White Rabbit for Industrial Timing Enhancement

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On behalf of WRITE consortium

10th White Rabbit Workshop
6 October 2018
CERN, Switzerland
● The Italian National Metrological Institute
● In charge of definition and realization of the SI

Primary atomic clock based on a Cs fountain Accuracy: $2 \cdot 10^{-16}$

Optical atomic clock based on Yb atoms Present accuracy: $4 \cdot 10^{-17}$
Italian Link for Frequency and Time

High-accuracy frequency dissemination (Coherent fiber link with Doppler stabilization) and time distribution coexist on the same fiber.

- 1850 km Dark Fiber
- 5 Research Institutes Connected: CNR, LENS, ASI, INAF
LIFT: the Italian optical link

- 3 Industrial Partners Connected: Thales Alenia Space Italy, Telespazio, Consortium Top-IX

Link improvement with WR-PTP technique for time dissemination for radioastronomy, aerospace industries and finance.
To be connected: Leonardo Company

Time over fiber for the Financial Market

- 160 km fiber link dedicated to financial users (Turin-Milan)
- Under operation since 2016
- Validation within H2020-Demetra now available as a service
- Cooperation with Consortium TOP-IX (telecom consortium)
- White Rabbit / IEEE 1588 Time dissemination
- Co-existence with Data Traffic (DWDM architecture)
European fiber links

- In Europe there is an intense research activity on fiber links
- There is a variety of techniques: Coherent Fiber Links, Electronic Stabilized Links, PTP High Accuracy (White Rabbit) Time Transfer, Optical Combs over fiber
- So far, large projects involving links (NMI coordination):
  - EMRP-NEAT-FT / EMPIR-OFTEN
  - H2020-CLONETS/ H2020-DEMETRA

- C. Lisdat et al., Nat Comm, 7, 12443 (2016)
- E. Dierickx et al., IEEE Trans UFFC, 63, 945-952 (2016)
- D. Calonico et al., EPL 110, 40001 (2015)
- J. Grotti et al., Nat. Phys (2018)
European projects on fiber links

H2020-INFRAINNOV

Strategy and innovation for clock services over optical-fibre networks
16 partners, Coordination: OP
2nd level Specializing Master's Programme in
PHOTONICS FOR DATA NETWORKS AND METROLOGY
Campus: Politecnico – Lingotto, Turin January 2019
European Metrology Programme for Innovation and Research (EMPIR)

The main programme for European research on metrology. It coordinates research projects to address grand challenges, while supporting and developing the SI system of measurement units.
Industrial, Societal & Scientific Motivations

• WRITE (White Rabbit for Industrial Timing Enhancement) is an EMPIR project which aims at develop the metrological facilities necessary for the industrial adoption of WR-PTP.

• Synchronization and Certified Time Distribution
• Increasing request for safer, more resilient and more accurate timing
• Scientific Excellence and Challenges planning redundant and resilient networks, supporting industrial standardization

Start June 2018          End June 2021
Needs

TELECOMMUNICATIONS

FINANCE/e-COMMERCE

CALIBRATIONS

SPACE

POWER SMART GRID
The consortium, coordinated by INRIM, is composed of 11 partners and brings together the EU NMIs, active in WR-PTP, industries and academia.

SUPPORT FROM: CERN, Nokia, NIST, Fair-GSI, INAF, Sunet, Onsala Space Obs, Netnod, Schneider Electric, Sverige Radio
Projected Early Impacts on Industry


- **Smart power distribution grid to reduce the grid carbon footprint.** Robustness of WRITE solutions for a resilient, efficient power distribution grid.

- **Financial Markets.** The European Securities and Markets Authority (ESMA) with new regulation MiFID II, requires that trading venues and participants shall synchronize the business clocks to Coordinated Universal Time (UTC). This requires traceability and the highest security.
Projected Early Impacts on Metrology & Science

- **Relevant ESFRI** (European Strategy Forum on Research Infrastructures) like Radiotelescopes SKA, CTA, KM3NeT, ELT

- Particle Accelerators

- Time Transfer to Academia

SUPPORTED BY

[Logos of different organizations]
Projected Early Impacts on Relevant Standards

• The standard related to PTP, currently IEEE 1588-2008v2 “Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems”, soon to be replaced by IEEE 1588-2018

• The standards related to Recommendation ITU-T G.8271/Y.1366 for wireless telecommunications

• The IEEE Std C37.242-2013 "IEEE Guide for synchronization, calibration, testing and installation of PMUs for power system protection and control" for electrical power grids.
Objective 1: Scalability

• To develop scalable calibration techniques for PTP-WR
• Using existing telecommunication configurations
• Enabling the delay asymmetry of the propagation time to be accurately known for a time service competitive with GNSS systems

WP1: Scalable Calibration Techniques

• Propagation Calibration → Accuracy up to 200ps
• Absolute calibration
• In-Field protocols
Objective 2: Resilience

• To develop validated techniques for redundant and resilient time transfer

WP2: Resilient and Redundant Time Transfer

• Network topologies
• Resilience and hold-over
• Network Monitor
Objective 3: Performance

• New PTP-WR devices, with improved performance and better compatibility with existing protocols and standards.
• Target frequency instability: $< 10^{-13}$ @100s

WP3: Improving White Rabbit Performances

• Improving WR Hardware
• Local Oscillator, Physical PPS output, Digital electronics, FPGA
• Compatibility with other protocols
Objective 4: Real field

- Demonstrate the use of PTP-WR to deliver UTC to industrial users

WP4: UTC T/F Distribution for Industrial Users
- Protocols and stress test
- UTC(OP) to space industry (Thales)
- UTC(IT) to space industry (LEONARDO)
- UTC(VSL) to Point of Presence of Internet Exchange
- UTC(SP) to a telecom user
Objective 5: Impact

- Take up of the technology and measurement infrastructure developed by WRITE

WP5: Creating Impact
- Knowledge Transfer/ Training
- Stakeholder Committee
- Congresses/Papers
- Workshop
Conclusions

• WRITE aims at develop the metrological facilities necessary for the industrial adoption of WR-PTP

• WRITE targets both to methods and device improvement and in-field deployment

• WR-PTP can be supported by a worldwide community, to target also scientific excellence

• WRITE consortium has a world-class team offering the different expertise and point of views (scientific, industrial, metrological) to move forward the state of the art.
Thanks!

WRITE Consortium

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