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Technology Development Center at NICT

Kazuhiro Takefuji, Hideki Ujihara

Abstract

The National Institute of Information and Communications Technology (NICT) is developing and testing VLBI technologies and conducts observations with this new equipment. This report gives an overview of the Technology Development Center (TDC) at NICT and summarizes recent activities.

1. NICT as IVS-TDC and Staff Members

The National Institute of Information and Communications Technology (NICT) publishes the newsletter "IVS NICT-TDC News (former IVS CRL-TDC News)" at least once a year in order to inform readers about the development of VLBI related technology as an IVS Technology Development Center. The newsletter is available at the URL **http://www2.nict.go.jp/w/w114/stmg/ivstdc/news-index.html**. Table 1 lists the staff members at NICT who are contributing to the Technology Development Center.

Table 1. Staff Members of NICT TDC as of January 2013 (listed alphabetically).

HASEGAWA, Shingo	HOBIGER, Thomas	ICHIKAWA, Ryuichi	KAWAI, Eiji
KONDO, Tetsuro	KOYAMA, Yasuhiro	MIYAUCHI, Yuka	SEKIDO, Mamoru
TAKEFUJI, Kazuhiro	TSUTSUMI, Masanori	UJIHARA, Hideki	———

2. Current Status and Activities

We report about the progress of VLBI technology development hereafter.

2.1. Development of Gala-V: Brand New VLBI System

In order to conduct time and frequency transfer with a compact and portable VLBI system, NICT has been developing a system with a 1.5 meter antenna. As expected, the SEFDs of such a small antenna are quite large due to the size of the antenna and the ambient temperature of the receiver. Thus, we are developing a broadband VLBI system, which meets the requirements of VLBI2010, in order to improve the signal-to-noise ratio of the compact VLBI system. Because fringes will only be detected with the compact antenna if the second antenna on the baseline is large enough, our 34-meter antenna will also be upgraded with a broadband system. Before we started with the development, we measured the RFI conditions, in particular at Kashima, Ibaraki and Koganei, Tokyo. Figures 1 to 3 show the results of the RFI measurements in a range from 2 GHz to 18 GHz. It can be seen that RFI is very strong on the roof of our headquarters in Tokyo, but there are still some quiet frequency bands.

We designed the system so that it utilizes only bands in the RFI quiet zones and still provides a narrow delay function. We fixed the four bands with the zero redundancy array technique [Moffet(1968)] to be set with frequency differences in a 1:3:2 proportion at 3.2-4.8 GHz, 4.8-6.4

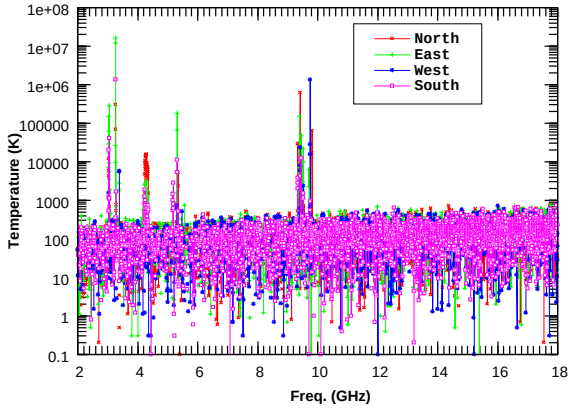

Figure 1. RFI survey in Kashima.

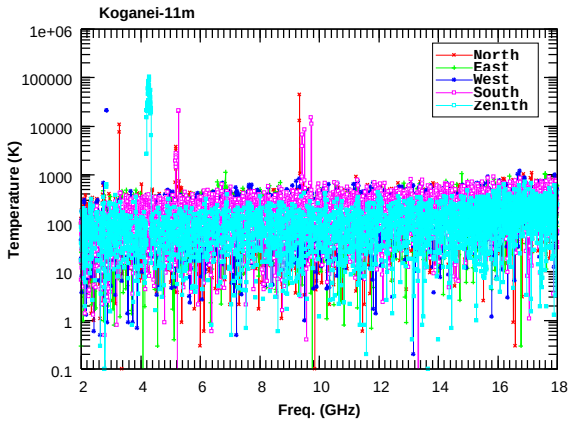

Figure 2. RFI survey near the 11-meter antenna in Koganei, Tokyo.

