The challenges of UTC traceability
The pros and cons of S/W vs H/W time-synchronised data

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Corvil - October 2017
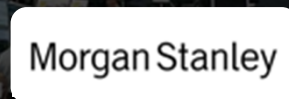
MiFID II Reportable Event, Capture Requirements
Monitoring, Order Record Keeping & Transaction Reporting

RTS-6: Requires comprehensive real-time monitoring and surveillance systems for algorithmic trades

RTS-24: Requires precise record keeping of all messages and events involved in trade execution life-cycle

RTS-25: All "reportable events" (ESMA/2015/1909 Section 3.1) need to be UTC synchronized with 1/100uS accuracy "or better"

**Intention is to enable audit and forensic inspection
of the sequence of trade events across all venues and members**

The Challenge
Time Stamping - Clock Synchronization - Traceability to UTC
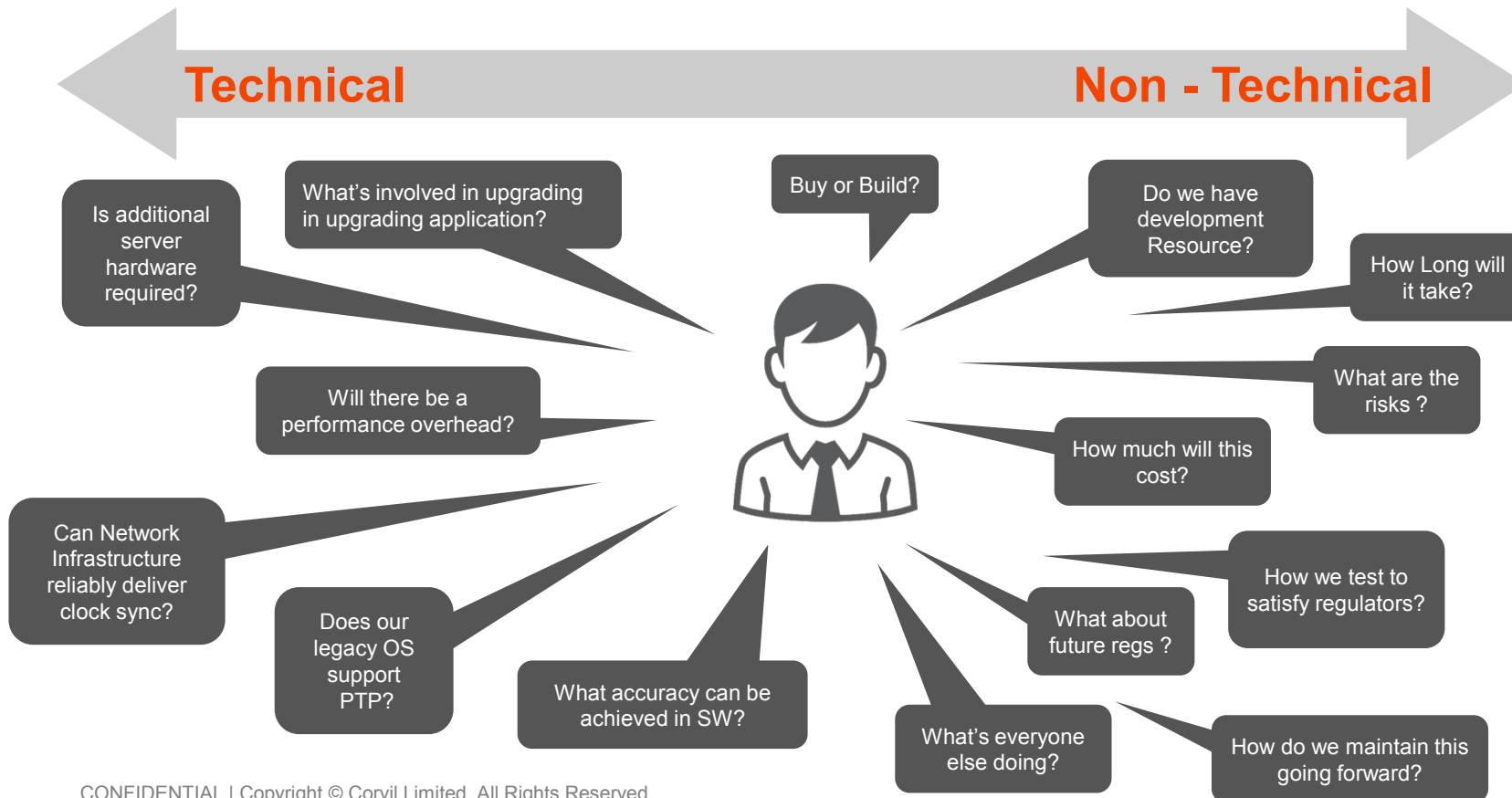
RTS-25 Article 4

