Methodology to Compare Time Stamping Accuracy

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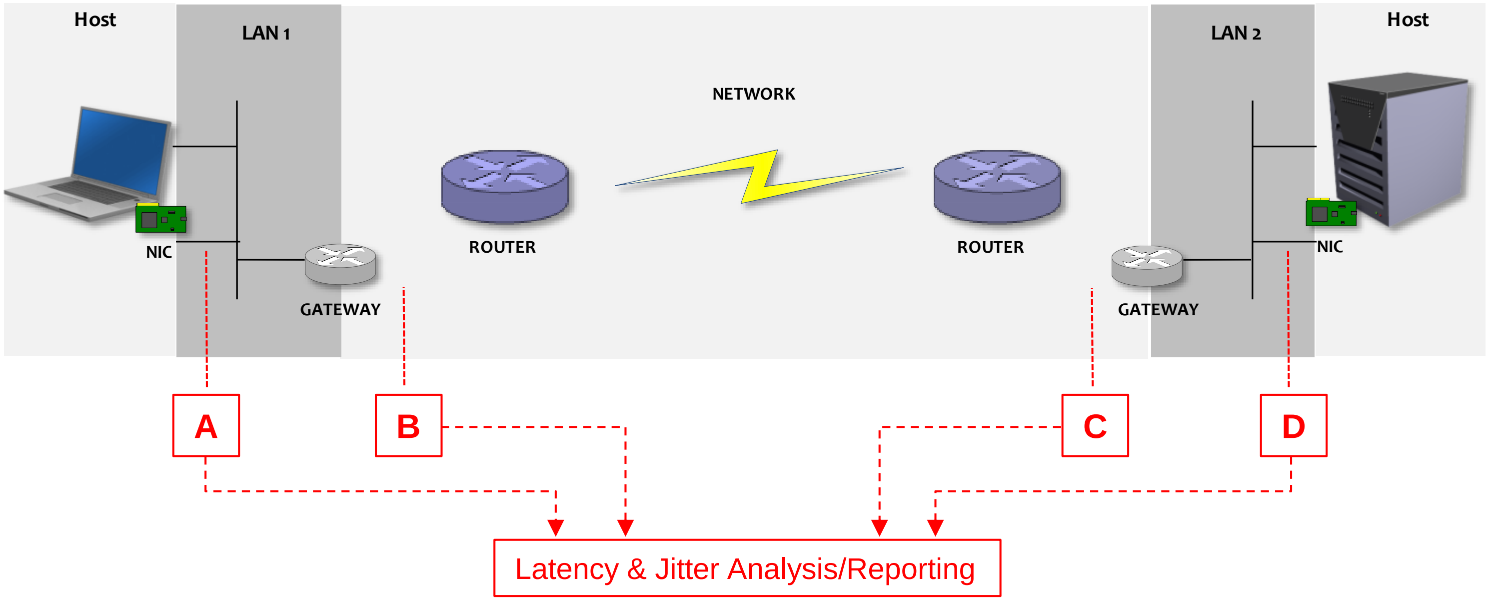
Context & Scope of This Short Document

- 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

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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