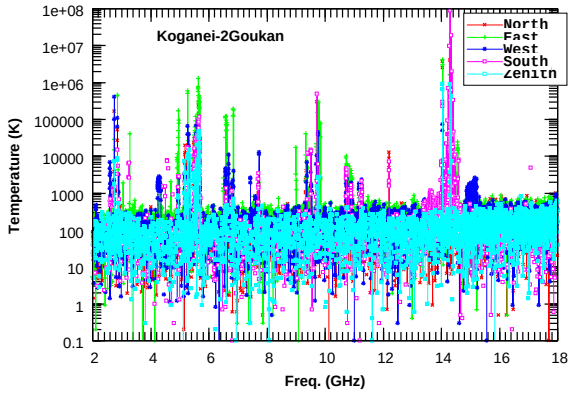

Figure 3. RFI survey on the headquarters roof in Koganei, Tokyo.

GHz, 9.6-11.2 GHz, and 12.8-14.4 GHz, in accordance with frequency ranges of VLBI2010. The proportion of 1:3:2 shows the differences between the starting values of the four bands, so, (4.8-3.2 GHz):(9.6-4.8 GHz):(12.8-9.6 GHz) = 1.6 GHz:4.8 GHz:3.2 GHz = 1:3:2. Then we started to develop the broadband system based on these fixed bands. We named the whole broadband VLBI system the Gala-V (Galapagos VLBI, which we hope will be a unique evolution in VLBI.) The effective frequency of the Gala-V bands becomes 4.4 GHz. Also the Gala-V bands have a great advantage for sampling. In the case of 12.8 GHz, they can be covered with high order sampling without any analog frequency conversion. Thus, we are developing a new digital A/D sampler with a sampling speed of 16 GHz. The sampler has two input channels, in order to sample four bands (1-1.6 GHz wide) at two polarizations.

2.2. Development of Wideband Feeds

Wideband feeds have been developed at NICT, NAOJ (National Astronomical Observatory of Japan), and universities in Japan for VLBI2010 and SKA. SKA is an international project in radio astronomy to construct a Square Kilometer Array. In this fiscal year, a novel wideband feed is being developed for the Kashima 34-m antenna, which will be used for our time and frequency transfer project and also for radio astronomy.

The feed, named the IGUANA feed, has unique specifications and structure. Operational frequency bands of the feed are carefully selected to avoid RFI and to satisfy the Gala-V bands and also the feasibility conditions of a nested feed (Figure 4). The beam size of the feed is nearly proportional to the operational frequency. Thus the frequencies for each of the nested feeds must be separated, and the inner feed must be small to prevent it from decreasing the beam patterns in the outer feed. To receive the four fixed bands and to achieve a sharp beam pattern for the installation at the Kashima 34-m antenna, a nested feed is the only candidate feed. The lower two channels are received with the outer IGUANA feed, which is a corrugated horn. Currently we will use the original C band of the Kashima 34-m to check the effectivness of the nested structure. The higher two channels are received with the inner IGUANA feed, which is a multi-mode horn and was derived from designs of multi-mode horns for the ASTRO/VSOP-2 and VERA projects. The feed is currently being manufactured, after a half year of development with numerical simulations (Figure 5) and it will hear the first radio noise from the universe in spring 2013.

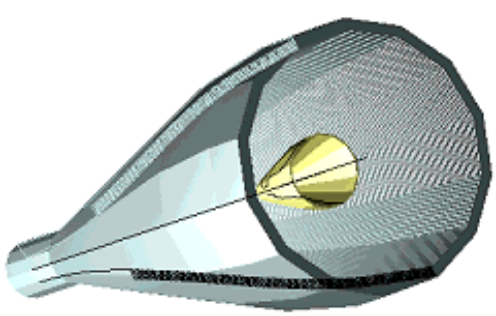

Figure 4. Conceptual model of the IGUANA feed.