"**Operators of trading venues and their members or participants shall establish a system of traceability to UTC**. They shall be able to demonstrate traceability to UTC by documenting the system design, functioning and specifications. They shall be able to 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. Reviews of the compliance with this Regulation of the traceability system shall be conducted at least once a year. "
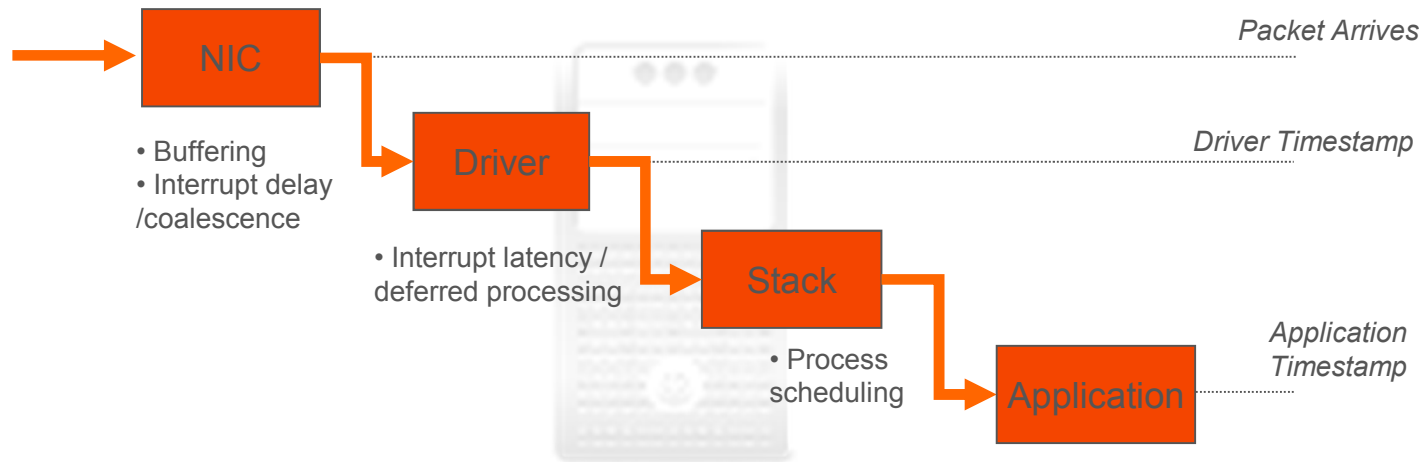
Type of Trading	Time Stamp Granularity	Traceability / Divergence
Manual Trading	1 second	+/- 1 sec
Others	1 millisecond	+/- 1 millisecond
HFT	1 microsecond	+/- 100 microseconds

NTP ?

PTP ?

Implementing Clock Synchronization & Timestamping

Technical ←——————————→ **Non - Technical**

- Is additional server hardware required?
- What's involved in upgrading in upgrading application?
- Buy or Build?
- Do we have development Resource?
- How Long will it take?
- Will there be a performance overhead?
- What are the risks ?
- Can Network Infrastructure reliably deliver clock sync?
- How much will this cost?
- Does our legacy OS support PTP?
- What accuracy can be achieved in SW?
- How we test to satisfy regulators?
- What about future regs ?
- What's everyone else doing?
- How do we maintain this going forward?

Jan 2018

Application Timestamping – NIC & Stack Latency

NIC

• Buffering
• Interrupt delay /coalescence

Driver

• Interrupt latency / deferred processing

Stack

• Process scheduling

Application

Packet Arrives

Driver Timestamp

Application Timestamp

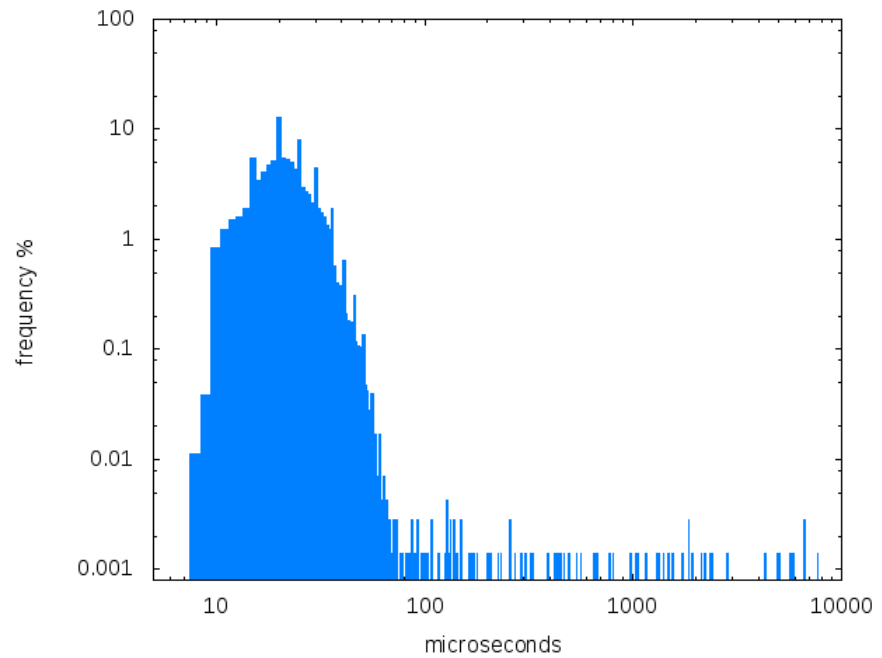# NIC & Stack Latency

Stack latency – difference between:

- Kernel timestamp
  - Taken in ISR
- Application timestamp
  - Taken just after recv()

