The European Project DEMETRA: Demonstrating Time Dissemination Services

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ABSTRACT

Recently an European Consortium of 15 partners from 7 different countries, started to work on a research project, DEMETRA (DEMonstrator of EGNSS services based on Time Reference Architecture), funded by the European Union in the frame of the Horizon 2020 program, aiming to develop and experiment time services based on the European Global Navigation Satellite System (GNSS). DEMETRA aims to be a prototype of an European time dissemination service, based on the timing signal of the European Galileo system, adding particular features like certification, calibration, or integrity, that could be of interest to some specific users like traffic control, energy distribution, finance, telecommunication, and scientific institutions.

INTRODUCTION

The DEMETRA project is part of the European funding program for research and innovation “Horizon H2020” running from 2014 to 2020. The duration of the proposed study is 24 months, beginning in January 2015.

The partnership involved in the development of the demonstrator are 4 metrological research institutions (ORB, VTT, NPL, INRIM), 1 university (POLITO), 4 industry (TAS-F, TAS-I, VEGA, DEIMOS), 1 SME (ELPROMA), 1 SME consortium (Antares, created to promote the innovation and development of SMEs in the space sector), 1 consulting large company (aizoOn), and 1 management & consulting company SME (METEC). In addition, the project is supported by the Czech metrological institution UFE, and the French space agency CNES. The DEMETRA partnership, including Scientific Institutions, GNSS Industries, and a Service Provider cover the different aspects of the project.

The overall concept of the DEMETRA Project [1] is to realize a demonstrator that allows the development, testing, and validation of time dissemination services. They are based on current or innovative technologies and introducing important new features such as certified time stamping, improved accuracy, resilience, integrity, not yet provided by GNSS systems.

The demonstrator is currently in the Assembly, Integration, and Validation phase, all the components will be integrated in INRIM in January 2016.

After the system integration, DEMETRA will be tested for more than six months. The planning for the tests campaign is shown in Figure 1: Experimentation planFigure 1. In a first phase a closed loop configuration will be implemented with the reference time source placed close to the User Terminal. Starting from June 2016 the different User Terminals will be moved to users premises to test the services in real pilot applications.

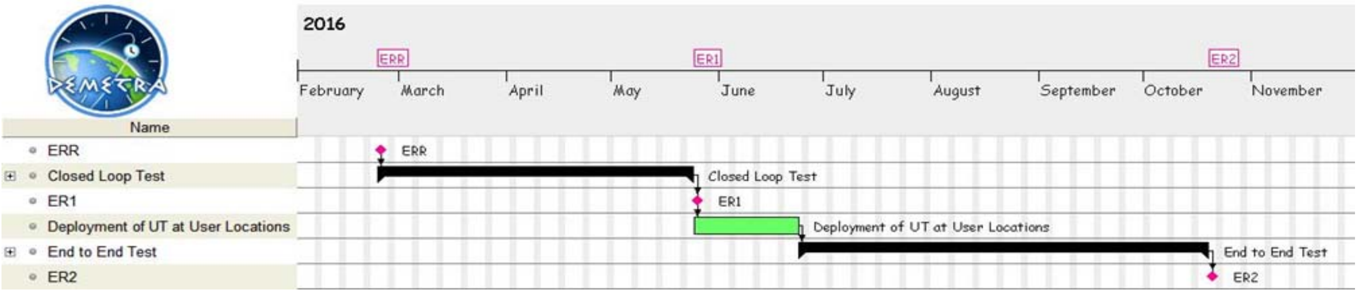

Figure 1: Experimentation plan

PROJECT OVERVIEW

Time dissemination is one of the key services provided by GNSS systems, nevertheless for some users time as obtained from a GNSS is not enough as redundancy, improved robustness, or certification, or other features may be needed. DEMETRA wants to realize a demonstrator capable to prove time services from 'end to end' and to explore the concept of time as a service.
DEMETRA demonstrator is based on a modular architecture that ensures scalability and flexibility of the prototype..

As depicted in the Fig 2, the demonstrator is based on a reference time facility, based on EGNSS and UTC time laboratories, a data storage system, and a validation facility which measures the quality of the disseminated time. This common infrastructure provides the support to 9 different time services, which disseminate time through different channels.

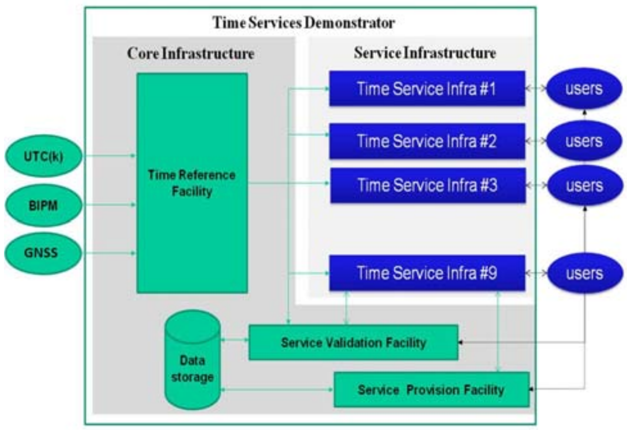

Figure 2: Overall architecture of DEMETRA

THE DEMETRA TIME SERVICES

A. The Timing Services

Nine timing services are developed through different technologies aiming to offer time steering, calibration, time monitoring, time integrity, and time synchronization. In the following an overview of the different Services.

