



Spece-Time Synchronization for 6G using T&F metrological technique

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The time-frequency standard has contributed to wireless communication primarily by providing frequency references. This applies to terrestrial mobile communication as well, and with the advent of 5G and 6G, which utilize even higher carrier frequency such as millimeter waves or terahertz, the need for frequency standards with low phase noise is increasing. However, it is also said that in the future, the importance of timing standards in mobile communication will rise significantly, similar to how TDD was standardized in 5G. Mobile communication networks rely on timing standards based on GNSS (Global Navigation Satellite System), and not only mobile communication networks but also various social infrastructure currently depends on GNSS. The United States has expressed concern about this and in 2019, the U.S. presidential order [1] called for research and development to ensure society can function even if GNSS fails.

NICT (National Institute of Information and Communications Technology) is a bit different from other national research laboratories specializing in time and frequency metrology. It primarily studies telecommunication research although our laboratory, space-time standards laboratory, in NICT determines the national standard of time and frequencies. Considering such intriguing situation, we propose the concept of space-time synchronization, where participants in mobile communication networks share precise time and spatial coordinates, enabling denser and more time-efficient communication and the ability to track spatial positions based on radio wave propagation delays. To achieve this goal, we have been developing three technologies: (1) CLIFS : Chip-level integrated frequency standards, (2) Wi-Wi: Wireless two-Way Interferometry [2], (3) Cluster clock timescale. These ideas and technologies are recognized in the sector of mobile communications and have been incorporated into a standardization document for 6G, Future technology trends in IMT-2030 [3], which are adopted in ITU-R WP5D. In this presentation, we would like to explain an overview of these technologies and discuss the role of timing standards in 6G, which is expected to be launched in 2030.

1. U. S. Government, Executive Order 13905 “Strengthening National Resilience Through Responsible Use of Positioning, Navigation, and Timing Services,” February 2020

2. N. Shiga, K. Kido, S. Yasuda, B. Panta, Y. Hanado, S. Kawamura, H. Hanado, K. Takizawa, and M. Inoue, “Demonstration of wireless two-way interferometry (Wi-Wi)” *IEICE Commun. Express* **6**, 2, November 2016, pp. 77-82 doi:10.1587/comex.2016XBL0181

3. Future technology trends of terrestrial International Mobile Telecommunications systems towards 2030 and beyond, ITU-R WP5D Rep ITU-R M. 2516-0