Photonic Services
Enable Real-time Applications over Long Distances

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CESNET, association of legal entities
Outline

• Czech NREN CESNET
• Time Transfer
• Frequency Transfer
• Photonic Services
• Alien wavelengths
• CEF Network Concept
• Critical Applications
Czech NREN CESNET

CESNET association of legal entities
- Support non-profit organizations in Czech Republic
- Manages and operates about 5000 km of optical fiber network
- Dark fibers
- Cisco and CzechLight
- Special applications

Call to joint deployment of photonic transmission systems developed by CESNET
http://www.ces.net/doc/press/2012/pr120814.html
Coordinated Universal Time – averaged from set of Cesium clocks
Distributed to many electronic devices
Cesium clocks are commonly compared over satellite links
Time Transfer

- Design of end-user devices
- Time stability of $8 \times 10^{-11}$ for average time of 500s
- E2E delay varies slowly

![Diagram showing time deviation and delay variation over averaging interval and days.](image)
Frequency Transfer

Aubervilliers

Paris

ILA #1

ILA #2

Reims

Villetaneuse

Univ. Paris 13

LPL

Penang, October 2nd, 2012

3rd International Conference on Photonics 2012

Source: Renater&PTB, CEF2012

- Improved stability
- Considerable network hardware modification

\[
\sigma_y(\tau) \propto \frac{1}{\tau}
\]

\[
\int_{0}^{\tau} \sigma_y^2(t) dt \leq \sigma^2 \tau
\]

- Graph showing the trade-off between integration time and uncertainty

- 540 km = 470 km on DWDM + 70 km on dedicated dark fibre

- 11km/-13dB
- 36km/-11dB
- 103km/-29dB
- 85km/-20dB
- 35km/-10dB

Source: Renater&PTB, CEF2012
Photonic Services

Defined by:
• Dedicated bandwidth
• Optical light-path

All-optical networks
• Application transparent
• Remote assignment

Source: Infinera
Alien wavelength

Alien Wavelength – reserved bandwidth in multiple domains
– 100, 50 or 25 GHz bandwidth according to ITU grid
– Increased transparency

source: Roeland Nuijts, CEF2012
Alien wavelength
CEF Network Concept

- Leased Capacity
- Dark Fiber Infrastructure
- Leased Infrastructure
- Owning the Infrastructure
- Teleco DWDM vendors
- Network Lighting
- CzechLight Open DWDM

Customer Empowered Fiber Networks

- SFB Lines
- Nothing In Line
- Fiber Pair Sharing
- Alien Waves
- Photonic Services
Critical Applications

- Hard real-time – applications with strict requirement of network response

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<th>Latency jitter limit</th>
<th>E2E latency</th>
<th>Penalty</th>
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<tr>
<td>Interactive human collaboration</td>
<td>10-50 ms (adaptive play-out delay buffer)</td>
<td>100-200 ms</td>
<td>Mild (user disappointment)</td>
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<td>High definition video and Cave-to-cave</td>
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<td>Remote control of vehicles</td>
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<td>Severe (vehicle crash)</td>
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<td>Comparison of atomic clocks</td>
<td>50 ps (short time) and 1 ns (long time)</td>
<td>Minimal</td>
<td>Mild (experiment failure)</td>
</tr>
<tr>
<td>Ultra-stable frequency transfer</td>
<td>NA</td>
<td>Minimal</td>
<td>Mild (experiment failure)</td>
</tr>
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</table>
• Time transfer feasible over current DWDM
• Photonic services – generalized approach
• Multi-vendor networks with Alien Waves
• CEF Networks Concept
• Supported by Open CzechLight DWDM system
• Critical Applications over optical networks
Acknowledgement

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Thank you for your attention.

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