The critical need for precision timing in the financial industry

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Agenda

1. Time-sync requirements in Financial Services Industry
2. Precision Timing in Financial Networks
3. Precision Timing - Challenges and Architecture solution
4. Summary

1 Time-sync requirements in Financial Services Industry

Time Legality

- How do you prove that something happened before (or after) a certain time?
- How do you prove that a new billing cycle has started?
- How do you correlate events across a large/global network?
  - Hacking attacks

ESMA and Regulatory Requirements

- MiFID-2 and MiFIR
- RTS and ITS
  - Fairer, safer and more efficient markets
  - Greater transparency
  - Stronger investor protection

- Clock/Time synchronization
  - RTS 25 – Regulatory Technical and implementing standards – annex 1 (September 2015 | ESMA/2015/1464)
  - Definition of business clocks and time accuracy requirements for business clocks

Adopted regulatory synchronization requirements

- Reference Time - UTC
- Compliance with maximum divergence requirements
- Level of accuracy for operator of trading venues

Gateway-to-Gateway latency time of trading system	Maximum divergence from UTC	Granularity of the timestamp
> Millisecond	1 millisecond	1 millisecond or better
=< 1 millisecond	100 microseconds	1 microsecond or better

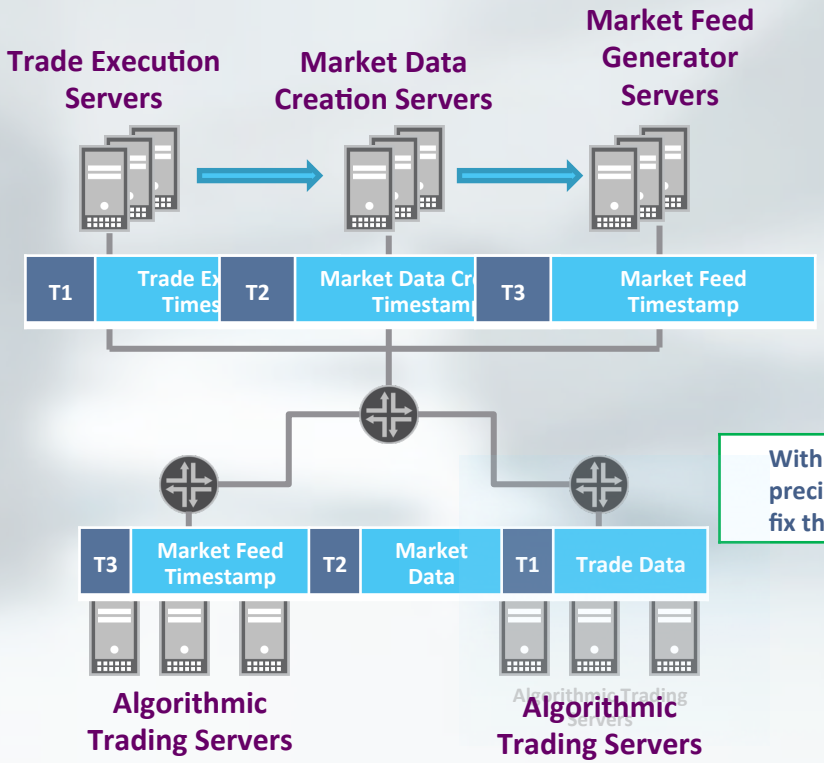
Regulatory synchronization requirements …

- Level of accuracy for member or participants of a trading venue

Type of trading activity	Maximum divergence from UTC	Granularity of timestamp
High frequency algorithmic trading	100 microseconds	1 microsecond or better
Voice trading	1 second	1 second or better
Request for quote systems	1 second	1 second or better
Negotiated transaction	1 second	1 second or better
Any other trading	1 millisecond	1 millisecond or better