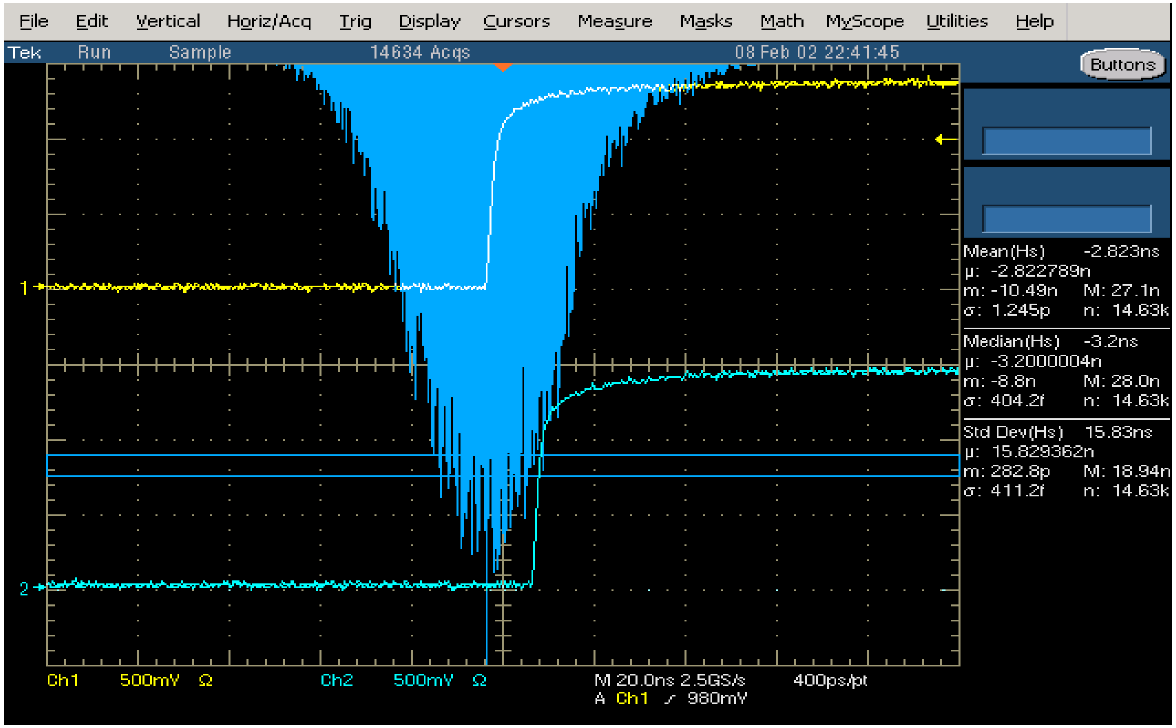
Local Clock Source

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

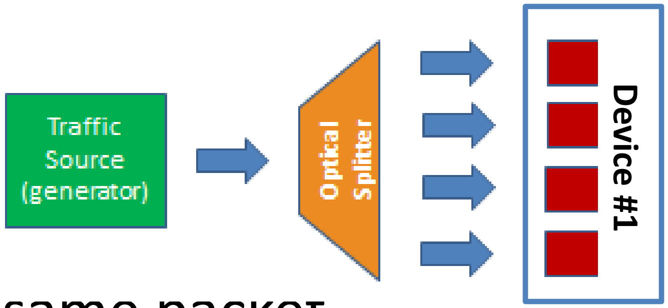
Commercial GPS Clocks are not Perfect

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

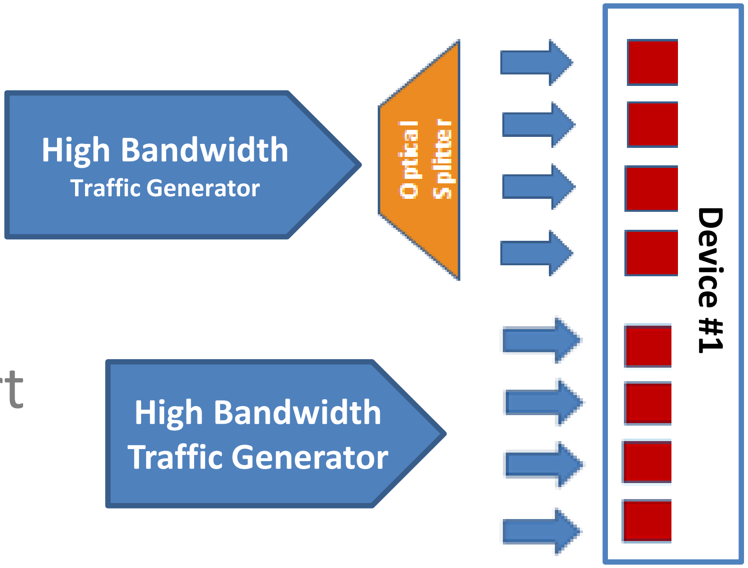
Validation of Consistency Between Time Stamps of the Same Event at Different Ports of Same Device



