IEEE 1588 PTP over WAN field trial

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Agenda

A field trial of PTP to assess performance in a real-world WAN environment and compare with GPS accuracy.

How PTP works
The field trial
Results
Anomalies
Conclusion
Questions

PTP

IEEE 1588-2008 (PTP) is a protocol for time distribution

- Simple Ethernet/IP transport
- Multiple clients per reference clock

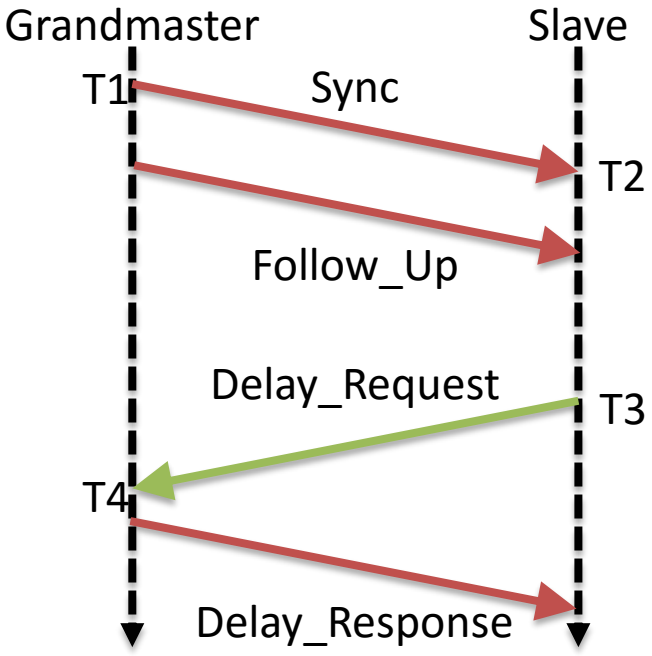
PTP works well in controlled environments

- Dedicated networks
- Transparent switches
- Sub microsecond accuracy

Can PTP deliver in Enterprise WAN environments?

- GPS not always available or practical
- Non-dedicated networks
- Non-transparent switching/routing

How PTP Works



- T2-T1 is Master to Slave Delay
- T4-T3 is Slave to Master Delay
- (T2-T1) + (T4-T3) is RTT
- RTT/2 is One Way Delay or Latency Estimate
- ((T2-T1) - (T4-T3))/2 is Offset from Master Estimate

This **requires** *symmetric* path delay.

Path *asymmetry* **cannot** be distinguished from Slave offset.

Field Trial

Our partner had some sites without GPS availability, but still required accurate timing. They wanted to know if PTP could be used to deliver accurate timing over their existing high performance WAN.

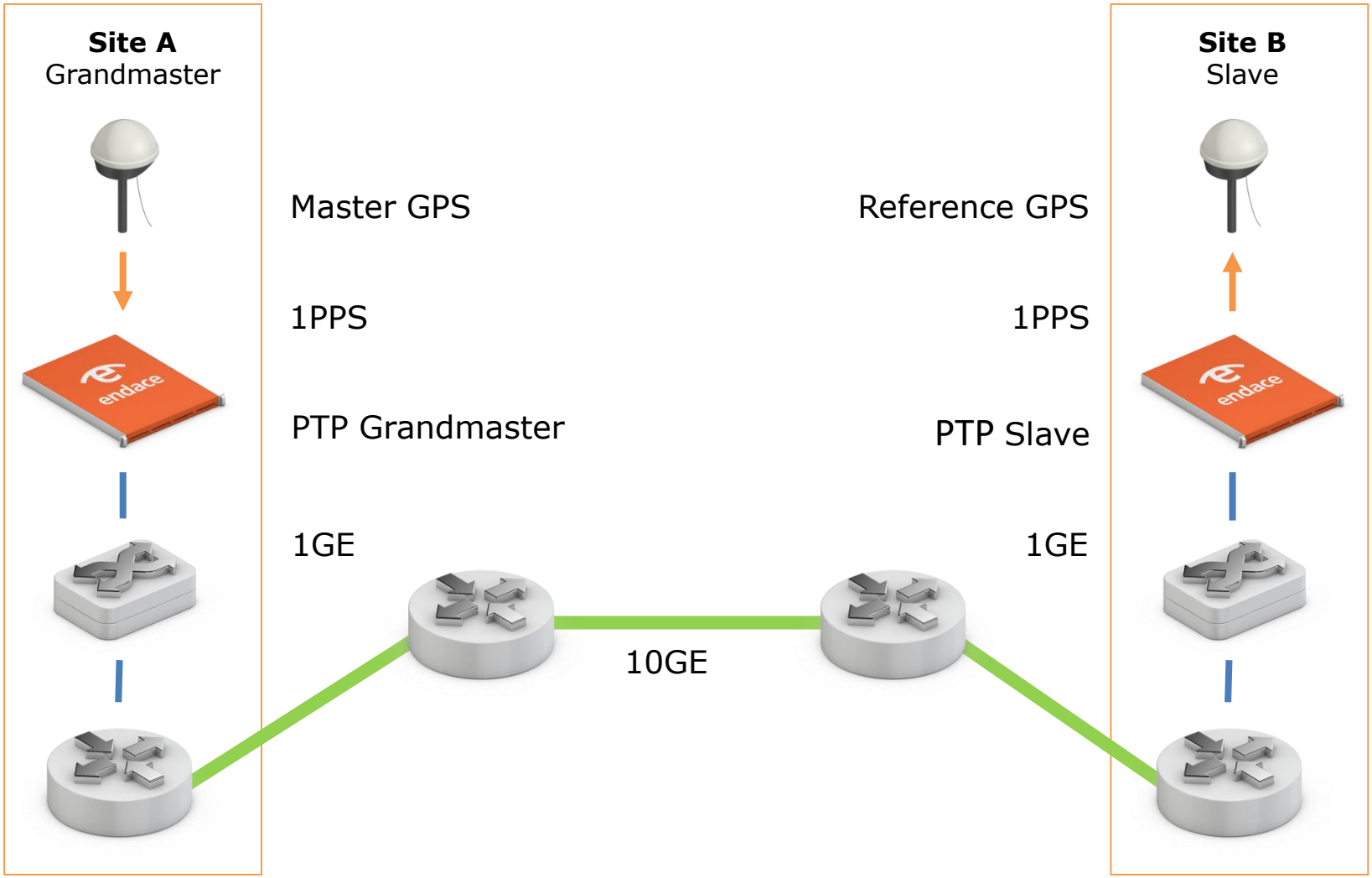
Two sites with existing GPS receivers

- Simulate a non-GPS site with PTP client, but compare to local GPS
- Installed PTP Grandmaster and slave
- Less than 2 miles apart 'as the crow flies'

High performance Enterprise WAN

- 10Gbps Ethernet core
- OSPF routed
- Network path includes 2 switches, 4 routers

