# T/F distribution in fiber optics and the European initiatives

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# Agenda

- User needs
- T&F service types
- National  and International T&F connections in Europe
- OTFN group activity

# Group of users

Navigation

Transport

Telecommunication (ICT)

Science

Power Grids

Finance

Defence

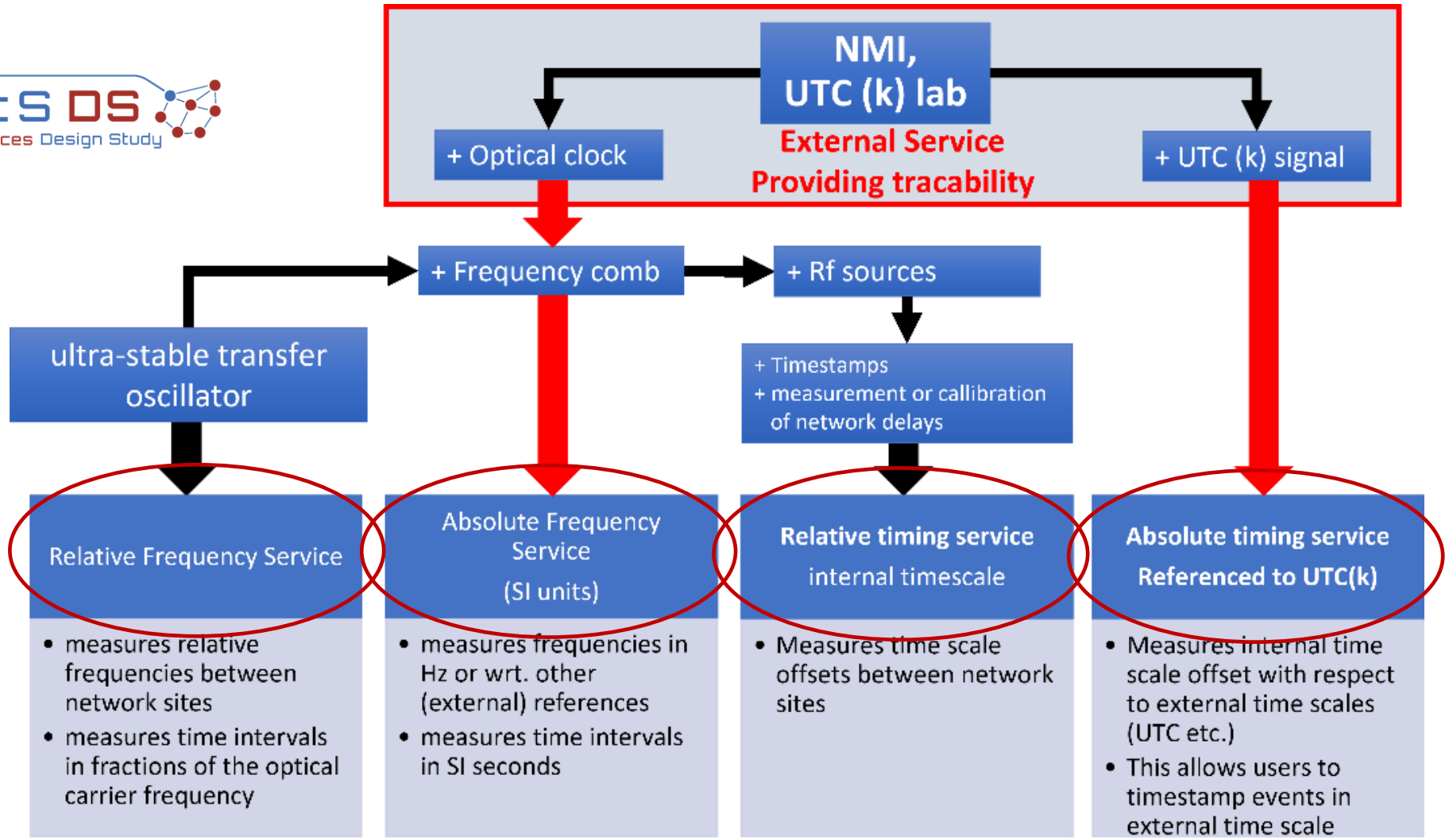
Security

# Group of users (based on Clonets-DS analyses)


| | |
|---|---|
| **Fundamental Science** | Vienna (AT), Bern (CH), Geneva (CH), Villigen (CH), Prague (CZ), Braunschweig (DE), Darmstadt (DE), Düsseldorf (DE), Garching (DE), Hannover (DE), Jena (DE), Mainz (DE), Stuttgart (DE), Cadiz (ES), Besancon (FR), Marseille (FR), Paris (FR), Zagreb (HR), Florence (IT), Torino (IT), Amsterdam (NL), Delft (NL), Krakow (PL), Torun (PL), Istanbul (TY), London (UK) |
| **Quantum Technologies** | Olomouc (CZ), Hannover (DE), Mainz (DE), Munich (DE), Stuttgart (DE), Ulm (DE), Vienna (AT), Innsbruck (AT), Barcelona (ES), Besancon (FR), Torino (IT), Matera (IT), Firenze (IT), Roma (IT), Milano(IT), Napoli (IT), Delft (NL),<br>all 27 European members states of the Europe Communication Infrastructure (EuroQCI) |
| **Earth Observation / Geodesy** | Bonn (DE), Wettzell (DE), Browiec (Poland), Herstmonceux (UK), Potsdam (DE), Grasse (F) Onsala (S), Zimmerwald (CH), Matera (I), Medicina (I), Ny Alesund (N), Metsahovi (FIN), Graz (AT) |
| **Astronomy** | Graz (AT), Zimmerwald (CH), Effelsberg (DE), Potsdam (DE), San Fernando (ES), Kirkkonummi (FI), Grasse (FR), Grenoble (FR), Nancay (FR), Medicina (IT), Noto (IT), San Basilio (IT), Matera (IT), Ventspils (LV), Westerbork (NL), Borowiec (PL), Onsala (SE), Cheshire (UK), Herstmonceux (UK) |
| **Position, Navigation, Synchronization and Timing / Telecommunication and Networks** | Braunschweig (DE), Bremen (DE), Frankfurt (DE), Paris (FR), Amsterdam (NL), Warsaw (PL)<br>all UTC(k)/NMI locations |

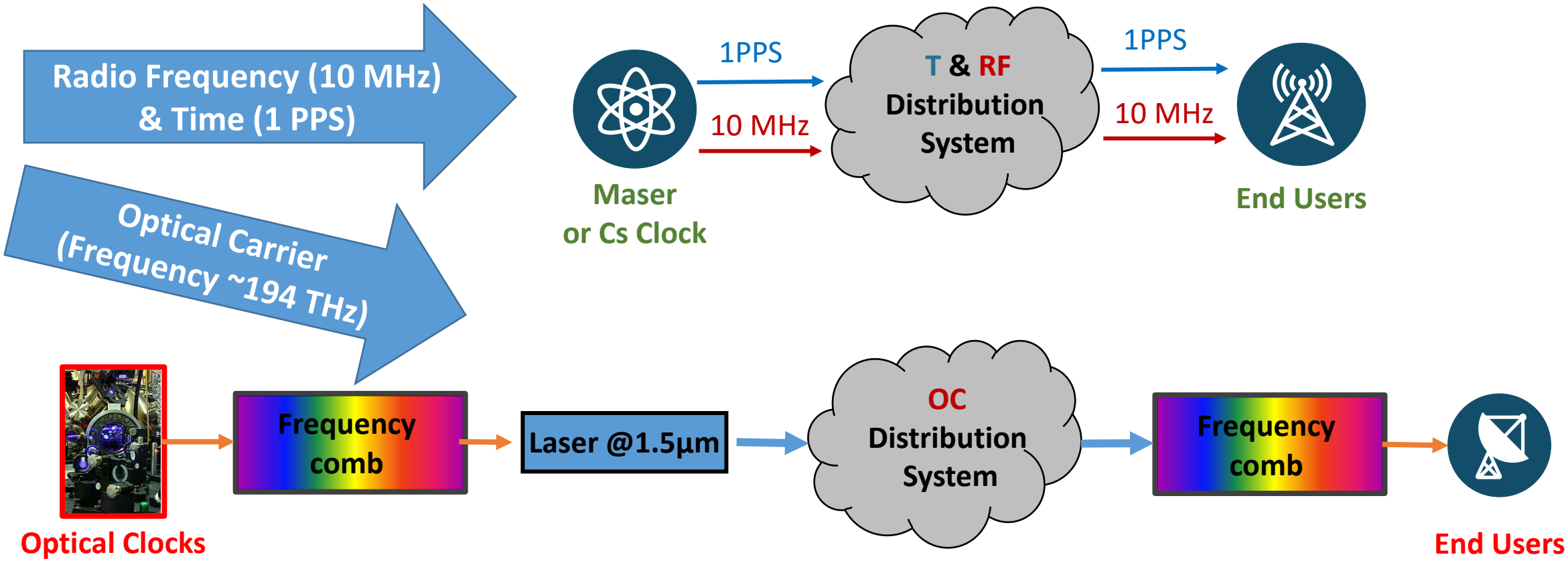
# Services provided by the envisioned core network