- 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

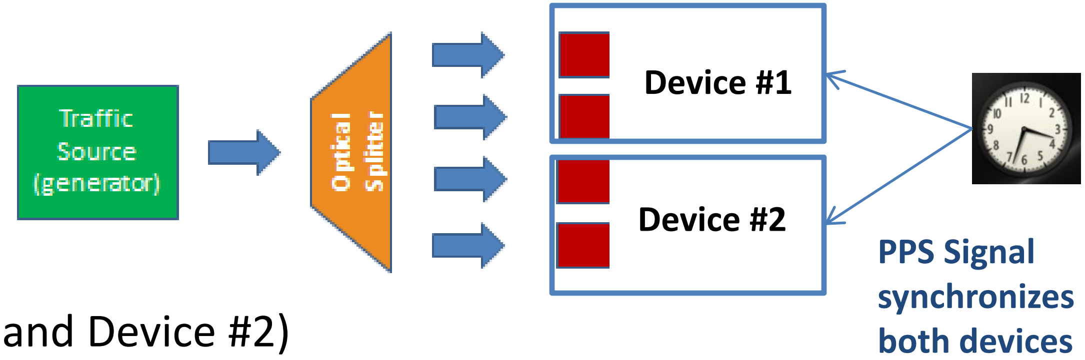
Validation of Accuracy/Precision for Substantial Traffic Load on the Ports of the Device Under Test

- 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 Synchronization Quality

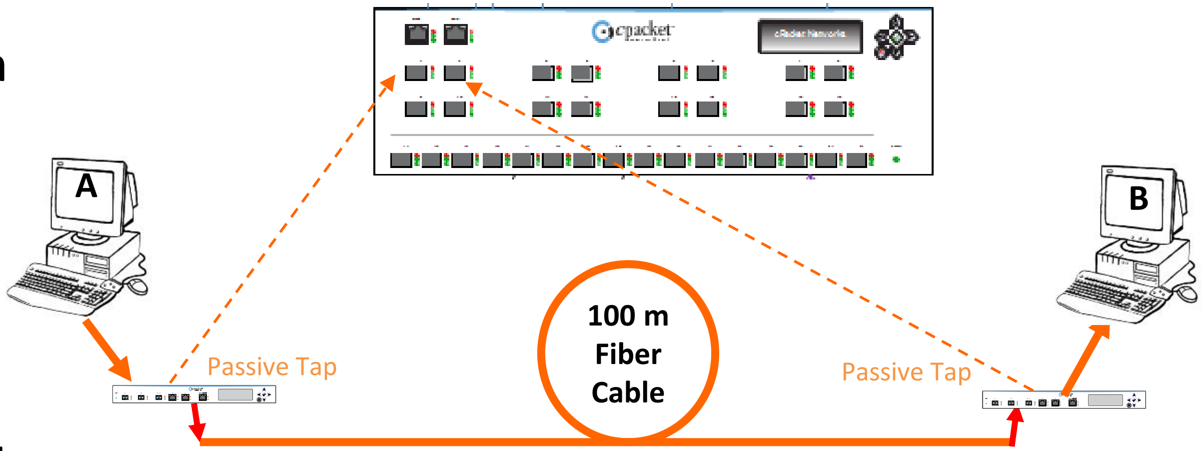
- Repeat the previous test, but use ports on two or more separate devices
  - Both devices (Device #1 and Device #2) should be synchronized over PPS to the same reference (e.g. GPS)



