# Photonic Services and their Applications,

*J. Vojtěch, P. Škoda, V. Smotlacha*

## Photonic Service

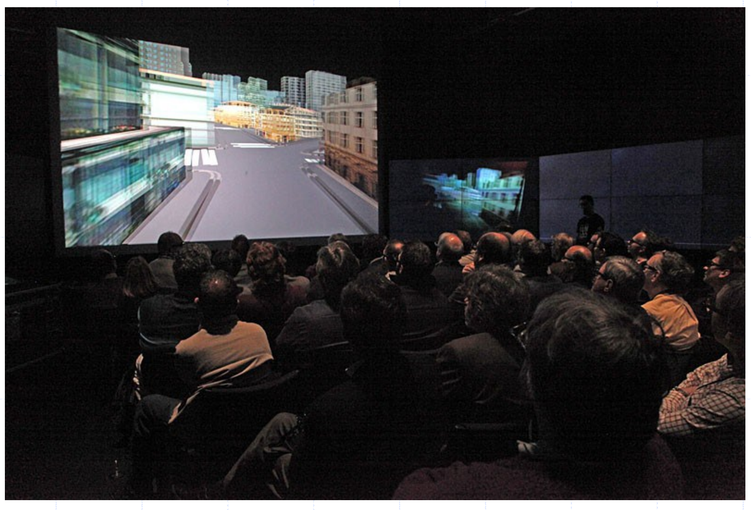
- End-to-end connection between two or more places in network
- Described by photonic-path and allocated bandwidth

- ***Features***
  - Transparency to modulation formats
  - Low transmission delay, the shortest photonic path is formed
  - Future-proof design due grid-less bandwidth allocation (in fine step of e.g. 1GHz)
  - Constant delay (i.e. negligible jitter), because none or only specially tailored electrical processing is present
  - Stable service availability due to allocated bandwidth

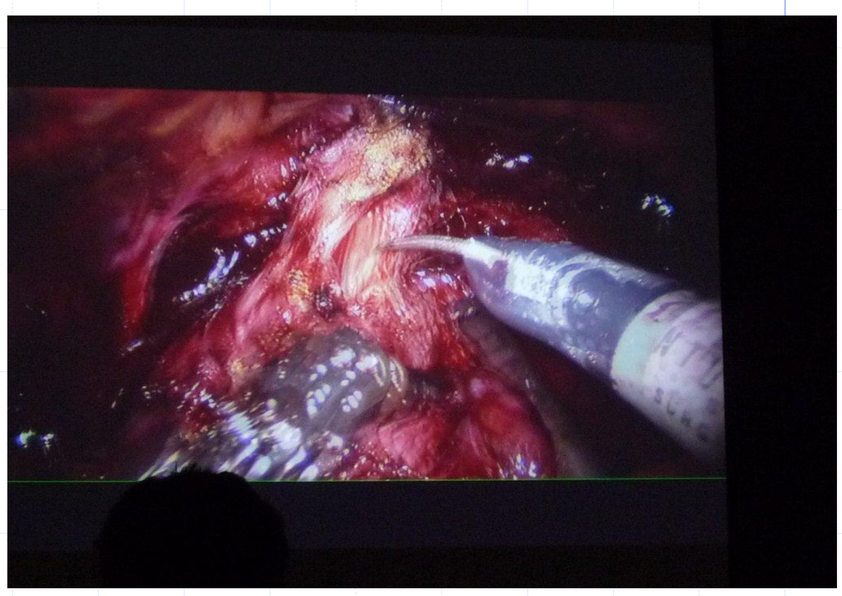
- ***Issues***
  - Limited reach - universal all-optical regeneration is missing, but it can be extended by specialized OOO and/or OEO regenerators (suitable just for limited number of applications)
  - Absence of global management and operation system or communication between separate management systems
  - Multi-vendor network interoperability, although first tests were already successful, ITU-T also 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***

## Remote collaboration – 3D HD+ video



*Collaboration on architectural model: Prague (CZ) - San Diego (CA,US) (Cinegrid 2011)*



*3D robotic surgery broadcast: from Usti n.L. (CZ)-Tsukuba (JP) (2010)*

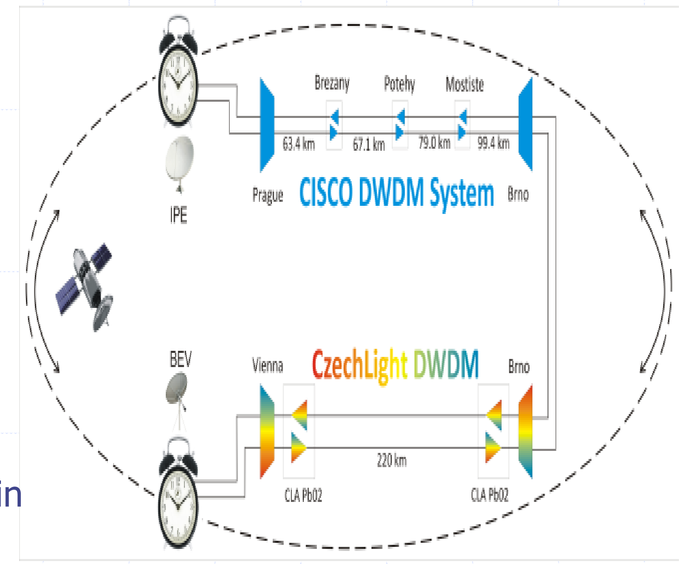
**pictures may appear blurry because of stereoscopy projection*

