Configuring monitoring entities through NETCONF and YANG in control and hierarchical management planes

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Abstract: This paper proposes a novel control and management scheme for elastic optical networks. YANG model for device configuration is presented and the scheme is demonstrated in a control plane testbed including hierarchical management plane.

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1. Introduction

Management plane of optical networks is receiving particular attention from network operators [1]. From the one side, the current trend of both operators and vendors of reducing network margins will force the management plane to handle a huge amount of alarms due to soft failures (i.e., degradation of the quality of transmission, e.g. bit error rate —BER— increase) [2]. Thus, management plane is required to be highly scalable, and an effective solution is to adopt a *hierarchical* architecture, so that each layer is responsible for only a sub-set of network elements or lightpaths (named also connections) [3]. From the other side, while several advances have been reached in the data and control planes, more effort is still required in the management plane, e.g., due to the presence of network elements by different vendors. An emerging standard protocol, NETCONF [4] is an appealing and promising solution both to control and manage data plane devices, since it leverages on the YANG based resources modeling [5], which provides a standard language to describe network elements. Thus, both control and management plane can interface with data plane independently from the vendor.

In this paper, we propose and demonstrate a novel control and manage scheme for reliable elastic optical networks (EONs) based on a hierarchical management plane. Both data plane devices (e.g., transponders) and monitoring entities at each layer are provisioned and configured by centralized controllers. In particular, monitoring entities are instructed about the lightpaths to be responsible of and about the information required to perform correlation [6] for failure localization. Thus, a YANG model is proposed enabling NETCONF to configure and manage monitoring entities. Then, monitoring entities subscribe to specific alarms (or notifications) depending on the events of interest (e.g., BER over threshold). In case of soft or hard (e.g., fiber cut) failure, the proper monitoring entities are notified and failure localization takes place. The aforementioned tasks are finally demonstrated in a control/management plane testbed composed of three hierarchical layers.

2. Control and management scheme

We assume a Software Defined Networking (SDN) EON managed by a hierarchical architecture as in [3]. The root of the hierarchy is the Operation Administration and Mantainance (OAM) Handler [3] (OAM H), a standard entity that has to verify and maintain the correct operation of the network. Each layer in the hierarchy is responsible for a set of lightpaths and performs the following tasks: 1) receiving alarms about potential problems; 2) correlating them (e.g., for fault localization); 3) triggering actions to preserve the services interested by a soft or hard failure. Three hierarchical layers are assumed and each monitoring entity is responsible: for a single lightpath at *layer 0* (monitoring is performed by the digital signal processing —DSP— at the coherent receiver); for the lightpaths starting from a given ingress node, at *layer 1*; for all the lightpaths provisioned in the the network at the root (i.e., OAM H).

The proposed control and management scheme is based on the workflow and the related tasks shown in Fig. 1. Upon connection (lightpath) request from source s to destination d, the SDN controller configures through NETCONF data plane devices: the transponders at the transmitter and receiver sides and the filters of the ingress, transit, and egress nodes (Fig. 1(b)). The transponder YANG model detailed in [7] and including the list of parameters monitored by the DSP (e.g., pre-forward error correction –FEC– BER) is assumed. Then, management tasks take place considering the three-layers management plane. Fig. 1(c) shows the chart of the management tasks. The monitoring entity at *layer 1* — in particular the one associated with node s and responsible for the set LP_s of lightpaths starting from s — is first configured. In case of soft or hard failure, such monitoring entity will receive and process (e.g., for fault localization) alarms related to the affected lightpaths in LP_s. In order to enable a correlation algorithm to localize a failure (e.g.,

