



Sync on TAP - Syncing Infrastructure with Software

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Agenda

- Data centre / General trends
- Motivation for Synchronization with Software
 - Time Apliance Project
 - O-RAN architecture
- Software (Virtual) Synchronization
- Options; results; Interfaces;

General Trends

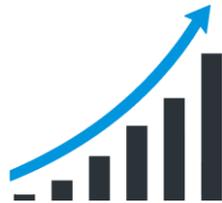
Miniaturization



Consolidation



Accuracy;
Resiliency;
Security



Cloud Trends

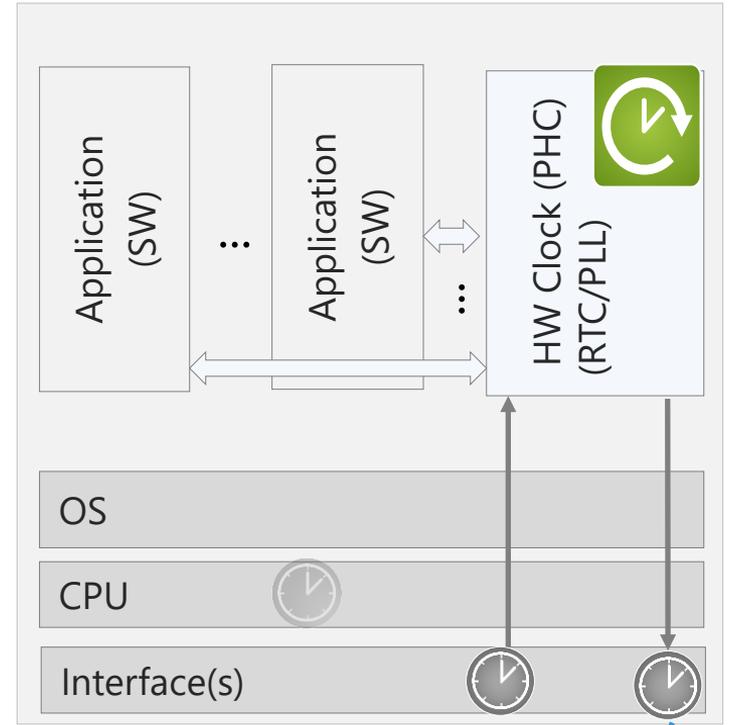
Scalability
(synchronization management) ⇒ Explosive growth

Sustainability ⇒ Open Source (White Box)
(efficiencies of scale)

New role of Software in synchronization

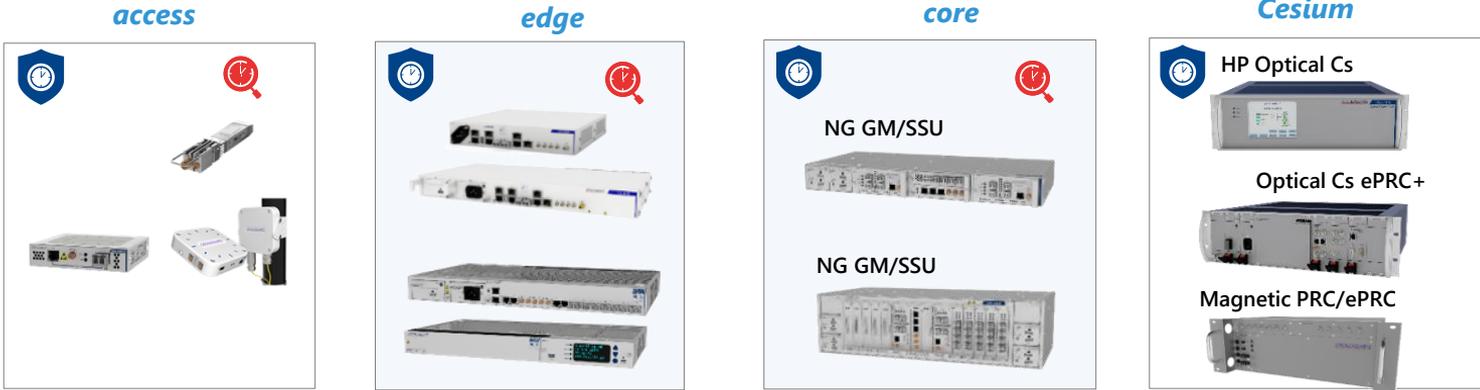
Clocks - Hardware with "soul"

- HW Timestamping of Events
- Accuracy HW (~1ns)
- Accuracy SW (~1us)
- Huge vendor investment



