Practicalities and analysis of using PTP over 5G systems with dedicated time synchronization support for media production

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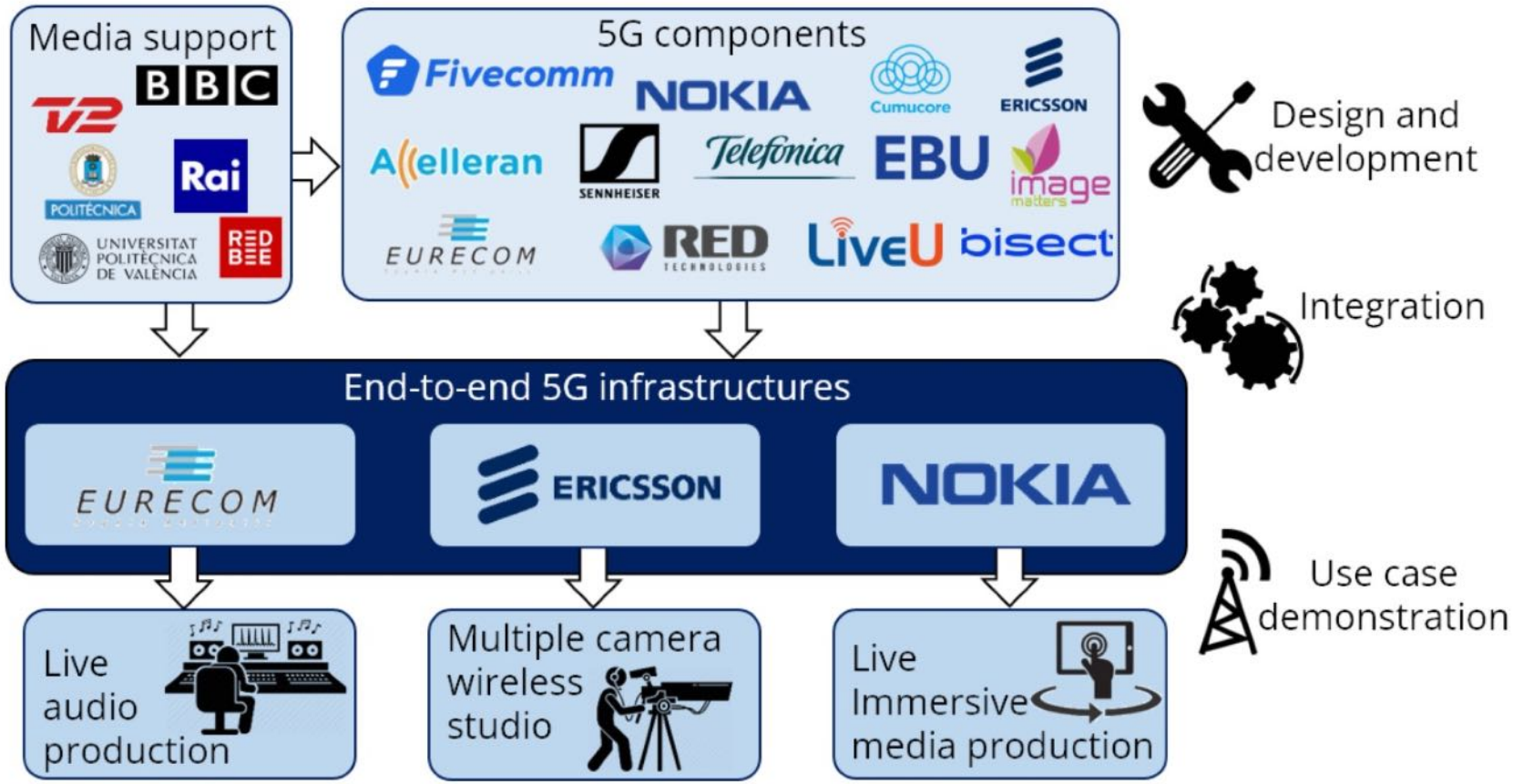
Co-Authors: Thorsten Lohmar (Ericsson), Mohamed Nabil Ibrahim (Ericsson), Thomas Kernen (NVIDIA)

IP SHOWCASE

Audio Engineering Society AIMS AMWA EBU SMPTE VSF

About 5G RECORDS



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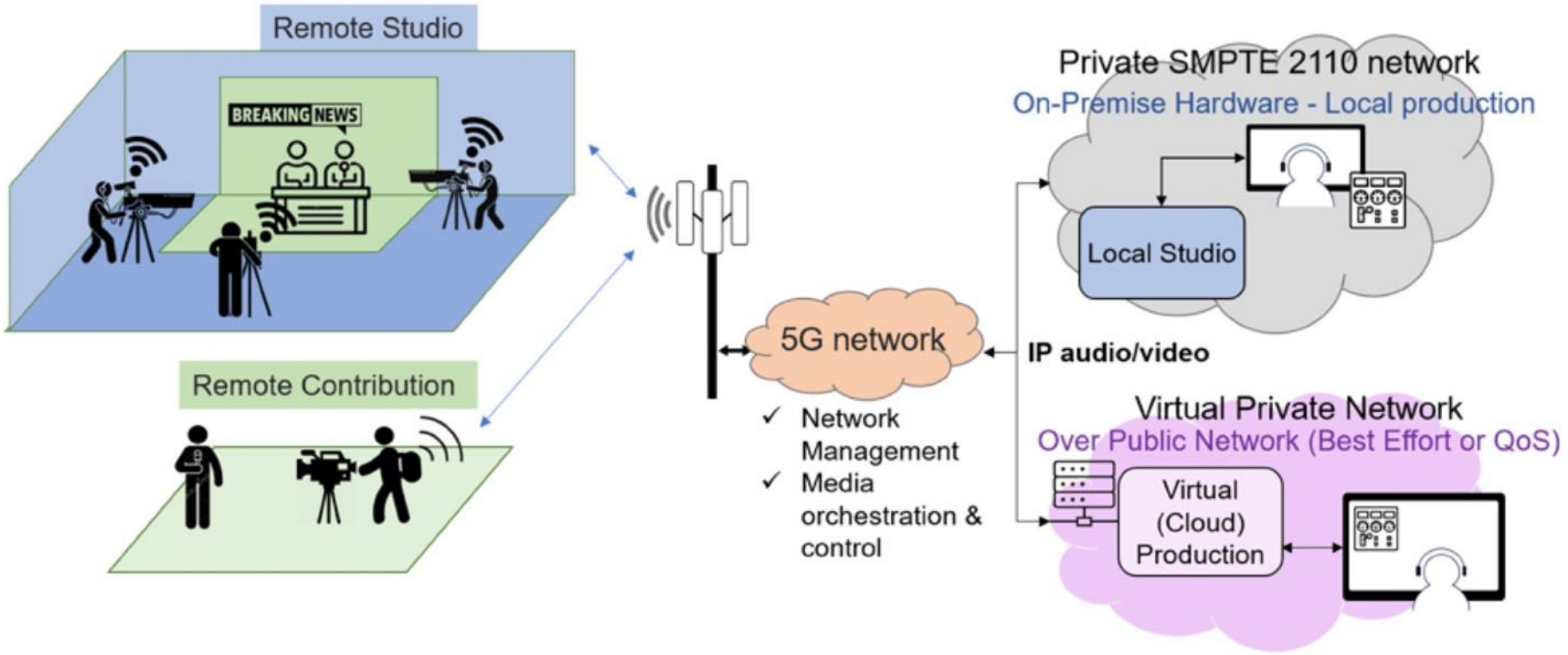
5G RECORDS