Field Trial


Site A
Grandmaster
Site B
Slave
Master GPS
Reference GPS
1PPS
1PPS
PTP Grandmaster
PTP Slave
1GE
1GE
10GE
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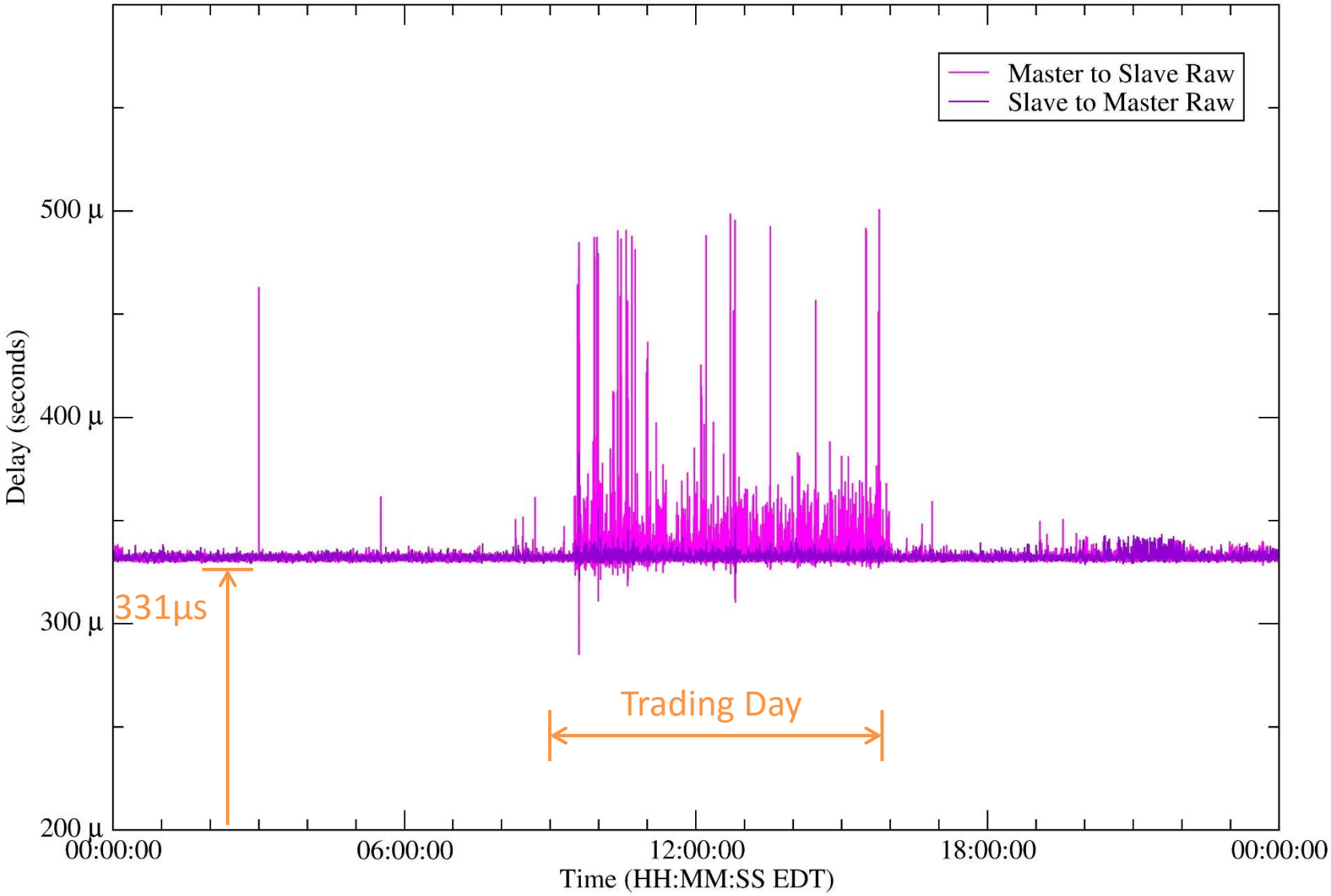
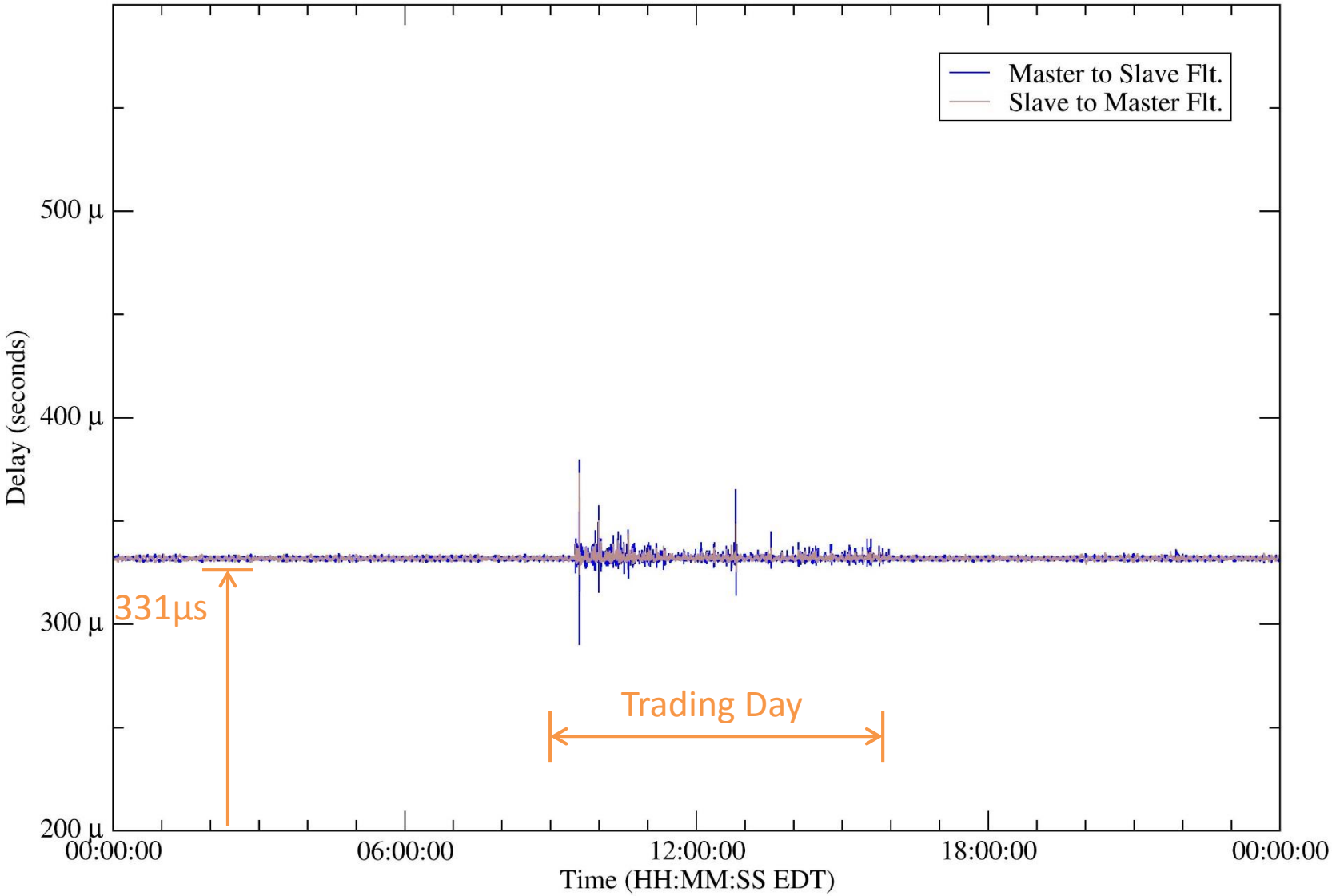
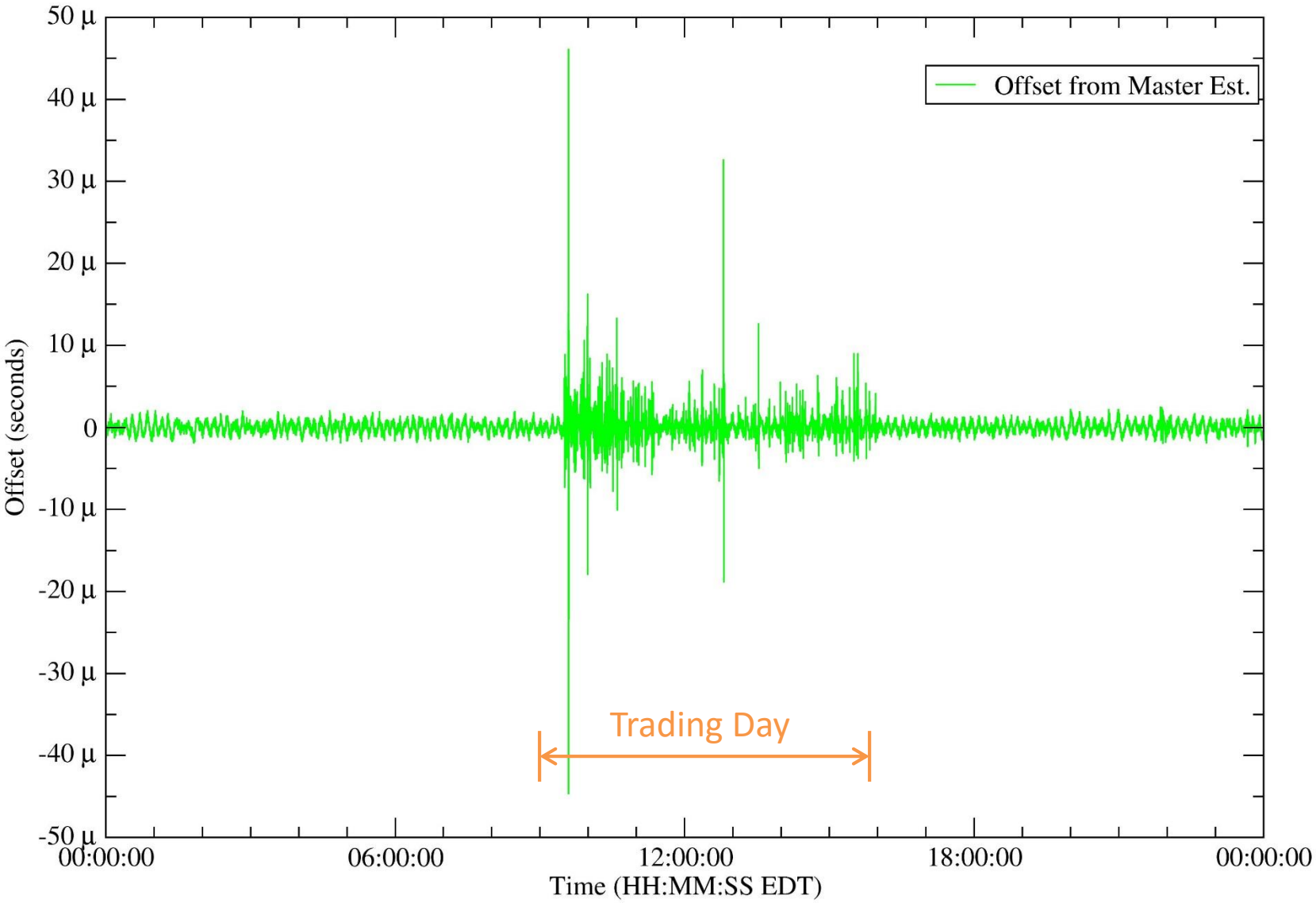
Raw One Way Delay Measurements



