

The White Rabbit Story at Deutsche Börse

13th White Rabbit Workshop
Dr. Georg Sauthoff

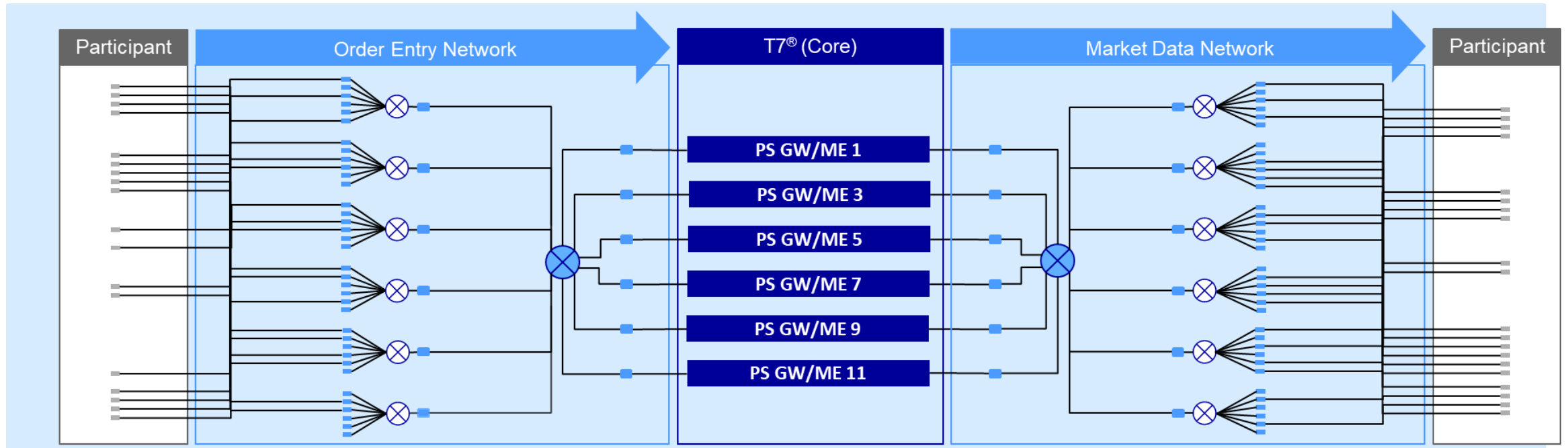
3/19/2024



DEUTSCHE BÖRSE
GROUP



The Big Picture

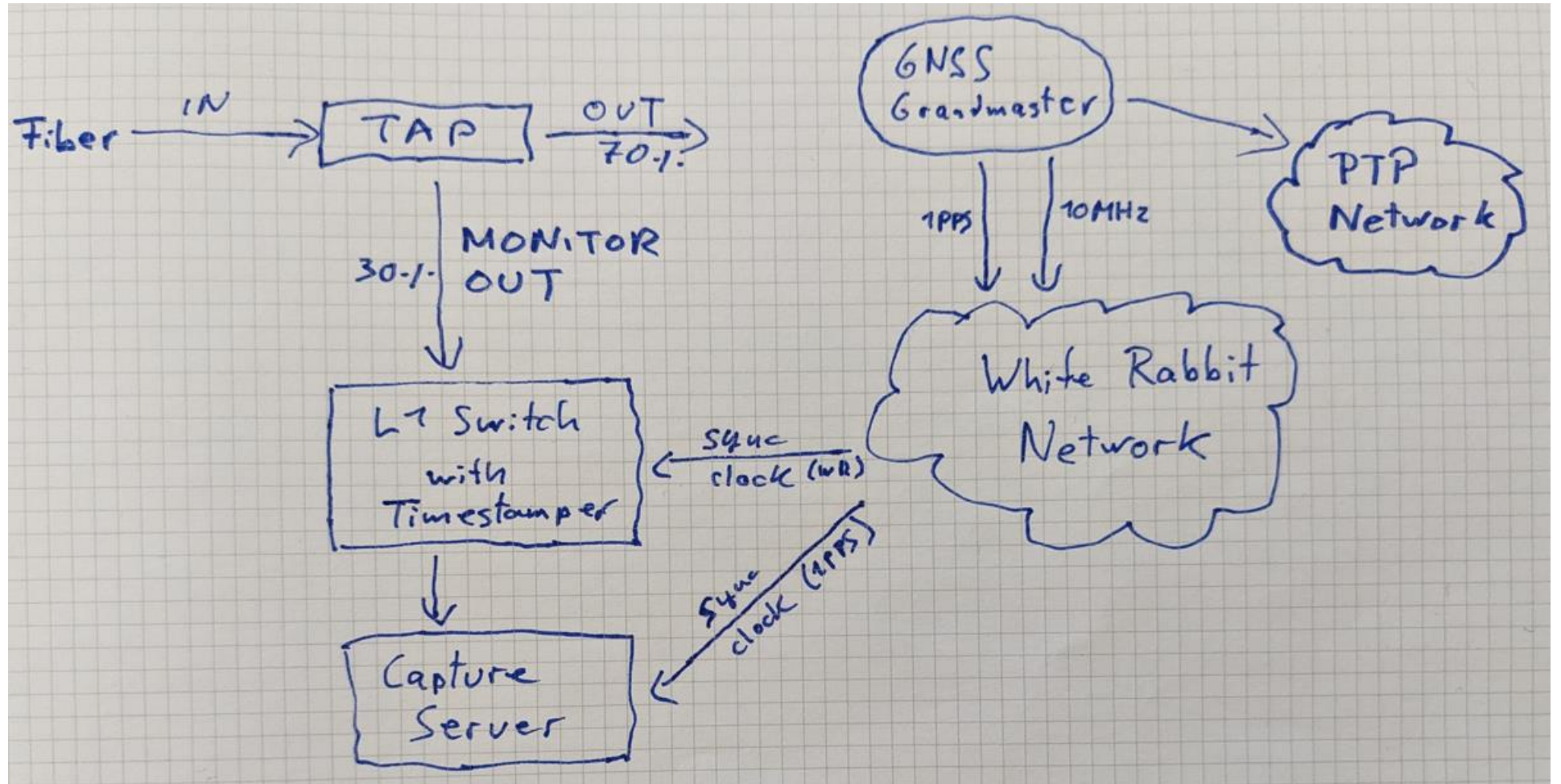


Colo 2.0 Topology

- ⊗ Distribution Layer Switch
- ⊗ Access Layer Switch
- Optical TAP (for capture and timestamping)

Timestamping Overview

NB: network TAP ~= Terminal Access Point (backronym)



Timestamping Overview

- For monitoring, all network traffic is captured
- Each captured packet is timestamped, i.e. a timestamp is attached
- Timestamps have sub-nanosecond resolution

Timestamp Trailer

- ▶ Transmission Control Protocol, Src Port: 19043, Dst Port: 45345, Seq: 137, Ack: 817, Len: 136
- ▶ Enhanced Trading Interface 11.0, ModifyOrderNRResponse (10108), BodyLen: 136
- ▼ Metamako ethernet trailer, Timestamp: 13:05:00.000151592, Source Device: 66, Source Port: 11
 - Original FCS: 0xb0aa5c32
 - ▼ Trailer Extensions, Sequence No: 680
 - Sequence Number: 680
 - ▼ Time Stamp: Jan 17, 2023 13:05:00.000151592 CET
 - [Time Difference: -0.000010408 seconds]
 - ▼ Flags: 0x03, Original FCS Valid, Has Trailer Extensions
 -1 = Original FCS Valid: Valid
 -1. = Has Trailer Extensions: True
 - 0000 00.. = Reserved: 0x00
 - Source Device ID: 66
 - Source Port: 11