- 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

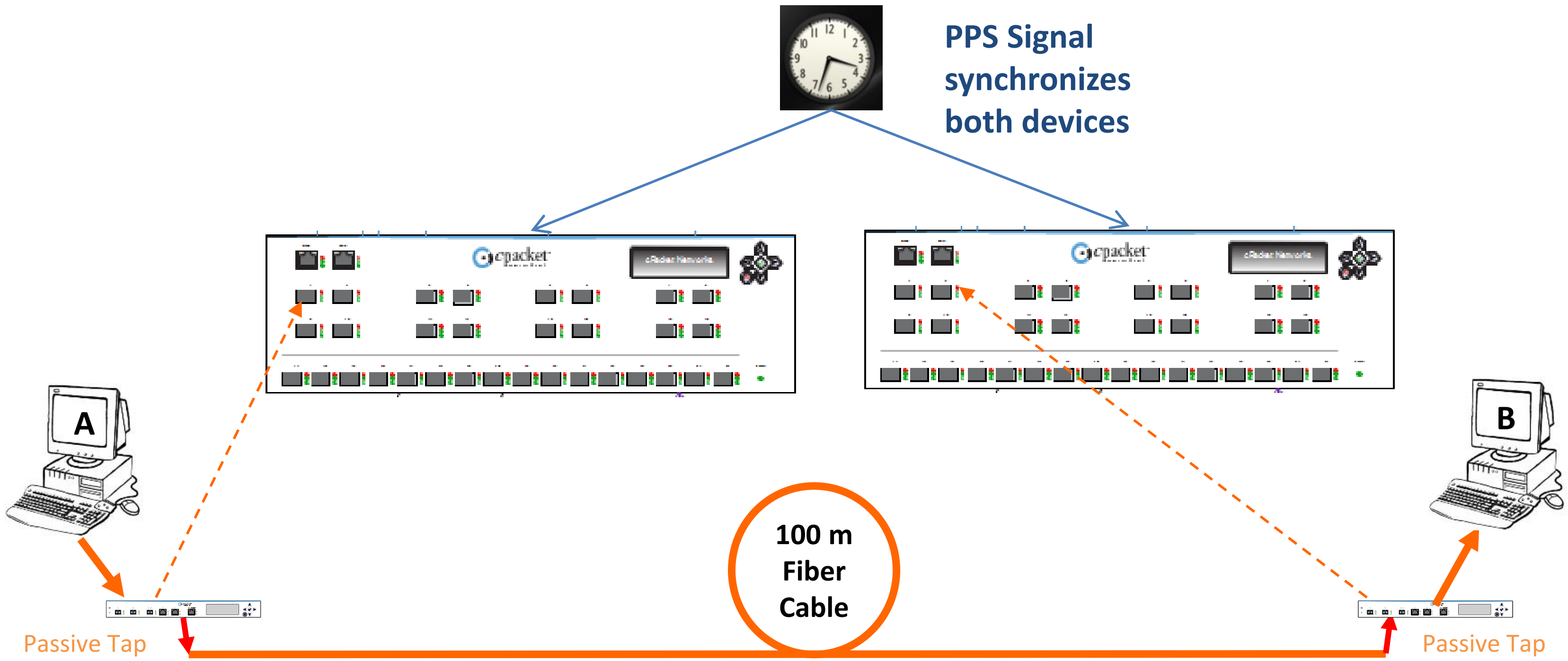


100 meters x 5 nanoseconds = ~500 nanoseconds (+/-?)

- 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 Known Latency Reference for Two Clock-Synchronized Devices

