EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Smart Grid Information Sharing Webcast: Synchrophasor Communications Infrastructure

December 17, 2013

Paul Myrda
Technical Executive
PMyrda@epri.com

Scott Sternfeld
Project Manager
SSternfeld@epri.com

Objectives of the Project

- Improve understanding of latency in a synchrophasor based control system
  - Implemented with C37.118 and IEC 61850 GOOSE messaging
  - Multiple vendor equipment/components
  - Three scenarios
    - Unicast
    - Unicast + PDC
    - Multicast
- Apply lessons learned to possible implementations

Why?

- Understand latency contributions by the network, transport protocols, different vendor equipment and system

- Create awareness for approaches and methods that can be used to minimize the latency

→Understand issues affecting deployment of automated and semi-automated closed-loop distributed control systems

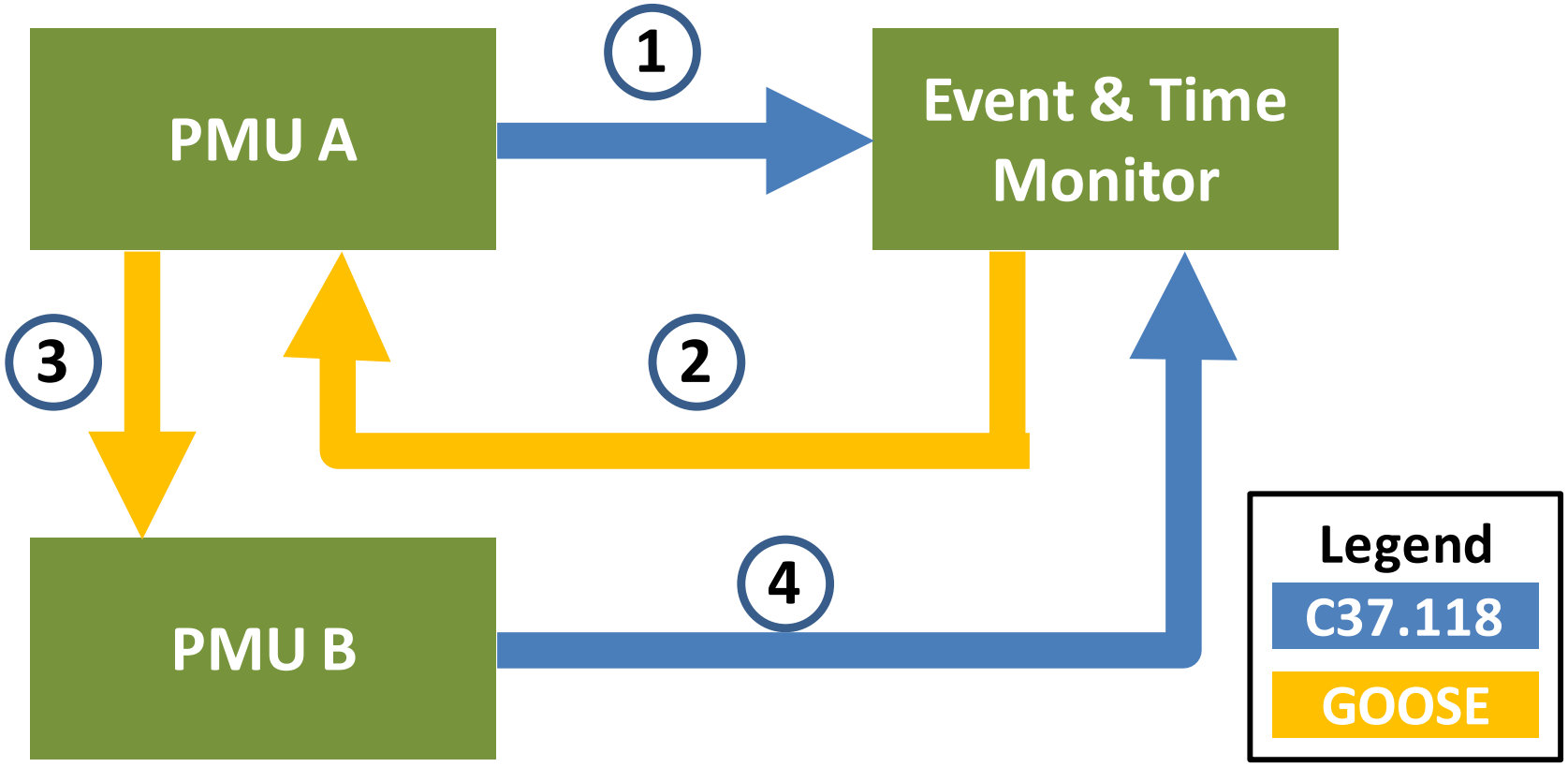
Questions:

- What are current system latency times measured from deployed systems?

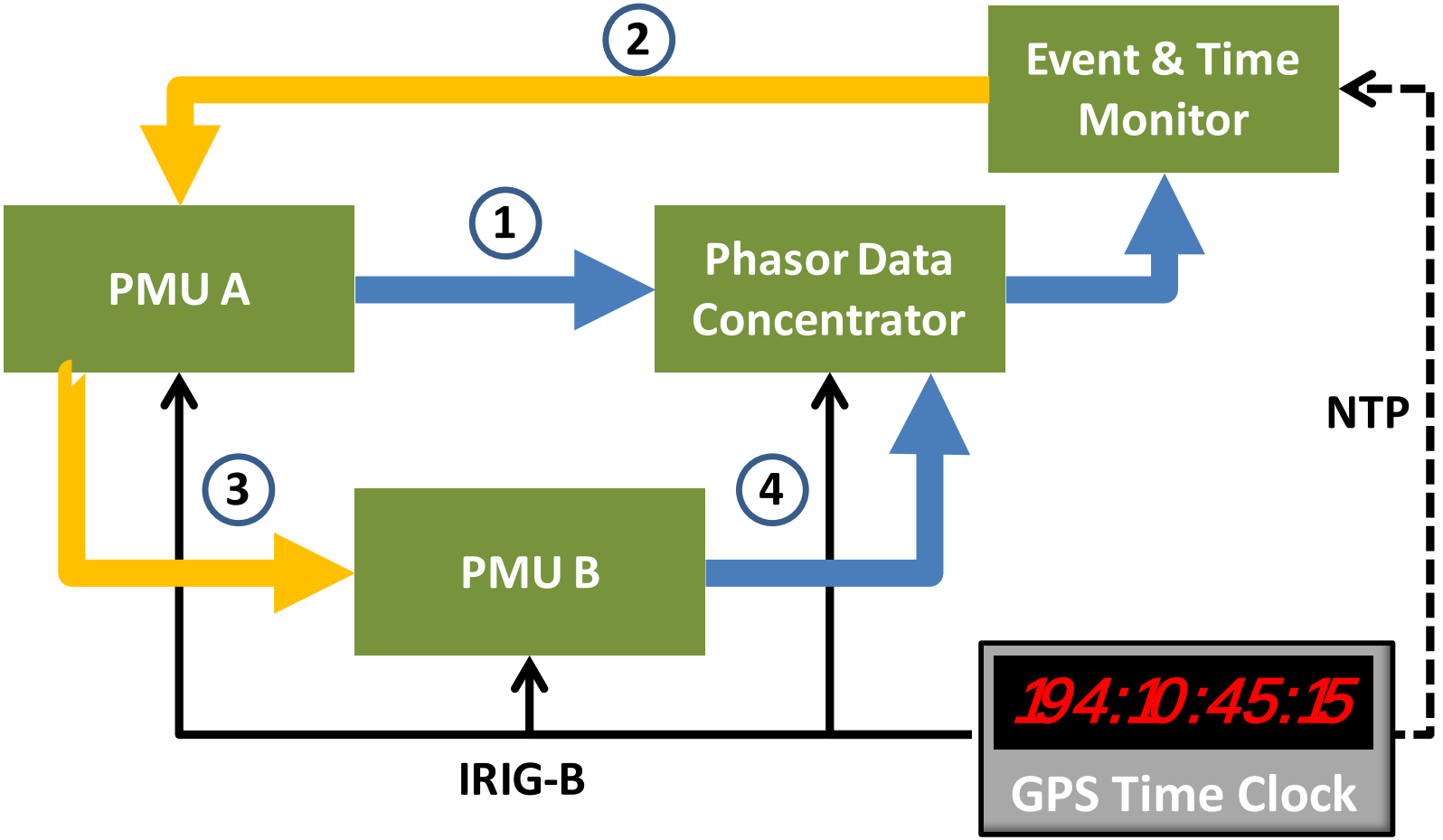
- Sample architecture:
  - Event transmitted by PMU →
  - Through substation PDC →
  - Through utility “centralized” PDC →
  - To ISO application (possibly through an ISO PDC)

