Open Photonic Devices and Systems

www.ces.net

czechlight.cesnet.cz

Josef Vojtěch, Miloslav Hůla
Lada Altmannová, Stanislav Šíma, Jan Radil

vojtech (at) cesnet (dot) cz

Open Photonic Devices and Systems

Authors participate on:

CESNET research program (www.ces.net),

GÉANT3 project (www.geant.net),

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

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Open Photonic Devices and Systems

Outline

- Introduction
- (Free)Libre SW vs. Open Source SW vs. Freeware
- Open Approach in HW
- Open Approach in Networking HW
- CESNET Network and EF - Concepts Used and Evolution
- Open Transmission Systems
- Building Blocks
- Description of Transmission Systems and their Building Blocks
- Acknowledgement
- Discussion

Open Photonic Devices and Systems
CESNET

- CESNET - Czech Educational and Scientific NETwork
- NREN in the Czech Republic
- Established as Association of Legal Entities – not for profit
- All research and public universities + Czech Academy of Sciences

The Czech Republic

- Area:
  - 78 866km^2 = 30 450 sq mi (South Carolina)
- Population:
  - 10 349 372 (Michigan)

source: http://en.wikipedia.org/wiki/Czech_Republic

Open Photonic Devices and Systems

Free Software

- Free software, software libre
  - (Libre is used to avoid dual meaning of the "free")
  - Freedom of usage, study and modification without restriction
  - Copied and redistributed in modified or unmodified form without restriction or with minimal restrictions only to ensure that further recipients can also do these things and that manufacturers of consumer-facing hardware allow user modifications to their hardware
  - Free software may be freely redistributed it is generally available at little or no cost. Free software business models are usually based on adding value such as applications, support, training, customization, integration, or certification
- Free software definition by FSF in 1986
  - Freedom 0: The freedom to run the program for any purpose
  - Freedom 1: The freedom to study how the program works, and change it to make it do what you wish
  - Freedom 2: The freedom to redistribute copies so you can help your neighbor
  - Freedom 3: The freedom to improve the program, and release your improvements (and modified versions in general) to the public, so that the whole community benefits
  - Practically 1 and 3 require source code to be available because studying and modifying software without its source code is highly impractical
- Commercial software - free software or proprietary software, contrary to a popular misconception that "commercial software" is a synonym for "proprietary software" (An example of commercial free software is Red Hat Linux)

source: wikipedia

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Open Source Software

- Open source is not only the access to source code
- Definition by OSI (to be able decided about licenses):

1. Free Redistribution
- The license shall not restrict any party from selling or giving away the software as a component of an aggregate software distribution containing programs from several different sources. The license shall not require a royalty or other fee for such sale.

2. Source Code
- The program must include source code, and must allow distribution in source code as well as compiled form. Where some form of a product is not distributed with source code, there must be a well-publicized means of obtaining the source code for no more than a reasonable reproduction cost preferably, downloading via the Internet without charge. The source code must be the preferred form in which a programmer would modify the program. Deliberately obfuscated source code is not allowed. Intermediate forms such as the output of a preprocessor or translator are not allowed.

3. Derived Works
- The license must allow modifications and derived works, and must allow them to be distributed under the same terms as the license of the original software.

4. Integrity of The Author's Source Code
- The license may restrict source-code from being distributed in modified form only if the license allows the distribution of "patch files" with the source code for the purpose of modifying the program at build time. The license must explicitly permit distribution of software built from modified source code. The license may require derived works to carry a different name or version number from the original software.

5. No Discrimination Against Persons or Groups
- The license must not discriminate against any person or group of persons.

6. No Discrimination Against Fields of Endeavor
- The license must not restrict anyone from making use of the program in a specific field of endeavor. For example, it may not restrict the program from being used in a business, or from being used for genetic research.

7. Distribution of License
- The rights attached to the program must apply to all to whom the program is redistributed without the need for execution of an additional license by those parties.

8. License Must Not Be Specific to a Product
- The rights attached to the program must not depend on the program's being part of a particular software distribution. If the program is extracted from that distribution and used or distributed within the terms of the program's license, all parties to whom the program is redistributed should have the same rights as those that are granted in conjunction with the original software distribution.

9. License Must Not Restrict Other Software
- The license must not place restrictions on other software that is distributed along with the licensed software. For example, the license must not insist that all other programs distributed on the same medium must be open-source software.