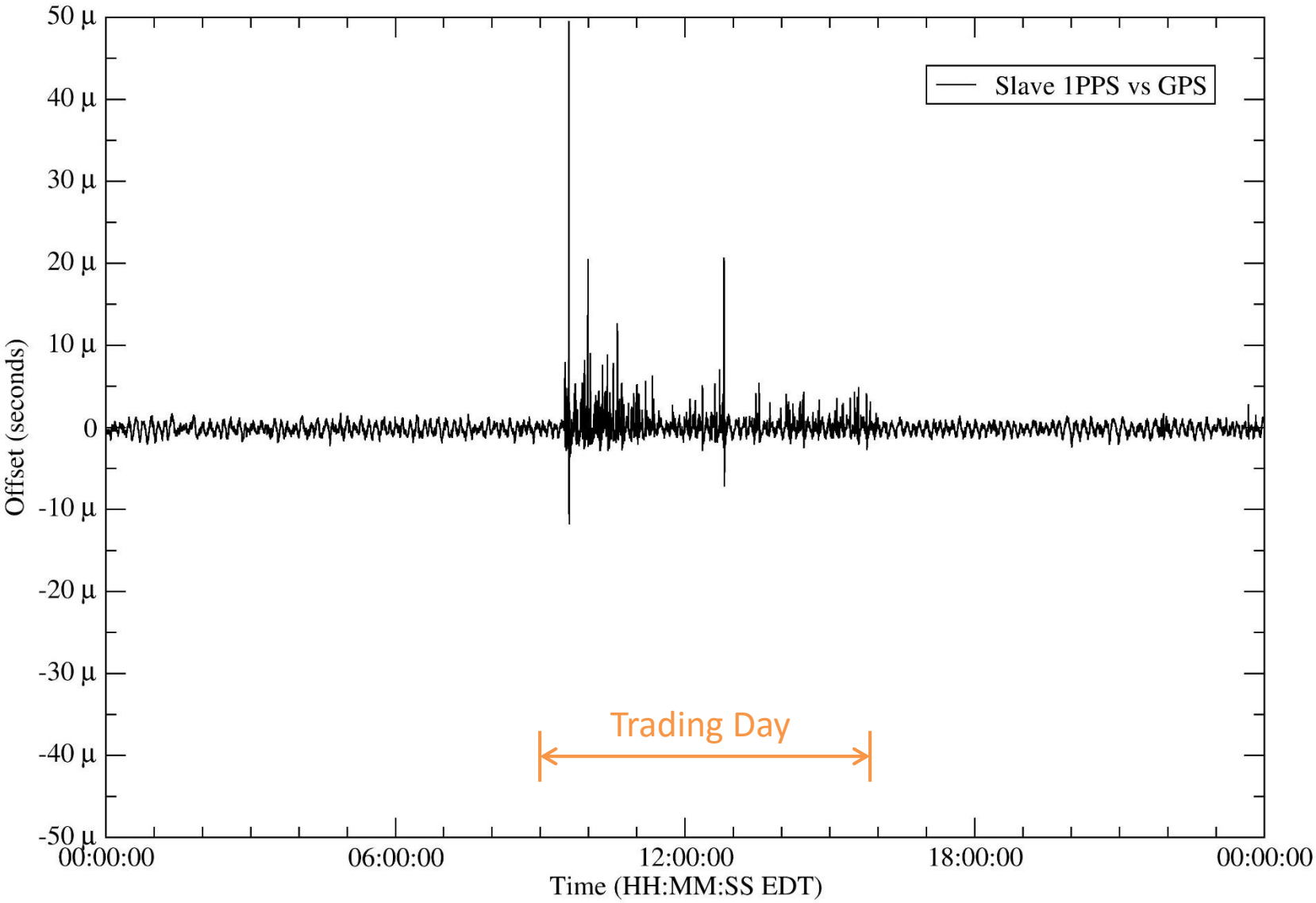
Filtered One Way Delay Measurements



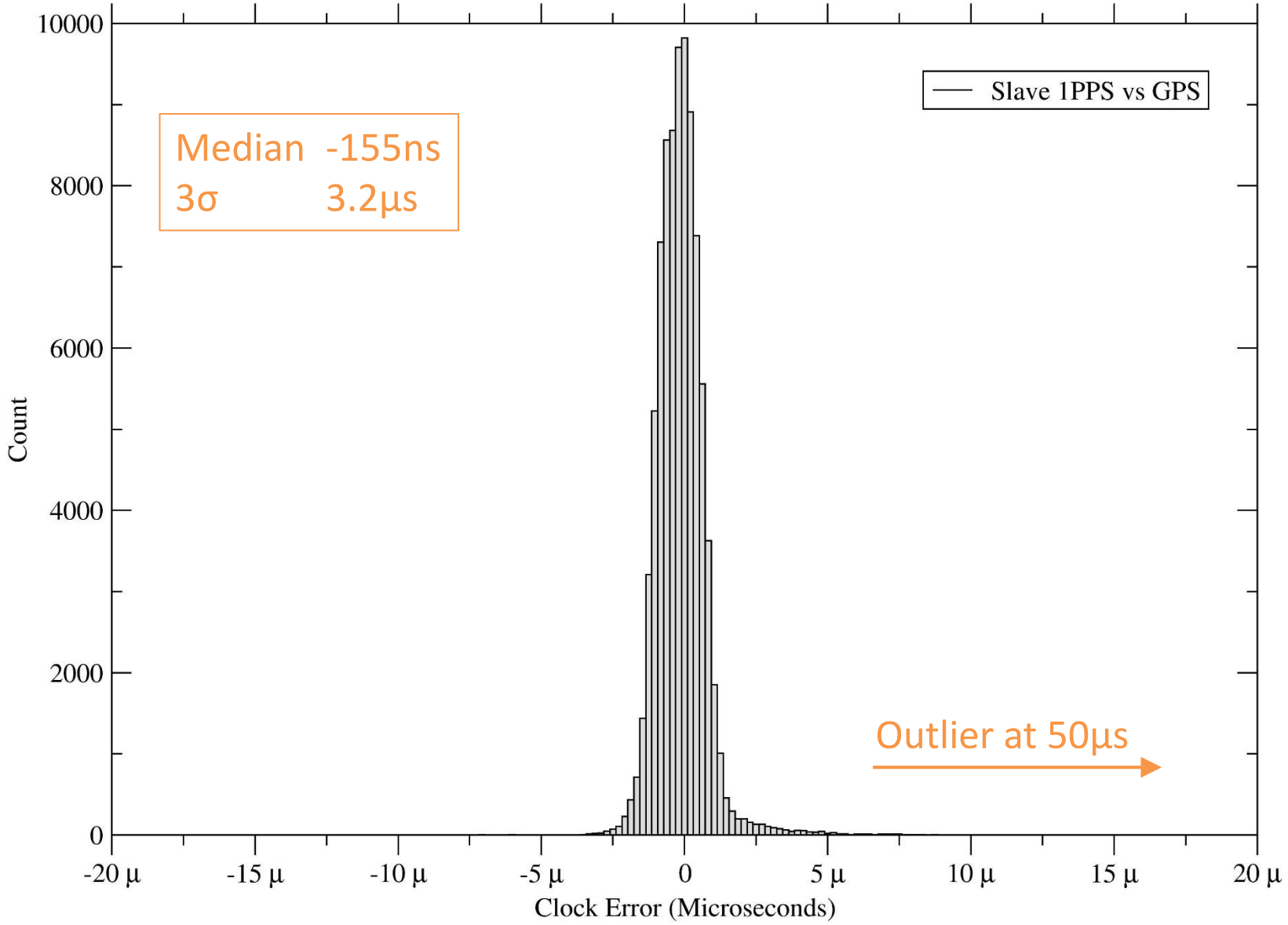
Estimated Offset from Master



