Optimizing Next-Generation Elastic Core Network Infrastructure

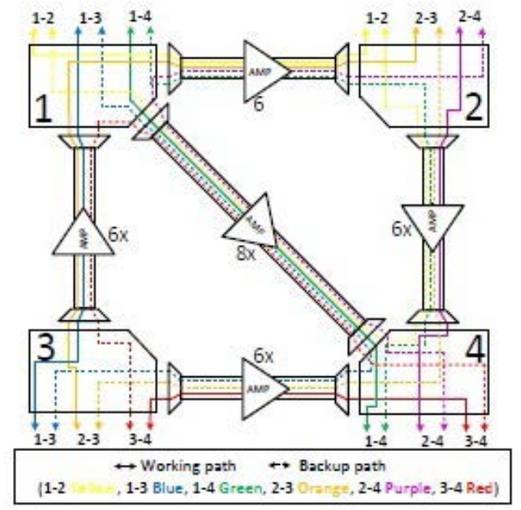


Fig. 1 Dimensioned network corresponding to a feasible solution for the survivable topological design problem.

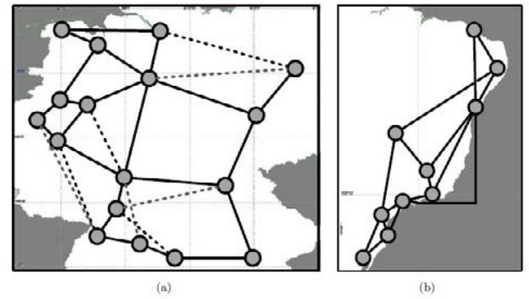
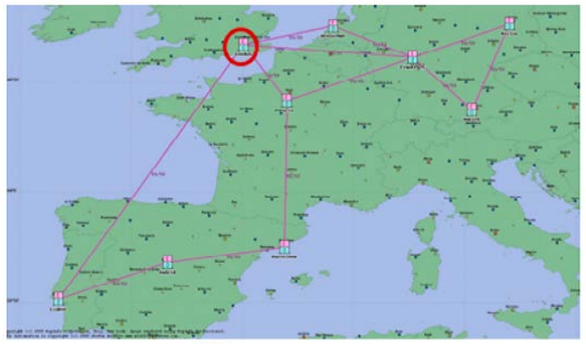
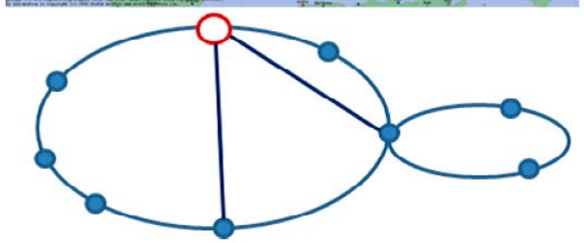


Fig. 2 Topologies obtained using the Integer linear programing model and the genetic algonthm for the node location of (a) German network and (b) Brazilian RNP network.

The increasing demand for transmission capacity in optical networks led to the Flexgrid concept, which allows a flexible aggregation of basic channels according to the demand. With the Flexgrid approach it is necessary to rethink many aspects of optical networks implementation: node architectures; planning procedures; protection and resilience options. These aspects were studied in ONECI.





PROJECT WEBPAGE URL
https://www.it.pt/Projects/Index/1859

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Funding Agencies

FCT	**151,843€**
Start Date	01/05/2013
Ending Date	31/07/2015

Indicators

Journal Papers	10 International Jour. (8 In IEEE Journals)
Conference Papers	17 Internartional Co. (9 By Invitation)
Concluded PhD Theses	2
Concluded MSc Theses	4

Two Main Publications

R. M. Morais, J. M. Pedro, P. Monteiro, A. N. Pinto, **Benefits of Node Architecture Flexibility and Hitless Re-Grooming in Transport Networks,** IEEE/OSA Journal of Lightwave Technology, Vol. 33, No. 21, pp. 4424 - 4436, November, 2015

S. Routray, G. Sahin, J. R. F. Rocha, A. N. Pinto, **Statistical Analysis and Modeling of Shortest Path Lengths in Optical Transport Networks**, IEEE/OSA Journal of Lightwave Technology, Vol. 33, No. 13, pp. 1 - 11, July, 2015

GENERAL MOTIVATION AND OBJECTIVES

Present communication networks have two complementing aspects: optical and mobile networks. The latter have the advantage of portability making possible the realization of the 'anywhere communications' concept. Due to their popularity mobile networks generate huge amounts of traffic, which must be delivered to the appropriate destination. However, mobile networks themselves cannot transport great amounts of traffic, possibly exceeding rates of 1000 gigabits per second. Here fixed line networks based on optical fibers play a fundamental role, by transporting the huge amounts of data generated not only by wireless networks but also by all types of communication networks. In this context, the key objective of the ONECI project was to research in detail a cost and power efficient optical transport network, based on the Flexgrid concept. The optimized optical network will be able to carry a wide range of signal bandwidths, varying in real time, direction and magnitude, some of which will have extremely large rates (greater than 400 gigabit/sec in the near future).

CHALLENGE

To achieve the goals of ONECI it was necessary do carry out interdisciplinary studies involving researchers with backgrounds in networking and physical aspects of optical communications, as well as mathematics. To perform an integrated rethinking of optical networks, the following interrelated aspects were considered: (i) design of Flexgrid node architectures; (ii) integrate the designed Flexgrid architectures into network planning procedures; (iii) design and evaluation of protection and resilience options using Flexgrid. It must be emphasized that the resilience aspect of optical networks is of paramount importance when compared with other network types, due to the huge amounts of data they transport.

WORK DESCRIPTION AND ACHIEVEMENTS

ONECI involved various interrelated aspects of optical networks: physical layer characterization and optimization, control plane optimization, and techno-economic studies. A brief description of each one of these aspects follows.

Physical layer. Routing algorithms with awareness of physical impairments in optical networks were developed. The main physical impairments in optical fibers were considered: noise, light polarization effects, Kerr effect.

Control plane layer. Development of optimization tools and control plane extensions to allow flexible grooming of traffic and elastic bandwidth allocation. Network survivability guarantees, CAPEX (capital expenditure) and energy consumption minimization were considered.

A techno-economic study was performed on Flexgrid and Fixed grid technologies. The CAPEX and OPEX (operating expenditure) models include equipment price, power consumption, footprint and maintenance. Optical transport networks were characterized statistically in terms of link lengths and shortest path lengths distributions, which allows CAPEX evaluation in the early stages of network planning.

This research activity resulted in various papers published mainly in reference IEEE journals. Also various optimization and planning tools were developed. Examples of these tools are described below.

-IARWA_NU (Impairment Aware Routing and Wavelength Assignment – Network Upgrader). Based on fiber network information and optical impairment parameters it determines the fiber links to be added to the network, and computes the routing to achieve maximum network capacity.

-MLO (Multilayer Optimization) – an application supporting both fixed-grid and Flexgrid optical network design. Input data: (i) the available network equipment types and costs, (ii) the network topology and (iii) the traffic data. It determines the required equipment (transponders/ muxponders and regenerators), the regenerator placement and the lightpaths routing.

-DONS (Dynamic Optical Network Simulator) – a family of 2 applications, one considering fixed grid optical networks (DONS-Fix) and another considering Flexgrid optical networks (DONS-Flex).