- Can optimizations be applied?

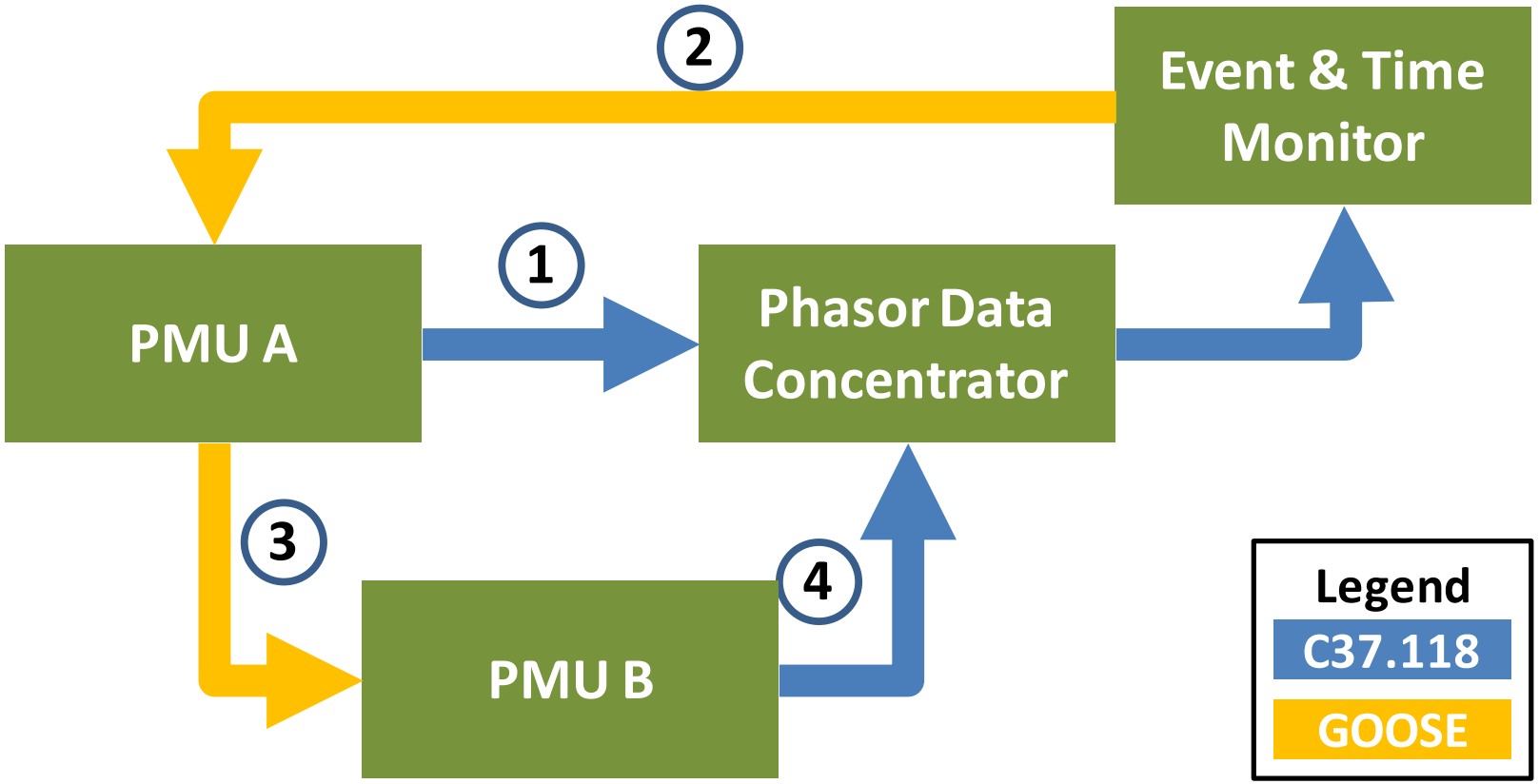
Simplified Control Signal Diagram



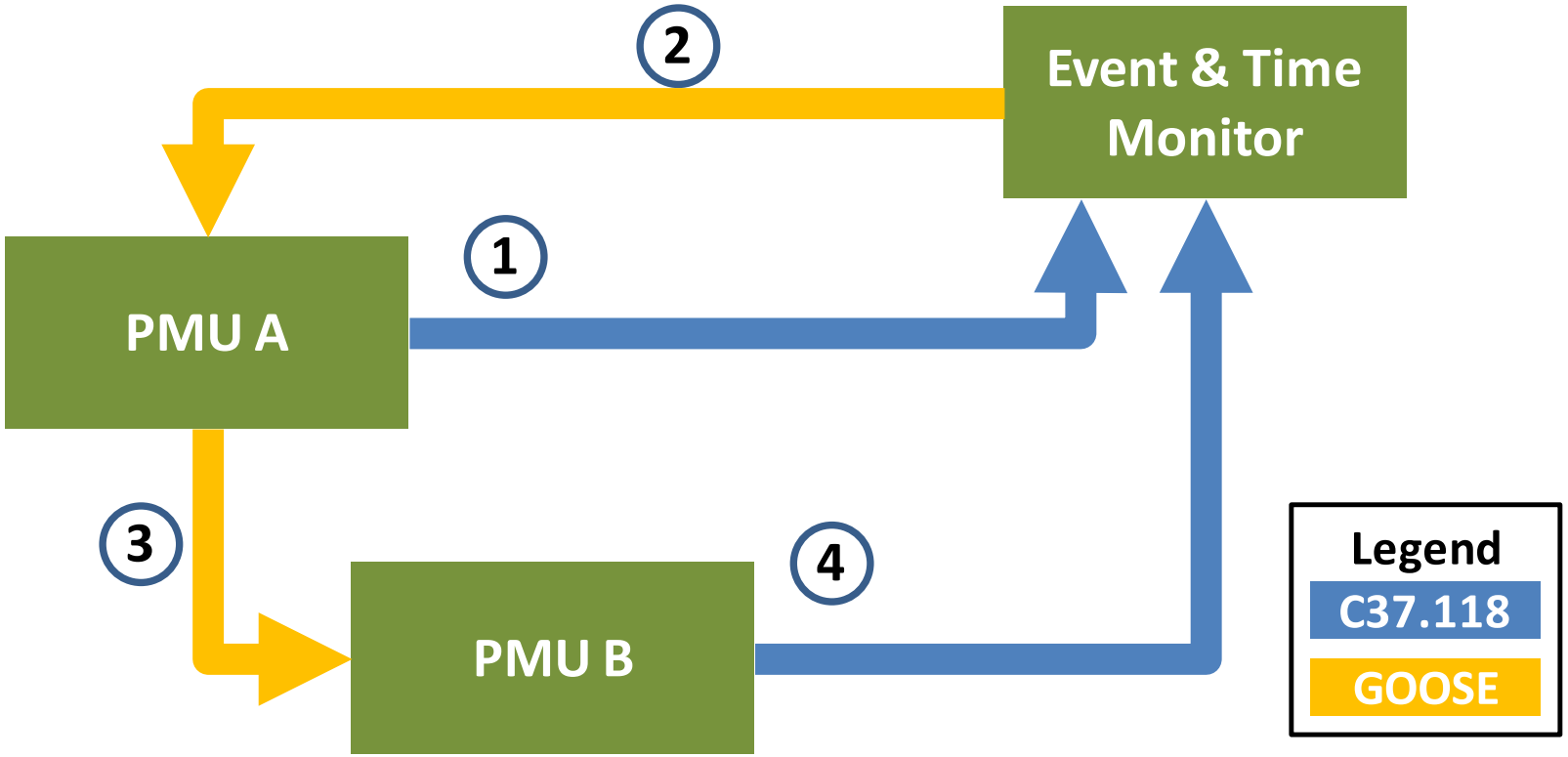
Test Bed Control Loop – Timing Arrangement



