

www.ces.net

LTTx: Lightpaths to the application From GOLEs to dispersed end users

Stanislav Šíma, Jan Radil, Lada Altmannová, Josef Vojtěch, Michal Krsek, Miloš Lokajíček, Jiří Navrátil, Václav Novák, Petr Holub, Miloš Liška, Milan Šárek

October 2, 2008



LTTx: Lightpaths to the application

Presented content do not necessarily reflect an official opinion of any institution or project.

Authors participate on

CESNET research program (<u>www.ces.net</u>),

ATLAS Project on LHC Accelerator (cern.ch/lhc, cern.ch/atlas)

D0 Project on TEVATRON Accelerator (www-d0.fnal.gov/public/index.html)

WLCG Project (cernc.ch/lcg)

Masaryk University research program Parallel and Distributed Systems

GÉANT2 project (www.geant.net)

Phosphorus project (http://www.ist-phosphorus.eu/about.php)

October 2, 2008



Understanding of physical layer is crucial to enhance applications

- There are no applications without physical layer
- Technology used in physical layer limits transmission speed and applications (by latency, non-determinism etc.). Savings of energy, space and costs must be solved primarily in physical layer design.
- There is electronic processing speed limitation (about 100 Gb/s per port), optical processing speed limitation will be about 1 Tb/s per port. Optical processing has significantly lower energy consumption. See for example presentation Tetsuya Miyazaki: "Node and Link Technologies for New Generation Networks", NICT, http://www.ict-fireworks.eu/fileadmin/events/9-10_une_2008_Brussels/Presentations/09-06-08/5B-Photonic_Networks/15-TETSUYA_MIYAZAKI_-_Photonic_Networks.pdf

October 2, 2008



Experimentation based on physical layer technology advances



۲

- The main source of possibilities to enhance applications lies in physical layer.
- In many cases we can gauge before network users, what new physical layer possibilities will bring improvements for future use
- Research and Development driven by experiments is important to verify and evaluate real possibilities, create new service offers for users, and find early adopters
- For example, main improvements of Research and Education networks physical layer are:
- In the past: dark fibres instead of telco services (although not in all lines)
 - In the future: photonic devices instead of electronic devices (although not in all positions)
- In GLIF: enhancing applications by connecting dispersed users to GOLE

October 2, 2008

GLIF 2008 Workshop, Seattle, Research & Applications session

4



Devices for network research and experimentation

- CESNET has developed family of open photonic devices (CL family), enabling early adoption of leading edge photonic technology
- Delivery from FTTx development company is available
- Supports future network research and experimentation on dark fibre level, fast testing and prototyping, support experimental applications requested by users or field experiments on dark fibre lines verifying feasibility of network improvements
- Proved very useful for GLIF applications development (especially for dispersed end users), CESNET2 NREN development, Experimental Facility development, CBF lighting, FTTx deployment, improvement of interoperability on the physical layer, as well as remote monitoring and control, low latency and deterministic multicast (see GLIF demos 2007 and 2008)

Main building elements are photonics components (mux/demux, VMUX, OA, ROADM, FBG, photonic switch, photonic multicast switch), industry PC kits, unix and other open source sw

Main advantages: freedom of design, ability to meet user needs, easy to modify if needs change, avoid delays in innovation (low needs to save investments), photonic transmission and processing speed, low cost, saving energy, space and user care.

October 2, 2008



Multicasting device demonstration

- CLM (Multicast Switch) has
 - photonic part multicasting (replicating) optical signal bands
 - electronic part for remote switching control via web interface
- Multicast by CLM is deterministic without jitter and delay, i.e. without OEO conversion, without store and forward processing and without loading of switch by multiple tasks
- Operation demonstrated in CESNET
- Operation demonstrated outside CESNET on University of Washington (8th Annual Global LambdaGrid Workshop on 1 October 2008 at Seattle), CLM was located at StarLight and managed remotely

Main CL devices: CLA (Optical Amplifier), CLS (Optical Switch), CL-VMUX (Variable MUX), CL-ROADM (Reconfigurable Optical Add/Drop Multiplexor), CLC (CD Compensator)

October 2, 2008

GLIF 2008 Workshop, Seattle, Research & Applications session

6



CLM Demonstration in CESNET



October 2, 2008







34th European Conference and Exhibition on Optical Communication (ECOC 2008)

- Expo Centre, Brussels, Belgium, September 2008
 FTTx is leading the implementation of fibre optic technology reaching to the homes and businesses throughout the world.
- FTTx Exhibition fttp://www.ecocexhibition.com/ modules/serve.cgi