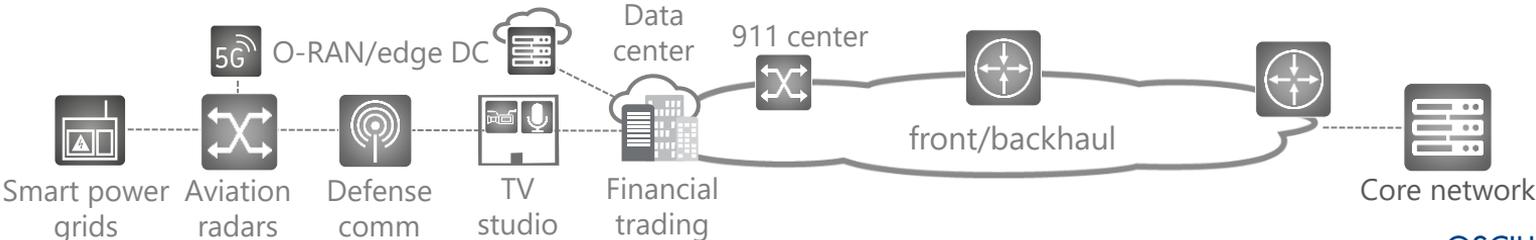
PPS or PTP

Existing clocks/applications use Dedicated HW



device/network Monitor

PNT cyber threats



Software Synchronization

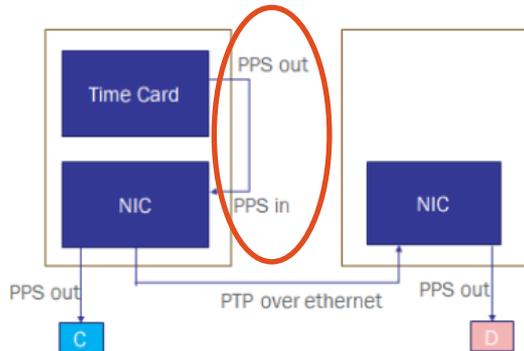
Why?

Datacenters - Open Time Server

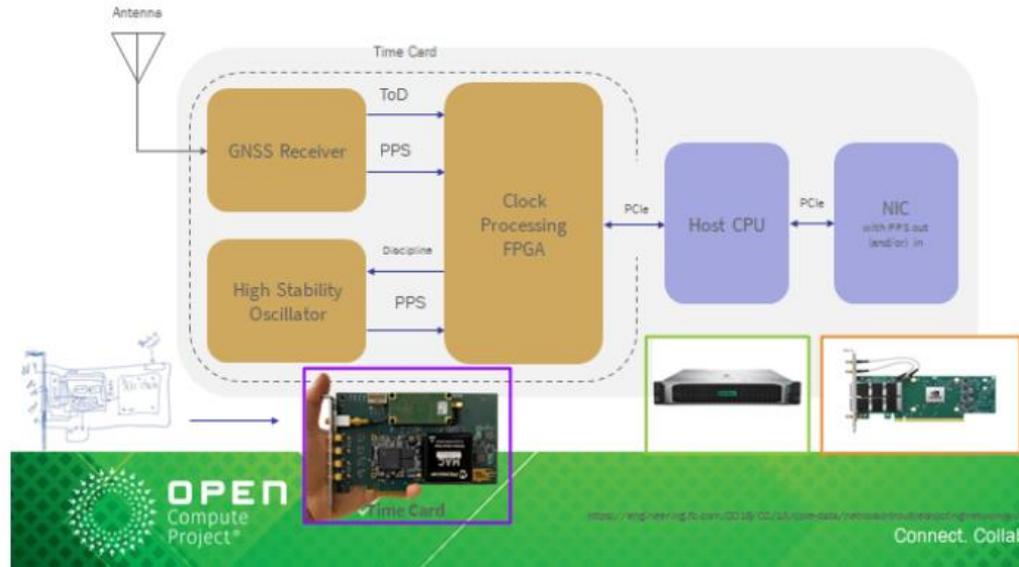
= TimeCard + **Standard Server** + Standard NIC

- Interconnect via PCIe (using PTM)
- Optional PPS connections (to ensure high accuracy)

TAP use case:

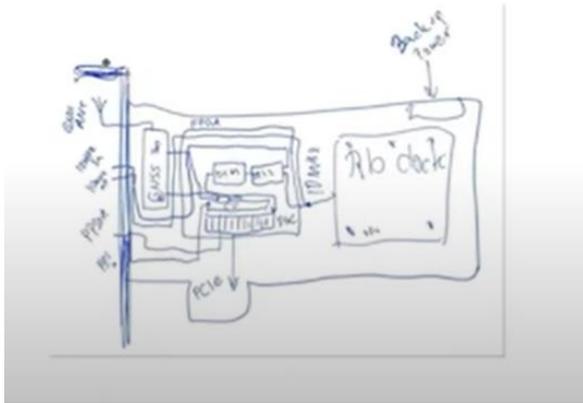


Open Time Server

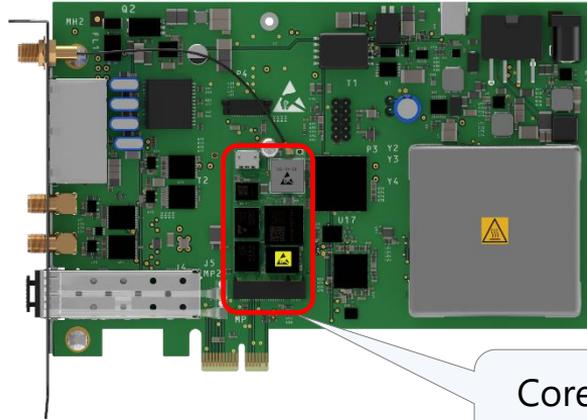


OSA PCIe TimeCard with M.2 module as core

Concept



Implementation

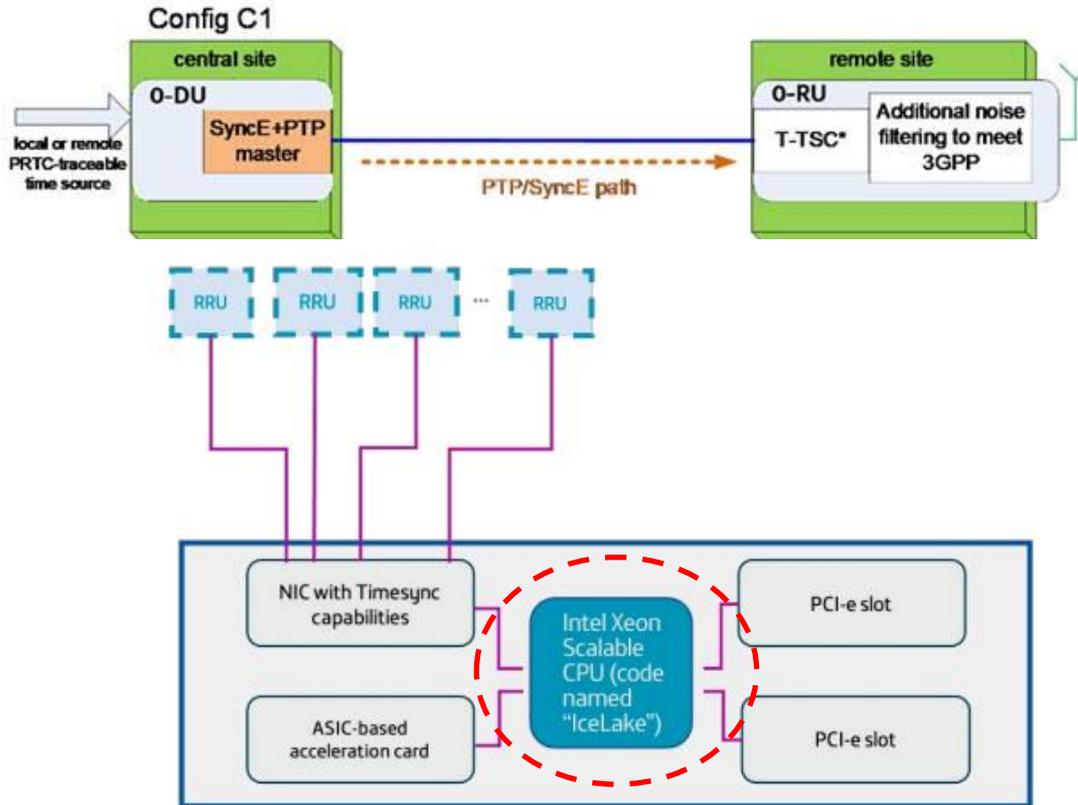


Core built as M.2 Sync Module

M.2 slot is commonly available and allows smooth sync add on

Telecoms - Open-RAN Architecture

O-RU based on whitebox server + NIC + Accelerator



High accuracy sync over PCIe

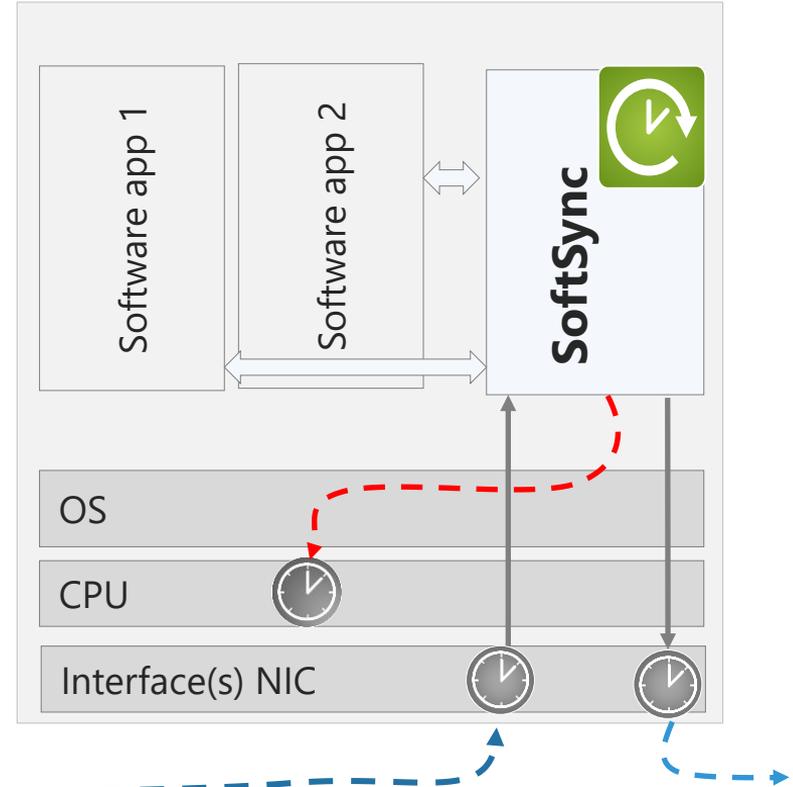
Software Synchronization

HOW?

Whitebox server with SoftSync

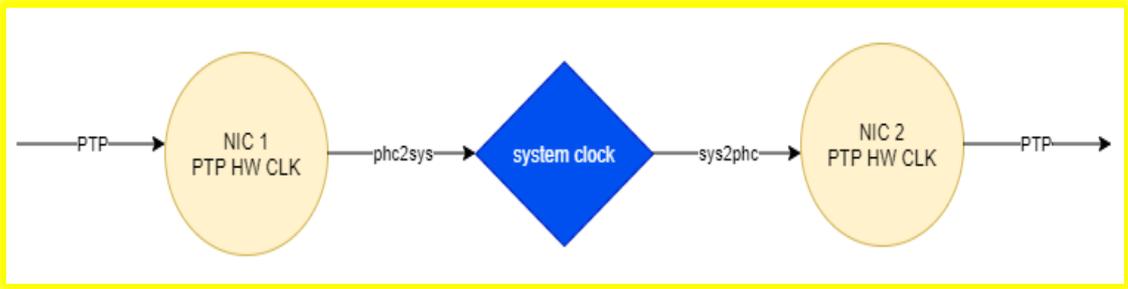
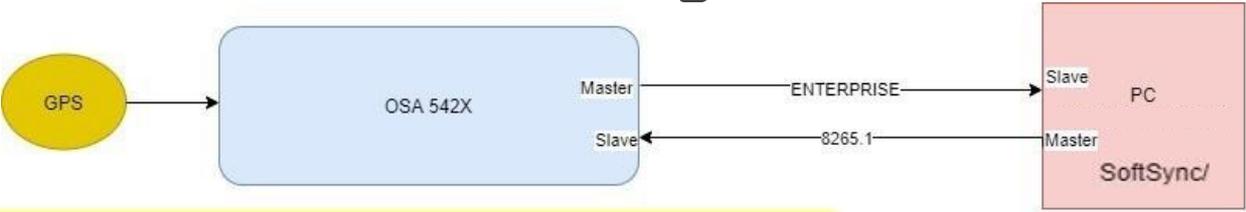
Oscilloquartz solution

