D2-01_08
Evaluations from accurately acquired and time stamped traffic to assess communication networks for IEC 61850 applications

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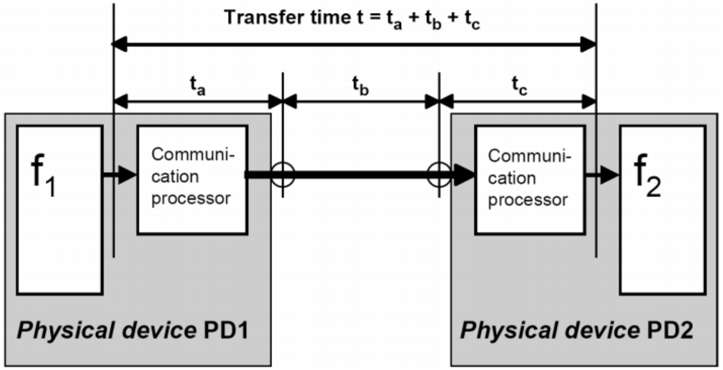
Performance of the communication network

- Timely delivery of information
  - GOOSE
  - Sampled Values
  - Tripping
  - Communication aided protection schemes
  - Differential protection

- Reliable delivery of information
  - Redundancy

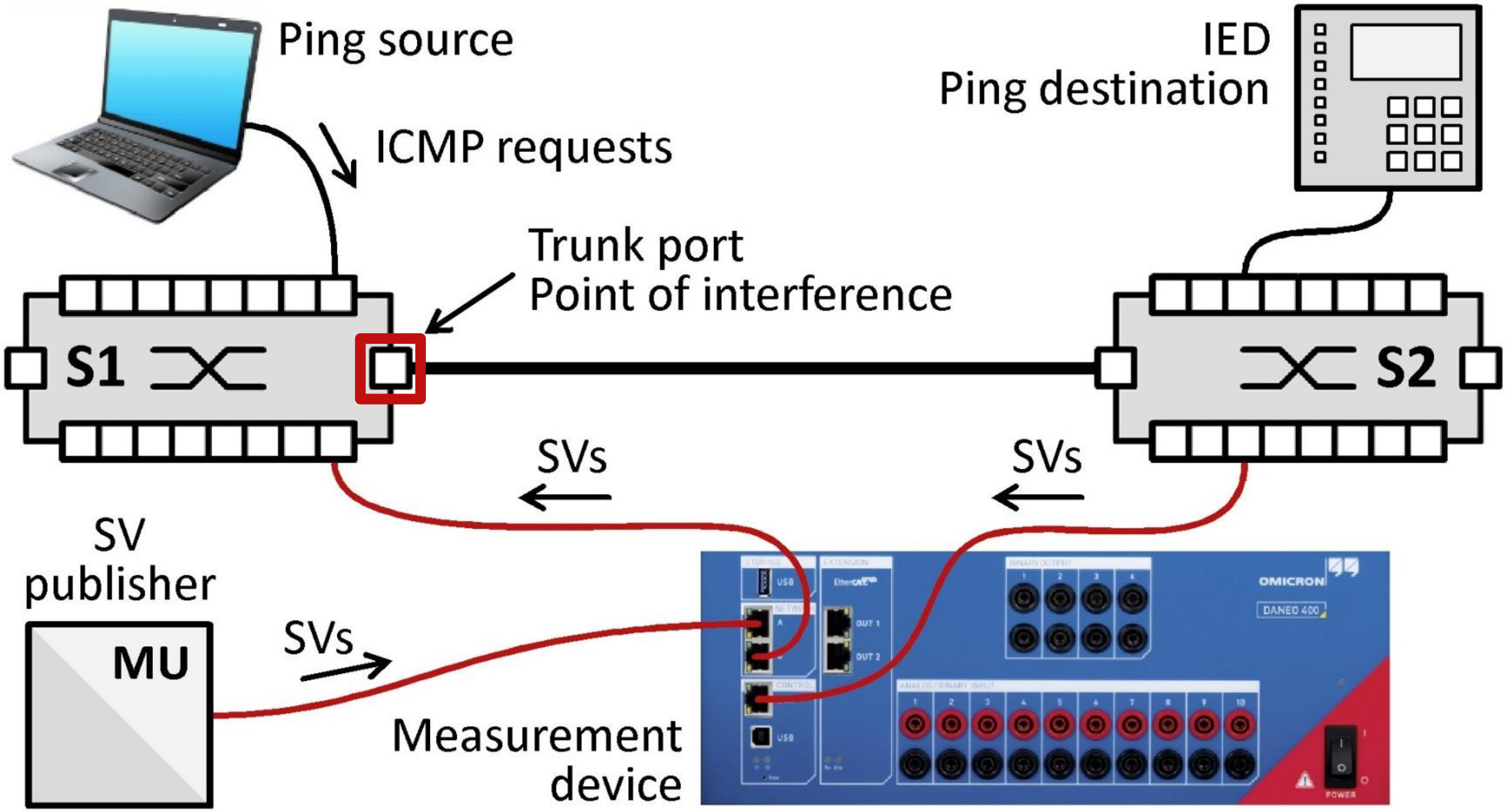
Performance in IEC 61850-5

- Transfer time of information
  - What is a reasonable time?
  - Depends on type of information and specific application

