TIME AND FREQUENCY ACTIVITIES AT NAOJ

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Abstract

The National Astronomical Observatory of Japan (NAOJ) maintains UTC(NAO) at the Mizusawa VLBI observatory. The Mizusawa VLBI observatory is one of the facilities of NAOJ. In this paper, NAOJ and the Mizusawa VLBI observatory are introduced first, and then the timekeeping system of UTC(NAO) is briefly described.

I. INTRODUCTION

The National Astronomical Observatory of Japan (NAOJ) [1] is an astronomical research organization comprising several facilities in Japan. It was established in 1988 as an amalgamation of three existing research organizations - the Tokyo Astronomical Observatory (TAO) of the University of Tokyo, International Latitude Observatory of Mizusawa (ILOM), and a part of Research Institute of Atmospherics of Nagoya University. NAOJ has been completely reorganized to incorporate the project system in system in accordance with the rearrangement of the inter-university research institutes on April 1, 2004.

Mizusawa VLBI observatory [2] is located in the campus of former ILOM in northern part of Japan. The aim of Mizusawa VLBI observatory is execution of VERA project [3] and RISE project[4]. VERA (VLBI Exploration of Radio Astrometry) is a VLBI array to explore the 3-D structure of the Milky Way Galaxy based on high-precision astrometry of Galactic maser sources shown as Figure1.

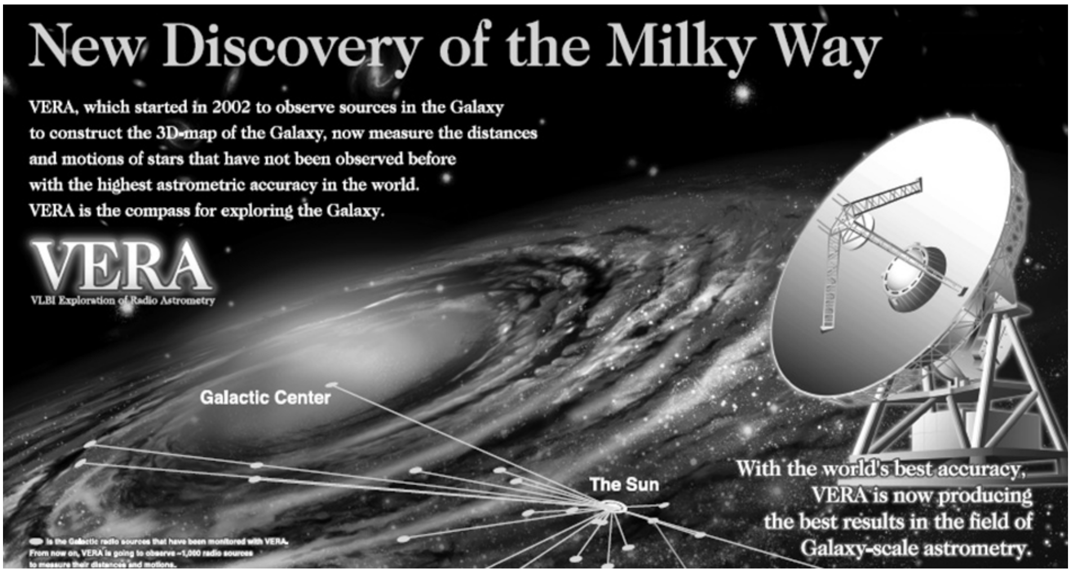

Figure 1. Conceptional explanation of VERA project.

In NAOJ, two timekeeping offices used to be organized. One was established in former TAO and the other was established in former ILOM. Both timekeeping offices were reorganized as the timekeeping office at Mizusawa VLBI observatory (NAO timekeeping office) in 1992.

II. TIMEKEEPING SYSTEM

The timekeeping system of NAO timekeeping office consists of four cesium clocks, one hydrogen maser located in VERA observation room, a SDI HROG-5, an Agillent 53132A counter, a Rapco 900 phase comparator, a Time & Frequency Solutions Timetrace GPS common-view receiver, three system controllers and four NTP servers. Figure 2 shows the block diagram of the timekeeping system. One of the four NTP servers is configured as stratum one NTP server and referenced by the other three stratum two NTP servers internally. The three stratum three NTP servers are operated by round robin configuration for the access from outside.

