Technology Development Center at CRL

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Abstract

Communications Research Laboratory (CRL) has led the development of VLBI technique in Japan and has been keeping high activities in both observations and technical developments. This report gives a review of the Technology Development Center (TDC) at CRL and summarizes recent activities.

1. TDC at CRL

Communications Research Laboratory (CRL) has published the newsletter "IVS CRL-TDC News" twice a year in order to inform the world about the development of VLBI related technology in Japan as an IVS technology development center. The newsletter has been published twice a year based on reports presented at an internal meeting held at CRL. However only limited members attended this closed meeting from outside CRL. Since April 1, 2001, CRL has become an independent administrative institution. We have taken this opportunity to change our meeting style from the closed meeting to an open symposium. According to this policy, the first CRL VLBI technology development center symposium was held at the Kashima Space Research Center on September 19, 2001. The symposium focused on recent VLBI related technology development and the status of current projects in Japan. CRL-TDC News is published as proceedings of the symposium. The newsletter is also available through the Internet at following URL **http://www.crl.go.jp/ka/radioastro/tdc/index.html**. The TDC symposium will be held twice a year from now on.

2. Staff Members of CRL TDC

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

3. Recent Activities

3.1. GALAXY

The real-time VLBI connection of the 64-m antenna at USUDA and the 34-m antenna at Kashima to realize a large virtual radio telescope is named GALAXY. GALAXY has been promoted in collaboration with the Institute of Space and Astronautical Science (ISAS), National Astronomical Observatory (NAO), and Nippon Telegraph and Telephone Corporation (NTT) [1]. In GALAXY, each antenna is connected by the high-speed ATM network with the network speed of 2.4 Gbps. Data rate of only 256 Mbps had been used for VLBI observations. The challenge to use a faster data rate for VLBI observations was made on June 23, 2001, and the first real-time VLBI fringes with 1 Gbps were successfully detected (Fig.1). Now it is possible to carry out 1 Gbps real-time VLBI stably.

Table 1. Staff Members of CRL TDC as of December, 2001 (alphabetical).

Name	Works
Amagai, Jun	Key Stone Project
Ichikawa, Ryuichi	Analysis software
Kawai, Eiji	Antenna system
Kiuchi, Hitoshi	Key Stone Project, real-time VLBI
Kimura, Moritaka	Giga-bit VLBI system
Kondo, Tetsuro	Internet VLBI
Koyama, Yasuhiro	Operation, monitoring, and analysis softwares
Nakajima, Junichi	Giga-bit VLBI system, VSI
Okubo, Hiroshi	Antenna system
Osaki, Hiro	FS9
Sekido, Mamoru	Correlator, VSI
Yoshino, Taizoh	Key Stone Project

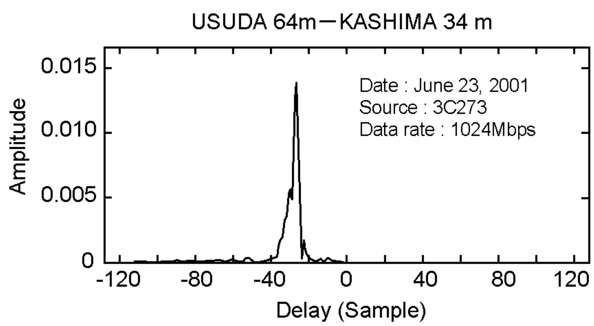

Figure 1. First real-time 1 Gbps VLBI fringes observed on June 23, 2001 on Kashima-Usuda baseline.

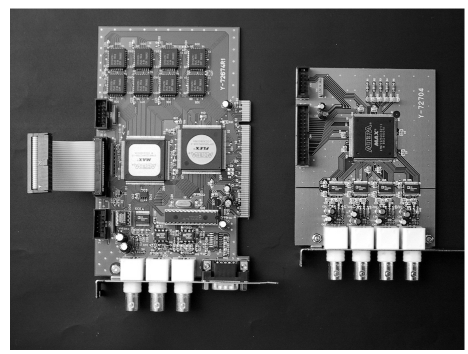

Figure 2. A PCI sampler board for the IP-VLBI system (left) and an auxiliary board for 4ch inputs (right).

3.2. Internet VLBI

To reduce network cost and to improve interconnectivity with other sites, we have been developing a new real-time VLBI system using IP (Internet protocol) technology that has already spread widely. We call this system "IP-VLBI". Two kinds of IP-VLBI system are under development by NTT and CRL. One is the substitution of protocol from ATM to IP. In this system, a serial high-speed data stream is directly sent by using IP instead of ATM. Although the data consist of several numbers of physical channel data, no channel-distinction is made in the transmission process. However, any kind of data stream can be transmitted by this system. NTT has been developing this type.

