

# Time Transfer in a Wide Area White Rabbit Network

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Time transfer over optical fiber has potential to outperform the best satellite based methods (TWSTFT and GPS-PPP) that are used for maintenance of UTC and other precision experiments. The White Rabbit Precision Time Protocol<sup>1</sup> (WR-PTP) uses a combination of synchronous Ethernet and enhancements to PTP (IEEE 1588) to achieve sub-nanosecond synchronization in local area (<10 km) optical fiber networks. Here we test how WR-PTP scales to wide area (1000 km) optical fiber networks.

The timing source of our WR network is a grand master (GM) node located in Espoo and locked to a one pulse-per-second (PPS) signal representing UTC(MIKE), our local UTC implementation. A 1000 km optical link to Kajaani is established by feeding the WR-PTP signal directly into a DWDM channel (ITU-T #60, 196.00 THz) of the Finnish University and Research Network (FUNET) operated by CSC. A slave node at Kajaani outputs the received time as a PPS signal. Both GM and slave PPS signals are fed to dual-frequency GPS-receivers (GTR50 and GTR51, Dicom), to allow independent verification of time transfer using Precise Point Positioning post-processing.

Time transfer results collected during 32 days in January – February 2014 are shown in Figure 1. The WR-PTP algorithm continuously measures the optical round-trip-time (RTT) ca. 10.4373 ms, with an estimated asymmetry between up- and down-link of 1.8  $\mu$ s. A constant fraction of the RTT is used to correct the slave node time. Temperature variations cause RTT variations of up to  $\pm 200$  ns over weeks and  $\pm 50$  ns daily. The time transfer error was determined as the difference between GPS clock solutions at Espoo and Kajaani obtained with CSRS-PPP<sup>2</sup>. The time transfer error reached a minimum time-deviation of 20 ps at an averaging time of 1000 s.

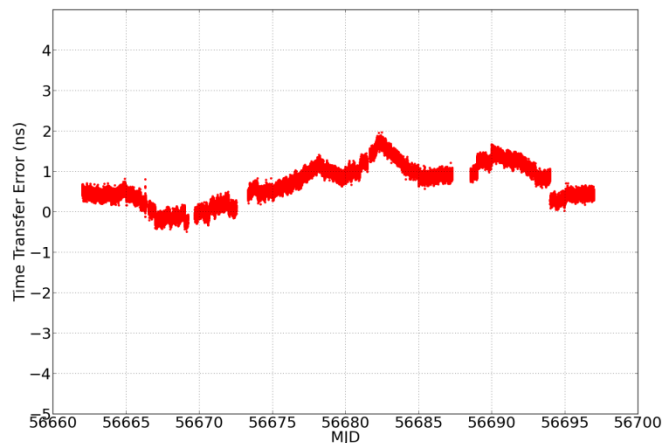


Fig. 1: 1000 km WR-PTP time transfer error during 32 days.

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<sup>1</sup> M. Lipinski et al., “White Rabbit: a PTP application for robust sub-nanosecond synchronization”, IEEE ISPCS, 35-30, 2011.

<sup>2</sup> <http://webapp.geod.nrcan.gc.ca/geod/tools-outils/ppp.php>