ARE WE THEN YET?

Defining time sync requirements for electronic trading

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ICE **NYSE**

WOJCIECH OWCZAREK

WSTS 2015, San Jose, CA, 9-12 March 2015

Background – ICE

› Global stock exchange operator

› ICE + NYSE group of companies

› Multiple exchanges in US and Europe

› Own clearing houses in US and Europe

› Global financial market access network operator

› State of the art DC: UK and multiple in US

› Global dark fibre backbone, highly resilient

› Nodes in all large finance hubs in EU and US

› Primarily 10GE, 40GE rollout since 2014

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Timing in electronic trading - specifics

› **All about phase**

No hard limits, poor sync harder to track:

› No dropped calls, no power grid collapse

› Can go unnoticed unless specifically monitored

› Most react, few detect

Exchanges vs. HFT players / hedge funds:

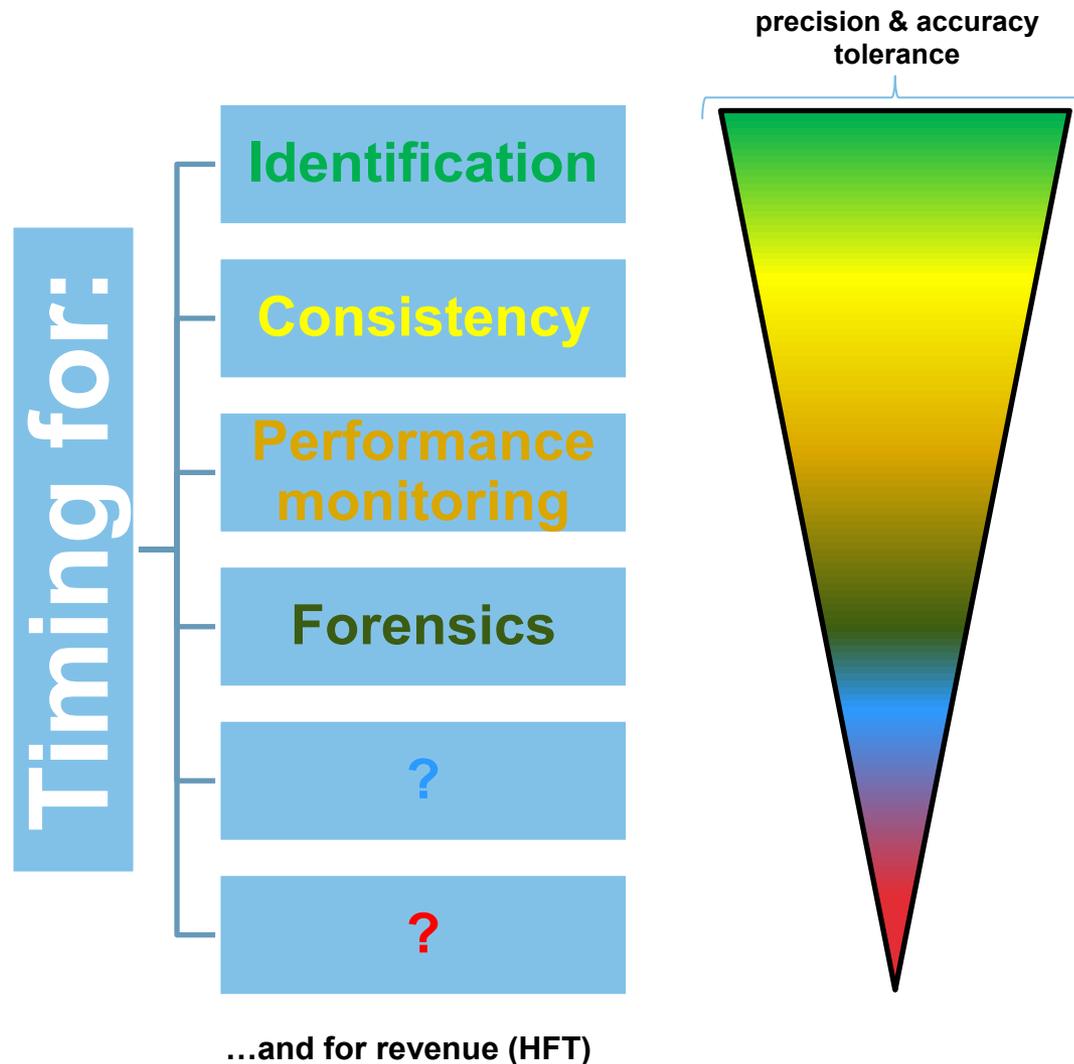› *Timing not critical for revenue*

› Less frequent H/W refresh

› Message rates can be lower

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Timing in electronic trading - specifics