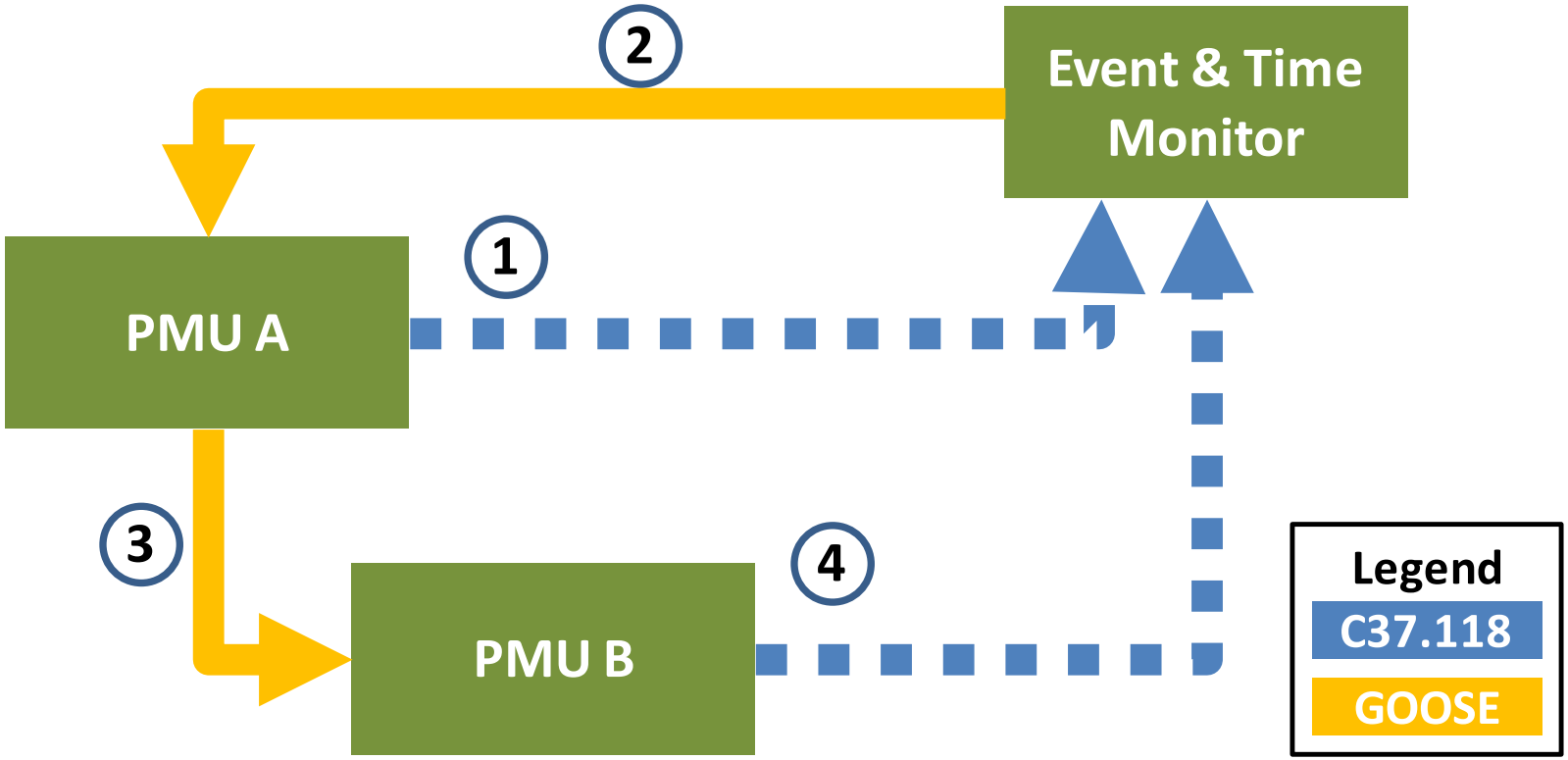
Configuration- IP Unicast with PDC



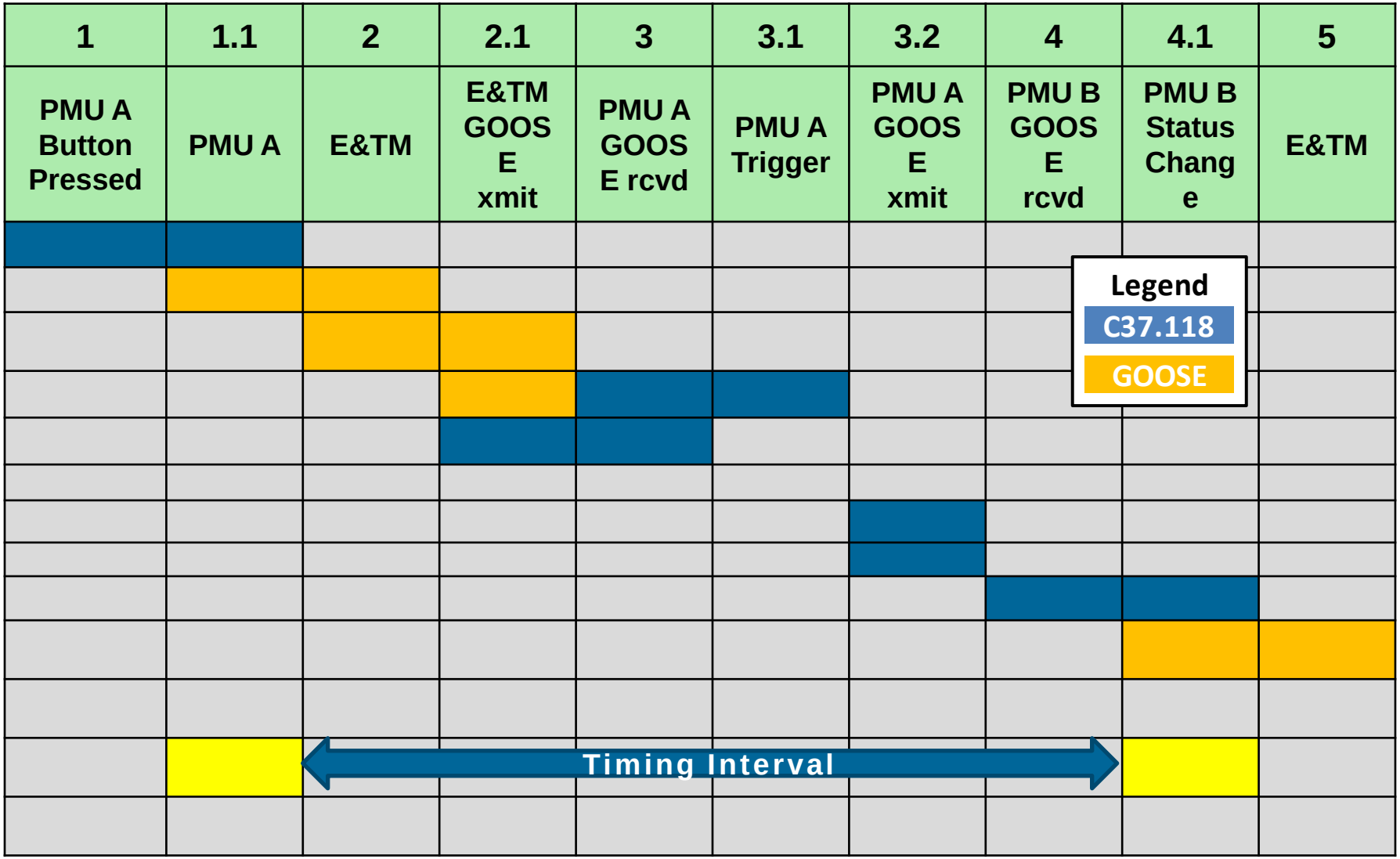
Configuration- IP Unicast without PDC



