WRITE WP4
Testbeds
Workshop
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carsten.rieck@ri.se
Improved White Rabbit for Industrial Applications

- WRITE offers **traceability**, improved **stability**, long **reach**, scalability, **redundancy**/resiliency
- Requirements may be moderate today, but evolving applications and regulations will demand TRL9 WRITE solutions

<table>
<thead>
<tr>
<th>Application</th>
<th>Time</th>
<th>Freq</th>
<th>Traceability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial MifidII</td>
<td>100 μs</td>
<td>-</td>
<td>yes</td>
</tr>
<tr>
<td>Transport ITS ETSI V2x</td>
<td>10 μs</td>
<td>-</td>
<td>no</td>
</tr>
<tr>
<td>Telecom ITU-T</td>
<td>-</td>
<td>1e-11</td>
<td>yes</td>
</tr>
<tr>
<td>Telecom 3GPP</td>
<td>0.2-3 μs</td>
<td>5e-8</td>
<td>yes</td>
</tr>
<tr>
<td>Broadcast AES/SMPTE</td>
<td>1 μs</td>
<td>Low</td>
<td>no</td>
</tr>
<tr>
<td>Power Grid phasers</td>
<td>100 ns</td>
<td>-</td>
<td>?</td>
</tr>
<tr>
<td>Navigation R-MODE</td>
<td>&lt;10 ns</td>
<td>low</td>
<td>yes</td>
</tr>
<tr>
<td>High-Tech Oscillators</td>
<td>-</td>
<td>1e-13</td>
<td>yes</td>
</tr>
<tr>
<td>Metrology TAI</td>
<td>&lt; 1ns</td>
<td>1e-15</td>
<td>yes</td>
</tr>
<tr>
<td>Space/Geodesy ACES</td>
<td>100 ps</td>
<td>1e-16</td>
<td>?</td>
</tr>
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</table>
Objectives and Tasks

- **O4: Real field**
  - Demonstrate the use of PTP-WR to deliver UTC to industrial users
  - from TRL 5 to TRL 9

- **Tasks**
  - 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

- **The demonstration of UTC T/F dissemination with WR consists of the following:**
  - PTP-WR link establishment, possibly on multiple links
  - Establishment of a comparative link, such as a calibrated GNSS link
  - PTP-WR calibration exercise applying the outcome of WP1
  - Production phase with a constantly running link over at least 6 months to cover statistically significant features of the implemented link
  - Near real-time assessment and monitoring of the link behaviour
  - Application of the results of the technology push (WP2 and WP3) with an iteration of the production cycle including a recalibration of links.
WRITE Testbeds

Connectivity UTC(VSL)

Precision and Stability UTC(OP)

Redundancy UTC(SP)

Accuracy UTC(IT)
1. UTC(OP) to space industry, Thales TED

- This task will address the precision challenge of White Rabbit
- Characterization of industrial and space clocks using White Rabbit
  - 1e-14@10ks ADEV
- Ca 50 km unidirectional DWDM in active 10GE channel telecom network and last mile dark fibre
- GM at the OBSPARIS campus disseminating UTC(OP).
- WR-Slave at Thales exposes electrical reference signals for characterization of production clocks
1. UTC(OP) to space industry, Thales TED

- Transportable clock evaluations system
- Three-corner-hat based evaluation of short term oscillator stability using two Morion MV341
- Link is established since beginning 2020
- System and method evaluated on spools and in loop back
- Deployment of WR devices at Thales facility is planned January 2021.
2. UTC(VSL) network to point of time consumer presence

- Addresses the connectivity challenge
- establish a WR network between VSL/Delft and Nikhef/Amsterdam close to the Amsterdam Internet Exchange (AMS-IX), and the NetherLight open light-path exchange
- Time consumers MNOs, financial institutions, electric utility grid
- To demonstrate the application of WR network topology and prove traceability throughout the network
2. UTC(VSL) network to point of time consumer presence

Addresses the
2. UTC(VSL) network to point of time consumer presence

- Established since August 2019 and since then continuously operated
- Calibration during installation, roundtrip offset is well below 1 ns
- Link features:
  - Reference delay offset corrections in GM WRS
  - Redundancy algorithm in OPNT WR nodes detecting
    - Link failures
    - Clock drift and offset detection
2. UTC(VSL) network to point of time consumer presence

- Short term performance

![Graph showing time deviation and sigma values](image)
2. UTC(VSL) network to point of time consumer presence

- Long term behaviour
3. Redundant UTC(SP) distribution to a telecom user

- Addresses the redundancy challenge
- Established two links from the redundant RISE time facility in central Stockholm to PTS time node installations operated by Netnod
  - Two independent UTC(SP) time scales
  - Two independent WR links
  - Two independent user nodes
  - Distribution of ePRTC to telecom users close to the local IX
- Redundancy tests and GNSS comparisons
3. Redundant UTC(SP) to a telecom user – Current Setup

- Independent realizations of UTC(SP)
- WRS with BMCA
3. Redundant UTC(SP) to a telecom user

BiDi link calibrated in lab prior to installation

CGGTTS/PPP links agree to about 1 ns
3. Redundant UTC(SP) to a telecom user – High Level

- Implement a redundant PTP2NTP bridge
  - PHC2SYS based
  - High performance NTP/PTP
  - CSAC or Rubidium holdover
- Calibration of WR-PTP on L2/L3
- GNSS comparative link
3. Redundant UTC(SP) to a telecom user – High Level

- High level redundancy scheme
  - Two WR links terminate into physical signals
  - Measured relative to local time scale
- Kalman filter based WR link combiner WP2
  - Detects bad links based on stability of the involved time scales
  - Holdover
- Group clock filter combines local and remote info
  - Real time steering of local time scale
3. Redundant UTC(SP) to a telecom user

- Calibration routine for BiDi setups
  - Recalibration of PTS sites
- PTS ring topology, WR level redundancy
- WR using SUNET-C on long links spanning RISE Borås and Stockholm
  - Long range redundancy
4. UTC(IT) to space industry, LEONARDO
Carsten Rieck

carsten.rieck@ri.se
@carstenrieck
+46 703 170705