Operationalizing partially disaggregated optical networks: An open standards-driven multi-vendor demonstration

E. Le Rouzic[1], A Lindgren[2], S. Melin[2], D. Provencher[3], R. Subramanian[3], R. Joyce[3], F. Moore[3], D. Reeves[3] A. Rambaldi[4], P. Kaczmarek[4], K. Weeks[4], S. Neidlinger[4], G. Agrawal[5], S. Krishnamoha[5], B. Raszczyk[6], T. Uhlar[7], R. Casellas[8], O. Gonzalez de Dios[9], V. Lopez[9]

[1]Orange Labs, *France;* [2]Telia Company, Sweden; [3]Fujitsu Network Communications, USA, [4]ADVA, Germany, Poland, USA; [5]IP Infusion, USA; [6]Edgecore, USA; [7]CESNET, Prague, Czechia; [8]CTTC/CERCA, Spain, [9]Telefónica I+D/CTIO, Spain

Author e-mail address: esther.lerouzic@orange.com

Abstract: We present and demonstrate service provisioning in partially disaggregated multi-vendor network automation scenarios with online physical impairment validation. This work uses and extends standard interfaces (OpenConfig and ONF Transport API) to retrieve network information interacting with TIP GNPy tool.

1. Overview

Telecommunications Operators (TELCOs) transport infrastructure is based on optical networks involving different aggregation levels (metropolitan, regional, and long-haul). TELCOs typically select, regionally, a solution from a single vendor. The motives are the complexity of optical networking, the low-level interoperability, and the improvement of maintenance activities. Optical Disaggregation decouples the network components (transponders, ROADMs, amplifiers, etc.) to multiple vendors, thus eliminating the lock-in situations and fostering competition and innovation in the transmission segment. However, it is required to have a solution to manage this heterogeneous scenario. SDN solutions become especially relevant in the disaggregation environments to build a scalable management architecture that integrates the components of an optical system. The partially disaggregated solution depicted below (Fig.1), the Optical SDN controller (SDN-C) configures and monitors the Open Terminals (OTs) and the Open Line System (OLS) separately for provisioning and managing the end-to-end services. Based on their maturity, open standards technologies like OpenConfig and ONF Transport API based on YANG modeling and NETCONF/RESTCONF can be leveraged and extended upon to operate these multi-vendor scenarios.

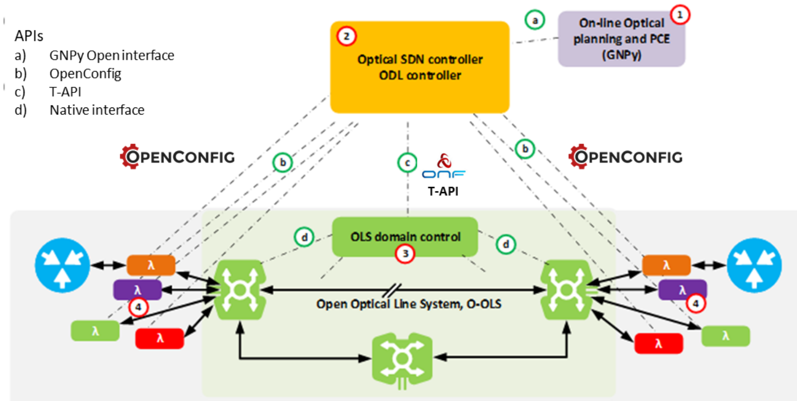

Fig. 1. Partially disaggregated open optical architecture.

Network programmability via SDN approaches opens the door to the Optimization-as-a-Service paradigm [1]. Thus, third-party applications can perform automatic optimization of the network at different levels. In optical networks, network planning and optimization applications are typically done as an offline process. There are two main reasons: (1) current optical device / system models do not expose to the SDN controller the required information, and (2) there have not been open tools for multi-vendor scenarios like Telecom Infra Project [2] GNPy open-source framework [3], which estimate the OSNR by applying the Gaussian Noise model [4].

2. Demonstration goals

The high-level goals of the demo are manifold: i) to demonstrate on-line provisioning of optical circuits including dynamic on demand path computation and QoT validation with dynamic transceiver mode selection using an external GNPy planning tool, establishing optical circuits (optical channels) between transponders and line

