1 Special Issue on Time and Frequency Standard

MORIKAWA Takao

It is often noted that the ancient Egyptian and Mayan civilizations possessed calendars as accurate as those of today; since the dawn of history mankind has been in search of more accurate calendars and clocks. This is because time (or frequency, the other side of the coin, so to speak) is the most basic physical quantity for mankind and has proven vital to the social and economic activities of every era. Even in today's age of advanced science and technology, researchers struggle to keep pace with increasing demands for more accurate time and frequency measurements. Time (or frequency) can be measured with the highest accuracy of all other physical quantities, and serves as the basis of important quantities such as length and voltage. Research on time and frequency standards today forms a significant part of the groundwork of science and technology, and has recently gained increased attention as an essential component of Japan's Science and Technology Basic Plan.

The time and frequency standard works effectively only when its three constituent elements—generation, comparison, and dissemination—are organically combined. The Communications Research Laboratory (CRL) has pursued research and development into each of these elements. With respect to the generation of standard time, research on accurate atomic clocks (atomic frequency standard) constitutes the central focus. The CRL has developed an optically pumped Cs atomic frequency standard and is now working to a more accurate (in the order of 10^{-15}) Cs atomic-fountain standard, as well as an ion-trap standard. In terms of comparison between standards, the conventional GPS common view technique is not sufficiently accurate for comparison among standard clocks featuring accuracy in the order of 10^{-15}. Currently more accurate techniques—such as two-way satellite comparison and GPS carrier phase comparison—have become necessary. To meet these needs, the CRL has pursued R&D in these areas and has taken the initiative in building a two-way satellite comparison network in the Asia-Pacific area. Dissemination of a standard time and frequency differs from generation and comparison in that public user needs must be taken into primary consideration; in this case service supersedes research in importance. On the other hand, user requirements in terms of standard time and frequency are increasingly diversified. On one hand, high-precision clock systems and satellite-borne atomic clocks are in demand for satellite positioning systems (requiring accuracy in the order of 10^{-14} to 10^{-15}), while on the other hand a number of applications require only low-cost, simple standards of significantly lower accuracy (involving low-frequency waves, for example). Changes in society have produced new needs in terms of time and frequency distribution methods and systems. In particular, with the continuing evolution of economic globalization, it has become increasingly important to determine methods of authorizing individual national standards on an international basis, and each national standard organization is expected to revise its standard time and frequency distribution system. At the same time, with the growth of information technology, new demands for a reliable network time standard have rapidly emerged. In particular, a chorus of demands has risen for an electronic time stamping technology in the near term.

Under these circumstances, the CRL, reor-

ganized as an Incorporated Administrative Agency in 2001, has set the following R&D goals in its mid-term plan for standard time and frequency.

1. Development of a basic technology for improving accuracy to the order of 10^{-15}, for higher reliability and greater diversity within the standard time and frequency system; international contribution to the standard time and frequency technology in its capacity as a central research organization in the Asia-Pacific area.

2. Development of an electronic time stamping system that will accredit the times of Time Stamp Authorities (i.e., organizations that provide time services to public users) and establish the reliability of the temporal component of data.

This special issue explains the basic concepts of standard time and frequency and introduces some research topics underway at the CRL concerning the three elements of time and frequency standards—generation, comparison, and dissemination.

MORIKAWA Takao

Research Supervisor, Applied Research and Standards Division