Adding timing to the network:

› Requires on-path hardware support

› Need to use enterprise hardware

› Separate timing network = wasted ports

› Hardware just about ready, not every tier yet

› Network architects must keep timing in mind

› Can't get away from HW

› Half measures short-lived

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Different facets of timing in electronic trading

precision & accuracy
tolerance

Timing for:

Identification

Consistency

Performance monitoring

Forensics

?

?

…and for revenue (HFT)

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Electronic trading – timing for… Identification

Timing for identification - orders:

› Timestamp each step: enter, route, execute

› Resulting public market data, timestamped

› Market data feeds back algorithms

Minimal requirement - resolution:

› Busiest market: 200,000+ mps / line (FIF, 2014)

› Peaks at over 10,000 mps / symbol

› **Sub-100μs resolution needed *at minimum***

› Many protocols still at 1ms timestamp fields

› Many moved or moving to 1 ns resolution

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Electronic trading – timing for… Consistency

Story of a quick trade…

Negative delays (very bad):   time @ node

› Bid submitted   (gateway or ME)   12:35:12.78**2000**

› Trade made   (Matching Engine)   12:35:12.78**0000**

› Path delay   (including software)   00:00:00.000100

GW vs. ME out of sync *or* time drift or spike on ME

App Timestamps usually generated in software

› **Order filled 1.9 ms in the future?**

Problems maintaining and measuring order lifetime

Max phase error allowed: ≤ path delay $_{GW \rightarrow ME}$

Easy?   Fun begins here.

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Electronic trading – timing for… Consistency

› Faster media, CPUs, NICs, ASICs… Path delay keeps shrinking

| Host wire to application (OS)	single ToR switch	single Core switch Increased for m/cast and many line cards
2010: 20 µs (OS only)	2003: 15 µs+ GE ToRs S&F	2005: 12 µs+ GE core switch chassis
2010: sub-10 µs (offload engine)	2005-2008: 4-6 µs+ Enterprise GE ToRs S&F	2008: 10 µs+ 10GE core switch chassis
2012: 2-3 µs (offload engine)	2008: 3-5 µs first 10GE ToRs S&F	2010: 4 µs 10GE core switch chassis
2011…: sub-1 µs (FPGA off switching ASIC)	2010: sub-1µs first ULL 10GE ToR C/T	2012: 4 µs Clos topology built with 10G TORs
2014: sub-2 µs (offload engine)	2013: sub-500 ns next-gen 10GE ASICs C/T	2013…: sub-1µs 10/40 GE ToRs capable of core role
(RoCE or RDMAoIB usually internal)	2013: sub-1µs 40GE ASICs C/T	

Evolution of data delivery latencies (LAN/DC) – application has caught up with the network

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Electronic trading – timing for… Consistency

