



REALISATION OF THE PROJECT: TIME SYSTEM OF THE REPUBLIC OF SERBIA

TIME DISSEMINATION OVER THE TERRITORY OF THE REPUBLIC OF SERBIA

Dušan Popović

Group for time, frequency and distribution of time

E-mail: dpopovic@dmdm.rs



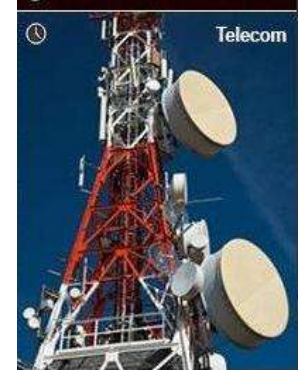
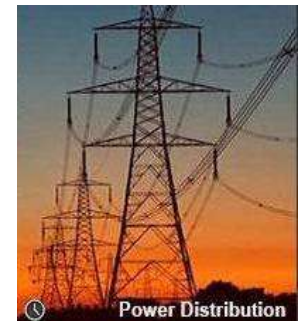
Introduction



Achievements of precise measurement of time and frequency enabled the realization of the time systems with exceptional characteristics that represent technological capital of the first-class value.

The practical application of these measurements was particularly evident in the control and management of all types of traffic, increasing the speed and quantity of information transfer in telecommunications, in banking transactions, automated robotic systems in production, in the military or police systems of automatic control, various measurement systems used in science etc.

Users have different requirements regarding “exact” time. Someone needs accuracy of the time on the order of a second, and the others need accuracy on the order of a microsecond or more accurate.





Theory in brief

Time system

- Time system is a set of standards and supporting devices, which role is realization and distribution of time data, its conversion, processing, storage and presentation in a form suitable for human and/or machine [1]
- The clock, as a measure of time, performs its function only if it is within the time system where it is uninterruptedly supplied with the information about the "correct" time.

[1] В. А. Шполянский, Хронометрические системы, Машиностроение, Москва 1980.



Dissemination - transfer of the time data 1

“It is useless to measure time, if it will not transfer”

J. L. Rigal

Dissemination

Dissemination of the time data implies its transmission to unlimited large number of users. It is the essence of the time system, since it provides harmonized appearance of the time data at clocks displays, which are situated at various locations around the of wide territory.

According to the size of territory that covers, dissemination of the time data can be: global, regional and local.

Accuracy of disseminated time data at the user place mostly depends on: propagation delay, settings of the local receiver and local effects (internal and external).



Dissemination - transfer of the time data 2

Users typically have access to some of the local approximation UTC through the national dissemination system, through global satellite systems (GPS, GLONASS, and Galileo soon) or via the Internet.

Offset of the UTC (k) scale is known (published in the monthly bulletin of the BIPM, Circular T) and it is negligible compared to the offset resulting from transfers to the users, which depends of transfer mode.

Required accuracy define the method of transfer of the time data to users. Table 1 shows the methods of dissemination of time data and their characteristics.



Dissemination - transfer of the time data 3

Table 1 - Methods of dissemination of time data [3]

The method and system	Accuracy of time data transfer	Coverage
Radio systems HF, LF, LF navigation- puls,	(1 – 10) ms 1 ms 1 μ s	Regional Global
TV system Terrestrial-satellite	(10 – 100) ns	Regional
Global Satellite Positioning System	10 ns	Global
Telephone computer time service	(1 – 10) ms	Regional
Mobile telephony	10 μ s	Regional
Internet	(1 – 200) ms	Global
The system of microwave links	(1 – 10) ns	Local
The system with optical fiber	(10 – 50) ps to 50 km 100 ns to 2000 km	Local
The system of coaxial cable	(1 – 10) ns	Local

[3] Agilent AN 1289 The Science of Timekeeping, 1997.



Role of National Metrology Institute (NMI) in the dissemination of time

- The Law on Metrology (“Official Gazette of RS”, no. 30/2010)

article 7.13, DMDM is responsible to perform time dissemination activities

- In most countries, the NMI covers the complete dissemination of time, independently or in cooperation with another organizations (not necessarily state-owned).
- It can be concluded that the role of the NMI in the dissemination of the time information, is not only to produce and disseminate, but also to perform constant control of the functioning and upgrading of the system.



TIME SYSTEM OF THE REPUBLIC OF SERBIA

TIME DISSEMINATION OVER THE TERRITORY OF THE REPUBLIC OF SERBIA

Beginning

- In year 2006, Directorate of Measures and Precious Metals (DMDM) initiated a project of dissemination of time.
- TF group performed preliminary design, according to which, as the optimal solution in the first phase, dissemination over the Internet and leased lines is realized.
- Equipment is obtained through the CARDS program and in June 2009 realization started.



Realization of system of the time data dissemination 1

Aim of project

- This project continues the project:

Realization of the national standard of time and frequency and maintenance of the national time scale.

