PTP PRIMER

This document gives a brief overview of the requirements for time accuracy and traceability to MiFID II, background information on Precision Time Protocol (PTP) and the part it plays in satisfying these requirements, and considerations for proving equipment is fit for purpose as well as demonstrating that networks are compliant to MiFID II as per RTS 25.

PTP: Synchronizing Networks and Demonstrating MiFID II Time Compliance

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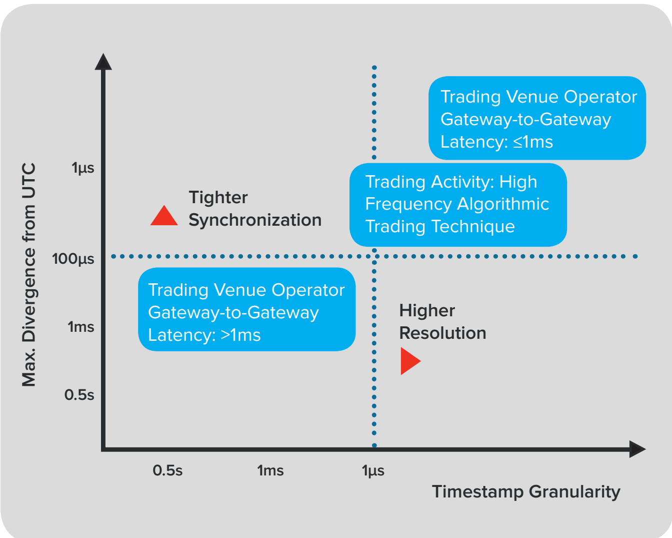
RTS 25 – Levels of Accuracy for Business Clocks

With MiFID II now in effect, it is essential that trading venues ensure they have the correct permissions in place to carry out the relevant regulated activities. Time accuracy of business clocks – as outlined in RTS 25 – is an essential part of this for purposes such as reporting of post-trade transparency data. Combinations of technologies will be used to achieve this, but the requirement to have consistent timestamping across applications within a trading venue means that Ethernet synchronization via PTP (Precision Time Protocol, defined in IEEE 1588-2008) will play a key role.

Elaborating on the need for accurate time when reporting on trades, it is made clear that timing sources within and between trading venues must have both accuracy (a maximum divergence from reference time) and a commonality to the reference time, to ensure that authorities can establish the timeline of reportable events correctly.

The levels of accuracy and maximum divergence from Coordinated Universal Time (UTC) specified for business clocks are dependent on the gateway-to-gateway latency of trading systems (in the case of Operators of trading venues) or the types of trading activities (in the case of members/participants). These requirements are illustrated below.



MiFID II/ESMA RTS 25 Timing Levels of Accuracy for Business Clocks

As seen, accuracy as low as 1µs, with no more than 100µs divergence from UTC, can be required for regulatory compliance.

The joint task of equipment vendors and trading venues is to determine how to:

1. Deliver timing accurately to, and within, venues.
2. Demonstrate time traceability, required for regulatory compliance at least once a year (RTS 25 Article 4).

'ESMA RTS 25: Regulatory technical standards on clock synchronization' provides further guidance on the requirements for timing accuracy and traceability required to be compliant to MiFID II.

Introduction to PTP (1588)

GNSS is commonly used for time synchronisation in communications networks around the globe. However, GNSS installations need outside antennas with clear sight of satellites (often difficult to achieve in urban environments) and suffer from an inherent lack of security (susceptible to jamming and spoofing). Relying solely on GNSS to accurately transfer time from one place to another clearly carries a risk.

