Methodology to Compare Time Stamping Accuracy

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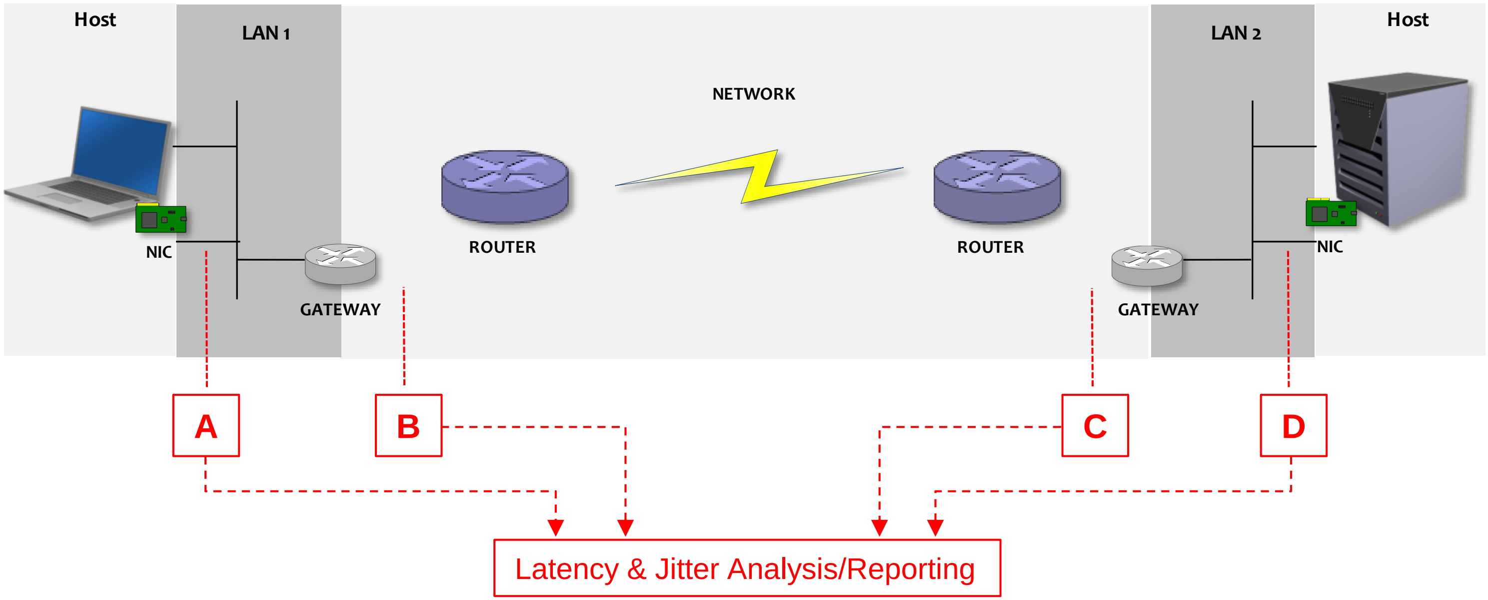
Context & Scope of This Short Document

- Context: hardware time stamping to enable latency measurement, analysis, and reporting
- Scope: describe simple experiments that can be conducted in any customer lab to compare accuracy/precision of the time stamping feature of different solutions

Monitor Latency/Jitter with HW Probes

- The solution: independent HW measurement



- Eliminate stochastic variability of queues, SPAN ports, and SW

One-Way Measurement Base Architecture

- Measurement is only as accurate as the weakest link
  - Must have clock reference, distribution, synchronization

Presentation Layer

Analytics Engine

Time-Stamped Packets (Events)