- The ultimate goal:

The establishment of a modern, functional and reliable system for time dissemination in the Republic of Serbia



Realization of system of the time data dissemination 2

Project tasks

1. Define and develop a multifunctional system for dissemination of real-time:
 - Capacity of thousands of users over the Internet and leased lines.
 - Accuracy of time on client side
 - from 1 ms to 100 ms, for Internet users
 - better for the users of leased-rent lines.
2. To provide connectivity of local DMDM network into the system.
3. System users who use the time for business purposes can access only through authentication (passwords) and must obtain verification of authenticity.



Realization of system of the time data dissemination 3

4. Time data that authorized user receives must be protected from potential abuse.
5. The system must be highly reliable.
6. Installing and maintaining software for authorized users should not be complicated.
7. System maintenance and service must be simple and quick.
8. Development and expanding the system should be simple.



Realization of system of the time data dissemination 4

Description:

The national standard of time and frequency

- DMDM maintain national time scale UTC (DMDM), which is the legal time in Serbia
 - National standard of time and frequency
 - Comparison with UTC
 - Traceability: Circular-T
- Signal of "exact" time is distributed from the Time and frequency lab



Realization of system of the time data dissemination 5

Dissemination system

- Dissemination of time data via the Internet, leased lines and radio waves (signals) will be used.

Users-Customers

Two types of users are foreseen:

- Those who receive time data with the required, appropriate protection and accuracy, and they pay a fee.
- Others, who have free access, but without any protection and with limited number of approaches.

Realization of system of the time data dissemination 6

Main idea of project

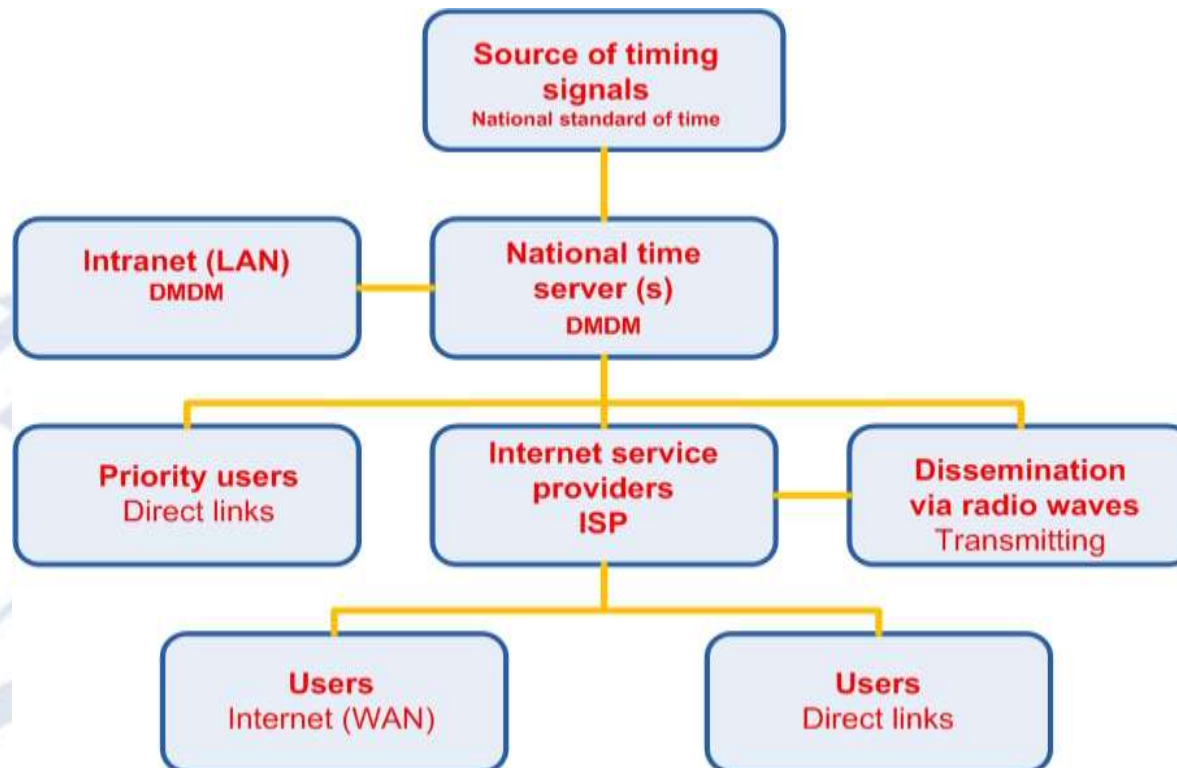


Figure 1. Preliminary solution of the system for distributing time information



Realization of system of the time data dissemination 7

- The basis for the dissemination of time data system via the Internet and leased lines form two network time servers (NTS), which distribute data over TCP / IP networks (including the Internet) using the application Network Time Protocol (NTP) [2].
- Clocks, sources of time, according to NTP, are divided into levels, stratum, that define the distance from the reference clock. The highest level of the stratum is zero (0).
- To generate accurate time information, as an external reference NTS are using: 1PPS and 10 MHz from Caesium clock, GPS, IRIG B coded signal and a second reference NTS.