- HW Timestamping NIC (Intel)
- SoftSync PTP client on host machine
- Synchronizes OS with system APIs
- Performance ~ 100ns (Timestamping NIC)

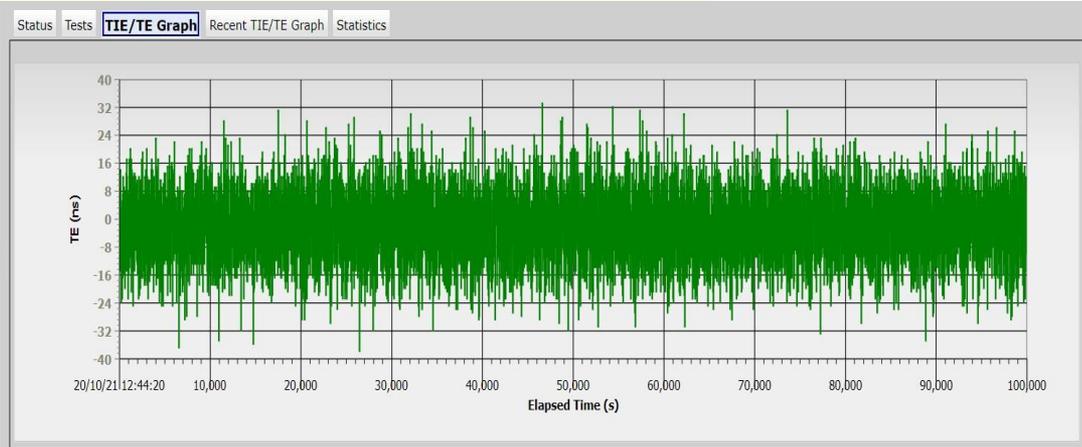


PPS or PTP

SoftSync Measurement using G.8265.1 Master

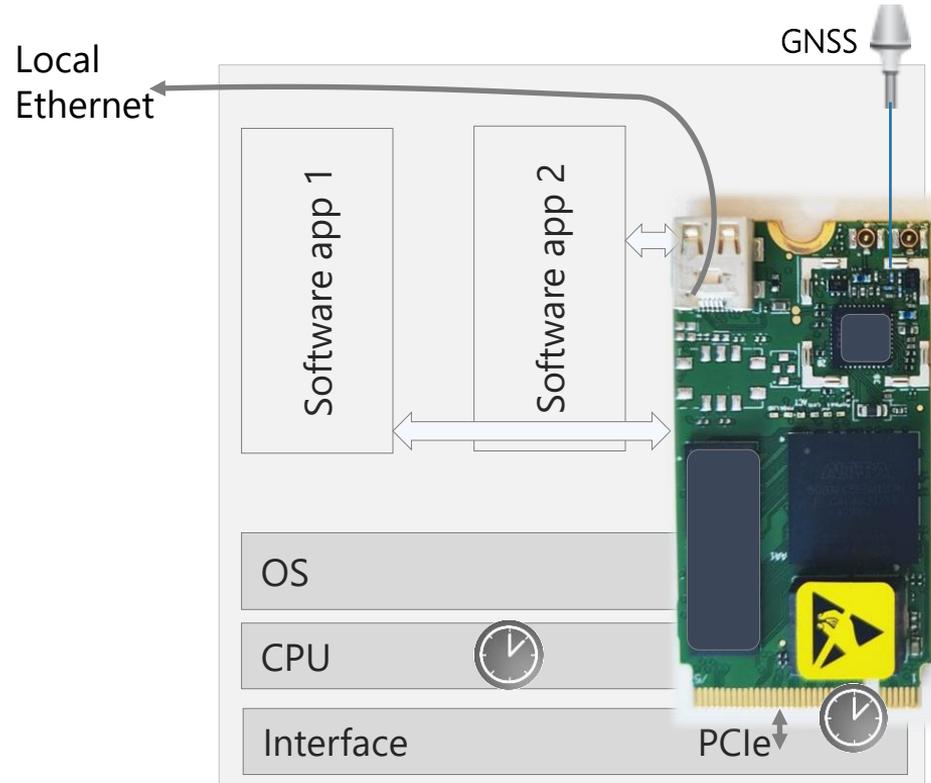


Back to Back



Whitebox server with PCIe / M.2 interface

- GNSS input
- Local Ethernet Port (PTP)
- No offset between GNSS and Ethernet
- PCIe port



Synchronization over PCI-e (PTM)

Precision Time Measurement

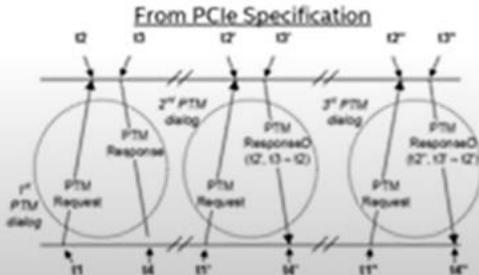
Using PCIe PTM to Cross-Timestamp

(PTM=Precision Time Measurement)

