Regional Time Service Platform Design Based on GNSS CV

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Abstract—Through the research on GNSS CV, a proposal of regional time service platform was proposed based on the China Standard Time of National Time Service Center to realize precise time service. This proposal can reduce the pressure on the servers of NTSC brought by users, but also help to reduce the cost of users needed.

Keywords—GNSS common-view, time service, regional time service platform, Beidou, time difference

I. INTRODUCTION

Time is the most basic physical characterization of physical movement [1], which provides the necessary time coordinate to all dynamical systems and measuring and researching of timing process. Widely used in basic research, applied research and national economy and national defense construction, time service has become an integral part of the national economy and public welfare projects, which is even crucial to national security. A country must have an independent and unified time standard to restrain the government and society, in order to ensure that national, social functioning unity, orderly continuous and security. At present, China's national standard time is established and maintained with the atomic time standard by the National Time Service Centre of Chinese Academy of Sciences (NTSC).

China has independently developed the Beidou satellite (BDS) navigation system with more availability and secure, which is not controlled and restricted by the other countries. Adopting a BDS and GPS redundancy technology for high time accuracy comparison and delivery can make up the long-time risks and dependence of GPS clock and solve the reliability problems of clock module on the common view.

II. THE BASIC PRINCIPLES OF COMMON VIEW

At present, the international timing methods mainly have three categories: satellite granted by microwave, ground granted by long wave propagation and network/phone granted by data exchange [5]. The representative timing technologies are the GPS satellites of United States and Beidou satellites of China. The satellite timing method can cover a wide range and the timing precision can reach 50ns, which is the highest accuracy method currently [2].

GNSS satellite common-view (GNSS CV) is a high-precision remote time transferring technology of high precision, wide coverage, low cost, continuous operation, etc. [3], which is presented by the US Institute of Technology Standard (NIST) in the 1990s. If one party of the common view is the laboratory maintaining the national standard time, the other party achieves a precise synchronization with the national standard time. National Time Service Center in China first proposed the method of timing services based on GNSS CV, which uses the Internet technology for real-time transmission and online processing of data to get the rapid determination of the relative clock difference between the users and national standards UTC (NTSC) and realize the high-precision time synchronization of the user and UTC (NTSC).

Common view means two atomic clocks at any location on Earth can receive and compare the same time signal of satellite at the same time and the common view is one of the basic means for the International Atomic Energy Cooperation at Bureau international des poids et mesures (BIPM) [4].

It’s assumed that $T_A$ is the time for place A to receive satellite signals, $T_B$ is the time for place B to receive satellite signals, $T_{GNS}^{\text{GNSS}}$ is the time of GNSS satellite signals, $d_A$ and $d_B$ are the path delay between the two stations and satellites, which are mainly for ionospheric and tropospheric delay and the two station observe one satellite $S$ at the same time.

Place A: $\Delta T_{AS} = T_A - T_{GNS} - d_A$
Place B: $\Delta T_{BS} = T_B - T_{GNS} - d_B$

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GNSS common view measuring principles are as follows: GNSS receivers of two places A and B on Earth under the same common view time schedule receive the time signal of a same GNSS satellite synchronize synchronously. Each GNSS receiver send the received second pulse to the time interval counter and the pulse will be compared with that from the local atomic.
\( \Delta T_{AS} \) between the local time \( T_A \) and \( T_{\text{GNSST}} \) is obtained at place A and \( \Delta T_{BS} \) between the local time \( T_B \) and \( T_{\text{GNSST}} \) is obtained at place B at the same time. Then, the communication network transmits the data to the other party, you can get the time difference between the two atomic clocks by the subtraction of the two time differences, which are shown in eqn.(1)-(3).

\[
\Delta T_{AS} = T_A - T_{\text{GNSST}} - d_A \\
\Delta T_{BS} = T_B - T_{\text{GNSST}} - d_B \\
\Delta T_{AB} = \Delta T_{AS} - \Delta T_{BS} = (T_A - T_{\text{GNSST}} - d_A) - (T_B - T_{\text{GNSST}} - d_B) \\
= (T_A - T_B) - (d_A - d_B)
\]

Common-view can completely offset satellite clock error [6] and offset the ionospheric and tropospheric delay error partially. When A and B are in the same area not far, \( d_A \) and \( d_B \) are almost the same and \( d_A - d_B \) are approximately zero. When the two ionospheric and tropospheric delay of A and B can be accurately calculated, the time difference between the two atomic clocks can be obtained accurately.