CloNetS DS
Clock Network Services Design Study
https://clonets-ds.eu/



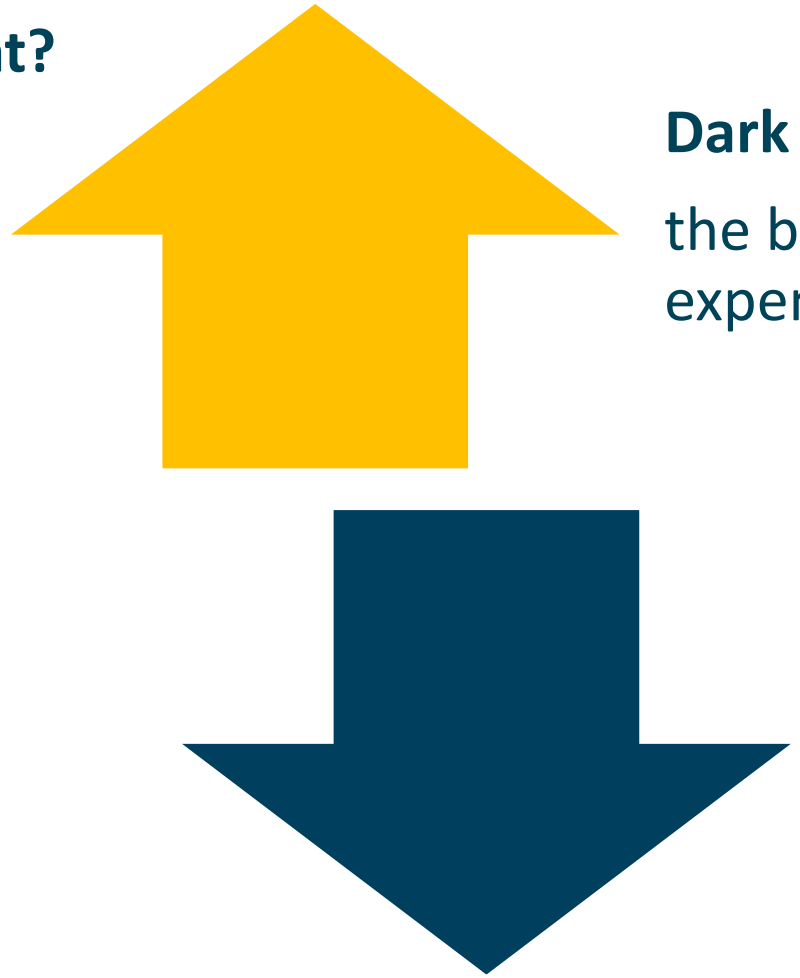
# T&F -> simple acronym – not easy decisions (1)

## What kind of signal will be transmitted?



# T&F -> simple acronym – not easy decisions (2)

## How to implement?



**Dark Fibers**

the best option but also the most expensive

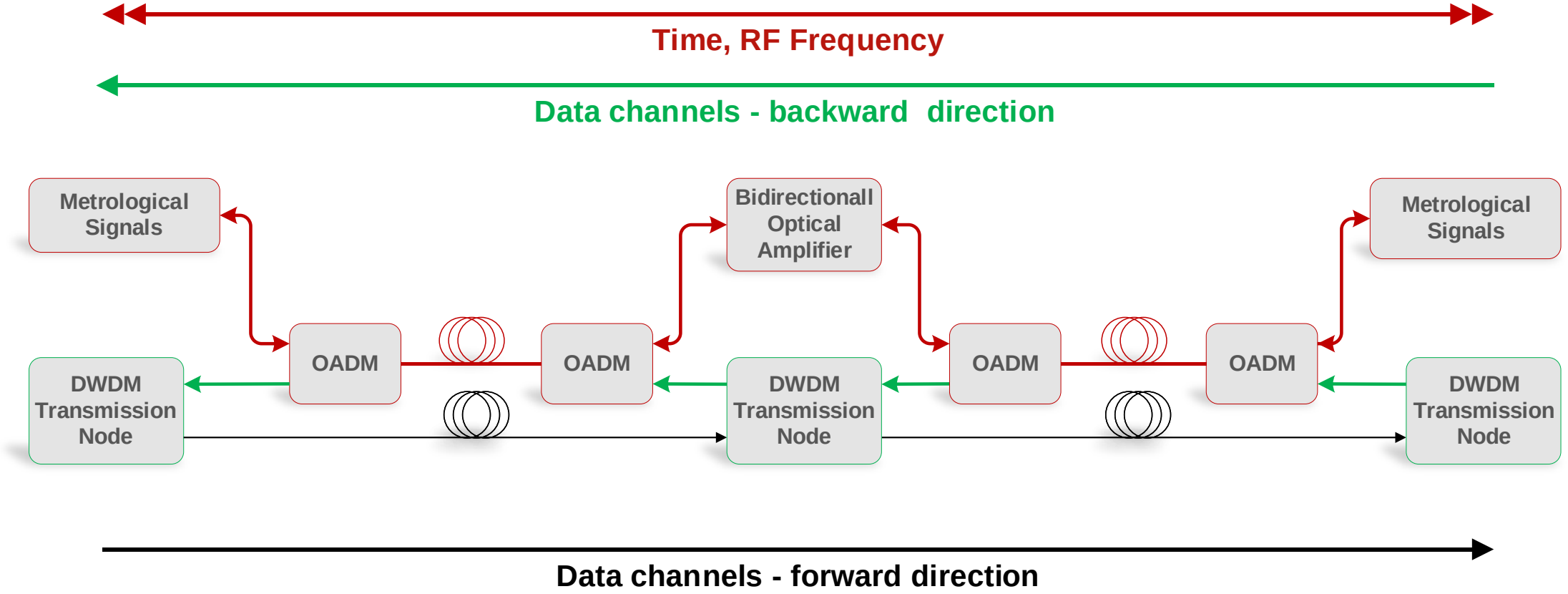
**Dark Channels**

does not require renting additional fibers, but requires difficult integration with transmission system (DWDM)