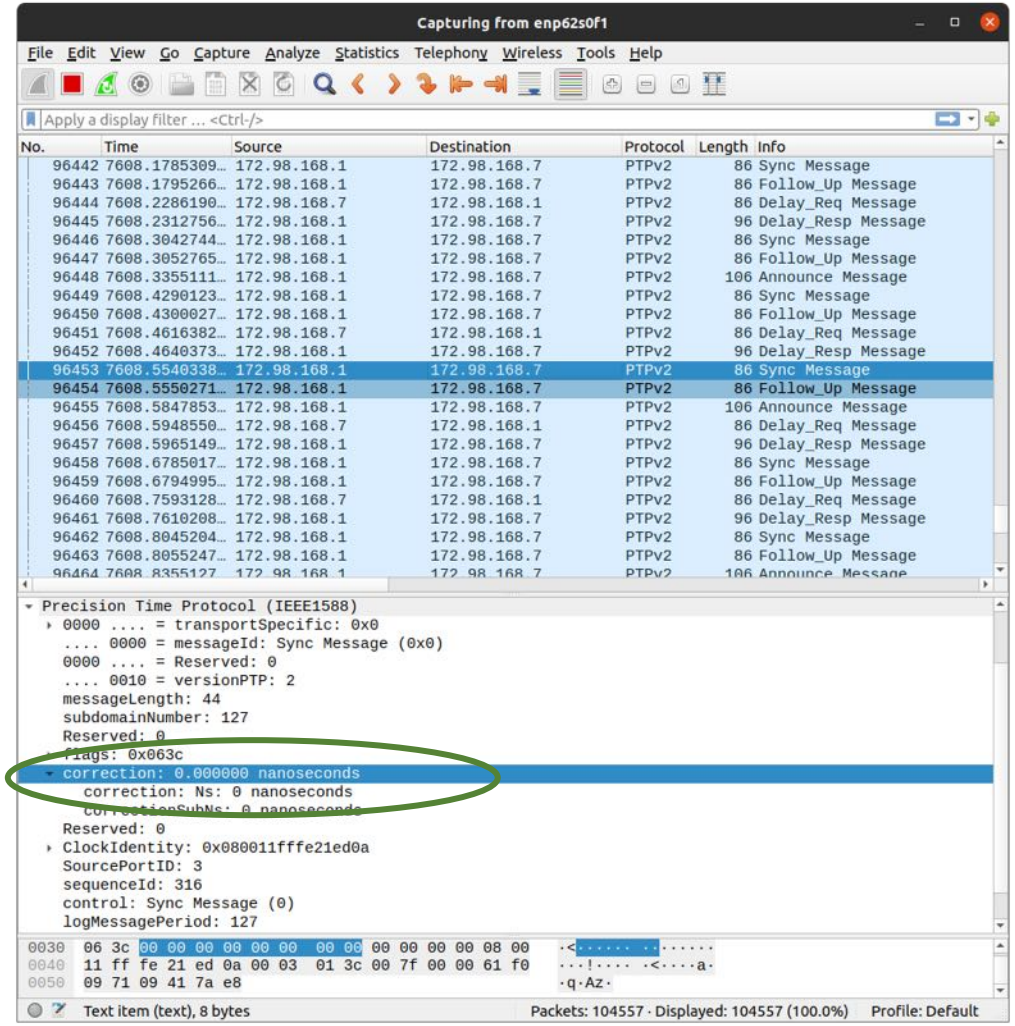
About UC2


Remote Studio
BREAKING NEWS
Remote Contribution
5G network
✓ Network Management
✓ Media orchestration & control
Private SMPTE 2110 network
On-Premise Hardware - Local production
Local Studio
IP audio/video
Virtual Private Network
Over Public Network (Best Effort or QoS)
Virtual (Cloud) Production

Problem Statement

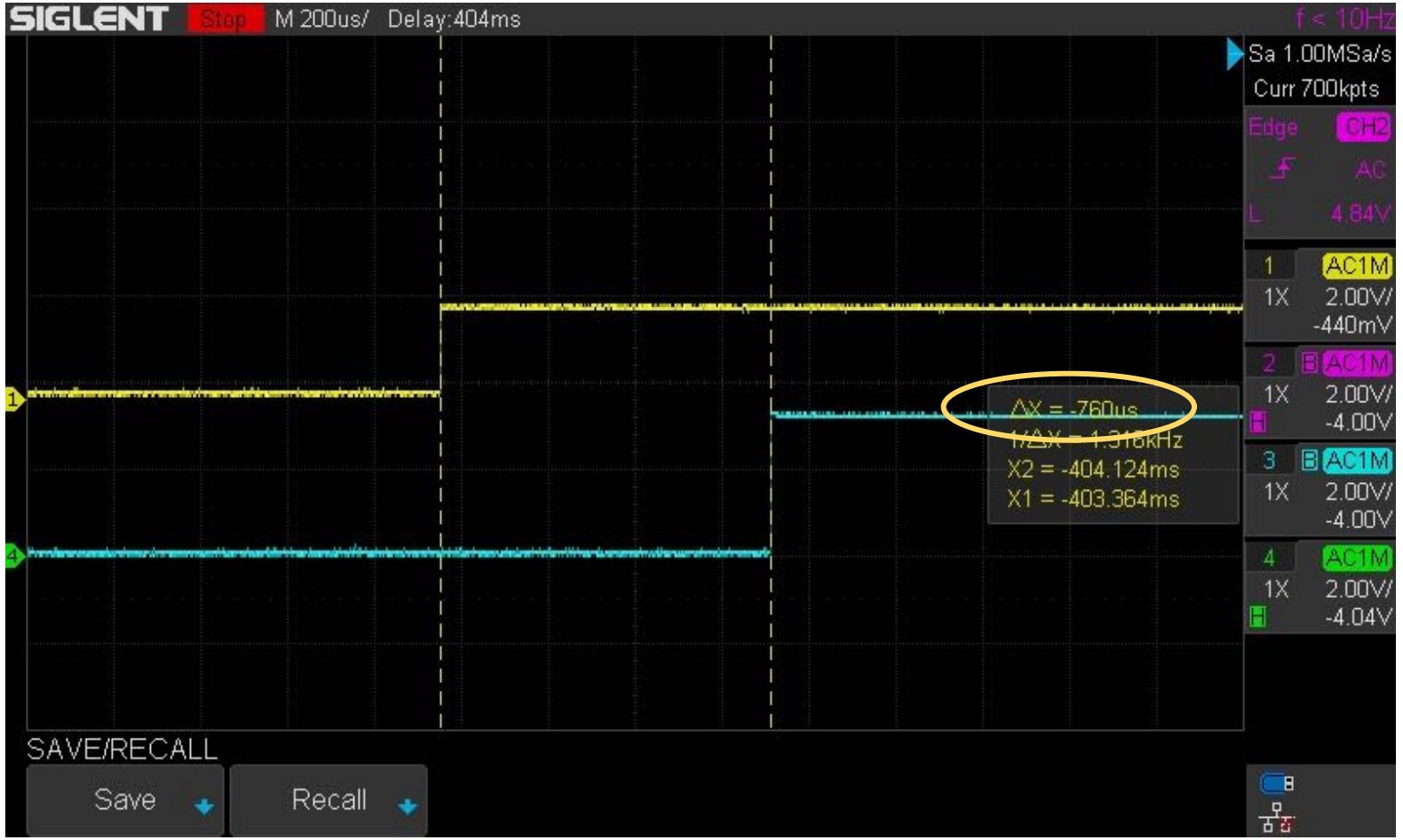
- How do we synchronize multiple wireless cameras?
- PTP vs NTP vs SIB9
- PTP is already used for ST 2110 on the wired side
- Will PTP work over 5G at all?
- What accuracy is good enough?
- Unicast/Multicast

