Demonstration of effective OAM for alien wavelength and transport network

F. Paolucci[1], **N. Sambo**[1], **F. Cugini**[2], **P. Castoldi**[1]
1: Scuola Superiore Sant'Anna, Pisa, Italy; 2: CNIT, Pisa, Italy
fr.paolucci@sssup.it

Abstract: We propose and experimentally demonstrate cooperation between alien and transport network controllers. Such cooperation guarantees proper alien transmission performance as well as the correct functionalities of Operations, Administration and Maintenance (OAM) in the transport domain.
OCIS codes: 060.4250, 060.4261.

1. Introduction

In the last years, network operators and service providers have considered the possibility of implementing *alien wavelengths* [1] besides traditional *wavelengths*. With the latter, "grey" interfaces (operating at 850 or 1310nm) are typically used to connect client equipment —such as IP routers— to the edge of a transport optical network. In this case, the transponder at the edge converts the "grey" signal and injects it into the transport network through a coloured interface (thus a *wavelength* at a given lambda). Differently from this, client equipment can already provide a coulored interface, thus generating a wavelength that can be directly injected in the transport network avoiding the transponder at the edge and only exploiting an optical bypass. This has brought to the concept of alien wavelength, as a client signal which only traverses the optical transport network. Consequently, the alien belongs to a different administrative domain than the one of the transport network. Alien wavelength is an appealing solution that could be adopted for example for signals related to data centers and would permit CAPEX savings for operators given the saving of OEO (optical to electronics to optical) interfaces at the edges [2, 3]. However, several issues must be considered such as: i) the alien has to experience proper quality of transmission (QoT) in an unknown host domain; ii) the operator has to guarantee the proper QoT to alien typically without knowing alien transmission parameters (e.g., used forward error correction —FEC). Alien wavelengths have been demonstrated with proper transmission performance in several field trials [2, 4]. However, the management of alien wavelengths, especially considering the cooperation between alien and host administrative domains, still has to be deeply investigated, not only with the objective of guaranteeing QoT of the alien. As an example, the host domain operator could leverage on alien wavelength QoT performance for its purposes, e.g. for the localization of a malfunctioning network device. In particular, typically, alien wavelengths have their own controller or Network Management System that performs the end-to-end monitoring of the alien performance (e.g., bit error rate —BER).

In this paper, we propose a framework where the host domain controller cooperates with the alien wavelength controller with the objectives of guaranteeing the QoT of the alien and the proper functionalities of Operation, Administration and Maintenance (OAM) in the host domain also with the help of monitoring information related to the alien. The cooperation between host and alien controller is experimentally demonstrated in an optical network testbed including reconfigurable optical add and drop multiplexers (ROADMs) and bandwidth variable optical cross-connects (BV-OXCs) and controlled by extended stateful Software Defined Network (SDN) controllers equipped with east-westbound REST API interfaces.

2. Cooperation between host and alien controllers

The network scenario of Fig. 1 is assumed. An alien wavelength (e.g., generated in a data center network) is injected through optical bypass at the edge of a transport network and still through optical bypass reaches a metro user after the egress transport node. It is assumed that host transport network is controlled by a Host SDN controller, while the alien by the Alien SDN controller. The Host SDN controller has access to all the monitoring information of its domain relying on power monitors deployed in the nodes and in the lines (e.g., after line amplifiers) and on end-to-end monitoring of its lightpaths (e.g., through digital signal processing —DSP— of coherent receiver it is possible to monitor the BER pre forward error correction —FEC— of an optical connection). The Alien SDN controller has access to the monitoring information of the alien, such as the launch power, the power at the ingress of the receiver, and end-to-end parameters measured by DSP, such as pre-FEC BER or the cumulated dispersion. Currently, no automatic mechanism of cooperation between the Host and the Alien SDN controllers are in place in today's deployed networks. In this paper, we consider the cooperation between Alien and Host controllers, that can be realized through a dedicated

