Multi-layer service provisioning over resilient Software-Defined partially disaggregated networks

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Abstract: This paper demonstrates a partially disaggregated network solution, completely based on standard interfaces integrated into the Software Defined Transport Network architecture. A proof-of-concept of multi-layer service provisioning over resilient disaggregated multi-vendor testbed is presented.

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1. Introduction

Any transport network is composed by multiple segments, composed by different technologies and layers (e.g. IP/MPLS, Optical and Microwave). The work in standardization performed by different groups allows a homogeneous control environment and to progressively get rid of traditional NMSs controlling each vendor's segment, whilst reducing the existing vendor lock-in the management plane. Optical networks are the basis of the Telecommunications Operators (TELCOs) transport infrastructure in the different aggregation levels (metropolitan, regional and long-haul). The TELCOs deploy in the different regional areas based on a single vendor, due to the complexity of optical networking, the low-level interoperability and the improvement of maintenance activities.

The authors in [1] presented the concept of Software Defined Transport Architecture (SDTN) architecture, which is depicted in Fig.1. The SDTN architecture is based on the concept of hierarchical orchestration, where each technology is managed by a SDN controller (SDNc). As the interoperability of the MW and IP elements is achieved, there's an SDNc for each technology. However, as stated before, the optical domain requires per vendor Optical SDNc per region to deal with physical impairments' calculus and OTSi signal equalization. Every domain SDNc abstracts the complexity of deploying a service within its own domain, delegating more complex logics to a higher-layer orchestrator, called SDTN controller (SDTNc). The SDTNc acts as the single entry-point for systems to request network resources and data. Its structure is divided into two logical layers: the E2E transport network control, capable of gathering data from the different layers and provide a coherent aggregated view; and the E2E transport service abstraction, in charge of implementing the logic for service mapping and multi-layer optimization. Each management layer intends to reduce the complexity to enhance network operation and service delivery by reducing integration costs between management layers.

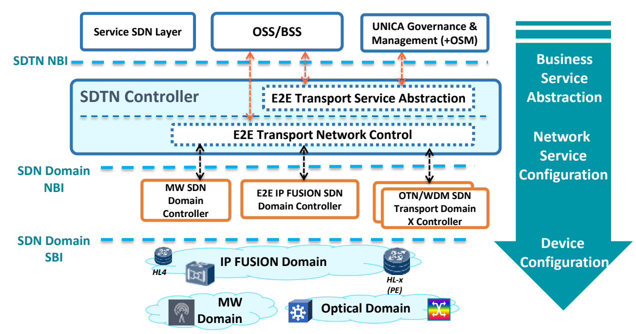

Fig.1. Software Defined Transport Network (SDTN) architecture.

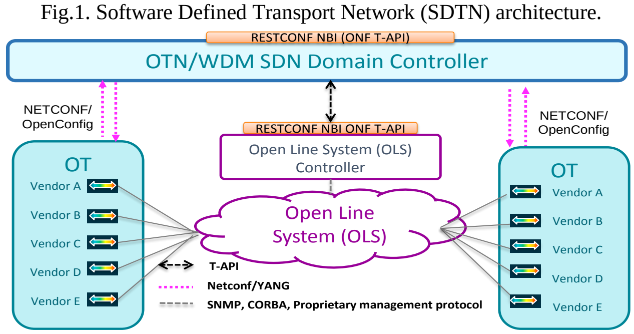

Fig.2. Partially disaggregated optical architecture.

Optical Disaggregation aims to decouple the components of a line system (transponders, ROADMs, amplifiers, etc.), to the terminal devices of other vendors, thus eliminating the lock-in situations and fostering competition and innovation in the transmission segment. SDN solutions are the basic principle of the SDTN architecture, and they became especially relevant in the disaggregation environments to build a scalable management architecture which integrates the WDM transport segment with the rest of technologies. For a partially-disaggregated optical network every optical line system (OLS) domain is controlled by the vendor's SDN controller. In the proposed architecture the OTN/WDM SDN Domain Controller (OSDNc) is responsible of the individual configuration and monitoring of the Open Terminals (OTs) and OLS separately for the coordinated management of end-to-end services, understood as services starting and terminating in Open Terminal (OT) devices (transponders, muxponders).

