SEVEN Solutions
When every nanosecond counts

Spanish Stock Exchange Case study

BME BOLSAS Y MERCADOS ESPAÑOLES

Inter-datacenter accurate time synchronization in a metro area using commercial telecommunication networks

Client Challenges

- Mitigate vulnerability of GNSS solutions to jamming, spoofing or any other interferences.
- Tightly synchronizing a large number of remote locations in a metro area
- Utilization of existing telecommunications networks for ultra-accurate, UTC-traceable and dependable time transfer
- MIFIID II regulation fulfillment

Solution

- Network based resiliency using redundant time references managed by BMCA on WR-ZEN timing node.
- White Rabbit over DWDM solution for long distance ultra-accurate time transfer.
- Interoperability with IEEE-1588 and NTP protocols.
- UTC traceability using the GNSS receiver integrated on the DOWR node.
- Holdover capabilities on WR-ZEN in case of link failure.
- Monitoring system regularly checking the indicators of quality of the time service and storing them in external servers.

Results

- Sub-nanosecond synchronization over a 44 km fiber link (this can be extended to metro area network distances and beyond).
- ± 15 nanoseconds traceability to UTC.
- Sub-microsecond time drift after 24 hours in holdover.

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Context

The finance industry is being pushed by MIFIID II regulation to register most of its operations with timestamps legally traceable to a Coordinated Universal Time (UTC) reference with 1 microsecond granularity and 100 microseconds maximum divergence. This poses a challenge for the sector, since the most commonly used solutions to provide time in the industry do not comply with the requirements. Furthermore, trading with ultra-tight relative timing over distributed locations represents an operational added value. This needs to be done with a dependable and traceable solution. While the typical network-based solutions might not be able to reach the required level of time accuracy when used in large networks, the GNSS-based alternative is vulnerable to external accidental interferences or attacks. Additionally, both approaches struggle to provide traceability to legal time.

The solution

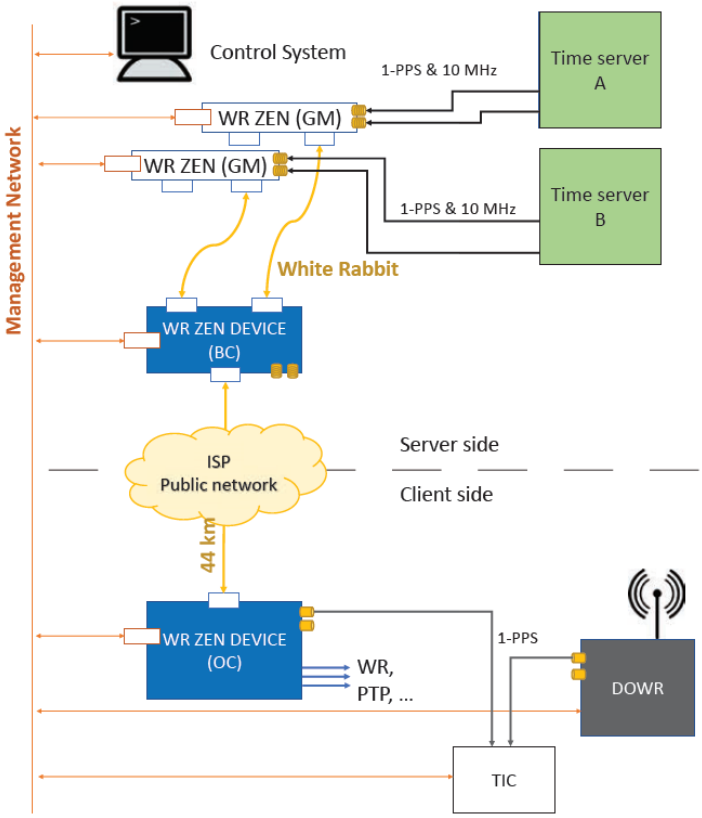
Seven Solutions provides ultra-accurate IEEE-1588-2019 (White Rabbit) time transfer over commercial optical fiber networks (using DWDM). This facilitates the regular and accurate cross-validation of a local atomic clock with respect the legal time reference. Furthermore, it provides time resiliency at a local node with holdover better than 1.5 microseconds drift after 24 hours. In this use case, the set up aims to provide a time service to the Spanish stock exchange. Seven Solutions' approach can be scaled to provide time as a service to a large number of BME's customers in multiple locations. Additionally, Seven Solutions provided inter-datacenter synchronization between the 2 sites of the stock exchange, situated 44 km (27 miles) away from each other, offering redundant time references and cross-validation on each location as well as failover capabilities.

The figure on the right shows an overview of the link architecture of the network.

