Monitor and Audit Time in the OS

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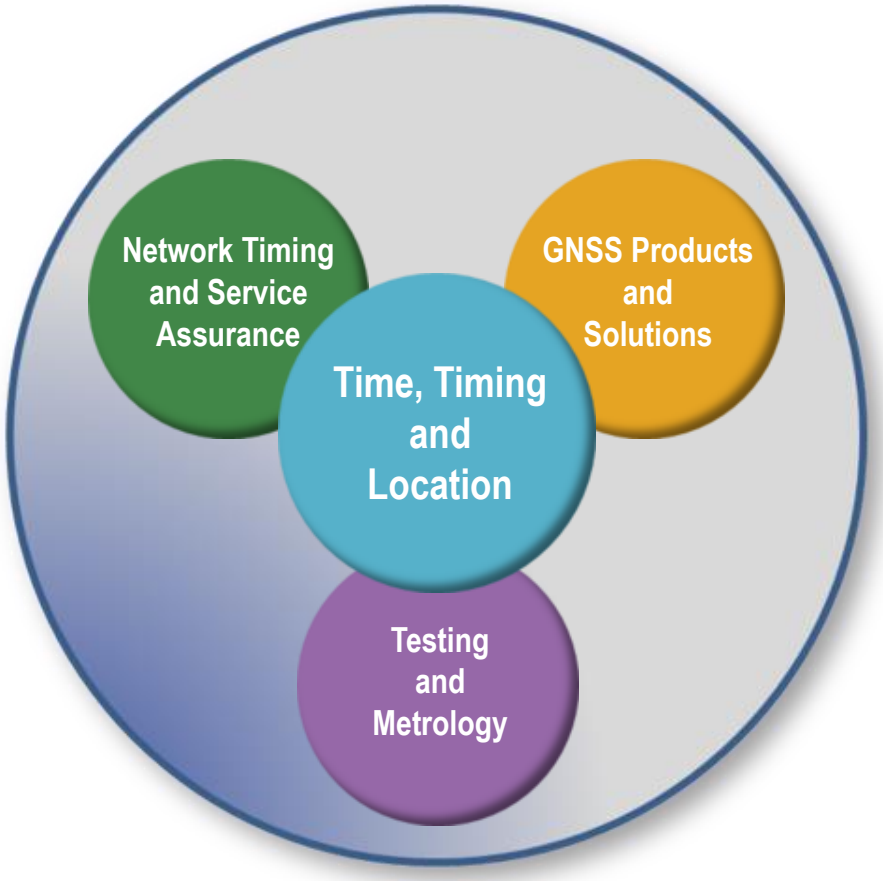
Version 0.1

Chronos – Expertise



What Do We Need?

- Time Synchronised to UTC

Article 1

Reference time

Operators of trading venues and their members or participants shall synchronise the business clocks they use to record the date and time of any reportable event with the Coordinated Universal Time (UTC) issued and maintained by the timing centres listed in the latest Bureau International des Poids et Mesures Annual Report on Time Activities. Operators of trading venues and their members or participants may also synchronise the business clocks they use to record the date and time of any reportable event with UTC disseminated by a satellite system, provided that any offset from UTC is accounted for and removed from the timestamp.

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Time in the Network

What Do We Need?

- Time Synchronised to UTC

Table 2

Level of accuracy for members or participants of a trading venue

Type of trading activity	Description	Maximum divergence from UTC	Granularity of the timestamp
Activity using high frequency algorithmic trading technique	High frequency algorithmic trading technique.	100 microseconds	1 microsecond or better
Activity on voice trading systems	Voice trading systems as defined in Article 1(7) of RTS transparency requirements in respects of bonds, structured financial products ect...	1 second	1 second or better
Activity on request for quote systems where the response requires human intervention or where the system does not allow algorithmic trading	Request for quotes systems as defined in Article 1(6) of RTS 9 transparency requirements in respects of bonds, structured financial products ect...	1 second	1 second or better
Activity of concluding negotiated transactions	Negotiated transaction as defined under Article 4(1)(b) of Regulation (EU) 600/2014	1 second	1 second or better
Any other trading activity	All other trading activity not covered by this table.	1 millisecond	1 millisecond or better