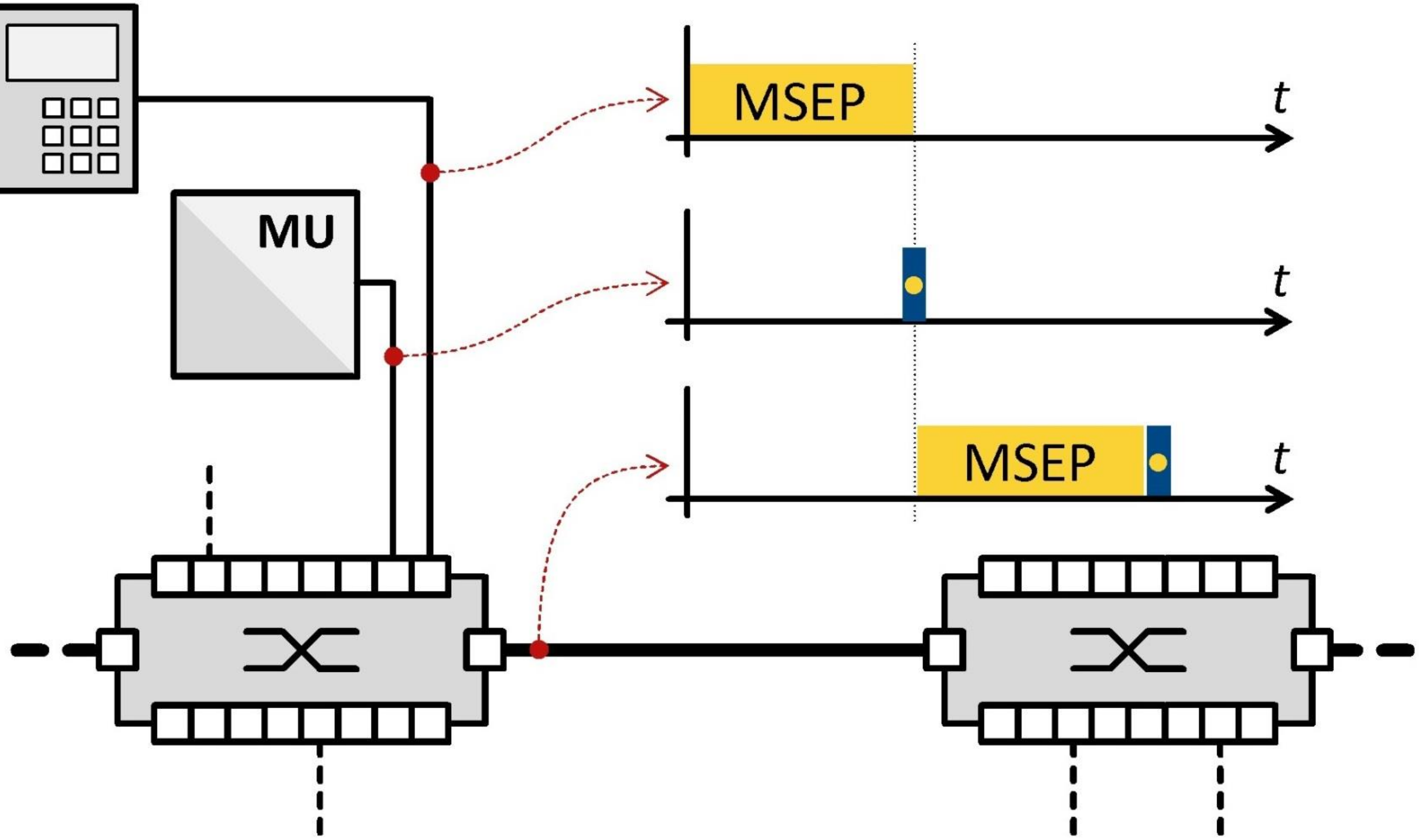


Message Type	Performance		Transfer Time	
	Class	Requirement description	Class	ms
1A. Trip (GOOSE)	P1	The overall transfer time shall be below the order of a quarter of a cycle	TT6	≤ 3
	P2	The overall transfer time shall be in the order of half a cycle	TT5	≤ 10
4. Raw Data (SV)	P7	Delay acceptable for protection functions using these samples	TT6	≤ 3
	P8	Delay acceptable for other functions using these samples	TT5	≤ 10

