Photonic Services and their Applications

V. Smotlacha, J. Vojtěch, P. Škoda

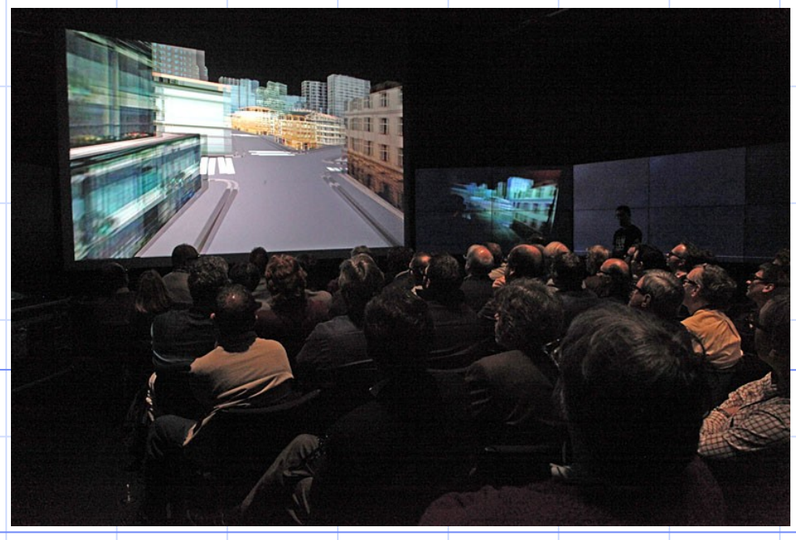
- ***Photonic Service Definition***
  - **End-to-end optical connection between two or more places in network**
  - **Described by photonic-path and allocated bandwidth**

- ***Features***
  - Transparency to modulation formats
  - Low transmission delay – shortest photonic path is formed
  - Future-proof design due to grid-less bandwidth allocation
  - Constant delay with negligible jitter - none or only specially tailored electrical processing is present
  - Stable service availability due to allocated bandwidth

- ***Issues***
  - Limited reach (universal all-optical regeneration missing) – can be extended by specialized OOO and/or OEO regenerators (suitable for limited number of applications)
  - Absence of global management and operation system or communication between separate management systems
  - Non-guaranteed multi-vendor network interoperability, however first test were successfull and ITU-T has produced recommendation G.698.2 - "Black link"
  - All-optical nodes should be grid-less and direction-less

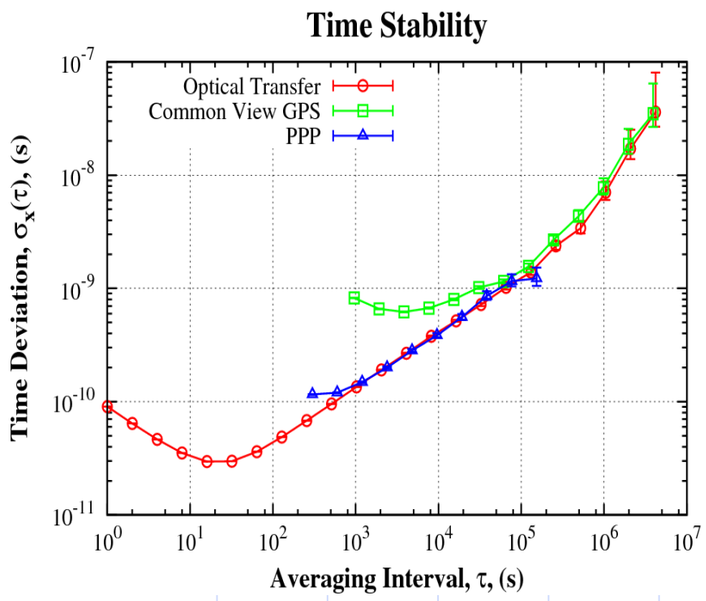
- ***Applications***
  - ***Interactive human collaboration***
  - ***High definition video and Cave-to-cave***
  - ***Remote instrument control***
  - ***Remote control of vehicles***
  - ***Comparison of atomic clocks***
  - ***Ultra-stable frequency transfer***

Collaboration on architectural model



Long distant high-definition 3D projection
Transfer from Prague to San Diego (Cinegrid 2011)