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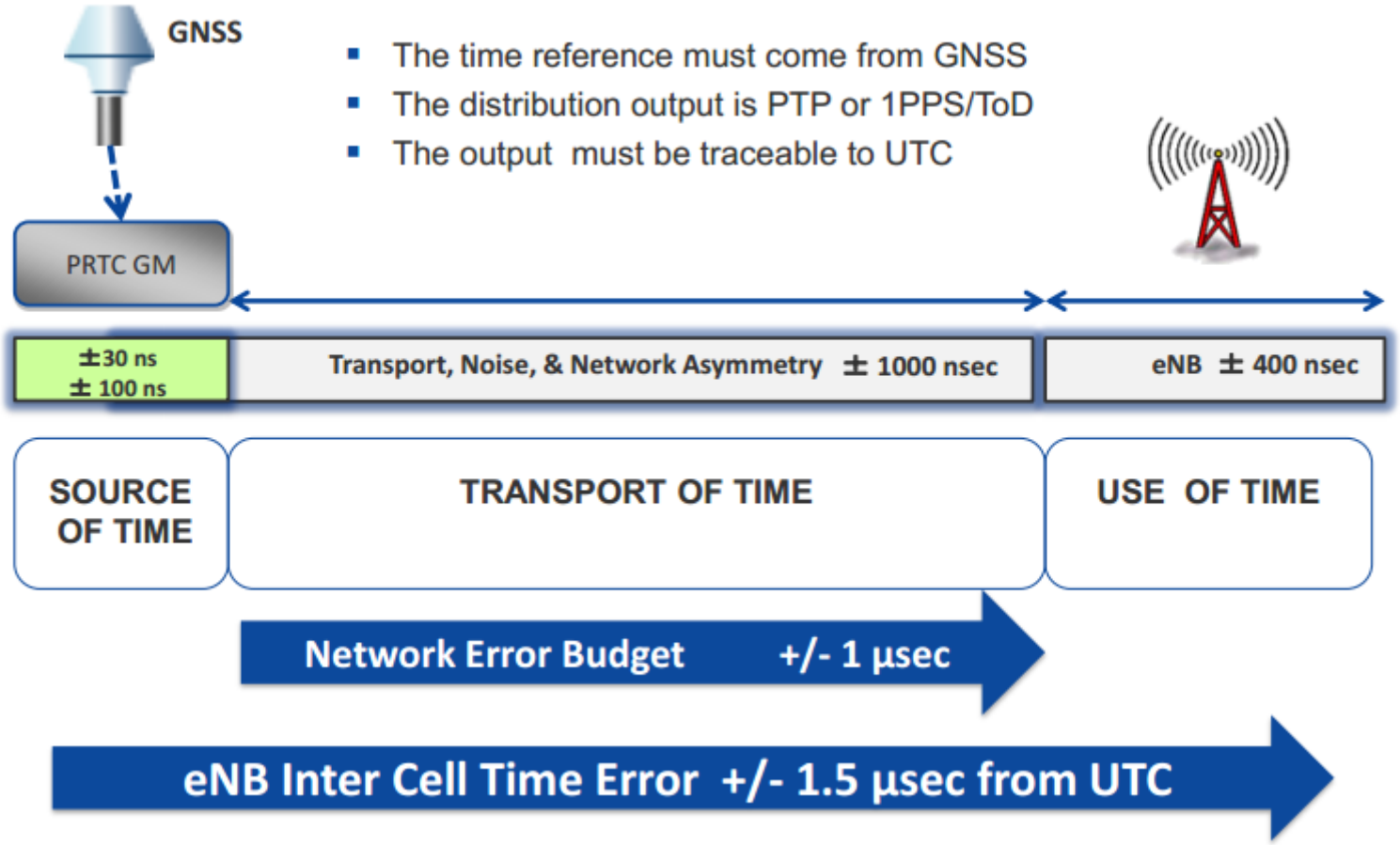
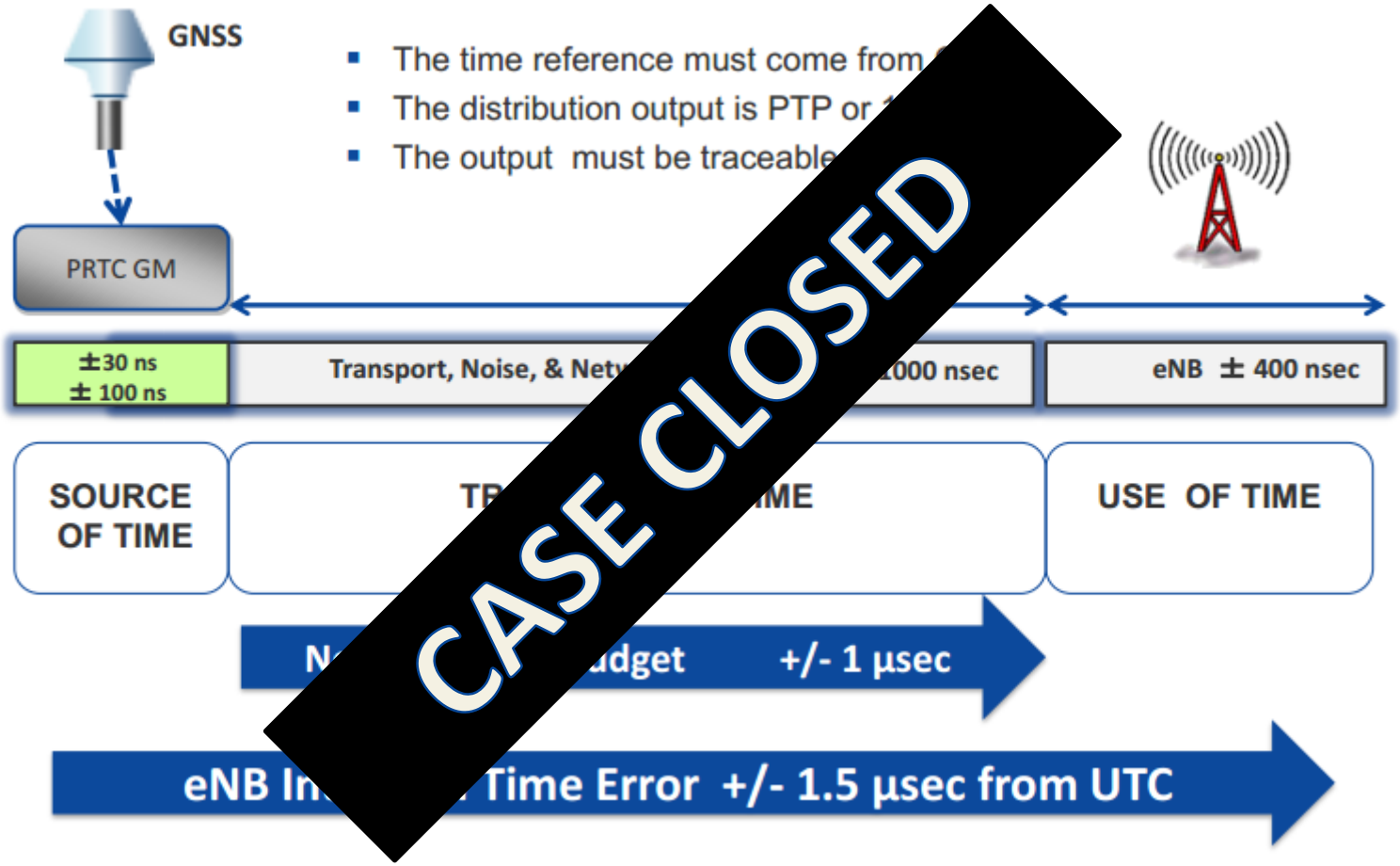
We're Already Doing It!!