978-1-943580-23-1/17/$31.00 ©2017 Optical Society of America

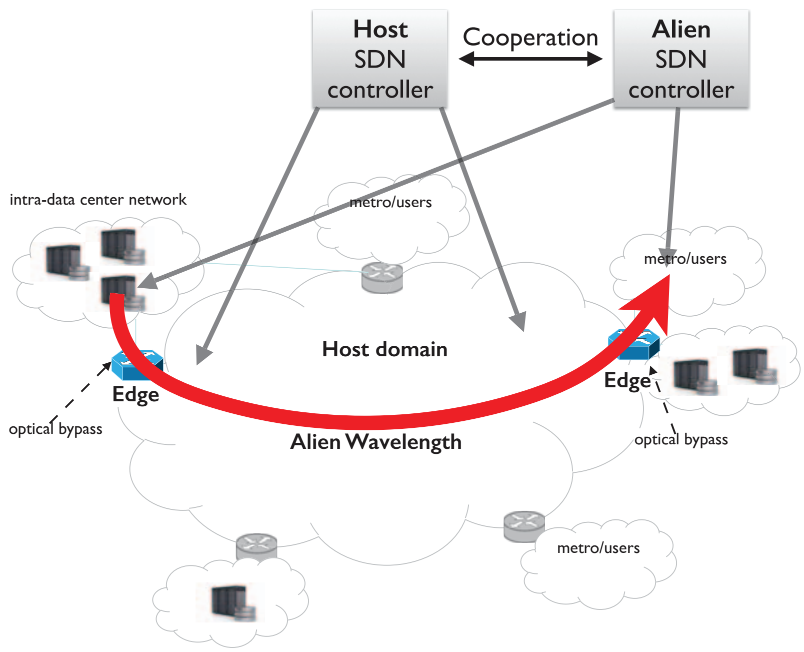

Fig. 1. Alien wavelength and cooperation between host and alien controllers.

east-westbound channel exploiting control plane protocols (e.g., PCEP, NETCONF, COP). For this purpose, in this paper we exploit XML-based REST API interface. Stateful capabilities are required by both controllers to identify the alien lightpaths generated by the client network and carried by the host network, along with the entry and exit points (e.g., edge nodes) in which the alien wavelength is injected.

Two use cases are assumed: 1) a malfunction of an host network device occurs, the Host controller asks for monitoring information to the Alien controller to localize the defective network device; 2) the Alien controller reveals a degradation of the alien QoT (e.g., pre-FEC BER increase) and notifies the Host controller.

3. Experiment

We have assessed the proposed cooperation approach in the aforementioned use case scenarios considering an SDN testbed controlled through extended OpenFlow protocol [5]. A client optical network including 2 ROADMs equipped with commercially available 100G transponder cards is attached through optical bypass to a host optical network including 2 programmable LCoS-based-waveshaper BV-OXC. SDN agents (i.e., local device controllers) running extended OpenFlow are located at the transponders and at the BV-OXC edges. Two stateful SDN controllers, implemented in C++, control the two networks. Moreover, extended REST API interface is implemented between the two controllers to enable cooperation. A alien lightpath with ID=23 is established between the two ROADMs passing through the host BV-OXC.

Use case 1 is triggered by externally configuring the attenuation of the BV-OXC port (through command to the LCoS-based waveshaper) that hosts the alien lightpath. Fig. 2(a) shows the control messages captured at the Host SDN controller (IP address 10.0.0.49) and exchanged with the Alien controller (IP address 10.0.0.50) and the edge node agent (IP address 10.0.0.1). The SDN agent located at the BV-OXC detects low amplifier gain and generates an extended PORT_STATUS message [6], indicating the affected port and the status set to "low launch power" (code 12). The host controller receives the message and identifies the active lightpaths crossing that port. In particular, the controller detects the alien lightpath generated by the client network. Therefore, it opens a REST API connection sending a query to the Alien Controller. The query includes the ID of the installed lightpath (provided by the host controller upon provisioning procedure) and specifies whether degradations are experienced in the client network. The Alien controller perform a STATS_REQ to the destination lightpath card, obtaining the pre-FEC value. Finally, a REST API reply under the form of a XML message is provided with the current value, specifying that end-to-end connection is alive and working and no recovery or adaptation actions are required. In this case the measured pre-FEC BER does not overcome the critical threshold, therefore FEC can recover errors due to the induced attenuation.

