Machine-learning Aided Quality of Transmission Estimation in Optical Line Systems
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Research context and motivation
• Data traffic demand will experience a dramatic increase by the implementation of 5G and by the expansion of bandwidth hungry applications such as high definition video, virtual and augmented-reality contents
• Backbone optical networks will sustain such a growth, and a key operator’s request is to exploit the existing infrastructure to maximize their returns over investments
• Operators interest is to exploit the capacity of existance fiber and infrastructure
• Such a need is directly related to the capability of orchestrating all the network layers to squeeze out all the available capacity from the existence infrastructure
• 100–GHz deployment, only relying on the available open source libraries, specifically on the TensorFlow platform

Addressed research questions/problems
• In optical networks, the enabler for the optimal exploitation of data transport – the dense wavelength division multiplexed (DWDM) transmission – is the control layer.
• In particular, software-defined network (SDN) controllers rely on a network abstraction where Quality-of-Transmission (QoT) degradation on Optical Line Systems (OLS) is given by the capability of OLS controllers to operate at the optimal working point
• The higher the accuracy in pursuing such a task, the lower the margin for traffic deployment and larger the deployed traffic rate.
• Moreover, network failures and recovery could be automatized and sped up. So, to reduce the margin it is mandatory to rely on a QoT estimator (QoT-E) that is able to reliably predict lightpath (LP) performance before its actual deployment, i.e., the generalized SNR
• (GSNR)=1/ISNR that includes both the effects of ASE noise and nonlinear interference.

Adopted methodologies
• We suppose a completely agnostic scenario, by relying only on data coming from the optical channel monitor (OCM) available at the end of the line system.
• To emulate an OLS, we experimentally setup an 11-EDFA line and we changed spectral loading, collecting data from an optical spectrum analyzer (OSA) mimicking the OCM
• The channel combs spectrally loading the OLS have been obtained by shaping ASE noise.
• The output of the ASE noise source is shaped by means of a programmable optical wave-shaper filter to generate a 100 GHz-spaced 35-channel WDM comb centered at 1550 nm and amplified by a booster amplifier
• The choice of the 100 GHz spacing was forced by the hardware availability as well as the limitation to 3.5 Thz.
• The optical line is composed by 11 spans, each made of a VOA, setting the optical span attenuation to 10 dB, followed by an EDFA, operating at a constant output power of -1 dBm per channel.

Novel contributions
• Our QoT-E using machine-learning techniques supposing the availability of a training data-set acquired before the deployment of real traffic, with the purpose of reducing the uncertainty on the estimated OSNR.
• We did not aim at developing specific machine learning methods, but only showing the effectiveness of ML for the objective purposes.
• So, we relied on the available open source libraries, specifically on the TensorFlow platform.
• We show that using deep neural network (DNN) algorithms, with some optimization, and properly exploiting the data-set, we reduced the uncertainty on the predicted OSNR down to 0.2 dB.

List of attended classes
01RONK – Python in the Lab (25/06/2019, 20h)
01QTEIU – Data mining concepts and algorithms (11/01/2019, 20h)
01QFFRV – Tecniche innovative per l’ottimizzazione (06/03/2019, 20h)
01TEHRV – Data Science for Networks (09/04/2018, 30h)
01QORRV – Writing Scientific Papers in English (28/03/2019, 15h)
01TCTRVR – Photonext: Hands on course on Photonics for Fiber Transmission (18/07/2019, 30h)

Submitted and published works

Future work
• Future analyses performed by including also the available telemetry data from the EDFAs may yield to further reducing the residual uncertainty
• The effectiveness of machine learning in optical line systems will exploit the hidden capacity of already infrastructure to maximize the operator returns over investments