Demonstration of Alarm Correlation in Partially Disaggregated Optical Networks

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Abstract: We present and demonstrate the alarm correlation capability executed as an SDN application in an open, partially disaggregated multi-vendor optical network. This SDN application reconciles device alarms from Open Terminals with service alarms from an Open Line System controller to perform fault isolation, alarm correlation, and optical restoration.

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1. Overview

The traditional approach to the control and management of optical networks is undergoing transformation driven by the rapid advances in software-defined networking (SDN) technology. Current deployed optical networks (shown in Fig.1a) use proprietary technology from a vendor which is not directly interoperable with other vendors and, as such, all devices (transponder, ROADM, amplifier), the network management system (NMS), optical planning, optimization, and monitoring tools are provided by the same vendor. The vendor lock-in is further expanded as the network is maintained and evolved over time. This is holding back flexibility and innovation in the optical network arena.

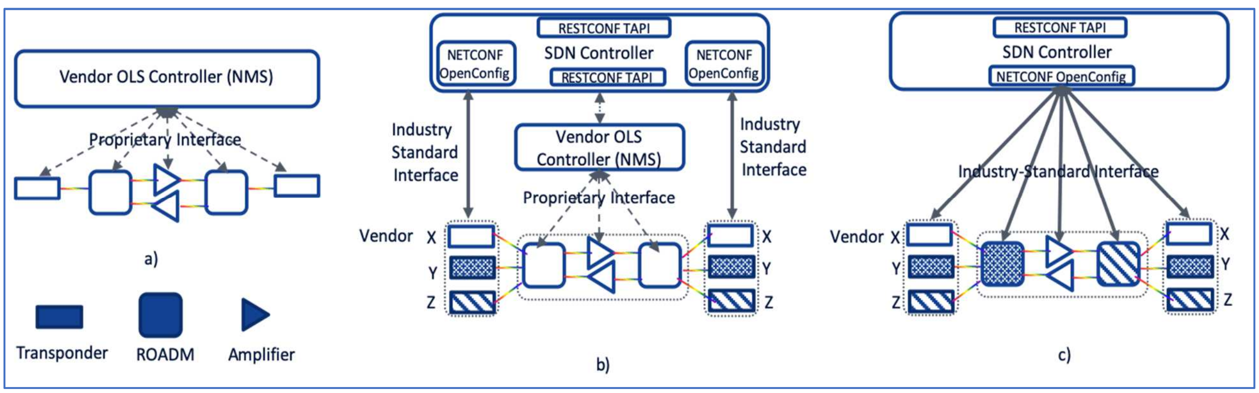

Figure 1: a) Current Optical Network; b) Partially Disaggregated Optical Network; c) Fully Disaggregated Optical Network

Increased optical networking flexibility, innovation, and reduced vendor lock-in can be achieved by opening the optical network, i.e., disaggregating the network and deploying an open SDN controller that can control and manage a multi-vendor network via open and standard interfaces. A pragmatic approach to opening an optical network is to evolve to the partially disaggregation architecture [1],[2]. . It can be used for short-term, brownfield deployment shown in Fig. 1b) where the optical terminal (OT) (transponder) is the first component being removed from the vendor lock-in. Transponders have a rapid innovation cycle and thus enable operators to offer new type of connectivity services with incremental speed, reach, QoT, among other attributes. However, due to the lack of standardization at Layer 0 (L0) and the complexity of optical transmission due to the presence of physical impairments, the vendor's Open Line System (OLS) controller needs to remain in the network and be responsible for controlling the devices in the OLS domain via its vendor-proprietary interface and performing the optical-impairment-aware path computation. The OLS controller interfaces with the SDN controller via a standard north bound interface (NBI) such as Transport-API [3]. The OLS domain is abstracted as a "TAPI node" in the SDN controller topology. The OT's, in this case, are controlled directly by the SDN controller via an open-source device data model over NETCONF protocol (e.g., OpenConfig [4]).

On the other hand, the fully disaggregated optical network architecture (Fig. 1c) is when the SDN controller configures and manages all devices of the network directly through open standard interfaces allowing the SDN controller to have direct access to the devices and providing it a complete view of the network topology. This fully disaggregated optical network architecture can be used for greenfield deployments; however, there are still many aspects to be researched as well as standardization, interoperability testing, and validation challenges to be overcome.