PTP without correction field

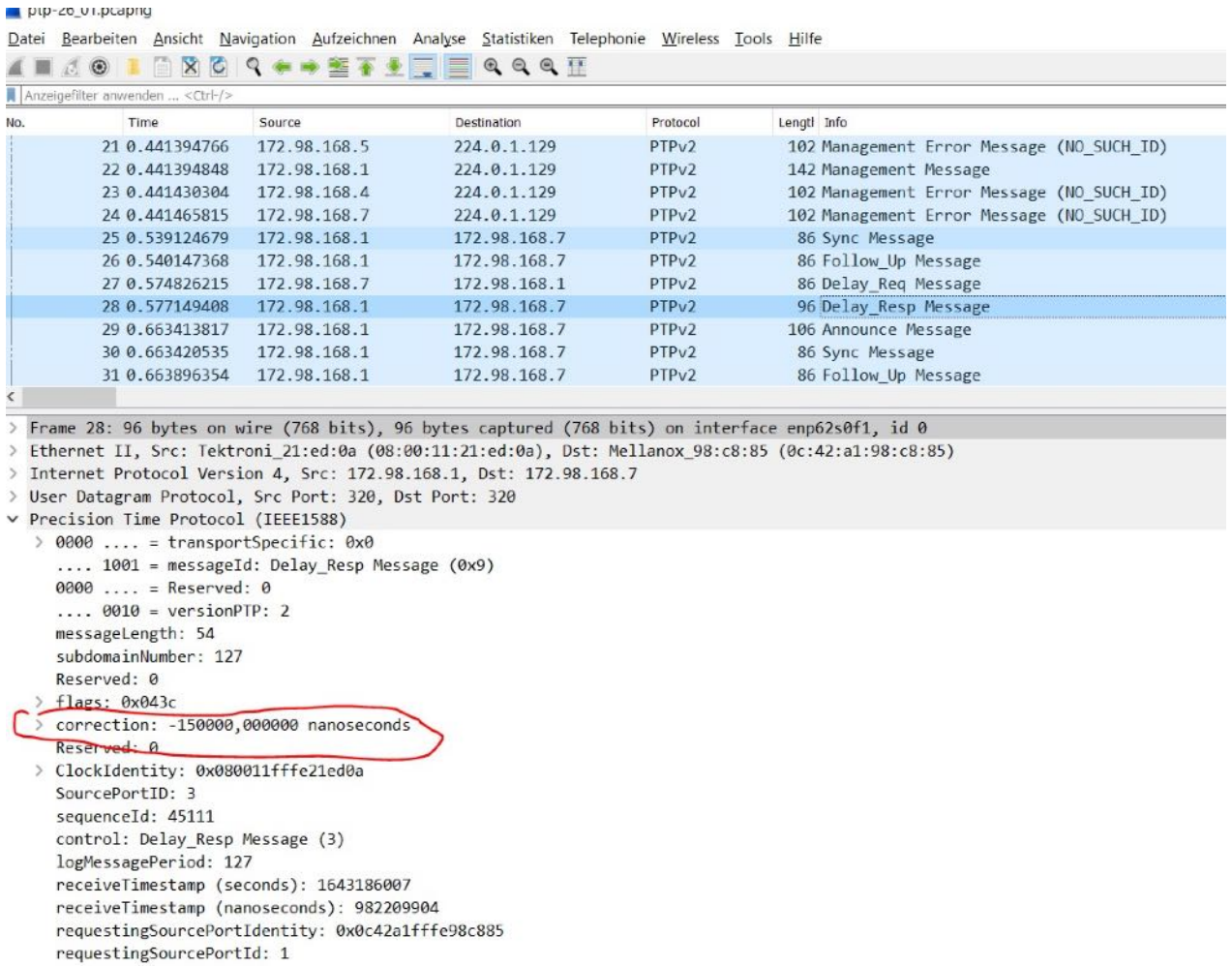


- PTP is vulnerable to path asymmetry
- Any constant asymmetry will produce a time offset equal to half of the differential delay.
- Dynamic asymmetries will generate unpredictable errors thus impairing the synchronization precision
- Correction fields can be used by the TC to mitigate this

Without Correction (PPS)

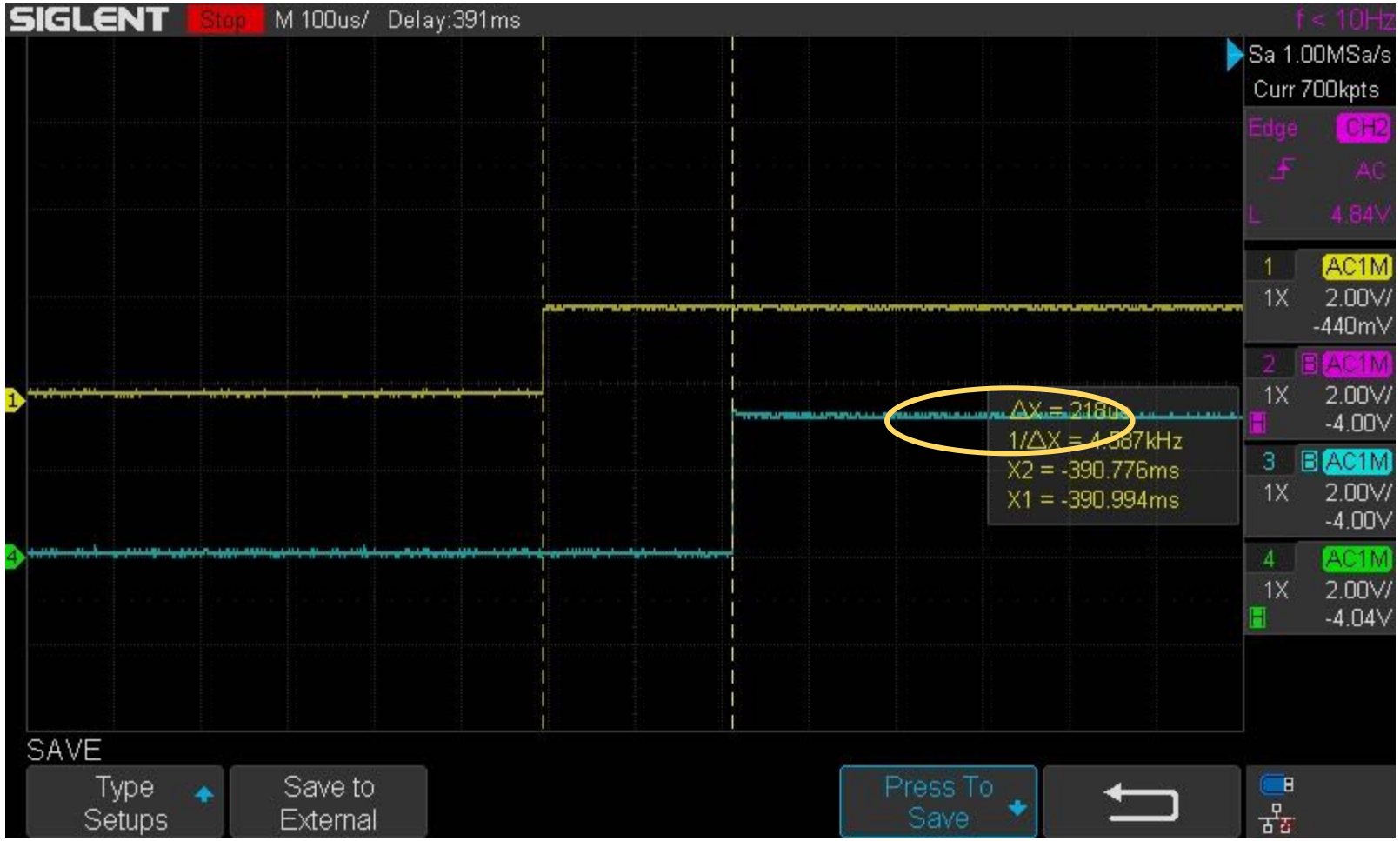


Static Correction



- Here, the correction field is manually inserted, using the delayAsymmetry property of ptp4l
- This can be used to fix constant asymmetry