### III. SYSTEM DESIGN

#### A. The overall design

JiangSu BDS Application Industry Institute intends to establish Beidou satellite time service platform in Jiangsu, which connects the National Time Service Centre and constitutes the region with precise time service system together. Beidou satellite time service platform in Jiangsu as a regional service centre timing provides accurate time service for east China.

The precise time service system contains five major components: the master observation unit, customer observation unit, system management unit, data processing unit and Jiangsu Beidou satellite service platform, which is shown in Fig. 1. The main observation unit includes GNSS CV observation equipment, standard time and frequency signals, whose main function is to measure the time difference between UTC (NTSC) and GPS, BDS, and GLONASS satellite clock. The client observation unit consists of GNSS CV observation equipment and local time source, whose main function is to measure the time difference between the local time and GNSS satellite clock.

System management unit includes customer data submission, data processing module calls, and the results delivery module and it contains hardware and software like data storage devices, network bandwidth, servers, and data systems, whose function includes acquisition, IGS precise ephemeris observational data, other products regularly downloads, data processing result delivery and so on. The data processing unit includes a data pre-processing party and a data comparing party. The data pre-processing module pre-processes the data submitted by the customer, determines the category of customers to submit data and hours of coverage, and transfers relevant observational data and IGS-related products from the local database. The data comparing module is to implement the GNSS CV computation for the customers and local GNSS observation data based on the results of the pre-treatment observation data. Jiangsu Beidou satellite time service platform is connected by a dedicated network to the national time service centre, in order to achieve offsite replication of the National Time Service Centre standard time signals and the accuracy, high stability, safe and reliability of regional timing system.

![Fig. 1: SYSTEM ARCHITECTURE](image-url)
B. System Description

Jiangsu Beidou satellite time service platform can be divided by function module: data submission module, data preprocessing module, data comparing module, the automatic results delivering module and data management module, which is shown in Fig. 2.

Data Submission modules: logging in the systems for customer and submitting data to the regional time services platform server;

Data pre-processing module: After receiving the data submitted by the customer, preliminary screening data, and determine the category of customers’ submitted data.

Data comparing module: Customer data pre-test, CV computation, the assessment of results.

The automatic results delivering module: After the customer data processing is completed, the corresponding result is returned to the client.

Data management module: Managing data submitted by the customer and transferring management of all types of data from NTSC server.

The single run flow of system is shown in Fig. 3. After the user logs in Jiangsu Beidou satellite time service platform, timing issue service requests are sent to the platform and CV observations data are submitted through the data. When the system receives service requests and data submitted by the user, it starts the online time services, including: calling data pre-processing module to determine the data type, observation time, preparing the master observations data and so on; calling data comparing module for data matching process; calling result delivery module to send the CV comparison results to the user; implementing precise synchronization between the user clock and UTC (NTSC).

IV. CONCLUSION

Common-view method can only be used for time alignment or time synchronization between a few users, and it does not have the characteristics while providing services for unlimited users [7].

The establishment of regional satellite time service platform realizes the time transferring and synchronization by connecting the NTSC server through network. When users access to regional satellite time service platform, they can achieve the time comparison with the National Time Service Center. In this way, not only a large number of the original NTSC users can access to the regional time services platform, which greatly reduces the pressure on the NTSC server, but also the cost of network users reduces.

More importantly, the timing of Jiangsu regional satellite service platform can establish a precise model of atmospheric delay in east China through long-term data collection. It can calculate the amount of delay by accessing the internet atmosphere, so users get accurate time difference between their own clock and the platform which provides a strong guarantee for the precision timing.

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REFERENCES