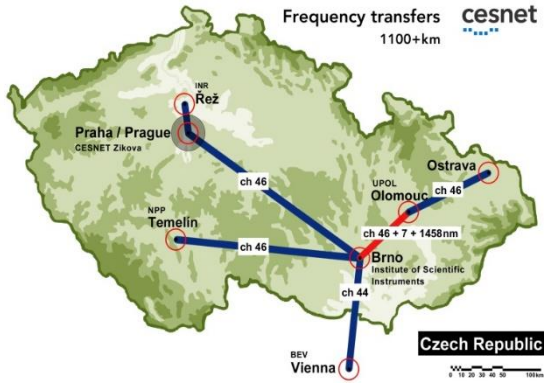
If Dark Channel which band?  C or L?

# T&F -> simple acronym – not easy decisions (3)

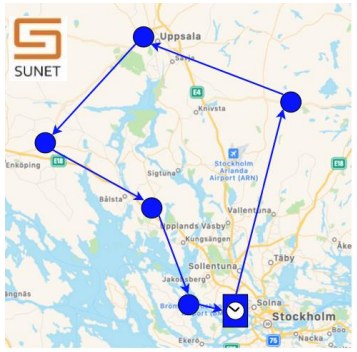
## Bidirectional time and frequency transfer in unidirectional DWDM

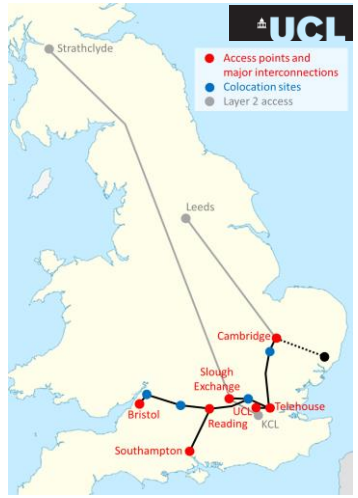


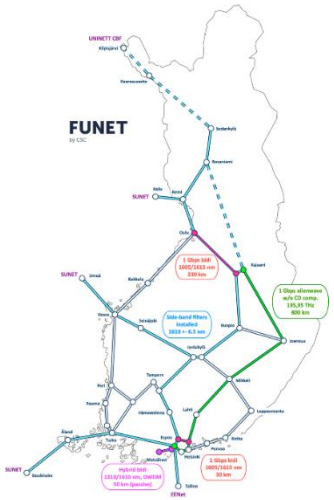
# National T&F connections in Europe – examples (1)