The partially disaggregated solution proposed (Fig.2.), includes open and standard interfaces (OpenConfig and ONF Transport API) based on YANG modelling and NETCONF/RESTCONF in the OSDNc SBI to coordinately manage OTs and OLS. On the other hand, the OSDNc exposes an unify management context through the NBI to the SDTNc, which in turn, conforms an end-to-end network management (IP, MW and OTN/DWDM technologies) view to higher layer customer applications, such OSS or OSM [2]. This context is defined as a logical inventory view of the network resources which provides a topology relation of the network infrastructure with a desired level of abstraction and a set of service endpoints from which the client can request services at different network level i.e., Digital Signal Rate (DSR), ODU, OTSi/OCh or Photonic Media layer.

2. VPN service deployment over resilient Software Defined disaggregated networks

The SDTNc is the entry-point for applications and systems (e.g. OSS and OSM) to request connectivity and capacity services across the transport network. The most common services deployed in the IP/MPLS network are Layer 2 and 3 VPNs in their different shapes (VLL, VPLS, EVPN, L3VPN). Data center interconnections (DCI) will grow in importance as virtualization services come into the market. Such services, based on Service Function Chaining (SFC) are required to connect VNFs deployed in remote DCs with a guaranteed QoS. The most popular implementation of DCI is via L2 services. Upon request, the SDTNc (whose implementation combines IP management and orchestration) gathers important data, such as service endpoints, encapsulation, QoS and maps the values for device specific configuration (i.e. information model). The service model is based on the L2VPN service delivery information model from IETF [3], while the information model for the IP devices is OpenConfig [4]. Multi-layer orchestration might be triggered within the SDTNc to request more network capacity to the optical transport layer if the above layers required so (e.g., when service requirements cannot be met by the existing setup).

In this paper, a multi-layer service provisioning use case is proposed over two types of resilient partially disaggregated networks. The OSDNc exposes an aggregated network context including a set of service endpoints in the DSR layer (Ethernet client ports of the terminal devices). When a service request is received from the SDTNc between any pair of service endpoints, the OSDNc triggers a specific orchestration workflow, according to the partially disaggregated network setup. The service setup in a disaggregated network consists of two parts: the provisioning of the media channel into the OLS according to the service needs (i.e., spectrum tuning capabilities of the terminal devices); and the configuration of the OT line transmission (frequency and transmission power) and client-to-line side cross connection. The OpenConfig initiative includes a set of management models (oc-platform and oc-terminal device plus extensions) to account for the OT's configuration and is the solution chosen for the architecture proposed. For the OLS, we introduce two possible OLS scenarios which are described below.

2.1 Autonomous optical restoration w/o wavelength change.

The first restoration use case assesses a colored ROADMs based network, where the channel wavelength is fixed and does not change in case the service is restored. This case implies no reconfiguration of the terminal devices when a failure occurs within the OLS. During external channel configuration, the same wavelength which is defined on filter client port should be assigned to the External Channels (ECH) entity. This configuration will cause, that the path computation algorithm during service establishment and restoration procedure, will use wavelength assigned to the ECH (wavelength defined on ECH is a constraint for path computation).

The operational workflow is as follows: the OSDNc retrieves the network topology information from the OLSc through TAPI topology service augmented with OTSI model extensions (Fig.3.a). This informs the OSDNc of the pool of L0 resources available in the service interface points of the Photonic Media layer i.e., the set of channels defined by its central frequency and the channel width, available to be tuned. In case of colored ROADMs, each a single channel allocation is possible. The service provisioning is started by OSDNc with the OT's configuration based on the known channel characteristics and its completed by the OLS's media channel service provisioning.

2.2 E2E disaggregated optical restoration

The second scenario accounts for an OLS network consisting of Reconfigurable-OADMs and not constrains for the channel selection during the restoration of an affected service. In a disaggregated network, this type of OLS brings the need of an end-to-end restoration to guarantee coordination between Open Terminals and OLS.

In this case, when the failure condition (fiber cut) occurs, the OLS employs the TAPI-notification service to inform the OSDNc about the services brought down by the network outage and the topology changes. Then, the OLS will restore the service and once the connectivity-service is restored the OSDNc is notify with the new connections created to restore the service, including the new channel frequency slot. Once the OLS service is restored, the OSDC configure the OTs with the new frequency slot completing the E2E restoration.

