Optical Infrastructure for Precise Time and Stable Frequency Transfer

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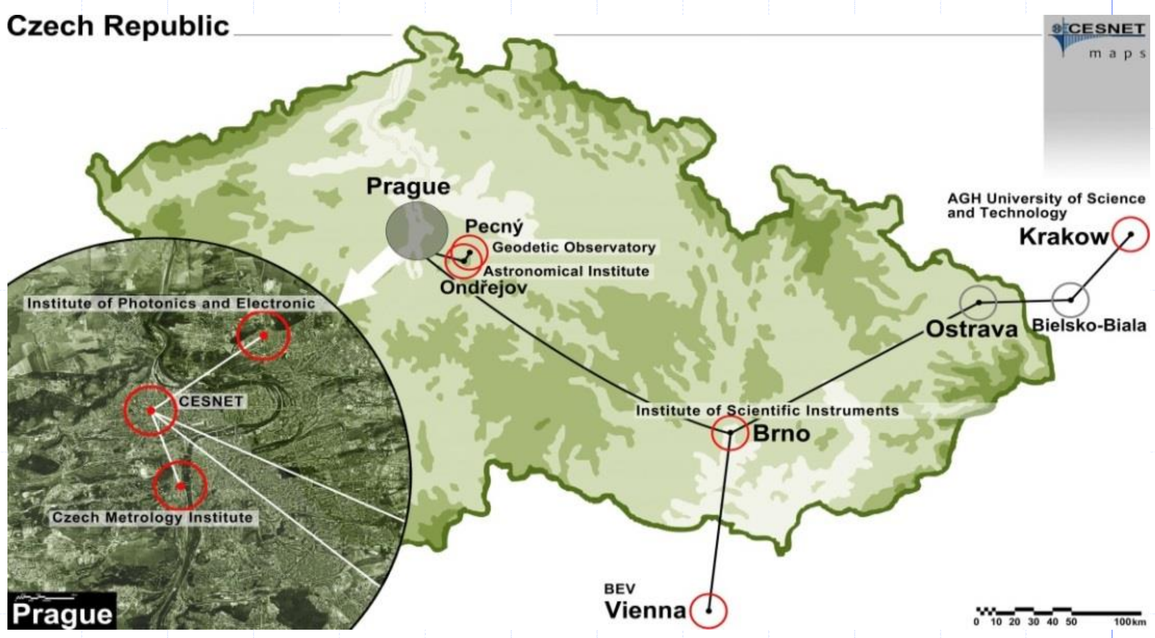
Goals

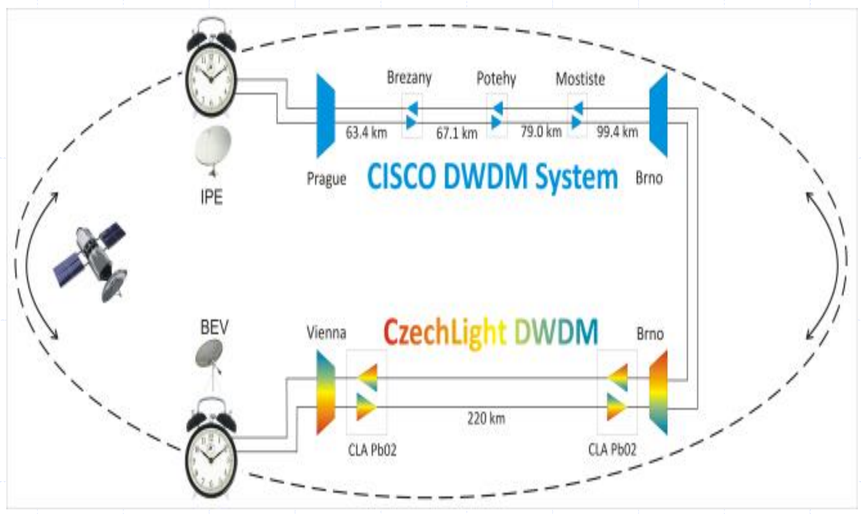
- Transfer time from several deployed Cesium primary standards and Hydrogen masers to Czech national time and frequency laboratory in UFE. Higher number of these interconnected clocks will improve accuracy and stability of UTC(TP) - the national approximation of UTC time scale
- Compare national approximation of UTC with that one in neighboring countries
- Check accuracy and stability of other connected atomic clocks
- Distribute accurate time and stable frequency to demanding users
- Obtain experience with the coherent frequency transfer