10. License Must Be Technology-Neutral
- No provision of the license may be predicated on any individual technology or style of interface.

source: http://opensource.org/docs/osd

Open Photonic Devices and Systems

Free vs./and Open Source Software

- Free vs. Open
  - Free software focuses on the philosophical freedoms it gives to users while open source focuses on the perceived strengths of its peer-to-peer development model
  - Not exactly the same class of software: „open" accept some licenses that we consider too restrictive, and there are free software licenses that „open" have not accepted
  - The differences are small: nearly all free software is open source, and nearly all open source software is free
- Free and Open Source Software (FOSS)
  - Inclusive term which covers both
- Free / Libre / Open Source Software (FLOSS)
  - To avoid any uncertainty ☺
- Freeware
  - No payment for use
  - Authors or copyright holders may retain all rights
  - Not necessarily permitted to reverse engineer, modify, or redistribute

source: wikipedia

Open Photonic Devices and Systems

Open Approach in Hardware

- Relative broad success of FOSS is well known, what about hardware?
- Open source hardware
  - Designed and offered in the same manner as free and open source software (FOSS).
  - Open source concept applied to hardware, typically information about the hardware is open to all
  - Information include the hardware design (e.g. schematics, bill of materials and PCB layout) and FOSS approach to the software that drives the hardware.
- Open design
  - Development of physical products, machines and systems through use of publicly shared design information

Source: wikipedia

Open Photonic Devices and Systems

Open Approach in Network HW

- Open approach exist in networks, especially in higher layers!
- Many smaller project exists, e.g. open routers
- But what big vendors? - Juniper opened JUNOS (Free BSD based) network OS and created Partner Solution Development Platform in 2007
- ISPs or users know the first what they need – it should allow fast development of new or innovative or cheaper services
- But what lower layers, especially photonics?

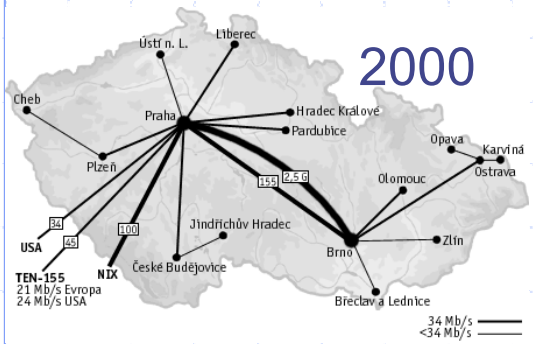
Open Photonic Devices and Systems
Concepts Used in CESNET

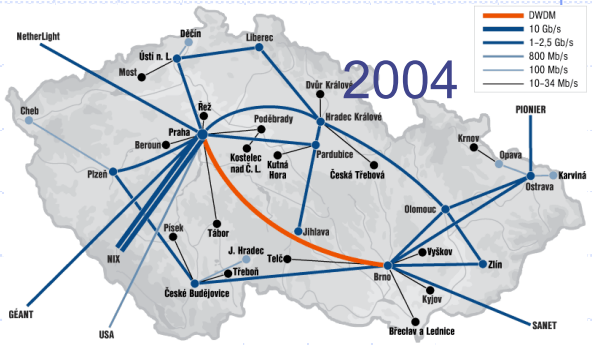
- Networks
  - Operational National Research and Educational Network (NREN) - CESNET2
  - Experimental Facility (EF) – CzechLight, conncted to GLIF (http://www.glif.is)
- Dark Fiber (DF)
- Nothing in Line Approach (NIL)
- Cross Border Fibers (CBF)
- Open transmission system

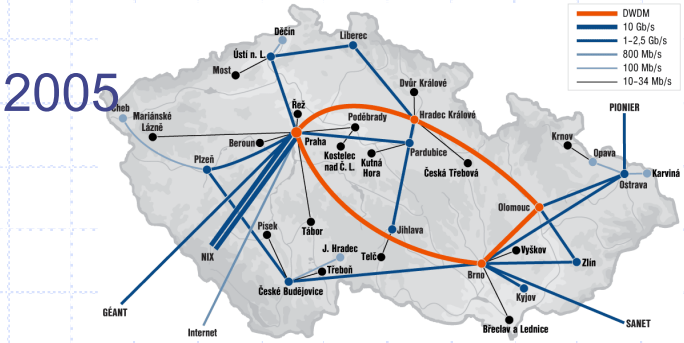
Open Photonic Devices and Systems

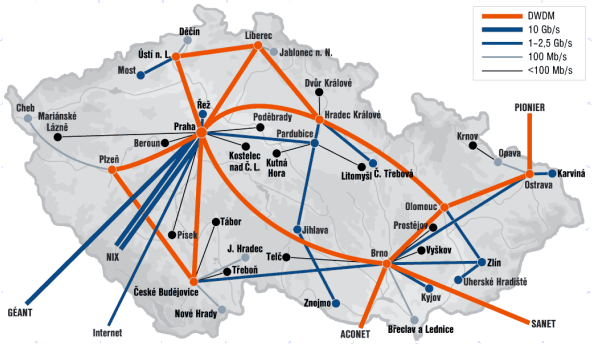
CESNET network evolution

- Evolution of the CESNET network 1999 – 2007 (not with all details).