The other one is based on channel data. A geodetic VLBI system usually receives 14 to 16 frequency channels at S and X bands. Each channel of data is transmitted independently by using the IP. We refer to this system as "Multi-channel IP-VLBI", because only establishing the system

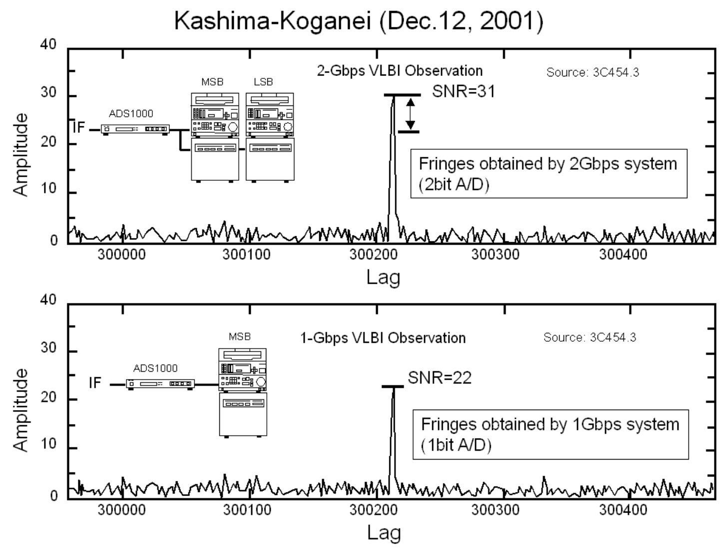

Figure 3. Fringes obtained 2 Gbps system (upper panel) and those obtained by 1 Gbps system (lower). Two 1 Gbps recorders were used at each station to record 2bit A/D data with a sampling frequency of 1GHz (i.e., 2Gbps). Note that the increase in signal to noise ratio compared with the case of 1bit A/D.

for one channel, we can easily expand it to the multi-channel system. Only the network speed limits the number of channels and sampling frequency. CRL has been developing this type to take over current geodetic VLBI system. We have been developing a PC-based IP-VLBI system consisting of a PCI-bus sampler board (Fig.2) and PC software to make real-time data transmission and reception. We also intend to carry out the real-time correlation by PC software. One sampler board can have 4 video signal inputs by adapting an auxiliary board and is designed to be able to sample each signal with a sampling frequency of up to 16 MHz with an A/D conversion resolution of from 1 bit to 8 bits. The sampler board has been evaluated and we confirmed sufficient performance of both "coherent sampling" and "real-time transmission" with a sampling frequency of up to 16 MHz. Regarding real-time software correlation processing, we can process 8 MHz sampling data in real-time at the present time. An improvement to the algorithm to make correlation processing faster is in progress [2]. Distributed correlation processing is also under consideration.

3.3. Giga-bit VLBI System

In addition to the success in 1 Gbps real-time VLBI, we also succeeded in 2 Gbps VLBI using ADS-1000 on December 12, 2001 but using tape-based VLBI (not real-time VLBI) (Fig.3). Two 1 Gbps recorders were used at each station. The sampling frequency was 1 GHz and we adopted 2-bit Analog to Digital conversion, so the data rate became 2 Gbps. We could confirm the increase of signal to noise ratio corresponding to the theoretical expectation compared with the case of 1-bit A/D conversion.

3.4. VLBI Standard Interface (VSI)

Some equipment adopting VSI have already been developed at the CRL. Some others are under development [3]. They are summarized in Table 2.

Table 2. VSI equipment.

Equipment Name	Function	Degree of Progress (%)
ADS-1000	Sampler (1ch×1024Msps(2bit-A/D))	100
ADS-2000	Sampler (16ch×64Msps(2bit-A/D))	50
VSI-K4-DIM	Data converter (VSI→K4)	70
VSI-S2-DOM	Data converter (S2→VSI)	70
VSI-100-DIM/DOM	VSI I/F to Giga-bit recorder GBR1000	80
GBR-2000D	VSI Giga-bit recorder	100
PC-VSI	PCI board equipped with VSI	20
PC-VSI-TG	PC-based VSI data generator	planned
ADS-4000	High speed sampler (≥2048Msps)	planned

Now we start the development of PC-VSI. That is a PC equipped with VSI. Our IP-VLBI and gigabit VLBI will be merged with the PC-VSI in the future.

4. Future Perspectives

CRL TDC will continue to make efforts to develop new technologies introduced in this report and to apply them to actual observations. We will also continue the development of the "Internet VLBI" system which is the successor to the current real-time VLBI technique but aims at realizing more economical (lower running cost) and flexible connections between VLBI stations by using the Next Generation Internet (NGI).

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References

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