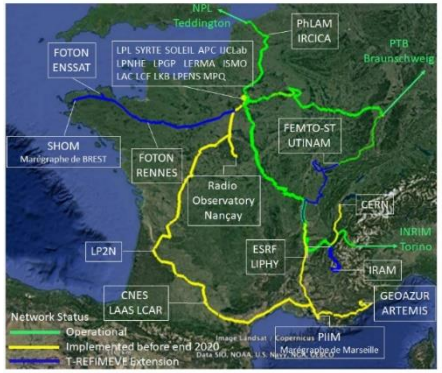


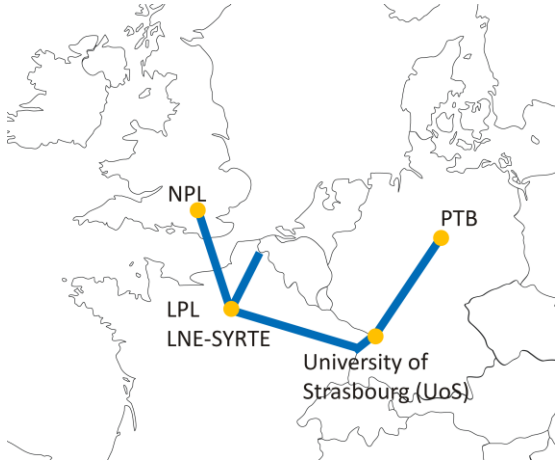




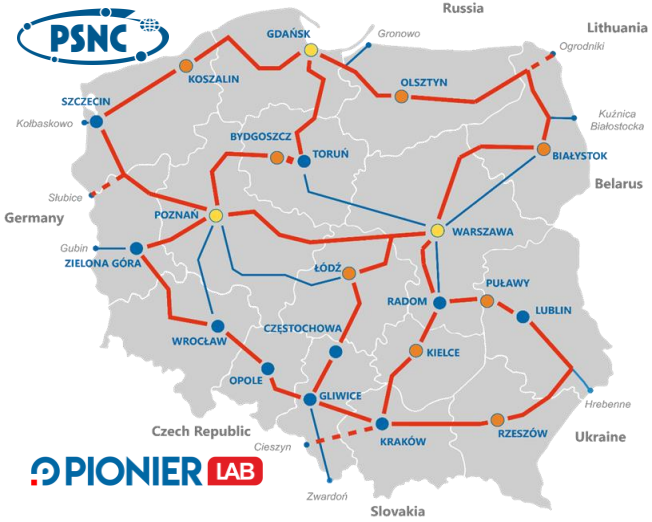







# National T&F connections in Europe – examples (2)

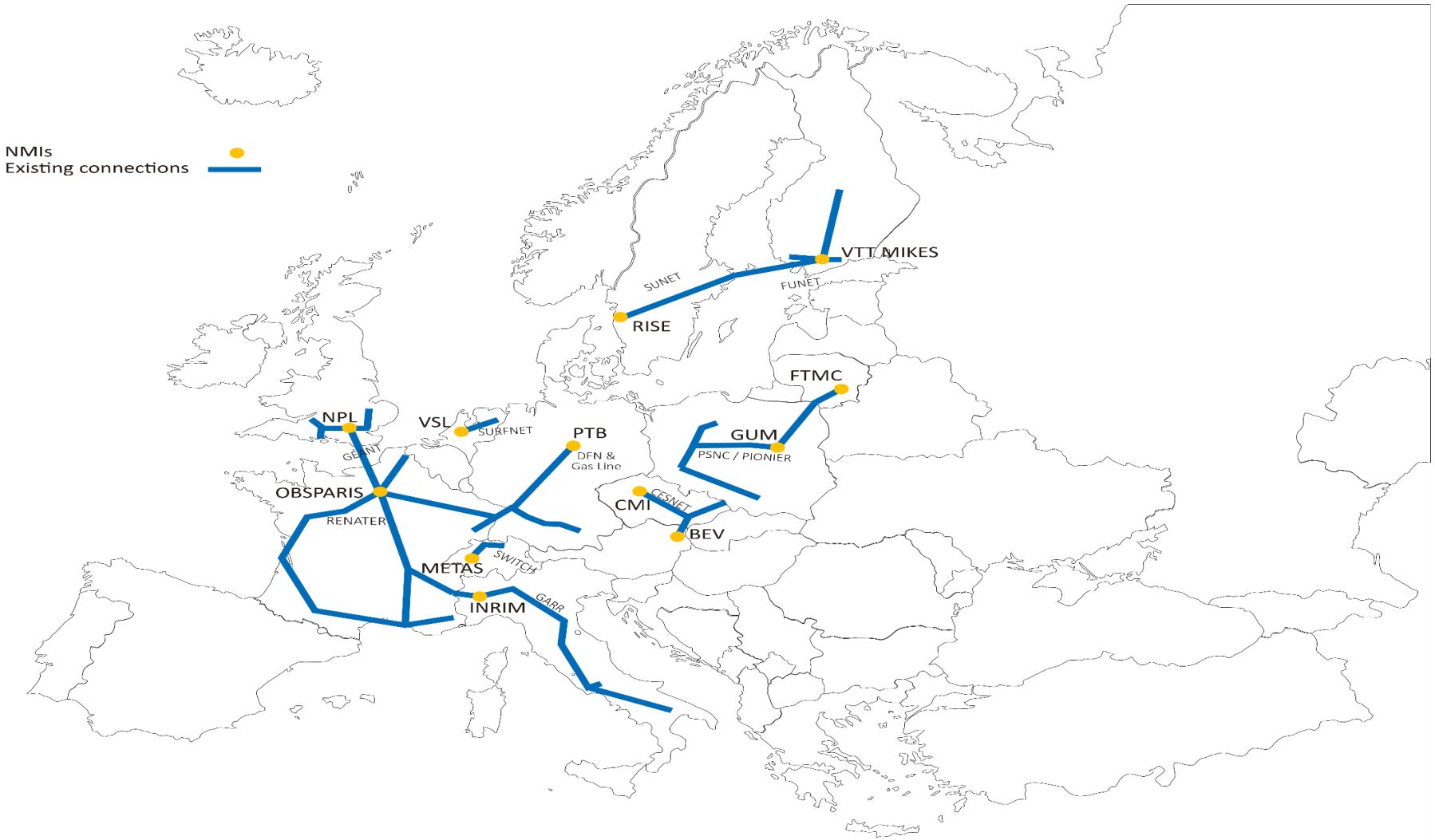
| Country | Type of architecture | T&F service implemented | Scope |
|---|---|---|---|
| France | Dark channel @194,4 THz | Frequency service (OC) | More than 2 000 km |
| Switzerland | Dark channel @190,7 THz | Frequency service (OC) | More than 200km |
| Czech Republic | Dark channel @ 194.4 and 194.6 THz | Time and Frequency (RF and OC) services | More than 1400 km of bidirectional channels and 2 100 km in DWDM |
| Poland | Dark fibre / DWDM | Time and Frequency (RF and OC) services | More than 1 100 km in dark fibre and about 1 600 km in DWDM |

