OpenROADM Compliant SDN Controller for a Full Interoperability of the Optical Transport Network

Ahmed Triki$^{(1)}$, Christophe Betoule$^{(1)}$, Gilles Thouenon$^{(1)}$, Olivier Renais$^{(1)}$
Nicolas Pelloquin$^{(1)}$, Guillaume Lambert $^{(1)}$, Malick Sylla$^{(1)}$, Shweta Vachhani$^{(2)}$,
Dhruv Bhardwaj$^{(2)}$, Masha Dorfman $^{(2)}$, Archana Soundararajan$^{(2)}$ and Martin Birk$^{(2)}$

$^{(1)}$ Orange Labs, 2 Avenue Pierre Marzin, Lannion, France, ahmed.triki@orange.com
$^{(2)}$ AT&T Labs, 200 Laurel Avenue South, Middletown, NJ, USA, birk@att.com

Abstract *We demonstrate the ability of TransportPCE SDN controller to automatically create and delete services in multi-vendor optical networks. Using opensource projects, TransportPCE relies on "OpenDayLight" as a development framework and "OpenROADM" for service, network and device data models ensuring interoperability.*

Introduction

The ecosystem of optical transport networks is evolving to include enhanced automation and interoperability. Operations in this area of the network are usually done by manual intervention of operating staff without process automation and an overarching view across multi-vendor domains. Consequently, the creation of an end-to-end service built with equipment from different vendors is still a long process which currently cannot be automated. The most important technical barriers to interoperability are i) the lack of openness in management plane protocols and Application Programming Interfaces (API), ii) the lack of interoperability between vendors' control planes, due to heterogeneous implementations and industry's reluctance to correctly standardize the optical layer, and iii) the lack of interoperability between data planes, including heterogeneous Forward Error-Correction (FEC) and complex ROADM optimization.

To reach full interoperability between optical equipment, operators are developing common open data model specifications. One that is particularly important to network operators and far along is "OpenROADM" defined by OpenROADM Multi-Source Agreement (MSA) initiative[1]. The OpenROADM data models provide a disaggregated description of the optical equipment (ROADM, Xponder, pluggable optics and optical amplifiers), as well as, an abstract view of the network services and topology. The target of this OpenROADM MSA initiative is to become, de facto, a reference architecture for the design of future optical networks and to replace the currently deployed monolithic solution based on proprietary controller (i.e. NMS, Network Management System) for each individual vendor solution.

By taking advantage of the flexibility offered through the OpenROADM data models and the rising impact of the "OpenDayLight" (ODL) framework[2], Orange, AT&T and others launched the TransportPCE (T-PCE)[3] project. T-PCE builds a controller to manage services (e.g., end-to-end 100 GE Ethernet service) in a multi-vendor and OpenROADM-compliant infrastructure. It aspires to provide the community with an opensource OpenROADM platform by proposing tests and code for a reference implementation that can be reused in third party-derived products.

Last year, AT&T successfully executed a field trial of SDN-controlled, single-wavelength 400 G channels carrying 400 GbE and 4x100 GbE services over a Metro OpenROADM Network[4]. In that field trial, AT&T used earlier versions of some key T-PCE modules: Service Handler, Renderer and Optical Line Manager. This paper highlights the latest developments in T-PCE contributed by Orange and AT&T. We firstly describe the different modules of T-PCE. Then, we describe the creation/deletion of an end-to-end optical service over different interoperability scenarios.

TransportPCE controller description

T-PCE is an open-source project to offer a user-friendly and automated way to manage services in an OTN/WDM network. The service management request can be performed by an orchestrator or another hierarchical controller. The project is currently in the incubation life cycle mode inside ODL which is an open-source network operating platform. We are using "Jenkins" tool[5], to perform continuous integration tests as further developments are added in the different modules.

The T-PCE controller creates services in a multi-vendor infrastructure. This is possible because of the OpenROADM MSA initiative launched by AT&T in 2016 with the target of a SDN enabled and multi-vendor interoperable optical network. OpenROADM defines a common optical specification and comprehensive open data models using YANG modeling for service management, network topology and each disaggregated optical device type.

The T-PCE controller exposes APIs, defined through OpenROADM data models. The T-PCE northbound REST API is used to communicate with a hierarchical controller or an orchestrator, while the southbound API is used to communicate with optical transport devices using the standard NetConf protocol.

The T-PCE controller architecture has a modular structure as depicted in Fig.1. East/West APIs are used for communication between its main building blocks and for the potential interconnection with external applications that could bring additional features. Controller modules exchange data through a shared data store provided by the Model-Driven Service Adaptation Layer (MD-SAL) of ODL. As the MD-SAL is YANG model driven, all data is stored according to the OpenROADM models which facilitates the read-/write process to the modules.

The current main T-PCE modules are:

i) The Service Handler receives a request (e.g., service creation) from the northbound Rest API and coordinates with the other T-PCE modules to achieve the request.

ii) The Topology Manager discovers the nodes and links of the topology using Link Layer Discovery Protocol (LLDP) and then updates the MD-SAL data store.

iii) The Path Computation Engine (PCE) calculates the shortest optical path based on a Dijkstra algorithm. The optical delay and the number of hops are considered as performance metrics. The PCE retrieves the topology from the MD-SAL data store that provides information about the availability of nodes, ports and links.

iv) The Renderer is in charge of configuring the different optical devices traveled by the lightpath. It also verifies the physical implementation of the path including ports.

v) The Optical Line Manager (OLM) is in charge of setting and calibrating the power levels through the different pieces of equipment to ensure proper and stable optical signals.