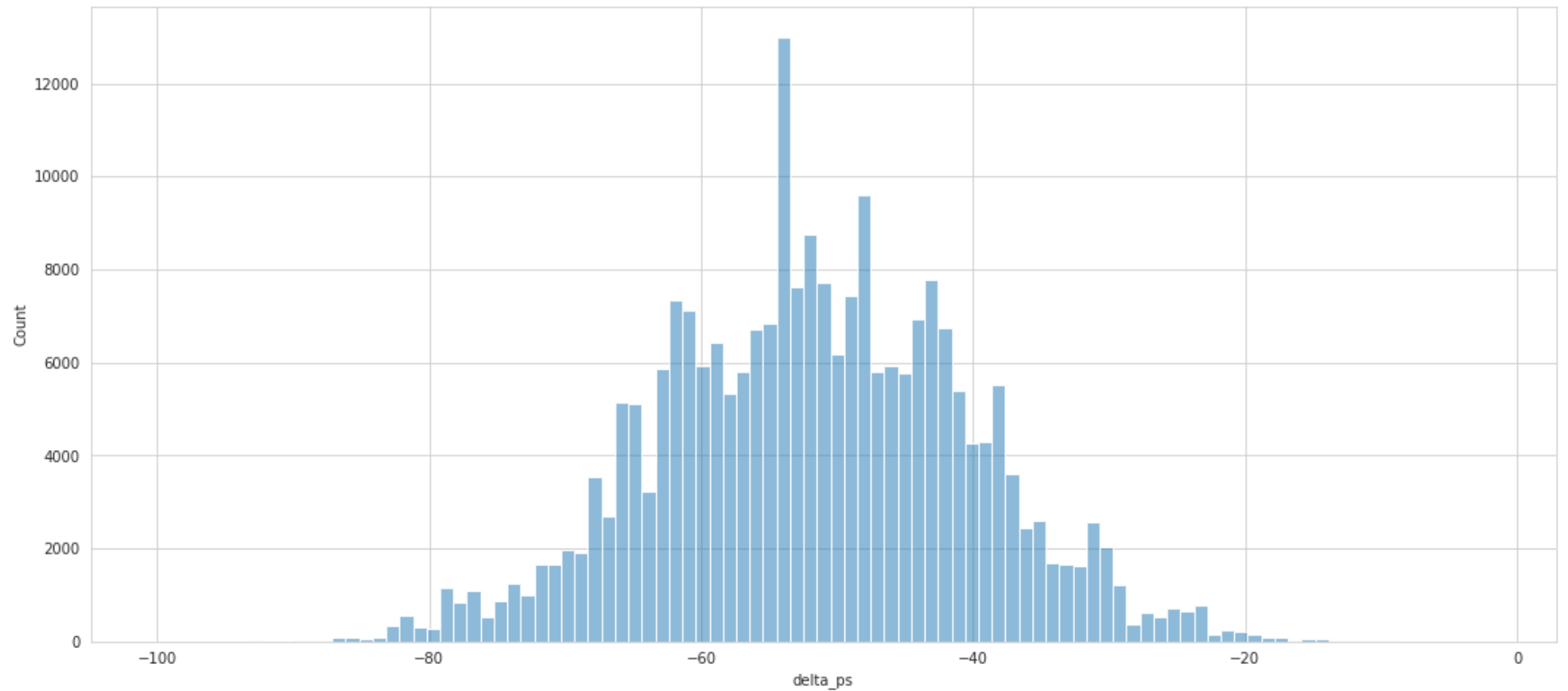
```
00d0 43 0a b0 aa 5c 32 00 02 a8 20 63 c6 8e ec 00 02 C:\2
00e0 50 28 03 00 42 0b P(\B
```

White Rabbit – A perfect match

- White Rabbit synchronizes clocks with sub-nanosecond precision and accuracy
