

Why We Should Care About the Photonic Layer

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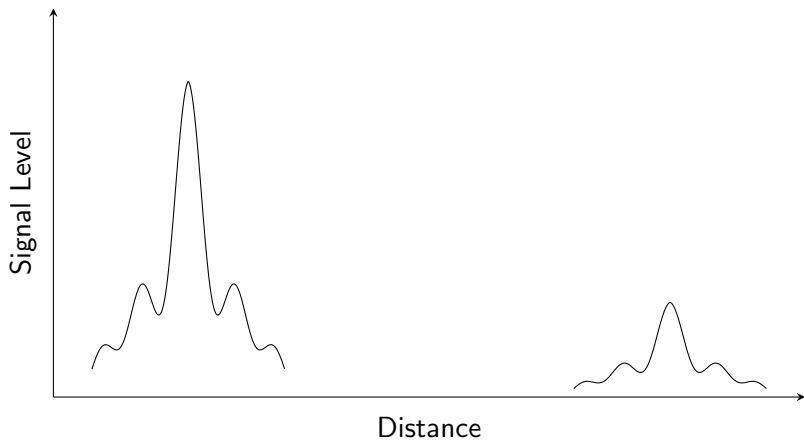
Fiber



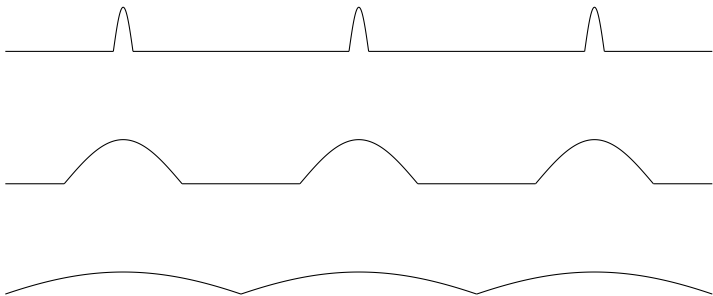


Image courtesy of the US military

Attenuation



Chromatic Dispersion



Dispersion Compensation

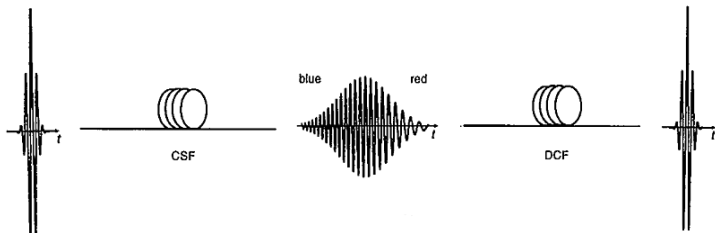


Image courtesy of www.fiberoptics4sale.com

100G Coherent Systems

- ▶ 100G Coherent Systems bring much better tolerance to the CD
 - ▶ 29,000 – 80,000 ps compared to 1,200 ps for 10G
 - ▶ DSP
- ▶ Vendors strongly recommend a **DCM-free network**
⇒ Problems when using 10G NRZ OOK and 100G simultaneously

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 - ▶ DSP
- ▶ Vendors strongly recommend a **DCM-free network**
⇒ Problems when using 10G NRZ OOK and 100G simultaneously
- ▶ What about the upcoming 400G/1T links?
- ▶ We **will** need DC for long lines anyway

Compensating the Chromatic Dispersion

- ▶ Not only DCF, also Fiber Bragg Gratings (FBG)
 - ▶ cheaper
 - ▶ no non-linearities
 - ▶ negligible delay (meters, not kilometers)

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- ▶ Not only DCF, also Fiber Bragg Gratings (FBG)
 - ▶ cheaper
 - ▶ no non-linearities
 - ▶ negligible delay (meters, not kilometers)
- ▶ Suitable CD compensation does **not** cause trouble
 - ▶ Both 10G and 100G on the same link
 - ▶ OK to run even $<1\text{G}$ PS with 100G at just 50 GHz separation

Having insight into the photonic layer saves
people money.



But How Exactly?