We're Already Doing It!!



Well Not Quite…

- Time Synchronised to UTC
  - “exact point at which a timestamp is applied”

Article 4

Compliance with the maximum divergence requirements

Operators of trading venues and their members or participants shall establish a system of traceability to UTC. They shall be able to demonstrate traceability to UTC by documenting the system design, functioning and specifications. They shall be able to identify the exact point at which a timestamp is applied and demonstrate that the point within the system where the timestamp is applied remains consistent. Reviews of the compliance with this Regulation of the traceability system shall be conducted at least once a year.

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Beyond the NIC?

- Time Synchronised to UTC

7.3 Compliance with the maximum divergence requirements

RTS 25 specifies two types of accuracy requirements: the maximum divergence from UTC and the timestamp granularity. This section of the guidelines only concerns the former requirement. Article 4 of RTS 25 states that 'Operators of Trading Venues and their members or participants should establish a system of traceability to UTC'. This includes ensuring that their systems operate within the granularity and a maximum tolerated divergence from UTC as per RTS 25. Furthermore operators of Trading Venues and their members or participants should evidence that the crucial system components used meet the accuracy standard levels on granularity and maximum divergence of UTC as guaranteed and specified by the manufacturer of such system components (component specifications should meet the required accuracy levels) and that these system components are installed in compliance with the manufacturer's installation guidelines.