Over 0.5% trades executed in sub-50 μs

Close to 5% trades executed in sub-500 μs

Not all orders filled immediately

Quote Lifetime: Corporate Stocks
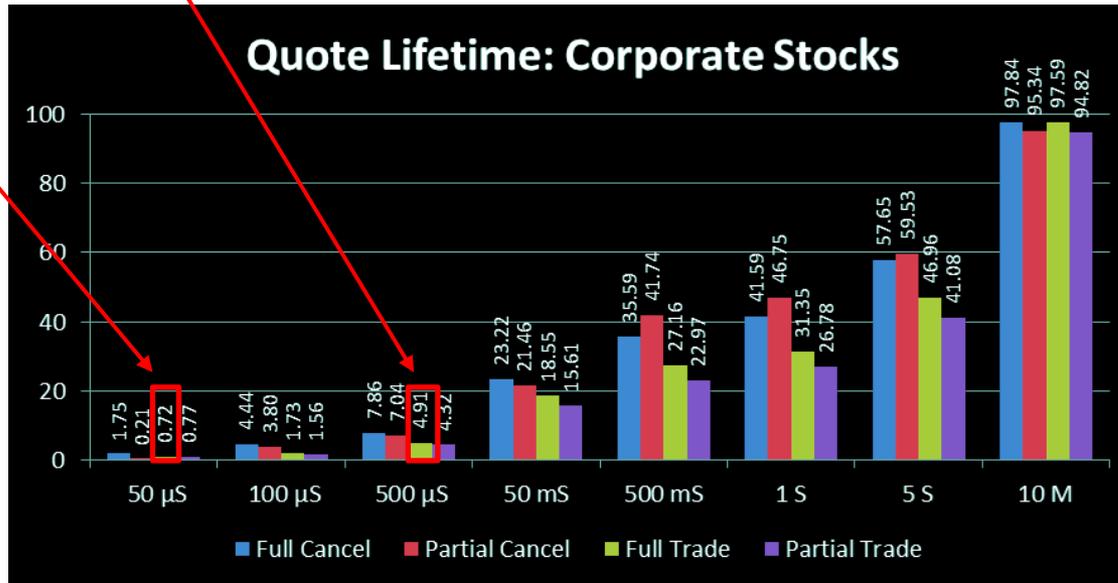
(US Securities and Exchange Commission, 2014)

Max phase error allowed: min (T_{fill})

(sync across whole exchange)

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Electronic trading – timing for… Monitoring

Technology:

› Passive taps, timestamp at TapAgg layer

› Port mirror + ingress timestamp on ToR

› ToR Switches with built-in analytics

› *OR* Applications using s/w timestamps for monitoring

> **For 10% uncertainty margin:**
>
> **1µs precision or better**

Latency monitoring probes:

› Data from taps at different locations

› Or tmestamped data from TapAgg

› Data hashed, correlated

› End-to-end latencies measured as low as 10µs

Time sync needed across monitoring kit only

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Electronic trading – timing for… Monitoring

Internal latency monitoring (within trading system):

› Self-computed figures not reliable unless…

› At sub-1 µs error no extra tools needed
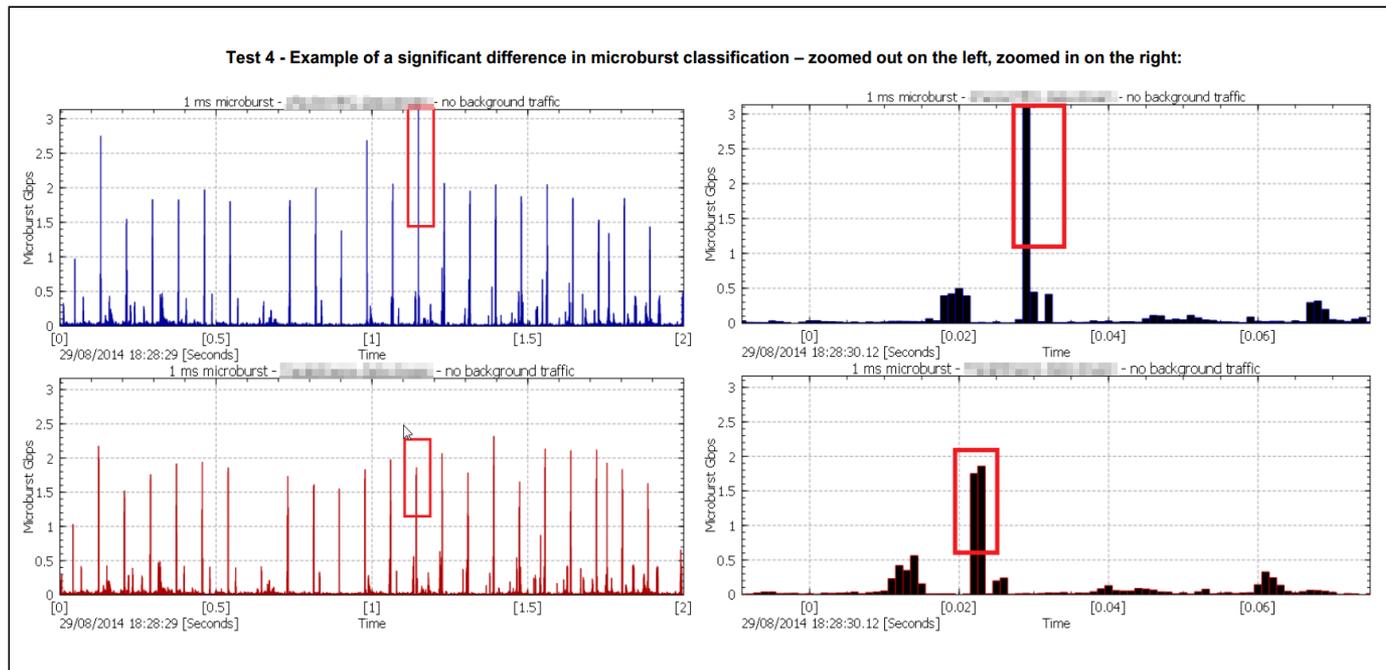
› At sub-10 µs error extra tools mostly not needed

