Open-Source Service Management for a Fully Disaggregated Optical Network Simulation

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***Abstract*—Fully disaggregated device deployments in optical networks propose to drive down network upgrade costs. These devices are managed by open-source control plane solutions for multi-vendor interoperability, which need to be tested in a simulation environment. We demonstrate a cloud-based solution which deploys 69 OpenROADM-based containerized optical networking elements, thereby simulating a nation-wide fully disaggregated optical transport network. Further, the planning, orchestration, and restoration of optical services can be decoupled from the simulated network, by using Transport Layer Security (TLS) enabled North-Bound REST APIs exposed by OpenDayLight TransportPCE, which is an open-source optical domain controller.**

***Index Terms*—Optical Network Planning, Network Simulation, Optical Service Management**

I. INTRODUCTION

Network operators across the world are planning 5G deployment for industry automation and mission-critical application support for enterprises. Dense Wavelength Division Multiplexing (DWDM) based optical networking is one of the major enablers for these technologies, due to its ability to carry high-volume high-speed data over long distances [1]. With the increase in software capabilities, vendor lock-ins for network and device management are bound to occur. In such a network, vendors typically use proprietary data model and interfaces, thereby restricting device choice. To overcome vendor lock-ins, fully Disaggregated Optical Networks (DON) are proposed, consisting of Open Terminals and Open Line System (OLS) [2].

To enable interoperability among vendors and to drive down deployment expenditures, multi-source agreements (MSA) have been setup to define standardized data models and interfaces for optical networking devices. To this end, OpenROADM MSA is one of the industry led standards, which defines required data models for devices, network, and services [3]. Using such models, underlying optical network devices like Re-configurable Optical Add-Drop Multiplexers (ROADMs) and Transponders (XPDRs) can be configured and monitored.

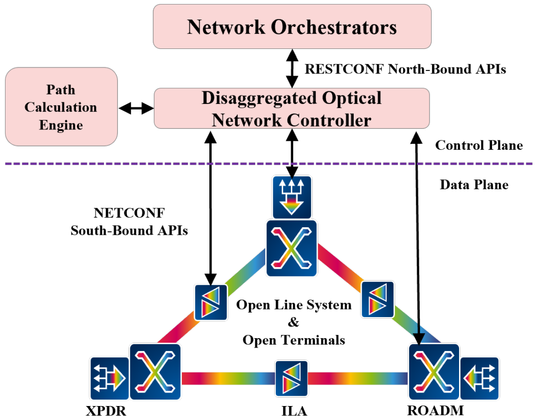

Fig. 1. Software Defined Networking (SDN) architecture for a DON.

To be compliant with OpenROADM MSA, vendors need to implement and expose standardized Application Programming Interfaces (APIs), which can be used by open-source network management and controllers to control such devices. An optical domain controller like OpenDayLight TransportPCE [4] uses these data models to expose south-bound interfaces for control of devices, and north-bound interfaces for communication with applications, as shown in Fig. 1.

Before deploying an open-source disaggregated controller and orchestrator on a live network, network operators need to evaluate it in a “sandbox” of simulated optical devices. Such a setup helps network operators to not only execute “what-if” scenarios, but also to simulate rare device outages and understand how the control plane reacts to them. Additionally interoperability demonstrations are typically restricted to a few network devices, thereby creating a need for a large-scale network simulation to understand network-wide effects.

Therefore, we demonstrate a cloud-based optical network simulation, which can communicate with an open-source op-

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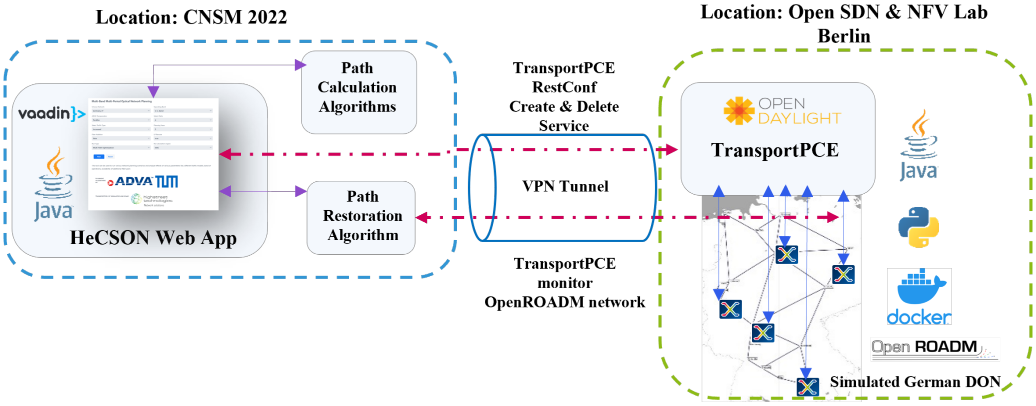

Fig. 2. Demonstration Setup

tical domain controller. Further, we demonstrate a network planner and optical service orchestrator, which communicates with the domain controller using secure RESTCONF APIs. The network planner and service orchestrator is offered as a web-application (WebApp), which can be deployed and accessed remotely.