Use case 2 is triggered with an higher attenuation than use case 1. However, in this case the SDN agent located at the BV-OXC does not perform gain measurements. Fig. 2(b) shows the control messages captured at the Host SDN

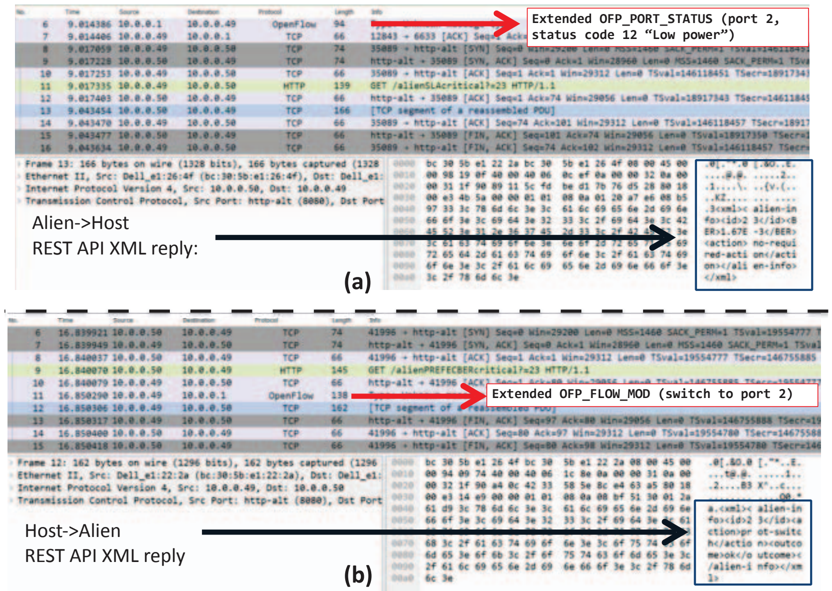

Fig. 2. Wireshark captures at Host controller: (a) use case 1; (b) use case 2.

controller and exchanged with the Alien controller and the edge node agent. Due to the degradation, the SDN agent located at the alien lightpath destination card detects a pre-FEC BER exceeding the critical threshold and sends an extended PORT_STATUS message to the Alien Controller, indicating the affected port and the status set to “critical pre-FEC BER” (code 20). The Alien Controller check whether degradations alarms are raised within its network. If no further degradation events are occurring in the client network, it invokes the Host Controller through a REST API connection. In this case the message encloses the affected lightpath ID and the detected degradation. The Host Controller identifies the involved source node (i.e., the BV-OXC) and performs failure recovery by switching to a pre-planned protection lightpath using a different output port. The recovery action is performed by sending a FLOW_MOD message to the BV-OXC. Once completed the recovery, the controller provides the reply XML message indicating the performed OAM operation and its outcome.

4. Conclusions

We proposed the cooperation between alien and transport network controllers. From the one side, the proper alien transmission performance can be guaranteed, from the other side, alien monitoring information can be exploited for the correct Operation, Administration and Maintenance (OAM) of the transport domain. The effectiveness of cooperation is experimentally demonstrated in a testbed.

5. Acknowledgements

This work was supported by the EC through the Horizon 2020 ORCHESTRA project (grant agreement 645360).

References

1. A. Lord, Y. R. Zhou, P. Wright, P. Willis, C. Look, G. Jeon, S. Nathan, and A. Hotchkiss, “Managed alien wavelength service requirements and demonstration,” in *Proc. of ECOC*, 2011.
2. Y. R. Zhou, K. Smith, R. Payne, A. Lord, W. Wakim, J. Keens, and L. Hanson, “Field trial demonstration and evaluation of a coherent 100G IP over WDM alien wavelength across 769 km of multiple WDM infrastructures without regeneration [invited],” *IEEE/OSA JOCN*, vol. 5, no. 10, 2013.
3. S. Melle, G. Bennett, C. Liou, C. Villamizar, and V. Vusirikala, “Alien wavelength transport: An operational and economic analysis,” in *Proc. of OFC*, 2009.
4. D. Ventorini, E. Moura, L. Paraschis, O. Gerstel, M. Silva, K. Wollenweber, A. J. Silverio, P. P. H. Junior, and L. A. C. H. Silva, “Demonstration and evaluation of IP-over-DWDM networking as ”alien-wavelength” over existing carrier DWDM infrastructure,” in *Proc. of OFC/NFOEC*, 2008.
5. F. Paolucci, A. Castro, F. Cugini, L. Velasco, and P. Castoldi, “Multipath restoration and bitrate squeezing in sdn-based elastic optical networks [invited],” *Photonic Network Communications*, vol. 28, no. 1, 2014.
6. N. Sambo, F. Paolucci, G. Meloni, F. Fresi, L. Potì, and P. Castoldi, “Control of frequency conversion and defragmentation for super-channels [invited],” *IEEE/OSA JOCN*, vol. 7, no. 1, Jan 2015.