- linux 2.6.25 on x86_64
- Intel 80003ES2LAN with   e1000e driver
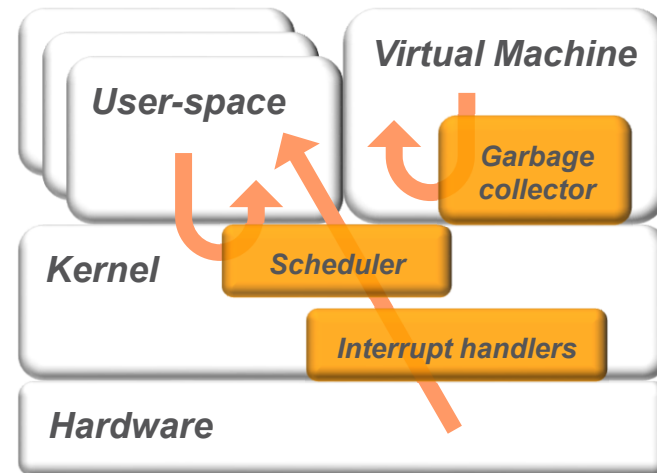
Software Timestamps

Hardware events

- PCI bus
- Interrupt masking

Software events

- Scheduler preemption
- Garbage collection
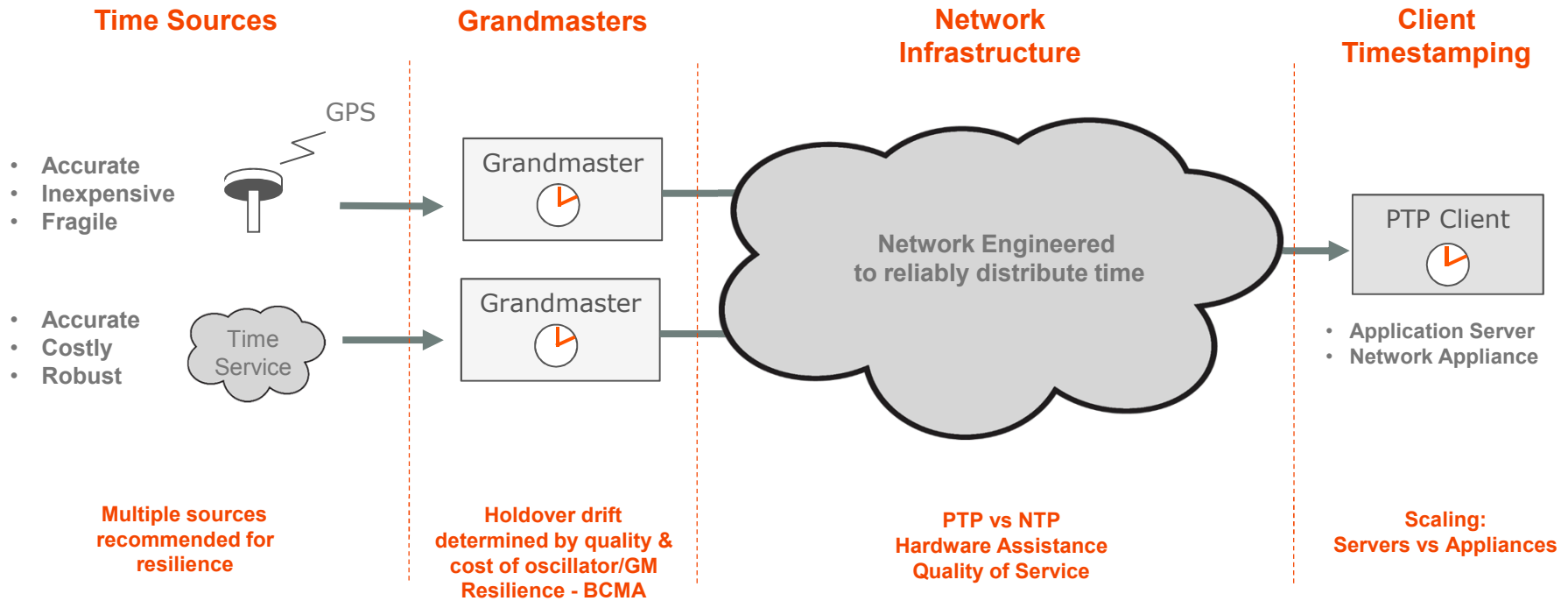
Accuracy of software timestamps to treated with caution…

MIFID II Challenges For The Business
Unquantified Cost, Complexity And Risk

	HW/SW/App Approach	On Wire (Corvil) Approach
Servers	Server OS and hardware upgrades to support PTP input	No change necessary *[Accurate Timestamping is offloaded to non-intrusive wire measurement system]*
Switches	PTP distribution to every Server – • possible Switch upgrades	Reduced size of the PTP distribution infrastructure – one wire measurement appliance/timestamping aggregation switch to hundreds of servers
Applications/DBs	Code changes to many applications, databases to implement MIFID-accurate timestamps.	No change necessary
Cost	💰💰💰	💰

System of Traceability to UTC will still be needed (RTS25, Article 4). **Banks must be sure of compliance and be able to demonstrate same. Without a time synchronization monitoring system, bank may not be deemed to have made "All Reasonable Efforts" to implement MIFID II UTC Traceability in full.**