II. BACKGROUND AND RELATED WORK

A. Background

The major components of a fully disaggregated optical network are XPDRs, ROADMs, In-Line Amplifiers (ILAs), and optical fibers. XPDRs aggregate grey optics client signals into a single optical channel, tuned to an available frequency on the optical spectrum. Such optical channels (or lightpaths) can carry up to 800 Gbps of aggregated traffic, with varying modulation formats. ROADMs are used to add, drop or pass through lightpaths as needed. Wavelength Selective Switches on each ROADM degree allow for routing optical channels in the network. ILAs are used to optically amplify all signals in a given frequency range of the optical channel spectrum. The photonic amplification also leads to the addition of a linear amplification noise, known as Amplified Spontaneous Emission (ASE) noise. The OLS devices are interconnected by an optical fiber. In many deployments, Standard Single Mode Fiber (SSMF G.652D) is used due to its low attenuation in C and L band frequencies. Each of these component degrades the Quality of Transmission (QoT) of the lightpath, usually measured as the Signal to Noise Ratio (SNR).

Network operators seek to reduce operational costs and failure risks by using multi-vendor devices in their network ecosystem [5]. To allow for interoperability, OpenROADM MSA and OpenConfig define YANG [6] models, which can control and monitor devices, and manage services [7]. These data models are manipulated using APIs exposed by the controller, allowing data interchange between the disaggregated optical network and higher layer applications.

B. Related Work

For in-operation network planning, fast Routing Configuration and Spectrum Allocation (RCSA) algorithms are needed. These algorithms should contain accurate path calculation engines, which are able to calculate the QoT of a lightpath. GNPy is an open-source tool, which provides RCSA and QoT estimation for optical services in the network [8]. However, GNPy is used primarily to validate physical parameters and cannot conduct network planning studies and forecasts independently.

For control of simulated optical networks, Troia *et. al.* presented an SDN based routing demonstration [9]. However, no information was provided on the usage of standardized data models, or on the QoT estimation of the deployed lightpaths.

Recently, Vilalta *et. al.* presented a concept for optical network digital twin, which envisions usage of emulated devices for a metro optical network [10]. This work highlighted the capabilities of open-source technologies in future optical network management. However, network-wide studies were not discussed in this early stage proof-of-concept.

III. DEMONSTRATION

A. Demonstration Setup

As seen in Fig. 2, the German DON is setup on a cloud server hosted in Open SDN & NFV Lab (OSNL), Berlin. Each network element uses the Network Topology Simulator (NTS) framework that simulates OpenROADM devices (ROADMs and XPDRs) as docker containers with a NETCONF server running in it. For setting up the 17-node German DON topology, 17 ROADM network elements and 52 XPDR elements are deployed using deployment scripts, which are available in an open-source repository [11]. The number of XPDRs at each node corresponds to its node degree, thereby allowing at formation of at least 26 end-to-end lightpaths in the network.

For service planning and deployment, we use a Java based web application called HeCSON [12]. The HeCSON WebApp will be presented locally at the conference. Apart from an integrated DON planning, HeCSON can also connect and send service requests to the TransportPCE controller using a Virtual Private Network (VPN) tunnel. To reconfigure optical services, HeCSON also includes a polling based network element monitoring. All the REST API commands used by

Fig. 3. HeCSON WebApp deploys services from CNSM 2022, which are visible in bold red on the network map of the simulated German DON.

HeCSON (*Service Create, Delete, and Monitor Network*) are sent to TransportPCE using TLS encryption. Fig. 2 visualizes the complete demonstration setup.

B. Use cases and Interaction

We demonstrate two use-cases with our setup, namely, *a)* planning and provisioning of services onto a simulated German DON (use-case 1), and *b)* monitoring failures and restoring services (use-case 2). The prerequisite for both the use-cases is that TransportPCE and the simulated German DON have to be successfully configured and deployed.

In use-case 1, conference attendees have access to HeCSON WebApp, through which a network planning of the simulated network can be run. For each candidate lightpath which has a valid QoT, clicking on "Add to TransportPCE" button triggers a HTTPS POST request from HeCSON to TransportPCE deployed in OSNL. Once TransportPCE configures the required network elements like ROADMs and XPDRs in the German DON, the administrative state of the service is set to "inService". This shows a successful end-to-end provisioning of the service. The attendees can now view and interact with the deployed service on the network map hosted in OSNL, as shown in Fig. 3.

For use-case 2, attendees can start network monitoring via the HeCSON WebApp. HeCSON retrieves the current state of all the connected network elements, and checks for a change in their status. In case of a loss of connectivity, it first triggers an HTTPS POST request to delete the affected services and then create new services using the unaffected network element. When all affected services are restored, the user receives a "Services Restored" notification.

IV. CONCLUSIONS

With ever-increasing traffic demands in transport networks, network operators aim to harmonize multi-vendor network elements. Using open-source data models like OpenROADM, coupled with an optical domain controller built for transport networks, we are able to demonstrate end-to-end service planning, provisioning, monitoring, and restoration. This solution can be deployed as a cloud-based offering, with the option to decouple various components. Inter-domain communication between the network orchestrator (HeCSON) and the optical domain controller (TransportPCE) is also demonstrated by using VPN tunnel and TLS enabled application layer secure REST APIs. This proof-of-concept opens development opportunities for network operators, to manage disaggregated optical networks. Future work involves development of zero-touch provisioning and restoration functionality using streaming telemetry and deploying scalable network elements, which emulate real devices, thereby creating a digital twin of the entire optical network.

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