Miffed at MiFID?
The practical issues to be considered when auditing paper clocks in the real world...

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Agenda

▪ Introduction
  – Financial Applications Requirements
▪ Audit process
  – Paper audits
  – Physical audits (where’s the clock?)
▪ Findings
▪ Summary
Time Enables ALL Infrastructures

- Data Centers
- Enterprise Communications
- Power Grid Communications
- Wireline Communications
- Seismic Exploration
- Secure Communications
- Cellular Communications
- Financial Exchanges
Requirements Evolution: Financial Trading Regulations

- From 3rd Jan 2018 EU legislation – Markets in Financial Instruments Directive ("MiFID II") - is in effect. Its scope includes the synchronisation of trading clocks to UTC and timestamping granularity:

<table>
<thead>
<tr>
<th>Type of Trading</th>
<th>Granularity</th>
<th>Max. Divergence to UTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice trading</td>
<td>1 s</td>
<td>± 1 s</td>
</tr>
<tr>
<td>All other trading</td>
<td>1 ms</td>
<td>± 1 ms</td>
</tr>
<tr>
<td>High frequency trading</td>
<td>1 µs</td>
<td>± 100 µs</td>
</tr>
</tbody>
</table>

- US regulation (SEC) Rule 613 (effective 2018): Synchronisation of business clocks to within 100 µs of NIST clocks

- The aim is to prevent trading irregularities & provide an audit trail for “reportable events”
COMMISSION DELEGATED REGULATION (EU) 2017/574:

Accuracy & traceability to UTC summary

Article 1 – Reference Time:
- Synchronisation of business clocks used to record date and time of any reportable event with:
  - UTC issued and maintained by timing centres listed in BIPM annual report on time activities
  - UTC disseminated by a satellite system provided any offset from UTC is accounted for and removed from the timestamp

Article 2 & 3 – Level of accuracy for operators, members and participants of trading venues (Eligibility criteria dependent):
- Level 1 = ±100µs, Level 2 = ±1ms, Level 3 = ±1s

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:
  - Demonstrate traceability to UTC by documenting the system design, function and specifications
  - Identify the exact point that a timestamp is applied and demonstrate that the point within the system where the timestamp is applied remains consistent
  - Conduct a review of traceability compliance of the system with the Regulation at least once a year
Requirements Evolution: Financial Trading Regulations

• COMMISSION DELEGATED REGULATION (EU) 2017/574: Accuracy & traceability to UTC summary

• But what is UTC? Where do I get it?
What is UTC? Where do I get it?

International Atomic Time (TAI)

Universal Time Co-ordinated

UT Earths Rotation

+/− Leap Second

National Time scales
UTC_{NPL} in UK
UTC_{USNO} & UTC_{NIST} in US

Things to note about UTC:

“it’s paper clock”
“it only exists in the past”

MiFID allows us to use & test to UTC_{USNO}
From the ESMA MiFID II requirements:

- Establish a system of traceability to UTC, where such a system shall:
  Demonstrate traceability to UTC by documenting the system design, functioning and specifications. This is to be accomplished by:
  - Establish a system of traceability of their business clocks to UTC, including ensuring that their systems operate within the granularity and a maximum tolerated divergence from UTC as per RTS 25. Evidence that their systems meet the requirements by documenting the system design, its functioning and specifications.

- 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 shall meet the required accuracy levels); and
  - that these system components are installed in compliance with the manufacturer’s installation guidelines.
  - 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.

Firms shall conduct a compliance review of the traceability system at least once a year.
Ensure procedures are put in place to establish a systems of traceability to UTC by documenting the system design, functioning and specifications and review such a system once a year.
Paper Audit – network design

- Network plans & drawings
- Specs/datasheets for all equipment that affects timing
- SLAs & Agreements for any Services provided by 3rd parties
- Logs/configs of all equipment
- Add some “Best Practice”
Auditing the clock + distribution...

- Physical things:
  - UTC delivery: GNSS receiver, PTP GM
  - UTC distribution: PTP BC, PTP Slave
  - Network design – how all the above things are connected together

- Non-Physical things:
  - UTC: consumption: Trading application!
Timing: a simplified model

Source of Frequency Time/Phase (Caesium, GNSS)

Option 1:
DIRECT e.g. IRIG, SSU

Transport of Frequency Time & Phase

Option 2:
INDIRECT e.g. ethernet

The Transport Network Can Introduce Error (jitter, PDV, noise, asymmetry)

Application: Use of Frequency Time & Phase

Clock is generated

Clock is conditioned & injected into the network

Distribution of Frequency Time/Phase (SSU, GM, NTP Server)

Clock drives the application if (and only if) it is within acceptable time error limits
Auditing the clock...