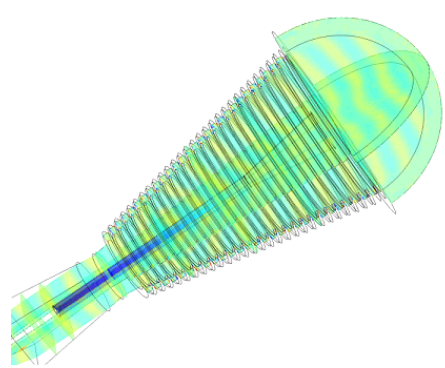

Figure 5. Experimental results of the Ey field in the Mom feed at 4.8 GHz with COMSOL.

2.3. Kashima Flexible Correlator (KFC)

In order to process the growing amount of data that comes along with the implementation of the VLBI2010 technology, NICT has started to develop the "Kashima Flexible Correlator (KFC)". This software correlator is expected to operate in a similar way as other existing correlators by making use of the Message Passing Interface (MPI) for distribution of the workload across several computing nodes. KFC will consist of three components (see Figure 6), i.e. one master control, several data streamers, and a certain number of correlators. The master control oversees the correlation process and manages all other components. Data streamers extract PCAL signals, decode the sampling data depending on bit resolution and the number of channels, and send the data to the packetized correlators where auto- and cross-correlation are computed. The initial development will only rely on CPU nodes, but the flexible software design will support heterogeneous CPU-GPU (or other multi-processor) platforms in the future as well.

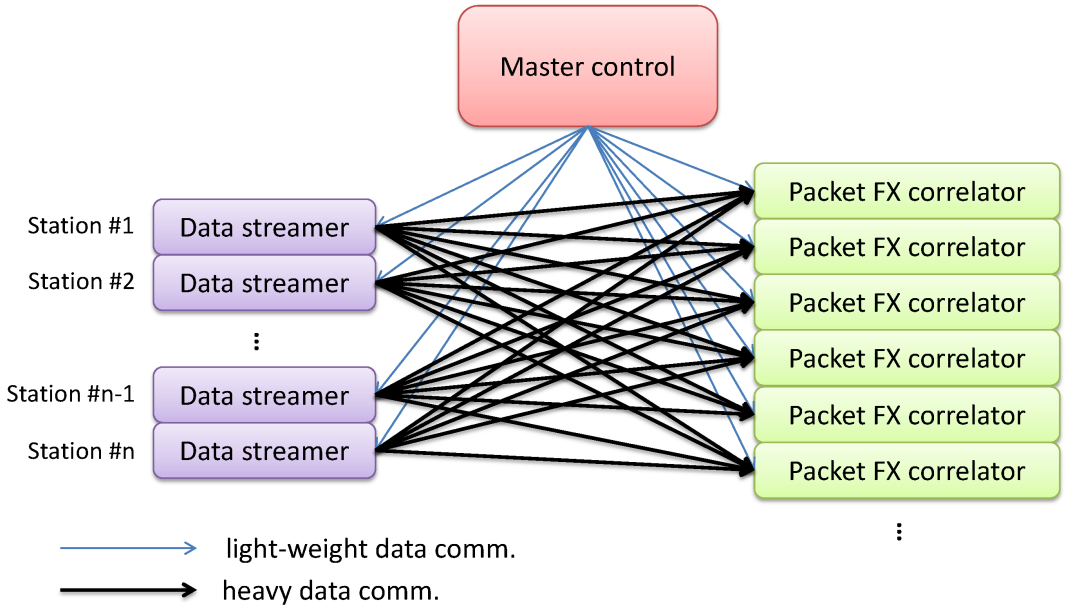

Figure 6. Basic concept of KFC.

References

[Moffet(1968)] A. Moffet, "Minimum-redundancy linear arrays," *Antennas and Propagation, IEEE Transactions on*, vol. 16, no. 2, pp. 172 – 175, March 1968.