Transport Networks for the Future Internet: The CELTIC Project 100GET

Thomas Michaelis
Nokia Siemens Networks GmbH & Co. KG
Munich, Germany
thomas.michaelis@nsn.com

Brian Teipen
ADVA Optical Networking, Meiningen, Germany

Eugen Lach
Alcatel-Lucent Deutschland AG, Stuttgart, Germany

I. Accomodating Future Traffic Growth

Exponential traffic growth is a usual challenge in the daily business of service providers and carriers. Since a few years the situation has changed and cost and revenue curves started to diverge around the mid-2000s.

The standard response to traffic growth in the past was to expand the capacity of existing fiber infrastructure, e.g. by means of novel technologies like wavelength division multiplexing (WDM) and optical amplification.

100GET - a CELTIC cluster project [1] - investigates a number of different physical-layer technologies and drives the development of a range of required optical and electrical components for channel bitrates of 100Gb/s, taking into account the fact that no single technology offers an optimum cost point for all applications. This can also be observed in the standardization for 40Gb/s and 100Gb/s short-reach Ethernet interfaces (IEEE802.3ba).

Optical channels with 100Gb/s data rate need to be engineered such that use of the installed 10Gb/s fibre infrastructure is possible and that they can traverse filter structures like WDM and optical add-drop (de)multiplexers (OADMs) of current and future optical networks.

Technologies under evaluation for short, metro and long-haul reaches include

- differential phase shift keying + three-level amplitude shift keying (DPSK-3ASK, ≤ 600 km),
- on-off-keying + vestigial sideband filtering (OOK-VSB, ≤ 600 km),
- coherent-demodulated polarization-multiplexed QPSK (CP-QPSK, ≤ 1500 km),
- differential quadrature phase shift keying (DQPSK, ≤ 1500 km),
- multicarrier modulation (orthogonal frequency division multiplexing (OFDM) and subcarrier modulation (SCM), ≤ 600 km).

II. Tighter integration & Interworking with the Future Internet

The re-use of fiber infrastructure will also be a key requirement for coping with future traffic growth. It is arguable, however, if the delivered capacity upgrades will be similarly cost-efficient when moving closer to the theoretical capacity limits.

Hence, a second key step is to leverage other research disciplines in order to make the whole network architecture less expensive. This is where multi-layer and multi-domain interworking and optimization aspects come into play, which can provide significant contributions to the optimization of the total cost of ownership (TCO), and thus help to reconcile cost with revenues.

For example, an infrastructure of transport tunnels can cost-efficiently channel and switch packet flows, as it eliminates precious packet switching significantly. In the core network, this tunnel infrastucture would consist of a hierarchy of packet, circuit and wavelength label-switched paths (LSPs) which need to be coordinated in several respects, including:

- Multi-layer planning, which provides the resources on the transport planes in the required amounts.
- Multi-layer control, mainly based on Generalized Multi-Protocol Label Switching (GMPLS) and Path Computation Element (PCE) technologies, which coordinates the calculation and provisioning of tunnels across multiple technology layers. This is an interesting opportunity for control integration, where a Future Internet would trigger the establishment of its transport tunnels on demand.
- Multi-domain control extends this notion to tunnels which extend over administrative, vendor and provider domains.

III. Related Standardisation Activities

The IEEE 802.3ba defines a base ("MAC") data rate for 100GbE signals, as well as multiple target specifications for 100Gb/s interfaces with various maximum reaches from ten meters to 40 kilometers, which will be used as client-side interfaces in transport networks.

In June 2009, the OIF published the "100G Ultra Long Haul DWDM Framework Document" as a description of OIF work on 100G transmission. The scope of the work includes target specifications for 100G DWDM line-side interface modules, and primarily targets 1000-1500 km reaches with up to six ROADMs.

The ITU-T Study Group 15 is working on an extension of ITU-T G.709/Y.1331 for OTN support, specifically towards a newly defined OTU4 for 100G.

Some amount of collaboration is being carried out between these standards organizations as well.

[1] http://www.celtic-initiative.org/Projects/100GET/ and Refs. therein