Both time servers provide a **WR-ZEN** grandmaster with an independently generated time reference each.

A **WR-Z16** receives the references from the redundant grandmaster devices and selects the one transmitted through the network based on the quality parameters reported by the devices, acting as a boundary clock (BC).

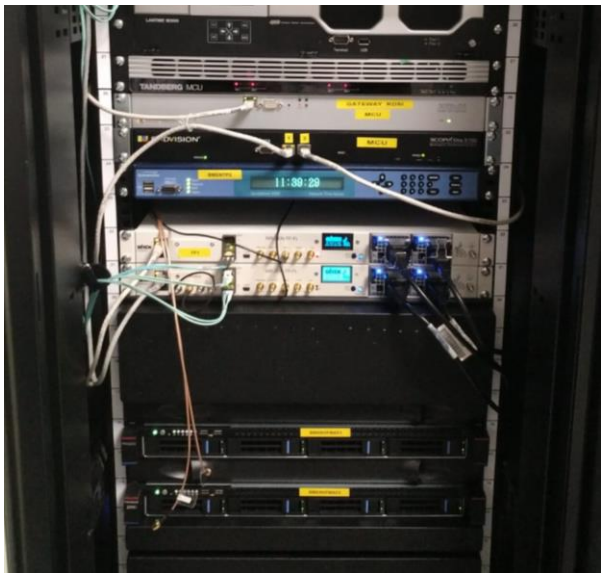
In case of failure of the selected reference, the WR-Z16 automatically switches over and disseminates time recovered from the backup reference.



At the customer side, a **WR-ZEN** is synchronized to the time server through a White Rabbit link and it provides the customer with time signals over different protocols for interoperability with other elements at the end nodes.

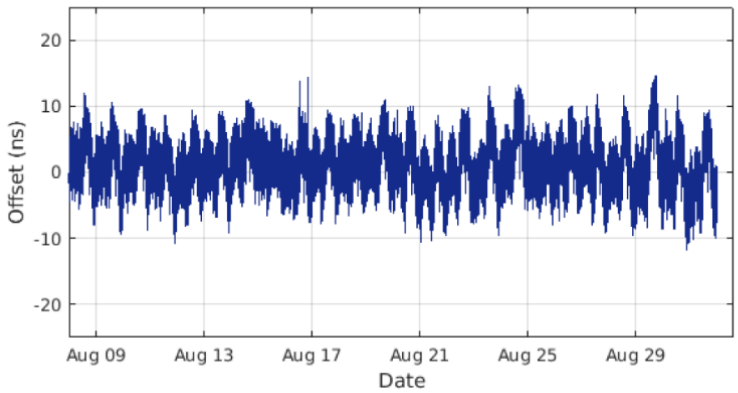
Timing is continuously monitored and compared to a **DOWR** GNSS receiver.

The image on the right shows part of the equipment located on the client side (BME).