2 Precision timing in Financial Services Industry

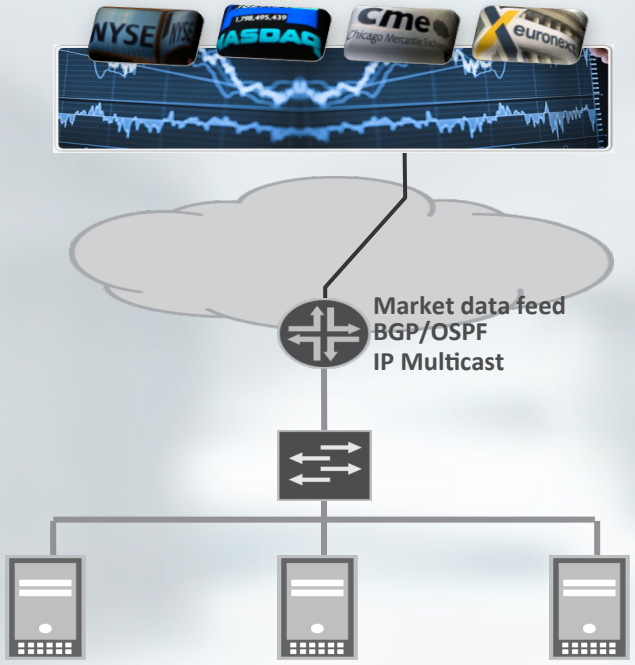
Case1 - Accuracy in Hi-FREQ algorithmic trading



With NTP precision, often **T3 < T2 < T1** – ie, market data is sent before it is created and even before the trade has been settled! Algorithms are confused leading to lost business and angry customers for the exchange

With PTP, exchanges can achieve better precision (1 us or less) that will let them fix this problem

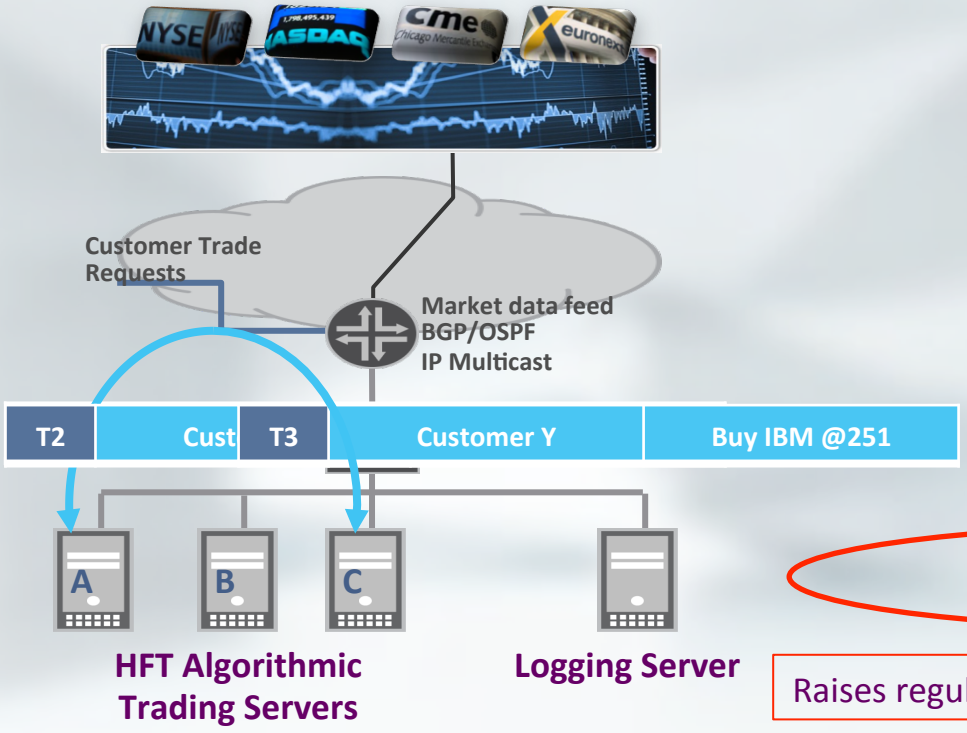
Case 2: END-To-END Latency analysis



HFT Algorithmic Trading Servers

- In HFT, latency is king
  - Race to “zero-latency”
  - Extensive investment in shaving off nanoseconds
- Different latency components
  - App-to-app latency across different cores in the same server, across different servers
  - App-to-NIC, NIC-to-switch, switch-to-router latency

Case 3: Logging for regulatory reasons



With NTP precision, it might be that **T3 < T1 < T2**, so this is how the log looks like when read after the fact:

Raises regulatory concerns around fair trading

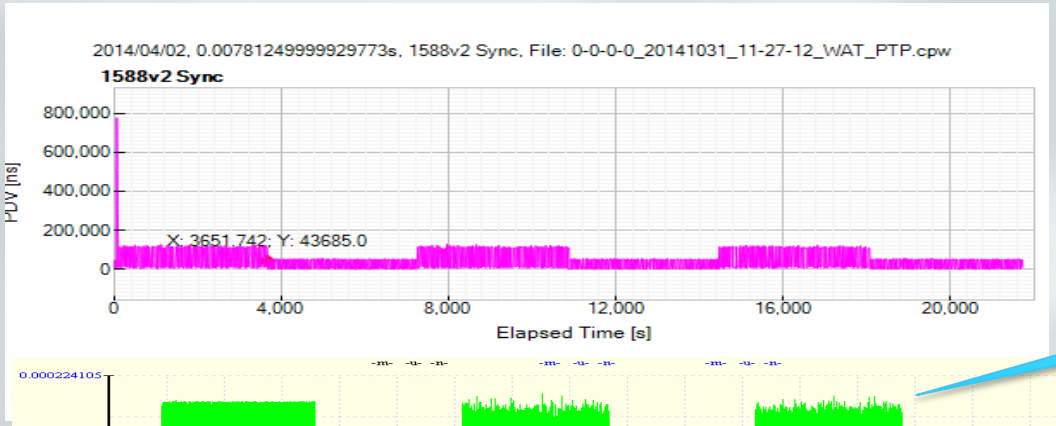
Precise timing provided by 1588 to achieve accuracy in logging operations to alleviate regulatory problems

3 Precision Timing - Challenges and Architecture solution

Challenges in Network based Precision Timing

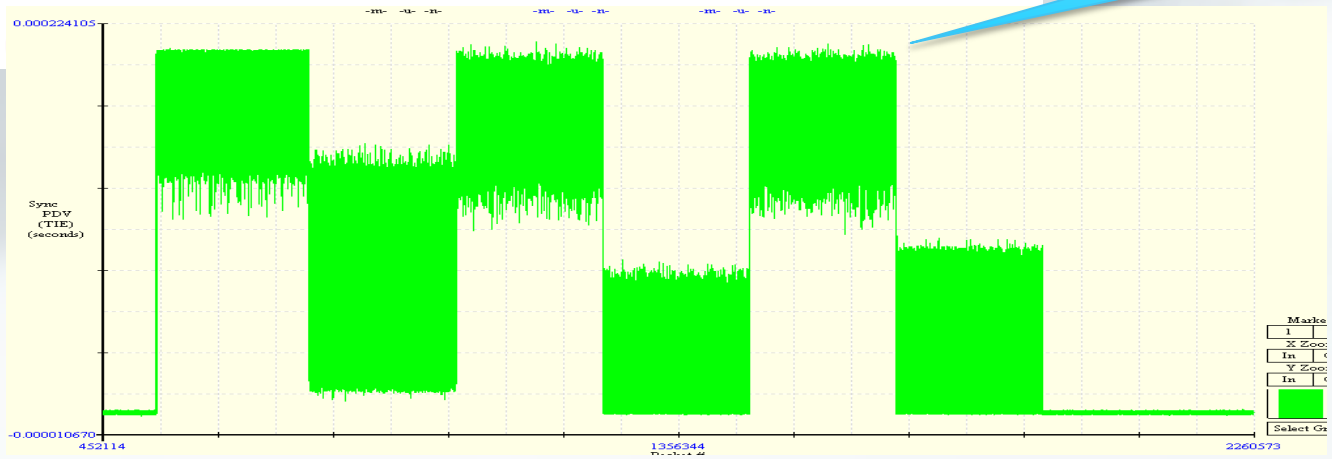
- Challenge 1 - Packet Delay Variation
- Challenge 2 - Scale : Number of PTP clients support
- Challenge 3 - Number of hops between Grand Master and PTP clients
- Challenge 4 - PTP profile to be used – IEEE1588 default profile or something else?
- Challenge 5 - Precision Performance Monitoring
- Challenge 6 - Vendor selection criteria