- ▶ FBGs instead of DCFs
- ▶ Single-fiber transmission
 - ▶ Up to 40% cost savings compared to a fiber pair
- ▶ Aggressive procurement policy with multiple suppliers

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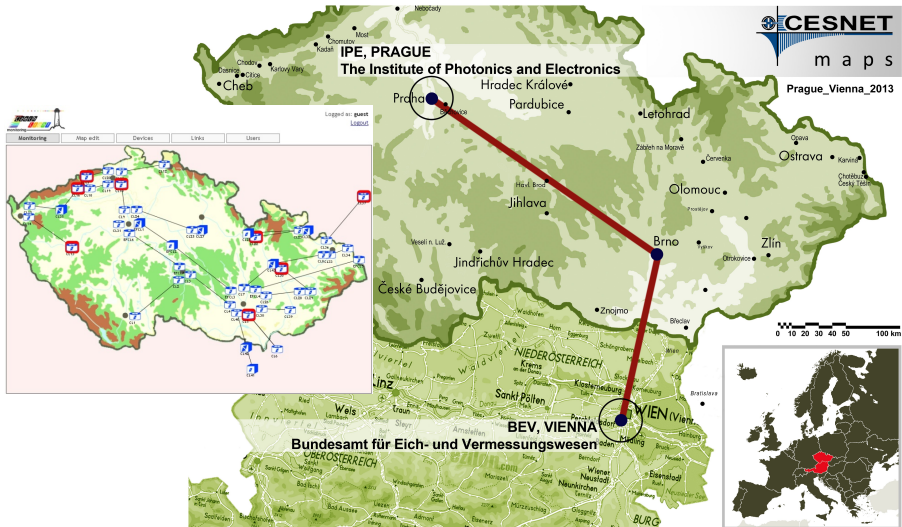
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- ▶ Single-fiber transmission
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- ▶ Aggressive procurement policy with multiple suppliers
- ▶ **Advanced Services**



What are these “advanced services” anyway?

- ▶ In general, making the network **more versatile** and **“smarter”**
- ▶ Some of them deployed for years already
 - ▶ Frequency transfer
 - ▶ Comparing atomic clocks of national time laboratories

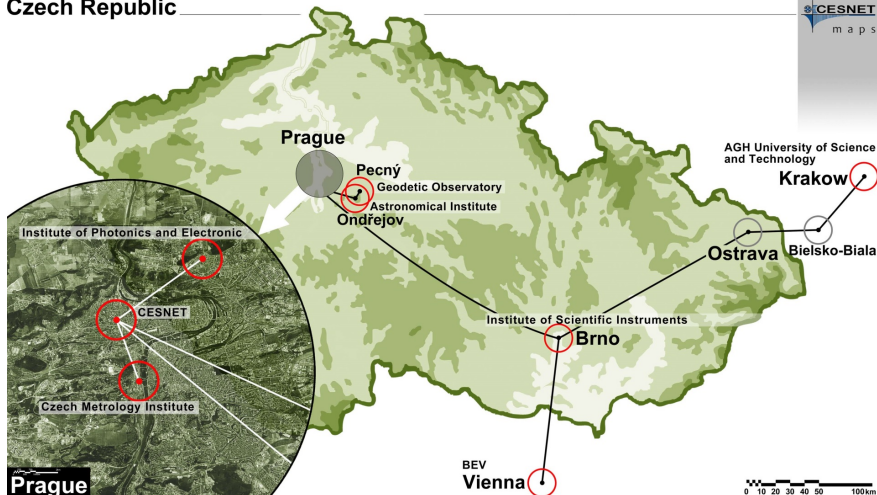
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Czech Republic

CESNET
maps



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- ▶ These are enabled by the **nature** of the Photonic Service
 - ▶ No OEO conversion
 - ▶ No DSP and the associated buffering



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- ▶ These are enabled by the **nature** of the Photonic Service
 - ▶ No OEO conversion
 - ▶ No DSP and the associated buffering
- ▶ **What does it bring?**



The Photonic Service

- ▶ Low latency
- ▶ Negligible jitter
- ▶ **Determinism!**



Some potential has not been realized yet

- ▶ Remote control?
 - ▶ Guaranteed transmission times \Rightarrow OK for hard realtime applications
- ▶ Telesurgeries?



