Experimental Demonstration of service deployment in open packet-optical networks

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Abstract: Disaggregation breaks conventional closed systems into components connected by open interfaces. This paper shows the experimental demonstration of service provisioning and partial replacement of network OS in a disaggregated open packet and optical converged network based on open interfaces and open source software.

1. Introduction

The Telecommunications Operators (TELCOs) deliver transport network services to their customers currently using systems and solutions developed by a single network vendor. However, closed solutions lead to delays in introducing new functionality and innovations, limitation of the functional variations and cost increase. In packet transport, hardware and software are currently coupled, so many functions of a vendor's IP device are in black-box and its capacity, features and operation are tightly coupled, that is, they are locked-in by each device's capability. Also, optical transport network systems, both transmission and line, are usually provided by single vendor. However, the life time of transponders (related to the traffic increase) is different from that of optical line-systems (related to the civil works) [1].

Disaggregation of network components and open integration of them are promising path for addressing those issues. Disaggregation breaks conventional network systems into some interoperable components, which expands choices of device or functional components [2]. Furthermore, integration of the components has a huge potential to lead more efficient, easily manageable and significantly adaptive transport networks. For accelerating the disaggregation and the integration, the Converged Architectures for Network Disaggregation and Integration (CANDI) was established in 2018, which is a sub-group of Open Optical and Packet Transport Project Group (OOPT) in Telecom Infra Project (TIP) [3]. The goal is to implement open and commoditized networks to achieve wide scale economy for some components and create an open market for disaggregated elements, both IP and optical. In [4] the authors showcase the service provisioning over a partially disaggregated optical network. In this work, the authors extend the scenario to include both packet and optical whiteboxes and have conducted the first proof of concept (PoC) of a packet and optical open network in collaboration with the open and disaggregated transport networks (ODTN) initiative of ONF [5].

2. Transport Service Deployment Architecture, standards and workflow

One of the fundamental use-cases to show the feasibility of disaggregated networks is the provisioning of a Transport Service, such as a layer 2 VPN (L2VPN). The control architecture (figure 1) considers that the open packet networks and optical networks are provisioned though a packet SDN controller and optical SDN controller (OSDNc) respectively, with a hierarchical Controller ensuring coordination. In this architecture, the OSDNc is in charge of configuring the Open Line System (OLS) and the Open Terminals. OLS elements could be configured either directly from the OSDNc or via an OLS controller. For this work, authors have chosen the path of using the OLS controller, as it simplifies the control of the Line System and removes the complexity from the OSDNc.

The configuration of both packet and optical networks for the path provisioning is done through open interfaces. The North Bound Interface (NBI) for the OSDNc and OLS controller is deployed using ONF TAPI and the configuration to the Open Terminals is done via OpenConfig. TAPI provides three main end-to-end functions: (1) topology information, (2) service provisioning and (3) path computation. On the other hand, OpenConfig enables the device management, thus is discovery, inventory retrieval and configuration management. The NBI for the hierarchical controller to receive a service request is based on Restconf + the IETF L2VPN Service Delivery model [6]. Such model describes the needs of a network VPN service in a vendor-neutral manner.

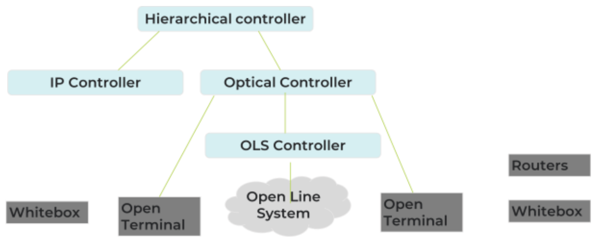

Fig. 1. Architecture

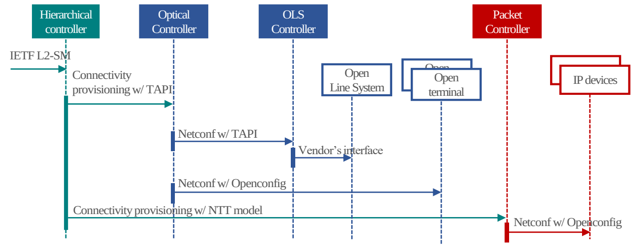

Fig. 2. Workflow

The Disaggregation or IP equipment is based on the ability to freely select hardware and software from various vendors. In such open model, it is required to control multiple devices by a common open protocol with vendor-neutral data model. To that aim, Netconf and OpenConfig are considered as the vendor-neutral interface. Figure 2 shows the schematic of workflow for packet and optical network management testing. This workflow starts from the network service call to the hierarchical controller, which contacts Optical controller if existing bandwidth is not enough and later contacts the IP controller for the VPN service setup in the whiteboxes. In addition, the controllers are periodically retrieving the context, that is, the current status of topology and ports.