Release 15 results (with static correction)



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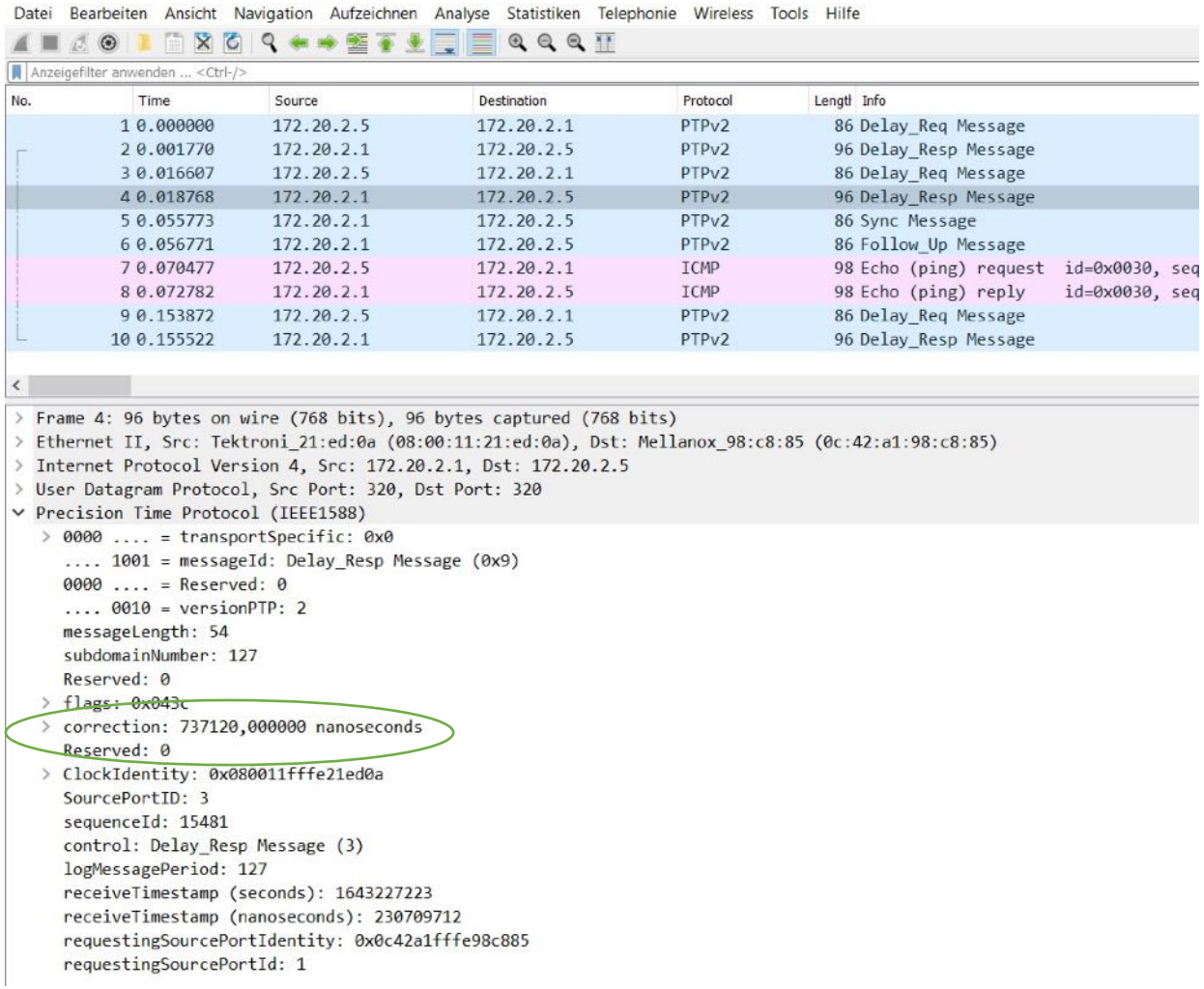
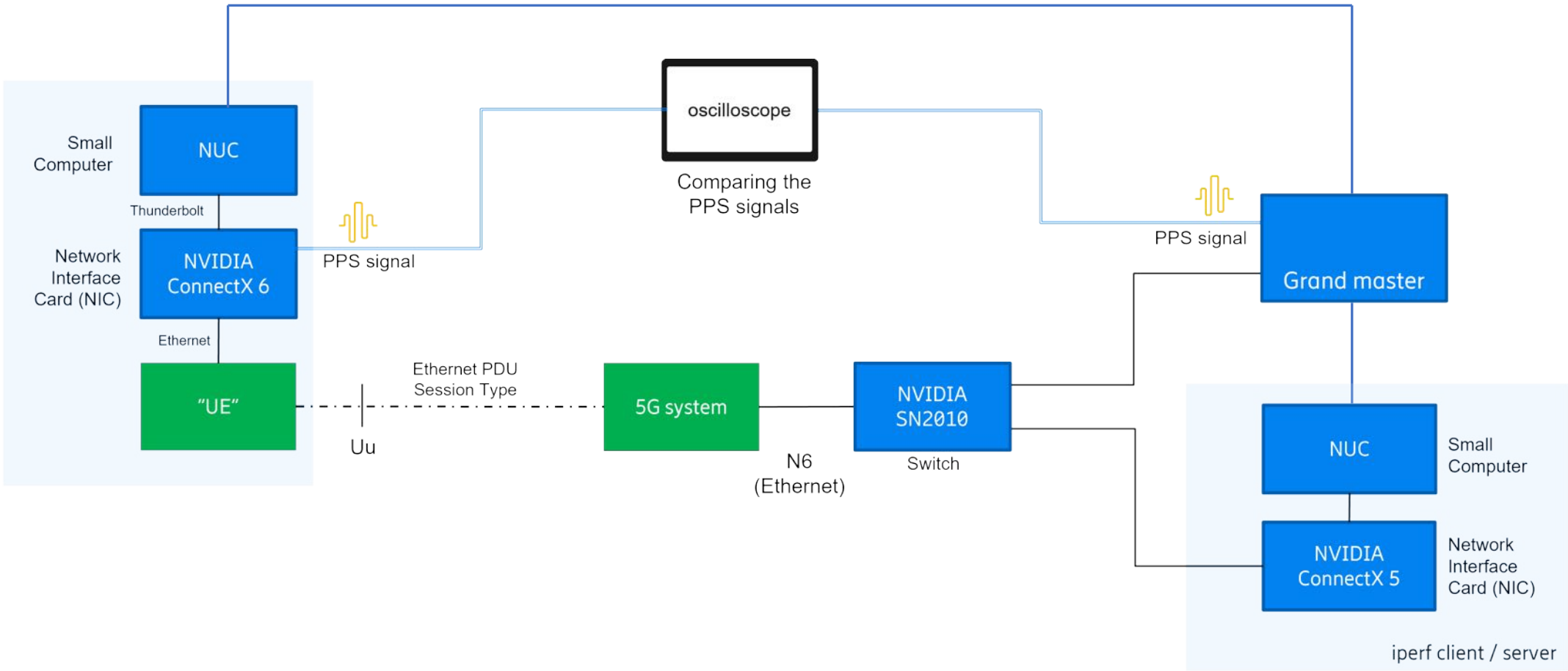
Dynamic correction



- Ericsson URLLC system can detect PTP packets and use the correction fields to signal residence time, thus acting as a TC

Experiment setup



URLLC test network (Rel. 16 + 17 features)