Capacity monitoring:

› Ultra low-latency switches (ULL), small buffers

› Burst can cause packet loss, needs monitored

› Capacity increased when hitting bursts often

› Line rate microburst measurement

› Derived from data rate seen in 1 ms

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Electronic trading – timing for… Monitoring

Capacity monitoring:

› Tools out of sync: false positives or negatives:

Test 4 - Example of a significant difference in microburst classification – zoomed out on the left, zoomed in on the right:

Example - two tools reporting almost 50% difference:

Caused by 160 µs phase error (ICE/NYSE lab, 2014)

For 10% margin,

max error appr. 30 µs

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Electronic trading – timing for… Market Forensics

Exchange-driven requirements end here

› **Tracking down a cascade of events**

› **Should be easy on one exchange**

Not so simple in real life:

MTFs	Dark pools	Exotic derivatives	Cross-listing
Private exchanges Multiple parties		Complex underlying dependencies	Listing on many exchanges
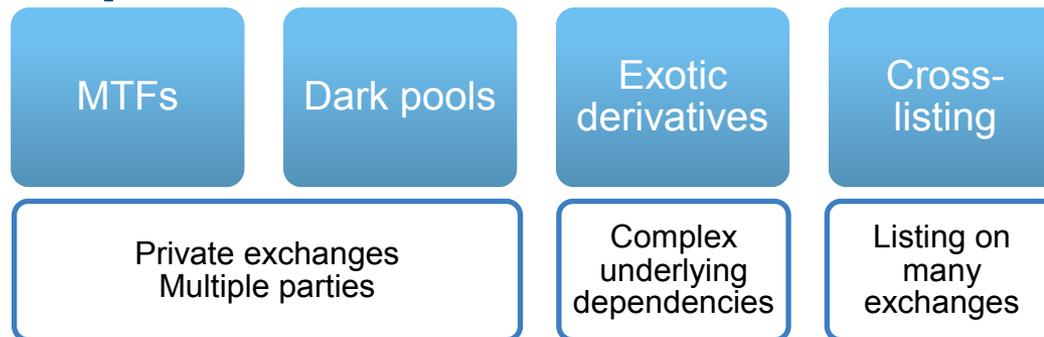
"Algos gone wild":

Algorithm places up to 30,000 quotes / second on the same stock (Feb 2014, NYSE – many other examples)

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Electronic trading – timing for… Market Forensics

Previous timing use cases:

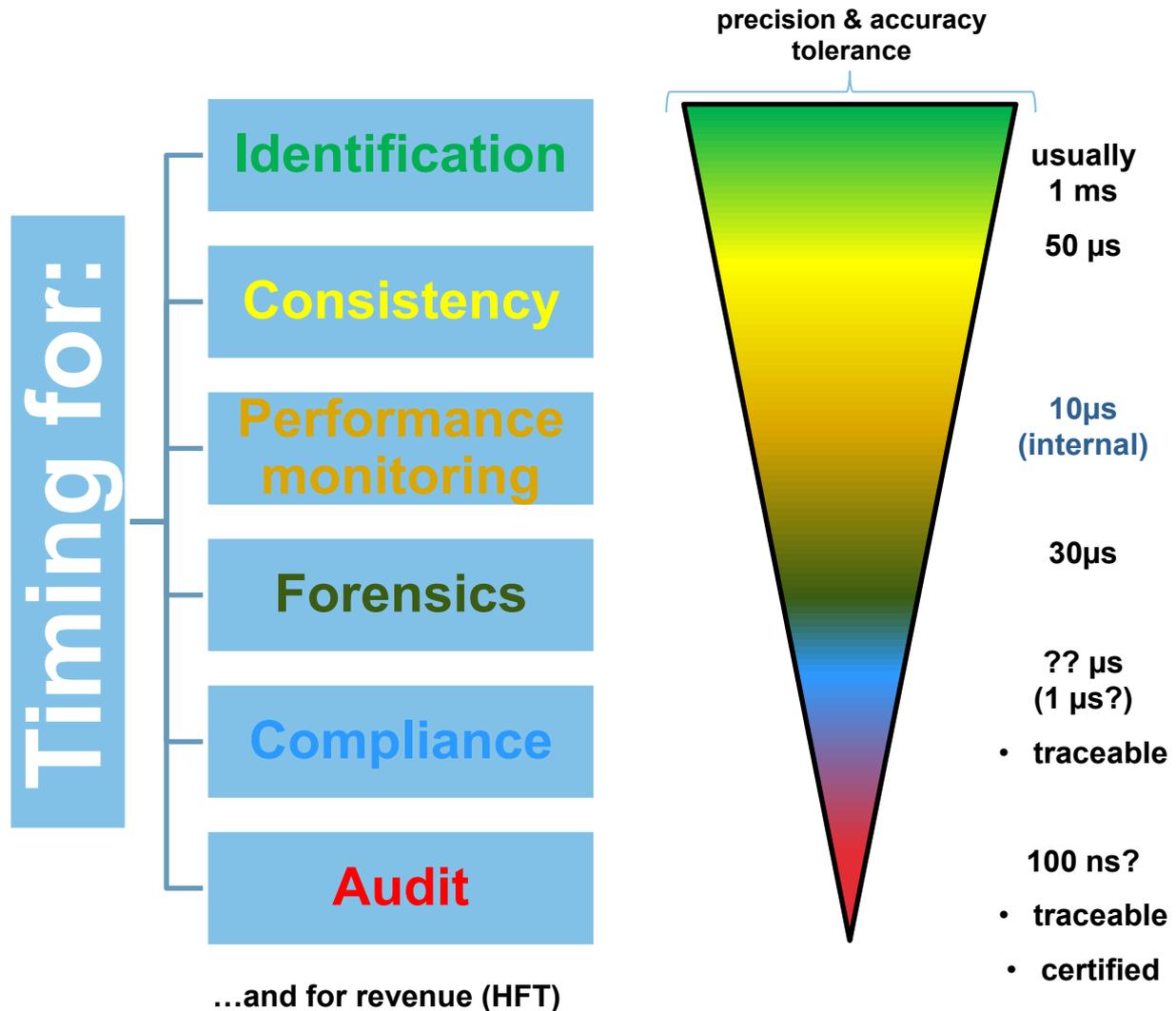› Exchange time taken as is

› Recording the order of trades good enough

Forensics in HFT land:

› Multiple order entry points

› Third parties behind members

› Private mini-exchanges

Required:

› Global UTC sync of all parties

› At least sub-30 µs error and decreasing

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Different facets of timing in electronic trading

precision & accuracy tolerance

Timing for:

- Identification
- Consistency
- Performance monitoring
- Forensics
- Compliance
- Audit

...and for revenue (HFT)

usually 1 ms

50 µs

10µs (internal)

30µs

?? µs (1 µs?)

- traceable

100 ns?

- traceable

- certified

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Electronic trading – timing for… Compliance

Current regulations on timestamps:

› **Can be met even with NTP over WAN**

› **FINRA: 1 s resolution. 1 s error vs. NIST:**

  ▪ **1 ms resolution only since Sep 2014**

    – **off-exchange trades only**

  ▪ **some pre-2000s rules such as: sync once per day**

› **SEC: 3 s from NIST or USNO until Feb 2014**

› **SEC rule 613 (CAT) - Feb 2014:**

  ▪ **1 ms resolution**

  ▪ **max error 50 ms from NIST**

› **Europe - MiFID1: no mention of time sync**

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Electronic trading – timing for… Compliance

ENTER MiFID 2:

› **May-Dec 2014**

  ▪ **Discussion Paper**

  ▪ **Call for comments**

› **Dec 2014 - tech advice released:**

  ▪ **1 ms resolution and accuracy**
    when venue's gateway-to-gateway time 1 ms+

  ▪ **1 μs resolution and accuracy**
    when gateway-to-gateway time sub-1 ms *(many)*

