Newsletter Issue #3

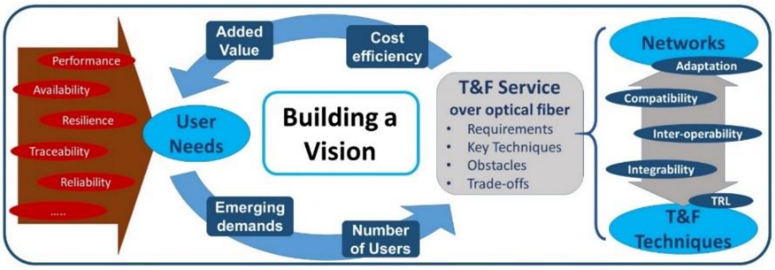
August 2019

Clock Network Services:

strategy and innovation for clock services over optical fibre networks

ENVISIONING A TIME AND FREQUENCY SERVICE OVER OPTICAL FIBRE IN EUROPE

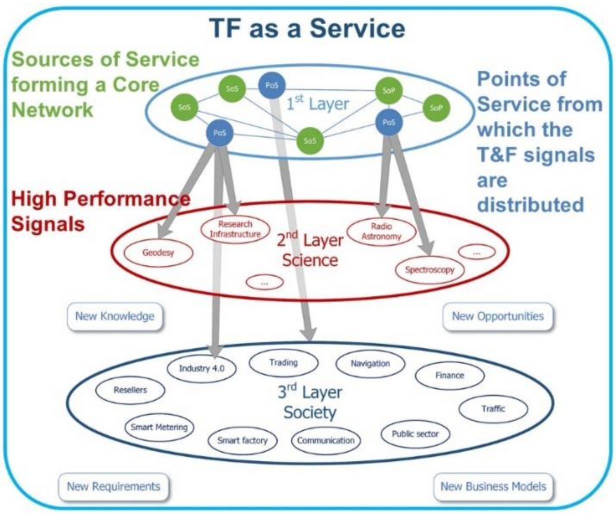
The CLONETS project has outlined an overall vision of a time and frequency (TF) service over optical fibre in Europe based on the TF needs of current and future users, the currently available and emerging TF transfer techniques and the capabilities of optical networks to support and integrate TF signals. The main results are summarized below, while more details can be found on the project's website (http://www.clonets.eu/).



OVERALL VISION FOR TIME AND FREQUENCY SERVICE DELIVERY

A major challenge in creating a vision for TF service delivery over optical fiber are the various different requirements placed on the TF signal by the different users. The type of signal, the performance level and the service characteristics all depend on the needs of the specific applications. CLONETS has identified three major types of signals, which should be supported by the core TF network in order to meet user needs:

- 1 pulse per second (PPS), which is a common output signal of clock devices. The sharp leading edge is synchronized with a reference timescale, often the local realization of UTC.
- 10 MHz or 100 MHz, which are standard operational radio frequencies derived from H-masers monitored by primary clocks. The signal is typically sinusoidal.
- Ultra-stable optical carrier, which is a high-end technology providing the best stability and accuracy crucial for the most demanding and cutting-edge applications.



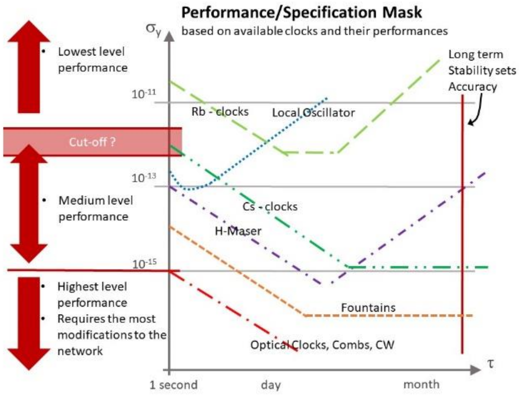
The TF service delivery has been conceptualized as consisting of three different logical layers. The first layer consists of the service providers, which can function as a source of service (SoS), a point of service (PoS), or both. A SoS provides the actual TF signals to the network, while the PoS provides access to the TF network. The PoS can either directly serve the end user or connect a regional network, which then redistributes the TF signals to users within its network. The second layer represents the users with the highest performance requirements on the TF service, generally scientific entities. Access to the TF network allows these users to further push the boundaries of their field, advancing science and technology. The third layer includes commercial and other entities, such as Industry 4.0, communication, smart grids, public sector, finance, etc., which depend on TF for their operations. The overall vision for a time and frequency delivery is described in Deliverable D2.1.