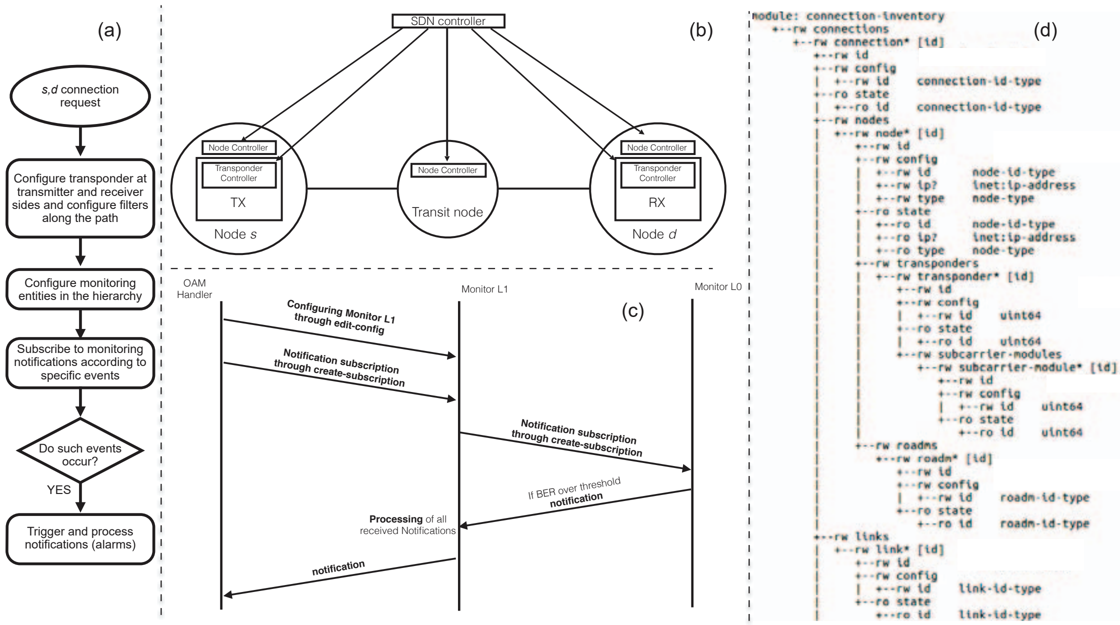

Fig. 1. (a) Control/management workflow; (b) data plane configuration; (c) management time chart; (d) YANG model tree for monitoring entity configuration.

identify the *id* of the failed link), such monitoring entity has to exploit path information of lightpaths in LP_s [6]: i.e., traversed nodes and links. Thus, OAM H firstly sends a NETCONF `edit-conf` message to install lightpath info in the monitoring entity at *layer 1*. A YANG model to describe this information is here proposed and discussed later. Then, OAM H subscribes to notifications (e.g., pre-FEC BER over threshold) related to the requested lightpath, by sending a NETCONF `create-subscription` message at *layer 1*. Consequently, the monitor at *layer 1* subscribes to the same notification by sending a NETCONF `create-subscription` message to the monitoring entity responsible for the requested lightpath at *layer 0*. If a soft- or and hard-failure affects some lightpaths and pre-FEC BER is exceeded, the monitoring entities at *layer 0* send a NETCONF `notification` to the *layer 1*. The monitoring entity at *layer 1* processes the received notifications by exploiting stored lightpaths' information and described with the proposed YANG model. Then, an aggregated `notification` is sent to OAM H. This limitation of responsibilities per monitoring entity guarantees high scalability [3]. The tree related to the YANG model, obtained with the commonly used *pyang* software, is shown in Fig. 1(d). The YANG model presents a list of connections, each one identified with a list of traversed nodes, links, and the adopted reconfigurable add and drop multiplexers (ROADMs) including the used transponders at the transmitter and receiver sides, so that each network element used by this connection can be identified and used for correlation in case of failure. Once the monitoring entity at *layer 1* informs the OAM H about affected lightpaths and the correlation result, if needed, OAM H performs further correlation.

3. Experimental demonstration

The workflow presented in Fig. 1 is implemented in a control plane testbed. Data plane configuration is implemented according to extended YANG and NETCONF as in [7]. OAM H is implemented leveraging on libnetconf library [8]. *Layer 1* monitoring entity (EL1) is build embedding Netopeer-server [8] and a custom libnetconf based module specifically developed to interact with lower monitoring entities. *Layer 0* entities (EL0s) are represented by transponder DSP as in [7]. Correlation algorithm for failure localization [6] is implemented at each layer of the hierarchy. We considered the topology in Fig. 2 composed of 3 edge and 4 transit nodes. The SDN controller is based on Berillyum Opendaylight (ODL) 4.2.0 [9]. We assume two different scenarios shown, respectively, in Fig. 2(a) and Fig. 2(b). EL1s become aware of the connections to be responsible from OAM H through the proposed YANG model of Fig. 1(d). In the first scenario (Fig. 2(a)), link 8 fails affecting three connections and EL1 entities do not properly localize the failure, e.g. EL1 related to ingress node A identifies links 1 and 8 as possible failed links (the common links of the connections starting from A). Thus, failure localization is solved at OAM H that can exploit also notification coming from EL1 related to C. In the second scenario, link 1 fails and EL1_A correctly localizes the failure, since link 1 is the only one in common of the two connections starting from A. The first scenario is now considered. Fig. 2(c) shows the capture of

