Project Achievements

CELTIC Telecommunication Solutions

Elastic Optical Networks

The EO-Net project aimed to design and demonstrate a novel networking concept based on “elasticity” for an improved utilization of resources in optical networks. A certain number of transmission parameters such as optical data rate, modulation format and wavelength spacing between channels, can now be made tunable while in current deployed networks they are fixed. This elastic concept that is very common and successful in other telecommunication areas, is a newcomer in optical transport networks.

Main focus

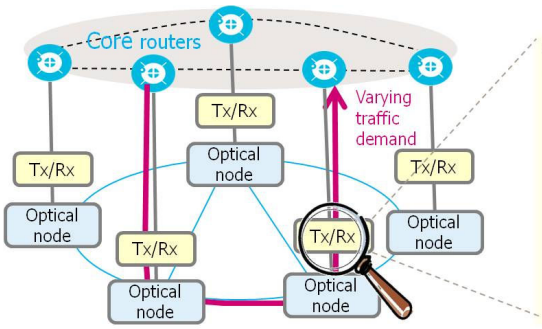
Optical core networks are currently designed for a fixed data rate per channel, each channel being separated by 50GHz from the next. In addition, resources are largely over-provisioned to absorb any fluctuation in traffic volumes and physical impairments. However, the capacity demand, fueled by FTTx penetration and new services, is forecasted to increase by 20-40% compound annual growth rate (CAGR) with no stopping in sight for the next 10 years while the available capacity on a single fiber will not grow much further in a cost- and energy-efficient manner.

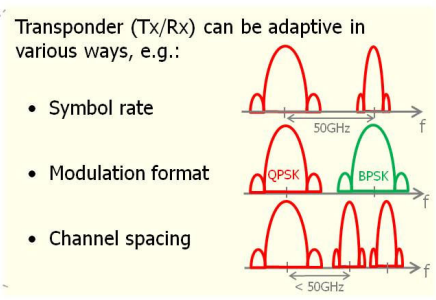
The introduction of elasticity in optical networks allows a more dynamic management of resources as closely as possible to the physical limits and to the capacity requirements. The expected benefits are: an increased network capacity, a cost reduction and an improved energy-efficiency. For instance, elastic devices are cost-efficient thanks to their ability to upgrade their data rate to follow the capacity growth without the need to uninstall and replace low-rate devices.

Approach

At the project start, very little work was performed on elastic optical networks. The EO-Net project made considerable headway in the proposal of technical solutions to introduce elasticity in optical transport. Research activities covered a global picture of optical networking since the introduction of elasticity impacts many building blocks, namely:

- **Transponder** designed to support variable data rate. In particular, the EO-Net project focused on the current 100Gbps transmission systems as it can be made adaptive in various ways with little added complexity.
- **Performance predictions**, e.g. the bit error rate predictions, are of importance to design optical links and be able to adjust the transmission parameters appropriately. The aim is to model accurately the impact of physical impairments, such as chromatic dispersion, noise accumulation and non-linear effects, on elastic optical signals.
- **Routing and resource allocation algorithm** accounting for physical impairments and elastic devices with variable





EO-Net

Project ID: CP6-006

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www.celticplus.eu/projects/celtic-projects/call7/EO-Net/eonet-default.asp

data rate were proposed for a wide range of scenarios.

- Interfaces between routers and elastic transponders with a flexible aggregation of client traffic on optical signals were considered and prototyped.
- Protocol extensions of **GMPLS control plane** were developed to support elastic parameters.
- The outcomes of all aforementioned activities have fed **detailed techno-economic studies** for a quantitative assessment of elasticity benefits in terms of cost-, energy- and spectral-efficiency.

Achieved results

EO-Net results consist of both analytical studies and experimental validations of the proposed technical solutions. The key achievements of the project include:

1. Prototypes of (burst-mode) transmitters up to 100Gbps with off-line reception capable of varying the modulation format among BPSK, QPSK (Binary/Quadrature Phase-Shift Keying), 8QAM and 16QAM (Quadrature Amplitude Modulation).
2. Studies on coded modulation were shown to be a competitive alternative to conventional QPSK and 8QAM modulation formats, i.e. coded modulations requires less power for the same amount of redundancy and the same bit error rate.
3. New constructions of error correcting codes based on reconfigurable code rate were proposed and some trials of hardware implementation were also tested. This has validated the parallel architecture solution capable of reaching 100Gbps (or more).
4. A live demonstration of real-time elastic muxponder was performed. A muxponder combines the functions of a flexible aggregation module and those of a transponder. This technology enables an optical transport network to have power consumption linearly proportional to the actual requested traffic.
5. Some new performance estimation models and software prototypes for elastic networks were introduced and were shown to be very accurate. These prototypes allow to speed up numerical simulations by a factor of 1000 and are able to provide a reliable estimation of the bit error rate of a wavelength as a function of its path, data rate, bandwidth and physical impairments (which also depend upon the characteristics of other signals propagating in the network).
6. A software tool, which includes a graphical interface, was created for the dimensioning of an optical layer with elastic devices. It leverages in the aforementioned performance estimation to efficiently allocate paths, data rates, bandwidths and optoelectronic resources to the incoming traffic demands.
7. GMPLS control plane was developed in support of elastic optical networks by enabling the GMPLS protocols to handle elastic parameters (spectrum allocation) based on proposed protocol extensions.

Impact

The disruptive approach of EO-Net has allowed its partners to propose innovative solutions. The elastic concept has now raised significant interest among the community and should become a reality in the near future. Both hardware and software prototypes developed within the project (7 in total) have increased the interest of the proposed solutions among the business units. First building blocks of EO-Net are already included into 2 products and are commercially available. Additional business realizations are foreseen to improve 7 other products with elastic functionalities in a short or medium term timeframe.

The consortium has also been very active in disseminating their research results on a worldwide scale: 47 scientific contributions were published in international conferences or journal publications.

The results of EO-Net will be partly used in the frame of the FP7 IDEALIST project which starts recently.

About Celtic

Celtic is a European research and development programme, designed to strengthen Europe's competitiveness in telecommunications through short and medium term collaborative R&D projects. Celtic is currently the only European R&D programme fully dedicated to end-to-end telecommunication solutions.

Timeframe: 8 years, from 2004 to 2011

Clusterbudget: in the range of 1 billion euro, shared between governments and private participants

Participants: small, medium and large companies from telecommunications industry, universities, research institutes, and local authorities from all 35 Eureka countries.

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