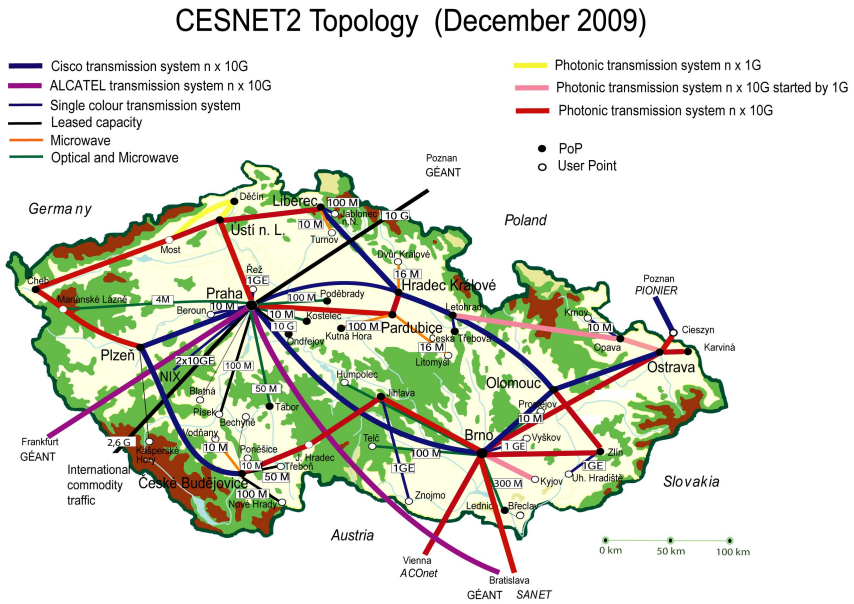




- 1999: first DF
- 2002: first optical amplifiers (EDFA)
- 2004: first OTS

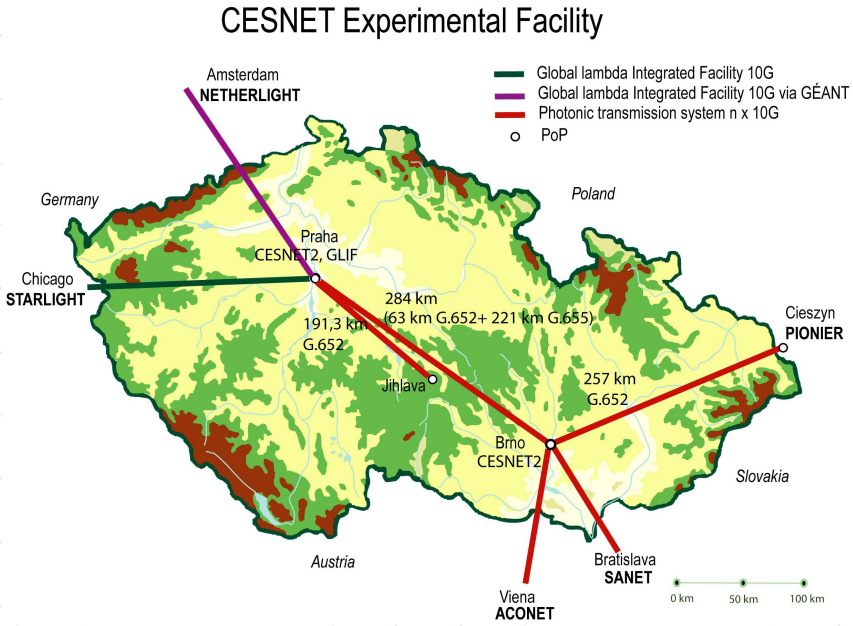
Open Photonic Devices and Systems
CESNET2

- CESNET2 network 2009
  - Multivendor architecture – coexistence and interoperability of proprietary and open DWDM systems at speeds up to 10Gbps
  - Proprietary DWDM 1407km (874mi) of DFs
  - Open DWDM 2660km (1653mi) of DFs
  - Incl. 980km (609mi) of single fiber DF links with bidirectional transmission



Open Photonic Devices and Systems
CzechLight EF

- 734 km (456 mi) of DFs
- An experimental and breakable optical network
- Independent infrastructure
- Operated by open DWDM system



Open Photonic Devices and Systems
Open Approach in Transmission

- „Open" transmission system developed in CESNET
  - Devices use open source SW derived from Debian and SLAX
- Again - users or developers can actively modify or improve SW, they know the first what they need – it should allow fast development of new or innovative or cheaper services
- They have freedom of:
  - Freedom to use devices for any purpose
  - Freedom to study how the system works
  - Freedom to improve the system
- Libre Transmission System instead of Open transmission system?
- Maybe FLO Transmission system is the correct ☺
- Business can profit from building block manufacturing, maintenance, custom modifications and design support of users

Open Photonic Devices and Systems
Bulding Blocks

- Building blocks of photonic transmission systems
  - Static: MUX/DEMUXes + OADMs , amplifiers, (DCU)
  - Dynamic: VMUXes, ROADMs or WSSs
- Available blocks of our open TS
  - Amplifiers EDFA/Raman,
  - Tunable CD compensators (FBG, GTE, VIPA, MZI)
  - Dynamic lambda processing: VMUXes, ROADMs, WSSs, wavelength converters, channel monitors
  - Photonic switches, with multicast option
- Next blocks are continuously added

