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Why DLT Needs Timing: How Does it Impact Consensus and Security?

Time and Money Workshop, NYSE Jan 2020

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Overview

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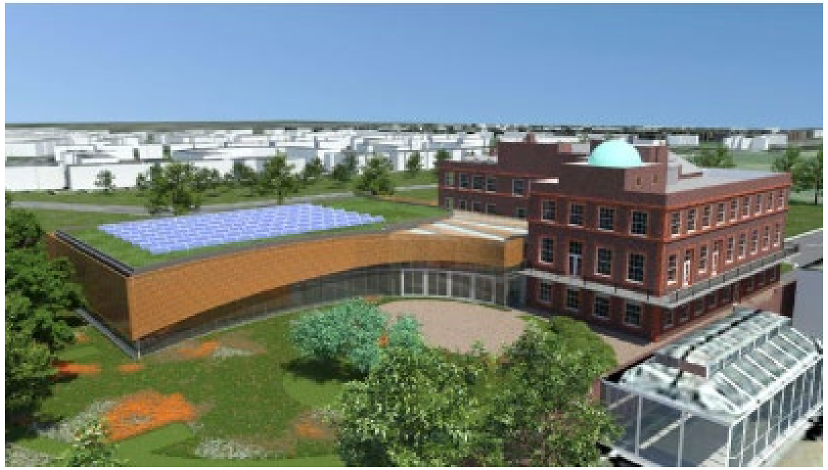
- The need for robust, secure and precise timing in DLT
- Optical fiber-based techniques as a secure alternative to GNSS: PTP and White Rabbit
- Proof-of-concept trial using timing over optical fiber in a Distributed Ledger testbed
- Impact on consensus
- Delivering precise time over optical fiber in Europe: Current status and future developments

About NPL

- The UK's national standards laboratory, founded 1900
- Ensures consistency & traceability of measurements throughout the UK
- Government owned company
- 750 employees (550 scientists)
- Located in Teddington, South West London
- New: Advanced Quantum Metrology Laboratory (AQML)



- Time and Frequency Group (~50 people)
- Maintain the UK's timescale UTC(NPL)
- Run the UK's primary frequency standard
- Develop next-generation atomic clocks
- Develop time & frequency transfer techniques
- Provide calibration services for λ and ν

The need for precise timing in DLT

Consensus on the ordering of events in a Distributed Ledger is a challenge

Steps towards this rely on timestamps based on a common clock (UTC)

Security and reliability of a timestamp from GNSS cannot always be guaranteed; optical fiber offers a robust alternative

A fiber link from a UTC(k) lab can guarantee traceability to UTC to meet regulatory requirements

The accuracy of the timestamp can also be increased by using PTP or White Rabbit protocols

PTP and White Rabbit overview

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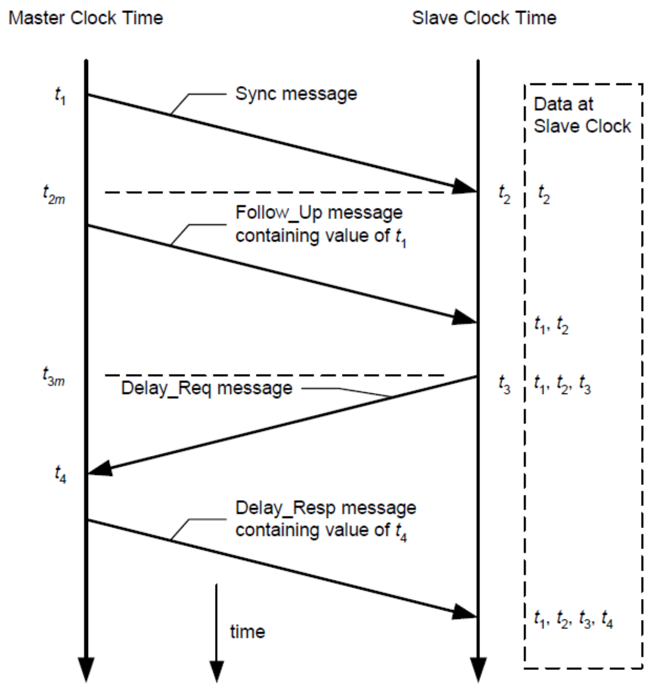
IEEE 1588-2008v2 or Precision Time Protocol (PTP) is a two-way time transfer protocol used to synchronize clocks throughout a network