Synchronized Devices

Clock Distribution Protocol

Communication Media

Global Clock Reference

Local Clock Source

Reference Result

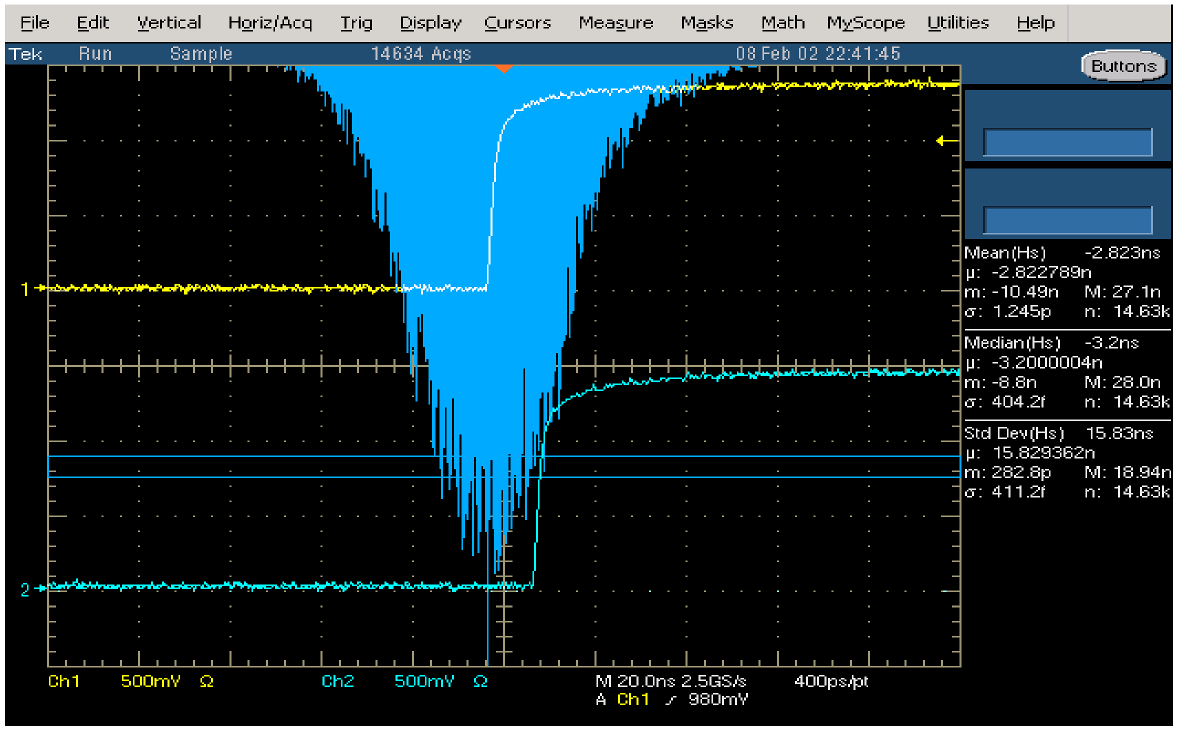
- Purpose: determine a bound on the accuracy that can be achieved by using GPS (or other) master clocks
  - Note that in addition to the inherent inaccuracy of the GPS themselves, additional inaccuracy will be introduced by the clock synchronization media and clock distribution protocols

- Setup: two independent GPS receivers at the same physical location with PPS (Pulse Per Second) output

- Methodology: compare the variability between the PPS outputs of both GPS devices by using an oscilloscope

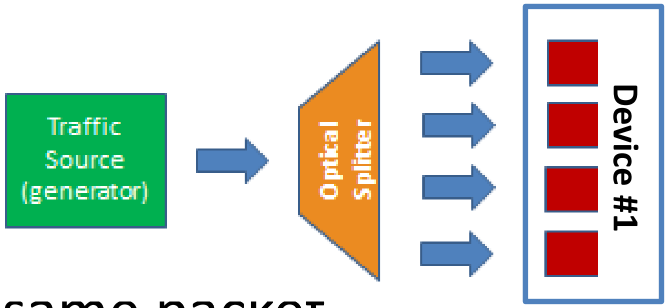
Commercial GPS Clocks are not Perfect

Oscilloscope Screen Capture



- Histogram of PPS discrepancy between two specific devices under test: Avg = -2.8 ns, Median = -3.2 ns, **Std = 15.83 ns**
- Implies that the variability at the 99 percentile (+/- 3 x Std) cause about 100 nanoseconds of uncertainty