Open Photonic Devices and Systems
Amplifiers

- CLA – EDFAs
  - Digital transmission, single or multi lambda:
    - terminal sides (preamp+booster)
    - dual inline
  - Analog transmission - CATV
    - from 1 to 64 outputs
- CLR – sources for Raman amplification
  - Fiber laser - single pump wavelength
  - Laser diodes - multi pumps, including TDM pumping

Open Photonic Devices and Systems
Tunable CD Compensation

- 10 and 40G, for higher speeds the DSP is planned
- Based on different technologies: FBG, GTE, VIPA, MZI

Open Photonic Devices and Systems
Dynamic Lambda Processing

- VMUXes, incl. colorless
- ROADMs, multidegree under development
- WSSs
- Wavelength converters (SOA based - up to 40G, multicast option)
- Optical channel monitor
- All devices C band, 40 ch, 100 GHz spacing, non-mechanically based, if reasonable 50 Ghz versions can be developed

Open Photonic Devices and Systems
Fibre Switches

- CLS 16x16 – mechanically based, broadband

Operational band	O + C + L
Insertion loss	2 dB
Switching speed	40 ms
Durability	10^9 cycles

- CLS 8x8 (PM) – solid state

Operational band	C
Insertion loss	4 dB
Switching speed	3 ms
Durability	MTBF 10^6 hrs (114 years)

- CLS 16x16 – solid state

Operational band	C
Insertion loss	5 dB
Switching speed	3 ms
Durability	MTBF $5*10^5$ hrs

Open Photonic Devices and Systems
Multicast Fibre switches

- Typically distribution of high speed signals, e.g. 4K, uncompressed HD
- CLM 4x4, 8x8, 2x16 – mechanically based, ultra-broadband

Operational band	O – L (1310-1600nm)
Insertion loss	9, 12, 14 dB
Switching speed	10 ms
Durability	10^7 cycles

- CLM 4x8

Operational band	C
Insertion loss	14 dB
Switching speed	6ms
Durability	MTBF 10^6 hrs

- CLS/M 8x8, CLS/M 16x16 multicast on demand (variable multicast ratios)

Operational band	C
Insertion loss	4-13, 5-17 dB
Switching speed	3ms
Durability	MTBF 10^6, $5*10^5$ hrs

Open Photonic Devices and Systems
Description of Transmission Systems and Building blocks

- Basic building blocks exist and are in operation
- Problem to guarantee interoperability with other transmission systems, including proprietary ones
- Situation can be better with open TS, but portable open description language is needed
- NDL?

Looking for tool...

- for description of pure optical devices
- not only active elements
  - EDFA, switch, ROADM, ...
- also for passive elements
  - fiber, attenuator, CD fiber, ...
- something universal

NDL discovered

- Network Description Language
- created on University of Amsterdam

- widely applicable
- multilayer model

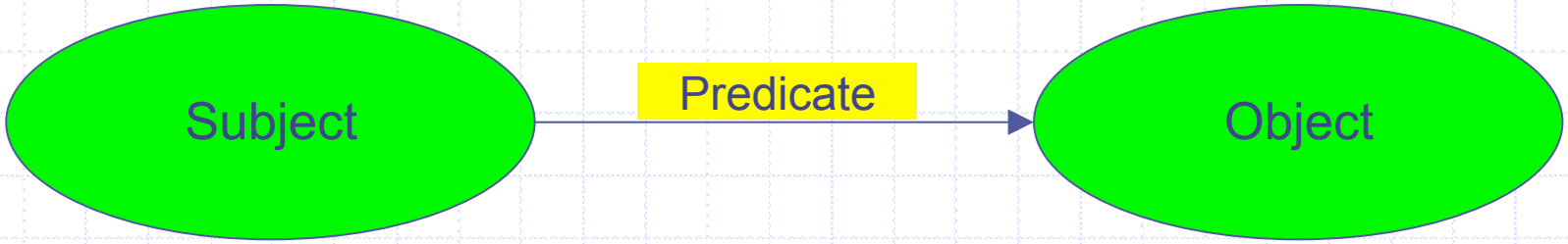
NDL multilayer model

- fully separated layers
  - topological, Ethernet, TCP, ...
- independent layers

- every layer needs schema
- NDL Optical Schema created

NDL syntax

- well-known XML
- rules of RDF
- all relations by triple:

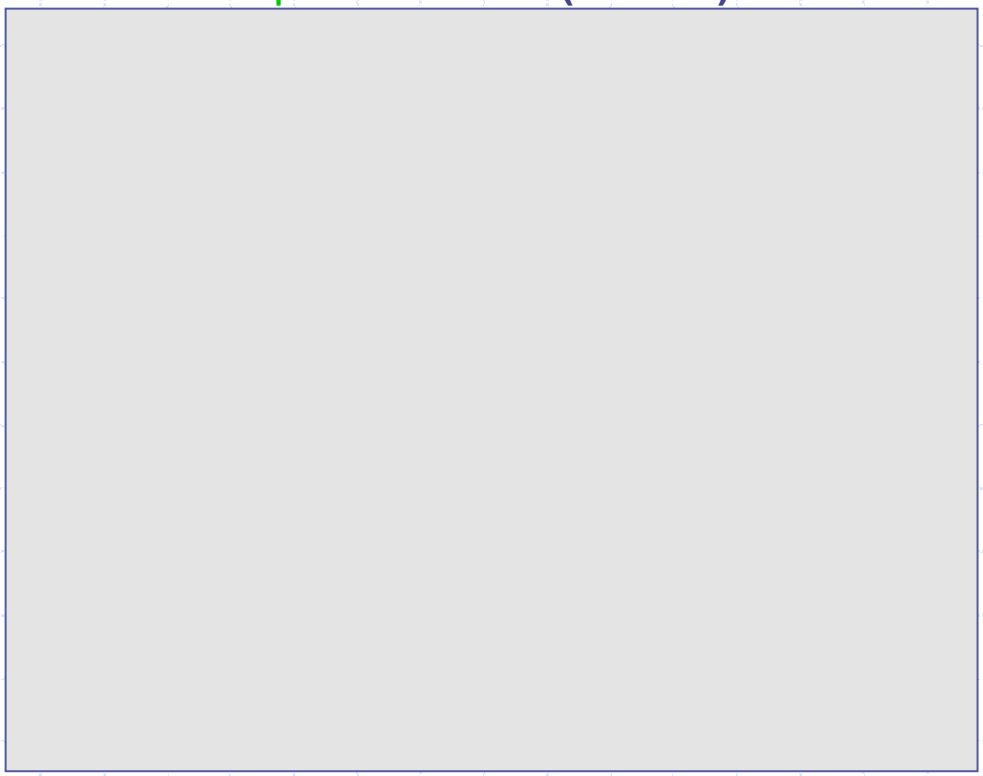


- excellent machine processing
- but verbosity

Using NDL Optical Schema

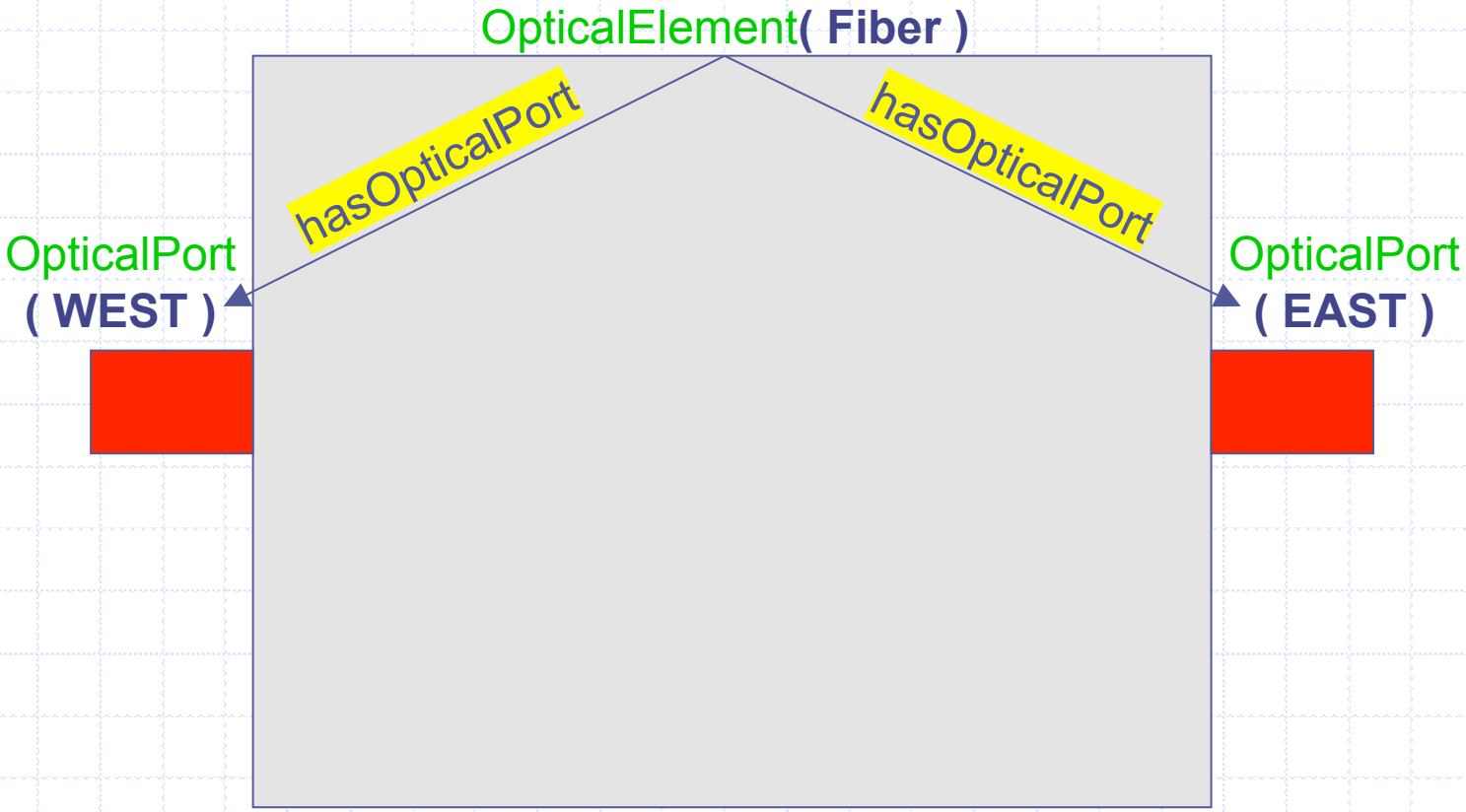
- fiber description example

OpticalElement(**Fiber**)