- When monitoring participants competing over single nanoseconds,
this performance is required
- More and more devices support it natively

White Rabbit Sub-Nanosecond Performance

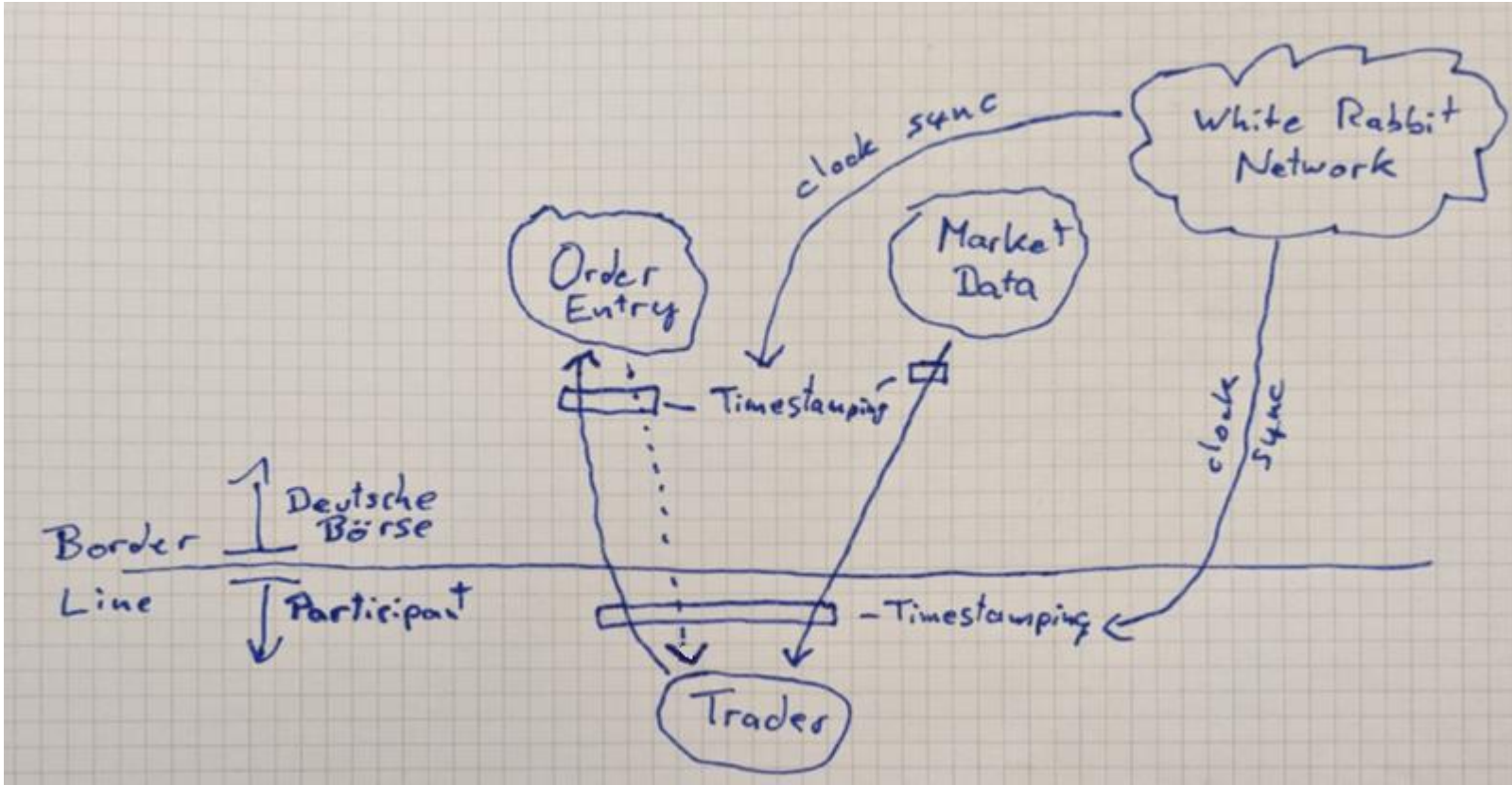
Offsets between two White Rabbit switches, over 2.5 days:



Deutsche Börse Services built around White Rabbit

- Monitoring that integrates high-precisions timestamps extensively (network/applications)
 - Troubleshooting
 - Verification that our trading system stays fair
 - Performance analyses
 - ...
- White Rabbit Network Access
 - Co-located participants can connect to our White Rabbit network
- High Precision Timestamp (HPT) Service
 - Provide transparency to participants

White Rabbit Access – Participant Point of View



Customer Feedback

- ‘DB even sells extra timestamps taken out of band for more insight.’
- ‘Very interesting!’
- ‘Great business model!’
- ‘Ultimate expression of time is money.’
- ‘Publishing internal timestamps is great for transparency.’



Outlook

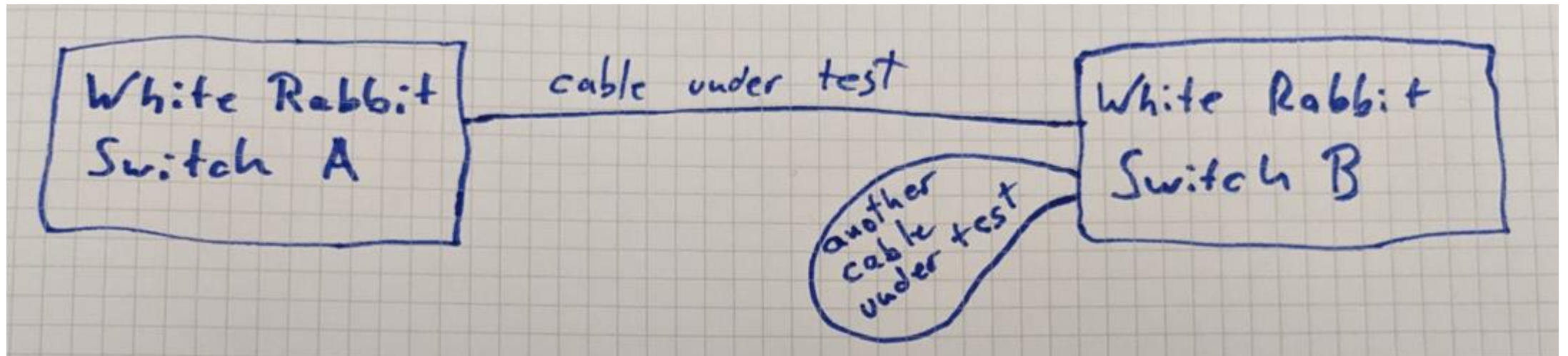
Use White Rabbit for all the things?

- Use White Rabbit for measuring the lengths of cables
- Why not just connect also all the server to the WR network?
 - => to increase accuracy/precision of server generated timestamps
 - status quo: servers are connected to dedicated PTP network

Cable Length Measurement

Since White Rabbit devices are very good at measuring delays ...