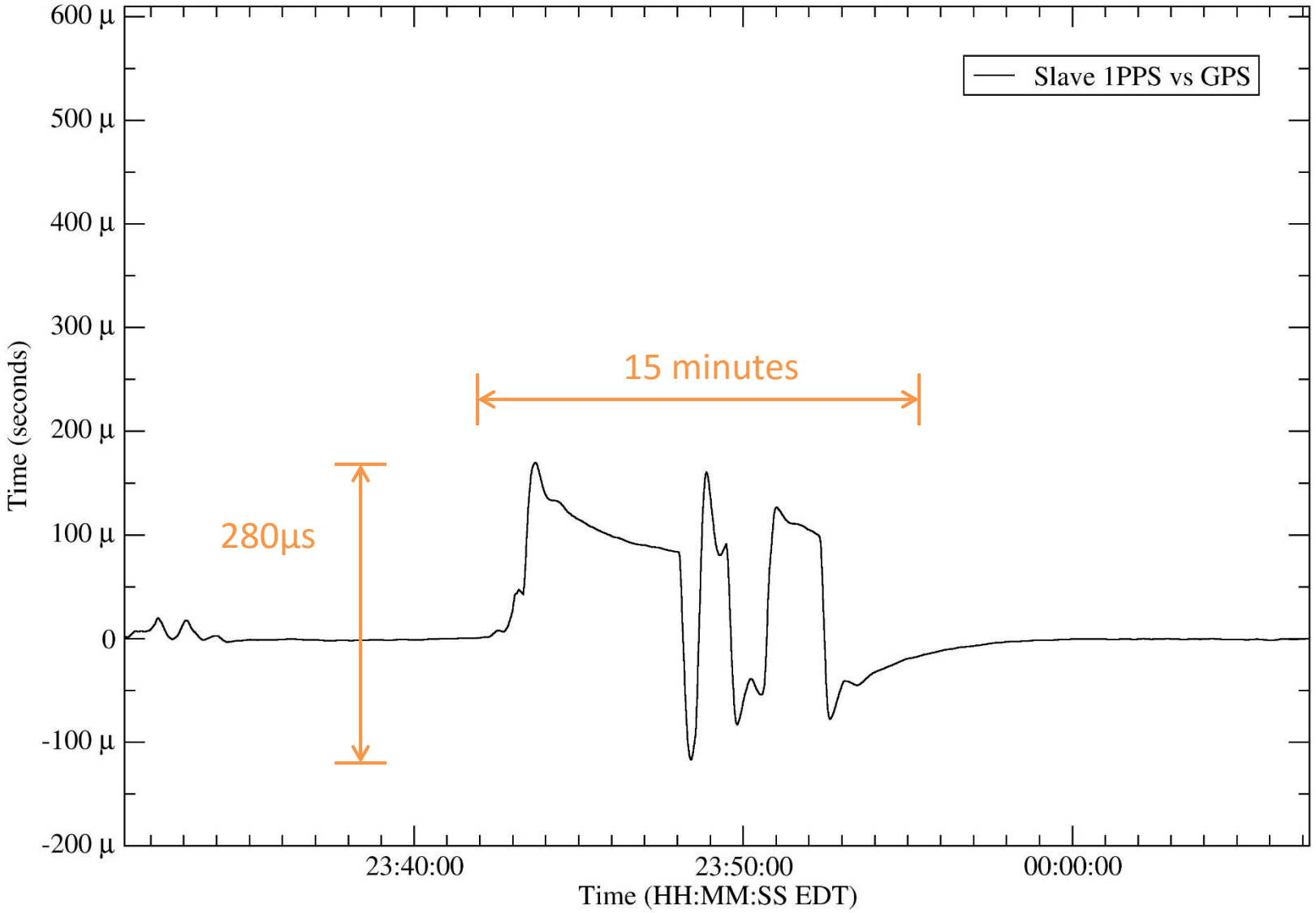
PTP Slave 1PPS vs Reference GPS



PTP Slave 1PPS vs Reference GPS Histogram



Anomaly: PTP Slave 1PPS vs Reference GPS