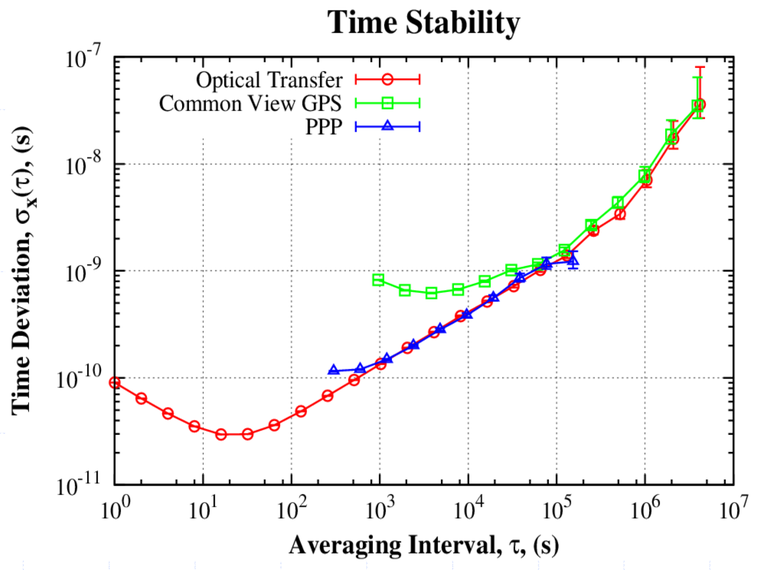
## Atomic clock comparison - Precise Time Transfer

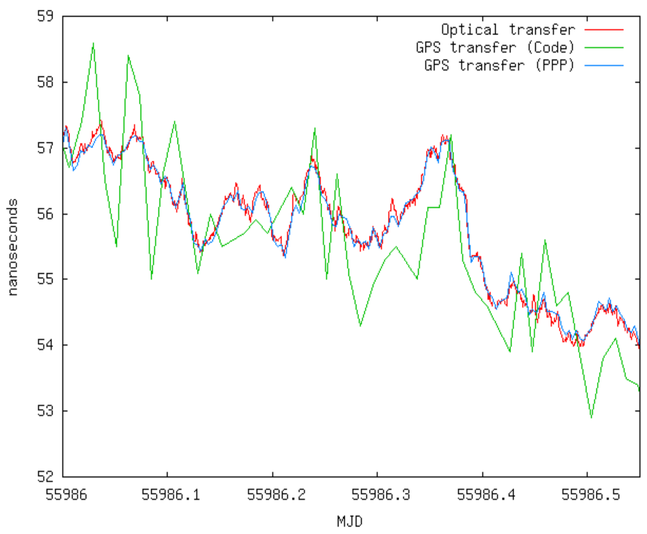
- Comparison national time scales UTC(TP) and UTC(BEV)
- Long-term measurement since August 2011
- Comparison with Common View GPS, PPP and BIPM Circular-T
- Optical path length 560 km, combination of: transmission systems, 652 and 655 fiber, different DCUs (fiber and FBG)

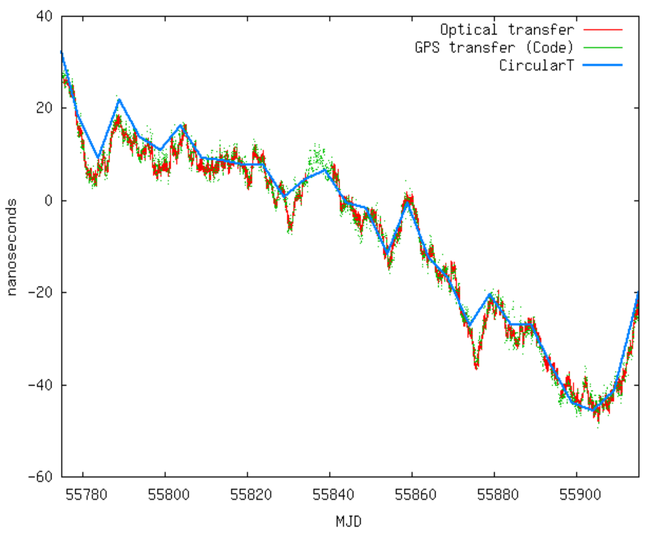
## Implementation

- ***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 devices
  - Unidirectional channels only
  - Amplification is done together with other channels - suffers from noise
  - Simple maintenance and putting into operation




*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 nº 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* and by Technology Agency of the Czech Republic grant TA01011105