Service 01: Time broadcasting over TV/Radio links

This service allows the dissemination of time, by adopting the Radio and TV signals, conceiving analog and digital modulations [1] . Time dissemination by means of Radio and TV signals allows to use already existing infrastructure, covering wide areas (national and international level), reaching millisecond accuracy performance, by using current/future market devices and solutions. A specifically designed code, carrying on time information, expressed in terms of Year, Month, Day, Hour, Minutes, seconds, plus additional information like the introduction of the winter/summer time, modulates Radio and TV analogic signals, as well as is carried on by the digital audio and video broadcasting systems (i.e. DAB and DVB, respectively).

Service 02: Time distribution using NTP

The aim of the service is to solve the problem that can be summarized by engineers in one sentence: "Time servers know nothing about client side time". Even most accurate time servers today still do not solve this problem. What they simply do is they transfer responsibility of proper synchronization to the client. However, the same problem might be defined different by lawyers. They might ask the question "Is the time you are using inside IT valid or invalid?". Considered that "Time is money" such synchronization strategy can lead to serious implications, for example in case of electronic financial transactions. To answer such question this timing service [11] provides set of three independent cryptographically protected functionalities, based on the NTP:

- Time Distribution (tool for delivering UTC time to clients)
- Time Audit (measurement utility to control clients time)
- Time Verification (checking retrospectively time validity)

Service 03: Time/Frequency distribution over Optical Fiber

In this Service, the reference time signal is disseminated using optical fibers. Different architectures and different techniques are available to meet user needs. An accuracy beyond the GPS level can be achieved through open source techniques (White Rabbit) and the more innovative Modulated Coherent Time (MCT). The reference time signal generated at INRIM is encoded by modulating the amplitude of a laser radiation, then routed on a commercial optical fiber network. The user is equipped with a receiver that demodulates the incoming light generating a set of useful reference signals for time stamping and frequency reference (1PPS and 10 MHz). The accuracy of the user time is better than 1 ns with respect to the disseminated reference time that in DEMETRA will be the INRIM timescale UTC(IT). A set of Key Performance Indicators monitor the system and the performances at the user-end ([3] [4]).

Service 04: Time distribution via GEOSAT

The system disseminates time and frequency in real-time via geostationary satellite. The proposed technology is based on consolidated telecommunication techniques (FDMA) that are applied in an innovative way, thus allowing for a reliable, competitive, and cost-effective final system.

The system for Time and Frequency distribution via GEO satellite is innovative because:

- The synchronization system is "standalone", i.e . it does not require any dedicated satellites
- It is independent of GPS/Galileo and hence it can realize full technological redundancy
- It allows for sensible reduction of the disturbances due to interference, typical of GPS/Galileo, thanks to a different spectral band and different receivers (intrinsic);
- It benefits from the same coverage capability as GPS/Galileo system (national scale)
- It uses techniques already largely experimented in telecommunications, which allow to realize both a reliable and low-cost system

The proposed system allows to synchronize user clocks in each subscriber station of a network by using a geostationary satellite and a set of two-way stations. Precise time dissemination is based on transmitting a signal that contains information on both synchronization and localization of the stations and satellite.

This system is meant to work in parallel with GPS/GALILEO-based systems in order to reach full technological redundancy and it addresses those networks that require outstanding timing accuracy (~100ns provided) and high reliability.

Service 05: User GNSS Receiver Calibration

This Service aims at calibrating GNSS stations for timing applications, i.e. determining the hardware delays in the antenna, cables and receiver [5] . Two methods can be used: absolute or relative.

The absolute calibration uses a GNSS signal simulator and a Vector Network Analyser which compares the simulated signal with the signal measured by the receiving equipment; the uncertainty on the measured delays is at the level of 1 ns. The relative calibration determines the hardware delays of the receiving chain with respect to a reference station already calibrated, with a combined uncertainty lower than 4 ns.

This service will allow GNSS time transfer with an uncertainty lower than a few nanosecond. The user will know the hardware delays of its GNSS receiving station, and will hence be able to determine accurately from the GNSS measurements the offset between its local clock and the GNSS time scale, and hence retrieve the disseminated UTC reference time.

Service 06: Certified Time Steering

The Service proposes a disciplined oscillator with traceability to UTC, together with trusted health information about user terminal equipment functionality.

Service 6 aims to disseminate precise and accurate time using GNSS (mainly Galileo) Time Transfer techniques and a real-time internet link, allowing the real-time monitoring and certification of the time offset between the User Terminal and the Time Reference Facility.