- Can achieve accuracy in the sub-microsecond range
- Used to synchronise financial transactions and telecoms networks to a reference clock
- Can provide precise timing in GNSS denied environments



White Rabbit is an extension of PTP to achieve much higher performance

- Can achieve sub-ns accuracy
- Was developed at CERN to provide accurate time synchronisation for the particle detectors
- Originally intended to operate over 10km links, but sub-ns synchronisation has been demonstrated over 1000 km fiber links
- Currently used to synchronise financial transactions in Madrid and Milan and has scientific applications for neutrino array detectors (KM3Net) and radio telescope arrays (SKA)
- WR is an Open Source collaboration https://www.ohwr.org/projects/white-rabbit

Time over optical fiber for the Finance Sector in the UK

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NPL*Time*® takes advantage of the UK national timescale UTC(NPL) to disseminate a time signal via fiber optic link to customers

This PTP-based service provides end users with resilient and certified timing and synchronisation of systems to a high level of accuracy

Time signal is independent of GPS with caesium clock holdover at two sites. The service is monitored by NPL and guaranteed to within ± 1µs of UTC(NPL)

Delivered as a fully commercial service to banks and stock exchanges in partnership with distributors:

ice NexGen NETWORKS colt

One distributor provides NPL*Time*® to locations in Europe: Frankfurt, Stockholm and Milan

DLT trial using precision timestamping NPL*Time*®

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- This research, carried out by the University of Strathclyde, investigates the importance of "time of execution" and the relevance of "precision time" in order driven transactions done over distributed ledgers.

- Publication: D. Broby, D. Basu and A. Arulselvan, The Role of Precision Timing in Stock Market Price Discovery when Trading through Distributed Ledgers, Journal of Business Thought, Vol 10, April 2019 - March 2020

https://doi.org/10.18311/jbt/2019/23355

- A Distributed Ledger Test Bed was created based on ChainZy architecture from Z/Yen Group, using stock market price data from the Toronto Stock Exchange (TMX)

- UTC timestamping of transactions at the nanosecond level was provided by PTP over optical fiber from the NPL*Time*® service

University of Strathclyde Business School

TMX | Toronto Stock Exchange | TSX Venture Exchange

Zen

Test data description

High-frequency test market data provision was from TMX (Toronto), located in London Data Centre Interxion. The researchers timestamped smart contracts of various lengths, written to execute a series of buy and sell instructions with different processing times.

The trades generated from the test data order books were sent to two separate servers:

- The NPL*Time*® signal provided nanosecond level, UTC traceable and certified timestamps to one server
- The second server used this timestamp plus a randomly generated time lag

Orders were then sent to a central clearinghouse also operating on UTC and written onto a ChainZy distributed ledger

By using financial market data, the aim is to establish the importance of the timestamp to distributed ledger technology in a real world scenario.

Results

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	Buy Transactions (ms)	Sell Transactions
Average Transaction Time	1.241157832	1.241496517
Standard Deviation	0.042861926	0.047737234
Coefficient of Variation	0.034533824	0.038451364
Minimum Transaction Time	1.149525	1.153183
Maximum Transaction Time	2.27233425	1.9697225
Transaction Time Deciles		
1	1.213001186	1.21227835
2	1.224037209	1.223527828
3	1.231090885	1.230132303
4	1.234937147	1.234666238
5	1.237730926	1.237925604
6	1.240347235	1.240914765
7	1.243460403	1.243963517
8	1.248182807	1.24965368
9	1.260513446	1.265761161
10	2.27233425	1.9697225
Decile Coeff of variation 3,7	0.004998691	0.005590412

The average time required to write the transaction to a distributed ledger is 1.24ms.