Measuring the effects of interferences in LANs



Ethernet packet interference



Influence of interfering traffic

Ping (ICMP) traffic to interfere with Sampled Values

Packet size	Packet duration @ 100Mbit/s	Packet frequency	Probability for interference
500 bytes (4000 bits)	40 µs	1000 s^{-1}	4 %
1538 bytes (12304 bits)	123 µs	885 s^{-1}	10.9 %

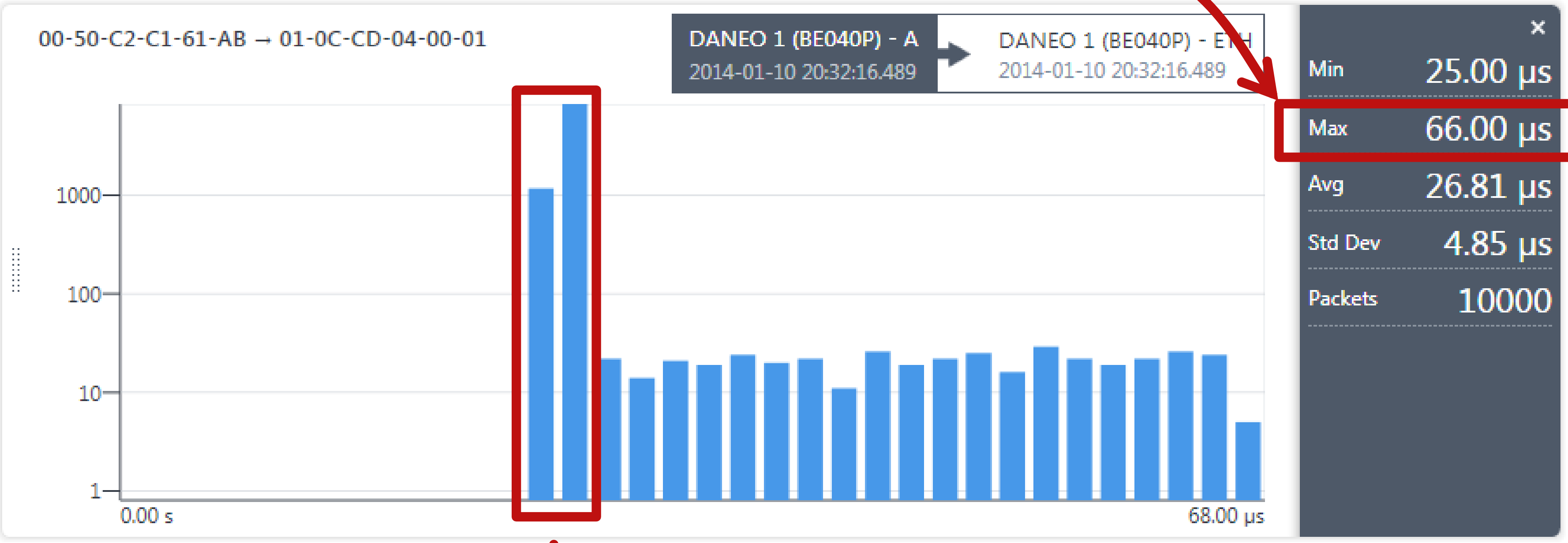
Occupied bandwidth ≡ probability for interference