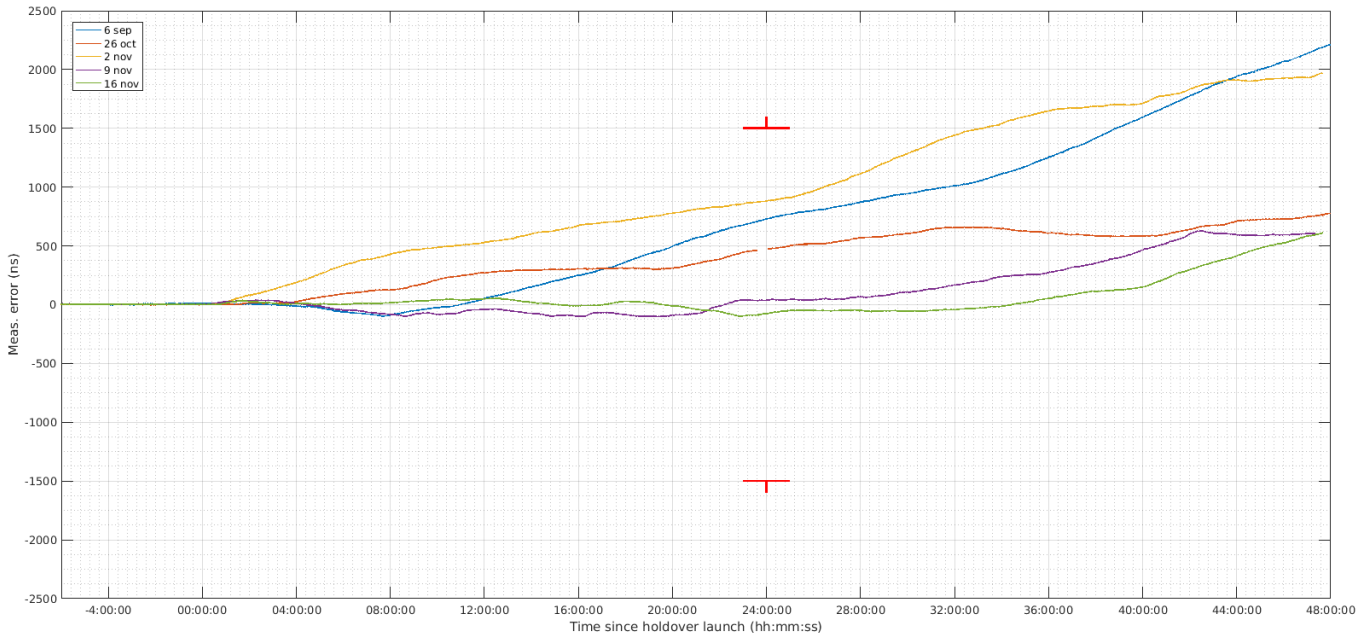


Results

The figure below provides an example of normal operation of the link during 25 days, where offset between customer node and a GNSS-DOWR is monitored. The end nodes time references deviation with respect to the time server is lower than 15 ns. The daily oscillations are due to variable ionospheric changes impacting the GNSS-based time monitoring device.



In the case of any kind of service disruption detected at the client site, the customer equipment holdover guarantees a time drift below 1.5 microseconds after 24 hours.
As an example, the Figure below illustrates the holdover performance (at different operational modes). Since the link was disabled during the test, a GNSS-DOWR at the client site is taken as reference. After 12 hours of holdover operation, the maximum observed offset stays below 550 nanoseconds. The results show that the offset stayed below 900 nanoseconds for 24 hours. Further detail is outlined in the Table below.



The following table defines the level of compliance of the service achieved during operation in February 2020, in relation to the Key Performance Indicators defined along with the Service Level Agreement.

KPI ID	**Requirement**	**Result**	
KPI #1	Maximum continuous downtime <4 hours	Pass: Maximum continuous downtime ≃18 minutes	Success
KPI #2	Average service availability > 99.7%	Pass: Measured service availability 99.94%	Success
KPI #3	Maximum time error (versus UTC) at the customer endpoint <15 ns	Pass: Maximum time error at the customer endpoint ≃9.88 ns* **Real error is below 1ns, but the precision on results is limited by the monitoring and measuring equipment.*	Success
KPI #4	Holdover mechanism at customer side guarantees < 1 µs during downtimes	The holdover mechanism was readily available but it never had to enter into operation during the reported period.	Success

Project scope

The work described in this document was realized in collaboration with GMV, in the framework of a project of ESA's NAVISP Element 2 program, being part of an operating network which was working uninterruptedly for more than 6 months. The objectives of NAVISP Element 2 are to ensure the readiness of the industry to respond to commercial opportunities by focusing the activities on technological innovation in equipment, systems and applications in the wide area of PNT, resulting in products ready for future exploitation within either the consumer, professional or institutional market.

The specifications and requirements of the service to be provided were defined by Key Performance Indicators (KPIs) within a Service Level Agreement (SLA).

Conclusions

Seven Solutions presents the motivation, architecture and operation of establishing a time service to the Spanish stock markets operator following a TaaS approach. Our timing products ecosystem allows the deployment of the most advanced and depandable TaaS services using Seven Solutions products as key TaaS enablers.

Regulation is currently pushing towards implementing auditable solutions that can provide legal traceability to UTC to a maximum divergence of 100 microseconds and a granularity of 1 microsecond or less. These requirements imply a technical challenge due to the geographically broad extent of the finance actors. The most commonly deployed solutions in the industry have difficulties reaching the required accuracy or are vulnerable to external interferences.
In order to overcome these challenges, the solution implemented by Seven Solutions provides BME with:

- End nodes with holdover capabilities guaranteeing that the time is kept well within the limits required by regulation after 24 hours of autonomous operation.
- UTC traceability with divergence below 15 ns and a monitoring system that continuously reports the indicators of quality of the time service.
- Sub-ns synchronization accuracy between the two sites of the stock exchange.

In summary, the architecture deployed by Seven Solutions is able to exceed the present requirements of regulators by more than three orders of magnitude. Since trading with ultra-tight relative timing over distributed locations represents an operational added value, this solution also allows the exchange to synchronize its different sites with state-of-the-art synchronization accuracy. This is done with a dependable and traceable solution.

If you want to know more about timing for finance, contact us at **info@sevensols.com**

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