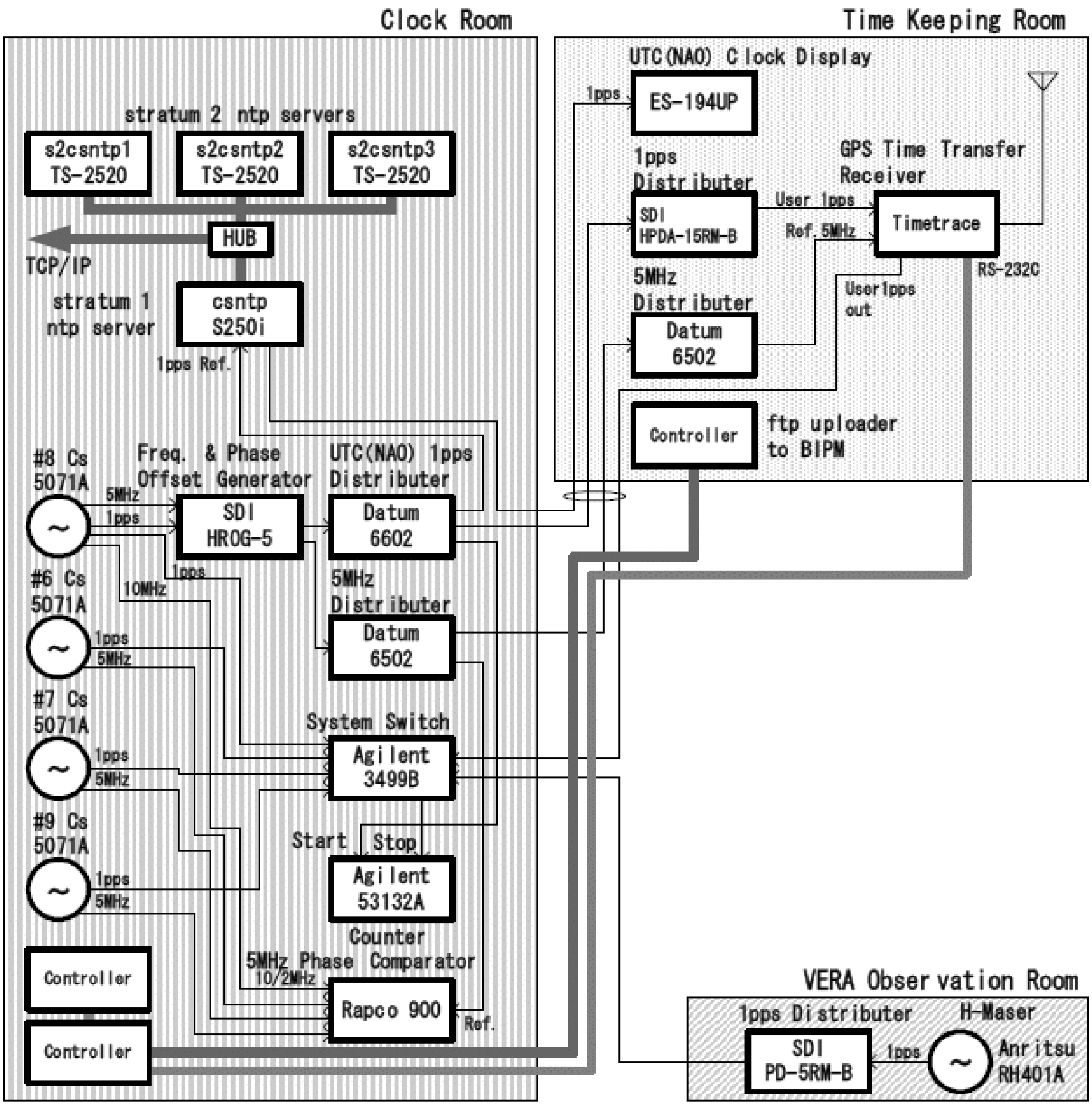

Figure 2. Block diagram of timekeeping system of NAO timekeeping office.