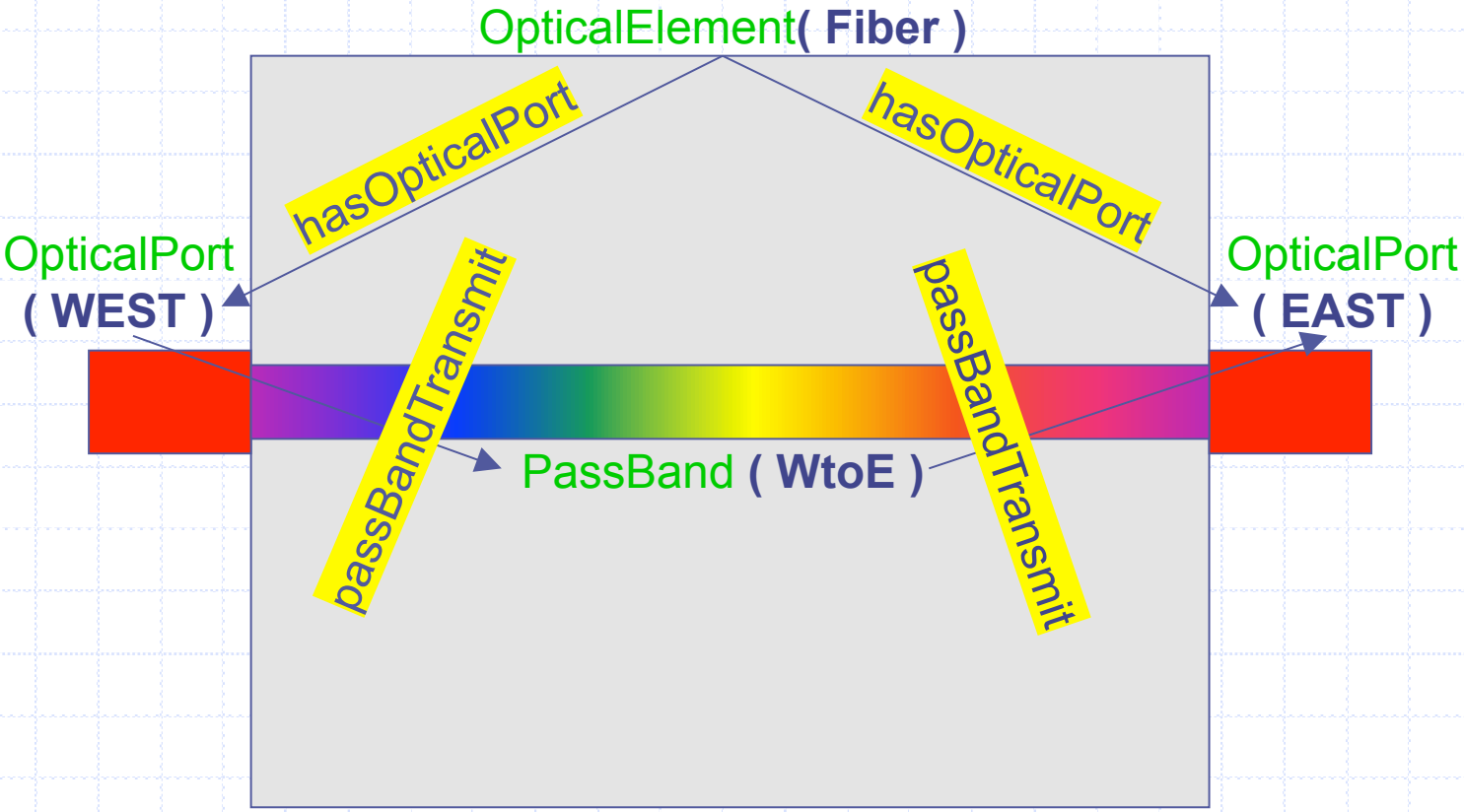
Using NDL Optical Schema

- adding ports



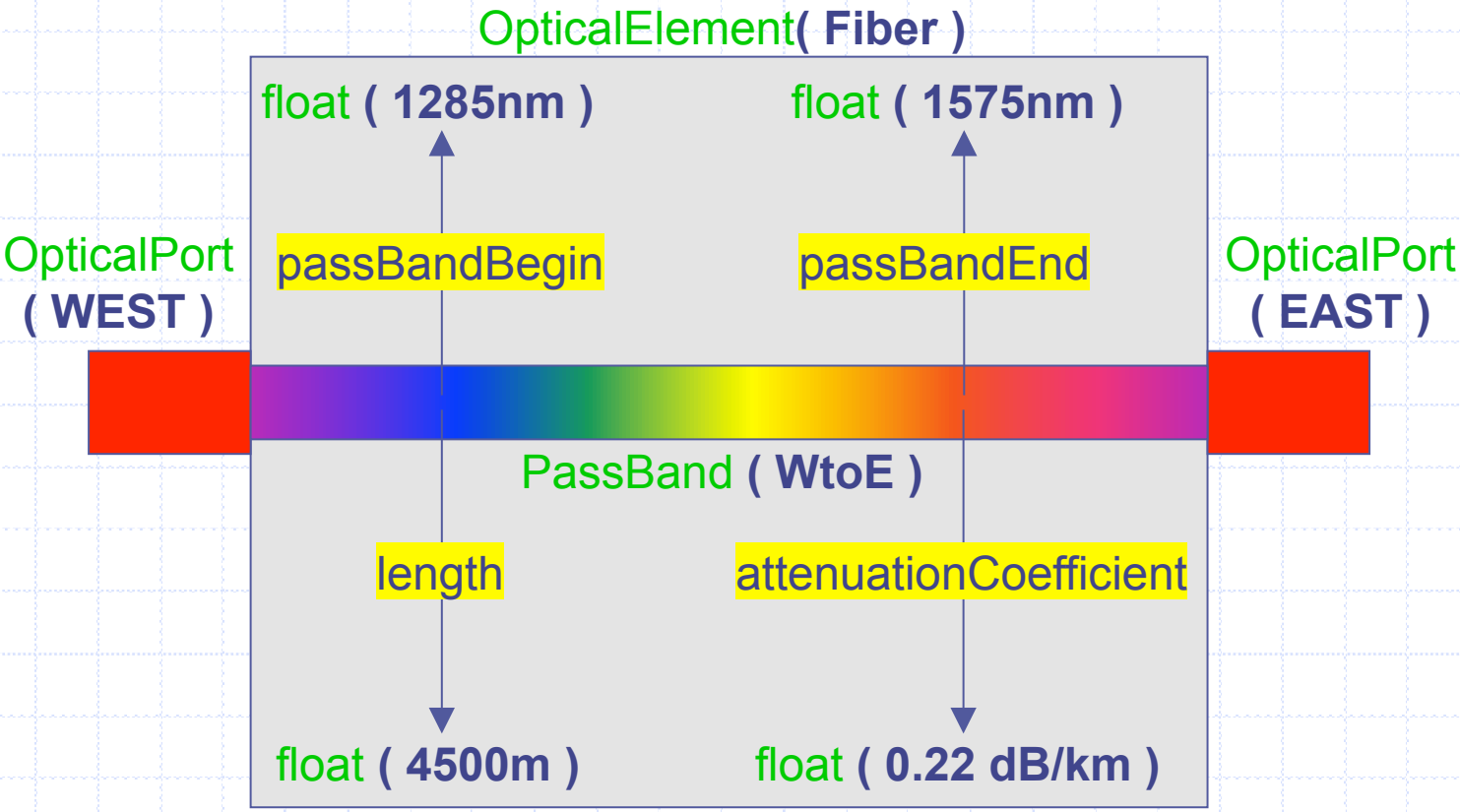
Using NDL Optical Schema

- adding passband



Using NDL Optical Schema

- passband parameters



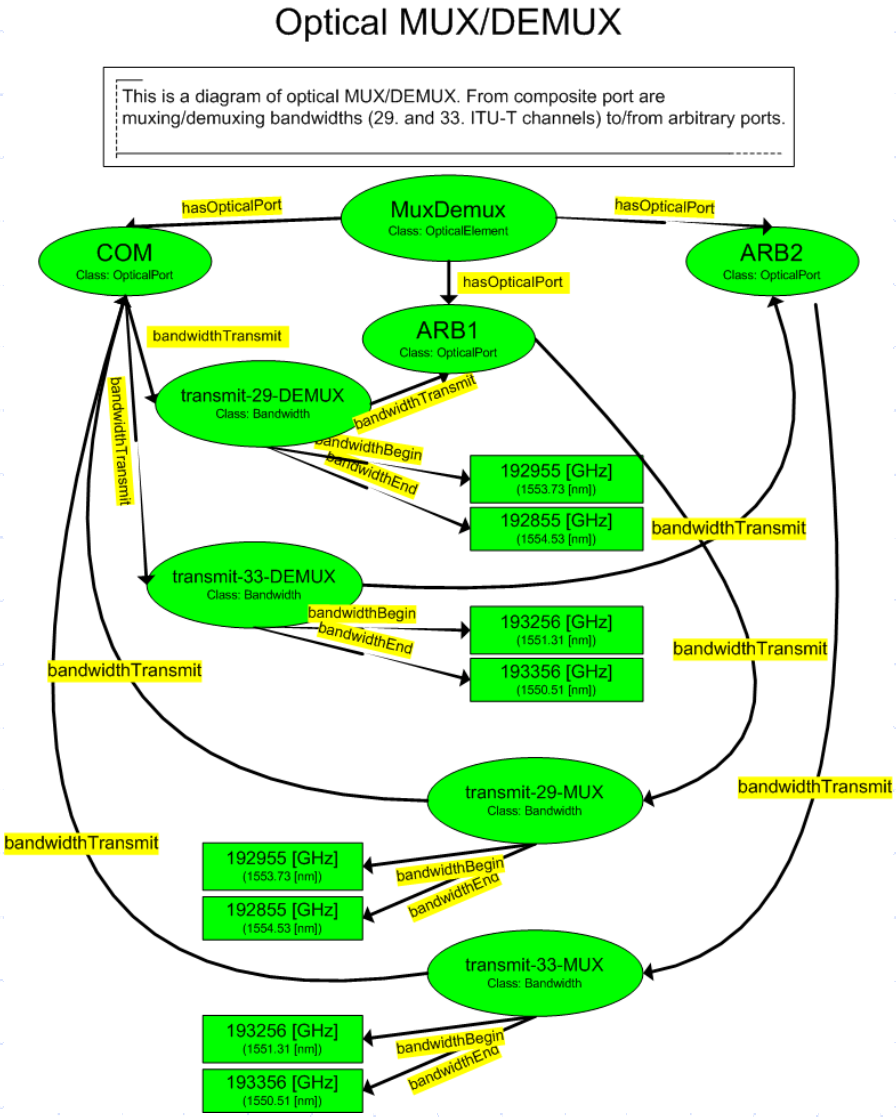
NDL code of example

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE rdf:RDF>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
         xmlns:ndl="http://clserver.cesnet.cz/rdf/ndl/optical_schema_v2.2.rdf#"
>

<ndl:OpticalElement rdf:about="#Fiber">
  <rdfs:label xml:lang="en">Optical fiber</rdfs:label>
  <ndl:hasOpticalPort rdf:resource="#WEST" />
  <ndl:hasOpticalPort rdf:resource="#EAST" />
</ndl:OpticalElement>

<ndl:OpticalPort rdf:about="#WEST">