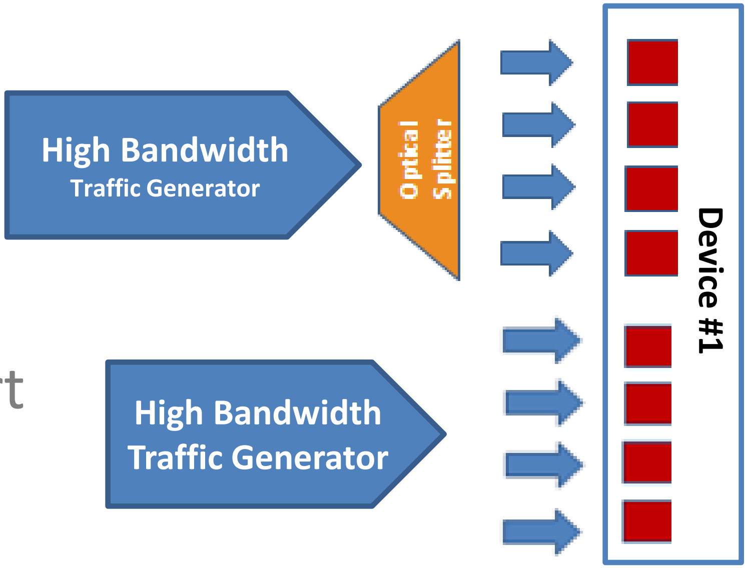
Validation of Consistency Between Time Stamps of the Same Event at Different Ports of Same Device



- Use any traffic source (e.g. laptop, or server or tester) to generate traffic
- Use a passive optical splitter to create multiple copies (e.g. two or four) of the same packet
  - Since the optical splitter is passive, it introduces minimal variability and the packets should arrive at the time stamping ports at ~about the same time
- Create separate time stamped pcap files for each receiving port (the example above shows 4 time stamping ports)
- Compare the hardware time stamp that is attached to each duplicate of each test packet
- Expected result: variations between the time stamp of the multiple instances should be smaller than the stated accuracy of the device under test

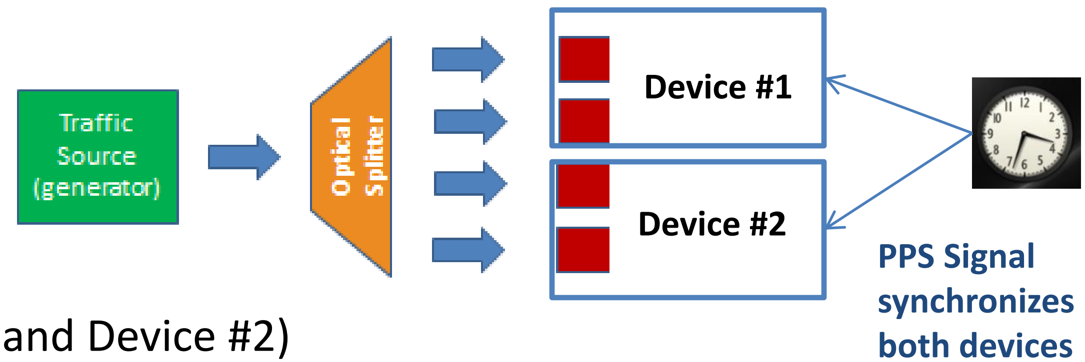
Validation of Accuracy/Precision for Substantial Traffic Load on the Ports of the Device Under Test

- Purpose is to confirm that the traffic load on the device does not impact time stamping accuracy
- Load the device under test with additional high bandwidth traffic (min size packets, IMIX, etc.)
- Create separate time stamped pcap files for each time stamping port (the example shows 4)
- Compare the hardware time stamp that is attached to each duplicate of each test packet
- Expected result: variations between the time stamp of the multiple instances should remain consistent with previous test; the amount, speed, and type of traffic should not impact the time stamping accuracy or precision



Validation of Consistency Between Time Stamps of Same Event at Separate Devices and <u>Synchronization Quality</u>