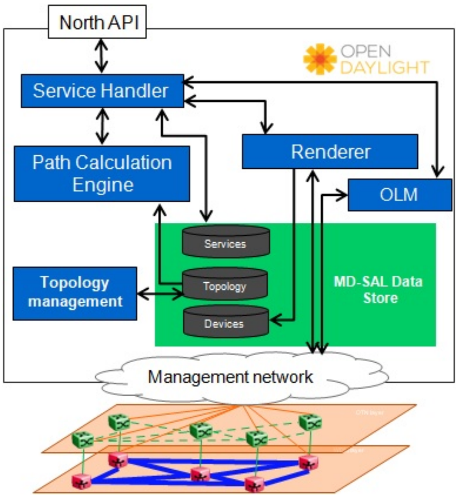

Fig. 1: Transport-PCE modules

The implementation of some T-PCE modules' functions is strictly tied to OpenROADM specifications: including the Service Handler, Topology Manager, Renderer and OLM. However, the implementation of other functions is less tightly coupled with the OpenROADM models. For example, in the context of an evolution towards long distance applications, some complex impairment-aware path computation and advanced line management might be required. The controller modular structure with clearly defined APIs allows flexible and appropriate substitution in this context, with the ability either to rely on external dedicated modules to satisfy these specific functions or to allow external applications/controller leveraging of T-PCE modules functionalities.

Interoperability scenarios

The establishment of a lightpath is done as follows. The Service Handler module accepts the service creation request and triggers the PCE module. The request includes the end points of the path to be computed. The PCE computes the path according to the abstract topology information available in the data store and sends back the result to the service handler. The path is presented as a set of "logical points" corresponding to the OpenROADM identifiers of the resources to be allocated within the equipments (e.g., ROADM port). The PCE assigns the path a unique identifier that remains constant during its life-cycle. Once a feasible path has been calculated, the Service Handler sends an implementation request to the Renderer that configures connections in the optical devices using the NetConf protocol. The Renderer registers all resources used in the service path for alarm suppression and starts configuring them using multiple threads. When the Renderer notifies the accomplishment of the configuration process, the Service Handler triggers the OLM. The OLM manages the WDM optical line by adjusting the optical power and setting the amplifier gain. During the life-cycle of the service, the OLM sends alarms and warnings if design margins are exceeded or the physical line is degraded. Periodically, the Service Handler populates and refreshes the service list according to service status. In case of unexpected provisioning failure, the controller invokes rollback which releases all the resources.

The deletion of a service is launched by the Service Handler after the reception of a service deletion request. The Service Handler asks OLM to turn down power levels and then the Renderer releases all the resources allocated to the service and updates the MD-SAL data store.

To validate the interoperability, we have carried out several tests using a testbed with commercially available OpenROADM equipment. The most relevant scenarios are:

S1: Create a path $[A^{Tpdr}\text{-}B^{Rdm}\text{-}B^{Rdm}\text{-}A^{Tpdr}]$ using two Xponders from vendor A, and two ROADMs from vendor B. One of the concrete use-cases is to interconnect two data centers equipped by vendor A via a transport network equipped by vendor B. This scenario meets the needs of operators for a dual-sourcing policy, to prevent the inability of the vendors to supply equipment on tight operational deadlines and to allow for competition.

S2: Create a path $[A^{Tpdr}\text{-}A^{Rdm}\text{-}A^{Rdm}\text{-}B^{Tpdr}]$ by "mixing Xponder" scenario consists in using two Xponders from two different vendors (A and B), and two ROADMs from the same vendor A. It has been made possible through the use of a staircase FEC as it is specified in the OpenROADM optical specifications. This scenario addresses the same objectives as the previous scenario with more flexibility in supplying Xponders. It enables flexible mesh networks where having bookended transponders is not possible. It is also an intermediate step towards the third scenario which is more comprehensive.

S3: The "mixing ROADMs" scenario consists in the creation of a path $[A^{Tpdr}\text{-}B^{Rdm}\text{-}A^{Rdm}\text{-}B^{Rdm}\text{-}A^{Rdm}\text{-}B^{Tpdr}]$ using four ROADMs, from two different vendors (A and B), with the service termination points on two Xponders from the vendor A or B. A possible real use-case of this scenario is to create an all-optical path between an edge node in the access network (equipped by vendor A) and the point of presence (PoP) node in the main metro network (equipped by vendor B). In this scenario, we accomplish a full interoperability between all Xponders and ROADMs regardless of their vendors.

Tab. 1: Service create/delete time (also includes wait times for channel turn up: 20s for ROADM and 120s for Xponder)

Module	Service Creation	Service Deletion
Renderer	26 seconds	63 seconds
OLM	182 seconds	49 seconds
Total	208 seconds	112 seconds

In the aforementioned scenarios, we have succeeded to automatically create an end-to-end optical service in a multi-vendor platform. The service creation time is in the order of several minutes. Tab.1 illustrates time statistics for "mixing ROADM" scenario. This considerably reduces the long process of the classical approach, based on the usage of one dedicated NMS per vendor, requiring many person-days to perform the multi-vendor interoperability. Moreover, we note the simplicity of testing and integration brought by the usage of a common data model as OpenROADM. Indeed, test templates can be easily reused for equipment coming from different vendors, which can save the time of testing and integration process in a large-scale network.

Conclusions

TransportPCE leverages open-source enablers (OpenROADM, OpenDayLight) to demonstrate for the first time the automatic creation/deletion of an optical end-to-end service within a network composed of multi-vendor optical devices. The routing, provisioning and configuring processes are performed under a total control of the operator policy. Various scenarios are tested to validate the high level of interoperability between manufacturers and to demonstrate the considerable time/effort savings that is manifested in reducing the service creation time to several minutes.

Acknowledgements

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References

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