Location	Ericsson Aachen
Setup type	Portable indoor setup (OTA)
Core	NR-SA (Rel. 16 + 17)
Supported band	mmW (28GHz): 27.5-28.3 GHz
Available bandwidth	1-2x 100MHz
MIMO support	2DL/2 UL
Features	TSN 2ms RTT URLLC slice vs eMBB

gNodeB

UE

Hardware components

Nvidia Mellanox ConnectX6 DX

- Dual 100 Gbps interface
- Supports high (single nanosecond) PTP precession
- Outputs PPS signal

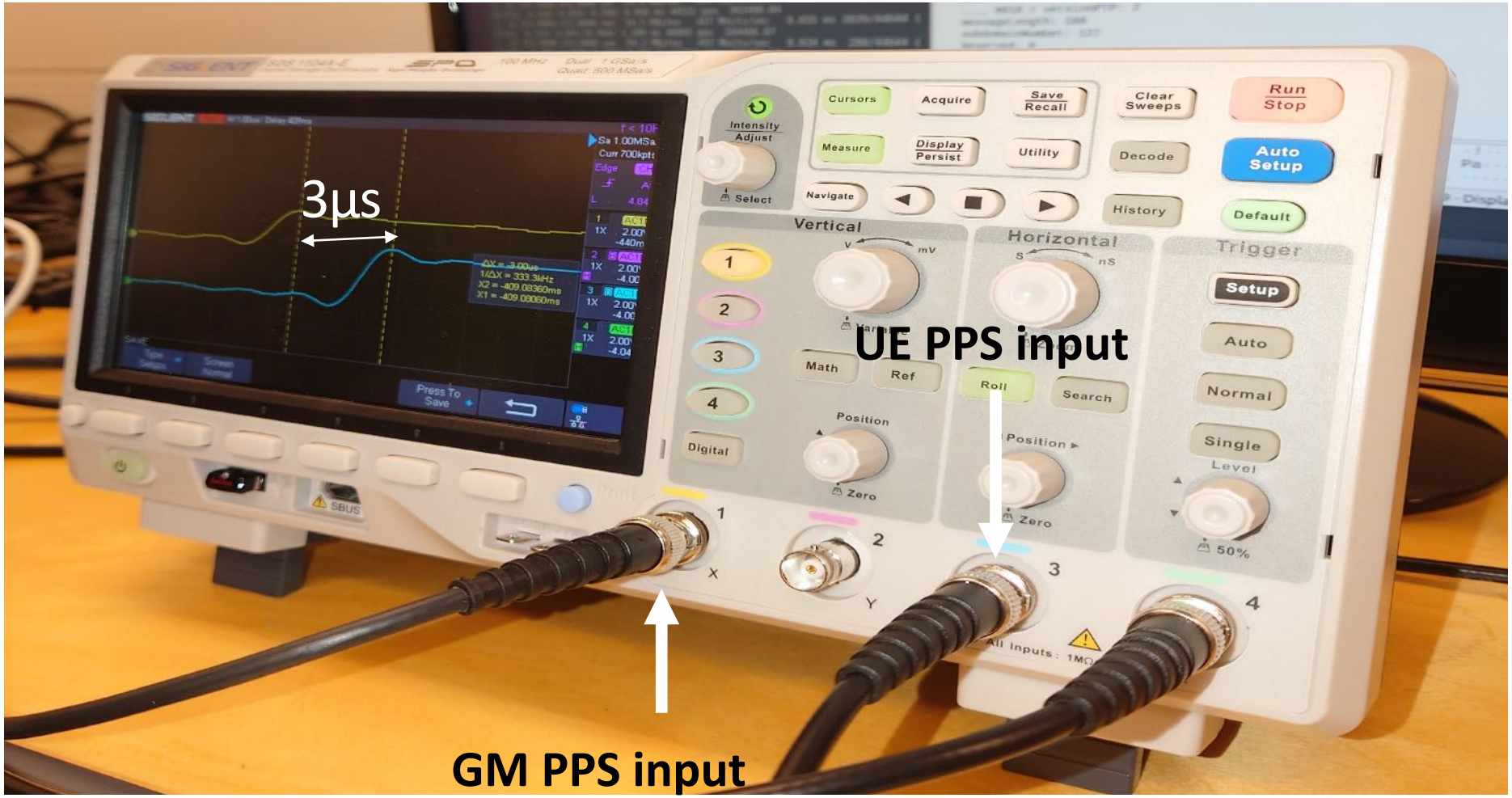
Nvidia SN 2010

Ethernet switch

Tektroniks SPG8000a

- PTP (IEEE 1588-2008)
- SMPTE ST 2059-2 profile in Unicast mode

Oscilloscope measurements



Test 1: Measurements without timing assistance or PTP client's parameters tweaking

The general parameters of the test:

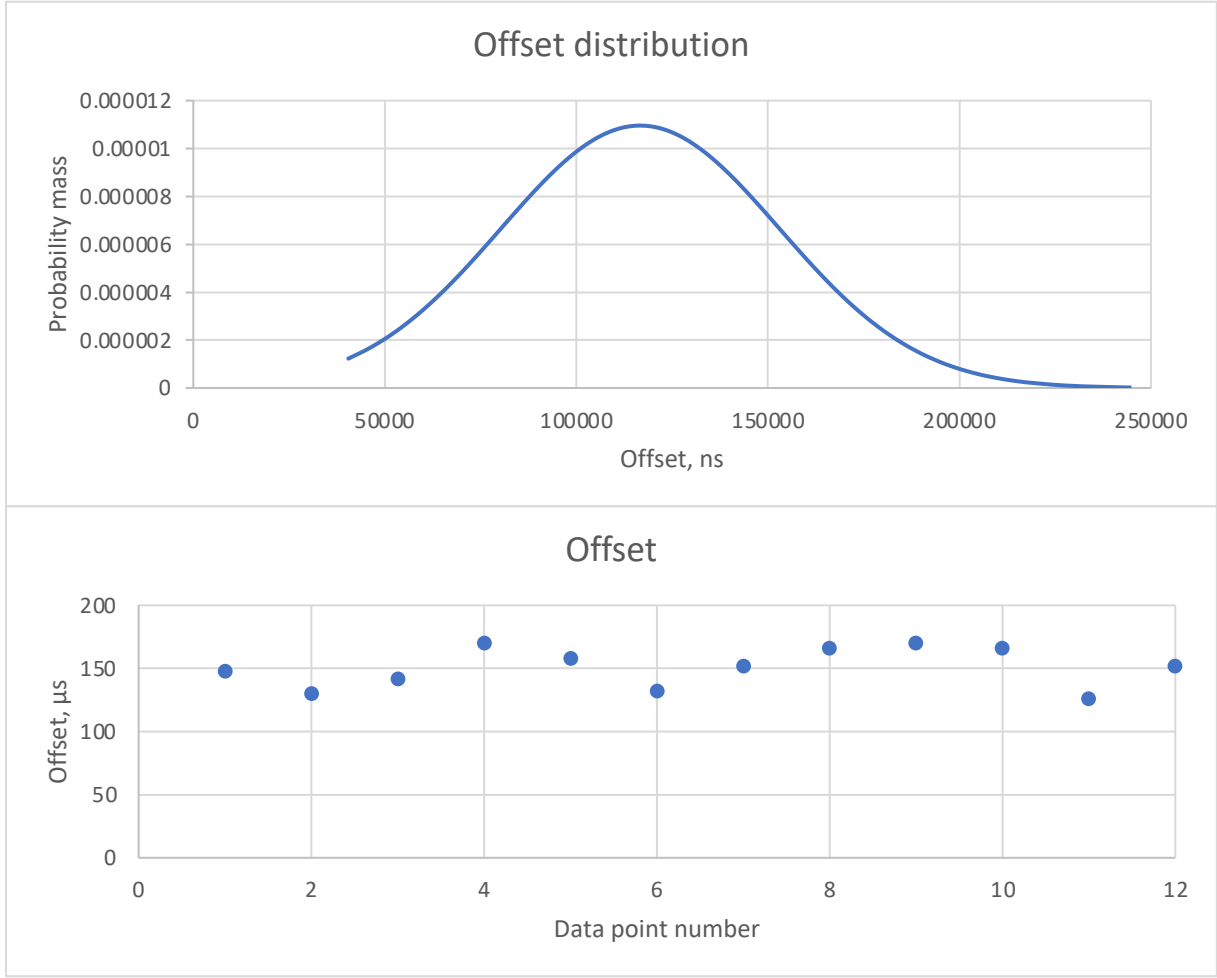
- Residence time provided: No
- PTP servo used: Linear regression
- Advanced servo parameters tweaking: No
- Number of data points: 1577