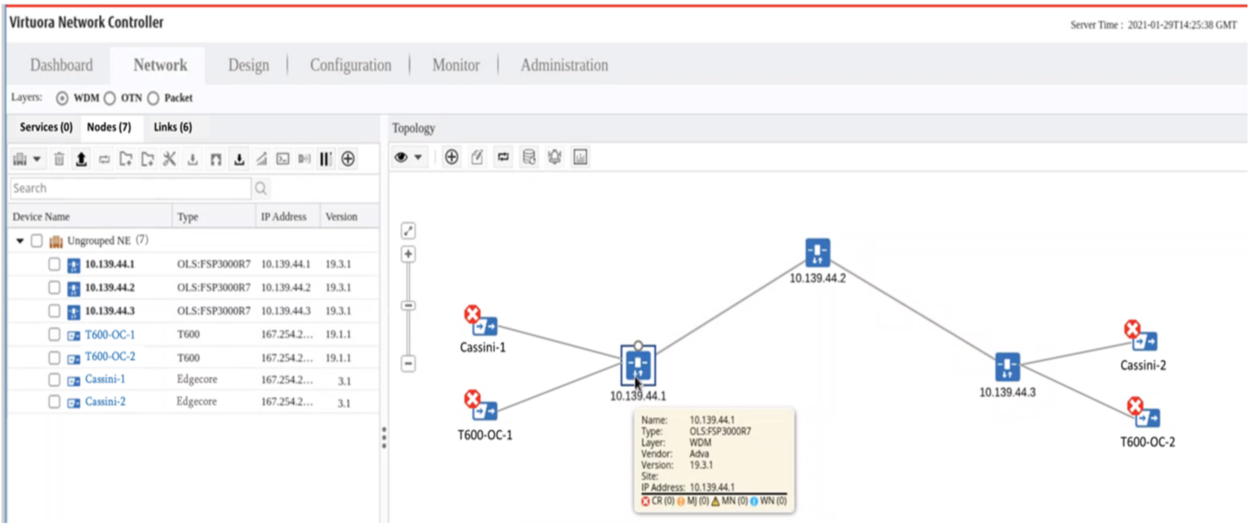

Fig. 2. Graphical User Interface for the end user showing the demo setup in TIP Community Lab London, with the Fujitsu and Cassini Open Config terminal devices and ADVA OLS ROADMs

interfaces from different vendors over partially disaggregated OLS, ii) to showcase the integration of an OpenDaylight-based SDN controller with GNPy, performing a detailed gap analysis of common data models and protocols towards standardization, iii) to extend SDN API in order to expose physical layer data, like power levels and fiber plant data via T-API and iv) validate the use of GNPy in an online disaggregated scenario, coordinating the retrieval and mapping of physical layer parameters including dynamically measured values. The completion of the demo allows us to highlight what is missing in TAPI and OpenConfig models and interfaces to be able to support partial disaggregation in an operator context, relying on GNPy which acts as a guideline to help identify required information in the models and propose related augmentations to standard bodies and industry groups.

3. Innovative aspects of the demo

Recently, several demonstrations have shown the applicability of SDN for the control of (partially) disaggregated optical networks, using open-source controllers and frameworks, including a dedicated OLS controller or the use of GNPy as a planner [5-9]. Compared to such works, this demonstration's main innovations include: i) the use of a partial disaggregation model with a hierarchical OpenDaylight-based controller *along with* ii) the continuous and dynamic topology management including retrieval and uploading of topological information composed of physical layer aspects and inventory (such as EDFA/fiber types and their characterization, open terminal operational modes, supported baud/bit rates, FEC etc.) and iii) the use of a TAPI-enabled OLS controller, *including experimental extensions for the required models addressing physical impairment path validation*, such as Optical Transmission Section (OTS) connection end-points encompassing transmitted and measured optical power attributes. The demo showcases the use of dedicated model extensions in support of links and nodes (ROADM and ILA) at the physical layer and to specify a strict route encompassing the outcome of the planning/validation function. Additional extensions required to dynamically configure and monitor amplifiers are under design at the time of writing. Ultimately this will lead to a new mode of network operations and true open networking including system vendor independence since network operators will be enabled to take over network integration and optimization.

4. Demonstration scenario and workflow

The demo runs at the Telecom Infra Project (TIP) Community Lab in London. The lab setup is depicted in Fig. 2. The OLS is composed of ADVA FSP 3000 product family (ROADMs and amplifiers) and the Ensemble OLS domain controller, which exposes a TAPI 2.1 interface, allowing the dynamic provisioning of network media channels (optical channels). Two Fujitsu 1FINITY T600s and two Cassini transponders are directly connected to ADVA's ROADMs. The Optical SDN controller enabling end-to-end service operations and network visibility is provided by Fujitsu's Virtuora SDN controller, based on OpenDaylight. The workflow (Fig. 3) is shown below:

- The SDN-C retrieves the topology TAPI context from the OLS-C, including detailed nodes (ROADMs), photonic media node edge points for the OTS, OMS and OCh layers, as well as the corresponding topological links and (OLS) Service Interface Points (SIPs). At this stage, the SDN-C processes physical layer attributes of the fiber links as well as EDFAs, ROADMs and related GNPy input elements. The SDN-C manages a GNPy-model initial inventory of amplifier and fiber types, as static inventory data.

