Demonstration of gRPC Telemetry for Soft Failure Detection in Elastic Optical Networks

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Abstract *Streaming-oriented telemetry allowing on-demand live monitor of EON is exploited for fast soft failures localization. SDN control and management is extended with telemetry modules based on the gRPC protocol. Experimental results show telemetry efficiency in terms of detection accuracy.*

Introduction

In Elastic Optical Networks (EONs), accurate and real-time knowledge of physical layer parameters and transmission impairments has the potential to significantly improve the efficiency of control and management operations. Relevant benefits are expected in failure detection, localization, and recovery mechanisms, particularly in the case of soft-failures where just minor signal degradations are experienced without causing relevant disruptions[1]. Detecting and localizing soft failures is extremely important since they may reduce system margin, introduce sporadic post-FEC errors or may reveal in advance possible malfunctioning of network devices.

However, current deployed monitoring devices and transponders typically provide statistics every 15 minutes. This time was historically selected to enable basic monitoring without overwhelming the management plane and the network controller with an excessive amount of data. Also network protocols deployed for carrying monitoring statistics, as SNMP or NETCONF, were designed and implemented to support such pace and amount of data. However, such basic monitoring and protocols, do not provide accurate and real-time knowledge of data plane info and are not really suitable for accurate and fast soft failure detection/localization.

Recently, the availability of higher bandwidth in the control/management plane, combined with the introduction of big data analytics and improved processing capabilities at the network controllers are overcoming the aforementioned limitations, opening the way for new and effective monitoring and management solutions[2,3].

In this paper, we implement and experimentally demonstrate a telemetry-based system, providing on-demand, accurate, real-time monitoring statistics, also suitable for soft failure. In particular, streaming-oriented telemetry based on the gRPC protocol is proposed, providing efficient fine grained monitoring in the time domain.

Soft Failure Detection Use Case

A portion of EON shown in Fig.1 is considered. The network includes a 400km link N3-N4 of 5-span. Lightpath L_A generated at N2 and terminated at N4 is a 100G PM-QPSK provided by a commercial system. Under steady state normal conditions, the lightpath has OSNR statistics in the range between 22.3 and 22.0 dB. As a typical commercial system[4], the 100G transponder provides such statistics every 15minutes (along with additional transmission parameters such as pre-FEC BER, received power, etc) through SNMP or NETCONF protocols to the centralized controller. A minor failure then occurs on an intermediate device, such as the optical amplifier D4. In particular, the amplifier starts introducing limited (e.g., 1-2dB) and sporadic fluctuations on its launch power. Such fluctuations do not significantly impact the received power of L_A since it is recovered by the subsequent EDFA D5 (Pre-amplifier of node N4). However, on span D4-D5, such fluctuations slightly affect the signal to noise ratio of the traversing signals, inducing a so called soft failure on lightpath L_A: the overall power at the receiver is not changed while the received OSNR statistics sporadically change in the range between 21.6 and 21.0 dB. The average statistics collected every 15minuts are typically not adequate to detect sporadic minor issues affecting the EDFA launch power or OSNR performance, which remains largely below warning thresholds. This implies that the minor malfunctioning of the EDFA (i.e., the soft failure) is traditionally *not* detected, even if it may be extremely useful to reveal in advance that a device is running out of specs, with high probability to experience in the near future a major fault, potentially affecting many end-to-end services.

Proposed gRPC Telemetry Control

Network telemetry, i.e. streaming of real-time sample values, with rate of seconds or below, is proposed to be activated (on-demand, by the maintenance operator or automatically by

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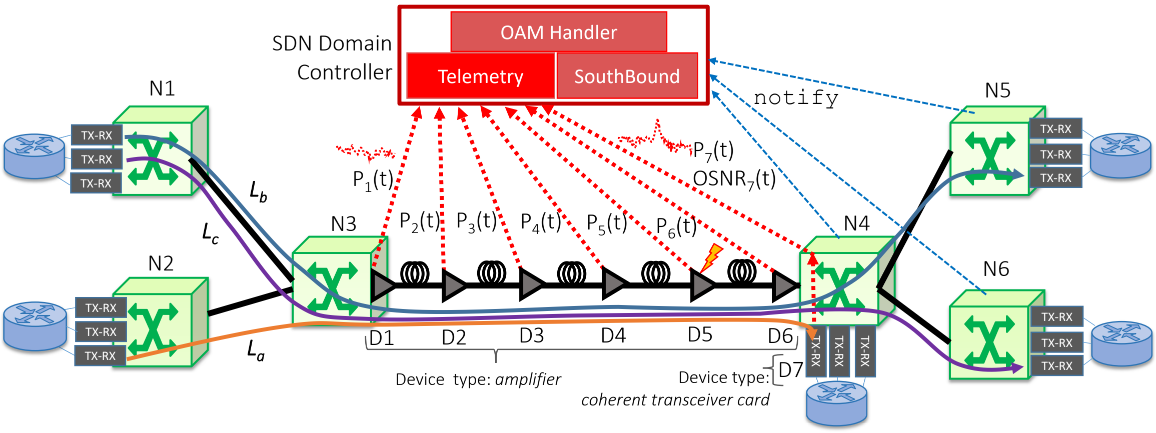

