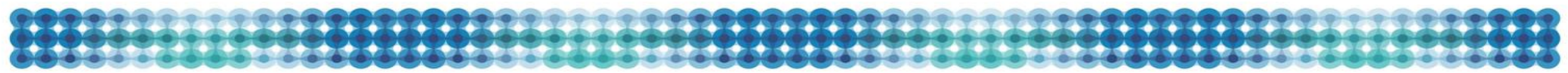


<100us UTC: a view of IMC's clock sync implementation

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Senior Performance Engineer
12 September 2017



Topics:

- PTP Deployment: Best practices
- Monitoring: Agreement
- Monitoring: Self-Health
- PTP Research

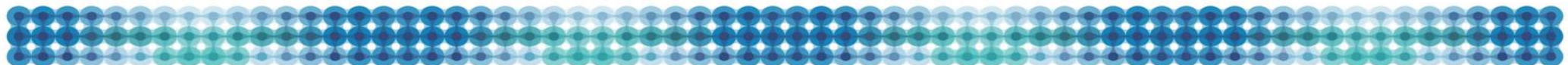


IMC Financial Markets:

- Global liquidity provider
- Very strong incentive to optimize Performance
- Multiple upgrades to its Time systems since 2010

A) PTP Deployment - Best practices:

- Redundant GPS infrastructure
- Redundant PTP switches
 - Stable internal network
- Custom PTP clients
 - multi-clock robustness
 - WAN filters



B) Monitoring: Agreement



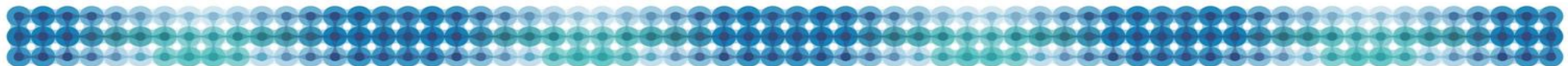
- Continuous monitoring that clocks agree to each other on:
 - Delays to/from Exchanges
 - Delays on the IMC internal network
- Why does it work?
 - No negative delays
 - No (too) large delays (=> performance issue)
 - Expected delay = length of the cables



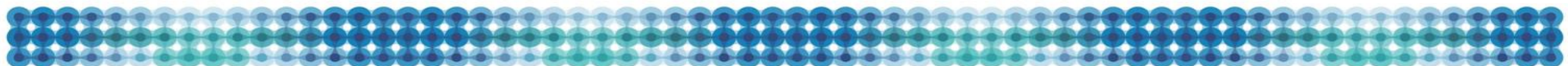
C) Monitoring: Self-Health



- Continuous monitoring of:
 - Self-reported clock offsets
 - Self-reported error conditions
- Coverage
 - All GPS servers
 - All PTP Switches
 - All PTP Linux hosts

