Technology Development Center at NICT

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Abstract

National Institute of Information and Communications Technology (NICT) has led the development of the VLBI technique and has been highly active in both observations and technical developments. This report gives a review of the Technology Development Center (TDC) at NICT and summarizes recent activities.

1. TDC at NICT

National Institute of Information and Communications Technology (NICT) has published the newsletter "IVS NICT-TDC News (formerly IVS CRL-TDC News)" at least once a year in order to report on the development of VLBI related technology as an IVS technology development center. The newsletter is available through the Internet at the following URL: **http://www2.nict.go.jp/w/w114/stsi/ivstdc/news-index.html**.

2. Staff Members of NICT TDC

Table 1 lists the staff members at NICT who are involved in the VLBI technology development center at NICT.

Table 1. Staff Members of NICT TDC as of December, 2009 (alphabetical).

Name	Works
AMAGAI, Jun	K5/VSSP32, GPS analysis, TWSTFT[1]
HASEGAWA, Shingo	K5/VSSP32, K5/VSI
HOBIGER, Thomas	VLBI analysis, e-VLBI
ICHIKAWA, Ryuichi	MARBLE[2] system, Delta-VLBI, VLBI analysis
ISHII, Atsutoshi	MARBLE[2] system
KAWAI, Eiji	34 m and 11 m antenna system
KIMURA, Moritaka	Giga-bit system, K5/VSI, software correlator, e-VLBI
KONDO, Tetsuro[3]	K5/VSSP32, software correlator, e-VLBI
KOYAMA, Yasuhiro	e-VLBI, VLBI analysis
MIYAUCHI, Yuka	software correlator
SEKIDO, Mamoru	e-VLBI, Delta-VLBI, VLBI analysis
TAKEFUJI, Kazuhiro	e-VLBI
TAKIGUCHI, Hiroshi	VLBI analysis, e-VLBI, GPS analysis
TSUTSUMI, Masanori	K5 system, e-VLBI

[1] TWSTFT: Two-Way Satellite Time and Frequency Transfer
[2] MARBLE: Multiple Antenna Radio-interferometry of Baseline Length Evaluation
[3] On leave at Ajou University, Korea

3. Current Status and Activities

3.1. e-VLBI

e-VLBI technology has been intensively developed in recent years. International e-VLBI experiments for ultra rapid UT1 measurements have been conducted as a pilot project for testing the operational stability of e-VLBI observation and correlation processing. A distributed correlation processing scheme has been developed and has been used for the rapid UT1 measurements [1]. A record of the minimum latency of UT1 measurement of less than 4 minutes was achieved on 22 February 2008 on the Tsukuba—Onsala baseline with a 256 Mbps data rate. The observation and correlation has been performed by Onsala and GSI. NICT has contributed to it by providing an automatic correlation system, automatic Mark III database creation via NetCDF[1] (MK3TOOLS [2]), and an automatic UT1 analysis scheme with OCCAM developed by T. Hobiger. Also we have participated in several e-VLBI demonstration events with the K5 data acquisition system (DAS). Flexibility in data format conversion is one of the important aspects of e-VLBI. We have developed a series of A/D converters for VLBI (ADS1000, ADS2000, and ADS3000), and they can be used for a variety of observation modes.

The Kashima 34 m telescope participated in the e-VLBI demonstration experiments for the opening ceremony of IYA (the International Year of Astronomy) conducted by JIVE in January 2009. We developed a Mark 5B emulator data sender for this event and adapted our K5/VSI system (see Figures 1 and 2) for the international e-VLBI experiment.

Figure 1. The ADS2000 can sample 16 baseband channels at the sampling rate of 64 Msps suitable for the bandwidth synthesis.

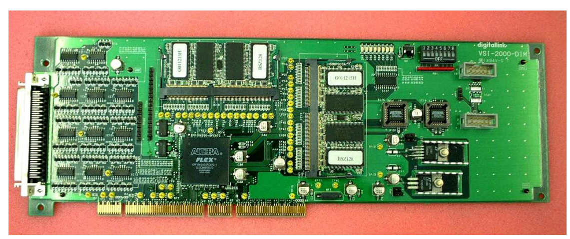

Figure 2. VSI-card can capture a high-rate data stream ($\leq$ 2 Gbps) through a VSI-H interface to a commodity PC.