Source of time e.g. GNSS + PTP GM

Distribution e.g. PTP BC

Consumption e.g. PTP Slave + application

Tester + Independent Reference e.g. GNSS
Optional extra...?

NIC + PTP slave:
“sorry, we didn’t think we needed the 1PPS option”
Auditing the clock...

- **Physical things:**
  - UTC delivery: GNSS receiver, PTP GM
  - UTC distribution: PTP BC, PTP Slave *no 1PPS (or other) clock O/P!*
  - Network design – how all the above things are connected together

- **Non-Physical things:**
  - UTC: consumption: Trading application!
No signal at pulse-per-second (PPS) output (PTP CLK connector)

The [data sheet](http://www.1588 RTP data sheet_c78-707001.html) describes a "IEEE 1588 PTP with pulse-per-second (PPS) output" feature, stating "Network administrators deploying IEEE 1588 PTP often find it challenging to measure the accuracy to which each device is synchronized. To assist in this effort, the [data sheet](http://www.1588 RTP data sheet_c78-707001.html) platform includes a 1-PPS output port that can be used to measure timing drift from the grandmaster clock."

On the front panel of the [device](http://www.1588 RTP data sheet_c78-707001.html) is a coaxial mini DIN connector labeled PTP CLK. My understanding is that this is the 1-PPS output port referenced in the data sheet.

I have configured the network switch to enable PTP, have connected a PTP grandmaster, etc. and am attempting to observe the signal output by the PTP CLK connector using an oscilloscope. I am not observing any pulses being output by this connector.

How do I enable this PTP CLK connector?
After discussing this issue with a TAC engineer, I learned that while this PTP CLK connector is present on [obscured], and [obscured] (front panel names), there is no software support for this connector at this time. There is also no time frame for [obscured] to support this PTP CLK connector.
There is no clock to audit

- *Turn up on site and nothing to measure!*
- Add test slave – compare output
- Mirror port - capture PTP packets
- SECURITY hampers the audit process
- GNSS receivers calibrated
- Packet captures all OK
- Test slave 1PPS ~10µs
  - Agrees with other work
PTP packet capture

- Security policy/paranoia hampers capture!
  - Request “mirror port”
  - Announce Message: GM ID, UTC-TAI offset
  - Message rates etc. as expected
    - Two-step, Layer3 (UDP/IP)
      Sync: 2Hz Del_Req/Resp: 0.5Hz
      Announce: 0.5Hz
Surrogate PTP slave

- Comparative position in the network hierarchy
- Security/paranoia again – mirror port/MAC whitelisting etc.
- Does the test slave behave exactly as the real one?

Source of time e.g. GNSS + PTP GM

Distribution e.g. PTP BC

Consumption e.g. PTP Slave + application

Test PTP Slave

Tester + Independent Reference e.g. GNSS
Surrogate PTP slave

Symmetricom TimeMonitor Analysis
Phase deviation in units of time: f = 1.000 Hz; fo = 1.000000 Hz; 2010/06/02 11:17:14
SyncWatch Phase: Samples: 295; StartPC: 2010/06/02 11:17:13; MeanChan1; Input PPS; RefChan: CSAC; Local time; UTC Offset: 0:00

Graph showing phase deviation over time.
Findings

▪ GNSS 1PPS output confirms:
  – Cable delay not set at all
    ▪ ~500ns error – “standard” 100m cable drum used
    ▪ Questionable install?
    ▪ GNSS GM manufacturer states
      “probably no need to set cable delay compensation”

▪ PTP Packet capture confirms:
  – GM Identity + network performance

▪ Test Slave confirms:
  – Approximate/Achievable performance
Summary

- 1PPS outputs!
  - Telecom learned this lesson already

- BREXIT the new focus – MiFID is “done”
  - money/resource was allocated 2016/17
  - difficult to get commitment now it seems the “MiFID compliance” box has already been ticked

- If/when the regulator imposes penalties on traders this may change...

- Meaningless requirements need to be updated
Thank you for listening

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Hardware assisted, two-way time transfer techniques ensure accurate, stable UTC-traceable time is delivered to the PTP Slave.

Once inside the server at the Motherboard/OS/application layer deterministic time-transfer is lost…
Typical Trading Clock (b)

UTC_{(USNO)}

PTP GM

PTP Slave

Physical Server

PTP Algo

Trading Application

Kernel OS time
Profiling the application space

- Lab test plots
Profiling the application space

UTC_{USNO}

PTP GM

PTP Slave

Custom PTP Slave

PTP Algo

Measurement App

Trading Application

Kernel OS time

monitor + measure

monitor