Fig. 1: EON Soft Failure Use Case and Telemetry solution.

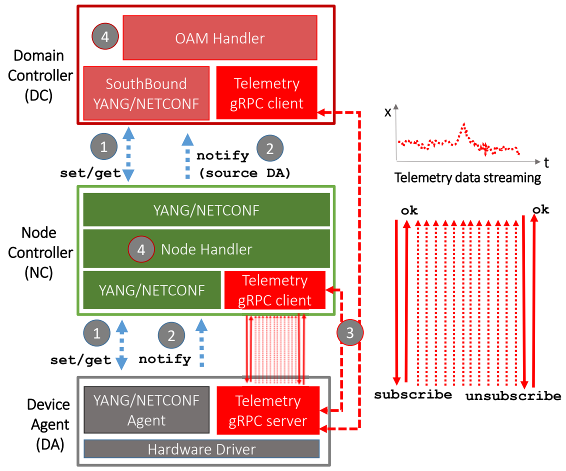

Fig. 2: Network Control extended with gRPC Telemetry

network controllers) for a selected amount of time in parallel over a subset of target devices, identified by means of correlation methods (e.g., link devices shared by affected lightpaths L_A, L_B and L_C in Fig. 1). Correlation algorithms in the time domain among the telemetry samples set allow to perform fast soft failure detection and localization.

Fig. 2 shows the proposed control architecture exploiting telemetry for soft failure detection. Three hierarchy control/management levels are considered, following the framework of optical white boxes: the SDN-based Domain Controller (DC), responsible for the entire network domain configuration and management; the Node Controller (NC), responsible for the configuration of ROADMs and OXCs modules; and the Device Agent (DA), controlling a single optical device within or outside a node. For example, a DA of type *coherent transceiver card* may be handled by its node NC, whereas a DA of type *line power amplifier* is an independent DA. SDN network configuration (e.g., lightpath configuration) based on NETCONF interfaces is supposed, occurring in the DC-NC-DA chain (step 1). Notification is also supported, allowing the asynchronous bottom-up communication of lightpaths/signal parameters degradations or hard failures[5]. Upon NETCONF degradation notification (step 2), the upper layer may decide to trigger a set of telemetry subscription instances for fine-grained live monitoring. To this purpose, both DC and NC are equipped with a novel dedicated telemetry client module based on the gRPC protocol[6], whereas the DAs implement a gRPC server, directly receiving values data from the hardware and ready to stream them to any controller client upon gRPC subscription request. Depending on the ownership of the DA subset to be monitored through telemetry, DC or NC opens a gRPC telemetry subscription to involved DAs, indicating the target physical parameters to be monitored, thus triggering the gRPC server to push real time streaming of the monitored values (step 3). Once the controller Handler (i.e., either the OAM Handler at DC or the Node Handler at NC) has performed time domain correlations and identified the soft failure source, it stops the telemetry streaming by sending an unsubscribe command to the DAs.

gRPC is a HTTP/2 open source high performance Remote Procedure Calling (RPC) framework developed by Google that can run in any environment. It includes pluggable support for load balancing, tracing, health checking and authentication. The choice of gRPC as telemetry protocol is dictated by its capability to support high performance server push streaming mode, allowing, besides independent YANG-based dataset and method definition, also binary data format compression and efficient wire encoding through protocol buffers serialization. Such capabilities make gRPC attractive to connect devices and sensors for telemetry streaming with respect to standard HTTP, RESTCONF, NETCONF interfaces based on XML or JSON formats[7]. To provide gRPC telemetry targets, the NETCONF protocol has been extended to include information about specific DAs handled by a NC. In particular, the gRPC server location