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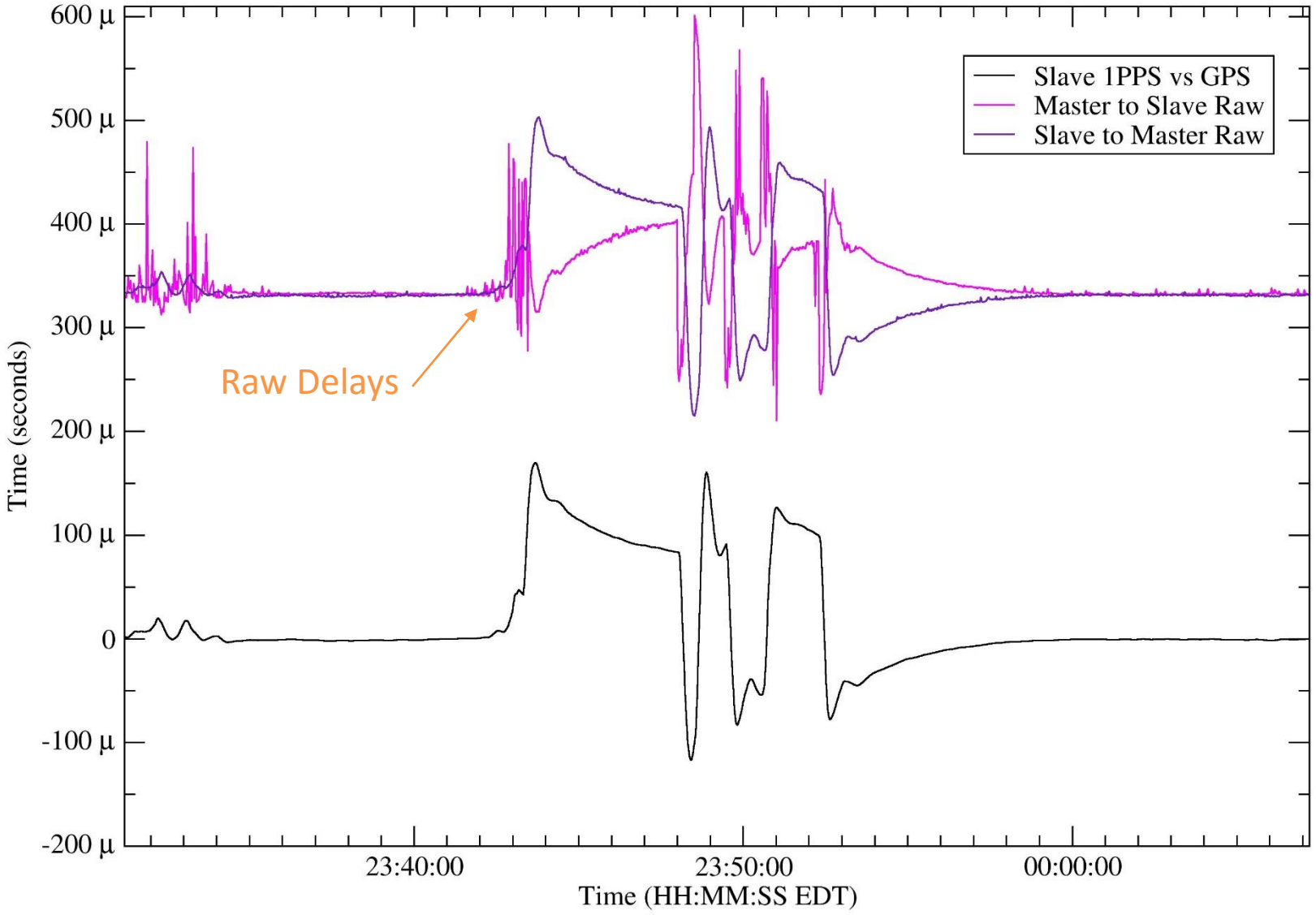

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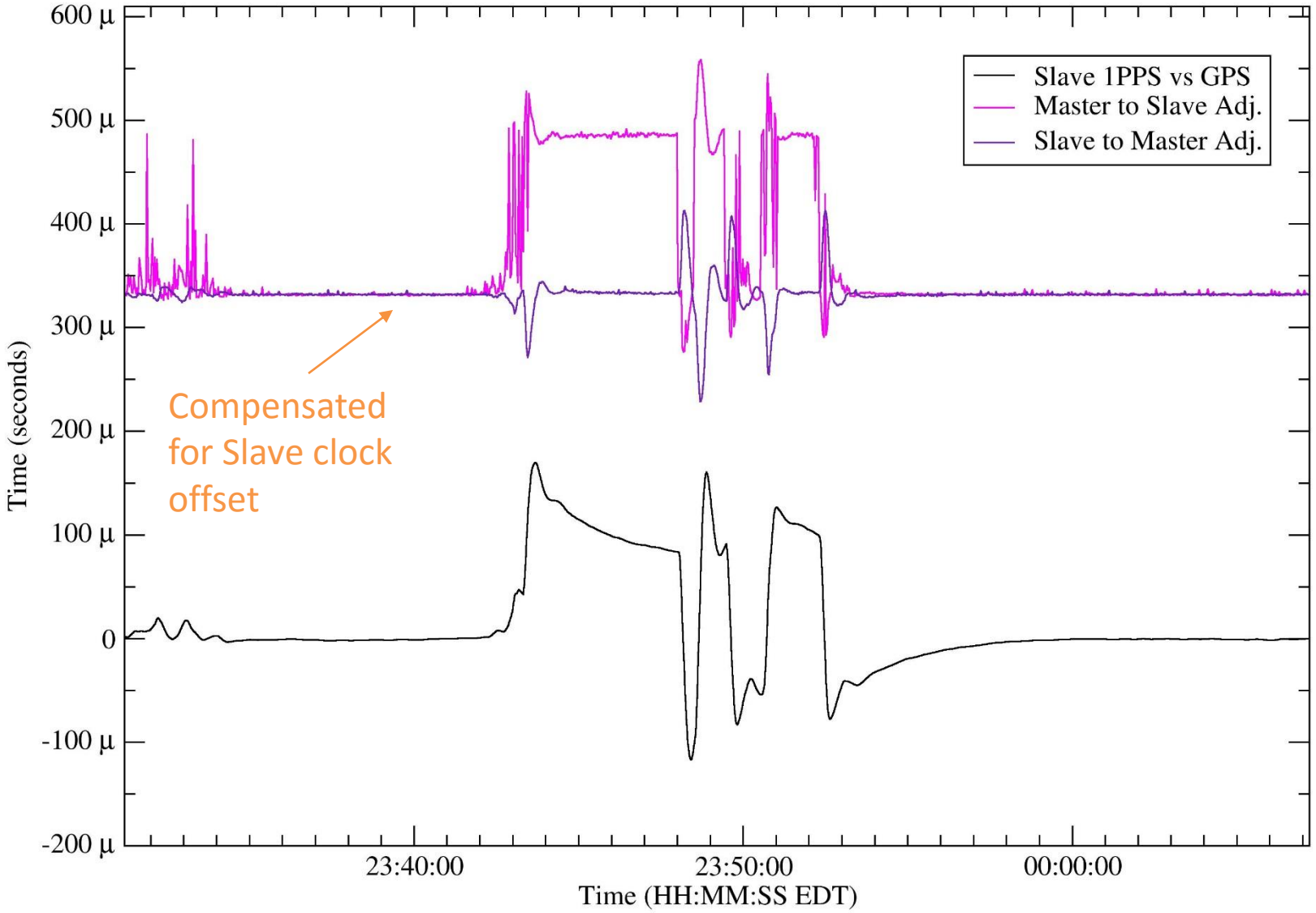