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- ▶ Telesurgeries?

What else?



Services offered by CESNET

- ▶ A well-equipped laboratory
 - ▶ See the backup slides for quick glance, **talk to Jan Radil**
 - ▶ **Partners for remote access much welcome!**
- ▶ Expert personnel



Services offered by CESNET

- ▶ Experience with unusual setups
 - ▶ Heterogeneous equipment
 - ▶ Simultaneous 100G and slow-speed “analogue” photonic signal
 - ▶ Time & frequency transfer, both across fiber pairs and single fiber & custom HW
 - ▶ Automatic & distributed power balancing for power saving and lifetime improvements
- ▶ Hardware design – OpenDWDM CzechLight
 - ▶ Licensed to several 3rd-party manufacturers for actual production
 - ▶ Deployments outside and inside the CESNET network



What is missing?

- ▶ Software tooling
 - ▶ Vendor-neutrality is a must
 - ▶ Full-stack integration with inventory management and NOC monitoring
 - ▶ CESNET is interested in collaboration here



What is missing?

- ▶ Outreach – **talking to the users!**
- ▶ The network operators shall **be involved** in the network design
 - ▶ Delegating the network design to a supplier is suboptimal on multiple fronts



Conclusion

- ▶ Having insight into the photonic layer is beneficial
- ▶ It isn't hard, either
 - ▶ And we can help you!
- ▶ Ask CESNET if you are interested



Acknowledgement

Thanks to my colleagues at CESNET for their work

- Ondřej Havliš, Michal Hažlinský, Miloslav Hůla, Jan Radil, Stanislav Šíma, Pavel Škoda, Martin Šlapák, Radek Velc, Josef Vojtěch et al

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Thank you!

Questions?



Backup Slides



CESNET's Optical Laboratory

- ▶ Dark fibre facility with C and L band transmission
- ▶ **Remote access – partners much welcome!**
- ▶ Testers, analyzers and oscilloscopes and other expensive and not-so-common equipment
 - ▶ Bit error rate testers (BERT): for 1/10/40G, 100G in near future
 - ▶ Sampling oscilloscopes and constellation analysers for speeds up to 100G (and beyond)
 - ▶ Testers for chromatic and polarization mode dispersion
 - ▶ Fibre spools, G.652, G.655 (i.e. extension of field dark fibres)
 - ▶ Different types CWDM/DWDM muxes, filters etc.
 - ▶ Different amplification units (EDFA, PDFA, Raman, hybrid) for C and L bands
 - ▶ ROADMs, including multidegree and flexigrid
 - ▶ Different CD compensation units – **Alien Waves** etc.

ALU 1830PSS Photonic Service Switch Platform



APEX-T AP2443B Optical Complex Spectrum Analyzer

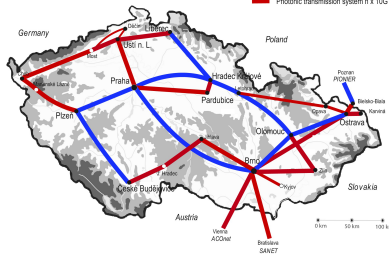


Prague, October 25th,
2012

Transmission systems by CISCO

■ Cisco transmission system n x 10G

● PoP
○ User Point



Transmission systems by CESNET

■ Photonic transmission system n x 1G

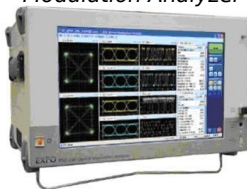
■ Photonic transmission system n x 10G started by 1G

■ Photonic transmission system n x 10G

Cisco ONS 15454 Multiservice Transport



EXFO PSO-200 Optical Modulation Analyzer



Oclaro OTS- 4000



Optical laboratories of CESNET



Optické komunikace 2012
Slide from OPTOKOM 2012 in Prague