… and many others

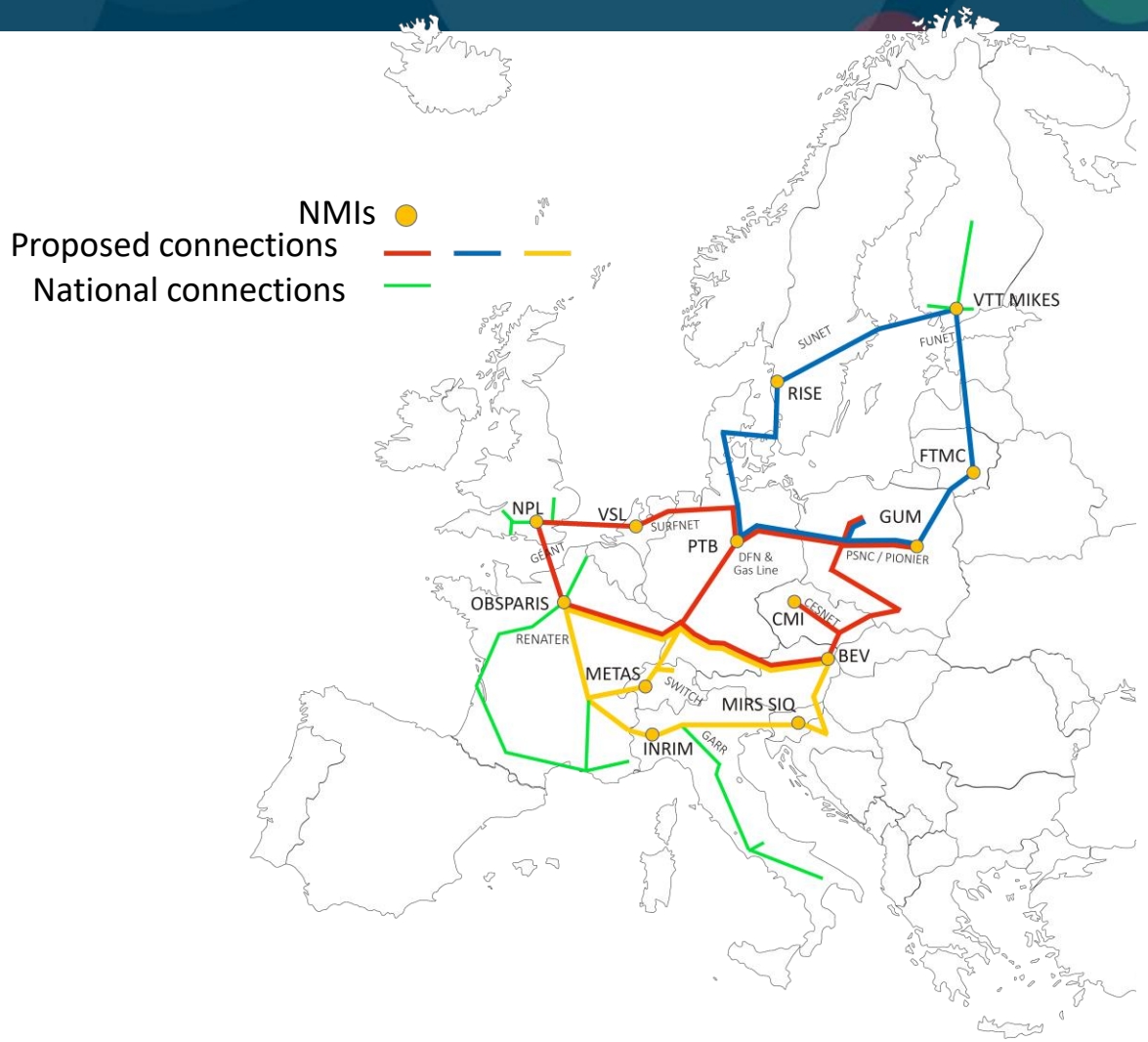
# T&F service distribution techniques

| Technology | Advantages | Disadvantages |
|---|---|---|
| Optical Carrier | • Best ultrastable frequency service performances<br>• Has been operated in different setups (dark channel and dark fibre) | • Limited number (but more demanding) of end-users because frequency combs are required to use the distributed signal<br>• Most of equipment is designed to work @ 194.4THz (C-Band)<br>• Requires highly trained personnel. |
| ELSTAB<br>Active cancellation with electronic delays | • Distributions Time and Frequency services<br>• Wavelength is fixed but can be chosen all over C-Band to fit any ITU channel | • Even greater performances might be required for the most demanding end-users (optical clock comparisons) |
| White Rabbit<br>PTP | • Easy to use<br>• A wide range of potential end-users<br>• Time and Frequency service<br>• Affordable prices | • Performances only slightly better than GPS |