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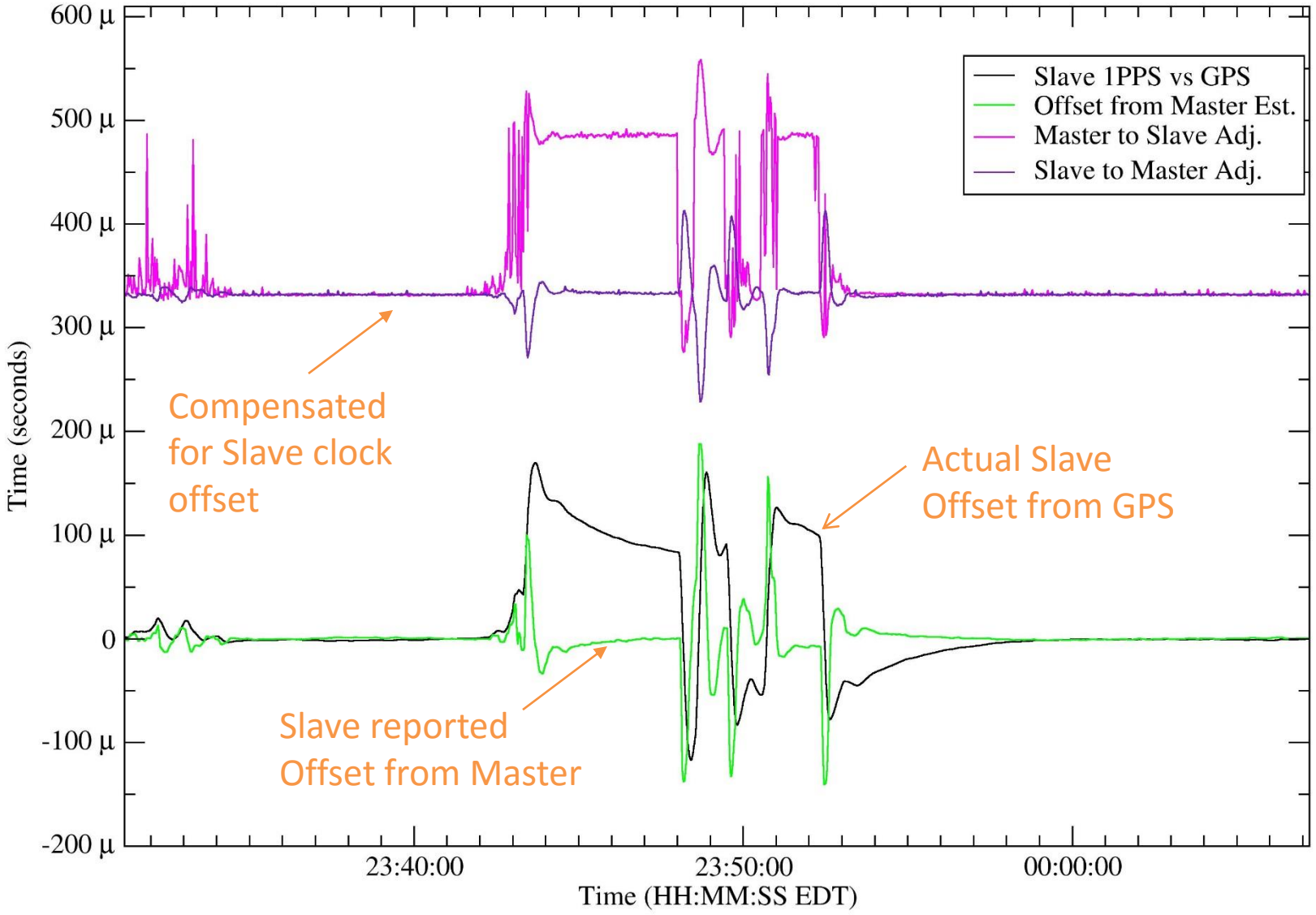
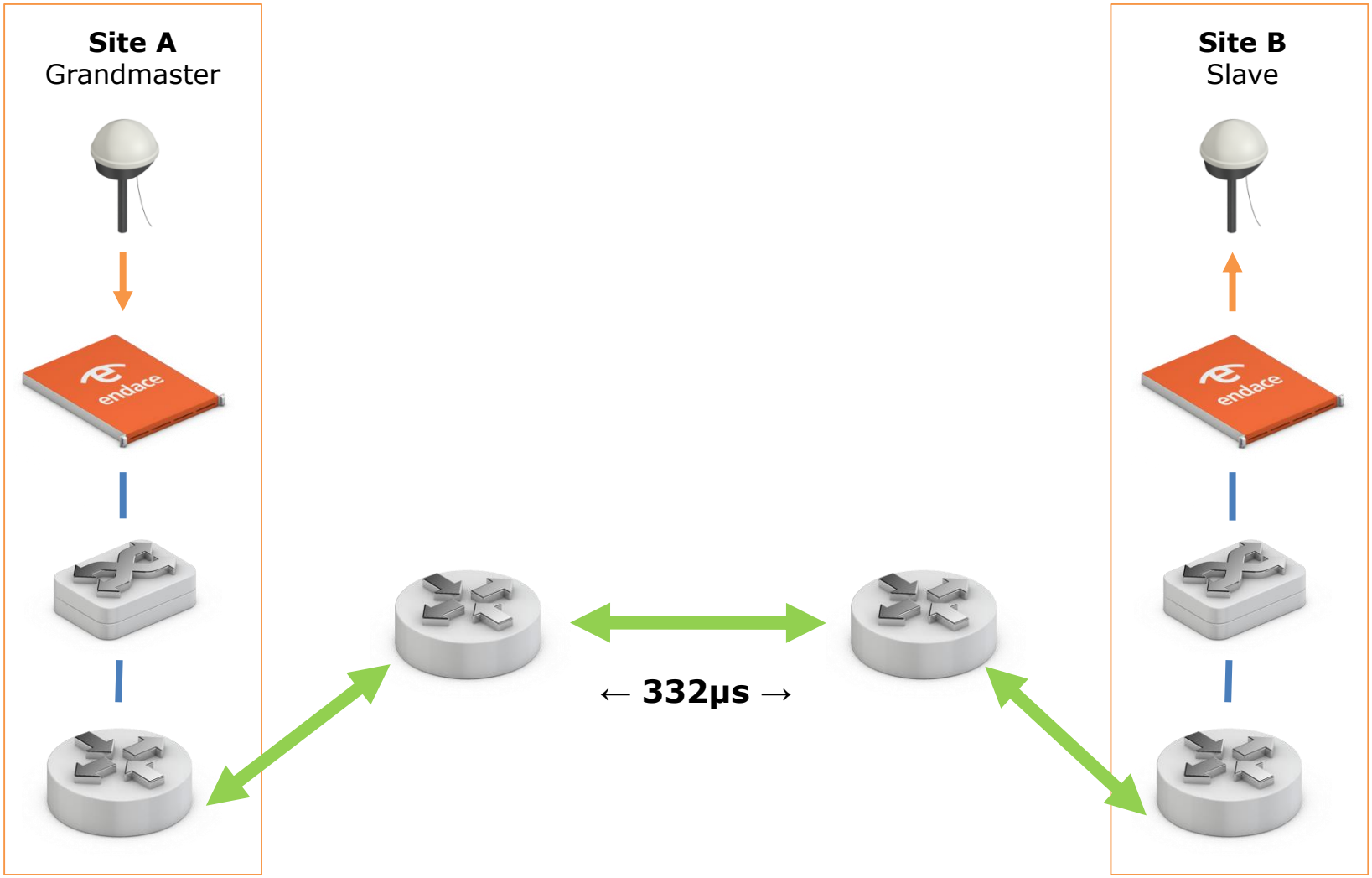


