Infrastructure Overview with Focus on Experimental Facility

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Abstract. CESNET's main role is to run, maintain and provide services for users of Czech NREN called CESNET2. It has more than 5 thousand kilometres of leased fibres of which 360 kilometres are represented by the Experimental Facility. Connection to other NRENs (mostly represented by GÉANT members) has capacity of 10Gbit, with exception of cz.NIC, where CESNET has 2x 10Gbit. Beyond this, CESNET also operates single fibre bidirectional transmission lines and offer several advanced services, mostly coming from its R&D activities. One example could be photonic service, based on pure fibre optic network advantages. Services such as wireless, security, storage, grid and others are mostly represented by particular CESNET departments.

Keywords: Experimental Facility, Testbed, CESNET, Optics, Networking, NREN, Czech, Photonic, Research.

1 Introduction

CESNET was established in 1996 as non-profit association of legal entities (represented by all public Universities and Czech Academy of Sciences). It operates Czech NREN and Dark Fibre Experimental Facility. It has high optical fibre density among NRENs of about 65 fibre meters per square kilometre. Production network covers more than 4700 km of all leased fibres. The rest belongs to the Experimental Facility, which will be explained in greater detail later on. About one thousand kilometres of all leased fibres are single bidirectional transmission fibres. For the detailed topology scheme see Figure 1. CESNET also offers some advanced services based on photonic transmissions (see chapter 3).

2 CESNET Infrastructure

Main connection to GEÁNT, which node CESNET hosts directly in its HQ in Prague has capacity of 10Gbit. Other key NRENs have the same connection speed to Czech NREN, including SANET (.sk), ACONET (.at) and PIONIER (.pl). To another Czech ISPs, CESNET is peering with 2x 10Gbit through NIX.cz association. CESNET

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experimental facility connection to GLIF has also 10Gbps. GLIF helps CESNET not only to promote advantages and importance of photonic services but also with research in lambda networking. Overseas connection to US has capacity of 2,5Gbps at the time of writing. CESNET infrastructure is made of leased dark fibres. They are lighted up by Open DWDM system designed and developed in CESNET (CzechLight family) or by Cisco.

Big advantage of the fully leased fibre network is that CESNET does not have to maintain and take care of the fibres. But of course CESNET has its 24/7 monitoring services, which supervises the link states.

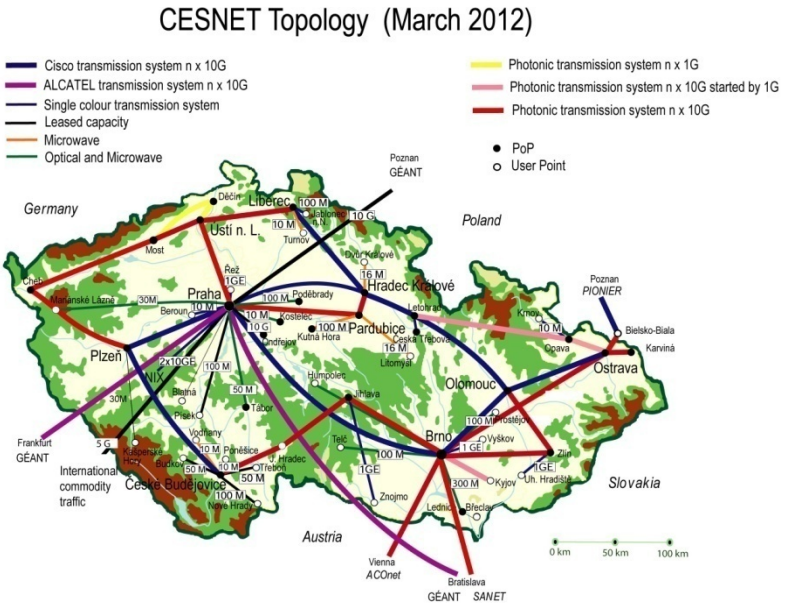

Fig. 1. CESNET Topology

CESNET was also one the first propagators of single fibre bidirectional transmission (hereafter "SFBC"), saving costs up to 40%, while keeping the same performance for typical NREN traffic. This approach can be used in case of lack of fibres and also as a backup solution to access provider's POPs. There are more than 1000 km of these lines in the topology. CESNET started with SFBC back in 2002, when proved its functionality for the first time.

Cross border fibres started back in 2004, while making significant contribution on cross border experiments such as atomic clock synchronization.

NREN infrastructure project is called CESNET large infrastructure, which will be connected to other e-infrastructure projects like those which are part of ESFRI infrastructure roadmap. Because of this, CESNET infrastructure is under improvement, started with upgrading of its national GRID infrastructure and PoPs

main DWDM devices. One example could be ESFRI infrastructure for biological data called project called ELIXIR.