› **Effective Jan 2017 if approved mid-2015**

photo: J McFarlane, flickr

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Electronic trading – timing for… Compliance

Timing questions in MiFID 2 DP:

› **National or pan-European source of sync?**
› **Is 1 µs resolution / precision acceptable?**
› **Maximum error? How often to correct?**

Industry's responses:

› **34 out of 200+ responded – not all who should have**
› **Some major exchanges and HFT did not.**

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Electronic trading – timing for… Compliance

MiFID 2 Discussion Paper - Industry's responses:

› **Nearly all agree on UTC**

› **Many myths, many naïve answers (educate!)**

› **Nearly all concerned with substantial costs (if 1μs mandated) – is it really that bad?**

› **Huge disparity - anywhere from 1μs to seconds**

› **Few agree on 1μs resolution / error**

› **Most suggest 1 ms. Some: correct at start of day!**

› **Very few suggest well-motivated 10 μs**

› **Very few raise the need for timing audit**

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Electronic trading – timing for… Compliance + Audit

MiFID 2 aftermath:

› **Even if not 1µs mandated, likely lower than 1 ms**

› **Sooner or later SEC / FINRA will follow**

› **Like it or not – everybody gets precision timing**

› **Only systems in critical order path**

› **Traceability required**

› **Reporting and logging needed – time sync audit**

› **Time sync audit also requires *certified time***

› **Need to develop and deploy time monitor tools**

*Vendors :
Sales opportunity*

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Time sync for Electronic trading: getting there

Yesterday – basic precision timing:

› **GM, soft slaves or HW slaves**

Today – partial on-path – separate timing network:

› **GM → BC/TC (distribution) → ToR (BC) → HW Slv**

› **GM → BC (distribution) → ToR (TC) → HW Slv**

Tomorrow – full on-path support:

› **DC core and WAN core gain TC and BC support**

› **Not really enterprise-ready today**

Day after tomorrow:

› **Ubiquitous sync must happen, TAACCS effort**

› `tod` **register and** `rdtod` **in CPU!**

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Time sync for Electronic trading: getting there

Road to full sync:

- **Most new NICs today, all tomorrow**
- **Most network kit today, all tomorrow**
  - **IEEE 1588 as standard feature from many vendors**
- **Realistically 10µs will do today (for trading systems)**
  - **Performance and monitoring need better**
- **Organic transition if legislation is paced**
- **Eventually in-hardware sync out of the box**

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Time sync for Electronic trading: getting there

What we need from vendors:

› **1PPS out and TIE measurement everywhere**

› **Multi-input, arbitrating GMs:**

  ▪ **GNSS, eLORAN, PTP in**

› **10GE GMs! In fact – at least more GE GMs!**

› **Core switches and core routers:**

  ▪ **enterprise PTP, not Telecom or SyncE (unless BC can translate!)**

› **Sync monitoring equipment (not lab kit)**

› **Certified time services**

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ICE / NYSE LAB

Belfast : Sep 2010 – Jun 2014

Install

Build & Operate

Dismantle

Shut down

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ICE / NYSE LAB

Basildon DC: Jun 2014 onwards

Secure & Move

Install

Build

Operate

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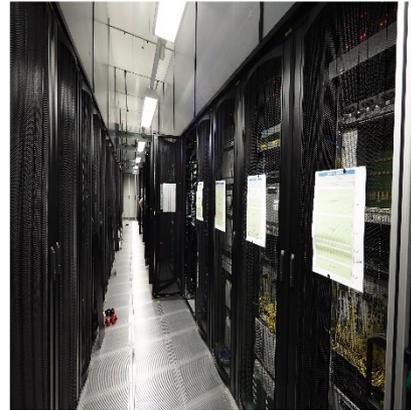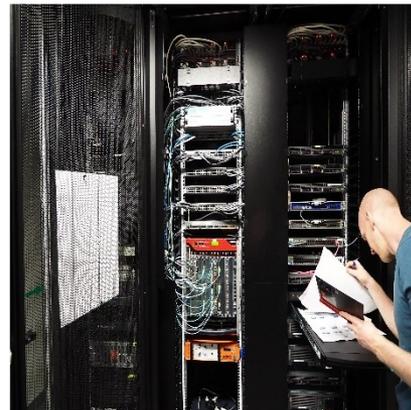
Time sync for Electronic trading: Thank you.

Questions?

wojciech.owczarek@theice.com