Path Asymmetry: Route Flap



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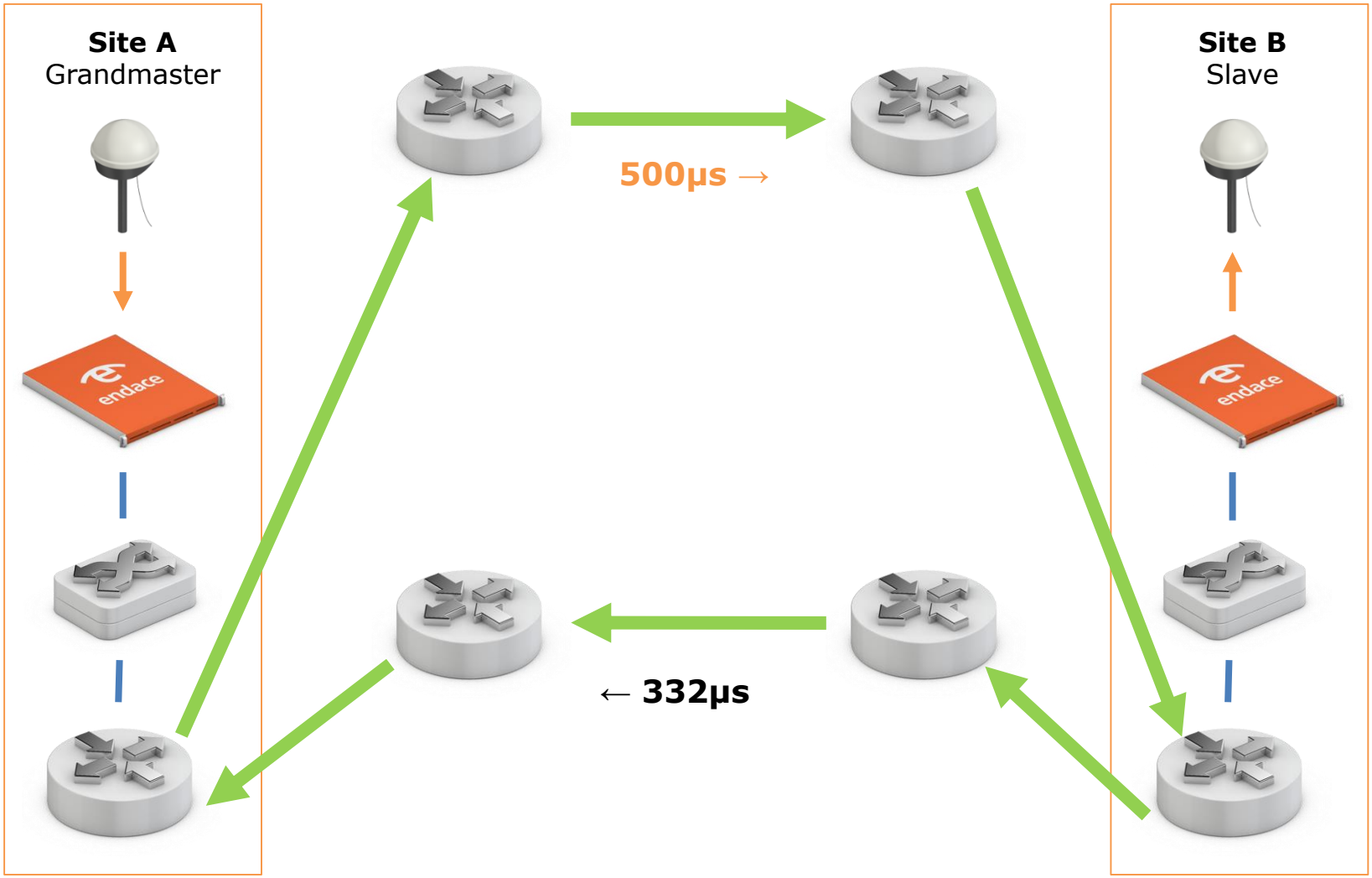
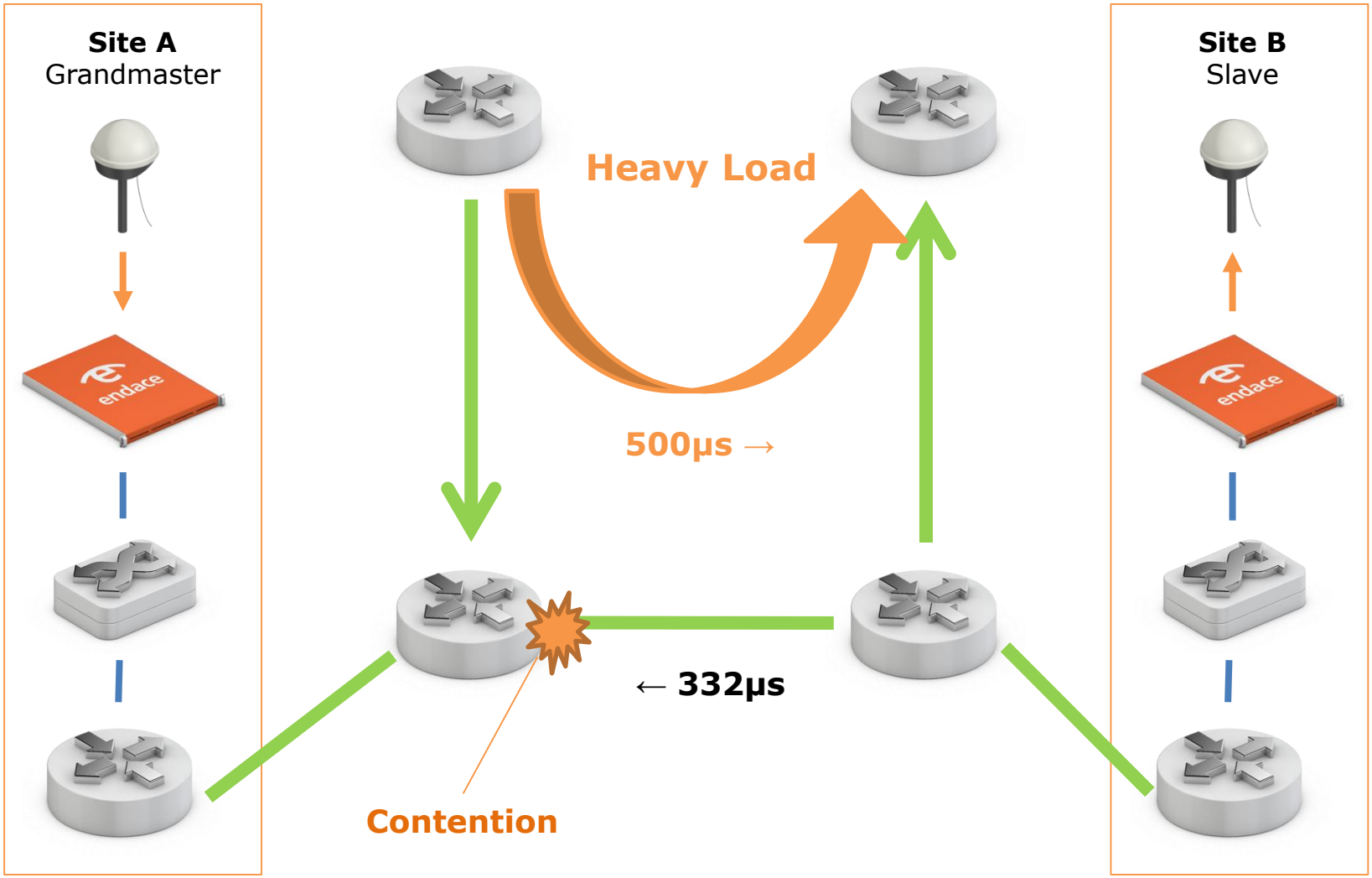