# T&F connections in Europe



# CLONETS-DS - Planned network topology

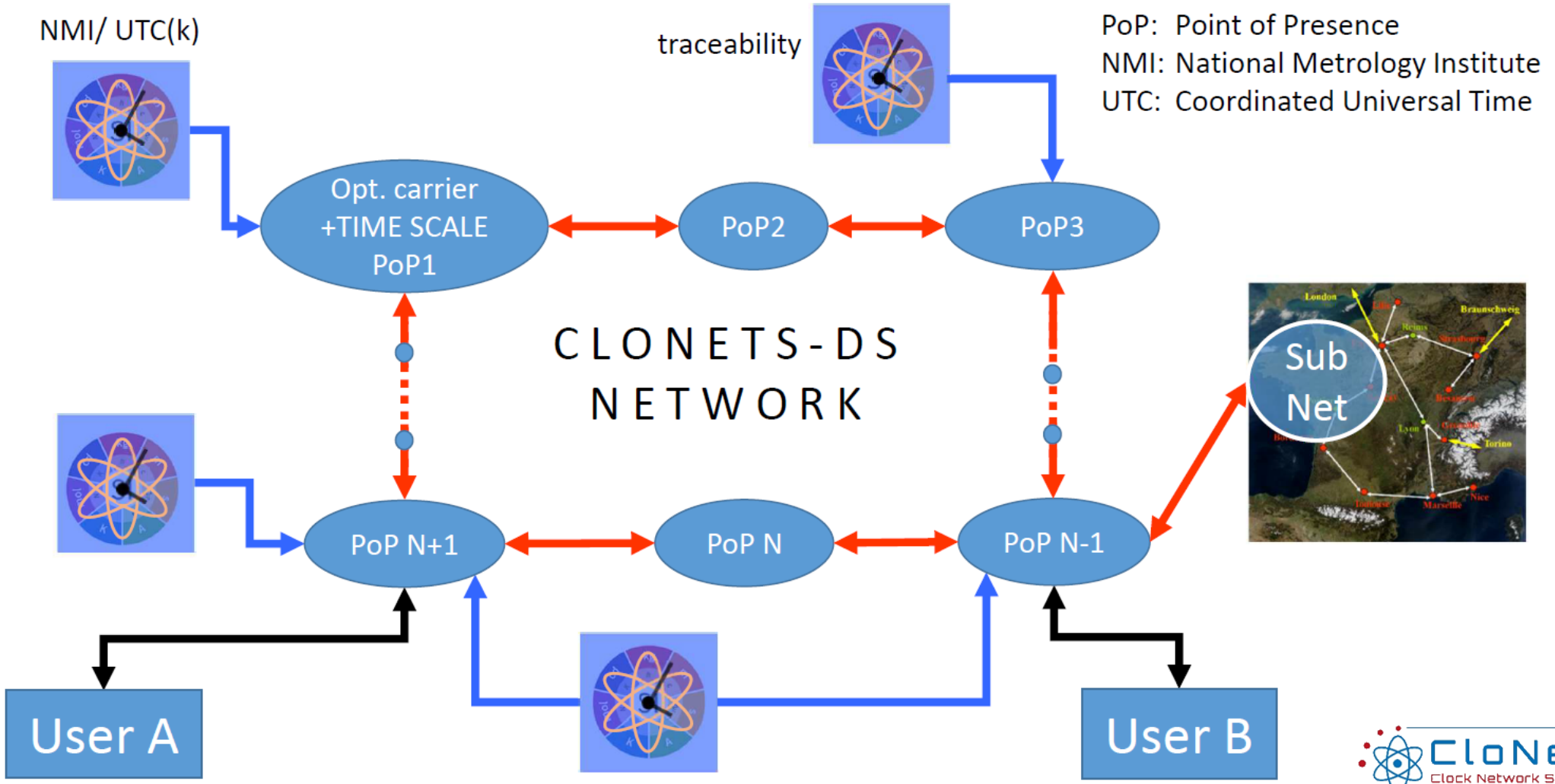



Benefits:

- allows the incorporation of national implementations
- allows the implementation of different techniques
- no constraint regarding dark channel or dark fibre
- no predetermined provider (NREN, GEANT, company...)
- open, expandable, adaptable structure
- easy implementation of novel concepts

CLONETS DS
Clock Network Services Design Study
https://clonets-ds.eu/

# The CLONETS-DS vision of a network



# Multidomain services - OTFN activity (1)

- **Support Gateway - the first source of information for NRENs on time and frequency transfer** in the broad sense, such as: signal sources in a given country (NMI, UTCk labs), existing T/F distribution networks, technologies used in a given network, cross-border sites …