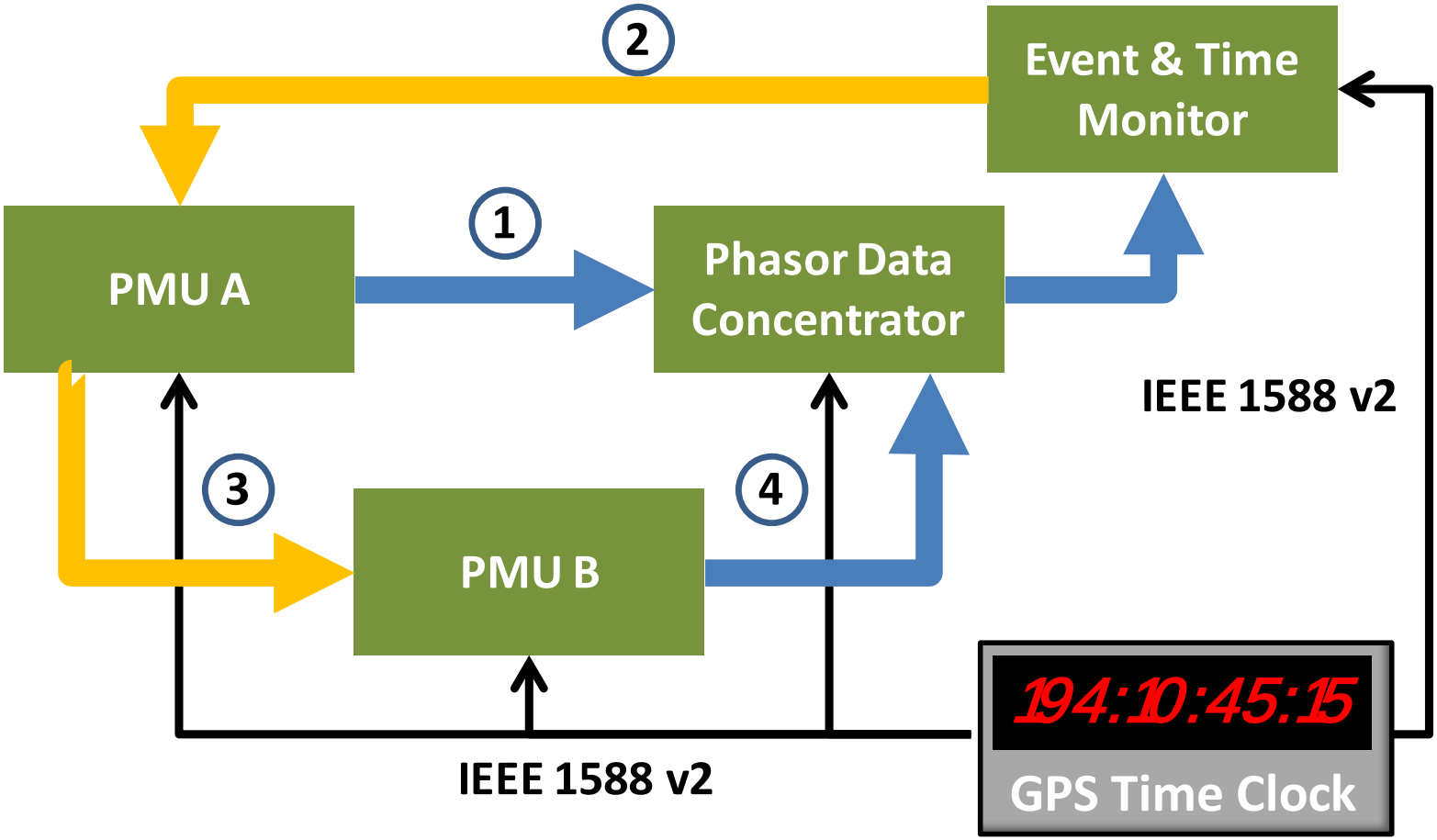
Configuration- IP Multicast



Timing Determination



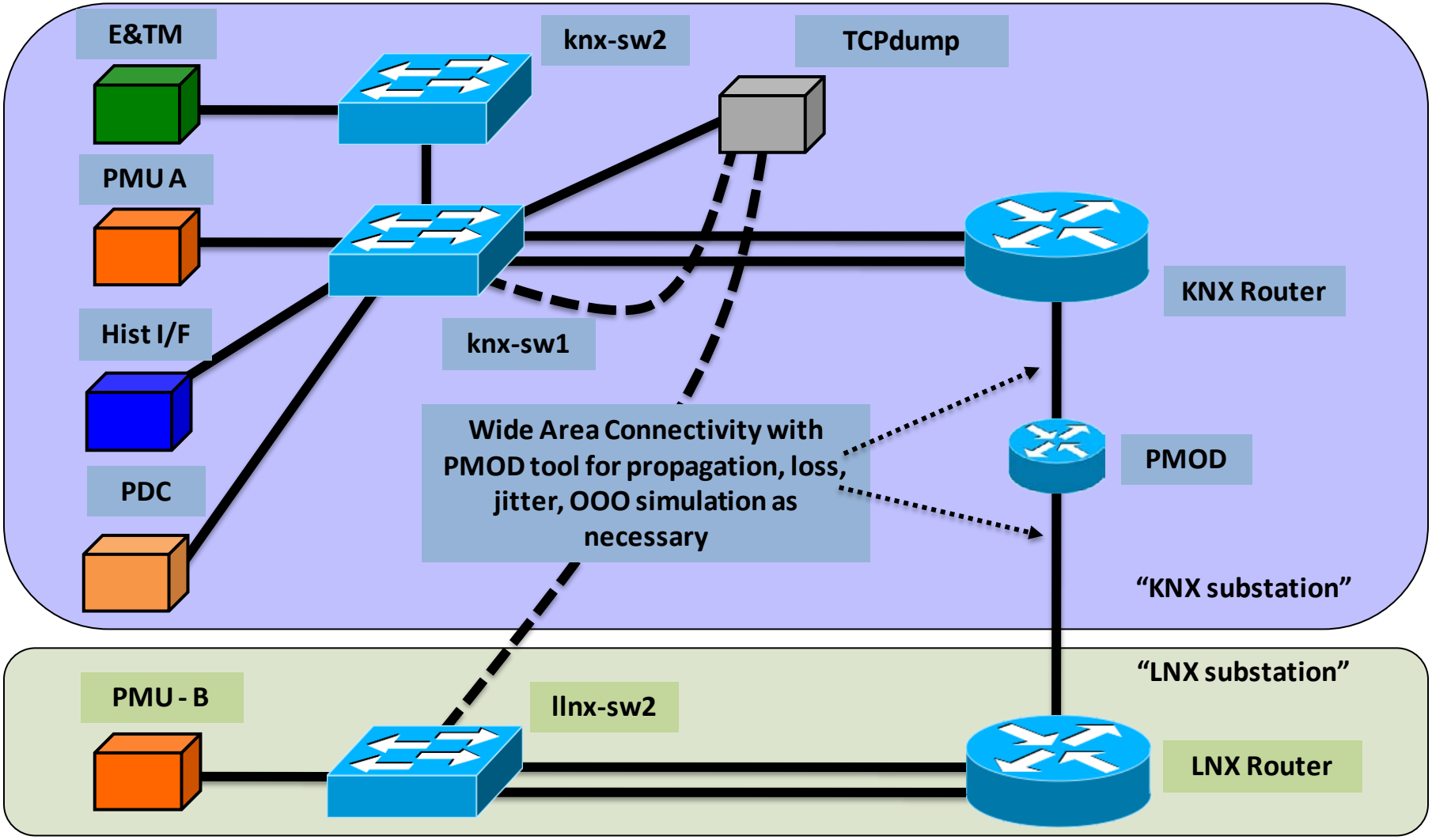