ARCHITECTURE OF THE CORE NETWORK

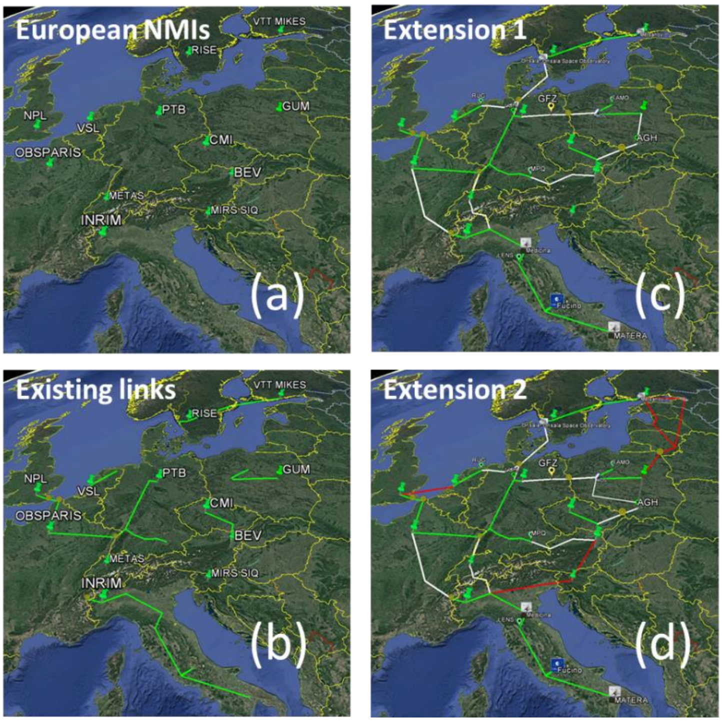
CLONETS envisions a core network with the highest stability and accuracy in frequency and timing. The service providers will be National Metrology Institutes or other UTC-laboratories, since these well-established institutions already maintain state-of-the-art time and frequency standards and have extensive experience in the dissemination of TF signals. This will allow the core network to provide reliable TF signals with the highest stability and accuracy across Europe and support the applications with the highest demands.

The following performances are required from the TF signals in the core network:

- For frequency applications, the frequency instability should be better than 10^{-15} at 1 s and reach below 10^{-19} after several hours of integration. Moreover, for routine operation the frequency transfer uncertainty should be better than 10^{-18} and should be traceable to a realization of the SI-second.
- For timing applications, the jitter should be lower than 1 ps for measurement intervals shorter than a few minutes and less than few 10 ps for one day of averaging. Additionally, the traceability to UTC(k) within 100 ps should be supported.



The performance of a TF service is, however, not only determined by the available clocks and oscillators, but also by the TF transfer technique employed. Therefore the network must be comprised of bi-directional TF fibre links, which allow for a maximal compensation of the optical fibre noise. This requirement is necessary to ensure that TF signals of the highest performance can be disseminated without a significant loss of stability and accuracy. There are two suitable approaches. The first relies on the use of dark fibres, which are exclusively dedicated to the transmission of TF signals. The second approach uses so-called dark channels. In this case, the bi-directional TF signal is integrated into an otherwise uni-directional data network and occupies a channel in parallel with the data traffic, with the difference that it bypasses any uni-directional elements in the network. Both approaches have been shown to provide the best possible overall performance in terms of stability and accuracy, but have their different advantages and disadvantages with regards to implementation, network management, maintenance, costs, etc. Four different scenarios based on these two approaches have been considered and are discussed in Deliverable D2.2 including an initial preliminary estimation of the costs.



The selection of potential routes forming the first phase of the core network has been discussed extensively in view of available clocks, already existing TF links, institutes involved in the development of TF transfer, presence of NRENs (in particular those involved in TF issues) and GEANT, and strategic points for future possible extensions and synergies with eventual TF users (such as radioastronomy stations).

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