Most of the work in this area has been done in [1], and [5], which focuses on the discovery and service provisioning in partially disaggregated optical network architectures. The question about how to perform the fault management with alarms correlation has not been addressed yet. Consequently, there is no prototype dealing with this crucial aspect, either.

To address this, we present and demonstrate here for the first-time an Alarm Correlation SDN application that performs alarm filtering, fault location, fault correlation, and reaction to a link failure scenario in a partially disaggregated multi-vendor optical network testbed.

2. Innovation

A network failure generates several alarms from the impacted devices. Certain alarms are considered as important for fault location and correlation. In contrast, other alarms are not relevant and consequently interfere with fault location and correlation. Filtering the alarms reported by OT's and/or the OLS Controller is an essential capability in a partially disaggregated architecture to select the most relevant alarms caused by a network failure. The OpenConfig and TAPI alarm filtering capability will be demonstrated as a part of a 4-step demo scenario.

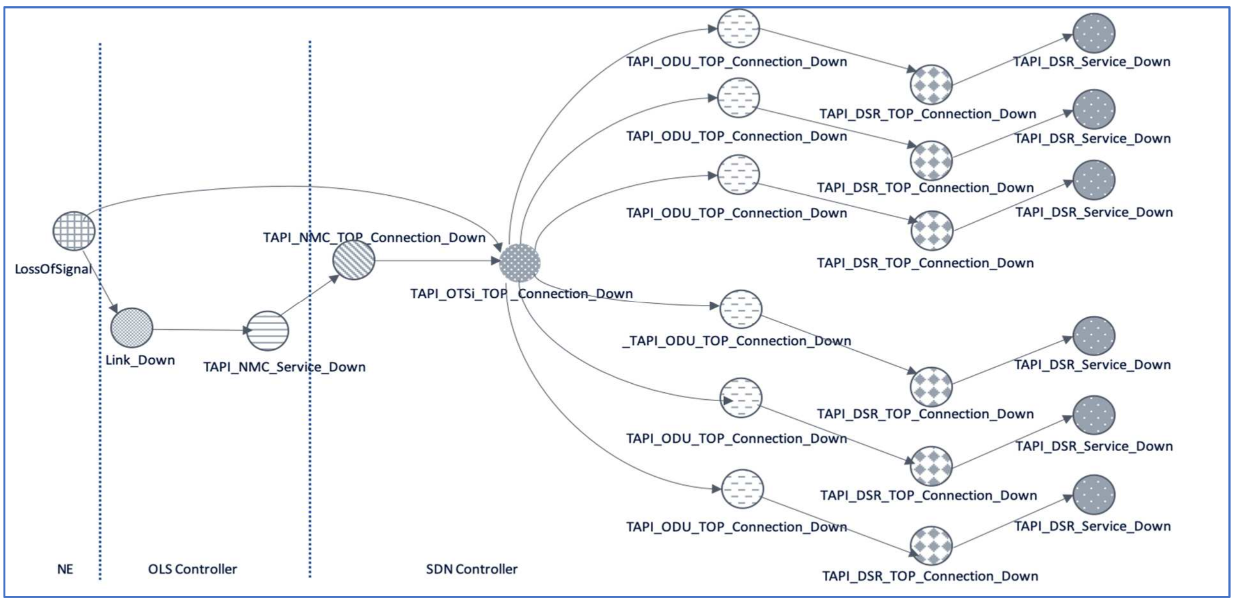

Figure 2: Bottom-up Alarm Correlation in Partially Disaggregated Optical Network

On the other hand, given a failure observed at the physical layer (L0), how to get the information about the impacted connections and services through the alarm correlation process is also another important feature. We present and demonstrate how an SDN application that performs alarms correlation in a multi-vendor partially disaggregated optical network completely based on the standard interfaces OpenConfig, and TAPI. The alarm correlation application engine is implemented based on a dependency graph-based technique and TAPI service models (topology context and connectivity context) combining with a bottom-up correlation approach (e.g., described in Fig 2). In this demonstration, when a port state goes out of service as caused by an optical link failure, the LOS (Loss of Signal) alarms are sent by the OTs and the ROADMs, AMPs to the SDN Controller and the OLS controller respectively. The fault management application of OLS controller correlates the LOS alarms to the LinkDown alarm, which in-turn correlates the alarm to TAPI Photonic Connectivity (i.e., Media Channel - MC) Service Down alarm. The OLS controller reports this alarm to the SDN controller via TAPI notification service. At the SDN controller, it receives the MC Connectivity Service Down alarm and correlates the alarms to the impacted TAPI TOP connections [6] of higher layer (that is, OTSi TOP connection, ODU TOP connections, and Digital Signal Rate (DSR) TOP connections).