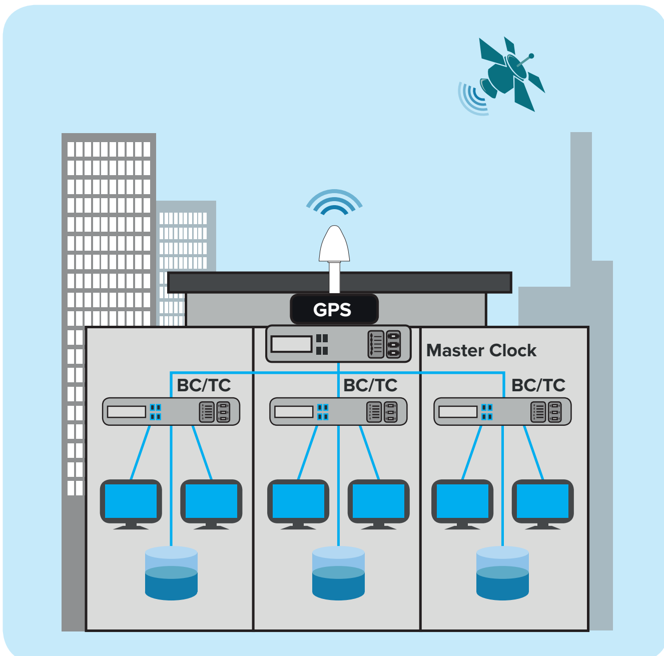
An alternative, and highly accurate, method of transferring time is PTP. Furthermore, in trading institutions as in other markets and applications such as telecoms, utilities and broadcast, the benefits of delivering robust timing through Ethernet networks already being used for application critical information has numerous benefits.

What is PTP?

PTP is a message-based time transfer protocol that is used for transferring time (phase) and/or frequency across a packet-based network. It ensures various points in the network are precisely synchronized to the reference (master) clock so that the network meets specific performance limits according to the network's application.

PTP timing messages are carried within the packet payload. The precise time a packet passes an ingress or egress point of a PTP-aware device is recorded using a timestamp. Because packets take different lengths of time to travel through the network – caused by queuing in switches and routers on the path – this results in Packet Delay Variation (PDV). To reduce the impact of PDV, Boundary Clocks (BCs) or Transparent Clocks (TCs) can be used to meet the target accuracy of the network.

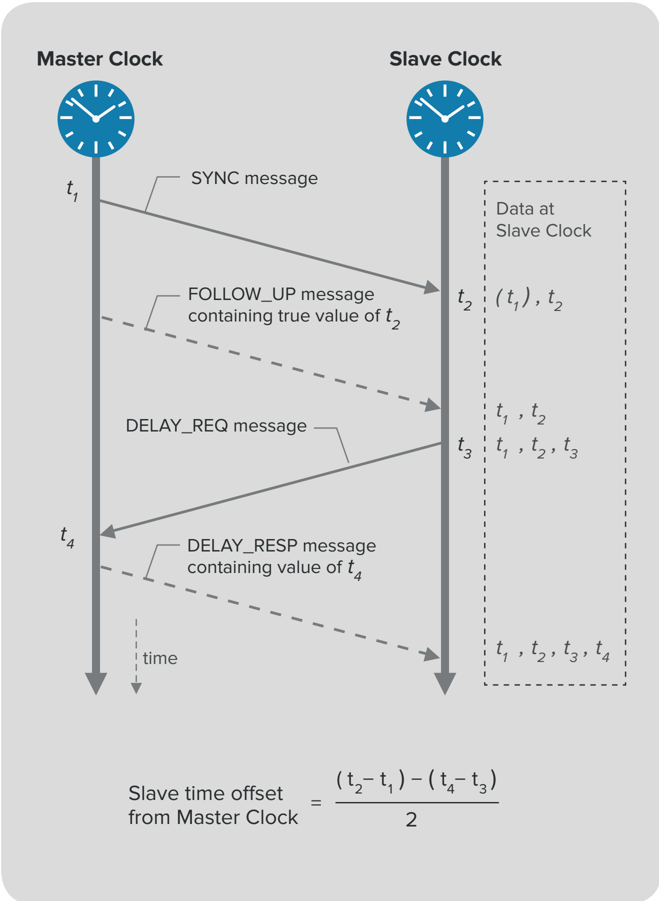
Assessing the Time Error introduced by these devices is critical in determining network topology, suitability of equipment, and demonstrating network timing compliance.



- BCs calibrate themselves by recovering and regenerating the PTP timing from the previous clock in the chain, thereby minimizing the PDV accumulation at the slave.
- If TCs are used, the measured link delay and residence time is written by each TC into a correction field within the packet. The end slave then has a record of the delay for each TC on the path.