Forwarding Asymmetry: Congestion Queueing



Conclusions

PTP is **inherently sensitive** to asymmetric latency

- *Static* asymmetries must be calibrated out manually, otherwise invisible
- *Dynamic* symmetry changes cannot be calibrated out
- Possible causes include physical path changes or congestion queueing
- Slave *Offset from Master* estimate may be significantly incorrect

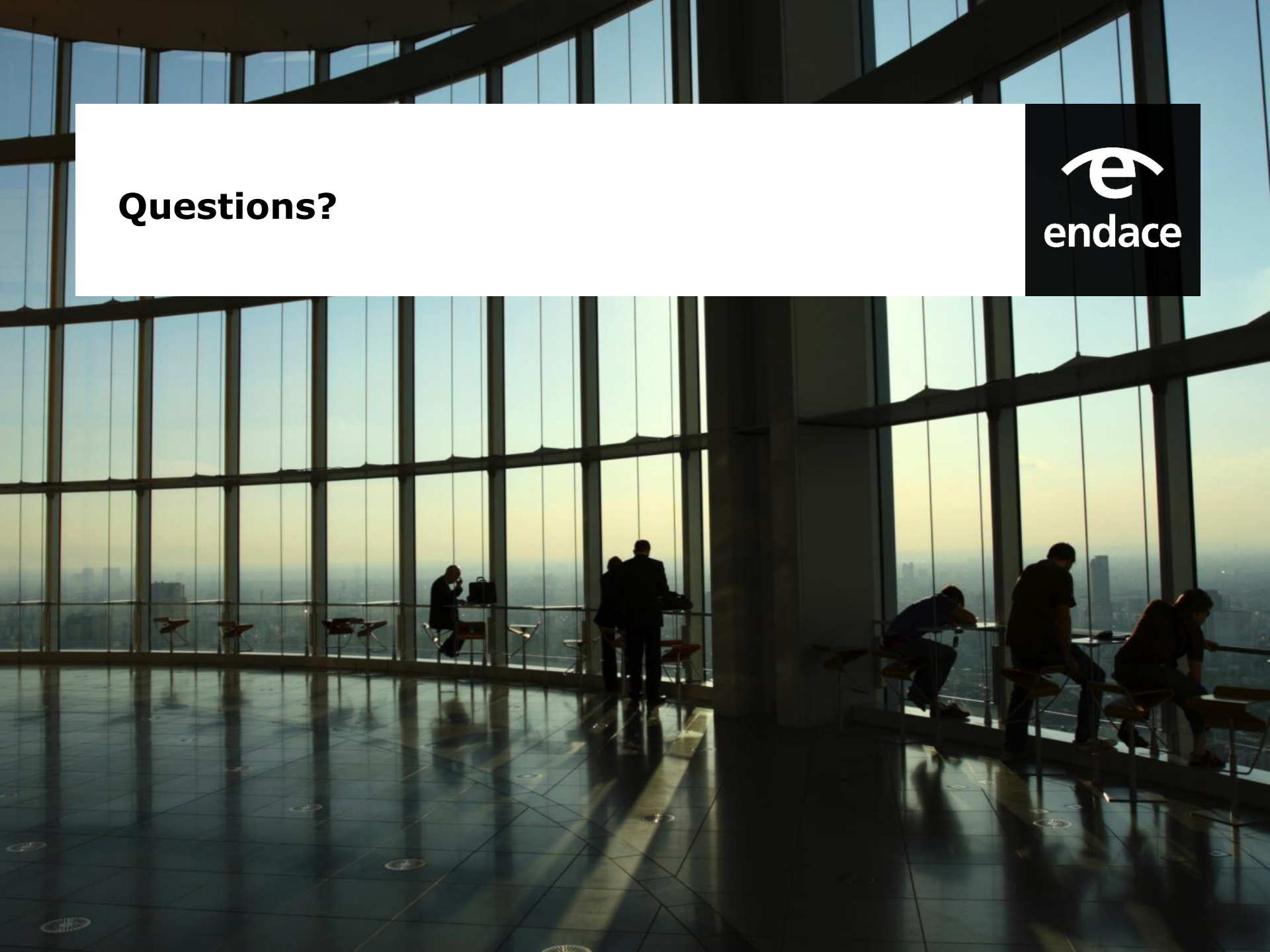
PTP **may be** viable over WAN – depending on requirements

- Measured Clock synchronization within ±3.2µs at 3σ
- Largest outlier over working day was 50µs
- Improvements possible through improved filtering and tuning

PTP is a **potential** solution for sites without GPS

- Simpler and potentially cheaper to provision to a site than GPS

GPS is **still** the gold standard


Questions?
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Opinion

	Best accuracy	Worst accuracy	Deterministic	Audit trail
GPS	~50ns	~100ns	Yes	Yes
PTP (LAN)	< 1 µs	> 10µs	Maybe?	Maybe?
PTP (WAN)	< 10 µs	> 100µs	No	No

Recommendations

Where possible:

- Use PTP transparent equipment
- Use dedicated networks to avoid congestion
- Use priority tagging
- Avoid L3 Routing
- Avoid L1/2 redundancy mechanisms
- Use Traffic Engineering to provision symmetric network paths

Consider:

- Multiple Grandmasters
- Multiple diverse paths
- Dedicated dark fibre