[2] D. Miles, Network Time Protocol (NTP) General Overview, University of Delaware 2004



Realization of system of the time data dissemination 8

- NTS are programmed on such a way that continuously communicate with the user-customer device with which they have a connection.
- In the client-server mode, the client sends a request to the server. Server continuously monitors whether there is a request via the NTP protocol.
- Upon receipt of the request, NTS sends time data that is reprinted (timestamping) in the client device that has sent the request.
- The customer clock continues further work using its own internal database until next time correction.
- The more often adjustments of the customer clock are performed, offset from the reference will be less. Process of communication between client and server is shown in Figure 2.



Realization of system of the time data dissemination 9

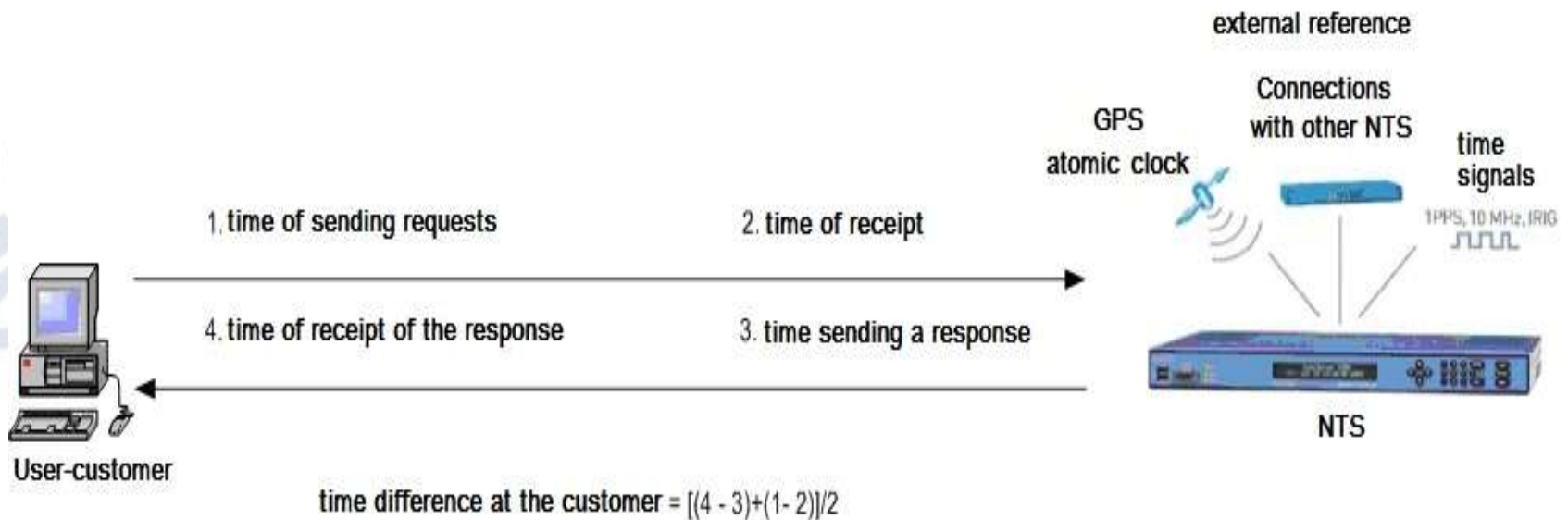


Figure 2. The process of communication client-server



Realization of system of the time data dissemination 10

- To synchronize the clock with NTS a client needs to know delay in the network and time difference (offset).
- Synchronization is correct when both path to the server, outgoing and incoming, have symmetrical nominal delay. If it is not, there is a systematic error of half the difference of the outgoing and incoming time.
- Accuracy on the client side primarily depends on the quality of the network and symmetry paths to and from the server.
- Dissemination of time data via the Internet and leased lines, depending on the user-customer, can be divided into restrictive and public.
- The first one includes those whose time data use in business and official communication and whose requests, in terms of accuracy and protection, are of vital importance for their work. They are normally connected to the NTS stratum 1 level.
- The second ones includes all others and they are in the network of lower stratum level: 2, 3, ...; 12.



Realization of system of the time data dissemination 11

Realization of Phase I

Based on the requirements, in the first phase has been defined and implemented a system for disseminating time information through the Internet and leased lines.

A block diagram of this system is given in Figure 3.