Anatomy of Time Distribution

Time Sources

Grandmasters

Network Infrastructure

Client Timestamping

GPS

- **Accurate**
- **Inexpensive**
- **Fragile**

Grandmaster

- **Accurate**
- **Costly**
- **Robust**

Time Service

Grandmaster

Network Engineered to reliably distribute time

PTP Client

- **Application Server**
- **Network Appliance**

Multiple sources recommended for resilience

Holdover drift determined by quality & cost of oscillator/GM Resilience - BCMA

PTP vs NTP Hardware Assistance Quality of Service

Scaling: Servers vs Appliances

GNSS / GPS Considerations

Physical Disturbance

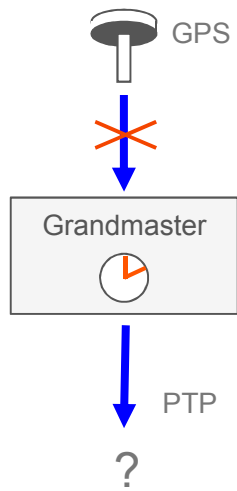Signal blocked

Weather

Solar Storms

Sabotage

Bugs

Alternatives?

- NPL Service (UK)
- PTP Service Providers
- Other RF services (eLoran)

Costly or emerging technology

Grandmaster Clock – Loss of GPS signal

GPS

Grandmaster
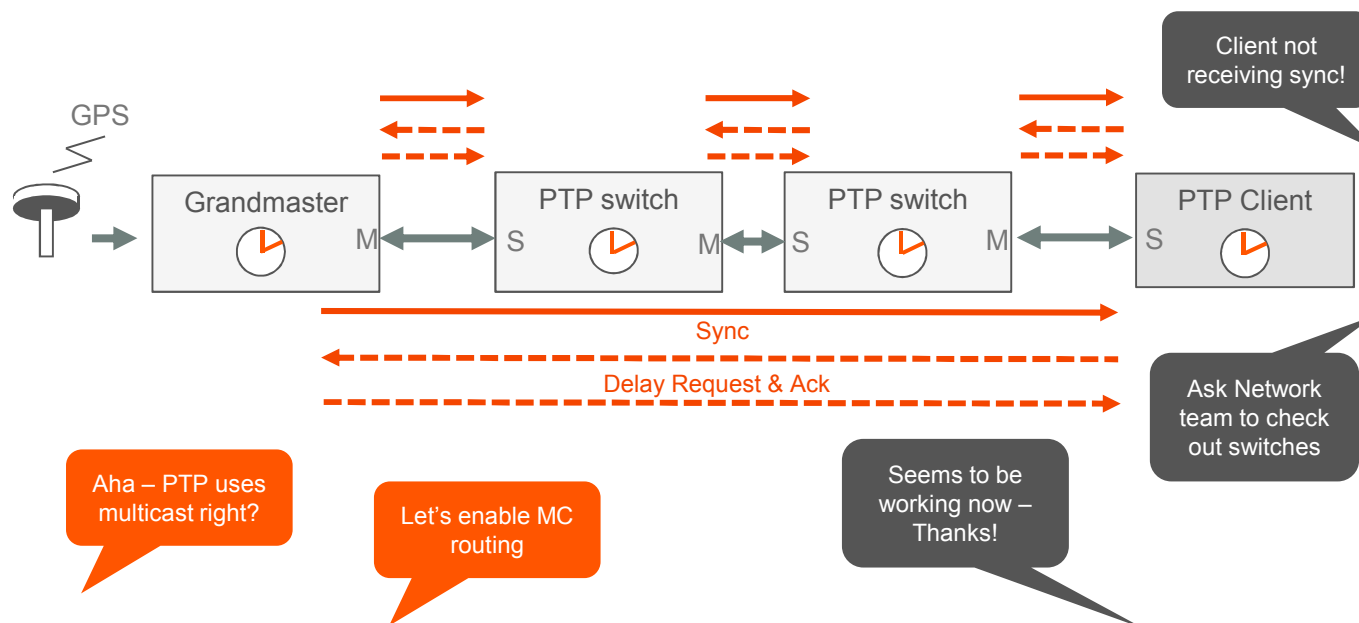
PTP

?

- GM goes into holdover & continues providing time
  - Rate of drift and accuracy of time is dependent upon the quality of the clock (and cost of Grandmaster)

- Example 0.1 ppm = 100ns per second
  - After 1 minute off by 6us
  - After 10 minutes off by 60us

- Important to consider resilience

PTP Jitter – Switch Misconfiguration

- DON'T enable multicast
- Enable PTP instead!