Relevant and proportionate testing of the system should be required along with relevant and proportional monitoring thereof to ensure that the divergence from UTC remains within tolerance. The relevance and proportionality will depend on the applicable maximum divergence from UTC.

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Time Delivery in the Network

- Reference Time
  - Enterprise Master Clock with GNSS
- Minimise GNSS Risks
  - Rubidium Holdover
- Accuracy required (100µs or 1ms)
  - Master Clock <100ns to UTC
  - PTP Aware Network
  - Physical Layer PTP NIC (1µs at NIC)

Demonstrating Time Delivery

- Prudent Design
  - Resilient Architecture
  - Minimise Assymetries and Transitions
- Ongoing Monitoring and Audit
  - Flow Management Tools
    - InstrumentiX, Corvil
  - Time Sync Tools
    - Domain Time II, TimeKeeper
- Periodic Audit
  - Independent Performance Measurement

So What's the Issue?

- Requirement 100µs or 1ms
  - GNSS Master and PTP NIC can deliver single figure µs!
  - Even PTPd will meet this
- If all Reportable Events are Time Stamped at the NIC then it's job done!
- Any Events timed in Application?
- Then you've got 99/999µs to burn in Linux!

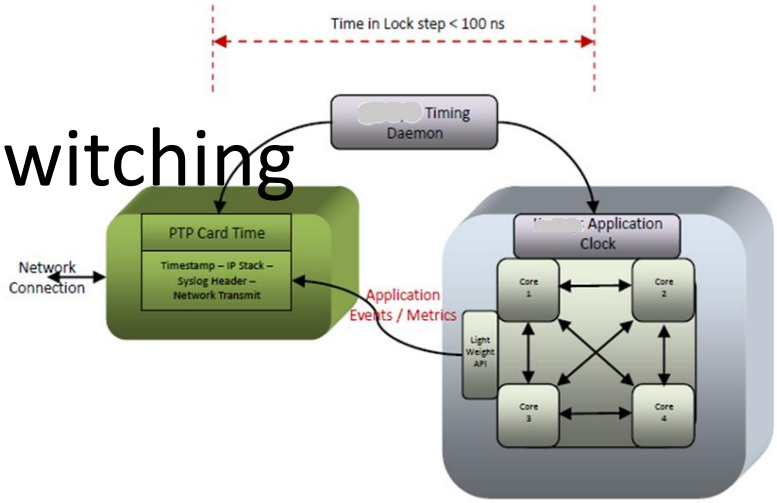

Time to the Application

Get Inside the OS

- Microsecond timing at the NIC
  - Hardware Time Stamping
  - Optimised Network Design
  - Resilient Time Design
- Frittered away in the Linux stack!
  - Linux System Clock inaccuracies
  - API calls suffering bridge / bus latency
    - NIC time very accurate but…