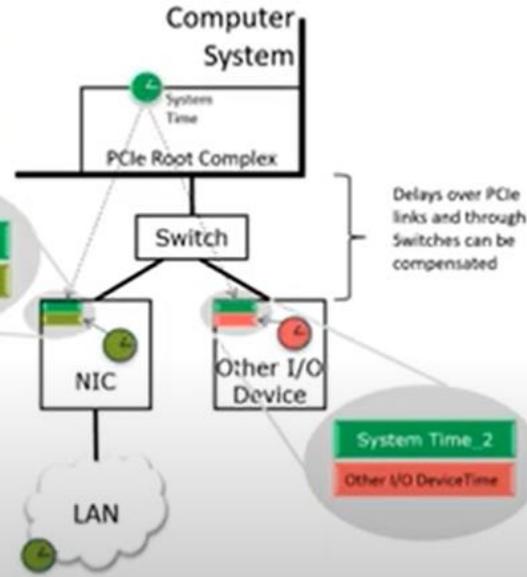
Sample Scenario:

1. Device Driver Triggers Cross-Timestamp
2. Device initiates *PTM Request* TLP to Root Complex
3. System Time is Returned (delays are compensated)
4. (PTM Time, PTP Time) returned to NIC Device Driver
5. Software "disciplines" Coefficients per clock: m (and c)

Cross Timestamps,
Captured Simultaneously



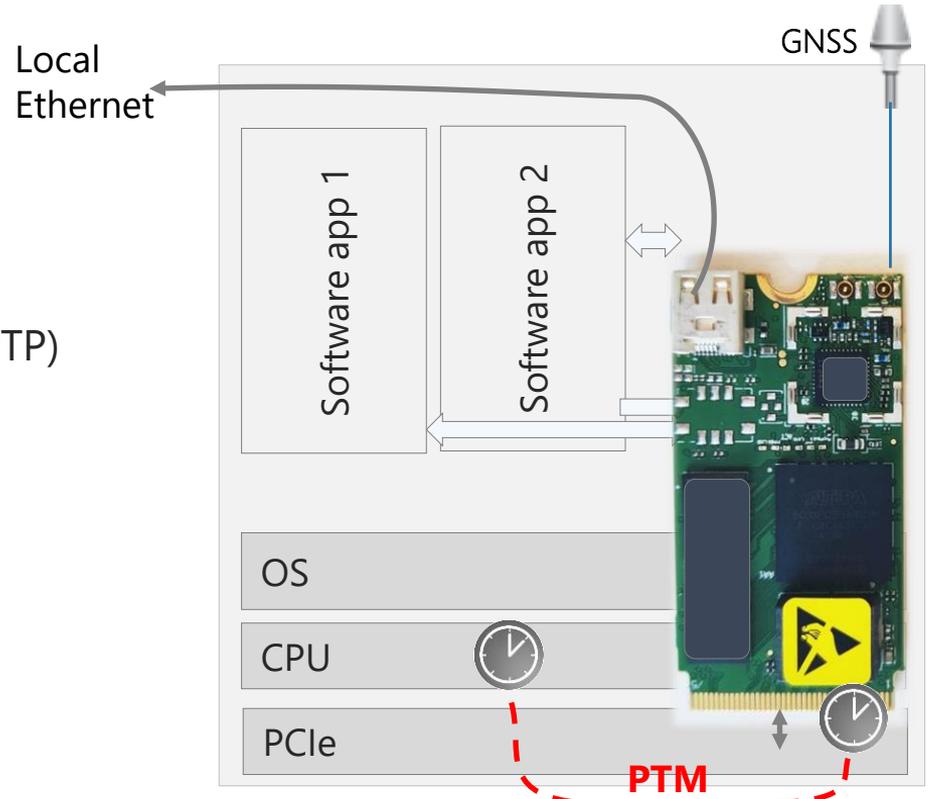
Cross Timestamps → 'm' and 'c' Coefficients