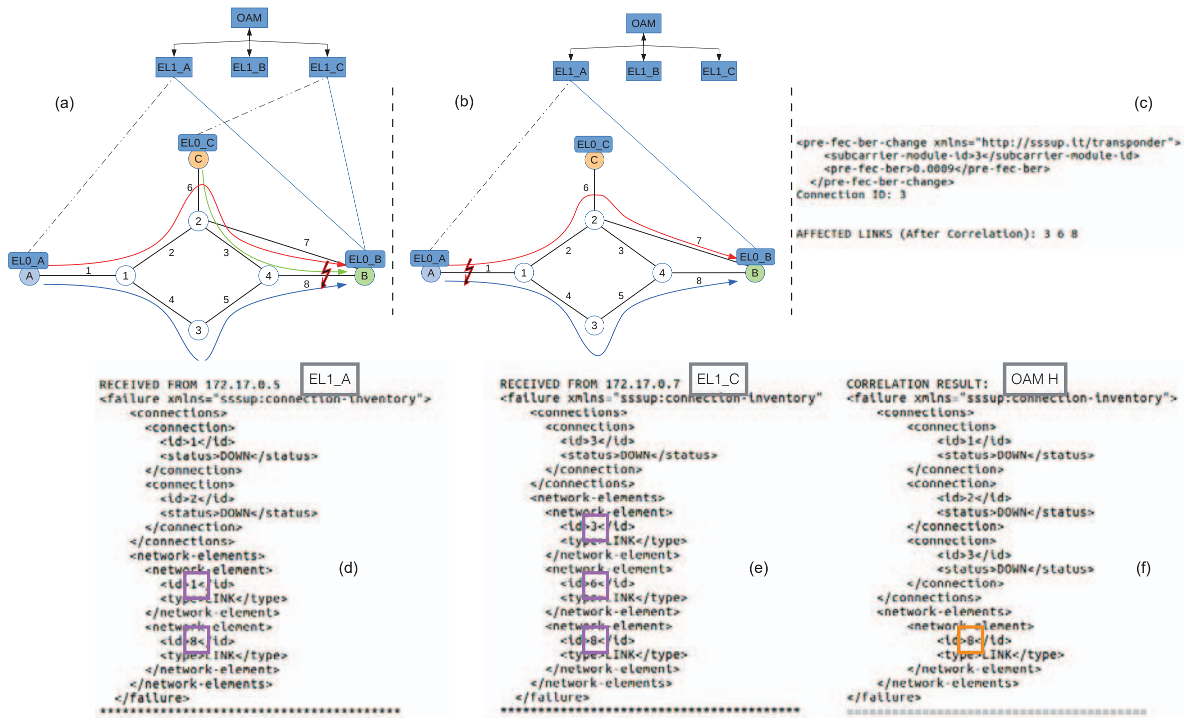

Fig. 2. (a) First network scenario; (b) second network scenario; (c) `notification` sent by *layer 0*; (d) *layer 1*-correlation at EL1_A; (e)*layer 1*-correlation at EL1_C; (f) correlation at OAM H.

the `notification`, related to the third connection, sent by EL0_B to EL1_C, identifying a problem in links 3, 6, or 8. Fig. 2(d) shows the result of the correlation (links 1 and 8) at EL1_A, which is incorporated in the `notification` sent to OAM H. Fig. 2(e) shows the result of the correlation at EL1_C, again incorporated in a `notification` sent to OAM H. Fig. 2(f) shows the result of the correlation performed by OAM H exploiting the `notification` messages received by EL1_A and EL1_C. Thus, OAM H successfully solves failure localization. In the second scenario, correlation is successfully solved by EL1_A (for space reasons the `notification` content is not shown).

4. Conclusions

This paper presented a control and management scheme for EONs and a YANG model to configure monitoring entities giving their management responsibilities on specific lightpaths. The scheme is successfully demonstrated in a control and management testbed considering failure localization at different layers in the management plane.

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