PTP Switches – Bugs and anomalies found in the field

Misconfiguration, impacting Delay-Response, causing incorrect clock offset.
- PTP hybrid mode misconfiguration – causing zero offset
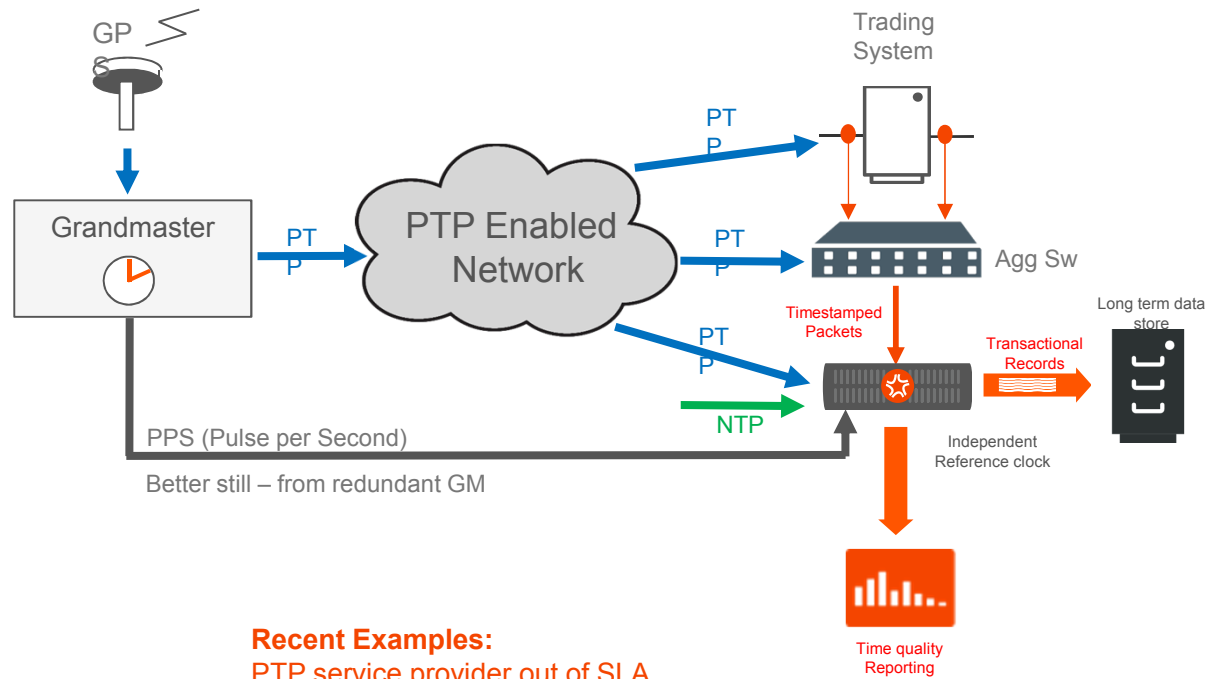- Port BW misconfiguration 100Mbps / 10Gbps - 5.5us offset

Architecture
- Non-PTP switch in path – negates benefit of hardware assisted switches. E.g. 12us to serialise 1500bytes onto 1Gbps link

Bugs
- Switch that appeared to sync to random offsets from UTC
  - E.g. 18 min, 19.5 secs or 55 minutes
  - Bug: Multiples of 2^{40} nanoseconds
- Numerous other bugs causing: jitter, incorrect path delay ~microseconds

Validating time quality downstream

GP S

Trading
System

Grandmaster

PTP

PTP Enabled
Network

PTP

PTP

PTP

PTP

Agg Sw

NTP

Timestamped
Packets

Transactional
Records

Long term data
store

PPS (Pulse per Second)

Better still – from redundant GM

Independent
Reference clock
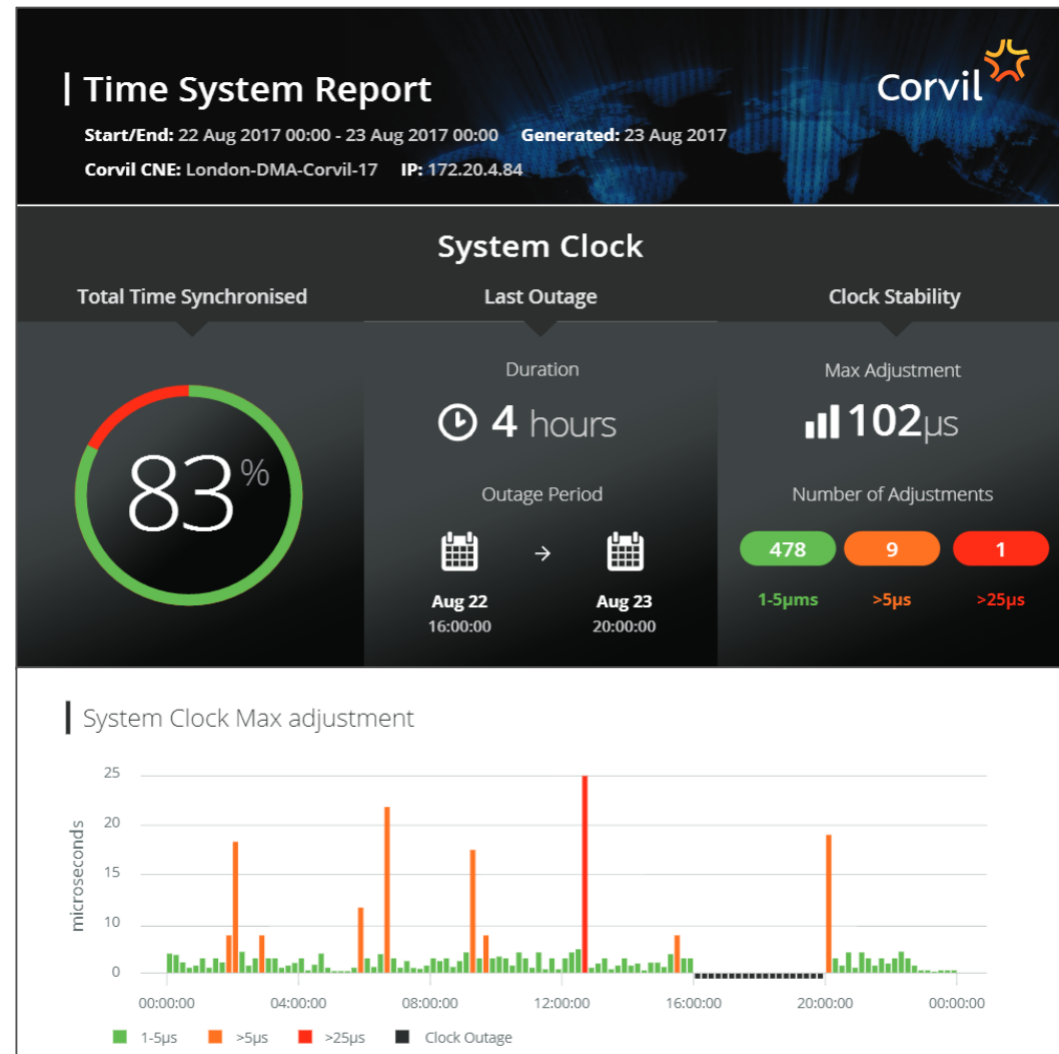
Time quality
Reporting