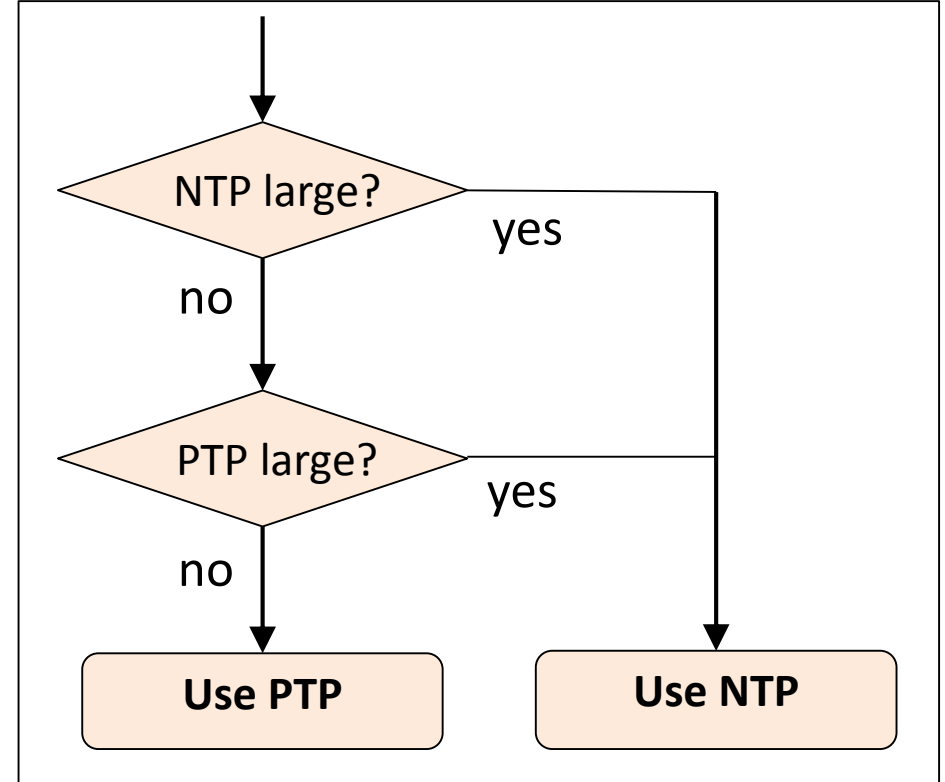
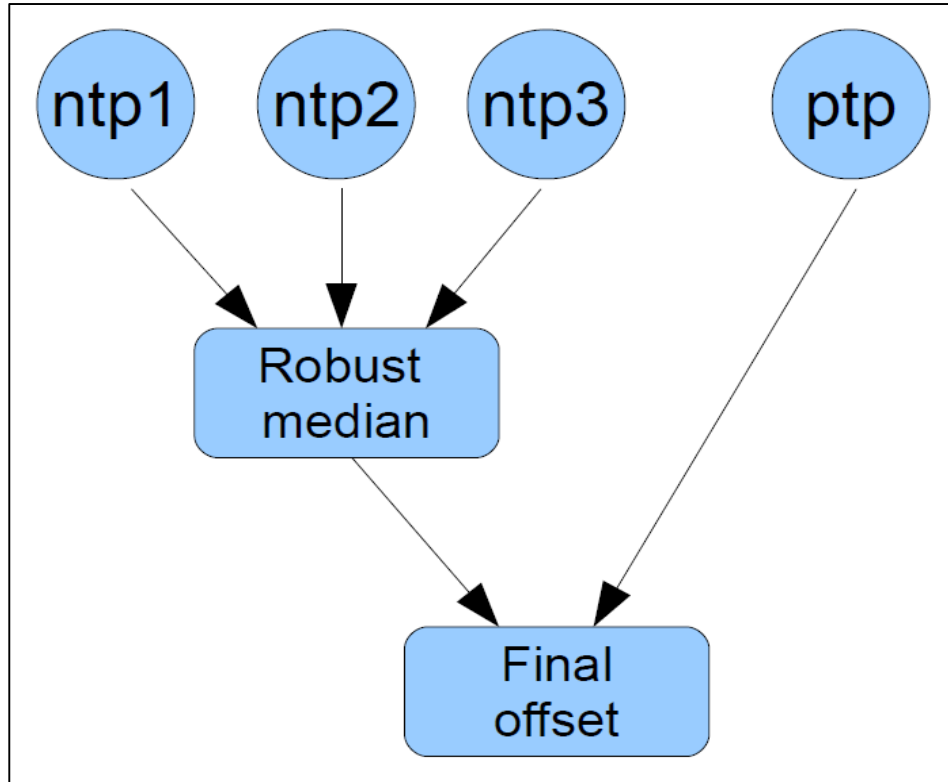


