# Device synchronization in industrial network for 3D metrology using Precision Time Protocol

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## Background

Accurate dynamic position measurement with e.g. a multicamera system requires a simultaneous imaging of targets with multiple cameras. Triggering and timestamping of measurements and e.g. robot actions using a common timebase like UTC time facilitate control manufacturing environment. Ethernet-based synchronization protocols and hardware reduce the need for e.g. separate triggering cables, and also compensate for (ethernet) cable lengths or constant delays.

The widely used TSN (Time Sensitive Networking) standard uses PTP (Precision Time Protocol) , and can be used instead of e.g. EtherCAT for syncronization in communication network.

Here we study the use PTP over ethernet for measurement timing. We use indutrial PCs running linux and economical intel i210 network cards providing hardware PTP support and programmable outputs. The master clock is here a White Rabbit switch in PTP mode.

## Experiment with laser pulse detection

Figure 1 shows the main setup used for generating the results shown in Figure 2, and which was then varied for the rest of the experiments.

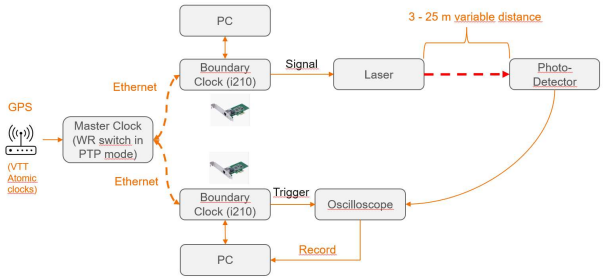


Figure 1. Arrangement for proof-of-concept testing PTP synchronization. Laser pulses are generated by one clock and detected against another.

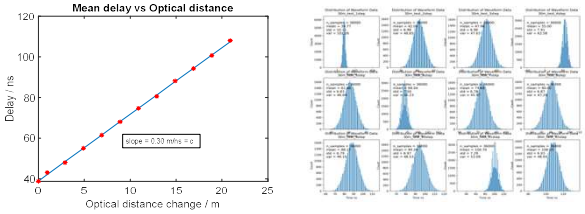


Figure 2. The observed time delays for different optical path distances. Means of the pulse edge arrival times were used for creating the graph at the left

## Ethernet cable length and common offset

The compensation of different length of ethernet cables was tested successfully by connecting the signals directly to oscilloscope and using different length ethernet cables for one PC. However both PC's clocks were similarly slightly ahead of UTC/TAI pulse per second signal. (Figure 3)

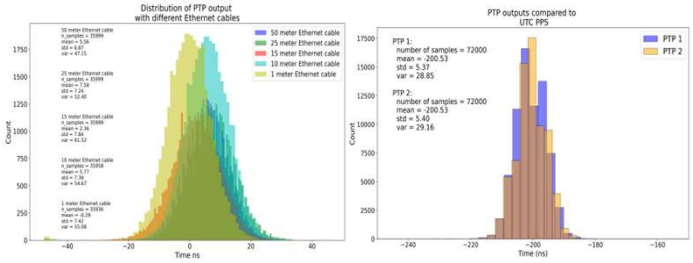


Figure 3. Negligible Effect of changing length of one ethernet cable (left). A common systematic offset was observed when the pulse trains generated by the i210 cards were compared to the "gold standard" PPS (Pulse Per Second) output from the White Rabbit switch (trigger)

## Worse results with certain TSN switch added

Surprisingly, by adding a certain COTS TSN ethernet switch between one PC and the Master Clock, the performance was degraded to the 10 µs level. (Figure 4)

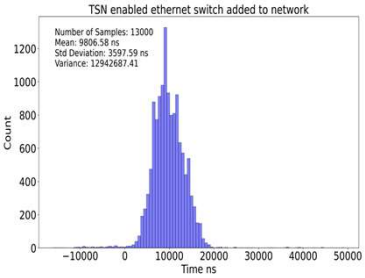


Figure 4. Time difference of pulse from the PCs when one PC (i210 card) is connected via switch

## Conclusion

- **PTP can be used for microsecond-level clock synchronization and signal generation in wired ethernet**
- **Attaining sub-microsecond or nanosecond level requires selection and testing of network components**
- **Bad selection of components and settings may result in over 10 µs deviations**

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