October 2, 2008



Connecting dispersed users to GOLEs



- It was successfully demonstrated (but not yet fully published) for example in GLIF2007 workshop in Prague as connection between Charles University and GOLE Prague, used for all demos
- Photonic lightpath connected to GOLE Prague are available in CESNET2 NREN and in CESNET Experimental Facility, including CBFs
- Commercially available transmission systems alows optical reach of 10G photonic lightpaths about 1000 km now and extension to about 2000 km is prepared, as well as upgrade to 40G transmission rate

October 2, 2008





LTTx: Lightpaths To The x

FTTx development enables large change of network services, see http://www.ftthcouncil.eu/ Openness to all service providers and low transmission latency is crucial, see Herman Vagter: Fiber-from-the-home (as the customer percieves him/herself to be the centre of the universe), http://www.oecd.org/dataoecd/36/28/40460647.pdf Lightpaths to home or company users will be very probably one type of service on FTTx (LTTx is acronym suggested by speaker here) Lightpaths service to the office or home (including home working) is enabling new applications and wider deployment Experience from GLIF experiments using dedicated fibre last miles are important for FTTx development Development of many applications based on lambda services depend on our ability to connect real end users in their office or home

October 2, 2008

GLIF 2008 Workshop, Seattle, Research & Applications session

12



EU adopts law to raise telecom competition

The European Parliament adopted measures to give consumers a wider choice and less-costly services, see <u>http://www.iht.com/articles/2008/09/24/business/telecom.php</u>

Proposal force telecommunication companies to run their network and retail services as separate businesses to give competitors easier access to their networks

From long term strategic point of view, it will help also to deployment of Lightpaths services for the office or home

October 2, 2008



Metropolitan DWDM for e2e connections (September 2008)



Photonic transmission system n x 10G

Dark fibre prepared for n x 10G

- AS The Academy of Sciences of the Czech Republic
- CU Charles University, Praha
- CTU Czech Technical University, Praha

October 2, 2008



CESNET Experimental Facility (September 2008)



15



October 2, 2008



CESNET photonic fibre lighting

Fibre footprint 5 210 km

- 4 470km CESNET2 (including 1 050km of single fibre lines)
- 740km of CESNET EF (Experimental Facility)

Results: lambdas without OEO in CESNET2, 4 lines in CESNET EF and 4 lines in CESNET2 are lit by open photonic devices, 5 other lines will be lit still in 2008, interoperability without OEO achieved, single fibre bidirectional DWDM n x 10G is in operation (about 40% of fibre pair lease cost savings)

Confirmation: Photonics approach to lighting is quite "green": saving energy, housing space, travelling to huts and costs

October 2, 2008





GLIF Applications supported by LTTx in CESNET

Running or Previous (selection)

- GLIF demo on 7th Annual Global LambdaGrid Workshop in 2007 at the Carolinum, Prague, Czech Republic
- HEP data access and processing for ATLAS and ALICE on LHC, D0 on TEVATRON, STAR on RHIC
- First VINI sites in Europe (Prague, Pilsen)
- Intercontinental Remote Education on High Performance Computing between Masaryk University Brno and Louisiana State University
- CESNET-TWAREN Hinchu lightpath: peering CESNET-TWAREN, Multicasting and IPV6

Searching for international partners

- VirtCloud & Magrathea project (L2 switched infrastructure for virtual machines)
- MediMED/RediMED / ePACS (regional or national PACS solutions)
- Private networks SAN/POSN
- 3D Modeling / Collaboration environment
- Live Surgery

October 2, 2008



Czech participation on HEP projects

- LHC (Large Hadron Collider at CERN) distributed data simulation, processing and physics analysis under the WLCG (Worldwide LHC Computing Grid) project (cern.ch/lhc, cern.ch/lcg) for experiments ATLAS (cern.ch/atlas) and ALICE (aliceinfo.cern.ch)
- Experiment D0 at Fermilab data simulation and processing
 - http://www-d0.fnal.gov/public/index.html
- Experiment STAR at Brookhaven data simulation and processing
 - http://www.star.bnl.gov/
- Prague serves as Tier2 regional computing centre for HEP experiments
 - Connection to Tier1 preferred centre Karlsruhe (via GÉANT2)
 - Connections to BNL, Fermilab, Taipei via GLIF are used as backup (it is not part of LHCOPN network between LHC Tier1 centers)
- Further references about Czech participation:
 - www.particle.cz/farm/, <u>http://www-hep2.fzu.cz/d0/,</u> <u>http://czechlight.cesnet.cz/en/index.php</u>