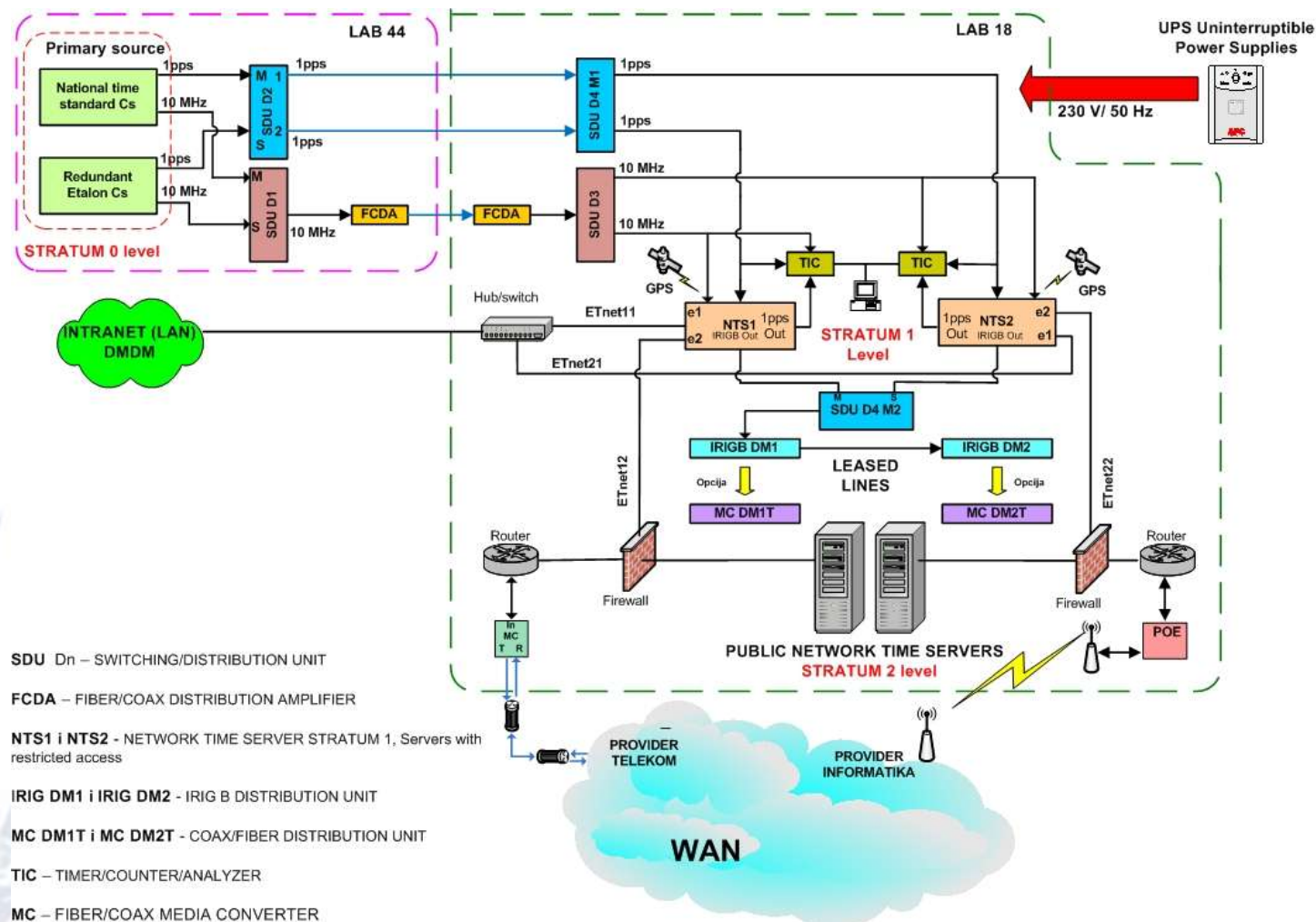


Figure 3. Block diagram of the system for the dissemination of time over the Internet and leased lines



Realization of system of the time data dissemination 12

This system was implemented and put into trial operation in 2011 and since then has been continuously in use.

System performs daily control of the time differences (offset) of the servers with restricted access (NTS1 and NTS2) and public servers (virtual clients-PC computers in DMDM), using open source applications recommended by the manufacturer.

Examples of results of the network servers monitoring are shown in Figures 4, 5, 6 and 7.

The results are in accordance with defined requirements for the accuracy of the time data, for the time data dissemination system (item 1 of the Project tasks).

It can be concluded that the first phase of time data dissemination is realized.