Price discovery in order driven markets can be done much faster than milliseconds. Therefore with distributed markets, it is important to know which order to process first to avoid “front-running”. Hence the need for precise timestamping.

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TMX Toronto Stock Exchange | TSX Venture Exchange

Yen

There were 1.28 million buy transactions and 1.30 million sell transactions in the data set. This Table shows the details for the transaction times (in milliseconds), which is the time taken for the central server to write the transaction to a distributed ledger, for the buy and sell transactions in the data set.

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The Coefficient of Variation (CV) is the ratio of the standard deviation (sd) to the mean (x), $CV = sd/x$

Buy Transaction Time CV = 3.4%

Sell Transaction Time CV = 3.8%

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Decile based Coefficient of Variation (DCV)

$$DCV = \frac{D_7 - D_3}{D_7 + D_3}$$

TMX Toronto Stock Exchange | TSX Venture Exchange

Buy Transaction Time DCV = 0.5%

Sell Transaction Time DCV = 0.6%

Zen

The statistics on the transaction time, which is the time required to write the transaction to a distributed ledger are shown in the table.

Conclusion: Precise timestamping is required

The level of variation in transaction writing time is extremely low: the decile based Coefficient of Variation is less than one percent of the average transaction time.

As the average time required to write the transaction to a distributed ledger is in milliseconds (10^{-3} seconds), discrimination at the level of microseconds (10^{-6} seconds) is the minimum required to differentiate between transactions within a distributed ledger.

This suggests that a high precision timestamp at the microsecond level or better is required to maintain the integrity of distributed ledgers

Conclusion: Precise timestamping is necessary to avoid front running

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Challenges associated with transaction processing:

- Distributed systems must process transactions in the correct order to avoid ‘front-running’, where a market participant uses advance knowledge of future liquidity, in order to make a profit.

- While precision timestamping was required by the ledger to record the order of each transaction’s arrival, it was not sufficient to do this on the ledger only.

- To prevent front-running, transactions must be ordered for execution by booking time, not by time of receipt, ideally at the nanosecond level.

Impact on consensus

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- A distributed ledger consists of a network of nodes with no central authority