Whitebox server with PCIe / M.2 interface

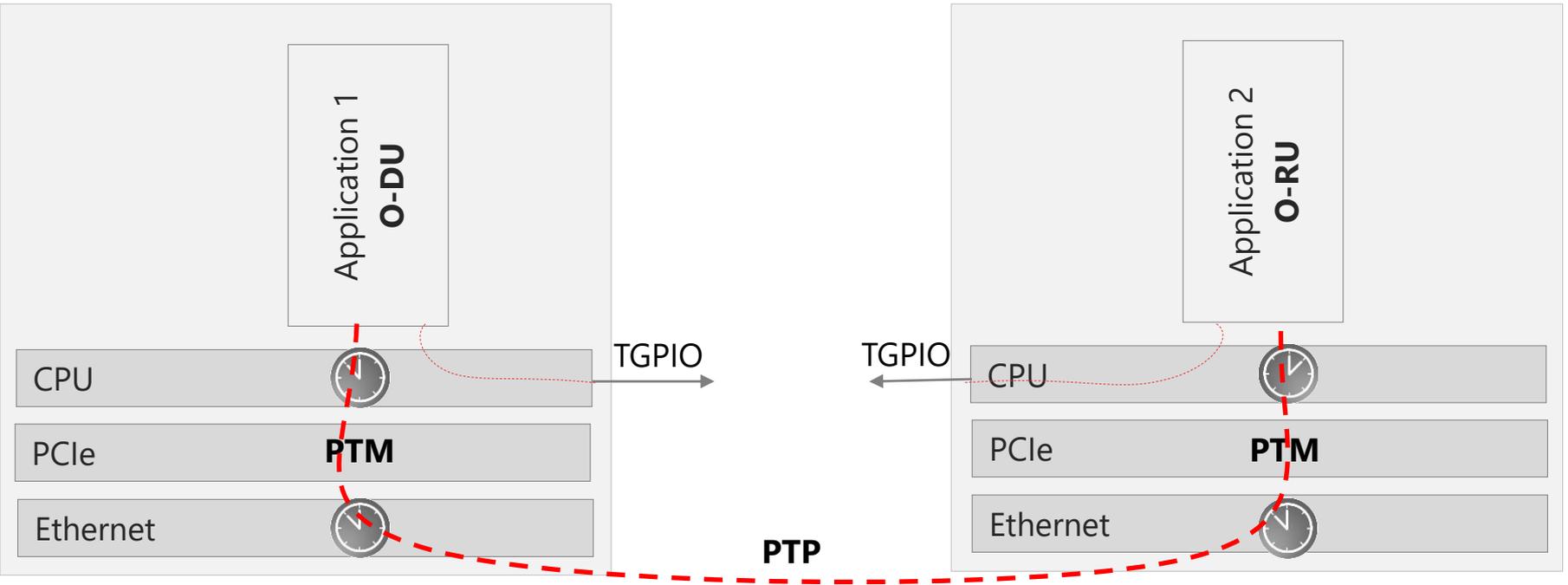
PTM on PCIe to improve performance

- PTM support on PCIe
- PCIe \leftrightarrow CPU $\sim 10\text{ns}$
- CPU \leftrightarrow OS $\sim 1\text{ns}$
- No offset between GNSS and Ethernet (PTP)
- Class C BC possible
- PTM available 2023



Infrastructure synchronized by SW

Synchronization of virtualized applications E.g. O-RAN



What Other Applications?

Conclusions

- 1) Highest Accuracy applications requires dedicated HW
- 2) Sync on COTs Server (TAP; O-RAN)
 - Available today ~100ns (e.g SoftSync)
 - PTM enables ~10ns accuracy (also for virtualized sw)
 - PCIe = Timing interface
- 3) M.2 Sync Module = small footprint PCI-e



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Thank you

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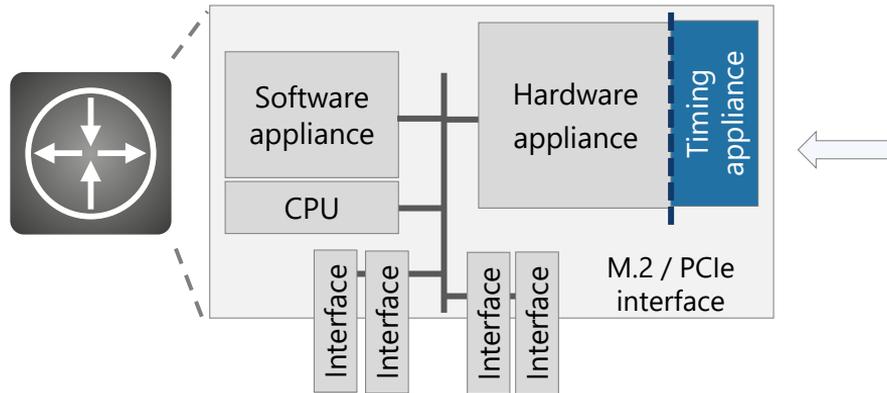
Back-up slides

While M.2 Sync Module natively supports PCIe...

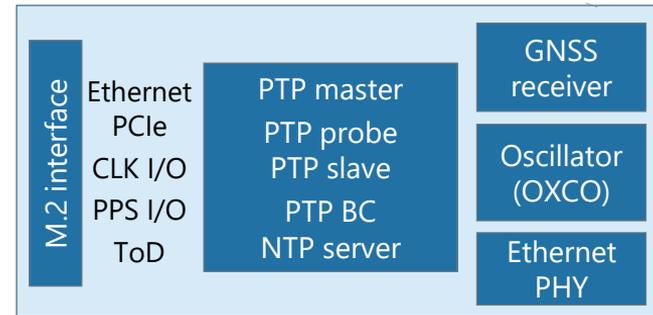
It can be extended to other applications