- The SDN-C retrieves OT operational modes and maps the list of supported operational modes to equipment characteristics. It checks the status of the OT for pre-configured operational mode, nominal central frequency, and output power. It maps the OT line port to the OLS client port(s), i.e., the Service Interface Points from the OLS TAPI context, along with applicable tunability constraints.
- Upon request from the user, specifying transceiver client ports and data rates, the SDN-C will sequentially perform a constrained path computation using the underlying OLS topology, obtaining an ordered list of links. At this point, the SDN-C sends the path for validation to GNPy: for each link in the path to be validated, check attenuation levels, the insertion losses, e.g., mapping the link to a (list of) physical spans. To do so, it relies on an experimental Yang/REST interface to GNPy for online validation.
- Upon validation of the path, the SDN-C configures the Open Terminal mode, frequency, and output power and, in turn, requests the OLS controller the provisioning of a connectivity service between the OLS client ports (e.g., ROADM add/drop ports)/SIPs. It uses additional constraints to define the pre-computed path. The demo ends with the successful provisioning of the service.

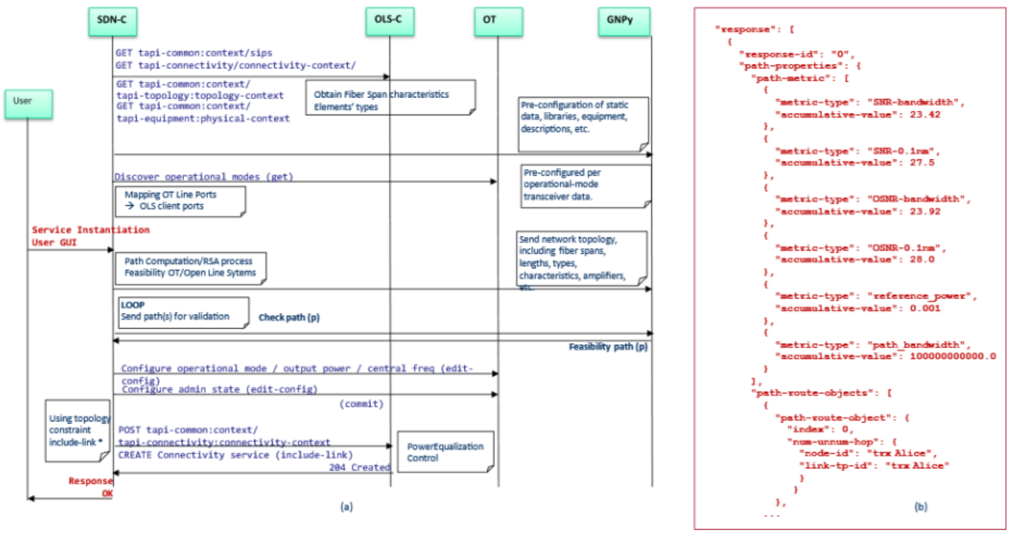

Fig. 3. Simplified demo workflow showing key interactions (a) and example of GNPy based path validation (b)

5. OFC Relevance

The demonstration is of high relevance to OFC and OFC audience since it addresses several trends in the research space: first, the adoption of SDN as a control plane for (partially) disaggregated optical networks, showcasing the benefits of automatic control leveraging device programmability. Second, the integration and use of an Open-Source planning tool with an experimental REST based interface and Yang-modeled interfaces for physical impairment validation, using the Gaussian Noise model approach. Third, addressing an on-going gap analysis of state of art data models and interfaces, identifying missing functionality and proposing suitable data models. And fourth, enabling a new mode of network operations and system vendor independence. The outcome of the demonstration and the lessons learnt during its development can be exploited by operators in the short term to bring needed information/process into standards and reflect them into products.

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6. References

[1] M. Garrich et al., "Open-source Network Optimization Software in the Open SDN/NFV Transport Ecosystem," JLT, 2018.
[2] Open Optical & Packet Transport (OOPT) group. http://telecominfraproject.com/open-optical-packet-transport
[3] GNPY library. https://github.com/Telecominfraproject/oopt-gnpy
[4] P. Poggiolini, "The GN model of non-linear propagation in uncompensated coherent optical systems," JLT, v. 30(24), pp. 3857-3879, 2012.
[5] A. Campanella "ODTN: Open Disaggregated Transport Network. Discovery and control of a disaggregated optical network through open source software and open APIs", OFC2019, San Diego, USA.
[6] Liang Dou, "Demonstration of Open and Disaggregated ROADM Networks Based on Augmented OpenConfig Data Model and Node Controller", OFC2020, San Diego, USA
[7] Quan Pham-Van, et "Demonstration of Alarm Correlation in Partially Disaggregated Optical Networks" OFC2020, San Diego, USA
[8] Jan Kundrát, "Physical-Layer Awareness: GNPy and ONOS for End-to-End Circuits in Disaggregated Networks" OFC2020, San Diego, USA
[9] O. G. de Dios, et al., "Experimental Demonstration of service deployment in open packet-optical networks," in *Optical Fiber Communication Conference (OFC) 2020*, OSA Technical Digest (Optical Society of America, 2020), paper W3C.1.