How does PTP work?

PTP uses the exchange of timed messages to communicate time from a master clock to a number of slave clocks. The timed messages are SYNC, FOLLOW_UP, DELAY_REQ and DELAY_RESP as shown below.



These messages yield four timestamps (t1, t2, t3 and t4), from which it is possible to calculate the round-trip time for messages between the master and the slave (assuming that the slave clock is advancing at a similar rate to the master).

The time offset is then estimated using the assumption that the one-way network delay is half the round-trip delay and is used to correct the slave time base to align to the master.

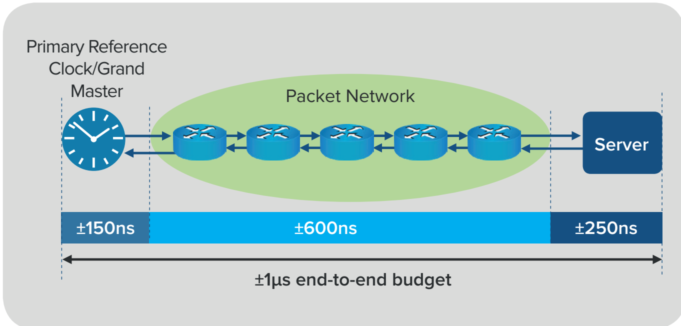
Note that this assumes symmetry, that is, the forward and reverse paths are of equal length. If they are of different lengths, usually caused by queuing in switches and routers, this will introduce an error into the time offset estimate; this is asymmetry.

Determining and validating PTP performance

What is the required network and equipment performance? As described above, RTS-25 has requirements of maximum ±100µs divergence, which implies a maximum of ±1µs time-signal divergence between the reference (master) clock and the hardware slave clock (leaving ±99µs for the application and software).

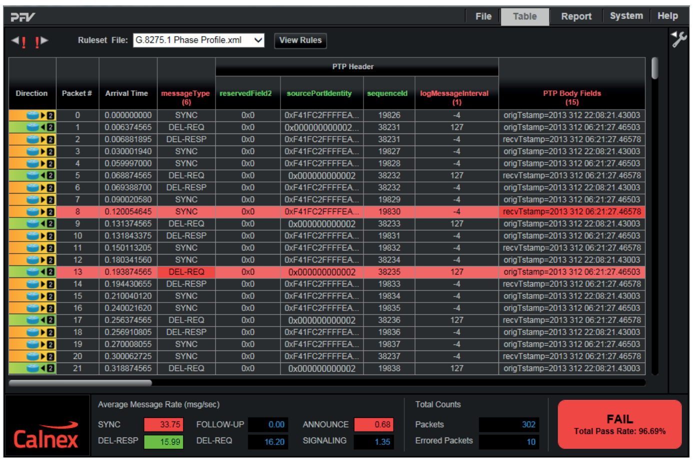
The illustration below gives an example of how this specification can be broken down to provide equipment specifications for Grand Master devices, PTP aware network switches/routers (Boundary or Transparent Clocks), and slave functionality at the server (typically integrated into a NIC).

Dependent on the number of network hops between the end points of the network, BC and TC performance limits can vary by application and deployment. As per the illustration, 5 hops would give a per device limit of ±600ns / 5 = 120ns per device.



PTP protocol interoperability

Often overlooked, a key item in deploying robust PTP networks is ensuring all devices apply the same PTP profile correctly and consistently. Initial 'onboarding' and evaluation should include validation of PTP message fields. This avoids lost time due to misconfiguration, and identifies large scale interoperability issues.

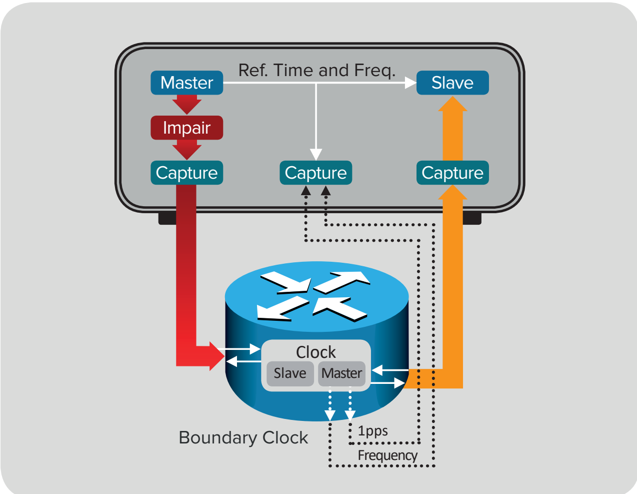


Are devices fit for purpose?