Results 1

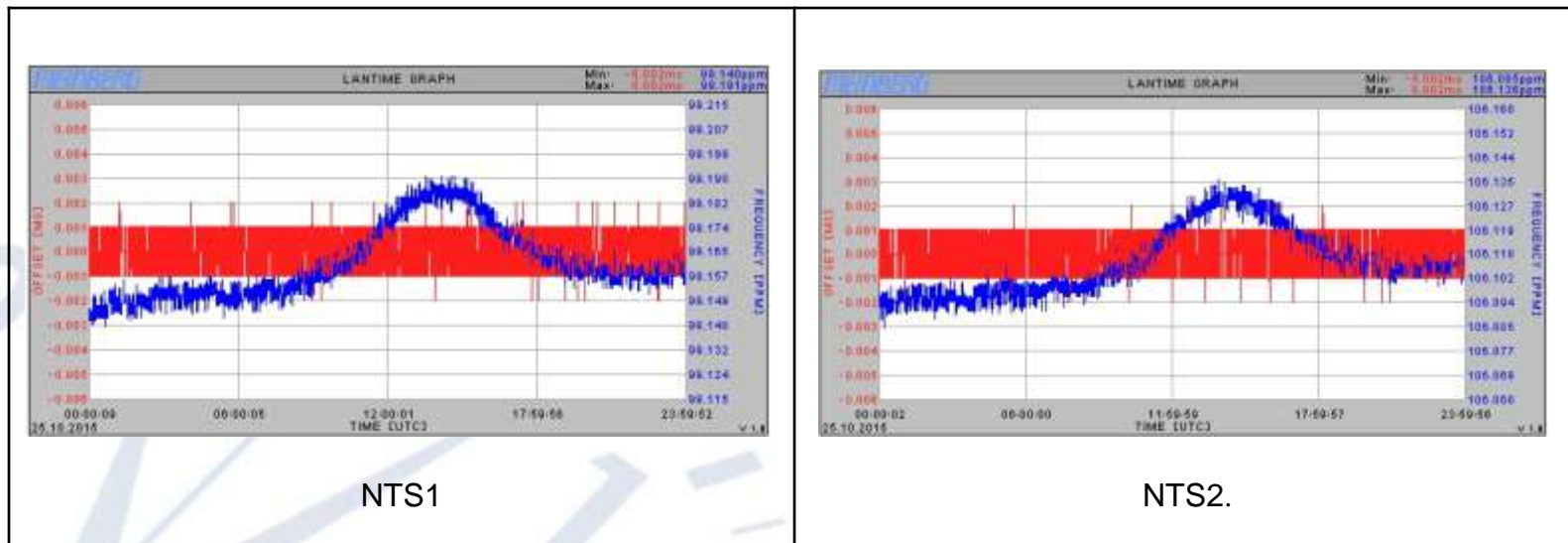


Figure 4. An example of results of daily monitoring of time servers with restricted access



Results 2

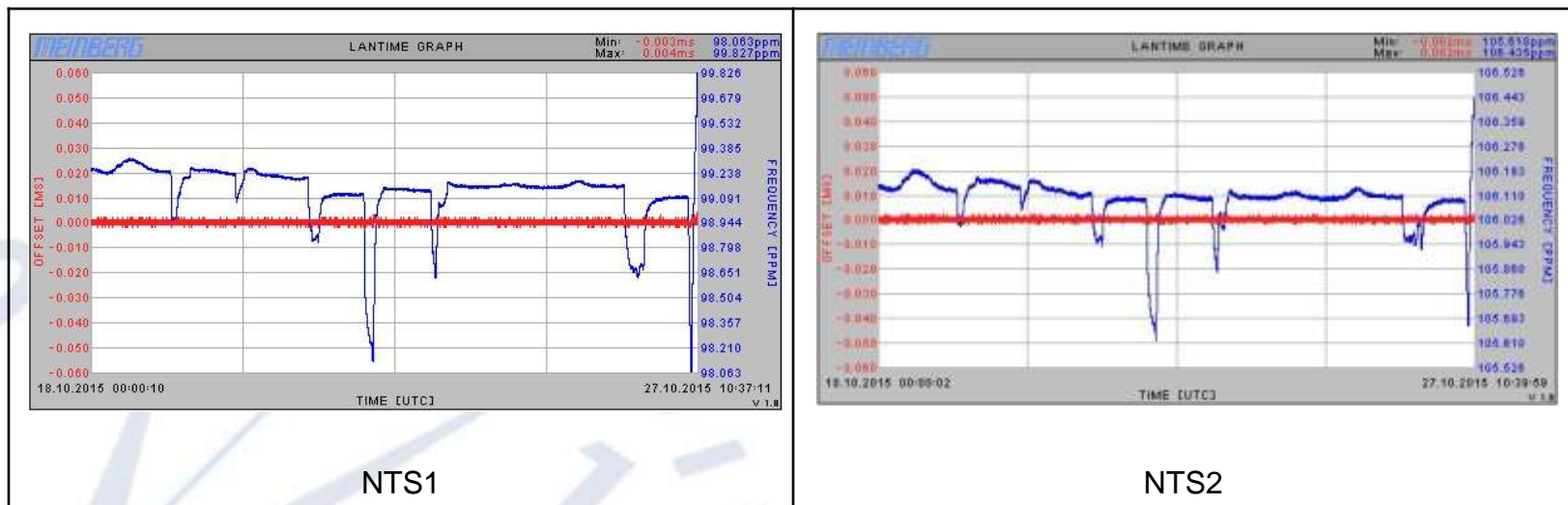
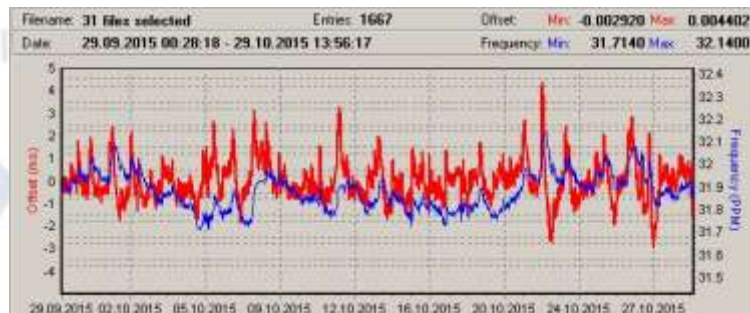


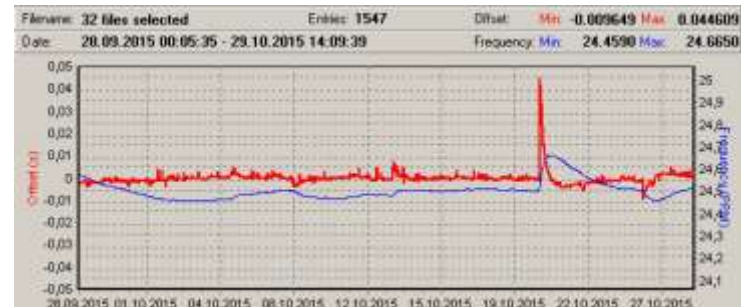
Figure 5. An example of the results of the ten-day monitoring time servers with restricted access