Atomic Clock Comparison

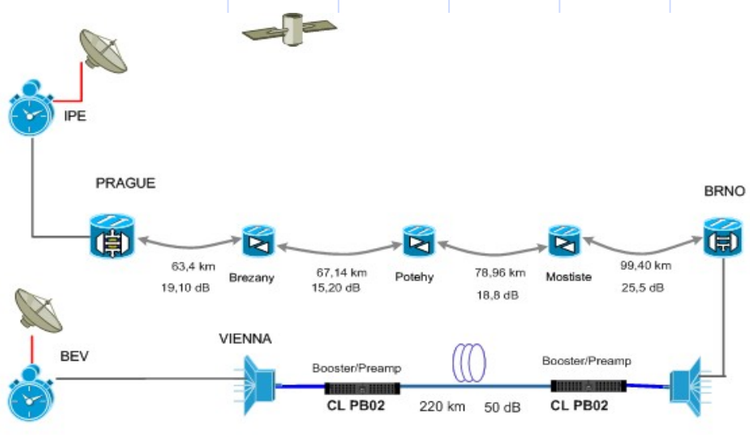


Photonic service implementation

Dark fiber - *unlit fiber*
- Fiber full bandwidth available
- Freedom on deploy any equipment
- No limit in directionality or amplification
- Renter must pay all rental cost, acquire equipment and deal with its maintenance
- Difficult troubleshooting and putting into service

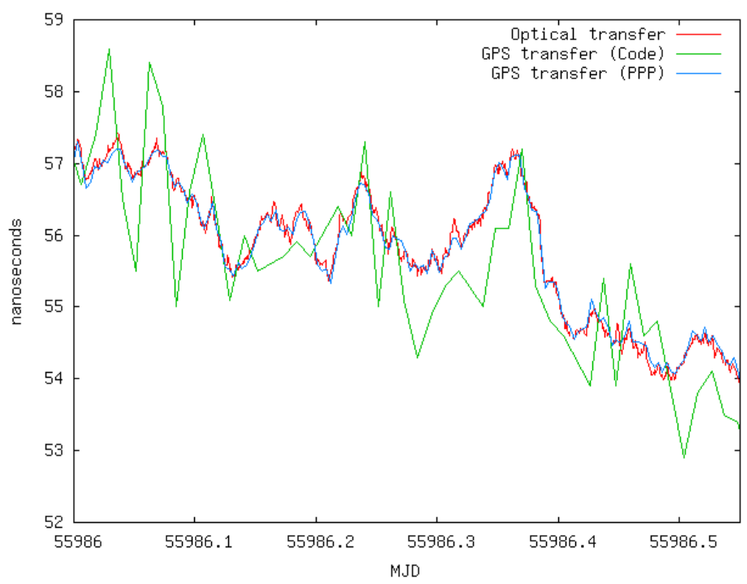
Dark channel - dedicated bandwidth or one channel within traditional transmission system
- The bandwidth is branch off before traditional equipment and branch in after the equipment placed in "huts"
- Reduced cost - channel typically consumes 1/40th or 1/80th of available spectrum
- Freedom on equipment deployment
- Amplification must respect other channels
- Easier putting into service and troubleshooting

All-optical Lambda - lambda passing through regular transmission system
- Low cost, no special inline device
- Unidirectional channels only
- Amplification is done together with other channels - suffers from noise
- Simple maintenance and putting into operation
- DCM might affect lambda timing

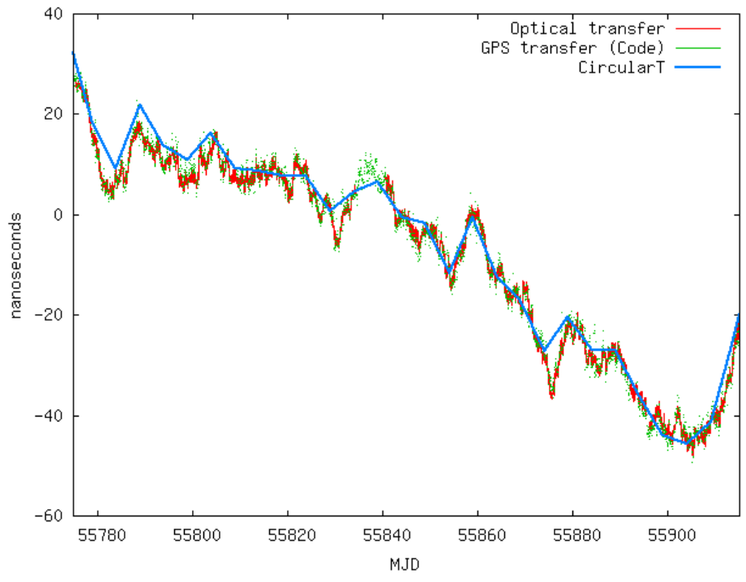


Schematic diagram of the photonic path between Prague and Vienna (550km)

- **Precise optical time transfer between Prague and Vienna**
- **Comparison national time scales UTC(TP) and UTC(BEV)**
- **Long-term measurement since August 2011**
- **Comparison with Common View GPS, PPP and BIPM Circular-T**
- **Optical path length 550 km**



Optical time transfer short-term comparison with GPS Common-view and PPP time transfer



Optical time transfer long-term comparison with GPS Common-view time transfer and Circular-T

The research leading to these results has received funding from the European Community's Seventh Framework Program (FP7/2007-2013) under grant agreement n° 238875 (GÉANT).
This work was supported by the Ministry of Education, Youth and Sport of the Czech Republic as part of the CESNET Large Infrastructure project LM2010005