Generic architecture of a network device

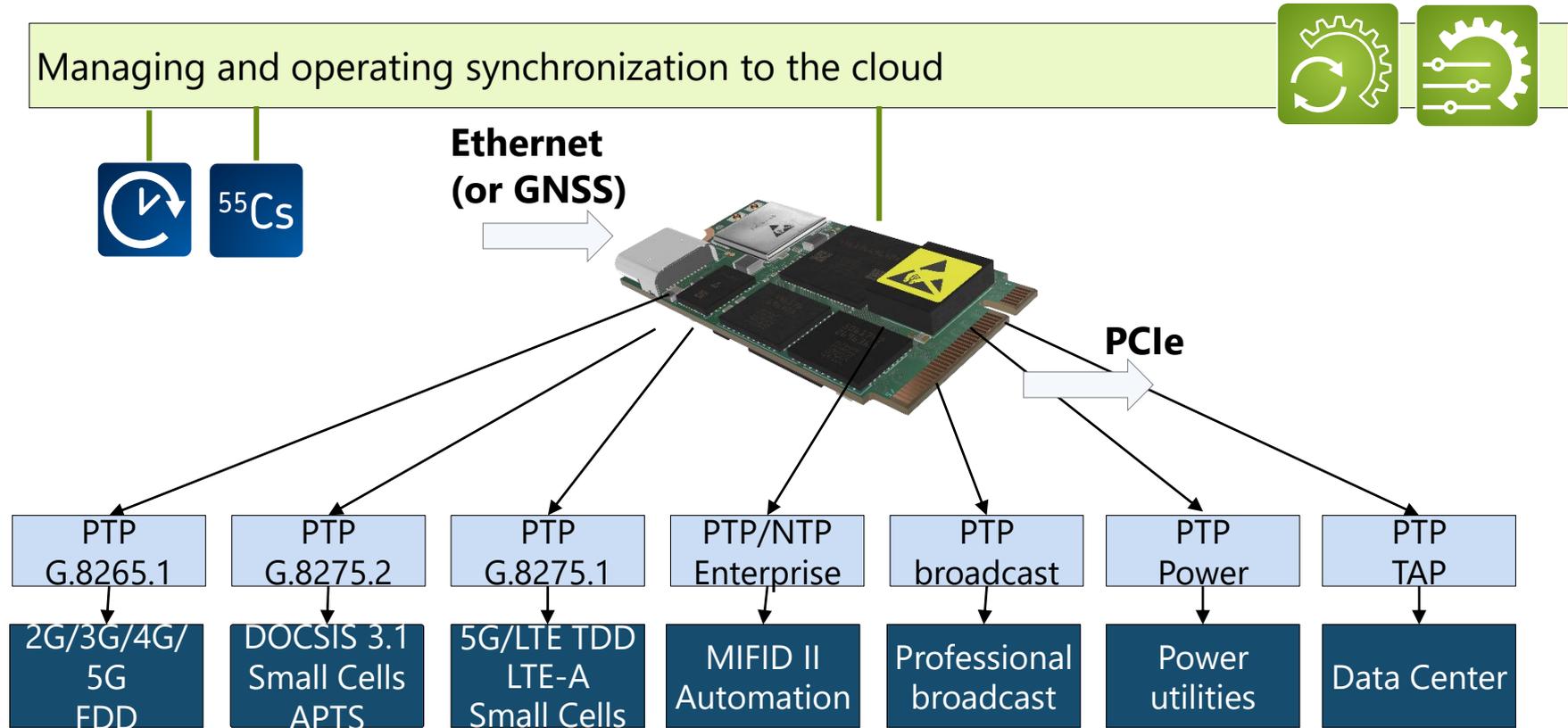


M.2 Sync Module



M.2 provides sync to host devices

M.2 Sync Module synchronize many applications



Time Appliance Project

Platform for cross-industry Sync with focus on DataCenters

Open Compute Project

<https://www.opencompute.org/>

Mission

1) Create specifications and references for **Data Center Timing** appliances, applications and networking infrastructure:

- Open Time Server
- DC profile coming...



2) Promote openness in **Timing Appliances** and interfaces through open-source implementations

Major sources of Time error

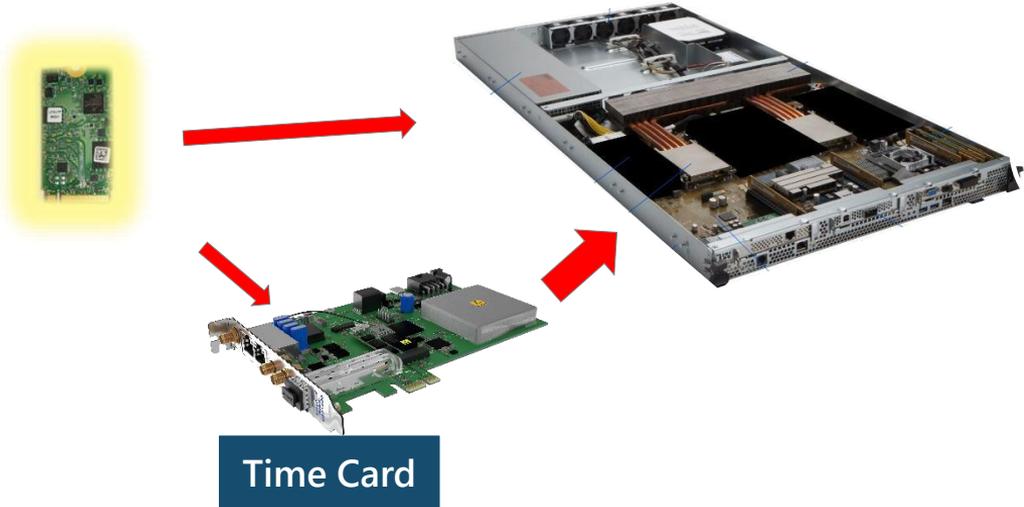
Ranking may vary...

Error Category	Error type	Solution
Antenna delay compensation	Offset; Hassle	Use PTP from antenna
PTP over non-sync network	Risk	High packet rate; Evaluate; Monitor; Pray...
PTP over PCI-e (Soft Sync...)	Temporal	PCI-e with PTM support; (PPS connection)
GNSS outages	Risk; Bomb	Backup; Multiband GNSS; Spoofing mitigation;