Results 3



NTS1, Provider Telekom Srbija



NTS2, Provider Informatika ad

Figure 6. An example of results of monthly monitoring on the place of client - October 2015.
(application ntp-time-server monitor 104 Meinberg)



Results 4

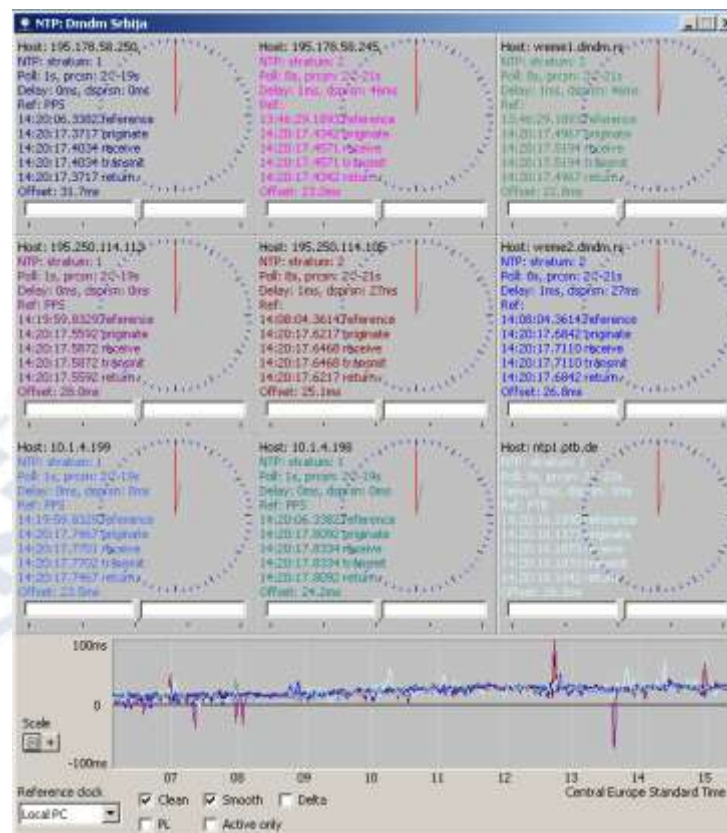


Figure 7. An example of the results of daily monitoring on the place of client (30.10.2015.) (application monitor NTP 5:14 David Taylor www.satsignal.eu)



Realization of Phase II

Time dissemination system via the Internet and direct lines were unable to cover all users-customers. Also, to increase the reliability of the entirety of the system, in 2014 year started implementation of the second phase, ie. dissemination of the time data via radio waves (signals).

The basic idea in the selection of the system for dissemination of time data via radio waves (signal) was to define a system that would, using existing resources, meet the needs of users in the country adequately and on financially acceptable way.



It was necessary to define the users who will use this method of dissemination of time data, ie. to define the accuracy of the time they require.

Those who uses time information obtained through public clocks, which can meet the accuracy within 1 s, are recognized as users of this dissemination method.

An important factor is the availability of time data to the users, which should be higher than 95% on the entire territory.

Serbian legal regulations defined that at least 90% of the territory must be covered by the FM signal (now, coverage of the territory is better than 80%, but will very quickly reach prescribed legal requirements)

Guided by these facts as well as the current legislation, it was concluded that the most appropriate way of disseminating time via radio waves (signal) is using RDS (Radio Data System), where signals are transmitted within the VHF / FM band (80 to 108) MHz.



Figure 8. Coverage of the territory of the Republic of Serbia by FM transmitters and repeaters

This was one of the most important facts that it is possible to use dissemination of time data via radio waves (signal) RDS system in Serbia



Brief introduction to RDS

Radio Data System RDS is a standard for sending short information messages using a standard FM signals emitted by the radio station. RDS system standardizes several types of information transmitted, including those that are most important for the dissemination of the time data :

AF - Alternative frequency. Allows a receiver to automatically re-tune to a different frequency providing the same station when the signal of fundamental frequency station becomes too weak

CT - Clock Synchronizes the clock in the receiver with the master clock. The time is displayed in hh: mm without seconds.