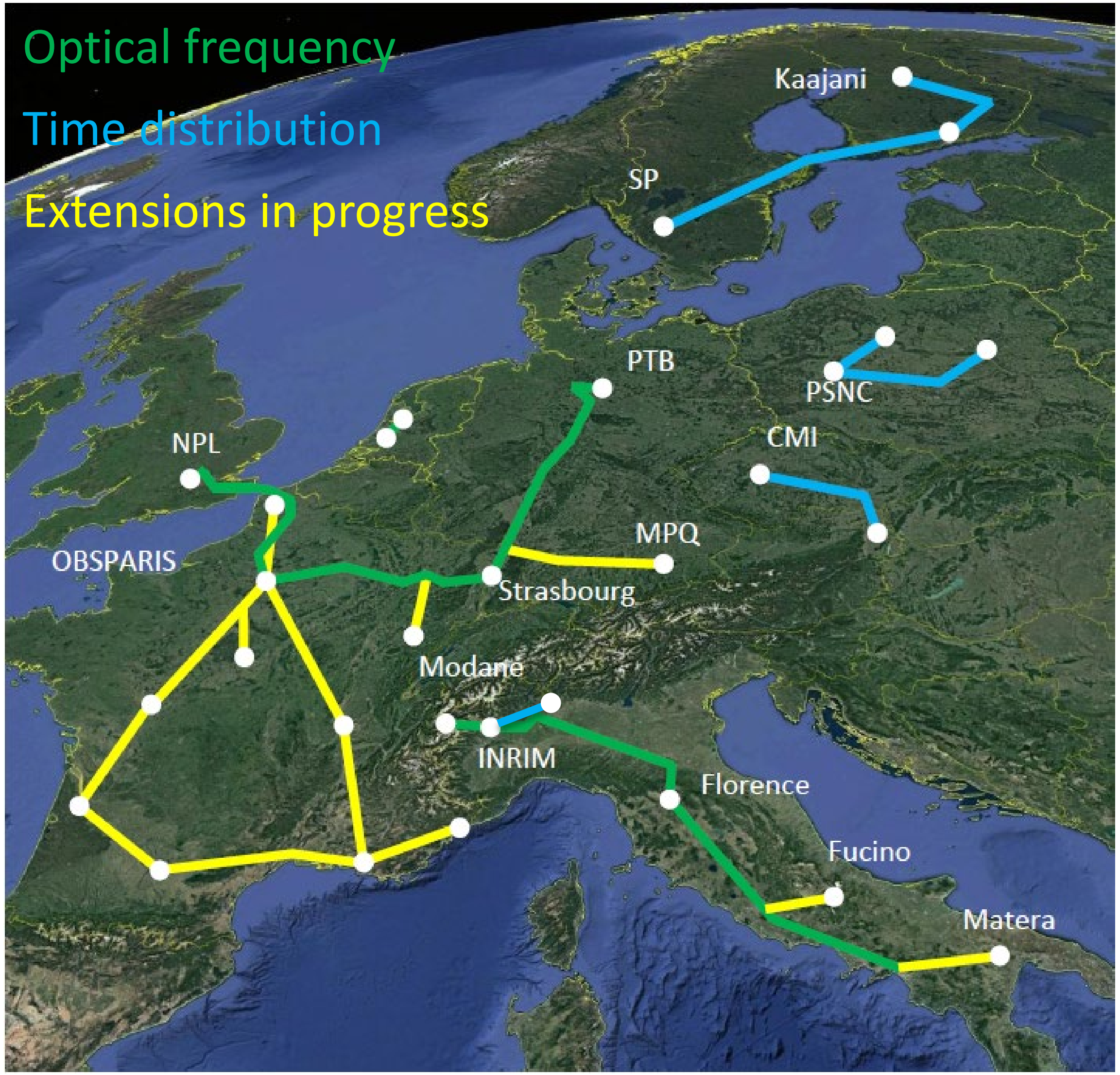
- The audit trail is reached by consensus, whereby all nodes agree on which transactions are legitimate. Ideally all nodes would be synchronised to UTC.

- By including a precise, UTC traceable timestamp of a transaction in the cryptographic signature or ‘hash’ passed to each node, a traceability chain could be formed.

- The distributed nature of the network increases the number of messages exchanged to convey information such as timestamps. Issues include the security of the timestamp, network reliability and server processing speeds.

Current status of Time & Frequency reference signals over optical fiber in Europe

- Every country has their own National Measurement Institute (NMI)
- The distance between neighboring NMIs is 100s of km
- Fiber utilization is necessary due to the increasing number of optical clocks
- Collaboration between NMIs is supported by international projects



WRITE - White Rabbit for Industrial Timing Enhancement

Project started in June 2018, duration 3 years

http://empir.npl.co.uk/write/

Development of precision time for industry

WRITE project objectives:

- Scalability – develop calibration techniques to measure asymmetry over telecoms fiber networks
- Resilience – develop holdover capabilities and improved network monitoring
- Performance – improve hardware and compatibility with existing protocols and standards
- Real field – Demonstrate UTC(k) distribution to space and telecoms industries
- Impact - Knowledge transfer and training; workshops and papers

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

WRITE - White Rabbit for Industrial Timing Enhancement

Workshop details:

Time and Frequency Dissemination over Optical Fibre Networks

24-25 March 2020, 09:30 – 16:30pm, Observatoire de Paris

https://www.eventbrite.co.uk/e/time-and-frequency-dissemination-over-optical-fibre-networks-workshop-registration-90928745325

Two international consortia working on the EMPIR projects 'TiFOON: Time and Frequency Over Optical Networks', and 'WRITE: White Rabbit Industrial Timing Enhancement' are hosting a workshop for research, measurement and industry specialists.

Project speakers will present their current aims, research and development, along with presentations from industry, research and measurement service partners.

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Acknowledgements

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Thank you for your attention

Department for Business, Energy & Industrial Strategy

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EMPIR EURAMET

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

17IND14 Project WRITE White Rabbit Industrial Timing Enhancement

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