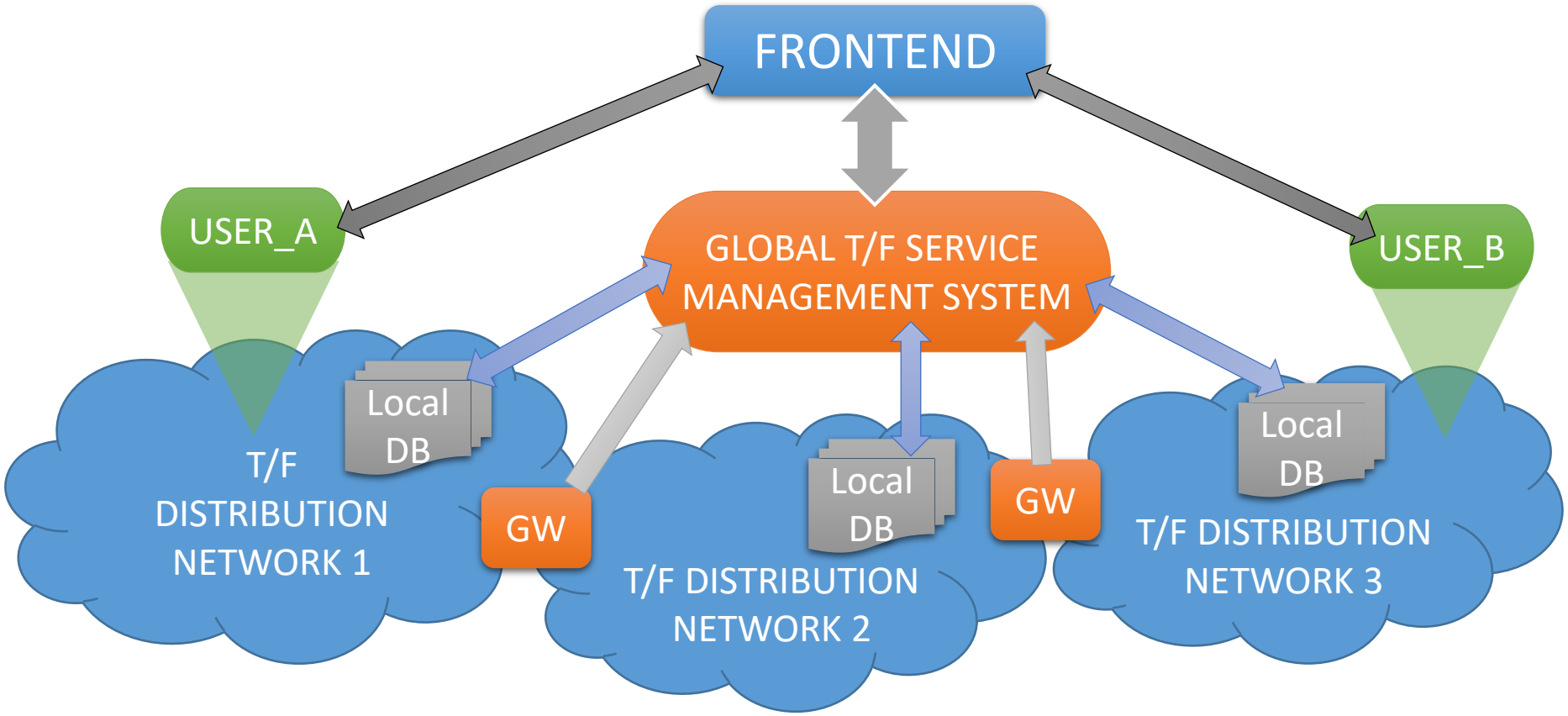
  https://wiki.geant.org/display/NETDEV/TF+Gateway

- **Knowledge base - information on selected aspects of time and frequency transfer** including studies on T/F distribution network monitoring issues, calibration of time transfer for different technologies, links to useful software (calculation of Sagnac correction)

  https://wiki.geant.org/display/NETDEV/Monitoring+and+Calibration

# Multidomain services - OTFN activity (2)

- **Development of an architecture to support the maintenance of the T/F infrastructure and the exchange of measurement data in a multi-domain environment.**



# Multidomain services - OTFN activity (3)

Frontend:

- user authorisation and resource access allocation (scheduling of measurements, access to measurement data, reporting and receipt of tickets)
- access to real-time measurement data and the status of a given connection
- resource scheduling (booking of measurement sessions)

Global T/F Service Management:

- gathering and processing of measurement data
- aggregation of measurement data from local databases for selected international connections
- update of the status of connections in the multidomain network
- the main source of information for the frontend

# Multidomain services - OTFN activity (4)

Local Data Base / management :

- Function similar to Global T/F Service Management but limited to one domain/subnetwork only

Gateway (GW):

- connection point between two different T/F domains
- requires measuring equipment that continuously records the relative differences of the signals transmitted in adjacent domains
- recorded data should be streamed to the global database in real time

# Thank You!

**OTFN Group**

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