Figure 9. shows the multiplexed signal that is transmitted within the FM and consists of the following components: Mono (L + R), Stereo carrier pilot, Stereo (LR) and RDS

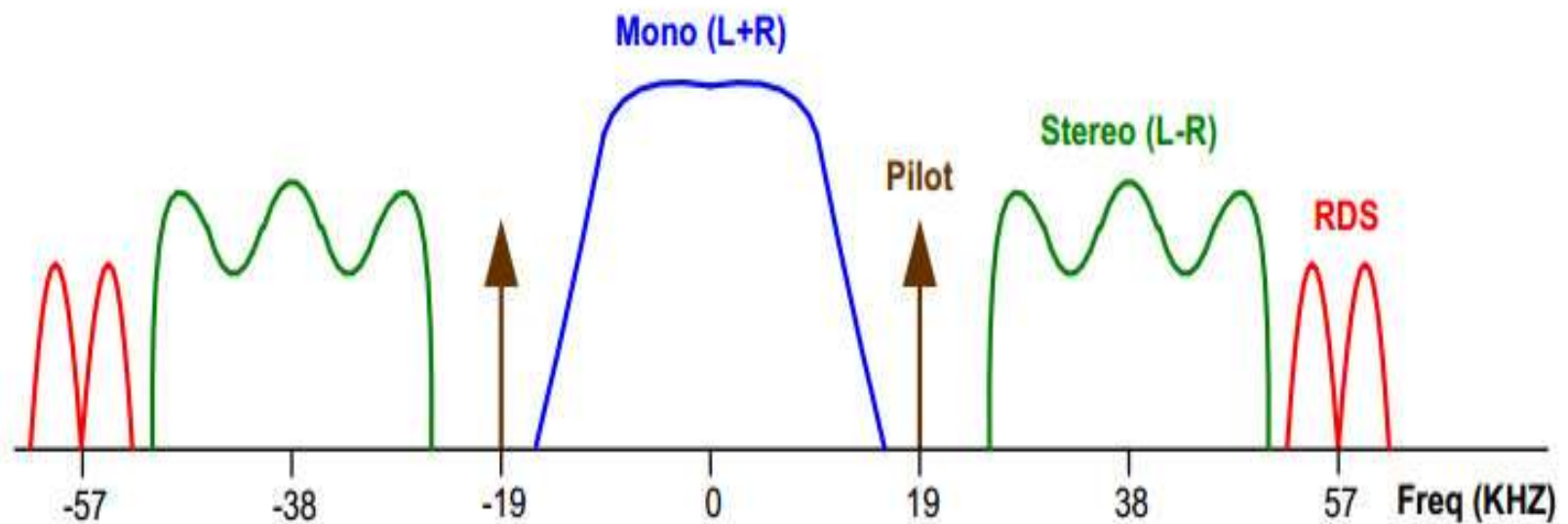


Figure 9. FM multiplexed signal

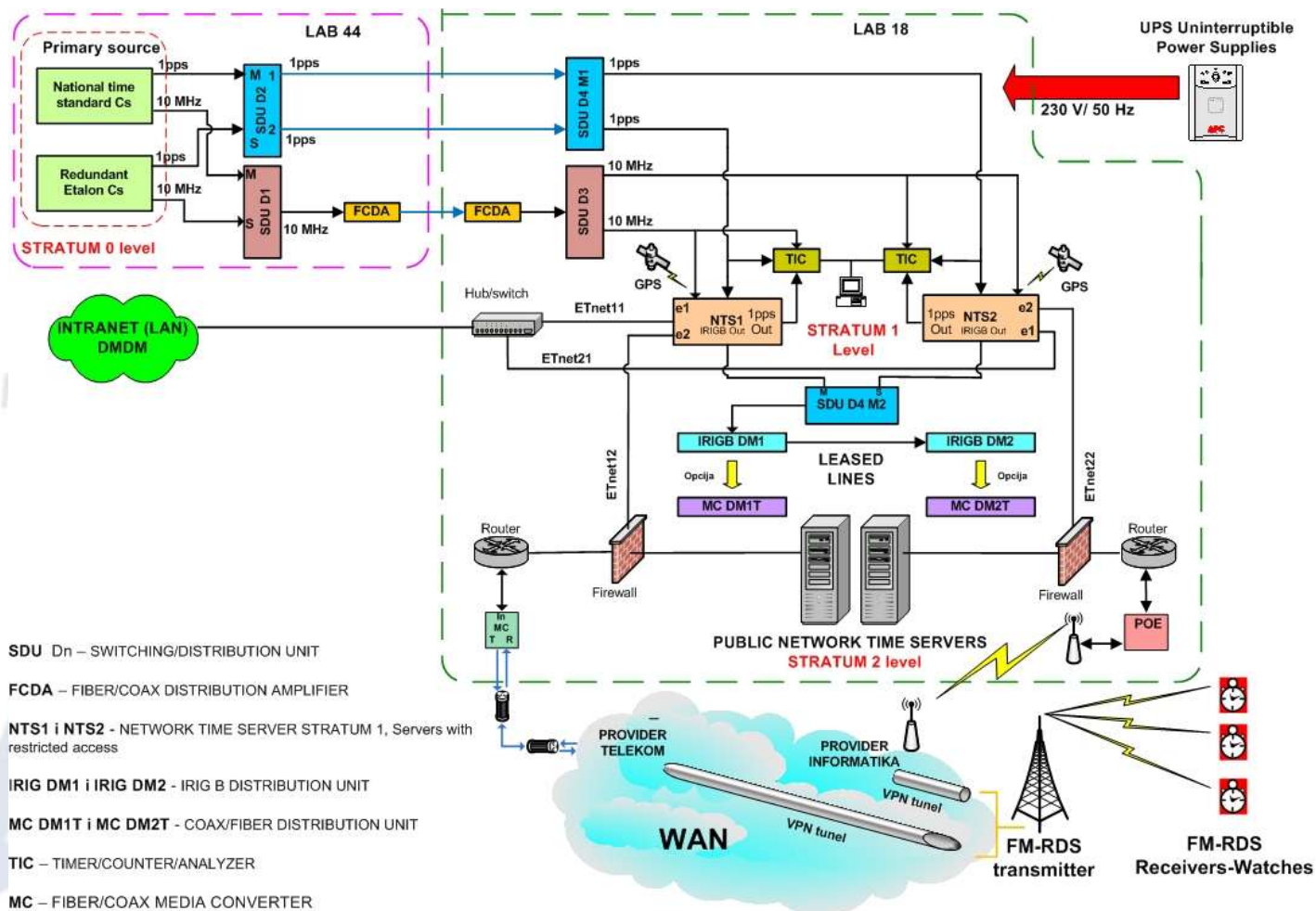


Figure 10. Block diagram of the system for dissemination of time with additional distribution system via radio waves(signal)



Results and realization

Time dissemination via RDS signal is experimentally realized in 2014.

RDS signal was inserted into the signal of station Radio Belgrade 1, Belgrade Radio 2, Radio Belgrade 202 and broadcast via transmitters AVALA, ČOT and OVČAR.

The reception of time data was verified.

Source for the time data signals were time servers NTS1 and NTS2, with restricted access in DMDM, and data is transmitted through the VPN tunnel to broadcasters JP Emisiona tehnika.