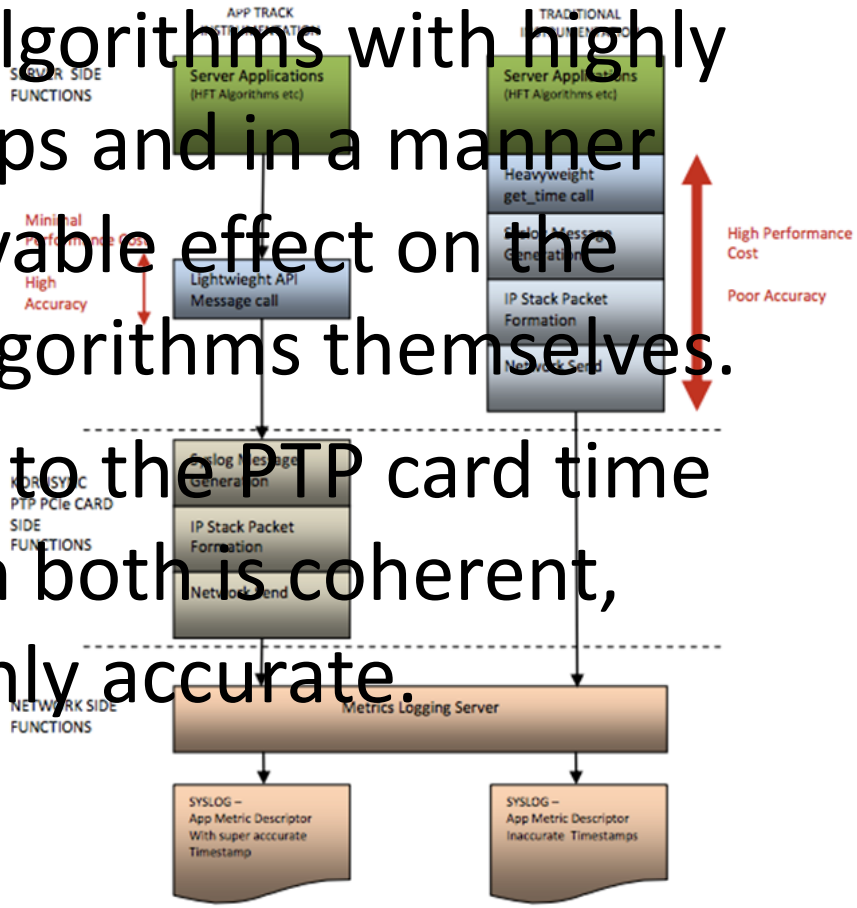
Building Block 1 - AppClock

- Lightweight API
- Time tied to NIC
  - Time from NIC to 100ns
- Scalable and monotonic across multi-core systems.
- User Mode, no context switching
- Nanosecond Resolution

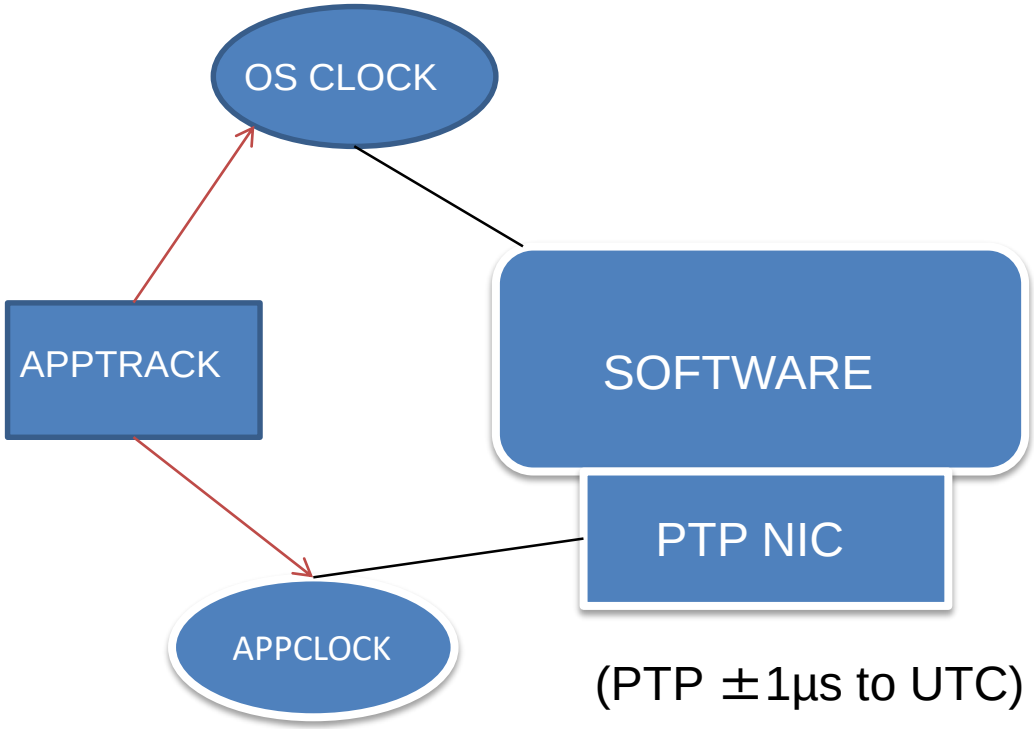


Building Block 2 - AppTrack

- AppTrack provides the ability to record events inside the algorithms with highly accurate timestamps and in a manner that has no perceivable effect on the operation of the algorithms themselves.
- AppClock is locked to the PTP card time so the timebase on both is coherent, consistent and highly accurate.



Monitor and Audit



UTC	GM	NIC	OS	Processes / Stack / Latency etc.
	100ns	1µs	XXµs	100µs

Dashboard

- Database can reside on server or blade
- Threshold templates
  - User definable
- Offsite replication
- Offsite Audit data
- Web GUI interface
- SNMP northbound alarms
- API for integration