Used resources

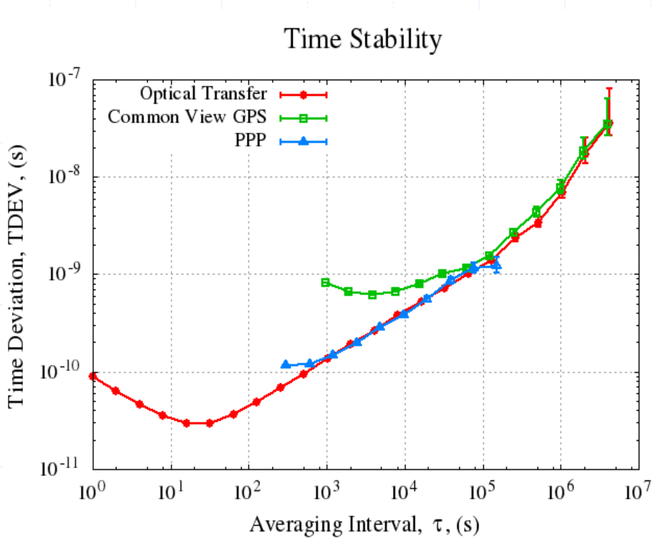
- Shared infrastructure with data via DWDM - cost of fiber pair rental in CZE 0.5 €/m/year ≈ 0.6 $/yard/year
- pair of channels (with the same wavelength in both directions) in a operational DWDM optical network
- pair of DWDM channels with different wavelengths in single fiber bidirectional transmission system
- pair of DWDM channels (both uni- and bi-directional) in experimental links
- dark fiber – usually the last mile in the urban area.

UFE - BEV

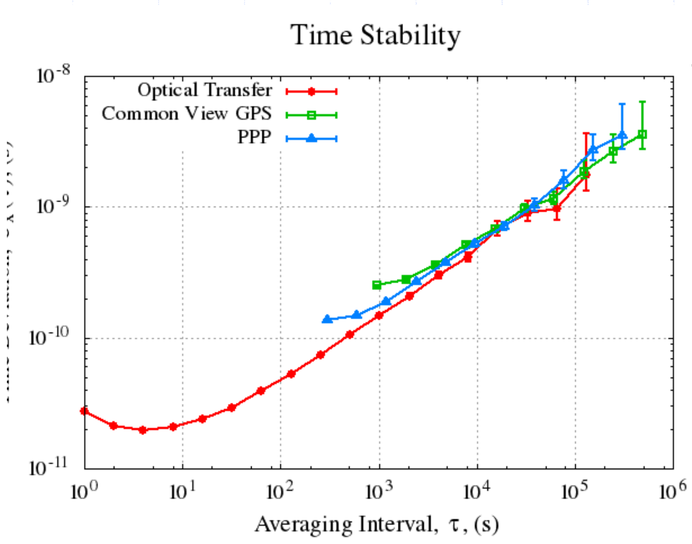


- Comparison national time scales UTC(TP) and UTC(BEV)
- Long-term measurement since August 2011
- Comparison with Common View GPS, PPP and BIPM Circular-T
- Parallel transmission with ordinary data, including 100Gbps
- Optical path length 550km (342mi) one way, passes through two transmission systems and two local fiber loops
- Combination of G.652 and G.655 fiber, different DCUs (fiber and FBG)