- 2012: **First paper** on the main PTP Scientific conference. Paper describes multiple issues deploying of PTP worldwide
 - http://tagus.inesc-id.pt/~pestrela/ptp/Challenges_deploying_PTPv2_in_a_Global_Financial_company.pdf
- 2014: **Best paper award** on the main PTP Scientific conference, with Deutsche Borse and ICE/NYSE. Paper describes a solution for the PTP robustness problem.
 - http://tagus.inesc-id.pt/~pestrela/ptp/Pedro_Estrela_-_ISPCS_2014_best_paper_-_Increasing_PTPv2_robustness_-_presentation.pdf
- 2014: Contributed to the FIA EPTA/FIA Europe official comments to **ESMA RTS-25**
 - https://epta.fia.org/sites/default/files/content_attachments/ESMA_MiFID2_CP_FIA%20ASSOCIATIONS_REPLYFORM.pdf
- 2015: Contributed to the FIA recommendation on the **2015 Leap Second**
 - https://fia.org/sites/default/files/content_attachments/FIA%20Leap%20Second%20Exchange.pdf

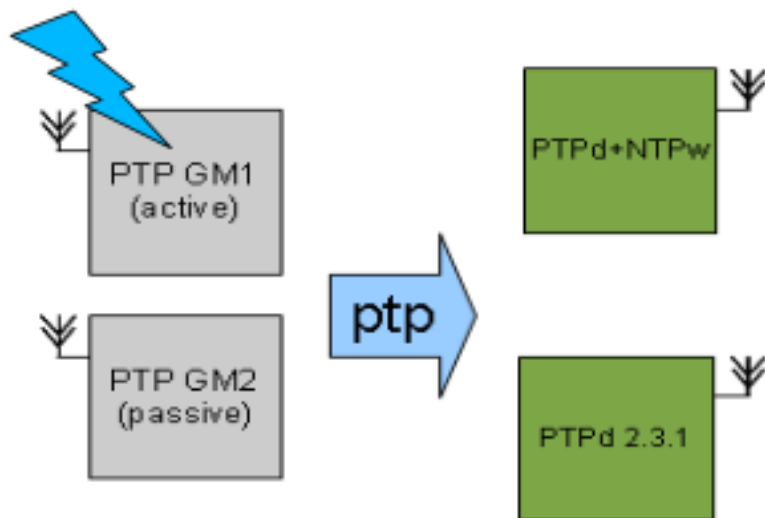


3 independent sources = 1 failure

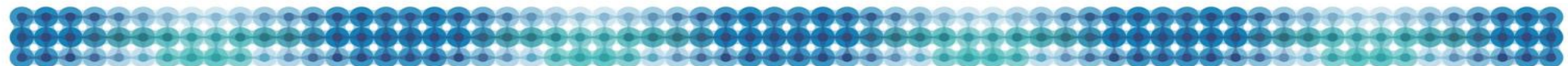
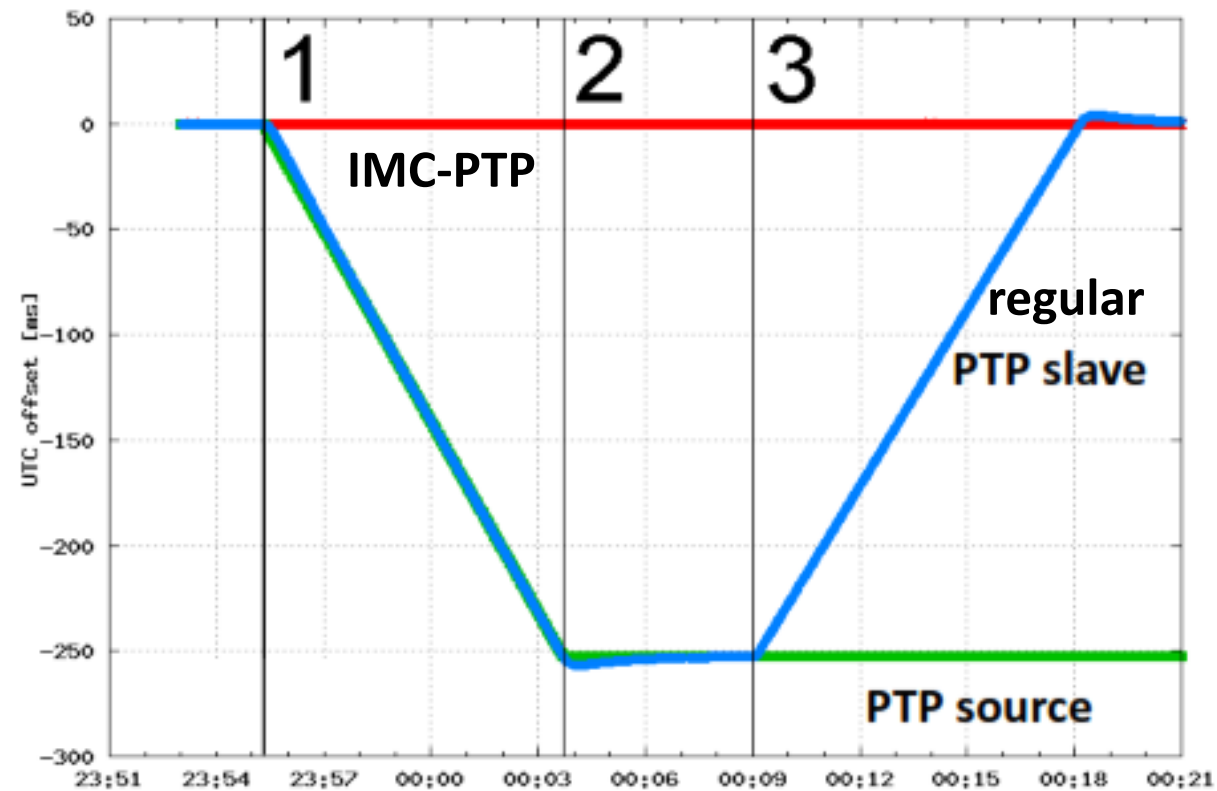
- Configuration errors
- Implementation Bugs
- Leap seconds issues
- Human errors
- Multicast / Routing errors