- ... why not use a White Rabbit device for measuring the length of cables
- => insert the cable into the path somehow, query the delay, convert delay to length



Connecting servers to White Rabbit

Possible approaches:

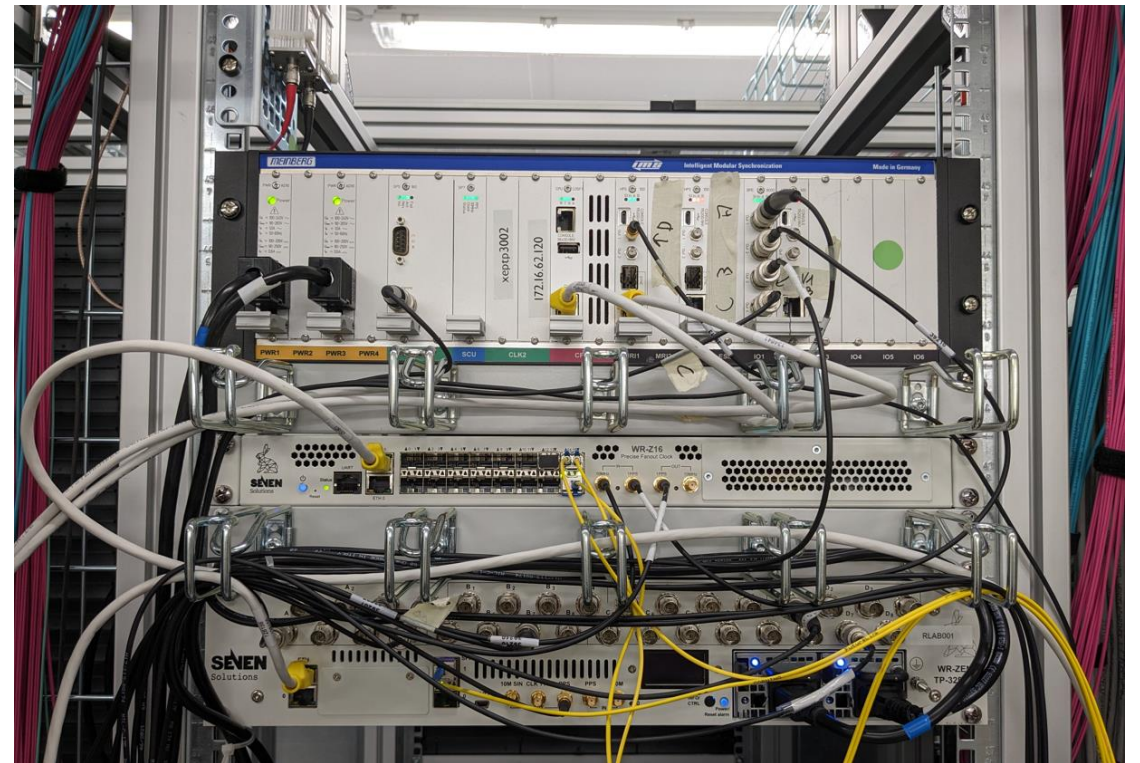
1. Hybrid – White Rabbit into a rack and the last meters:
 1. 1PPS
 2. PTP / SyncE
2. Find a Network Interface Card (NIC) that supports White Rabbit

Hybrid: 1PPS

WR endpoint + 1PPS splitter



1PPS splitter that directly connects to WR



Hybrid: 1PPS

Advantages:

- Good network cards (NIC) with 1PPS input are easy to find

Disadvantages:

- Requires NIC with high quality oscillator
- Easy to introduce errors in the 1PPS cabling
- Operationally challenging

Network card with native White Rabbit

Arguably, having a good network card with native White Rabbit would be the best solution.

- For hardware timestamping on the NIC
- Next step: PTM to better synchronize the system clock to the NIC clock

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Appendix

Where to get more Information

- Insights into Trading System Dynamics (Deutsche Börse's T7), May 2023
<https://www.xetra.com/resource/blob/2419076/e8d4df56f75c9a96fb0f6fff6b18a14f/data/Deutsche%20B%C3%B6rse%E2%80%99s%20T7%20-%20Insights%20into%20trading%20system%20dynamics.pdf>
- HPT Analysis Example Notebook (2018-12-10)
<https://www.mds.deutsche-boerse.com/resource/blob/1486254/682c971319c8233513fe9a046db85c6c/data/High-Precision-Timestamps-hpt-zip.html>
- Follow Stefan Schlamp on LinkedIn for market (micro) structure analyses snippets