The setup of the system consists of two main components:

- The Time Signal Generator is a server operating as part of the Time Service Infrastructure. It receives real-time streams with the observations of the reference receivers at the Time Reference Facility and the User Terminal and broadcasts the real-time correction stream which is the time offset between the Time Reference Facility and the User Terminal.
- The User Terminal is composed of a high precision GNSS receiver, a steerable oscillator, and a computer with internet connection. It collects the real-time correction stream in order to discipline the steerable oscillator, and hence to improve its medium term stability and accuracy.

Service 07: Time Monitoring & Steering

This Service consists in monitoring the user atomic clock or time scale in near real time at the nanosecond level, alerting the users about any abnormal phase or frequency jump of their clock or time scale. The system will be based on the Precise Point Positioning using the GNSS collected by the user receiver driven by its atomic clock. A set of indicators about the user GNSS station well-functioning will also be provided. The service will additionally provide to the user daily information for the steering of his atomic clock or time scale to be aligned with UTC, as well as a prediction of the difference between its time scale and UTC for the next days.

The user sends hourly RINEX files via ftp. Each hour a PPP clock solution of the last 24h is computed for the user clock, for the TRF reference clock, and for some time laboratory having a realization of UTC named UTC(k). The synchronization differences between the user clock and the TRF reference are plotted on the web page and updated hourly. The webpage also displays the user GNSS station performances. Daily files are sent to the user via ftp, containing the PPP solutions and the steering parameters. Additionally an alarm is sent by email in case a clock or frequency jump is detected in the user clock solution [7] .

Service 08: Time Integrity

The Time Integrity Service aims to test the capability to deliver a time integrity service to the GNSS users providing integrity information to improve user timing accuracy as well as positioning. The status of Galileo satellite clocks is continuously monitored, detecting in real time possible anomalies and generating automatic alerts in case the satellite is considered unusable ([8] [9] [10]). The Service is additionally monitoring the timing parameters broadcast in the Galileo Navigation Message, providing to the users a validation and performance assessment of the timing information disseminated by the Galileo System. The service is intended as a first step to test the concepts and performance of a Galileo time integrity system with the double aim:

- to provide information about the satellite clock status, reporting as not usable the satellites for which an anomaly is detected and excluding them from the timing information and position determination;
- to validate the performance, also at user level, of the timing information disseminated by the Galileo System

Service 09 : Time synchronization

Service 9 is based on SynchroNet, a Thales Alenia Space Italia patented system for high performance network synchronization. The Service is exploiting GNSS (GPS and GALILEO) synchronization algorithms and techniques into a higher level distributed infrastructure, matching critical systems requirements. SynchroNet offers several benefit and features that are normally available using different timing products in single, integrated and monitored solution. SynchroNet can work both using a flat network topology or using a hierarchical one and is designed around the concepts of scalability and robustness both in terms of service coverage (number of terminals and terminals geographical distribution) and in terms of performances allowing configuring each node with a specific HW setup to match actual performance needs that can be up or downscaled in later stages without requiring any SW or Architectural modification.
The base idea behind the SynchroNet solution is to develop a product that can scale with customer needs and adapts to different application domains but doesn't force to invest on irreversible trade-off between reliability, autonomy or performance since the beginning. At any time the service can be re-tailored simply boosting the HW of each node and an upgrade plan can be delivered incrementally. SynchroNet is also designed taking into account the integration problem in already existing systems and infrastructures. For this reason its integration footprint has been minimized in terms of logistical constraints and in terms of logical impact by using tunneled and isolated network communication that can coexist with a large variety of already deployed network layouts, security schemes and network bandwidths. The compatibility with already deployed timing solution is guaranteed by means of standard output signals: 10MHz, 1PPS, and NTP.
SynchroNet wants to deliver added values to the timing service, in fact each SynchroNet user terminal is factory calibrated and tested in terms of reachable performances; the result of factory tests is then translated into a Service Level Agreement offering a continuous monitoring of each terminal during operational life allowing an integrity assessment and monitoring other important parameters (network connection, NTP performances, GNSS signal availability, etc.) thus allowing to detect and intervene in advance in case of failures. The outcomes of continuous monitoring are made available to the user that can exploit these information at its system level.

DEMETRA & USERS NEEDS

The importance of synchronization is crucial to deal with high precision requirements (agriculture, surveying), expanding networks that need to be monitored and controlled in real-time (energy, media), increased vigilance on rapid financial transactions (finance), bigger data global sets to co-ordinate (science), ever increasing endpoints connected to the internet (telecoms), safety-critical systems (transport, telecoms), etc.
The aim of the DEMETRA Project is to facilitate the improvement of timing service offerings to industry by collecting information on legitimate user needs and reporting it to timing service providers.
A first workshop to introduce H2020 DEMETRA Project at the users was held in Prague at the headquarters of the European GNSS Agency in July 2015. A second workshop is planned for next May 2016.

CONCLUSION

The European funded project DEMETRA will demonstrate and test the possibility to offer advanced time services based on the European GNSS signals and adding new features that are becoming important in different critical applications.

ACKNOWLEDGMENTS

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