Only Sampled Values – no interferences

Baseline for following measurements: 26µs

500 bytes packets interfering

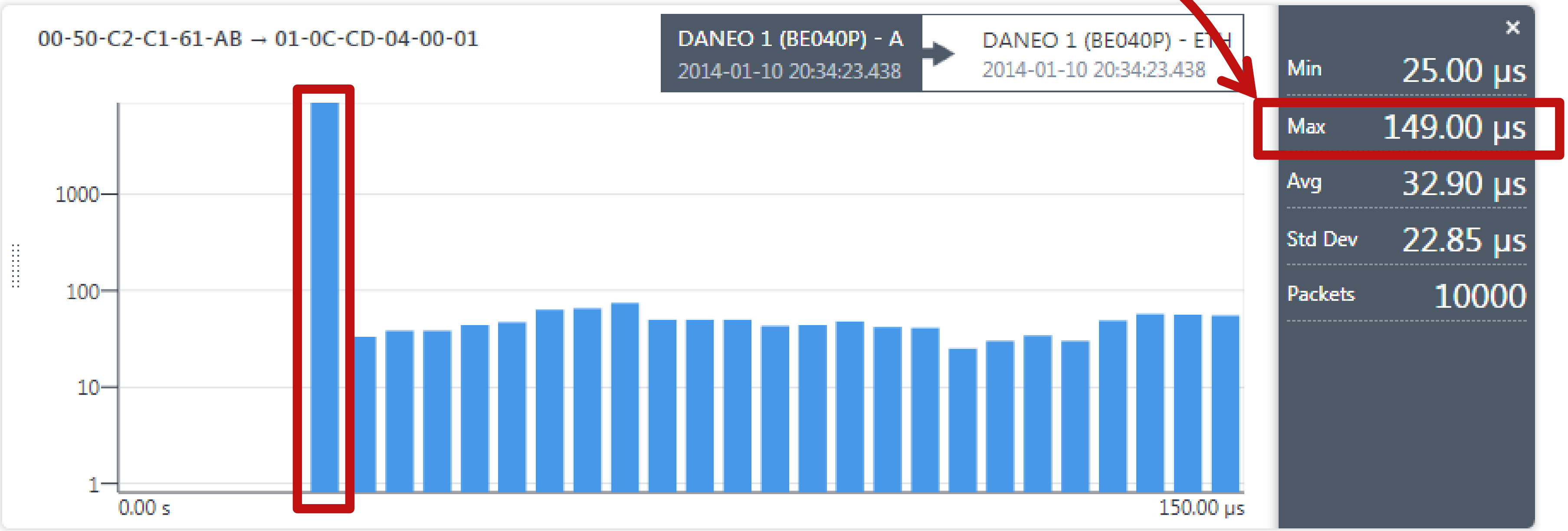
40µs + 26µs



9592 = 96%

1538 bytes packets interfering

123µs + 26µs



8894 = 89%

Theoretical examination vs. measurements

> Perfect match

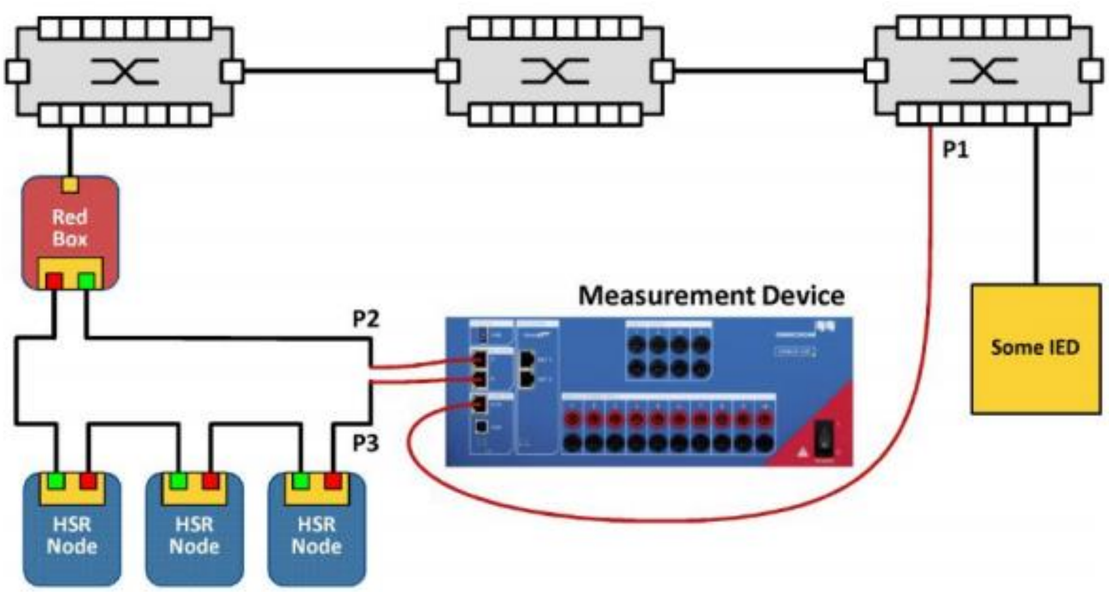
> Measurements reveal the expected effects