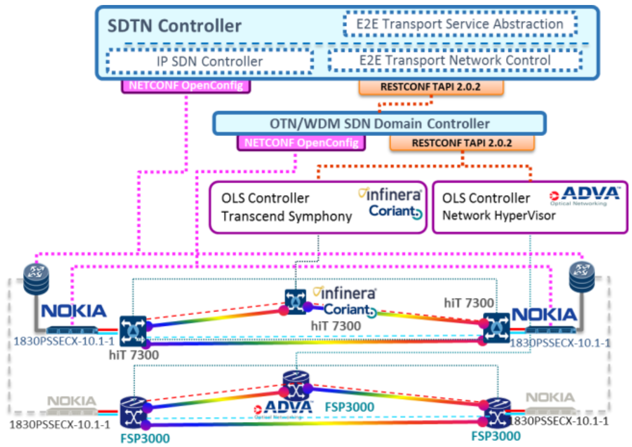

Fig.3. Telefonica Lab Testbed.

3. Experimental validation

The lab setup (Fig 2.a), ADVA FSP3000 product family (AMPs, and fixed filters) including its OLSc (Nework Hypervisor) exposing TAPI v2.0.2, was used to build an OLS segment based on fixed filters. In parallel, three hiT 7300 product family ROADMs from Coriant (now part of Infinera), including its OLSc (Synphony) exposing TAPI v2.0.2, conforms the flexible OLS. Nokia 1830PSSECX-10.1-1 muxponders are connected directly to the ADVA FOADMs and Infinera ROADM's ports, exposing its management capabilities through OpenConfig/Netconf. On top Telefonica OSDNc and SDTNc software appliances are employed to perform the orchestration workflows presented in section 2, through OpenConfig/Netconf and ONF TAPI v2.0.2/Restconf standard interfaces.

The two experiments realized has a common L2VPN service provisioning workflow performed by the SDTNc which request an 10GE connectivity service through ONF Tapi interface to the ODSC (Fig4.a). The two operational workflows explained in section 2.1 and 2.2 are shown in captures in Fig 4.b-d, including the relevant TAPI OTSI objects employed for the orchestration. Besides, the E2E restoration workflows include the TAPI notification sent by the Coriant/Infinera OLSc towards to OSDNc to trigger the restoration process (Fig4.d).

4. Conclusion and next steps

Partially disaggregated optical networks solution is a promising architecture to take advantage of decoupling the components of an optical network, while minimizing the complexity in their network operation. The utilization of standard interfaces is key to enable the interoperability of several vendors. This work demonstrates using commercial equipment a multi-layer SDN architecture based on IETF service models for the IP layer, the ONF Transport API for the optical layer and configures all network functions using OpenConfig models. To the best of the author's knowledge this is the first work that demonstrates this concept for a production ready solution.

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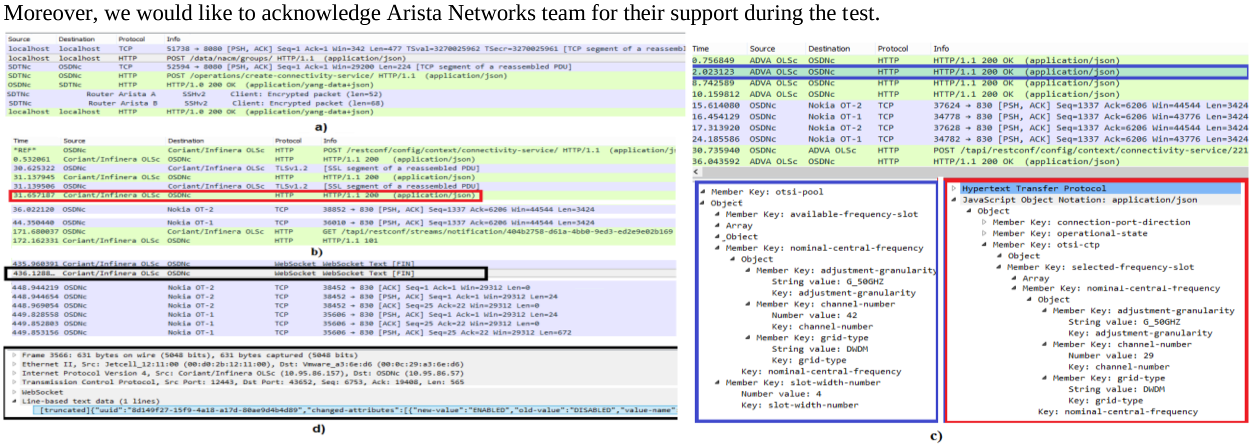

Fig. 4. Experimental results: a) Traffic capture from SDTN; b) E2E restoration capture from OSDC.c)Autonomous restoration use case service provisioning; d) TAPI OTSi extensions and notification.

5. References

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