The main results are the following:

- Average PTP accuracy: 116653 ns (~117 µs)
- Median PTP accuracy: 116036 ns (~117 µs)

PPS measurements results:

- Number of data points: 12
- Average offset: 152 µs



Test 2: Measurements with timing assistance and PTP client's parameters tweaking

The general parameters of the test:

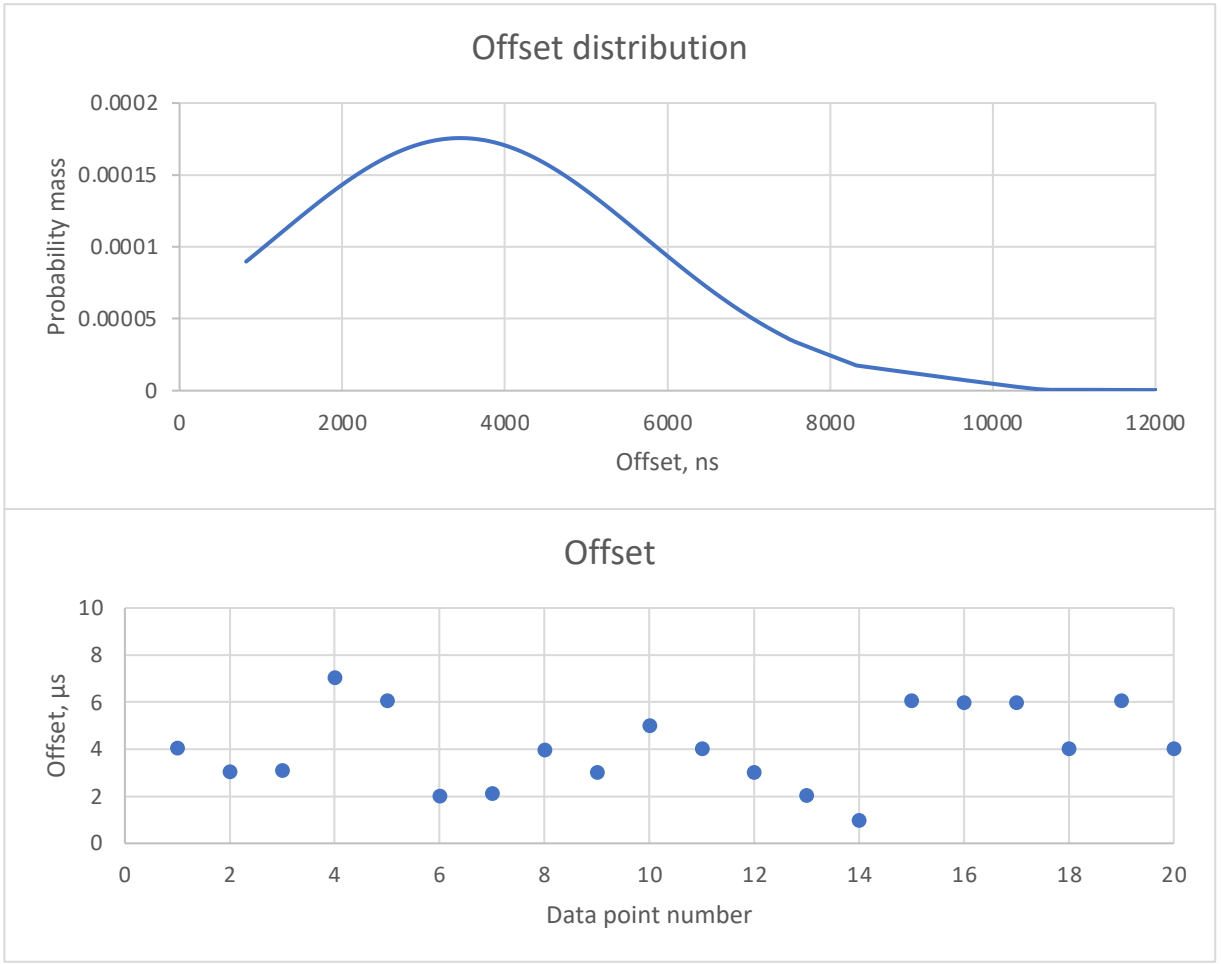
- Residence time provided: Yes
- PTP servo used: PI
- Advanced servo parameters tweaking: Yes
- Number of data points: 932

The main results are the following:

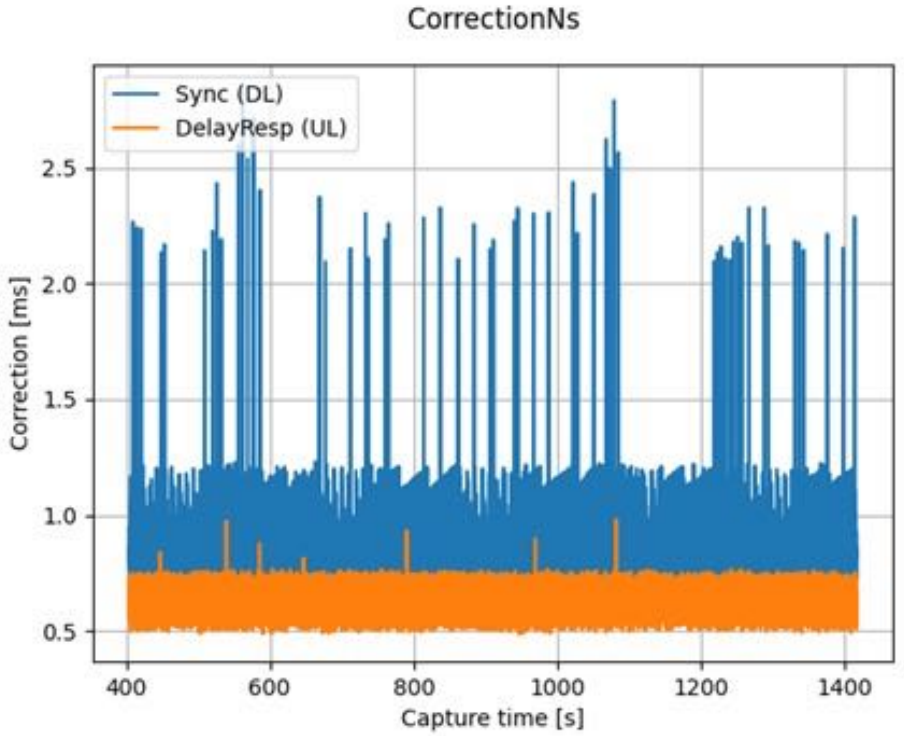
- Average PTP accuracy: 3451 ns (~3,5 µs)
- Median PTP accuracy: 2832 ns (~2,8 µs)