As outlined previously, by first understanding the applicable accuracy and traceability requirements for a particular application, then understanding the intended deployed network topology, performance requirements for individual devices can be determined – both for Operators of trading venues evaluating equipment, and also manufacturers of equipment providing proof-of-concept.

To prove the PTP performance of network equipment:

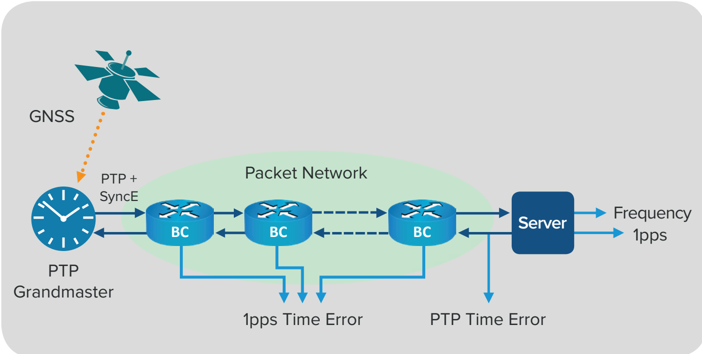
1. It must be shown that the equipment can connect and engage in a PTP session correctly. It is recommended to use test equipment that can generate and control PTP message exchanges to avoid, for example, masking of interoperability issues (a common problem when using commercial network equipment for test purposes).
2. 'Steady state' timing accuracy should be measured either directly on PTP messages, or on external timing outputs if present. It is essential that test equipment validating performance should have measurement accuracy an order of magnitude better than the device performance specification. This should cover the entire stimulus-to-measurement setup, which must be time aligned to confirm, for example, time traceability.
3. Response to likely negative conditions (protocol errors, timing offsets, etc.) should also be tested and measured i.e. 'worst-case performance'. Both long-term gradual timing offsets and short-term jumps in timing should be applied to check robustness of equipment. Again, this should be possible without affecting simultaneous timing accuracy measurements.



How can I verify and demonstrate network performance?

The Time Error of PTP and recovered clock (1pps/Phase) can also be measured at various points in the network to ensure performance before, during and after deployment, allowing operators of trading venues to demonstrate continuing compliance to MiFID II as outlined in RTS 25.

Network probing, sample testing, and device 'self-reports' are all potentially useful approaches, depending on the needs of the organization.



For more information on why and what to test in networks that use this time distribution protocol, refer to *'Time and Time Error – A Guide to Network Synchronization'* Calnex Document No. CX5013 available at www.calnexsol.com.

Related Products

Calnex Paragon-X

- One box Test Bed for Packet Sync – PTP (1588), SyncE
- PTP (1588) Master and Slave emulation (with optional SyncE support) for fully controllable protocol and timing test
- Unique test methodology for industry-best accuracy
- Complete Standards compliance testing to IETF Enterprise Profile, IEEE 802.1AS and ITU-T G.826x/827x

Calnex Paragon-t

- Speed up test time and reduce test complexity with multi-clock measurements
- Measure multiple outputs from a chain of Boundary Clocks and Slave Clocks
- 4 x Frequency (SyncE/E1/T1/2.048 M/10 M Wander) measurements
- 4 x Phase (1 pps accuracy) measurements
- 4 x ToD display measurements

Calnex Sentinel

- PTP, NTP, SyncE and TDM in one portable box
- Embedded GPS receiver and Rubidium (Rb)
- Measure ALL parameters at the SAME time
- Test networks for Frequency and Phase
- Test networks with Boundary Clocks and Transparent Clocks
- Standard industry masks and packet metrics, with built-in Pass/Fail limits when measuring the network
- Measurement reports in pdf format

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