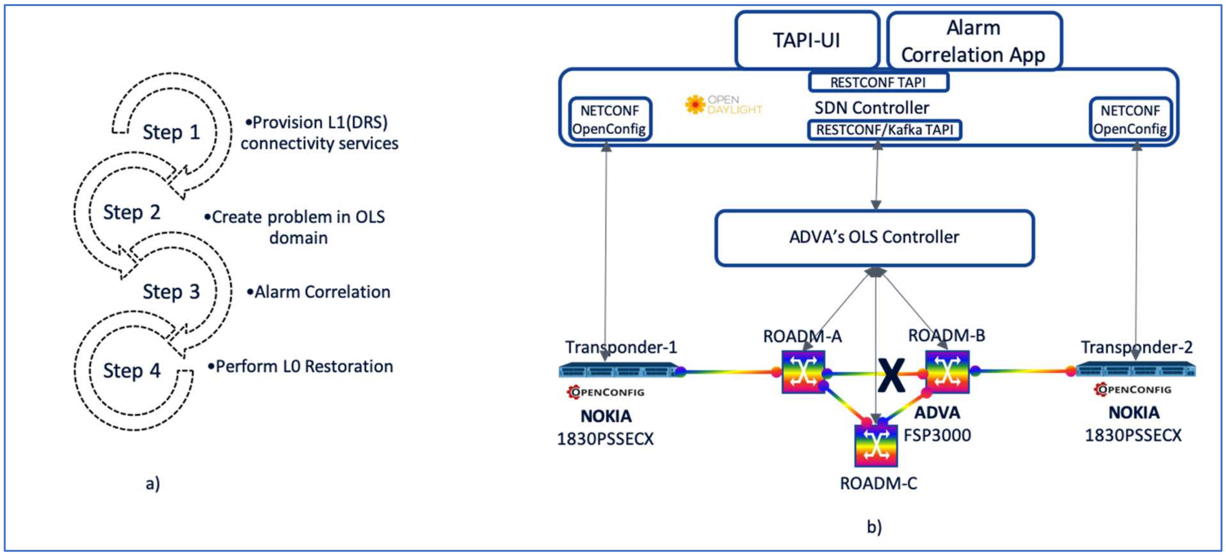

Figure 3:a) Alarm correlation demonstration scenario; b) Telefonica Lab testbed

The process continues up to the TAPI DSR connectivity services. As the LOS alarm is « critical », the SDN controller immediately triggers an L0 restoration process. The OLS restores the MC connectivity service and, once the MC connectivity service restoration is complete, the SDN controller is notified, including the new media channel frequency slot, which turns into the central frequency and power levels to be configured for the OT's if needed.

3. OFC Relevance

We show and explain the 4-step demonstration scenario to the OFC audience. The demo will be presented on-site via an SDN controller GUI relying on remote connections to Telefonica Labs in Madrid. In addition, we will also record a video of the demo. The lab setup is shown in Fig.3b. The ADVA FSP3000 product family (ROADMs, AMPs, and fixed filters), including its OLS controller (Ensemble Controller) exposing a TAPI interface, was used to build an OLS domain of 3 ROADMs. Nokia 1830PSSECX muxponders are directly connected to the ADVA colored ROADMs. End-to-end orchestration is provided by NOKIA Bell Labs SDN controller that performs the 4-step scenario (shown as Fig 3a) as follows:

- Step 1: Discovery and service provisioning – from GUI of SDN controller, we will first show how the SDN controller establishes the control channels and discovers OT devices and OLS domain. The SDN controller then constructs the TAPI topology context. Secondly, we will show the service provisioning of two TAPI DSR (L1 – 10Gbps) services on top of the 100Gbps L0 service between NOKIA transponder-1 and NOKIA transponder-2 going through ADVA ROADM-A and ADVA ROADM-B.
- Step 2: OLS domain disruption – We create a link failure between ROADM-A and ROADM-B. The SDN controller collects the alarms from the transponders and OLS controller.
- Step 3: Alarm Correlation **–** We now show how the alarm correlation application processes the alarms for troubleshooting with the bottom-up approach. The SDN Controller GUI will show the impacted TAPI TOP connections and L1 services.
- Step 4: (optional) L0 restoration trigger.

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4. References

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