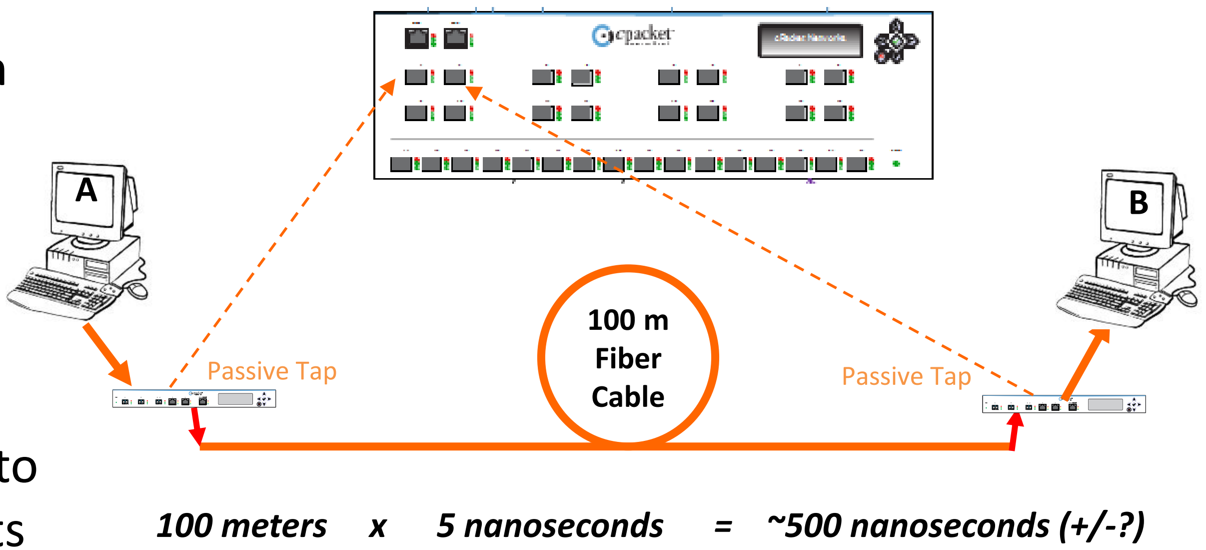
- Repeat the previous test, but use ports on two or more separate devices



  - Both devices (Device #1 and Device #2) should be synchronized over PPS to the same reference (e.g. GPS)
- Create separate time stamped pcap files for each receiving port (the example above shows 4 time stamping ports)
- Compare the hardware time stamp that is attached to each duplicate of each test packet
- Expected result: variations between the time stamp of the multiple instances should be smaller than the stated accuracy of the clock synchronization to external reference

Validation Against a Known Latency Reference for Separate Time-stamping Ports on One Device