Recent Examples:
PTP service provider out of SLA
NTP implementation not meeting vendors claims

UTC Traceability Report

- **Daily report** of "time in compliance" and alerts of instabilities

- **Continuous validation and policing of clock sync distribution accuracy**
  - Includes **Corvil clocks + external aggregator switch clocks**
  - **PTP comparison to PPS**
  - Auto-tagging of Order Records with sync status

- **Stable, independent timestamp reference** Corvil internal hardware clock and model.

- **Validate upstream 'aggregation device' clocks** against Corvil stable reference

| Time System Report   Corvil

Start/End: 22 Aug 2017 00:00 - 23 Aug 2017 00:00   Generated: 23 Aug 2017
Corvil CNE: London-DMA-Corvil-17   IP: 172.20.4.84

System Clock

Total Time Synchronised | Last Outage | Clock Stability

83%

Duration
4 hours

Outage Period
Aug 22 16:00:00 → Aug 23 20:00:00

Max Adjustment
102μs

Number of Adjustments
478 (1-5μms)   9 (>5μs)   1 (>25μs)

System Clock Max adjustment

1-5μs   >5μs   >25μs   Clock Outage

Summary of Corvil Traceability Solution

Features

- Generate **alerts on loss of sync**, including loss of GPS input to PTP distribution.

- Generate **PDF report** on-demand, showing **clock stability** over chosen period (such as "last month", "last week")

- **Granular sync data retrieval through API** for detailed record-keeping and troubleshooting if required

Benefits

- **Rapid Response**: Outages are detected FAST enabling action to be taken quickly

- **Proven compliance**: Reports prove order records timestamped by Corvil comply with MiFID-II RTS-25 requirements

- **Integrated with record keeping:** sync flag inline with streamed records

- **Support for troubleshooting,** analysis and long-term record keeping

Corvil Sensor – Instrumenting host communication
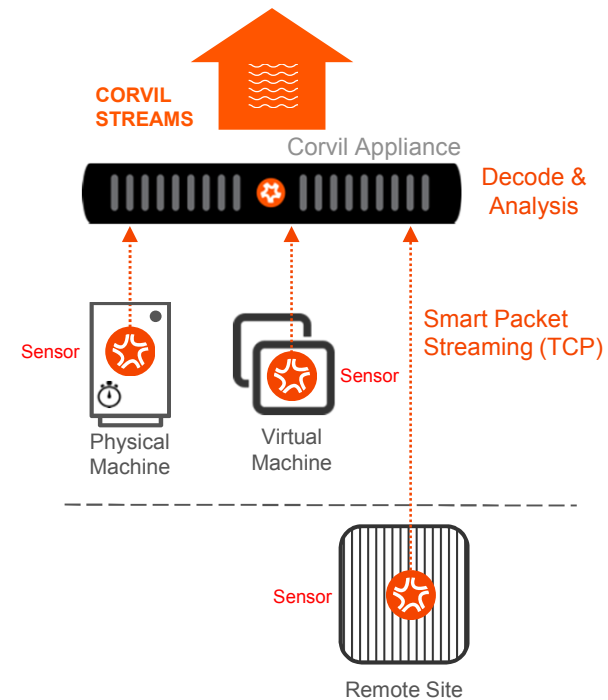## Low overhead & zero changes to application

What is Corvil Sensor?