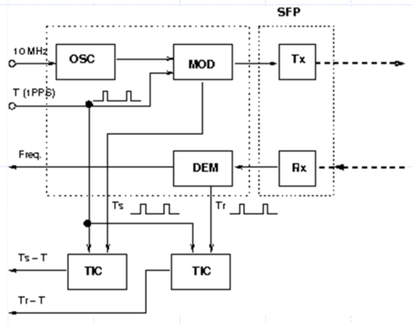
UFE - BEV

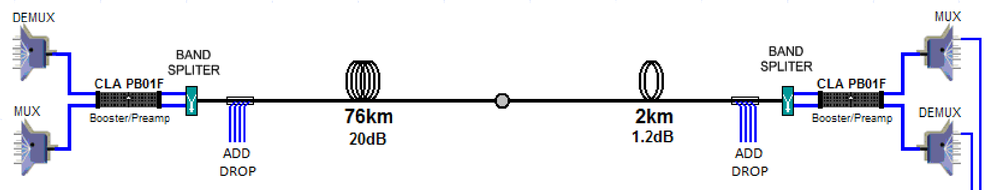


CESNET - VUGKT



Adapters





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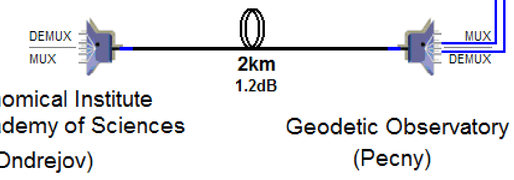
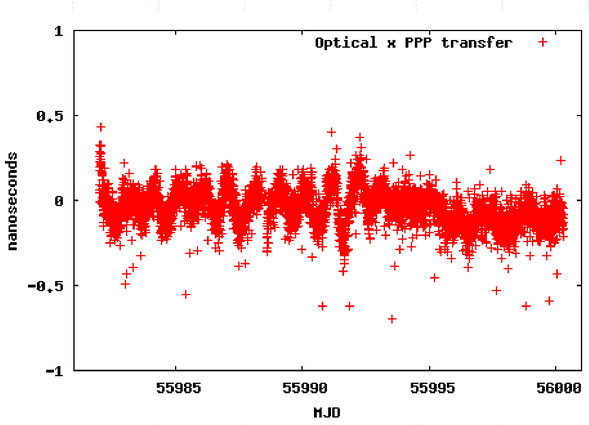


- First tested 2012, in trial operation since 2013
- Comparison with Common View GPS, PPP
- In parallel with ordinary 10G data services
- Optical path length 78km (48.5mi) uses two wavelengths in single fiber bidirectional transmission system, G.652fibre, no CD compensation
- Fixed directional asymmetry about 1.16ns
- Main source of uncertainty: about 40 ps in integrated FPGA interval counters
- Other effects: PMD, CD thermal dependency, Sagnac effect - less than 10ps in total

UFE - BEV



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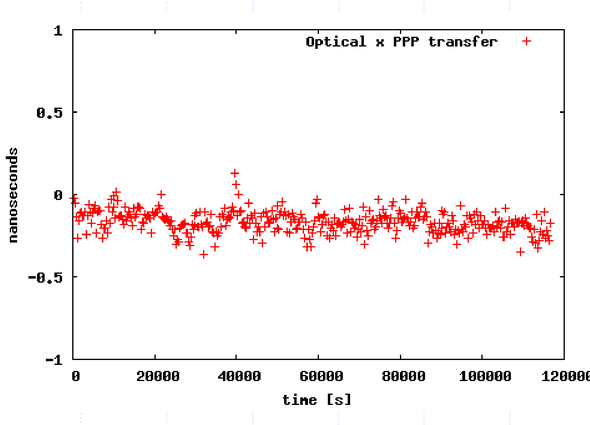
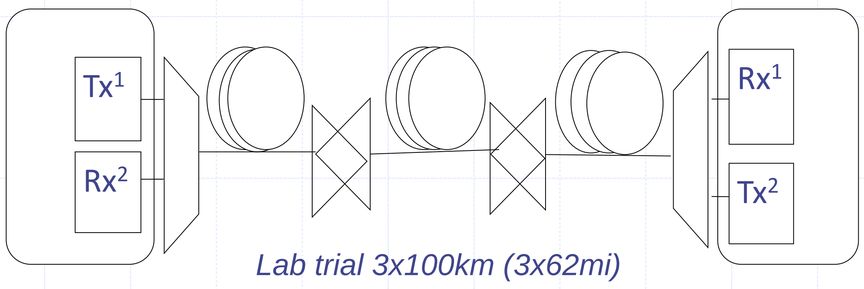


Further work challenges

- Single fiber bidirectional transmission is necessary
- Traditional telecommunication amplifiers are unidirectional
- Basic available technology EDFA, Raman, SOA, Brillouin



Lab trial 3x100km (3x62mi)

Results

- Optical time transfer has smaller noise than both PPP method for both links
- Noticeable difference is about 3 times lower phase white noise with single fiber bidirectional transmission

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