2.1 CzechLight Devices and Optical Lab

CzechLight (hereafter "CL") is a trademark for CESNET's devices intend to use in optical networks. It is outcome of its optical R&D activities. They include range of optical amplifiers (based on EDFA), CL Raman amplifiers (only for long distances and not widely used), fully tuneable chromatic dispersion compensators and photonics cross-connects (optical switches).

Department of Optical Networks also has two optical labs for its research purposes. Here the newly developed devices are tested and also this lab is used to do real network simulations, signal quality, chromatic dispersion and signal attenuation monitoring. This lab could be considered as a part of CESNET's Experimental Facility (more in chapter 4).

3 Advanced Services

In cooperation with GEÁNT CESNET started to promote term "photonic service" which leads to the new type of advanced service based on pure photonics. It covers critical and "real-time" applications in areas of metrology, seismology, remote instrument control and other emergency usage. Generally all advanced services that need fixed and low latency. Another example of new type services can be "lit fibre", which is based on CL devices family. Customer can order lit fibre, fully lighted up by CL devices and can use it for various tests and new technology prototypes verification. The photonic services could be user controlled by using fully tuneable CL devices.

The application area where CESNET network could benefit in and use its gained experience from GN3 activities is ENVIROFI case project (its Atmospheric Condition part respectively) of FI-PPP. However, CESNET its self does not have experience in "smart" project scenarios. Its infrastructure is prepared for these issues, but in most cases these applications also require mobile network. CESNET does not own or lease such kind of networks. On the other hand, it is an issue that is being under consideration at the time of writing.

Other services focus on transparent L2 like Carrier Ethernet. Common services includes Eduroam wireless network[1], data storage infrastructure and network security group called CSIRT. This security group monitors and resolves security incidents in whole AS 2852. Some of common security issues are:

- Intensive Scanning.
- Spam.
- Copyright issues.
- Phishing

[1] http://eduroam.cz/doku.php?id=en:start

CESNET also has its dedicated GRID infrastructure called "Metacentrum"[2]. At the time of writing it consists of more than 4000 cores overall. Approximately half of them belong to CESNET, half to connected organizations. Its purpose is to offer computation power and software resources to CESNET users and members. Software installations cover those which allow parallelism and other functionalities which could be beneficial in various research areas (bioinformatics, computation chemistry etc.). Hardware equipment is heterogeneous to be more flexible to user and software needs. Metacentrum infrastructure and its connected institutions can be found in the following figure.

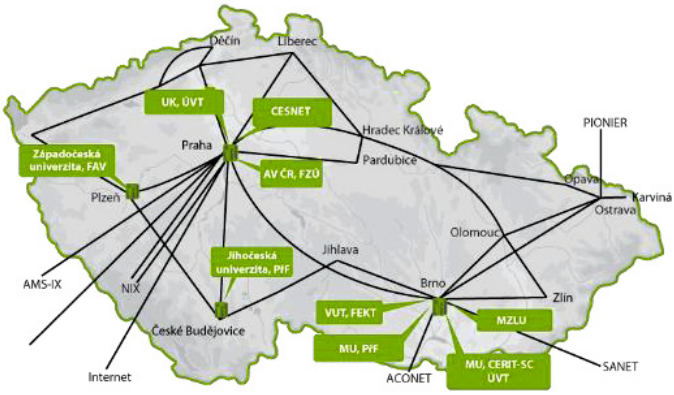

Fig. 2. Metacentrum Infrastructure

3.1 Certain Experiments

Highly accurate clock synchronization has been demonstrated to show potential of modern photonic networks. As written in [1], accuracy of 1 ns has been archived over distance of more than 500 km without OEO in the path and over production DWDM network. This Czech-Austrian experiment has been done between CESNET and its counterpart ACOnet and relied on prototypes of time signal transfer adapters developed by CESNET. Involved national time and frequency labs in Prague and Vienna: IPE (Institute of Photonics and Electronics of Academy of Sciences of the Czech Republic) and BEV (Bundesamt für Eich- und Vermessungswesen). The development of methods for accurate time signal transfer and the research into all-optical networks are parts of research activities put through by CESNET within the framework of its research project Optical National Research Network and Its New Applications.

Another demonstration of low-latency photonic service was unique real-time 3D Full HD stereo broadcast of a kidney surgery performed by a "da Vinci robot" [2].

[2] http://www.metacentrum.cz/en/

This experiment has been made between Masaryk Hospital in Ústí nad Labem and CESNET headquarter in Prague. The broadcast went through 10-gigabit link with fibre distance over 130 km and it was a part of standard production infrastructure. Signal delay along the transmission stream was less than 1 ms, enabling a truly real-time 3D Full HD stereo broadcast. In this experiment the images from the surgery were produced by CESNET's F10 AS3D ProjectionDesign stereo-projector.