OS-level software agent for physical or virtual hosts

Copies & timestamps all network I/O traffic

Forwards traffic to "Master" CNE over TCP connection

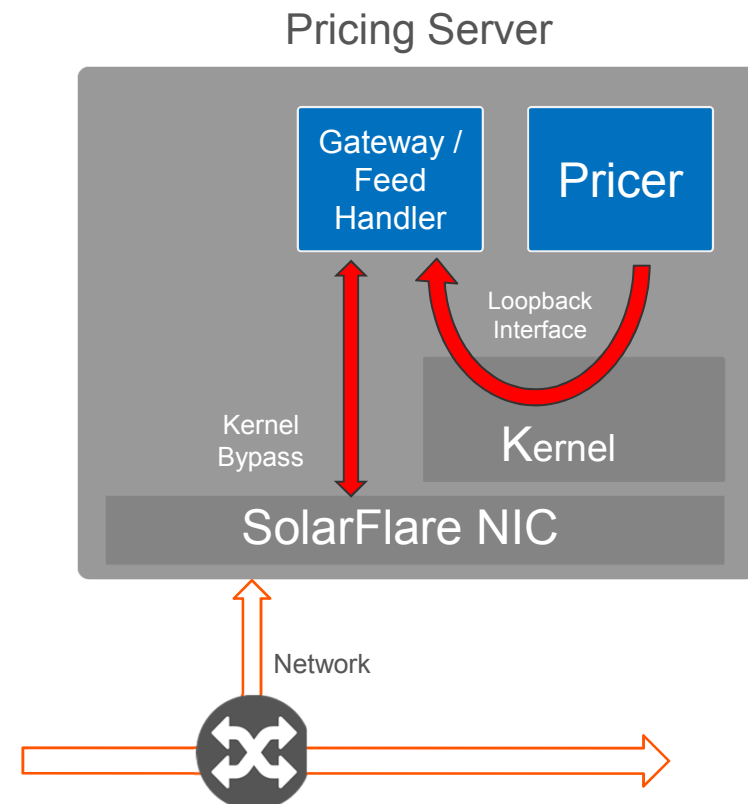Free to deploy, can be enabled/disabled on demand

CORVIL STREAMS

Corvil Appliance

Decode & Analysis

Sensor

Physical Machine

Virtual Machine

Sensor

Smart Packet Streaming (TCP)

Sensor

Remote Site

Sensor – Example Use case:
Inter-component & Network Visibility

Business Challenge:

- Fixed Income team needs visibility to optimize Pricing plant & timestamp records for MiFID II

- Several key components on a single Server (Gateway, Price Tierer)

- Opaque Low Latency environment

- Network Instrumentation cannot see inter-component communications

- Team struggles to identify source of performance glitches

Pricing Server

Gateway / Feed Handler

Pricer

Loopback Interface

Kernel Bypass

Kernel

SolarFlare NIC

Network

Sensor Use case:
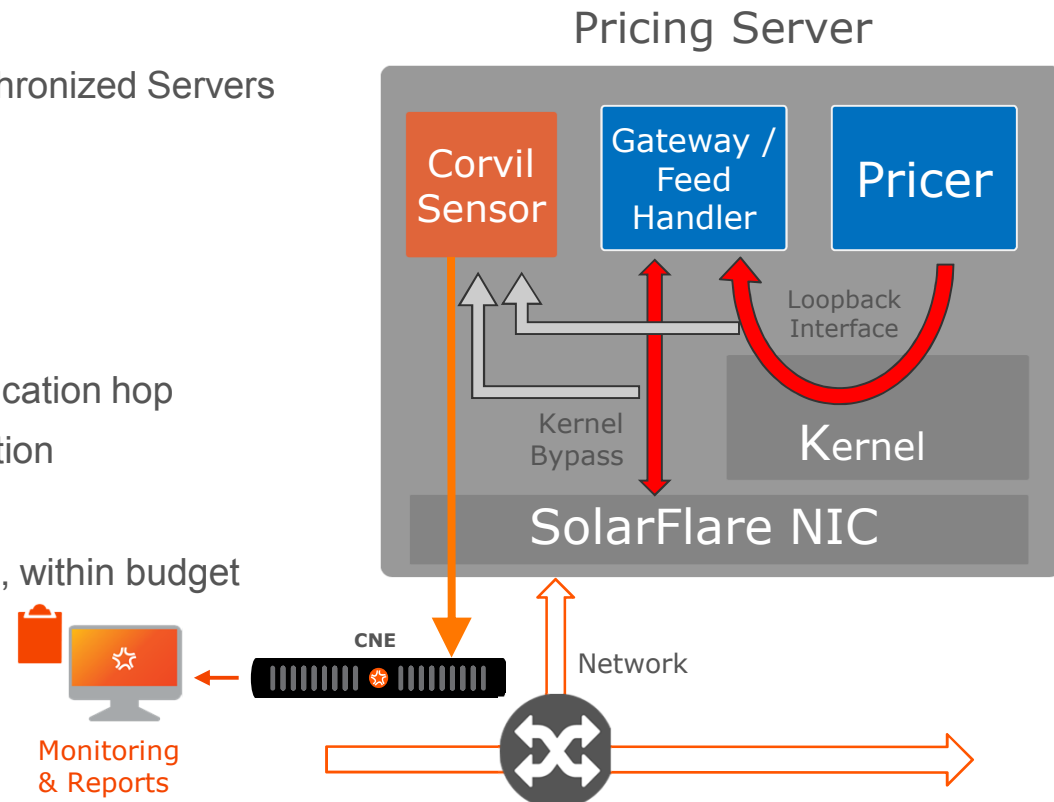## Inter-component & Network Visibility