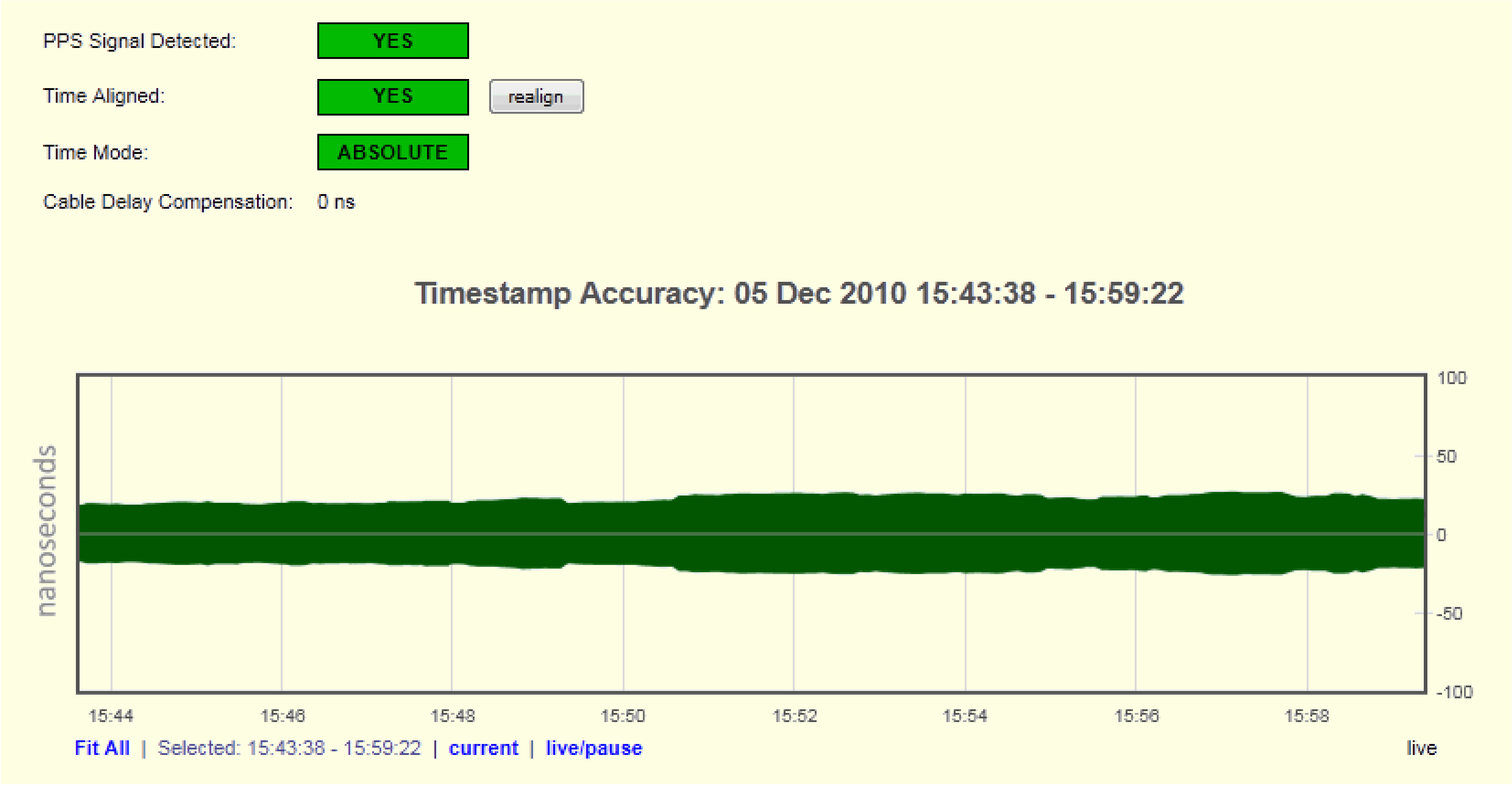
- Extend the setup of the previous test to two devices as described in the following diagram



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

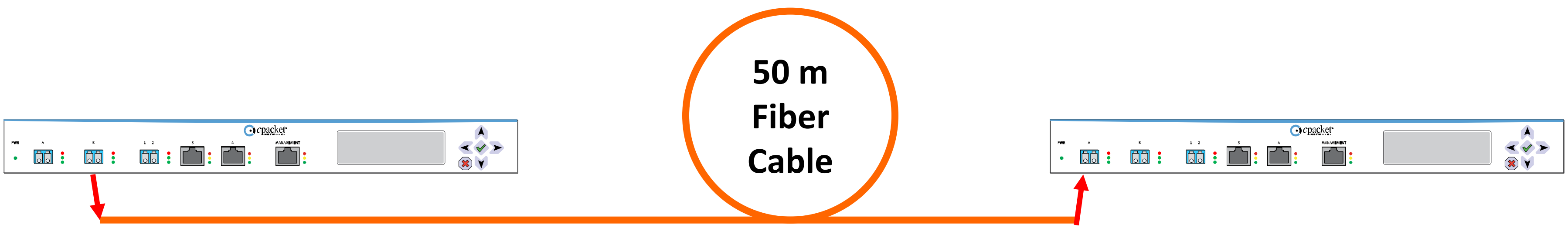
Additional Notes

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