi-layer WAN scenario. Note that this IT and network infrastructure interaction is recently available in the release five of the ETSI Open Source MANO NFV Orchestrator [6], developed in collaboration with the Metro-Haul project.

It is worth mentioning that works in the literature address the IT and network control/management separately, potentially leading to suboptimal resource usage. A network service chain is defined as a path coupled to traverse a certain sequence of VNFs given by a network service. The service chain unifies the concepts of SDN and NFV, so that, the NFV Orchestrator (NFV-O) is in charge of the VNFs instantiation in the datacenters and it should be coupled to the SDN-based configuration of the network devices in order to enable the associated route in the transport network. This approach is becoming relevant in the community, for instance, in works [7-9] authors present SDN/NFV proof-of-concept that optimizes the service chain provisioning in a joint IT and network infrastructure. Additionally, the work in [10] is focused on network service orchestration in WAN multi-layer networks. Also, in [11] and [12] it can be seen how the WAN are suitable for the appliance of the SDN and NFV techniques enabling the IT-network joint perspective in multi-layer networks. Note that [11] and [12] are based on well-known protocols (e.g. PCEP) but the architecture is an ad-hoc implementation.

In this work, we propose and implement a full-interconnected SDN-NFV scenario with an externalized intelligence hosted in

Net2plan open-source tool, acting as a network *Optimization as a Service (OaaS)* [13] to assist ETSI OSM in multi-VIMs and multi-VNFs network service instantiation and multi-layer WAN resource allocation from a unified approach. This novel contribution conforms a natural symbiosis of the SDN-NFV demonstration works presented in [7], [8] and [9] with the SDN-based WAN-aware capabilities within the NFV-O shown in [11].

2 Architecture for an SDN-NFV Wide Area Network

The architecture considered in this work to model the fully-interconnected SDN-NFV considering a WAN-based scenario relies on the three main pillars of a canonical SDN design with NFV capabilities: i) application plane, ii) control plane and iii) data plane. This architecture is depicted in the Fig. 1.

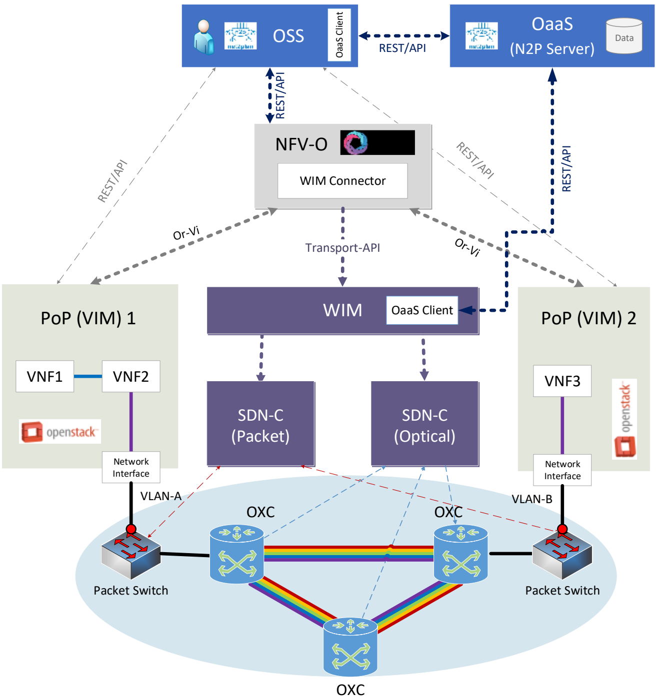

Fig. 1: Functional Architecture

Firstly, on top of the functional schema, the role of the operator that deploys network services is represented by the Operations Support System (OSS). A GUI programmed in a standalone instance of Net2plan plays the operator tasks. The network optimization tasks are externalized in the OaaS module. The network optimization procedures on top of network controllers promote a client layer of third-party applications to request, in this case, efficiency in IT and network resource allocations. The Net2Plan-based OaaS module exports a REST-API, which includes calls to request the computation of a joint VNF placement and multilayer resource allocation solution for a network service request. The VNF instantiation is communicated to OSM, while the multilayer allocation is stored in a database, and is later retrieved by another API call from the WIM.

