Real-time Detection of Anthropic Events by 10G Channels in Metro Network Segments

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Abstract: We present an experimental proof-of-concept on detecting SOP variations including information on mechanical stresses on the network footprint by tapping out a small amount of power from 10G channels. Data can be gathered and classified locally, in each node, delivering alerts through streaming telemetry

Keywords: *sensing, SOP, 10G, real-time*

1. Introduction

Optical networks are pervasive infrastructures, especially in metropolitan areas, so they can also be used for surveillance purposes thanks to the sensing properties of the optical fiber to mechanical stresses. In [1], it has been shown that the state of polarization (SOP) changing includes information on mechanical stresses in the network geographical footprint and can be detected by coherent receivers [2,3]. In this work, we show that a good sensitivity to the anthropic events can be also obtained with a much simpler setup by tapping out 10% of power from an IMDD 10G channel, that can be for instance the node-to-node service channel. We show an experimental proof-of-concept based on transmitting and receiving data on a deployed metro fiber using commercial 10G transceivers, and use a simple and potentially low-cost setup for the detection of SOP information. In this framework, the SOP variations induced by anthropic events can be observed in the tapped signal and can be locally processed in the node, enabling a real-time event classification. Such additional feature can be easily integrated in the already available streaming telemetry [4] and the centralized controller can rely on such information from different nodes as for instance to deliver real-time alerts and in general supports to the smart city management.

2. Experimental Setup

The measurement setup is depicted in Fig. 1. A 10 Gbps intensity modulated signal, carrying data, is generated by a commercial WDM card, equipped with a SFP+ TRX module.

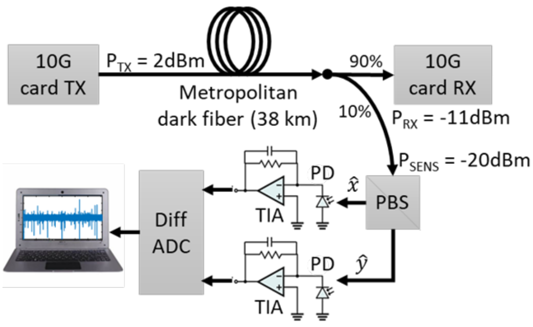


Fig. 1: Experimental setup sketch.

The data signal propagates along a 38 km fiber currently installed under the city of Turin and accessible on both ends from an optical terminal box at the LINKS laboratory. Using an unbalanced optical splitter, the 90% of the signal power is seamlessly received by the commercial card for conventional data transmission, whereas the 10% is provided to a polarization beam splitter (PBS) that separates the received signal into $\hat{x}$ and $\hat{y}$ orthogonal signals, which are then converted to the electrical domain by means of two commercial photodiodes (PD), followed by a trans-impedance amplifier stage (TIA). A 14-bit differential Analog-to-Digital Converter (ADC), working at 50 Sample/s, acquires the differential signal. As the anthropic events induce a fast power variation with opposite sign on the two ortogonal signal components, the composite amplitude variation is doubled, increasing the sensitivity of the measure.

3. Results

In Fig. 2 it is possible to observe an 8-hour capture of the real-time detector. The measurements were collected for 8 hours, roughly from 4 PM to 12 AM, on a working day. In order to translate the information of anthropic activities from signal fluctuations to an event counter, an algorithm able to estimate the average crossing of cars per hour was envisioned, based on frequency filtering, pseudo-Gaussian smoothing and peak detection in the time domain. Furthermore, the power spectrum of the captured signal was analyzed. Slow drifts were removed from each polarization component, subtracting its 1000-samples moving average. Then the two polarized differential