Test Bed Control Loop 1588 Timing



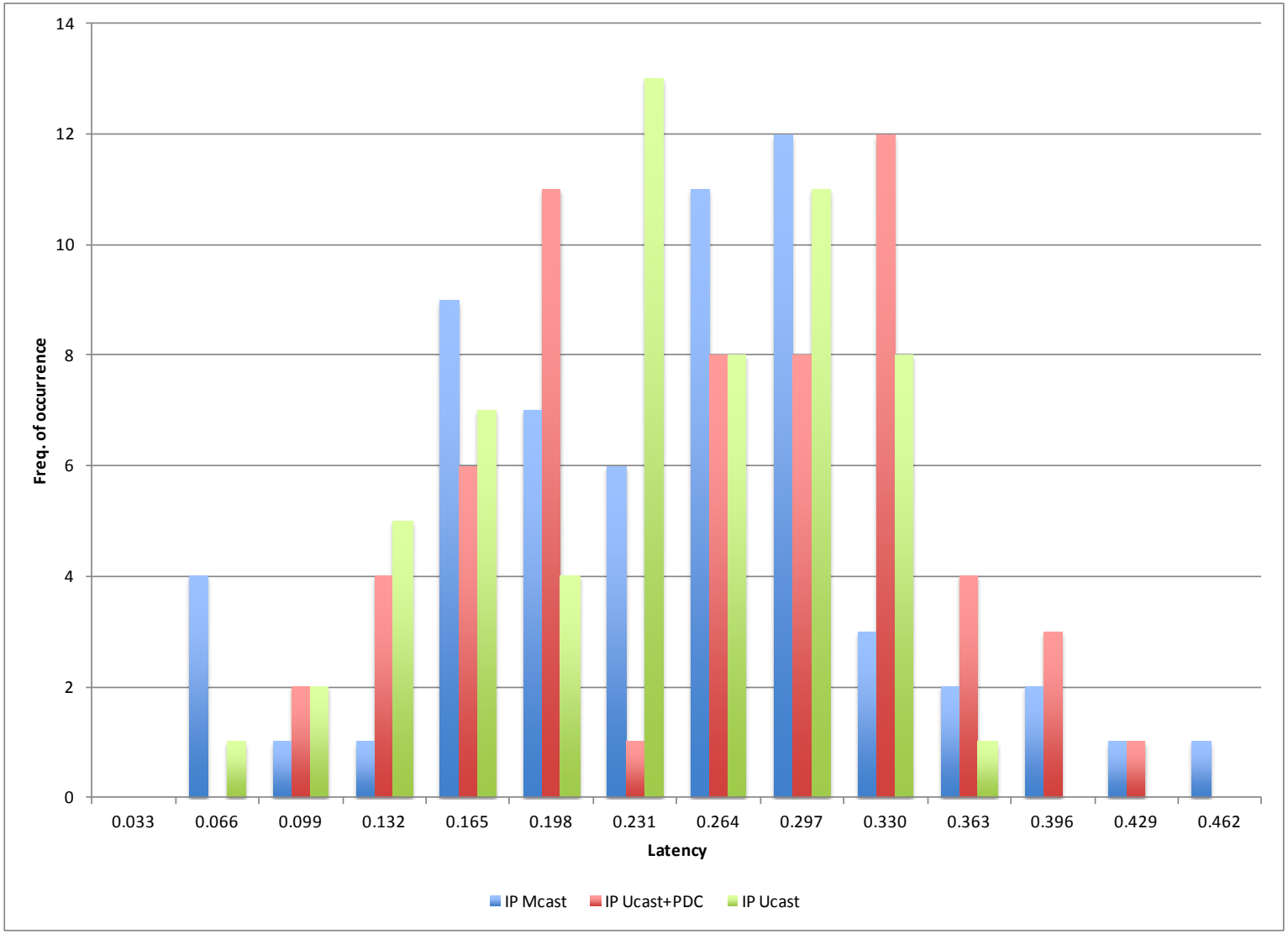
Testbed Network Diagram

KNX and LNX substations:

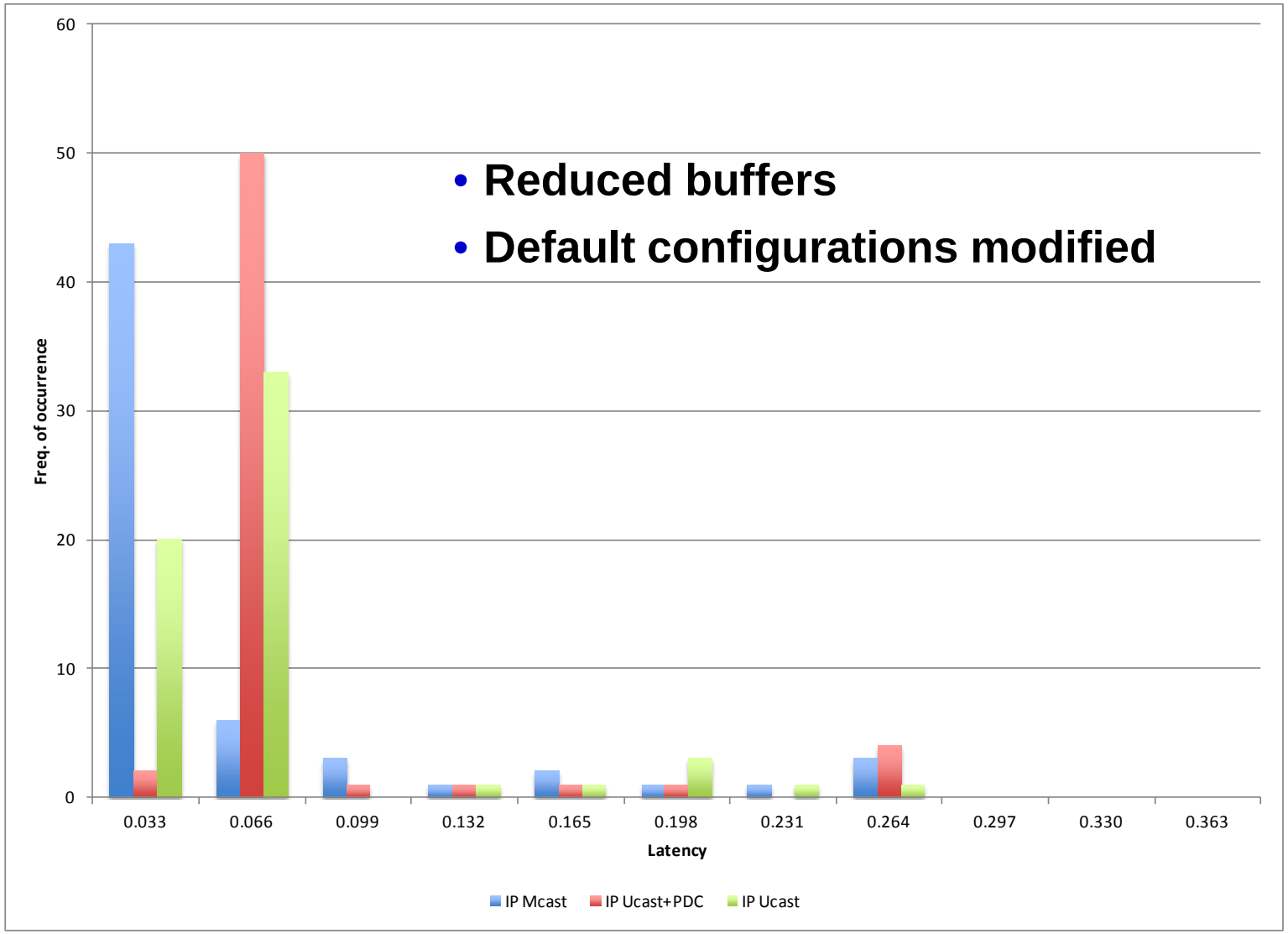
- Layer 3 for C37.118 messages
- Layer 2 for GOOSE messages
- VLAN filtering for Layer 2 traffic



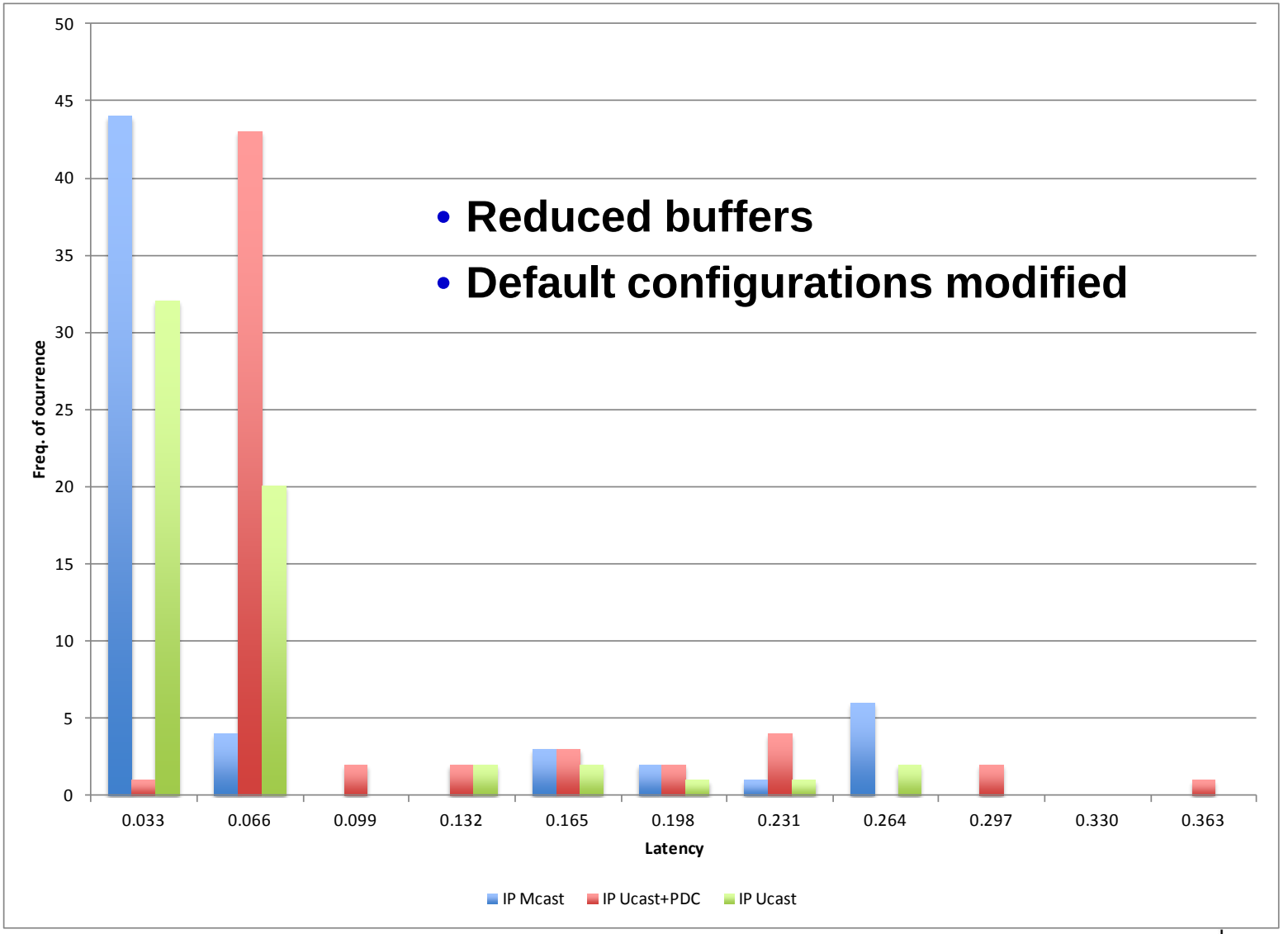
Test A: Latency Measurements
PMU sampling rate: 60 Samples/Second