3.2. MARBLE – Contribution to VLBI2010

We are developing a compact VLBI system with a 1.6 m diameter aperture dish in order to provide reference baseline lengths for calibration. We named the system “Multiple Antenna Radio-interferometry for Baseline Length Evaluation (MARBLE)” [3]. On December 9, 2008, we installed the first prototype of the compact VLBI system on the top of the building near the Kashima 34 m antenna and successfully detected the first fringe between the first prototype of the compact VLBI system and the Kashima 34 m on February 9, 2009 [4]. Moreover, we installed the second prototype of the compact VLBI system at the Geographical Survey Institute (GSI),

[1] http://www.unidata.ucar.edu/software/netcdf/

Tsukuba until the end of 2009. (See Figure 3.) We performed the first geodetic experiment using both prototypes on December 23, 2009, and we are now processing the obtained data sets.

Figure 3. The MARBLE compact VLBI system. The left panel shows the first prototype at Kashima, NICT, and the right panel shows the second one at Tsukuba, GSI.

3.3. ADS3000+ – Detected 4 GHz First Fringe!

NICT has been developing VLBI observation systems and data processing systems since the 1970s. The K5 VLBI system is designed with commodity products such as personal computers, hard disks, and network components. This strategy has been quite successful in developing flexible and high-performance observation systems and data processing systems for VLBI. Two independent series of systems, the K5/VSSP32 and the K5/VSI systems have been developed. The concept of the K5/VSSP32 systems is to develop A/D sampling units interfaced to commodity PC systems with USB2.0 interfaces with simultaneous 16 channel recordings. On the other hand, K5/VSI series are realized by high speed A/D sampler units and a commodity Linux PC system to record data with the VSI-H (VLBI Standard Interface - Hardware specifications).

Three high speed A/D sampler units, ADS1000, ADS2000, and ADS3000, have been developed to support various sampling modes. The next generation A/D sampler, which we called ADS3000+ and which supports up to 4 GHz sampling mode, is equipped with FPGA chips to realize a digital baseband converter (DBBC) and realtime RFI(CW) suppression.

A 4 Gsps (giga-samples per second) fringe test was performed on 27 April 2009 with ADS3000+ [7]. The Kashima 34 m antenna and the 11 m antenna were used. Both stations were set up with ADS3000+ with 4 GHz sampling mode. A target radio source was 3C273B. After being recorded with 1 bit quantization, the whole bandwidth spectrum of X-band is fully shown in Figure 4. A first fringe of 4 Gsps could be successfully detected after the correlation process, as shown in Figure 5. A signal-to-noise ratio (SNR) of the 3C273B fringe is estimated to be about 8.6 at 8 ms integration. The 4 Gsps fringe is the fastest record in NICT and IVS now.

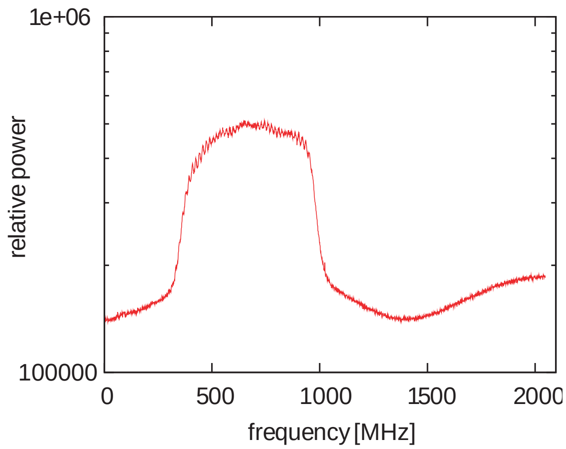

Figure 4. The spectrum of X-band at the Kashima 11 m antenna. The X-band bandwidth is 500 MHz wide; however, the 4 GHz sampling mode detects up to the Nyquist-rate, 2 GHz. The whole bandwidth spectrum of X-band can be obtained at one time.

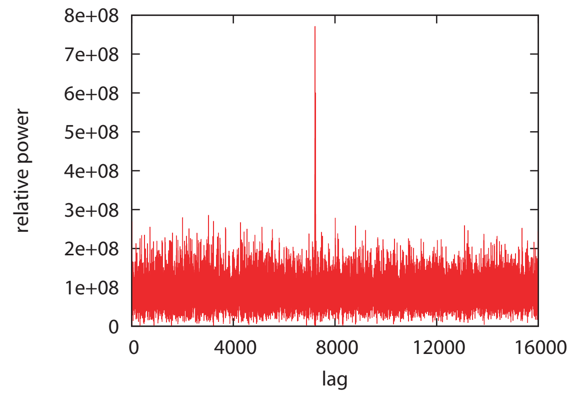

Figure 5. A first fringe of 3C273B at 4 GHz sampling speed with ADS3000+ in 8 ms integration time with the Kashima 34 m and 11 m antennas on 27 April 2009. The 4 Gsps fringe is the fastest record in NICT and IVS now.

4. Future Plans

- Fringe test with digital baseband conversion of ADS3000+ (extraction 16 channels) to comfirm compatibility with the K5/VSSP32 system.

References

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