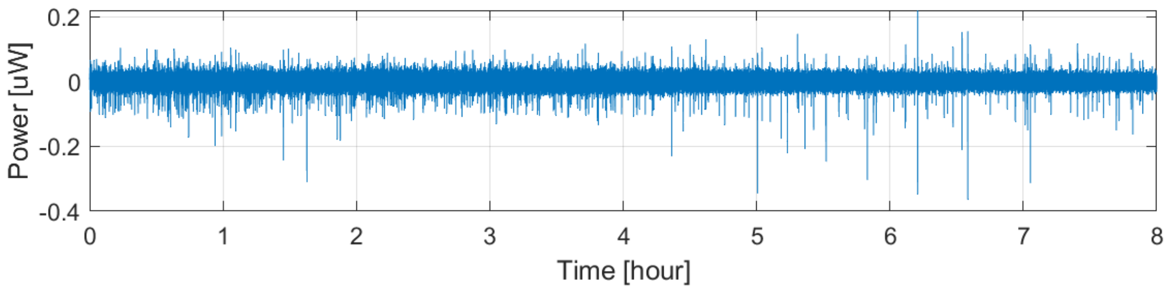
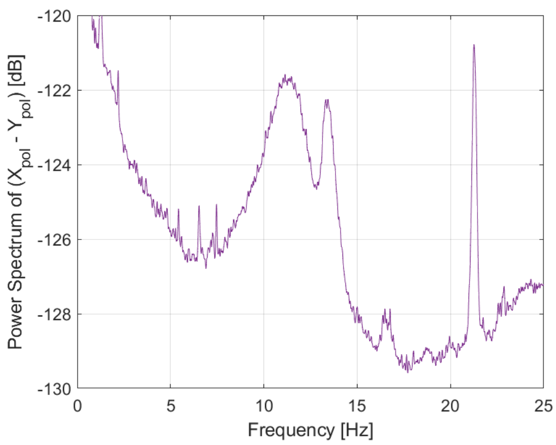
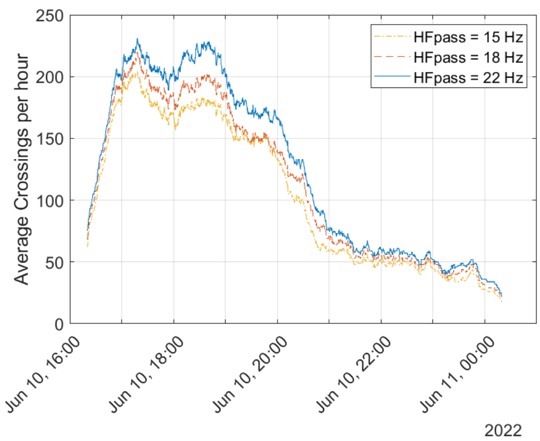


Fig. 2: 8-hour capture of the differential signal

signal revealed that the information about the peaks was all concentrated around three main frequencies located at 11, 13 and 21 Hz, as shown in Fig. 3(a). Low-frequency content of the spectrum, below 6 Hz, mainly consists of 1/f noise, with few 1 Hz-spaced superimposed harmonics. A band-pass filter at different low-pass corner frequency (15, 18 and 22 Hz; high-pass corner frequency is fixed at 1 Hz) was introduced and the amount of crossing events re-evaluated. As can be observed in Fig 3(b), the choice of different corner frequency does not significantly affect the shape of the crossings density over time, while reducing the number of crossing events. We concluded that, the 22 Hz peak was not related to the anthropic activity, but rather to some fans vibration that inevitably takes place near the laboratory measurement equipment. Furthermore, a very intensive traffic, as expected on a Friday afternoon in a big city like Turin, is detected during the first 5 hours. From 9 pm, the number of crossings reduces significantly.



(a) Spectrum of the differential signal



(b) Average crossing on (X_{pol}-Y_{pol}) per hour depending on different cut frequency

Fig. 3: Post-processing of captured data

4. Conclusion

In this work, a real-time detector of anthropic events, realized with commercial and cheap optoelectronic components, able to exploit a small part of a received intensity modulated signal, has been proposed. Detected data can be processed locally in nodes and the event classification and/or alert can be delivered to the centralized controller through streaming telemetry.

References

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