The control plane is composed of, i) the ETSI NFV Orchestrator, Open-Source MANO, in charge of orchestrating network services over optical metro networks and the VNFs instantiation, ii) two Virtual Infrastructure Managers (VIMs), implemented with OpenStack clusters, are responsible for the virtualization infrastructure by hosting the virtual machines (VMs) of the VNFs, iii) the SDN-control is split in an SDN controller per layer, one related to the packet layer and the other in charge of the optical layer, and finally, iv) the WIM hierarchically on top of the SDN controllers. Especially relevant for SDN-NFV WAN-based work is the presence of the WIM. The WIM plays the role of a link between the NFV-MANO and the SDN-controllers, via Transport API. Additionally, the WIM interconnects remote VNFs, belonging to the same network service, instantiated in different VIMs along the multi-layer transport network in a WAN environment. Moreover, the WIM includes an OaaS client to request optimal paths from the OaaS server.

Finally, the data plane considers a multi-layer transport network, where the packet layer is represented by packet switches interconnecting the compute nodes under the control of the VIM, over the optical layer. The devices, both packet and optical layer, are abstracted by the T-API based WIM for configuration purposes.

3 Workflow of a WAN-based Network Service Instantiation

Providing intelligence to the network service deployment is a relevant task expected to be accomplished in the framework of the Metro-Haul project. Figure 2 shows a schema of the workflow to test the SDN-NFV WAN architecture and is described as follows:

a. Firstly, the OSS queries OSM for the VIM IP addresses and the Network Services (NSs) available to be instantiated via OSM REST API requests.
b. Once the IP addresses of the VIMs are known by the OSS, it retrieves all the IT information (CPU, RAM, HDD) of the compute nodes and it is stored in a .n2p

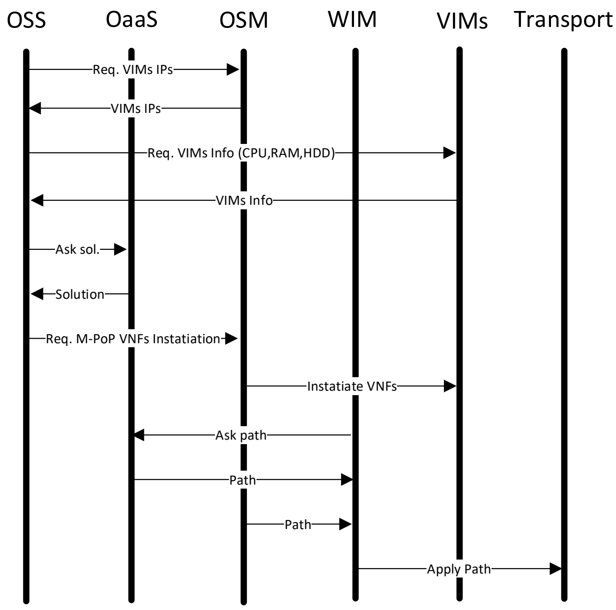

Fig. 2: Simplified Schema of the Workflow

(Net2plan) file. Additionally, the multi-layer transport topology was previously loaded in the file.

c. The OSS defines service chain requests regarding the network service to be deployed and it is included in the .n2p file, ready to be sent via REST/API to the OaaS server as inputs of the algorithm.

d. The OaaS server receives the inputs and the algorithm jointly solves (i) the VNFs placement (in the VIMs), (ii) the allocation of the flows between VNFs over the multilayer network. The VNF placement is returned to the OSS, whilst the calculated network allocations are stored in an internal database.

e. Then, the OSS instance commands OSM to instantiate the VNFs in the VIMs selected by the OaaS-based algorithm.

f. OSM informs the WIM about the multi-VIM connectivity request. In this case, the WIM queries the OaaS module for the previously calculated path in the transport stored in the database.

g. The WIM contacts both packet and optical SDN Controllers to configure the transport devices in order to provide connectivity between the VIMs enabling the VNFs connection; thus satisfying the network service deployment.