Deployment:

- Across multiple sites with 6x PTP-synchronized Servers
- Sensors run on production servers
- Corvil appliance(s) processes traffic
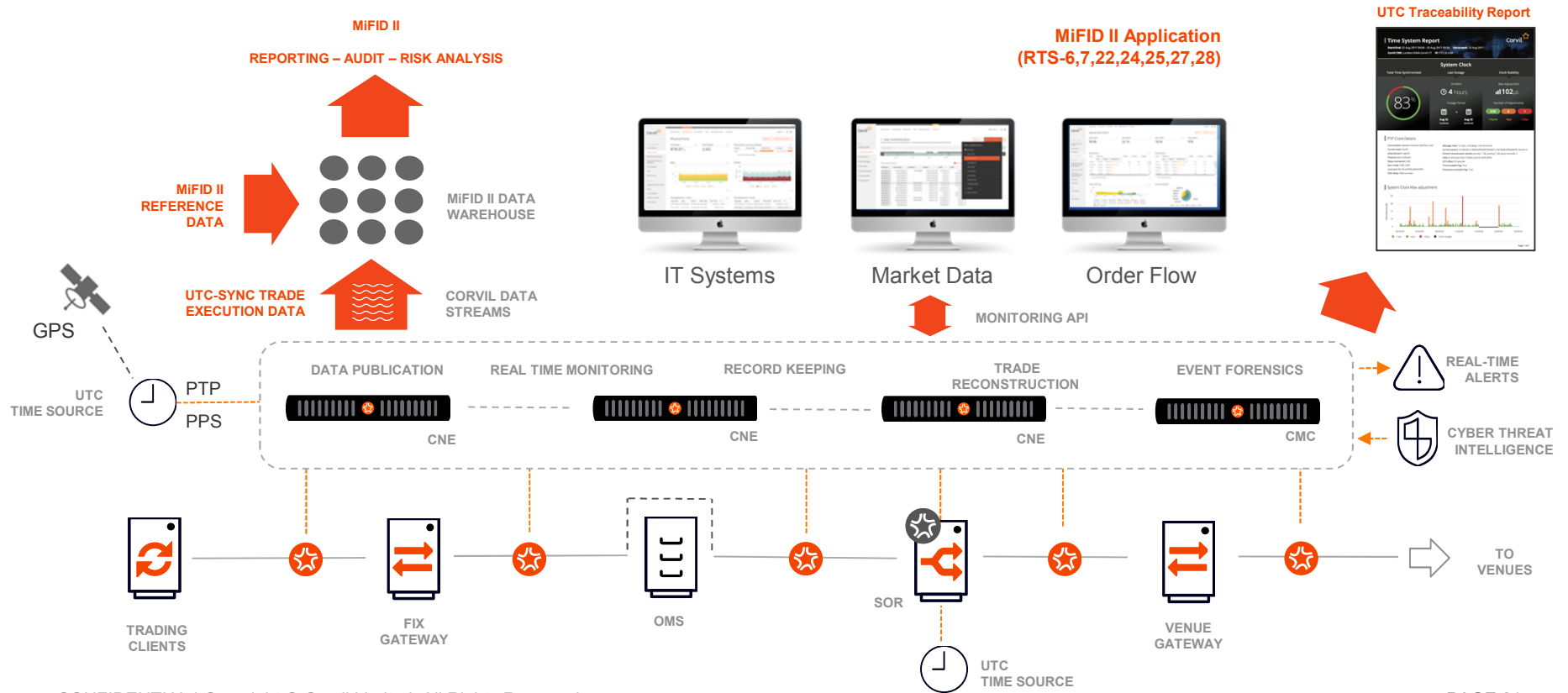
Customer Value Proposition:

- Full and accurate visibility of each application hop
- Economic and scalable deployment option
- Simple and fast to deploy and manage
- Full real-time analytics for the business, within budget

Pricing Server

Corvil Sensor

Gateway / Feed Handler

Pricer

Loopback Interface

Kernel Bypass

Kernel

SolarFlare NIC

CNE

Monitoring & Reports

Network

The Corvil Solution & Ecosystem
A Streaming Data Capture and Analytics Platform For MiFID II

UTC Traceability Report

MiFID II
REPORTING – AUDIT – RISK ANALYSIS

MiFID II Application
(RTS-6,7,22,24,25,27,28)

MiFID II
REFERENCE
DATA

MiFID II DATA
WAREHOUSE

UTC-SYNC TRADE
EXECUTION DATA

CORVIL DATA
STREAMS

IT Systems

Market Data

Order Flow

MONITORING API

GPS

UTC
TIME SOURCE

PTP

PPS

DATA PUBLICATION

REAL TIME MONITORING

RECORD KEEPING

TRADE
RECONSTRUCTION

EVENT FORENSICS

REAL-TIME
ALERTS

CNE

CNE

CNE

CMC

CYBER THREAT
INTELLIGENCE

TRADING
CLIENTS

FIX
GATEWAY

OMS

SOR

VENUE
GATEWAY

TO
VENUES

UTC
TIME SOURCE

Thank You

Please meet us at the Corvil booth