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Exploiting Terrestrial Meshed Optical Data Networks as Environmental Sensing Smart Grids

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Optical networks for data transmission have become a pervasive infrastructure in the last years in order to cope with the increasing bandwidth request, thus there is a huge potential to be employed as a wide fiber optic sensing network. In the terrestrial scenario such networks are usually arranged on meshed topologies densely covering large areas of hundreths or thousands of kilometers. On the network's nodes, dedicated hardware is used to routed the data traffic between the connections' endpoints. Such nodes are interconnected by optical fiber links of hundreds of kilometers long, repeated every tenths of kilometers using optical amplifiers.

To fulfill the modern traffic requirements, optical networks are evolving towards multi-service autonomous, flexible, software defined entities based on a centralized intelligence orchestrating the networking functions and communicating with the network elements using standardized interfaces. This trend opens the perspective of using the optical network for evironmental sensing, such as earthquake detection or anthropic activities monitoring.

Indeed, distributed acoustic sensing (DAS) systems based on Rayleigh scattering have demonstrated that optical fibers are excellent sensors of mechanical stress. However, such systems are expensive and pose some limitations on the maximum reach, so they cannot be deployed extensively. In this context, re-using the already deployed optical data infrastructure to support and integrate dedicated system sensing may be highly beneficial. In this work, we propose an optical data network architecture exposing sensing functionalities with minimum or no additional hardware simply by exploiting the pervasiveness of the telecommunication infrastructure and getting data from the physical quantities already monitored for data transmission purposes. Such architecture on a typical terrestrial optical data network is outlined in figure.

Modern coherent transceivers based on digital signal processing already track the evolution of the transmitted optical signal phase and polarization to recover the transmitted data at the receiver side. As those quantities are strongly affected by external strain, they already contain environmental information. Furthermore, some polarization-based processing can be implemented on cheaper non-coherent transceivers available at each amplifier site as data-service channel, providing several sensing sources.

In addition, further optical devices such as add-drop multiplexer or optical amplifiers typically have several other sensors already embedded (power monitors, temperature sensors) or they can be equipped with some others which can provide environmental data from other physical quantities.

The set of all such environmental data streams produced by the network elements constitutes the streaming telemetry fed to a network controller. A post-process agent may be implemented by exploiting the computational power available in typical network elements to perform local data analysis and reduce the amount of data sent to the sensing controller. By cross-processing the data coming from the network elements, a sensing controller is able to detect and localize events making the network act as a smart grid by continuously monitoring large areas and providing early warning signals.

To support our proposal, in this work we show the results of an experimental activity aimed at detecting and localizing anthropic activities in the city of Turin using a deployed fiber ring.