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Time Synchronization in Financial Services Industry – A deep dive

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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 ...

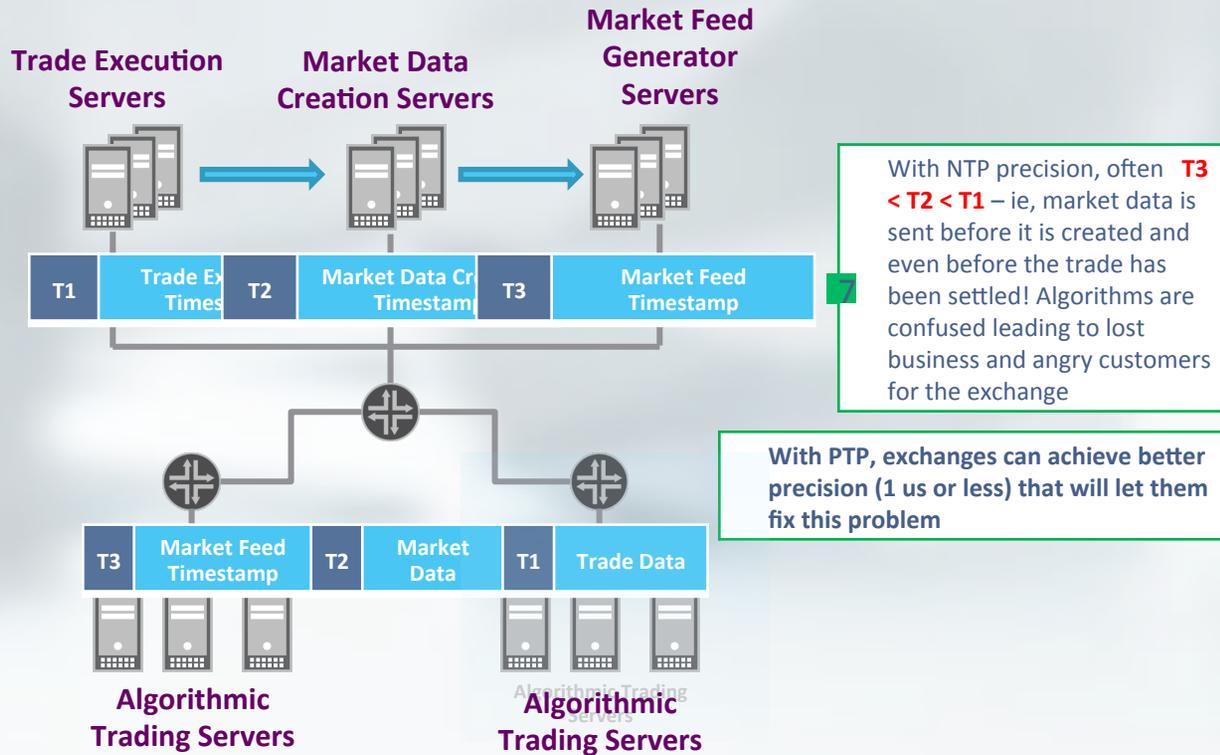
- Level of accuracy for member or participants of a trading venue

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

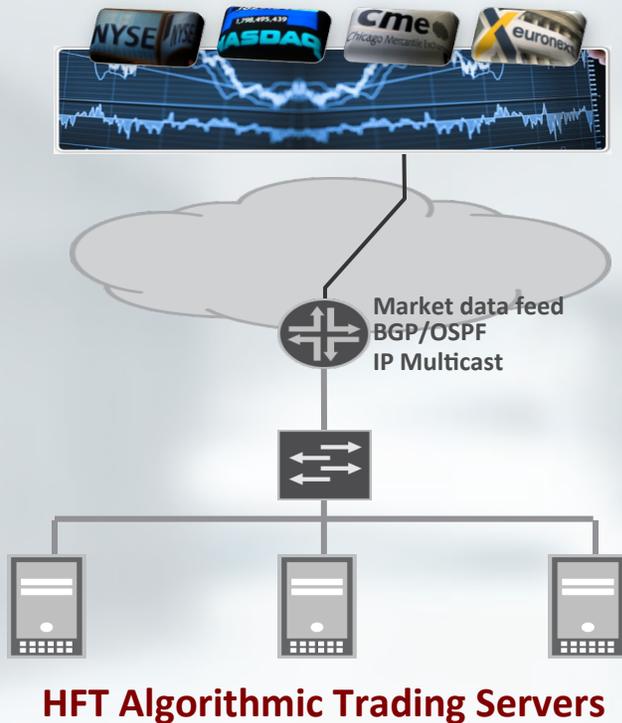
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Precision timing in Financial Services Industry