4. Demonstration Testbed Configuration and Experimental Outcomes

The experimental setup to implement this SDN-NFV WAN architecture proposal has been performed in two testbed islands, the two Net2plan instances (OSS and OaaS) were located in a laboratory in Cartagena (Spain) whilst the VIMs, the ETSI OSM, WIM, SDN controllers and the multi-layer topology were placed in the High Performance Networks group facilities at University of Bristol (UK). Both testbeds were connected by a private VPN to provide control plane visibility. The multi-layer infrastructure consists of two OpenStack datacenters interconnected by a combination of packet switches and optical cross connects (OXCs) which are SDN-enabled and managed by a combination of SDN controllers as described in the functional schema exposed in Fig. 1. The topology shown in Fig. 3a) assumes that one datacenter is placed in Bristol and the other one in London; where the optical network between the datacenters emulates a realistic WAN domain. Fig. 3a) displays the Net2plan GUI with the service chain solution, corresponding to the instantiation of a two-VNF network service solved by the OaaS module with the VNF placement and the path in the multi-layer transport network. Notice that Fig. 3a) depicts the information to be stored in the database after the optimization task, origin and destination nodes and the set of links that compose the path traversing the VNFs in the correct order. Fig. 3b) shows a capture of the REST/API GET request regarding the WIM query for a transport path coming from the OaaS module. It includes the link IDs of the path calculated by the OaaS related to the one previously shown in Fig. 3a), the origin and destination nodes, the instantiated VNF IDs and their related network service. After processing the reply from the OaaS module, the WIM oversees the inter-VNF connectivity over the multi-layer infrastructure.

5 Conclusion

Network optimization and network service deployment automation are key tasks for the accomplishment of 5G KPIs. This work has proposed and tested an architecture where the open-source Net2Plan tool is used in an Optimization-as-a-Service module, to jointly compute the VNF placement and WAN resource allocation to assist Open-Source MANO (OSM) and a WAN Infrastructure Manager (WIM) in the deployment of a network service chain in full compliance of the Wide Area Network architecture.

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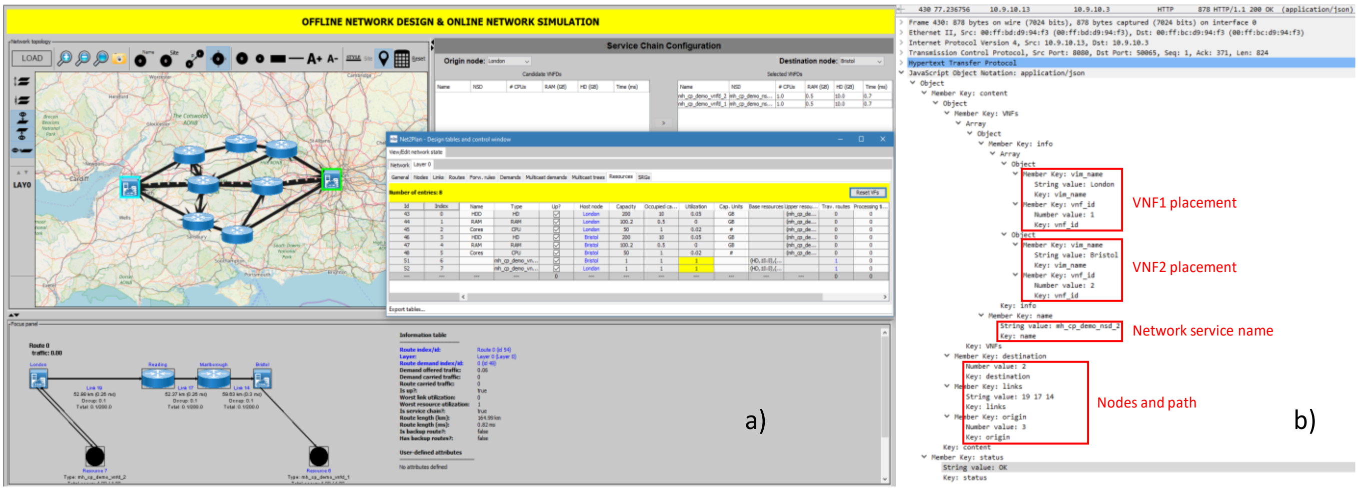

Fig.3. a) Net2Plan (OSS) GUI with the SC solution, b) a Wireshark REST-based GET capture between the OaaS server and the OaaS-WIM client.

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