3. Experimental Setup

The experimental testbed (Fig 3) implements a partially disaggregated optical layer and a whitebox based IP packet layer. This optical layer is composed for two different paths. The first path used two commercial transponders from ZTE with open interface and client ports of 100Gbps connected to an open line system (OLS) from ADVA. The OLS is composed by 3 nodes in ring topology (bottom Fig3). The optical media channel will use a 50GHz grid. The second path used 2 Cassini whiteboxes (used as transponders) from Edgecore with software from IPInFusion with 40Gbps client ports connected to the IP whiteboxes. The 40Gbps ports are added into a 200G lambda that is connected through the OLS.

The optical layer is managed by ONOS Optical controller, using the interfaces proposed in the architecture, TAPI with OLS controller and Netconf/OpenConfig with the open terminals (Cassini and ZTE Transponders). The parent controller from the Metro-Haul project [7] is used as hierarchical controller to connect via RESTCOF TAPI to ONOS and REST to packet controller (MSF) [8]. In IP segments, total three kinds of NOSs are installed on whiteboxes, commercial Cumulus and Ocnos and open-source Beluganos [9]. The use of three OS is aimed at testing partial replacement of network OS. In order to facilitate the follow up of the experimental traces. Figure 3 shows all the optical devices, IP devices, controllers and orchestrators involved in the testbed.