October 2, 2008

GLIF 2008 Workshop, Seattle, Research & Applications session

20

GLIF Lightpaths to HEP projects participants in the Czech Republic

CESNET



CESNET

Lightpath BNL – IoP via NYC/Amsterdam/Praha



October 2, 2008

CESNET

Lightpath FNAL – IoP via Chicago/Amsterdam/Praha





Lightpath Taipei – IoP via Amsterdam/Praha





First VINI sites in Europe

- VINI is a virtual network infrastructure that allows network researchers to evaluate their protocols and services in a realistic environment that also provides a high degree of control over network conditions
- VINI supports simultaneous experiments with arbitrary network topologies on a shared physical infrastructure.
- VINI currently consists of 37 nodes at 22 sites connected to the National LambdaRail, Internet2, and CESNET (Czech Republic)
- GLIF Lightpath Praha Amsterdam Chicago is used
- Two VINI nodes are running in the Czech Republic Praha and Plzeň

See more on <u>http://www.vini-veritas.net/</u>

October 2, 2008

Lightpath Chicago/Amsterdam/Praha for VINI

CESNET





TWAREN-CESNET collaboration

Focused on Multicast and IPv6 experiments

more details are available on <u>http://www.ces.net/netreport/CESNET2-</u> TWAREN-peering/

multipoint DVTS videoconference focusing on the tele-medicine

October 2, 2008



TWAREN-CESNET via Taiwan/USA/Amsterdam/Praha





Asia-Europe Telemedicine

- CESNET in cooperation with a group of advanced Asian Internet networks organized multipoint DVTS videoconference focusing on the tele-medicine. The video session was organized an add on of the professional conference called CESNET Conference 2008, organized by the CESNET association held 25-26 September 2008 at the Faculty of Electrical Engineering of the Czech Technical University, Prague, Czech Republic.
- The videoconference started with presentation of Dr. Shuji Shimizu from the University Hospital in Kyushu, Japan.
- In the final part he described configuration of current event on which participated 8 sites from 5 different countries (Japan, Taiwan, Spain, Italy and Czech). In last part Dr. Navratil shown the networking part of this event. Besides local network of participating organization and NRENS in particular countries (SINET, TWAREN, REDIRIS, GARR, CESNET) many global networks as GLIF, TEIN2 and APANJP was used.
- From the Czech Republic take part on this event: Central Military Hospital in Prague and Krajská zdravotní, a. s. – Masaryk Hospital in Ústí nad Labem. Experts can watch the entire teleconference in auditoriums of these medical facilities.
- More details are available on http://www.ces.net/doc/press/2008/pr080924.html

October 2, 2008



DVTS video conference as part of CESNET08



September 25th 2008, Prague, Usti o.Elbe., Fukuoka, Kyoto, Rome, Barcelona

October 2, 2008



VirtCloud & Magrathea project

- Virtual networking for virtual clusters
 - each cluster has its own VLAN
 - L2 switched infrastructure for easy migration of virtual machines
 - building switched networks over larger infrastructures
 - when implemented, it can work without administrative rights over the network (and without need to be reconfigured by network administrators)
- Prototyped over DWDM/Xponder system of the CESNET2 network
- GOLE CzechLight can be used to build Grids based on VirtCloud – as discussed with international partners now

more details are available on project pages: http://meta.cesnet.cz/cms/opencms/en/docs/software/devel/magrathea.html

October 2, 2008







October 2, 2008



- University education by real time videoconferencing in High Definition video quality between Louisiana State University and Masaryk University in Brno, Czech Republić, connected by Lightpath via GOLE StarLight and GOLE CzechLight
- Louisiana State University Course Information: http://www.cct.lsu.edu/csc7600/



Masaryk University Course Information: http://is.muni.cz/predmety/predmet.pl?lang=en;kod =PA177;fakulta=1433;obdobi=

Very good experience: it is experimental aplication, proved to be usable and reliable for real regular education in "university run time"



High-definition Video Transmissions

UltraGrid

- Low-latency uncompressed HD video (1080@30i) over IP transmissions
- Bitrate of 1,5Gbps per one video stream
- ~90ms end-to-end latency (video acquisition transmission – display)
- Stable SW releases, beta versions with new features
- CESNET and Masaryk University joint effort <u>https://www.sitola.cz/igrid</u>
- IGrid2005, SC'05, SC'06 and SC'07 demonstrations

October 2, 2008



Self-organizing collaborative environment

CoUniverse

- Support for high-bandwidth media streams comparable to link capacity of 10GbE networks
- Continuous adaptation on changing conditions based on built-in monitoring of applications, nodes, and network links
- Prototype implementation available
- https://www.sitola.cz/CoUniverse
- CoUniverse SW developped at Masaryk university
 Glif 2007 and SC'07 demonstrations

October 2, 2008



MediMED/RediMED / ePACS (regional or national PACS solutions)

the regional or national PACS server as secure databases for medical images, improving the efficiency of imaging departments by allowing medical information to be stored, récalled, displayed, manipulated and printed digitally. Anonymised image data with description are used also for education. cooperation and future development is solved in the frame of eTEN project R-Bay (http://www.r-bay.org)