Network PDV



No Floor Shift

Floor Shift

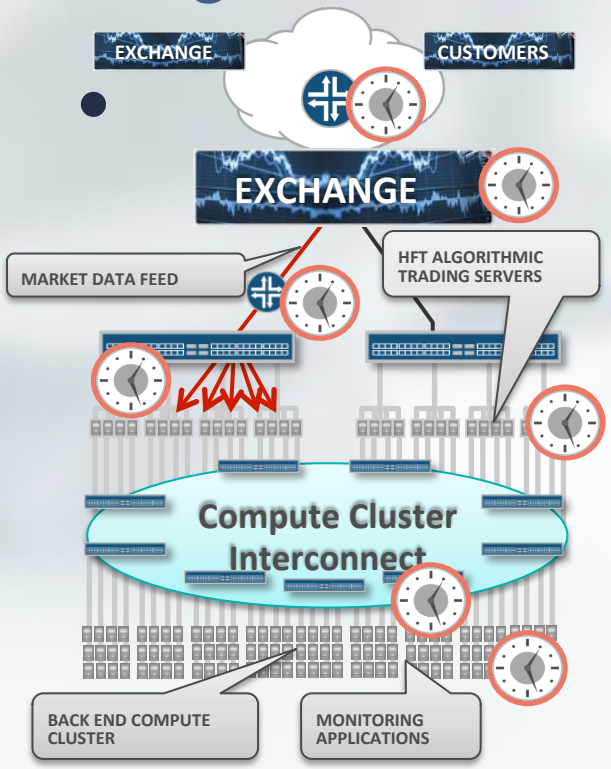


Solution for Network PDV and Node PDV

- Network PDV
  - Full path support
  - Use TC or BC clocks every hop between GM and Slave/Client nodes
  - Limit the number of hops based on the individual node performance
- Node PDV
  - Validate the Node performance and ensure that hardware based (PHY or MAC) time-stamping is supported
  - A simple PDV measurement with Data/Load traffic competing with PTP traffic – a good case to validate

Challenge 2: PTP clients scaling

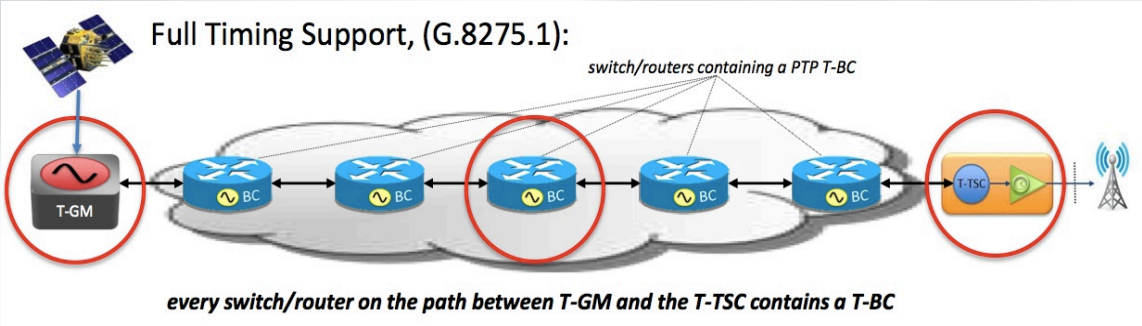
- There can be 10 or 100 thousands of servers in the financial trading network.
- No vendor GM can support 100 thousands PTP clients
- Network design shall make use of Boundary clocks hierarchically to serve group of servers (PTP clients)



Challenge 3 – Synchronization Network Hops

- The length of synchronization chain from GM to end slave (Servers with PTP clients) is key to achieve less than time accuracy.
- Every node (BC or TC) introduce some time offset from its upstream master termed as Time Error (TE).
  - Time error can be additive in a worst case scenario
  - Sum of time error < Target accuracy

Reference topology from Telecom world



Challenge 4 - Selection of Timing Profile

- IEEE 1588 default profile
  - Generically written standard for PTP
  - All other profiles were derived from 1588
  - Supports BC, OC, TC clocks
  - Supports PTP over IPv4, IPv6 or L2 (Ethernet) transports
  - Unicast/Multicast packet exchanges allowed
- **IETF Enterprise profile**
  - Mainly focuses on Enterprise/Datacenter applications
  - Supports BC, OC, TC clocks and No Peer-to-Peer timing
  - Supports PTP over IPv4 and IPv6 only.
  - Sync and Announce messages – Multicast, Delay-request and response – Multicast or Unicast

Challenge 5 – PTP performance monitoring

- Monitoring timing accuracy at 10s of thousands of servers – Really challenging!!!
- SNMP traps/alarms can be generated and monitored for:
  - System state change – Locked to a source, lost lock to source, Acquiring to a source
  - BMCA changes including new source/master selection.
  - Clock qualification and signal failure condition
- 1PPS measurement?

Challenge 6: Vendor Selection Criteria

- Node/Product selection criteria
  - Oscillator used
  - High resolution PHY/MAC time-stamping or similar support
  - Full control to change attributes and packet rates
  - How Smart – The servo algorithm?
  - PTP clients scale
  - Provision to performance monitoring support
- Breadth of solution – not just timing, and how good it is?
  - Spectrum of products with “End to End” solution

5 Summary

Summary

- Three “important” attributes of FSI – Security, low latency trading and time synchronization.
- Failure of any attribute – may not be acceptable, can be catastrophic.
- Based on conditions of failure - lead to regulatory audits and penalties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Thank you