Four cesium clocks are installed in the clock room located on a basement floor of main building in Mizusawa VLBI observatory campus. The temperature of the clock room is controlled 24+/-0.1 degree Celsius. Figure 3 and Figure 4 show cesium clocks and the timekeeping system located in the clock room. The signals from the cesium clocks are monitored by the controller. One of the three controller is configured as ftp uploader and transferes the time comparision data to BIPM.

Figure 3. The cesium clocks in the clock room located on a basement floor.

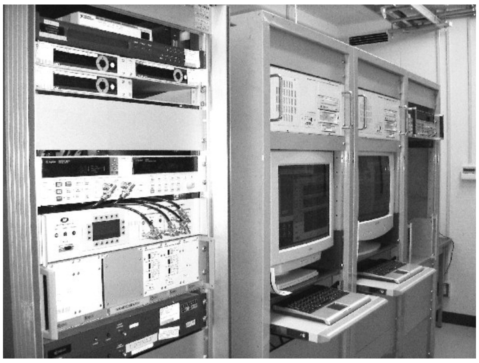

Figure 4. The timekeeping system in the clock room located on a basement floor.

One hydrogen maser frequency standard is installed in VERA observation room. This hydrogen maser supplies frequency standard to VLBI system shown in Figure 5.

Figure 5. Anritsu RH401A hydrogen maser frequency standard.

The antenna of Timetrace GPS common-view receiver manufactured by Time & Frequency Solutions Ltd is located on the roof of the main building shown as Figure 6.

Figure 6. A view of antenna location. The antenna of Timetrace GPS receivers is located on the roof of the main building.

The round trip cable delay of the GPS antenna cable in length of 15.38m is measured as 156ns. The value is derived to measure the traveling time of reflected pulse wave in the antenna cable. Figure 7 shows conceptional explanation of the method. The converted value to 5.07ns/m form measured cable delay is consistent to the normal delay value of 5.06ns/m for the RG-58 coaxial cable.

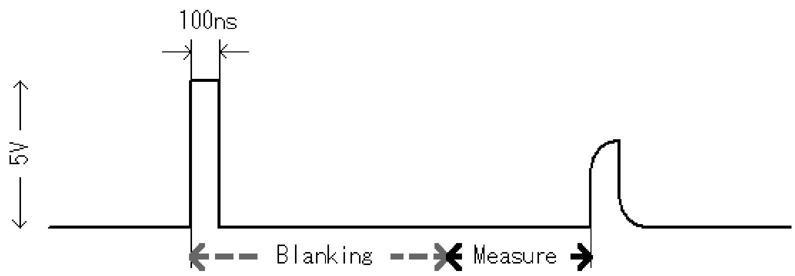

Figure 7. Explanation of the cable delay measurement. A pulse wave is injected to a cable. We measure the time interval between an injected pulse and reflected pulse. To exclude the noise such as a reflection from impedance unbalance in halfway, the blanking function of a time interval counter is effective.

III. STUDY OF NTP SYNCHRONIZATION ACCURACY

The clock offset between a GPS-based NTP time server and NTP time client software, installed to MS Windows Operating System (OS) and Linux OS on PCs, are measured and evaluated [5]. The NTP time client software on MS Windows OS adjusts the internal clock with the Application Program Interface (API) timer function. The clock offset on MS Windows XP OS shows time resolutions of 1ms for 1ms API timer mode and 10ms for 10ms API timer mode. The resolution of 1ms is depending on a hardware interrupt of IRQ8 (976μs) that is generated by a real-time clock on a PC. The resolution of system timer on MS-windows XP depends on a hardware platform and shows 10ms or 15ms. The clock offset on Linux OS also has a trend as well as a periodic divergency. The time interval of this divergency is estimated to about 35 minutes. The origin of this interval is presumed to be the loop constant of the kernel Phase Lock Loop (PLL). The Standard Deviation of this clock offset for 24 hours is 0.95ms.

Evidently, both MS Windows OS and Linux OS adopt different algorithms for keeping the internal clock. The accuracy of time synchronization by NTP is restricted by the algorithms. The limitation of the time synchronization accuracy on MS Windows OS is caused by the resolution of API that depends on a hardware interrupt generated in the hardware system timer and real-time clock in a PC. On the other hand, the loop constant of the kernel clock algorithm restricts the time synchronization accuracy by NTP on Linux OS.

REFERENCES

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