<u>http://www.telemedicinabrno.cz</u>

October 2, 2008

GLIF 2008 Workshop, Seattle, Research & Applications session

36



POSN – Private Optical Networks for Hospitals

Interconnection of data storage systems, used for replication of DB and during service of DB system

GOLE CzechLight can be used in regional connection or in health care net of one owner

more details are available on project pages: <u>http://posn.uvn.cz</u>

October 2, 2008



POSN Private Optical Networks for Hospitals



October 2, 2008



3D Modeling / Collaboration environment with high volume transfer of graphical data

3D modeling including the fusion of data from different resources (MRI, CT) for the purpose for reconstruction surgery

international cooperation has a law restriction, but is possible

http://www.fit.vutbr.cz/research/groups /pgmed/

October 2, 2008



October 2, 2008

3D Collaboration Environment

October 2, 2008

WIOL-CF Internet Live Surgery

October 2, 2008

Invitation to Future Internet Conference 11-13 May 2009, CLARION CONGRESS HOTEL Prague

Organized by the EC and CESNET during the Czech Republic presidency

http://www.future-internet.eu/events/eventview/article/eu-conference-the-future-of-the-internet.html

October 2, 2008

CESNET

Invitation to 5th Customer Empowered Fiber Network Workshop May 14 – 15, 2009 Prague, Organized by CESNET in location of GLIF2007 Previous workshops <u>http://www.ces.net/doc/seminars/cef2007/</u>

Universitas Carolina, founded in 1348

October 2, 2008

Long term collaboration with Prague is important! Charles bridge built in 1348

October 2, 2008

The Czech Republic, Sázava monastery, established in 1032

October 2, 2008

Acknowledgement

Jan Gruntorád and CESNET team

GLIF Workshop Organisers

Thank you for your attention!

Slides for off-line reading follow

October 2, 2008

No easy life above 10G wavelenght rate

- Interoperability on lambda level will be big issue in the future (different modulation formats, filtering, etc.)
- Legacy WDM systems usually strongly limits selections of effective modulation formats (narrow band filtering is limitation for alien lambdas)
- Active collaboration and pre-procurement with vendors is necessary
- Each vendor has "the best solution for us", we strongly need vendor-independent knowledge verified by theoretical work and experiments in real environment

What WDM we should ask for our fibre footprint (GEANT, NRENs, MANs, campuses)?

October 2, 2008

Photonic (all-optical) services From lab to real world

dark fibre Experimental Facility (EF) needed

- user participation of EF is directed by experiments
- EF can be used for experimental services to NREN (testing of EF DWDM lines by real traffic of NREN)
- deployment of photonic services in R&E networks
- saving energy, housing space and cost (especially with bidirectional single fibre transmission)
 - photonic experts able to work in R&E network environment needed

federated and interoperable photonic services for R&E

upgrade of dark fibre lease to lit fibre lease (contracting) deployment of photonic technology by fibre provider, based on our lighting project), with dedicated or shared fibre capacity deployment of photonic services in ISP/enterprise networks

October 2, 2008

GLIF 2008 Workshop, Seattle, Research & Applications session

50

Network design for high speed multidomain e2e services

- Domains: GEANT, NRENs, MANs, campuses will be using different DWDM equipment
- OEO conversion needed for domain interconnection is expensive (especially, if domains are small) and limits transmission speed
 - Photonic Integrated Circuits (PIC) help in part only (PICs will not be used in all domains)
- How to achieve interoperability on optical level? How to achieve lower power consumption and save space and costs? We need at least:
 - neutral FTTx (home run fiber available to any service providers)
 - knowledge of optics (what alien lambdas can domain accept?) verified by experimentation (technology testing)

October 2, 2008

GLIF 2008 Workshop, Seattle, Research & Applications session

51

Kyoto Price 4K transmission via CESNET

- "The Kyoto Prize" is an international award to honor those who have contributed significantly to the scientific, cultural, and spiritual betterment of mankind.
- 4K uncompressedlive streaming (6 Gbit/s)
- Kyoto to Stockholm, L2-10GbE over 21,000km.
- 4K compressed multicaststreaming (500 Mbit/s)
- Multicast by hardware packet replicator
- World's First Trans-Pacific and Trans-Atlantic (21,000km) Real Time Switching and Streaming Transmission of Uncompressed 4K Motion Pictures, Nov 10-11, 2007 from Kyoto to Stockholm via Chicago and Prague
- http://www.dmc.keio.ac.jp/en/topics/07 1126-4K.html

October 2, 2008

International Networks for the Kyoto Award Streaming By T. Shimizu, NTT

October 2, 2008 GLIF 2008 Workshop, Seattle, Research & Applications session

CoUniverse - GLIF2007 demo maps

CoUniverse - GLIF2007 demo network scheme

October 2, 2008

October 2, 2008

TWAREN-CESNET Link

drawed by TWAREN/SURFnet/SARA/CESNET