4 Experimental Facility

CESNET testbed[3] consists of fully leased open dark fibres for experimental usage and testing of new technologies. They are lighted up by CL devices and the infrastructure has connection of 10Gbps to GLIF. It also has 10G connection to Netherland's Netherlight, which is one of GLIF Open Lightpath Exchanges. CESNET also provides dedicated Experimental Facility (hereafter "EF") for Physicists and thank to its Large Infrastructure project it is open and ready to provide means for interconnection of any modern European infrastructure project.

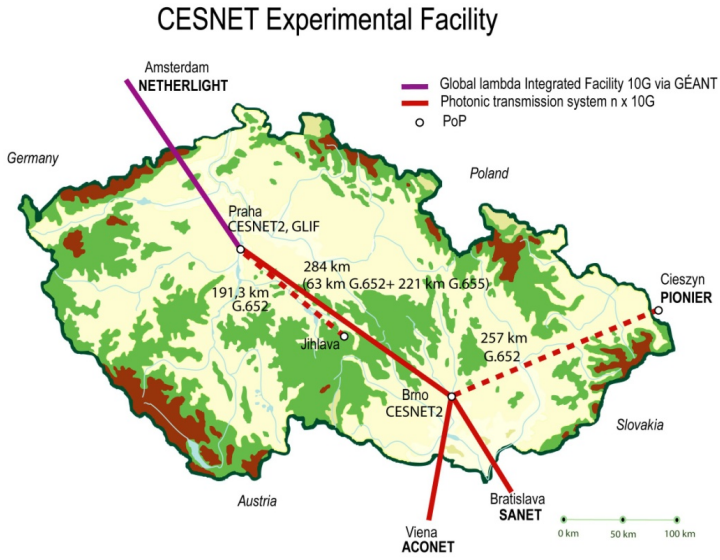

Fig. 3. Experimental Facility

The facility is now mainly used for testing of new photonic devices developed by CESNET and also for testing of new network technologies in cooperation with our partners and in international research projects. 100Gbps Alcatel-Lucent transmission system has been tested recently [3]. These test proved that CESNET optical

[3] CESNET prefers to use term "Experimental Facility", which refers to multi-purpose, long term and less technology/vendor dependent than regular testbed.

infrastructure is prepared to adopt 100GB signal speed, not only on its backbone lines [4].

CESNET uses EF for:

- Testing of new CL devices and new photonic products.
- Building and operation of testbeds.
- Disruptive experiments with new services and products before deployment.
- Support of experiments with new applications and research.
- Collaboration.
- First mile solutions testing.

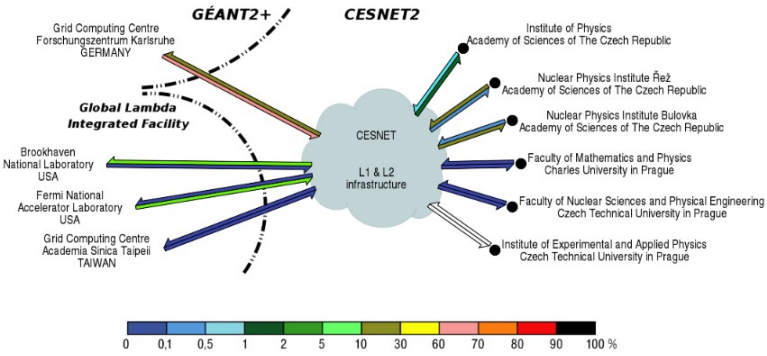

Fig. 4. Experimental Facility Utilization

CESNET's Optical Network Department also has metropolitan testbed in Prague (see Figure 5), which provides research cooperation with connected universities and their labs. This allows spreading optical research and project collaboration with CESNET partners. Also allows real-time demonstrations of modern optical network possibilities to university students. This EF is intended for E2E connections.

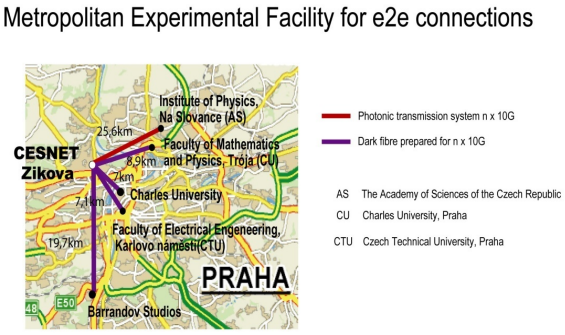

Fig. 5. Metropolitan Experimental Facility in Prague

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