Synchronization is a discipline

How to interface to a WhiteBox Card or Server

Module
M.2 interface to Host



Embedding timing expertise in 3PP network devices

Introduction- M.2 SyncModule



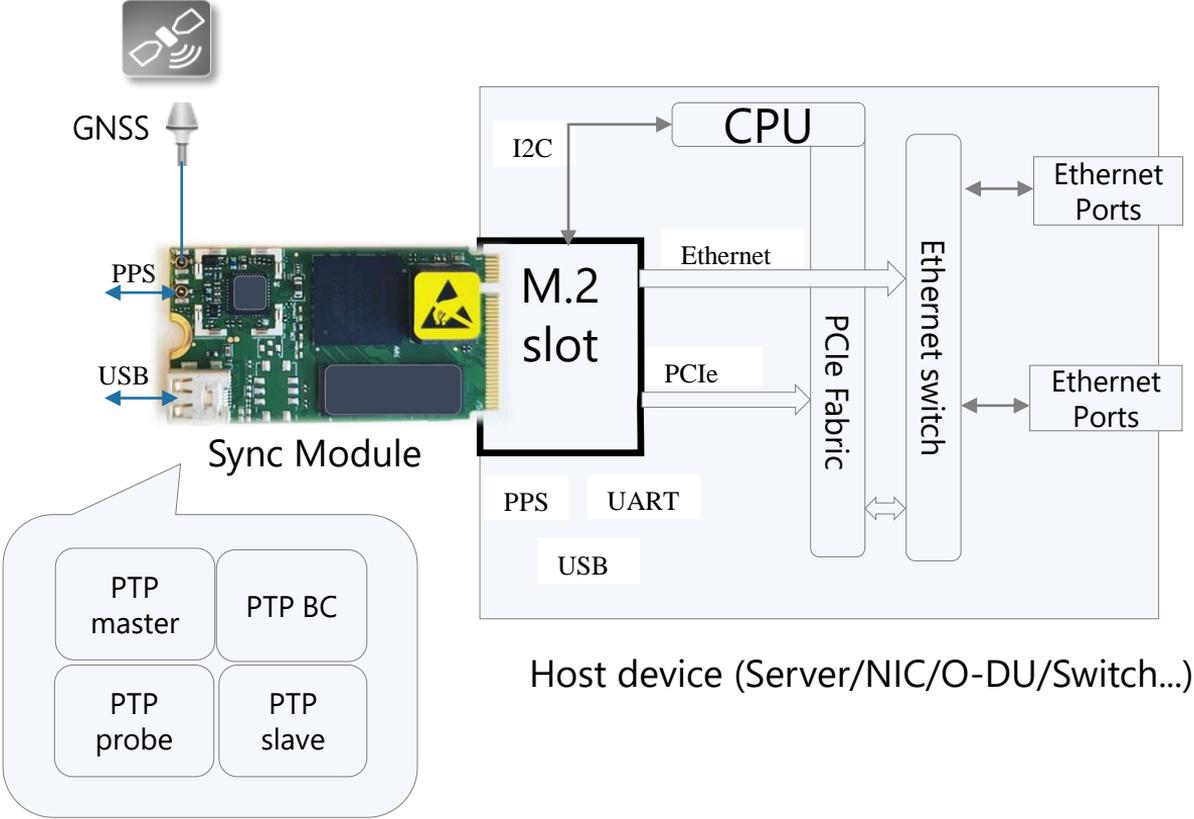
- Low-power, solution
- Easily integrated into systems due to M.2 interface
- Extended temperature range -40°C to +85°C components

Comprehensive sync capabilities

- IEEE 1588 PTP
 - grandmaster/boundary/slave clock
 - Up to 64 unicast clients at 128pps
 - Multiple PTP profiles
 - PTP profiles conversion
- GNSS receiver
- NTP server
- PTP input as backup to GNSS (APTS)
- Sync probe
- Sync-E In/Out
- OCXO based holdover

While M.2 natively supports PCIe...

It can be extended to other applications



TimeCard

GNSS antenna input

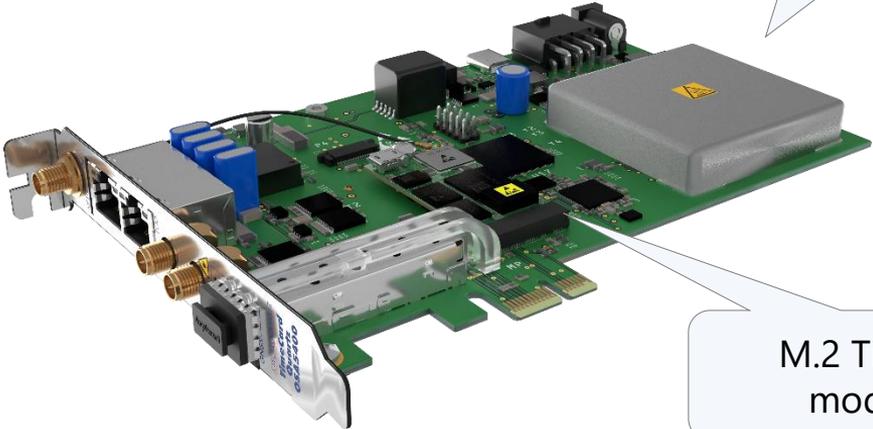
100M/1G copper + PoE Output

PPS+TOD (HW ready)

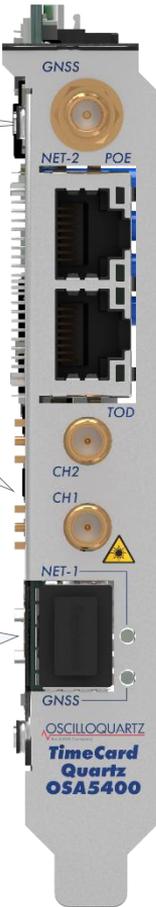
Qz/HQ+/HQ++/Rb options - extended holdover

CH1/CH2 I/O (PPS/CLK)

1G Fiber



M.2 Timing module



Using Smart Antenna to help with cabling