- GPS Jamming



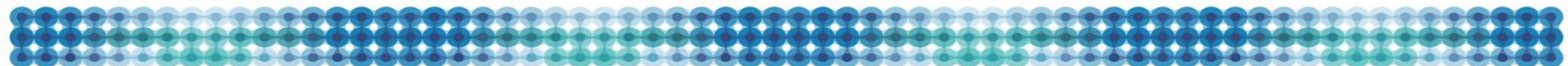
Testbed



Clock Error attack



Extra slides



Rule:

http://ec.europa.eu/finance/docs/level-2-measures/mifid-rts-25-annex_en.pdf

Maximum divergence from UTC: 100 microseconds

Guidelines:

<https://www.esma.europa.eu/file/20011/download?token=cHI6iMY4>

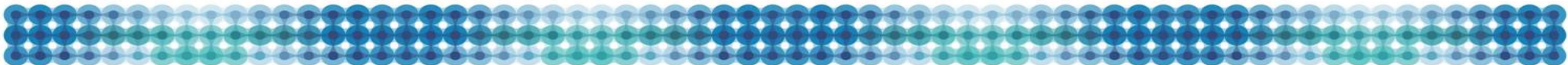
***Relevant** and **proportionate** testing of the system should be required along with relevant and proportional monitoring thereof to ensure that the divergence from UTC remains within tolerance.*



Proposal for recursive outliers



- RTS-25 today:
 - $<100\mu\text{s}$
- Idea:
 - X% of business time: $>0.1\text{ms}$ outliers
 - 0.X% of business time: $>1\text{ms}$ outliers
 - 0.0X% of business time: $>10\text{ms}$ outliers
 - 0.00X% of business time: $>100\text{ms}$ outliers



PTPv2 failures in Financial networks

- **Eurex, August 2013**
 - Active GM sent *bad* time (leap seconds = 0)
 - Backup GMs remain passive
 - Slaves jumped by 35 seconds
 - Trading halted => all customers affected
- **IMC, July 2011**
 - Same problem as above: Single time source