Test B: Latency Measurements
PMU sampling rate: 60 Samples/Second

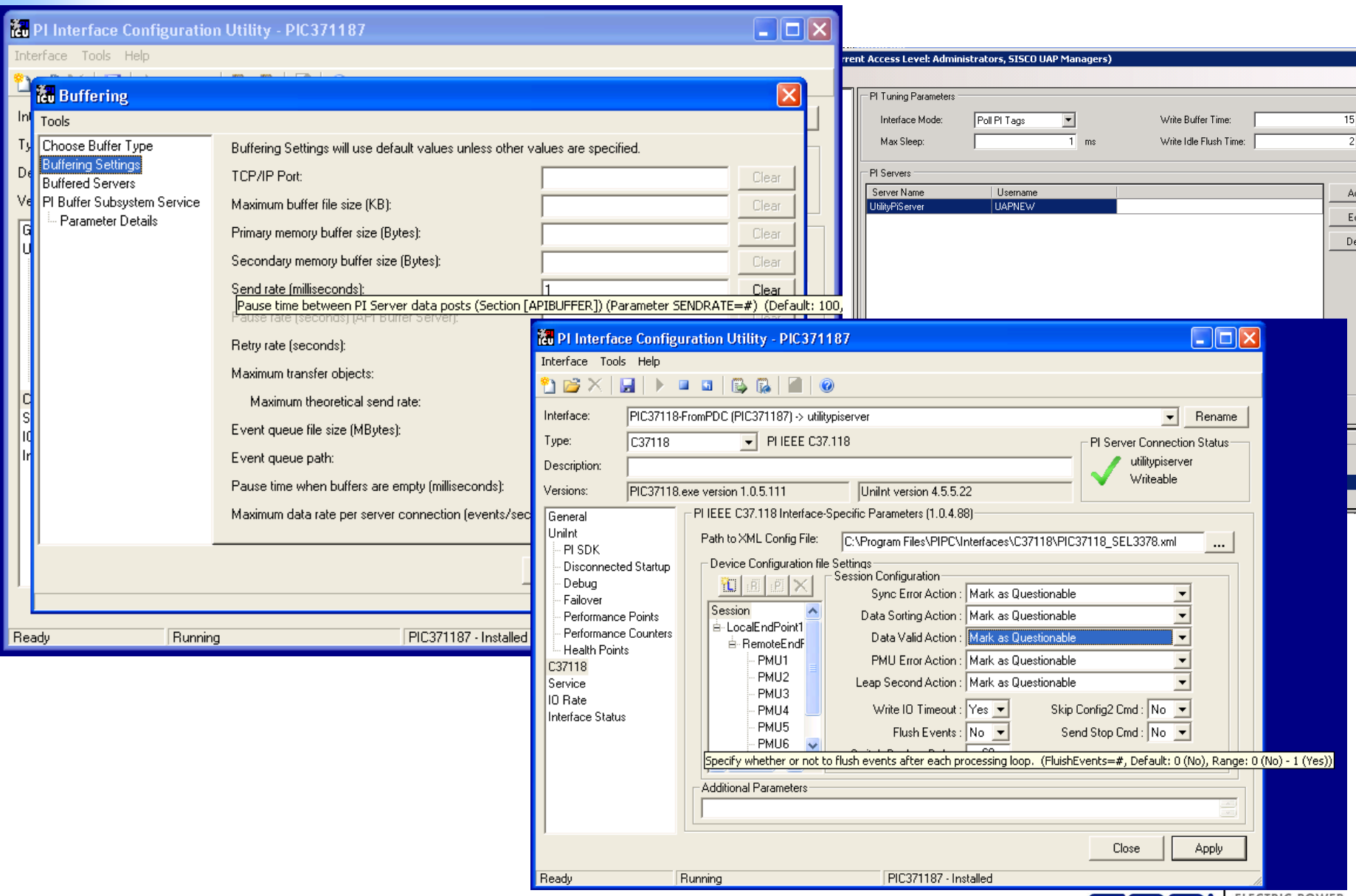


Test C: Latency Measurements
PMU sampling rate: 30 Samples/Second

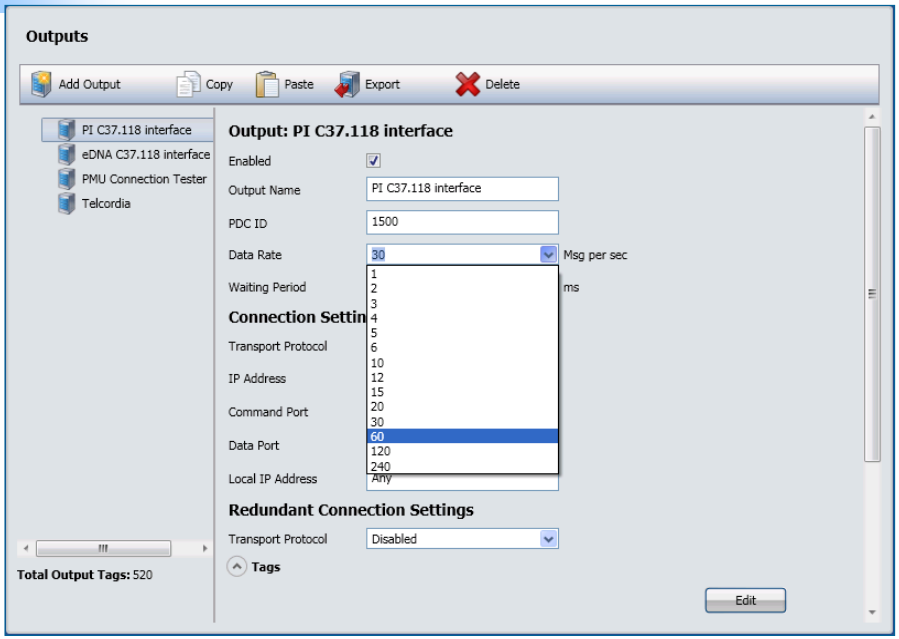


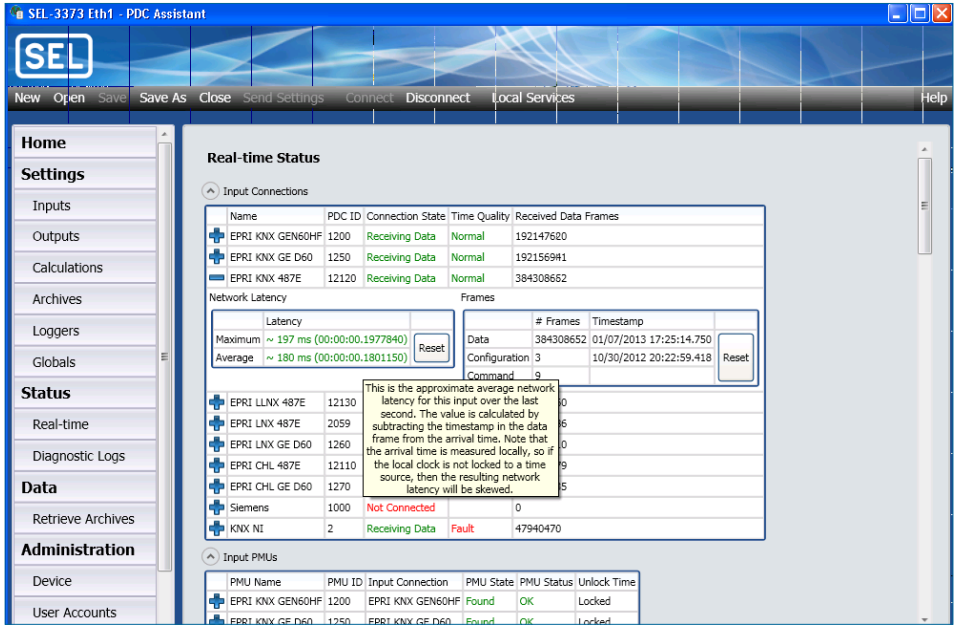
EPRI ELECTRIC POWER RESEARCH INSTITUTE

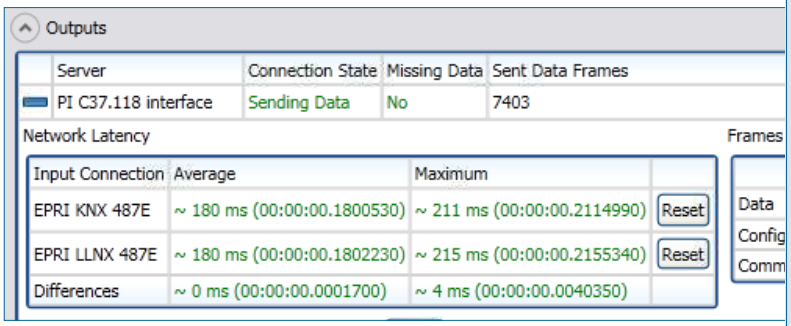
Optimizations - Buffering

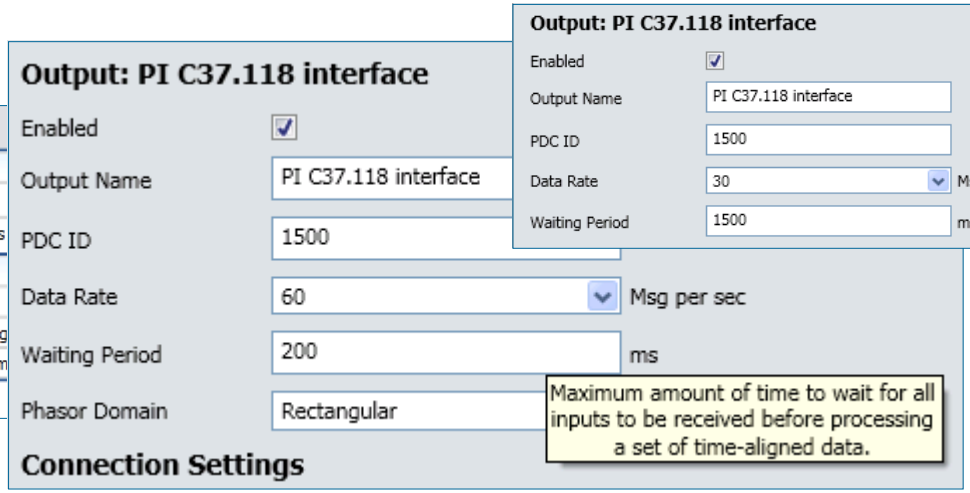


Optimizations/Configurations - PDC









EPRI ELECTRIC POWER RESEARCH INSTITUTE

Summary Table of Test Results – Mode

Mode	Samples / Cycle	IP Unicast	IP Unicast w/PDC	IP Multicast	Configuration
Test A	60	.283	.100	.233	Initial Configuration
Test B	60	.033	.050	.050	Modified Config 1
Test C	30	.033	.066	.033	Modified Config 1

- **Test A: Buffers were significant compared to measurement window**
- **Tests B/C: PDC adds very minor delay**
- **Test C: Test network was not complex enough to differentiate IP Multicast from IP Unicast**

Conclusions/Observations

- Difficult to accurately measure latency and know the contributing components in the system
- Significant improvements in latency achieved through device settings, network traffic configuration, software interfaces
  - Network traffic, use of VLANs
  - Proper set up of buffers and subsystems in software components
  - Distance (propagation delays), PDC marginally add to overall latency

  → Need to understand the intricacies of all the equipment
- Still some unexplained latency behavior (variation and trends up/down)
  - Non real-time OS, use of virtual machines, other?
- Much more to learn, but understand the test bed better and have it working!

Future Testing Areas

- IEC 61850-90-5
- Security overlay on WAN link
- Additional network traffic/loading
  - Add alt vendor PMUs (additional traffic and PDC wait time)
- WAN propagation delays
- Network impairment / availability
- Traffic prioritization / isolation
- IEEE 1588 / PTP synchronization to windows servers
- Upgrade to PI Server 2012

Questions:

- What are the PMU latency measurements between your utility and the ISO?
- Is *YOUR* PMU architecture or WAMPAC system optimized to reduce latency?

Technical Update, Aug 2013: 3002000604 Synchrophasor Communication Infrastructure: Impacts on Latency Part II

Paul Myrda
Technical Executive
PMyrda@epri.com

Scott Sternfeld
Project Manager
SSternfeld@epri.com

Together…Shaping the Future of Electricity