> Measurement method is viable

> Measurements reveal timing behavior in power utility communication networks

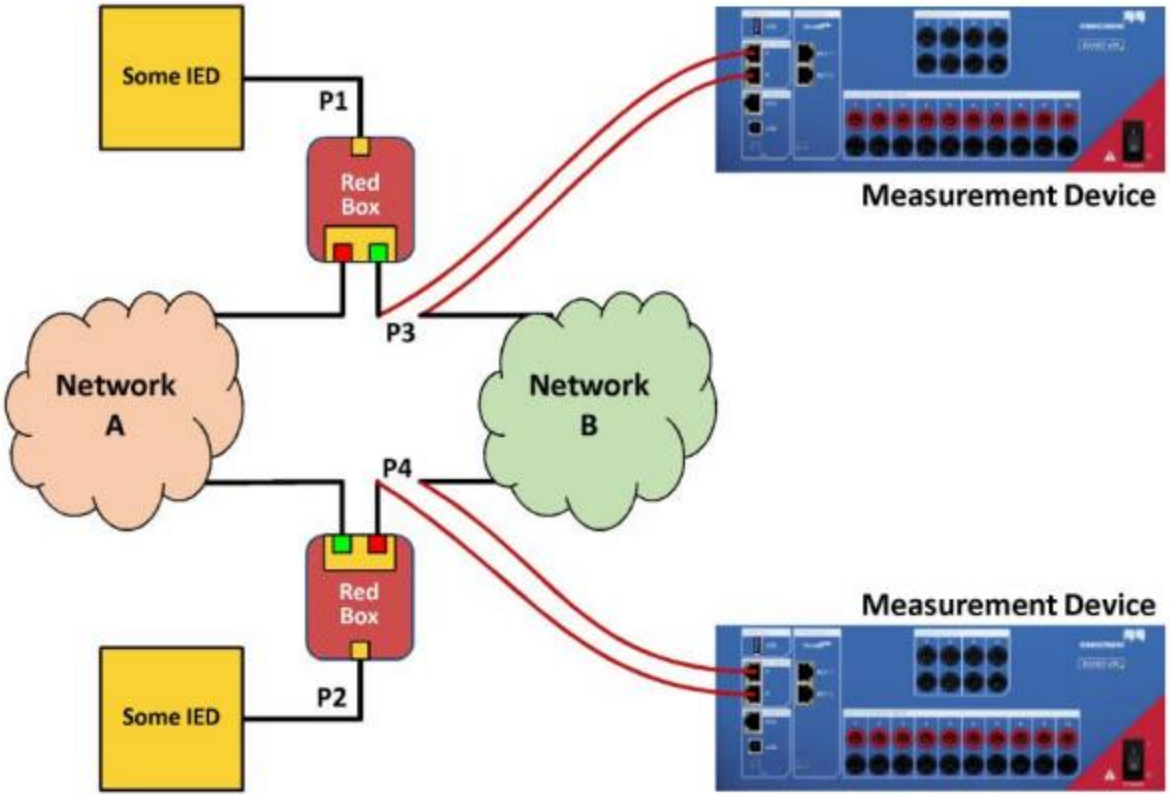
Measurements in Networks with Redundancy

- Redundancy methods:
  - HSR (High-availability Seamless Redundancy)
  - PRP (Parallel Redundancy Protocol)
- Assessment of:
  - propagation times
  - differences of times in the redundant paths
  - zero-loss of packets
- Measurements in a HSR network:

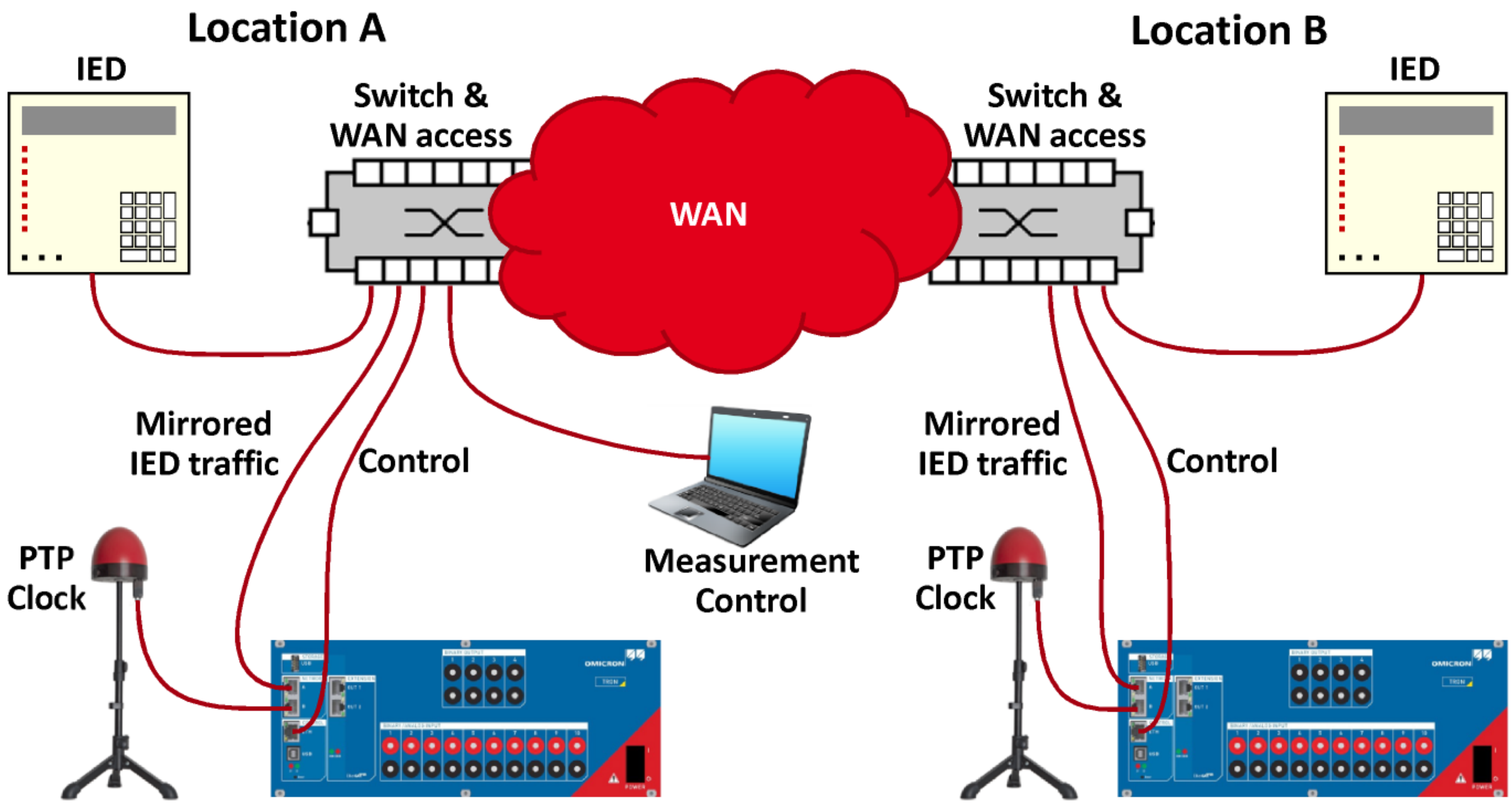


Measurements in Networks with Redundancy

> Measurements in a PRP network:



Wide area scenario



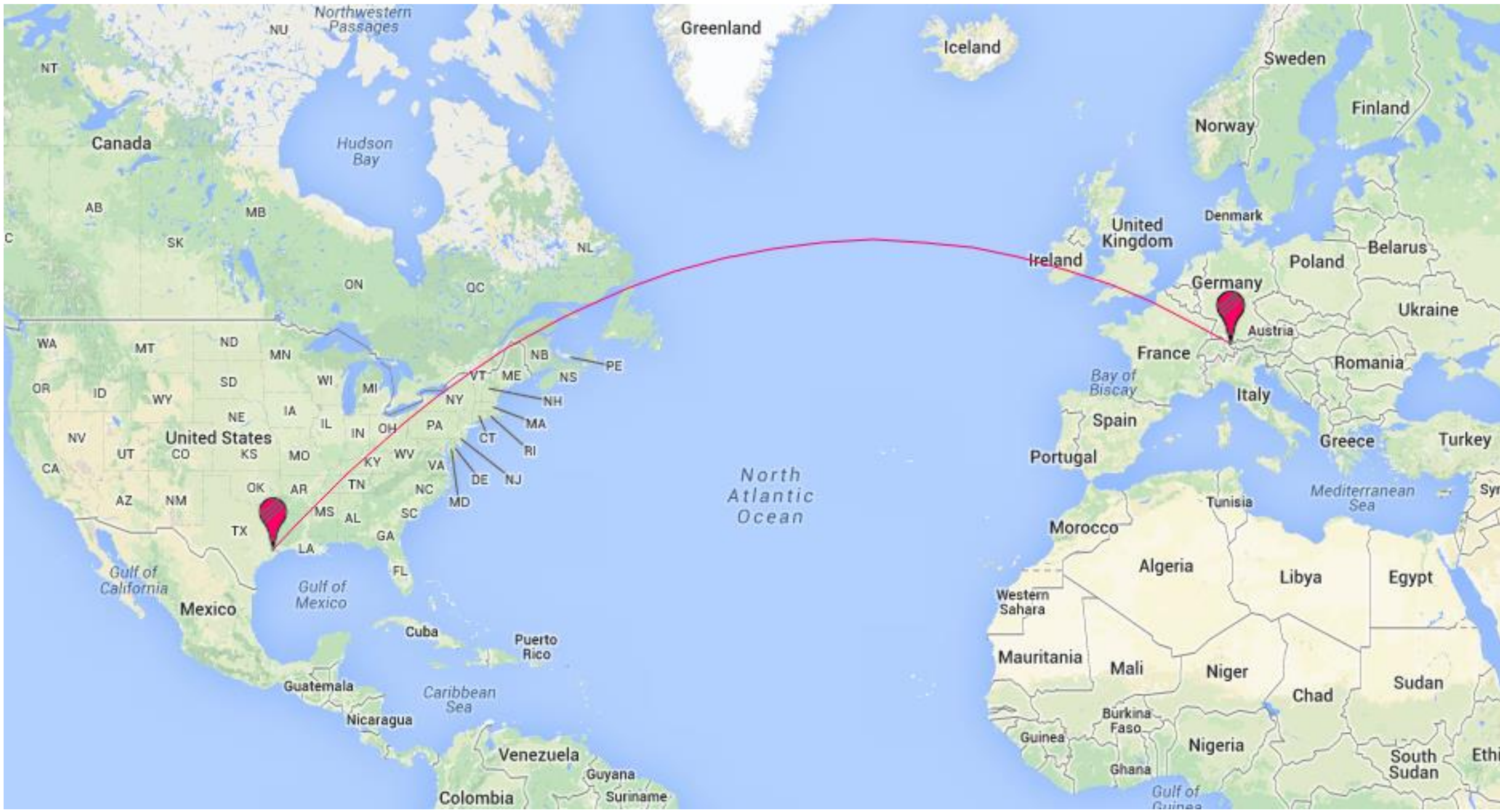
Measurements for a Transatlantic link

- Link between Houston, USA and Klaus, Austria

- Routed connection
  - Different subnets
  - Access and control of test equipment requires some preparation