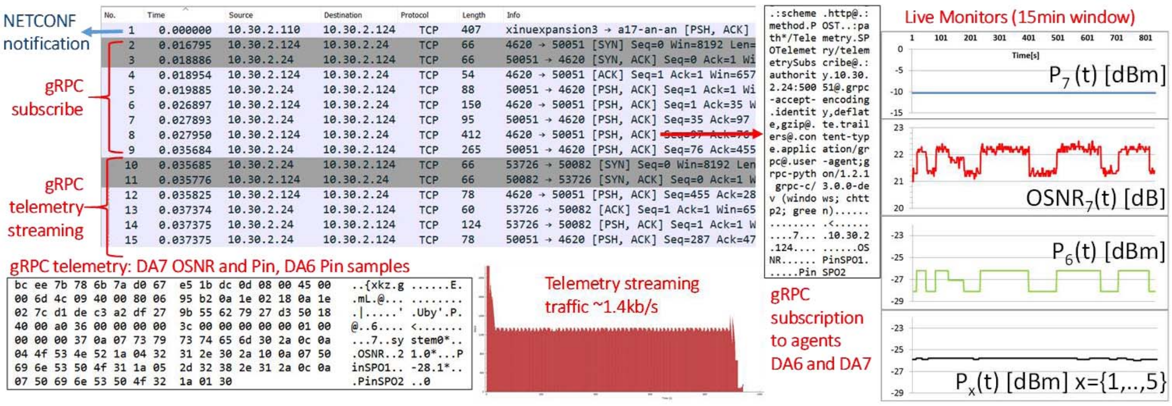

Fig. 3: Experimental results: NETCONF/gRPC captures and telemetry monitors

(i.e., address and attributes) of the affected source DAs are encoded within the NETCONF Notification message sent by the NC to the DC. Therefore, the OAM Handler can trigger parallel gRPC subscriptions for telemetry to target DAs.

Experimental Demonstration

To assess the proposed telemetry-enabled solution, an experimental demonstration has been carried out on the EON testbed representing a subset of Fig.1. Data plane includes nodes N2, N3 and N4. Nodes N2 and N4 employ Ericsson SPO-1400 ROADMs equipped with commercial 100G PM-QPSK transponder cards. The N3-N4 link includes 5 line EDFA amplifiers (D1-D5), 5 80km-long fiber spans and the SPO pre-amplifier D6. A Finisar Waveshaper placed between D5 and the fiber span is inserted to emulate the soft failure. The control plane includes a NETCONF-enabled DC[5], two NETCONF NCs at N2 and N4[5], and DAs, fully extended with gPRC modules. Each DA is a python-based monitoring system that leverages on proprietary protocols for the communication with data-plane commercial devices. Different types of DA are available. In particular, agents D1-D6 (type amplifier) monitor the line power, whereas D7 (type card) monitors the pre-FEC BER and the estimated OSNR. Lightpath L_a (100G, fc=193.1 THz, m=3) is setup from N2 to N4, terminating in D7. Standard NETCONF notification is activated when the D7 OSNR average value in the last 15 minutes falls below 21.7 dB. A soft failure of device D5 is induced by reducing its launch power of 1-2dB in a random pattern. The subsequent 15min slot triggers N4 NC NETCONF notification due to the slight OSNR degradation. Indeed, the controller identifies the N3-N4 link as a candidate degradation source. However, relying on just 15mins average statistics (i.e., without telemetry), it would not be able to localize the soft failure. Thus, to localize the soft failure, the controller triggers parallel gRPC telemetry subscriptions on the D1-D6 devices. Fig. 3 reports a capture of the control messages exchanged by N4 (NC IP 10.30.2.110), D7 (DA IP 10.30.2.24) and the DC (IP 10.30.2.124). The capture shows NETCONF notification sent to DC (frame 1), triggering gPRC subscription of D6 and D7 telemetry of 1s sampling rate. A gRPC telemetry sample carrying D6 P_{in} and D7 P_{in} and OSNR values is reported, encoded in only 123 bytes. Measured streaming rate is around 1.4kb/s. Fig. 3 reports also telemetry monitors in the time domain acquired in parallel for each DA in 15 minutes. Telemetry analysis clearly shows that P_{in} at D6, i.e. $P_6(t)$, and OSNR at D7 are highly correlated, while all the other DA $P_x(t)$ monitors do not reveal significant correlations, meaning that the other amplifiers are in optimal working conditions. This result allows the controller to successfully identify D5 as the soft failure source.

Conclusions

Telemetry-enabled SDN control was validated in EON soft failure detection scenario. Results showed its potential to improve monitoring in the time domain and the efficiency of server push gRPC streaming resulting in few kb/s traffic rate.

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