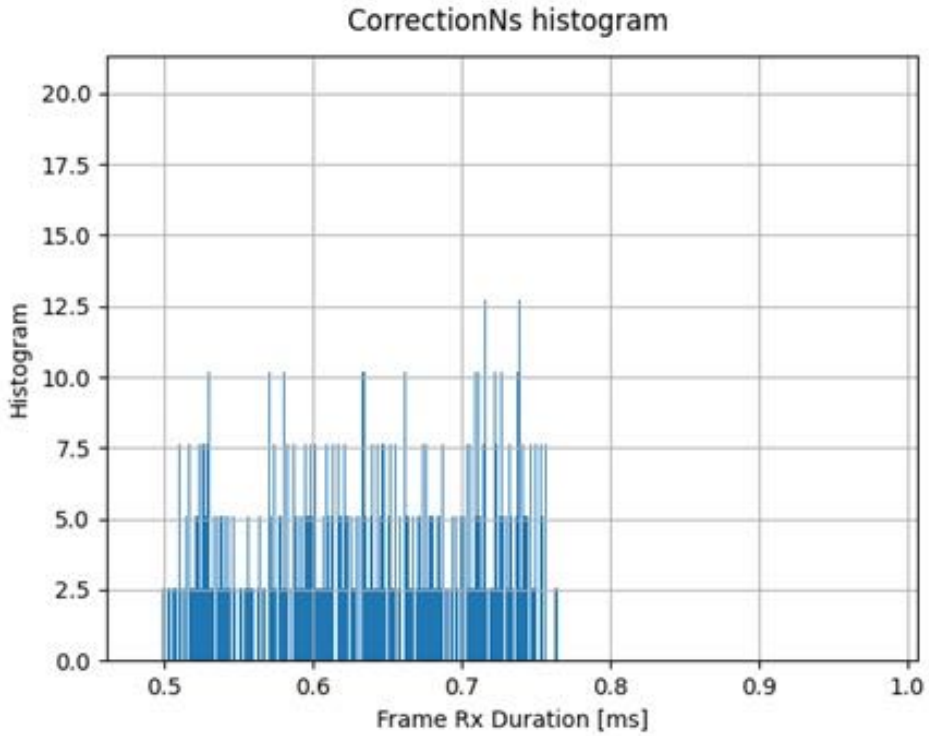
PPS measurements results:

- Number of data points: 20
- Average offset: 4,066 µs



Test 2: Measurements with timing assistance and PTP client's parameters tweaking





Residence time and a histogram of residence time reported by the testbed in correction fields over time for Test 2

Test 3: Measurements with timing assistance but no PTP client's parameters tweaking

The general parameters of the test:

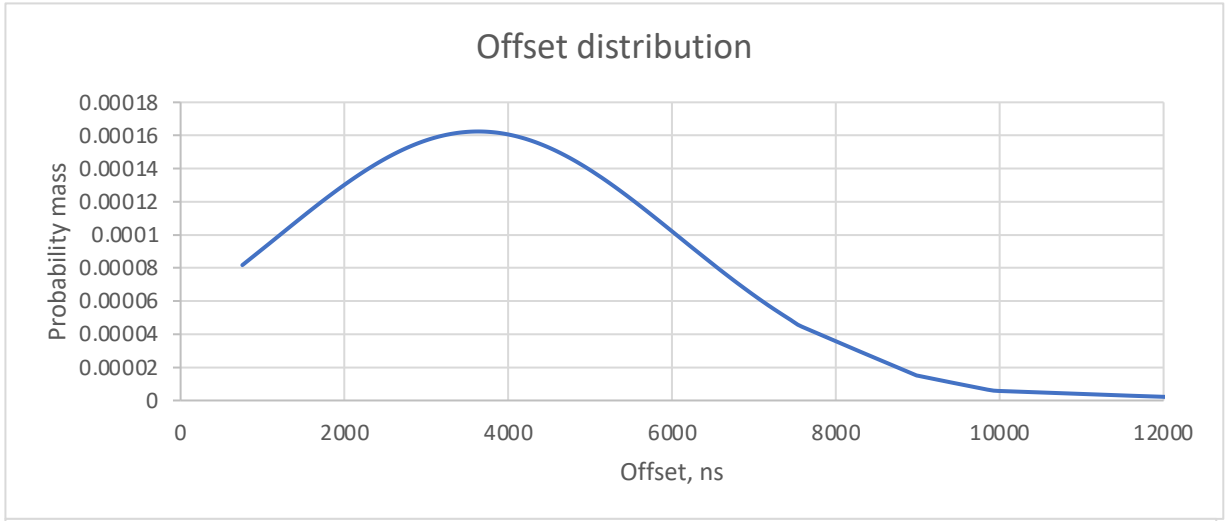
- Residence time provided: Yes
- PTP servo used: Linear regression
- Advanced servo parameters tweaking: No
- Number of data points: 449

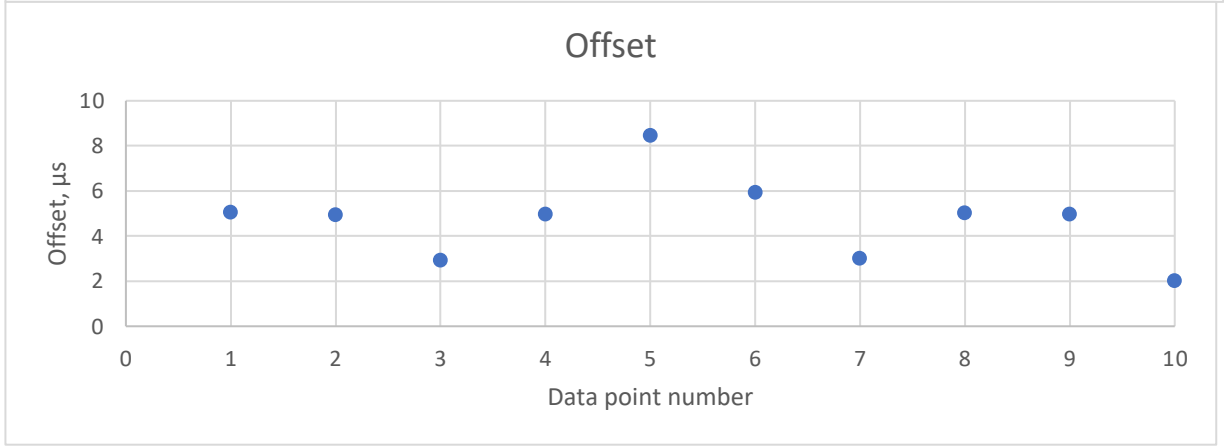
The main results are the following:

- Average PTP accuracy: 3633 ns (~3,6 µs)
- Median PTP accuracy: 3106 ns (~3,1 µs)

PPS measurements results:

- Number of data points: 10
- Average offset: 4,756 µs





Test 4: Measurements under load - in the presence of network congestion

The general parameters of the test:

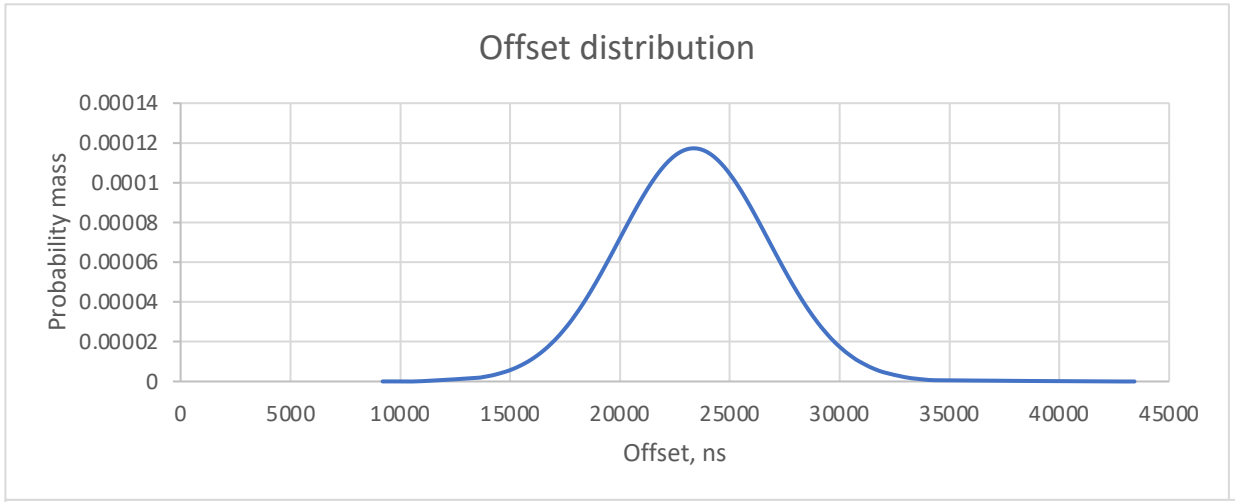
- Residence time provided: Yes
- PTP servo used: Linear regression
- Advanced servo parameters tweaking: No
- Number of data points: 737

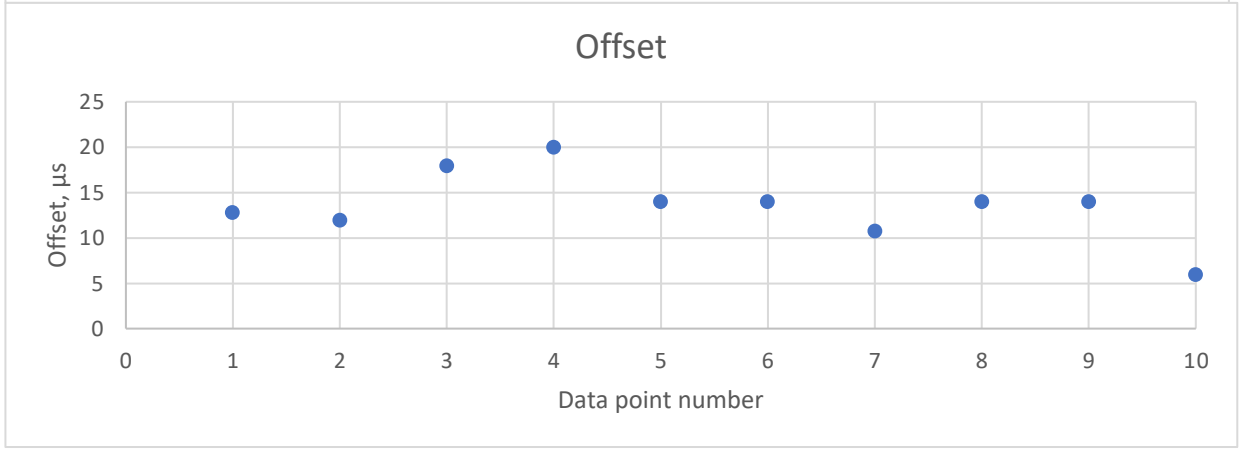
The main results are the following:

- Average PTP accuracy: 23358 ns (~23,4 µs)
- Median PTP accuracy: 23350 ns (~23,4 µs)

PPS measurements results.

- Number of data points: 10
- Average offset: 13,56 µs

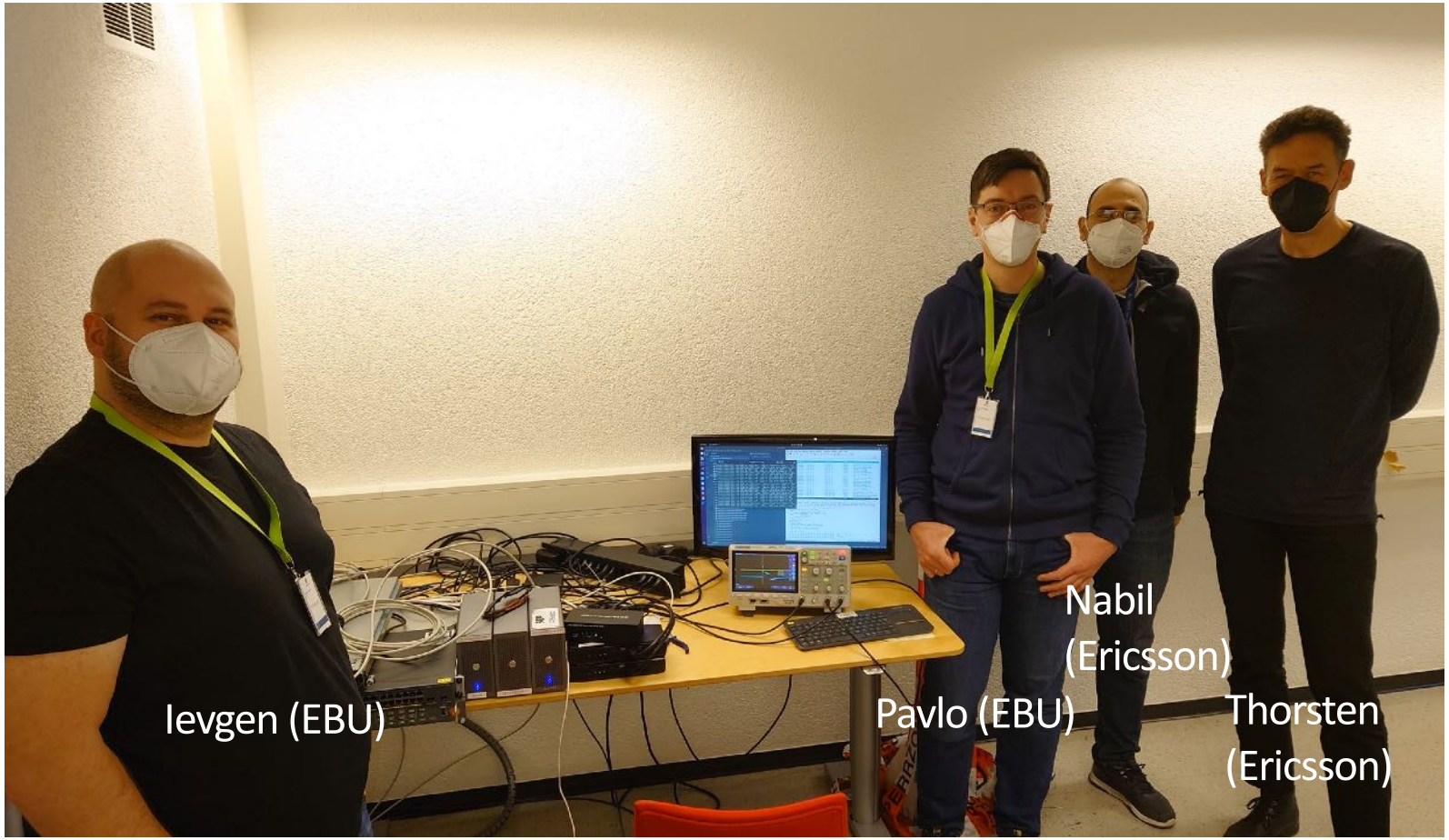




Conclusions

- Synchronization accuracy of less than 4 µs can be achieved with residence time measured and reported by the 5G system compared to ~120-150 µs achieved with the TSN features disabled
- In the presence of network congestion of 80-90% of available bandwidth the accuracy degrades to ~24 µs

Team



+ Not on the picture - Thomas Kernen (NVIDIA) and Ericsson support team

Thank You ….. Or ….. Any Questions?

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