Precise Time Transfer by Means of Geodetic VLBI Technique

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http://www.nict.go.jp/w/w114/stsi/

Coordinated Universal Time (UTC) is currently maintained and realized by a weighted average of many atomic clocks being operated around the world. At 49 time and frequency laboratories in the world, various types of atomic clocks or frequency standard systems are operated to maintain standard time and standard frequency precisely and accurately. For example, National Institute of Information and Communications Technology is operating 18 Cesium beam atomic clocks and one Hydrogen maser frequency standard system to maintain and disseminate the Japanese Standard Time. A primary frequency standard system, NICT-01, is also operated to provide accurate realization of a second. NICT-01 is the optically pumped primary frequency standard system and can provide absolute accuracy of a second at the level of $6x10^{-15}$. Efforts to achieve better accuracy reaching $1x10^{-15}$ are on-going by adopting the Cesium atomic fountain primary frequency standard system. The maintained time has to be compared with the other laboratories by means of common view GPS observations and bi-directional satellite time transfer methods to confirm the quality of the time standard and contribute for the realization of UTC. To compare the standard time maintained at each laboratory, a hierarchical time transfer network has been established. Currently, a few hundreds of pico seconds of uncertainty has been achieved for the long distance time transfer by using dual frequency GPS receivers.

In the near future, however, the accuracy of the primary frequency standard will reach a level of $1x10^{-15}$ and much better time transfer methods will be required to compare the frequency standard between the time and frequency laboratories over a long distance. Geodetic VLBI technique is expected to have a potential to improve the uncertainty of the time transfer at least less than a few tens of pico seconds. In the typical global geodetic VLBI observations coordinated by International VLBI Service for Geodesy and Astrometry (IVS), the clock offsets between observing sites are estimated with an uncertainty of about 20 pico seconds. In the community of IVS, the future system of global VLBI observations is being discussed under the name of VLBI2010 by using wide frequency band and by using phase delay observables. It is expected to improve the precision of the time delay observables down to 4 pico seconds in the VLBI2010. To use the geodetic VLBI technique for the precise time transfer between time and frequency laboratories, it is necessary to develop a small VLBI observing station to place it near the atomic clocks and frequency standards. Fortunately, the 11-m IVS observing station at Koganei is located very close to the atomic clocks and primary frequency standards, and we have just started to develop extremely small aperture VLBI antenna system to realize standard of distance for global geophysical survey. It is expected that the new developments of the small aperture VLBI antenna system will make it possible to demonstrate the precise time transfer over the long distance. We will discuss the possibilities to use the global geodetic VLBI observations for precise time transfer and introduce the future plans of research and developments for the geodetic VLBI systems.