Case1 - Accuracy in Hi-FREQ algorithmic trading

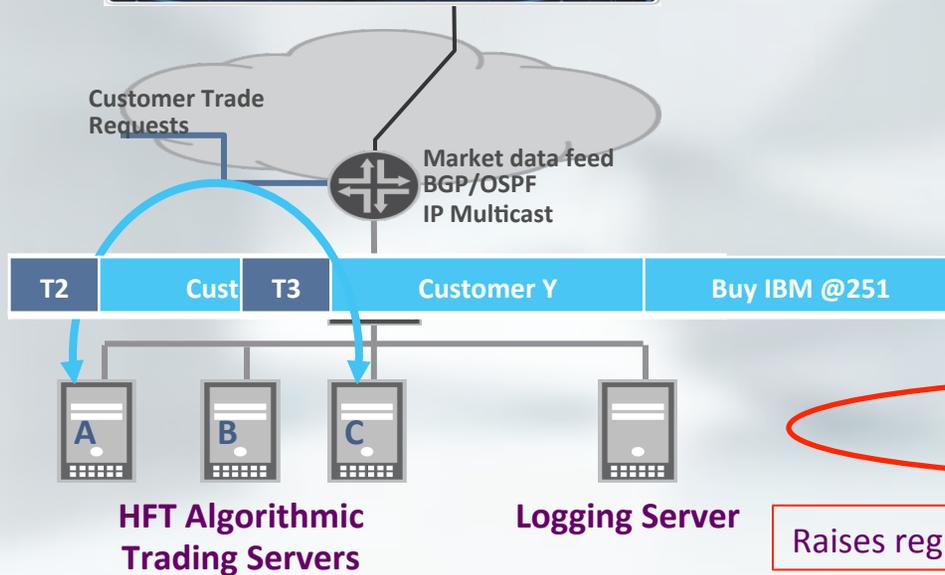


Case 2: END-To-END Latency analysis



- 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:

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

Case 4: Timing service provided by exchanges



HFT Algorithmic Trading Servers

Customer 1

Customer 2

Customer N

Exchange Co-location Environment

- Exchanges sell proximity services to buy-side and sell-side customers – Co-location
- Customers need to derive an accurate clock for Algo. engines
- Exchanges deploy IRIG-B or GPS services in every rack
 - Expensive
 - Often requires separate clock distribution network

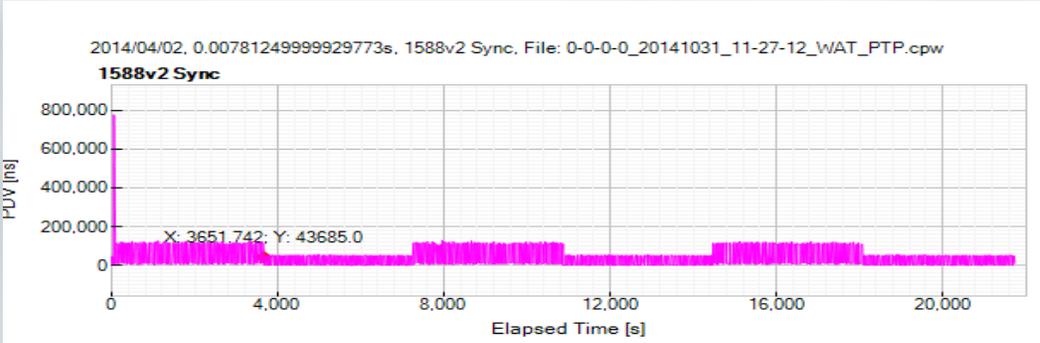
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Precision Timing - Challenges and Architecture solution

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

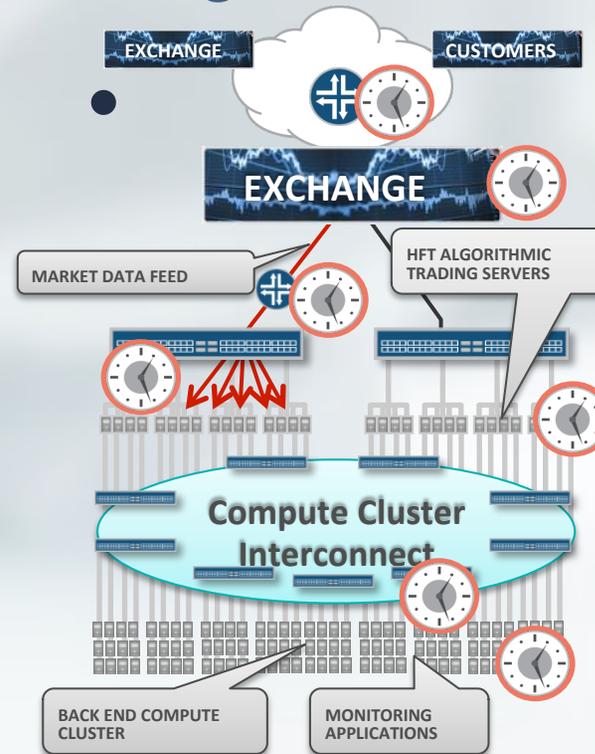
- Full path support
- Use TC or BC clocks every hop between GM and Slave/Client nodes
- Limit the number of hops based on the individual node performance

➤ 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 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

Thank you