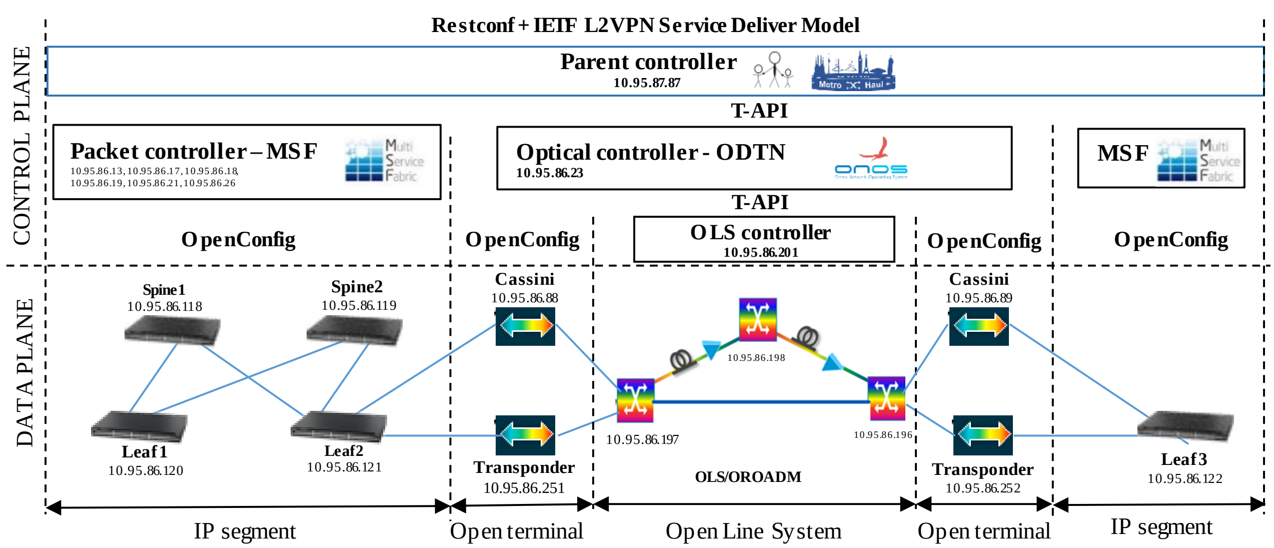

Fig. 3. Experimental setup

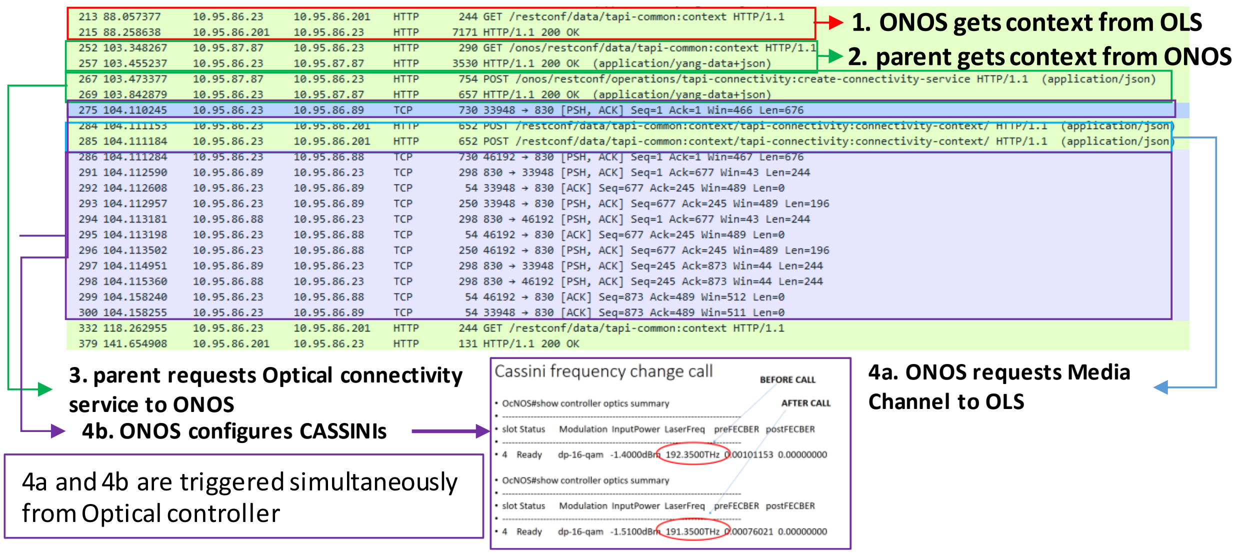

Fig. 4: Parent controller - Optical Controller (ONOS) - OLS Controller traces. OpenConfig traces between ONOS and Open Terminal. Frequency configuration in the Cassini open terminals

4. Results

E2E L2VPN service between two leaf routers over the optical layer was successfully established through both packet and optical controllers by the Hierarchical Controller. Figure 4 shows the full set of control messages taken at ONOS Controller. First of all, the figure shows the RESTCONF calls to GET the contexts (step 1 and 2) and configure the service from the hierarchical controller to ONOS (step 3). Figure 4 also shows the OpenConfig communication between ONOS and Cassini open terminals (4b), and the frequency configured in the Cassini open terminals by the ONOS SDN controller to establish the second optical path. Figure 4 right shows the RESTCONF traces to get the context of the OLS between ONOS and the OLS controller, as well as setting up the channel (4a). The channel is setup on the 191.3500 wavelength which is available on all the devices in the path. ONOS keeps track of available and used wavelengths across the end to end path and when a new path is requested such information is used by the intent subsystem to pick, an available, if any, wavelength. Through the intent subsystem ONOS also provides failover, reinstalling any configuration on the devices if they lose it and by computing a new path with a new wavelength on different devise if any of the involved ones fail. In addition to the optical path connection, L2VPN was established through MSF packet controller. A replacement of network OSs in packet layer was also successfully tested with a few restrictions such as a lack of uninstall function and a license locked by MAC.

5. Conclusions

In this study, authors experimentally showed the provisioning of packet-optical converged paths and the replacement of network OS in a disaggregated open packet-optical converged network. The SDN controllers applied in the tests are based on open source software and open interfaces. An open source network operating system (Beluganos) is also utilized on a whitebox switch. Disaggregated open optical-packet transport networks will enable operators to deliver more flexible, adaptive and prompt services compared to vendor locked-in solutions.

6. Acknowledgements

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7. References

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