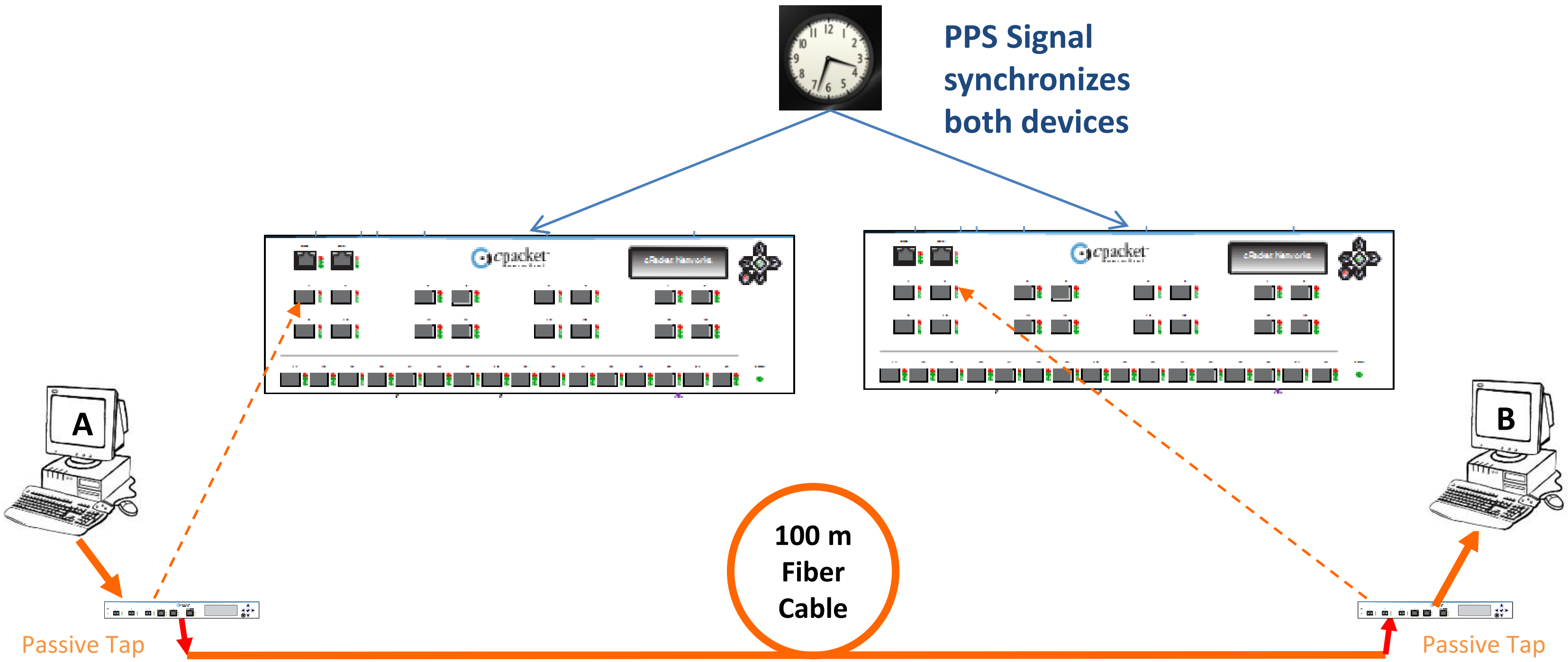
- Connect computers A and B with fiber cable (which allows to ping from A to B)
- Tap the link on both sides of the connection with passive optical taps and use a known cable length (e.g. 100m) between the passive taps
- Connect the tap feeds to the time stamping ports of the Device Under Test



- Create separate time stamped pcap files for each receiving port (the example above shows 4 time stamping ports)
- Expected result: subtract the time stamp on both time stamping ports and verify that it is within the target accuracy bound

Validation Against a <u>Known</u> Latency Reference for Two Clock-Synchronized Devices