For experimental measurements was developed RDS receiver that is capable of displaying the seconds.

The resulting offset from the UTC (DMDM) is less than 1 s, which is for users of this dissemination method of time data more than enough.

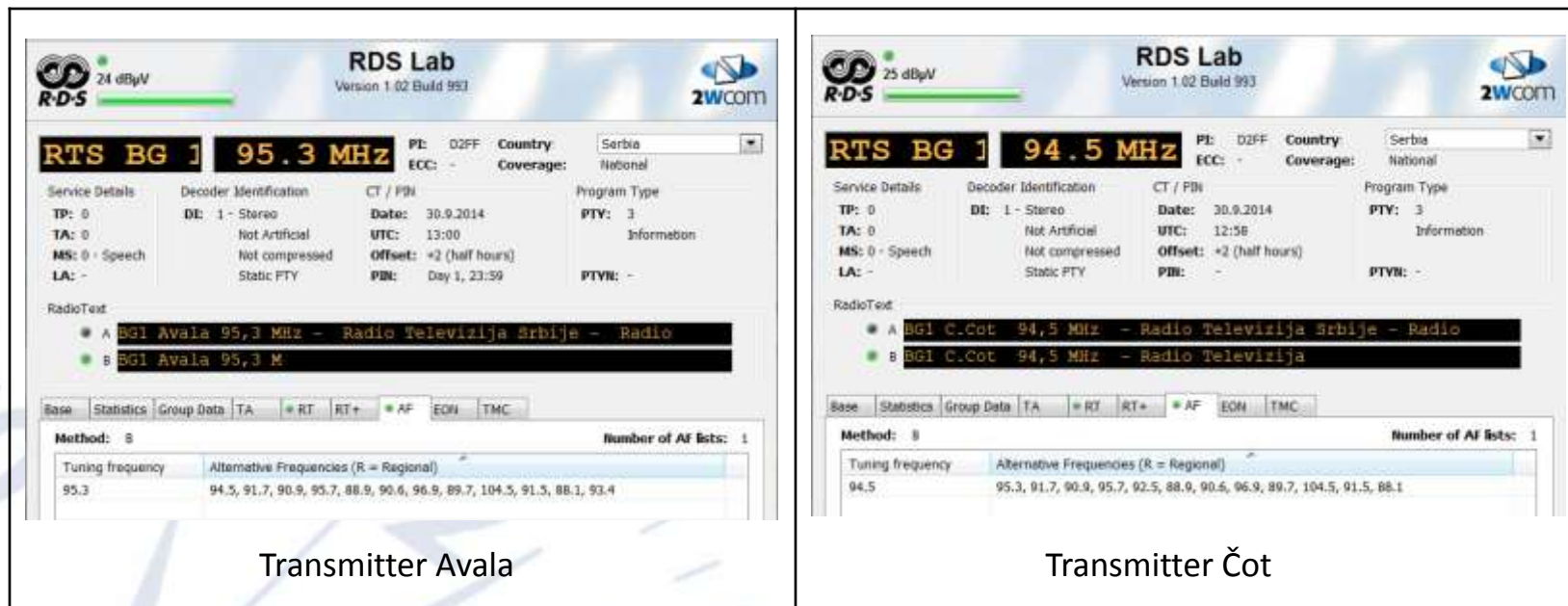



Figure 11. Verification of reception time data transmitted through the RDS system from transmitters Avala and Čot



Time data dissemination via radio waves (with the RDS system) still is in the experimental phase.

The achieved results are correct and in the scope of initial requirements.

Only after finalizing of RDS system, it can be said that the time system on the territory of the Republic of Serbia is complete.



Thank you for your attention