  <rdfs:label xml:lang="en">The first termination of fiber</rdfs:label>
  <ndl:passBandTransmit rdf:resource="#WtoE" />
</ndl:OpticalPort>

<ndl:OpticalPort rdf:about="#EAST">
  <rdfs:label xml:lang="en">The second termination of fiber</rdfs:label>
</ndl:OpticalPort>

<ndl:PassBand rdf:about="#WtoE">
  <rdfs:label xml:lang="en">Transmit from PORT-West to PORT-East</rdfs:label>
  <ndl:passBandTransmit rdf:resource="#EAST" />
  <ndl:passBandBegin>1285.0</ndl:passBandBegin>
  <ndl:passBandEnd>1575.0</ndl:passBandEnd>
  <ndl:length>4500</ndl:length>
  <ndl:attenuationCoefficient>0.22</ndl:attenuationCoefficient>
</ndl:PassBand>

</rdf:RDF>
```

Example is not perfect

- missing properties like
  - chromatic dispersion (or coefficient)
  - maximal input power per optical port
- passband should be divided to C-band and L-band (and more)
- all of these and more is possible with schema

Schema of MUX/DEMUX



Using NDL in devices

- always reflects device description and configuration
- over HTTP/HTTPS protocol
- remote monitoring
- configuration backup (easy replacement)
- prepared CLserver http://clserver.cesnet.cz

Open Photonic Devices and Systems
Acknowledgement

- Jan Gruntorád, Miroslav Karásek, Martin Míchal, Jan Nejman, Václav Novák, Karel Slavíček and Pavel Škoda

Open Photonic Devices and Systems

Thank you for your attention!

Can open photonic systems work as FLOS software?

Can portable vendor independent description improve interoperability?

Who is willing to cooperate?

References 1

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