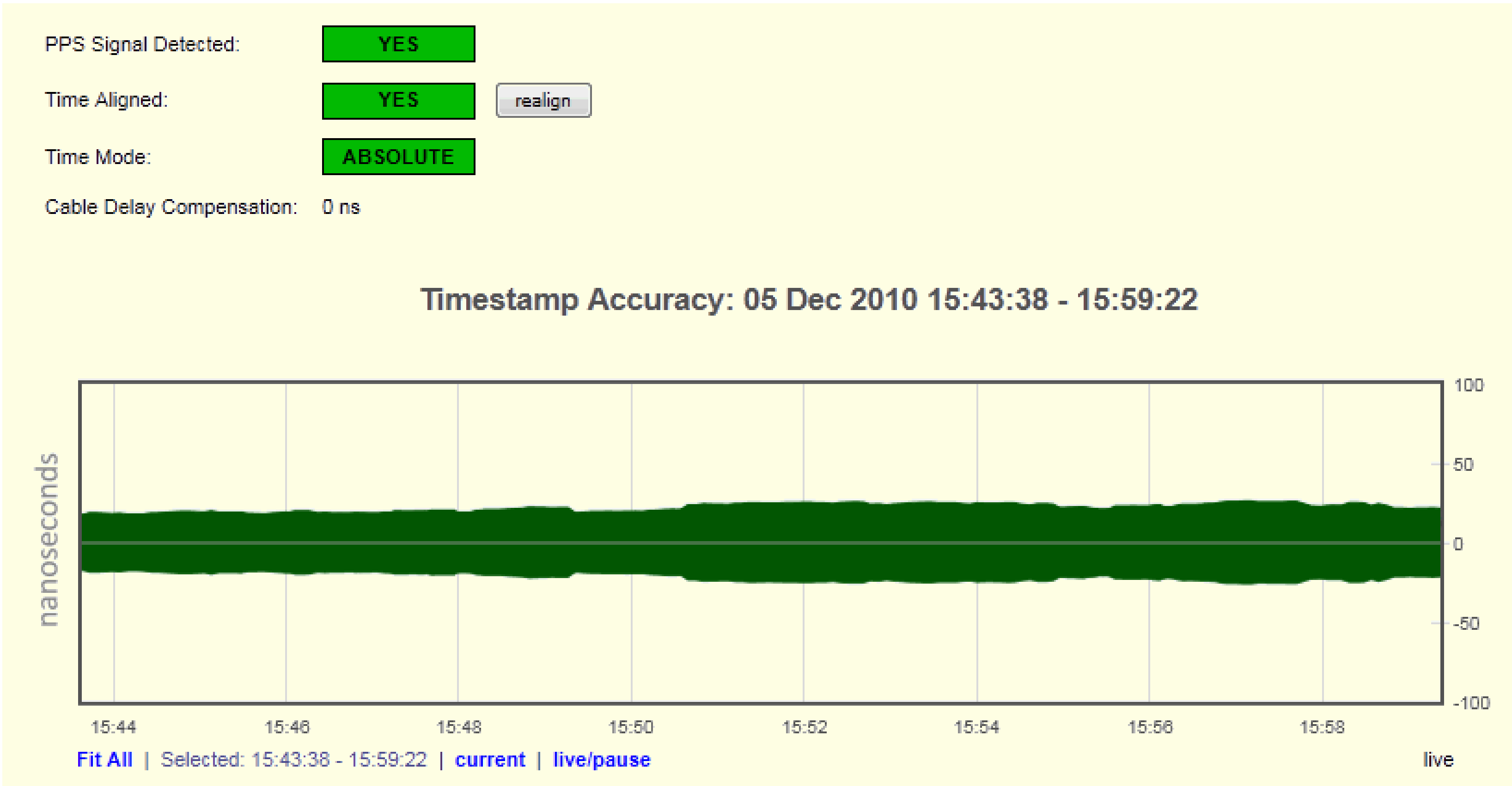
- Extend the setup of the previous test to two devices as described in the following diagram



100 meters x 5 nanoseconds = ~500 nanoseconds (+/-?)

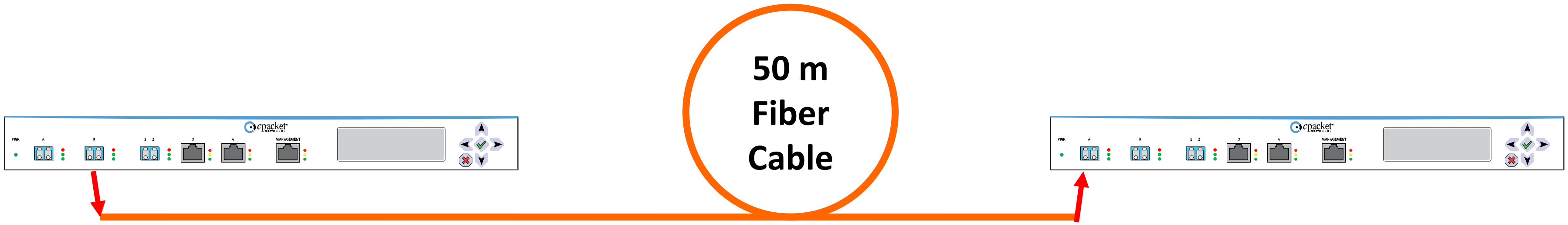
Additional Notes

Note: cVu320G-PT provides Accuracy Reporting On-the-Fly in Real Time



Validation Against a Known Reference

- Validate the time stamping coherency by measure the one-way latency through a known reference (benchmark)
- Propagation delay in fiber cable is about 5 nanoseconds per meter (at ~70% of the speed of light))
- Therefore the expected result is known a-priori



50 meters x 5 nanoseconds = ~250 nanoseconds