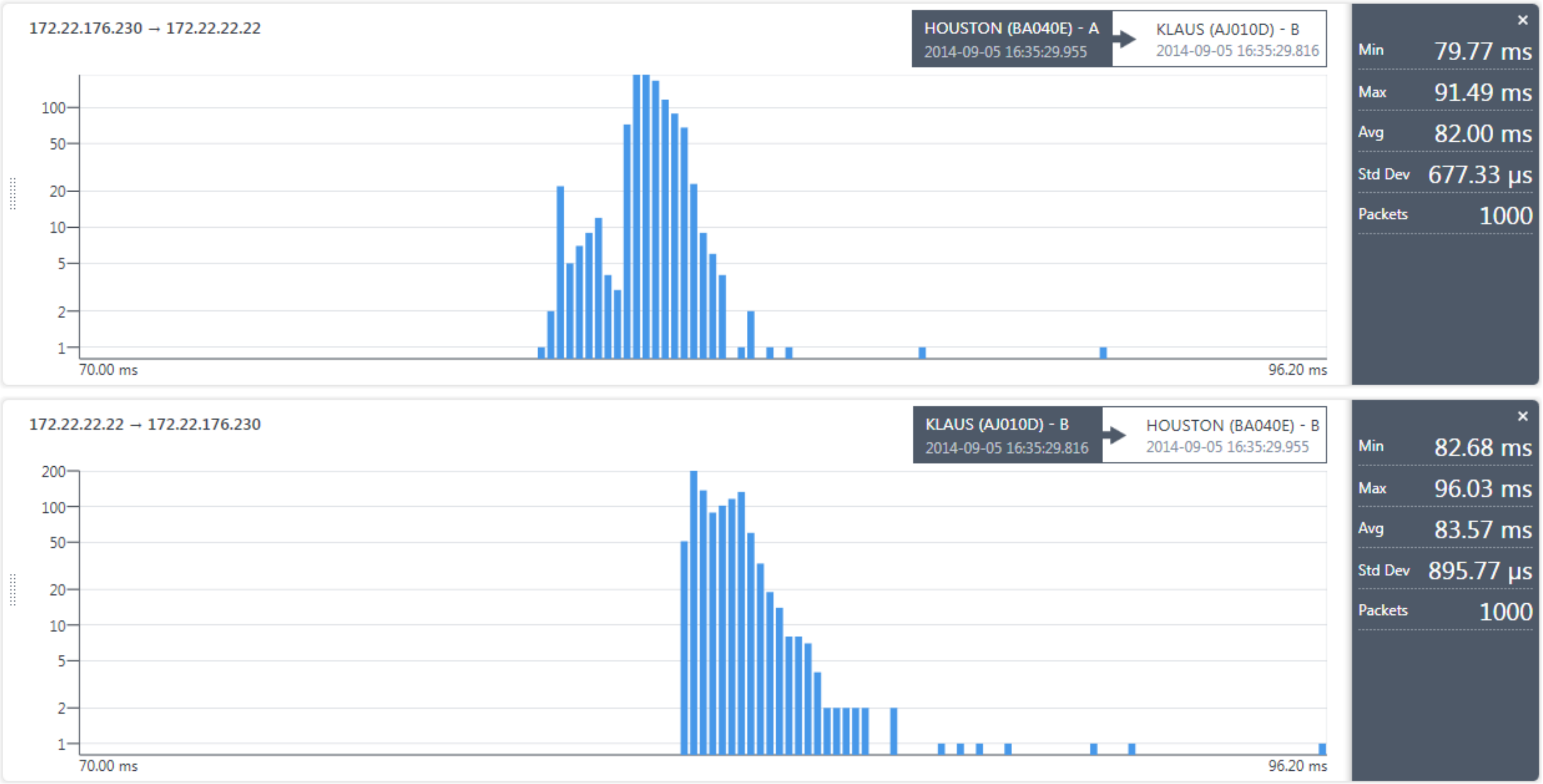
- Propagation delays
  - Different order of magnitude
  - Proof of concept

Transatlantic link: Locations involved



Map data © 2014 Google. Draft Logic distance calculator © 2014 draftlogic.com

Transatlantic link: Delay time distribution



Summary

- Verifying power utility communication networks

- Design criteria
  - Timing Performance
  - Crucial for protection applications

- Theoretical examination
  - Expected behavior
  - Important for the design

- Measurement
  - Verification of design criteria

Thank you for your attention!

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Questions of the Special reporter

Q1-13:

Is it possible to describe when and why you advice to assess communication networks for IEC 61850 during commissioning process?

<u>Answers:</u>

> It is important to assess the devices and solutions during their development phase by manufacturers as well as acceptance tests performed by utilities. Utilities should also perform proof of concept assessments when defining new architectures or adopting new technology. If all of above applies, during commissioning the focus is to verify all devices are installed and configured properly

> It is essential to verify under real conditions that the performance of the system meet requirements and that all devices had their configuration properly done during the project phase

Questions of the Special reporter

Q1-14:

What are your experiences using this method to troubleshoot possible IEC 61850 issues?

<u>Answers:</u>

> The time propagation delay method is essential to assess the communication network, independent of architecture and technology used, meets with the protection system requirements.

> The accurately acquisition of the traffic is important in troubleshooting possible issues related to IEC 61850. Based on our own experiences with some measurements, we could identify, as an example, problems related to:
  > Redundancy networks due to misconfiguration of devices (acceptance tests performed by a utility)
  > Bandwidth allocation
  > Sampled Values counter issues when the MU lost time-synchronization