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 development of VLBI related technology in Japan as an IVS technology development center to the world. One of them is published as the proceedings of the symposium held at the Kashima Space Research Center every autumn. The newsletter is available through the Internet at following URL **http://www.crl.go.jp/ka/radioastro/tdc/index.html**.

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.

Table 1. Staff Members of CRL TDC as of December, 2002 (alphabetical).

Name	Works
Ichikawa, Ryuichi	Analysis software
Kawai, Eiji	Antenna system
Kimura, Moritaka	Giga-bit VLBI system
Kondo, Tetsuro	Internet VLBI
Koyama, Yasuhiro	Operation, monitoring, and analysis softwares
Nakajima, Junichi	Giga-bit VLBI system, VSI
Ohkubo, Hiroshi	Antenna system
Osaki, Hiro	FS9, Internet VLBI
Sekido, Mamoru	Correlator, VSI

3. Recent Activities

3.1. PC Based Gigabit VLBI System (PC-VSI)

A new gigabit VLBI system integrated around a personal computer (PC) has been developed (Fig.1)[1]. The increase of PC's performance enables us to replace most of the VLBI back-end system by PCs. The new system consists of a gigabit A/D sampler based on the VSI standardization (ADS1000 or ADS2000) and a PC equipped with a PC-VSI interface board (PC-VSI2000DIM) (Fig.2) compatible with the VSI standardization with the maximum performance of 2048 Mbps.

VLBI data are recorded on the PC's hard disks through the PC-VSI interface.

Figure 1. The PC-VLBI system: PC with PC-VSI board, display and a giga-bit A/D sampler (ADS1000). In PC-VLBI observation whole telescope IF sampling is accomplished by this combination.

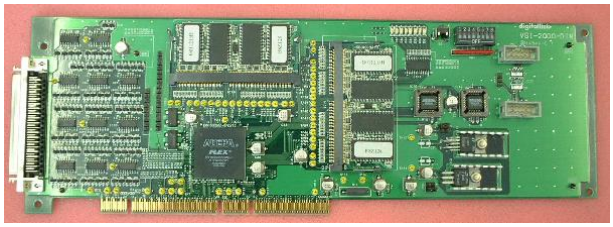

Figure 2. The PC-VSI data capture board. The 1024/2048Mbps VLBI data is transferred to PCI-bus continuously.

The Metsähovi Radio Observatory (MRO), Finland has also developed a PC-VSI interface board (VSIB)[4]. We conducted a VLBI experiment between Finland and Japan to examine the conformity between VSI-H compliant hardwares. CRL's gigabit sampler (ADS1000) was used at the MRO. VSI-H compliant data from the ADS1000 was recorded in MRO's PC system through the VSIB. Data were FTPed to Japan and were software correlated with the data recorded by CRL's PC system, and we got fringes successfully in October 2002 (Fig.3).

A gigabit VLBI system enables VLBI observation with a small antenna. We have developed a compact VLBI system for network based VLBI observation. This system is named the "Compact Antenna of Radio Astronomy for VLBI Adapted Network (CARAVAN)"[5]. The prototype CARAVAN consists of an equatorially mounted prime focus 65-cm parabolic antenna, an optical guide telescope, and a 22 GHz receiver. A handy controller with optical object database can track sources automatically by entering right ascension and declination of radio star. In other case, the telescope can be programmed from a scheduling PC. The entire view of the CARAVAN is shown in Fig.4. The price of the CARAVAN telescope is less than ten thousand US dollars. The receiver and down converter are assembled in the aluminum container and they are operated in normal temperature. Receiver noise temperature is 140K. System noise temperature is 210K.

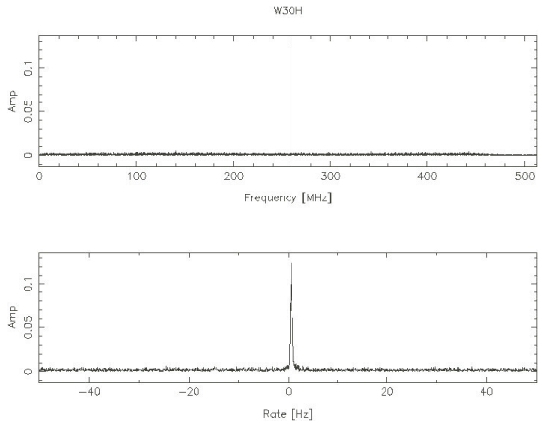

Figure 3. Fringes detected on Kashima-Metsähovi baseline using the PC-VSI system. An observation was carried out for W3OH at 22GHz on October 16, 2003.

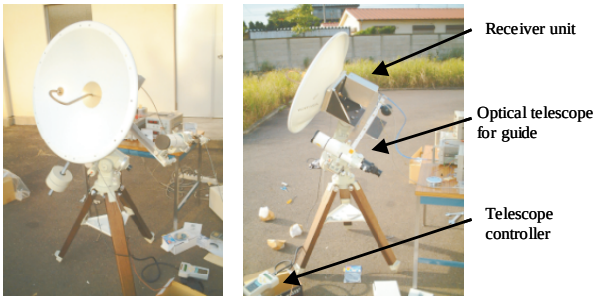

Figure 4. Left: The dish front view of CARAVAN. Prime focused horn is connected to the receiver by waveguide. Right: The side view of CARAVAN. Low noise Amplifier is located behind the small dish. Optical telescope is mounted beside the dish. Right ascension and declination axes are balanced by counter weights.

3.2. IP-VLBI (K5)

A new real-time VLBI system using Internet protocol (IP) technology has been developed to reduce network cost and to expand connection sites of VLBI network [2]. We call this system "IP-VLBI" or "Internet VLBI". We are developing the system consisting of a personal computer (PC)-based sampler equipped with a PCI-bus Versatile Scientific Sampling Processor (VSSP) board [3] and FreeBSD (and/or Linux) software to carry out real-time data transmission, reception and correlation. The IP-VLBI system developed at CRL is dedicated to taking over current geodetic VLBI system. A geodetic VLBI system usually receives 14 to 16 frequency channels at S and X bands. A VSSP board on a PC can sample 4 channels of data, hence 4 PCs can cover the current geodetic VLBI system and the system assembled this way is called "K5". In parallel with the development of the real-time system, we are also developing a quasi-real time (QRT) VLBI system. In the QRT system data are stored on a hard disk at first, then transmitted to a correlation site with a possible transmission speed of network. Of course off-line operation is also possible. In this case, data are transmitted after observations are made using an FTP or equivalent file transmission protocol.

We conducted the first US-Japan e-VLBI experiment in collaboration with the Haystack Observatory VLBI team on October 15, 2002. Kashima 34m antenna and Westford 20m antenna were used for this experiment. We carried out observations using the K5 at Kashima. After observations, K5 data files were FTPed to Haystack Observatory. From Japan to US, the GEMnet owned by NTT was used then connected to Abilene to reach Haystack. At Haystack Observatory the K5 data file was converted to Mark 5 data format, then correlated with Westford data using a Mark 4 correlator. On the other hand, Mark 5 data observed at Westford were FTPed to Kashima following the reverse network route. At Kashima Mark 5 data were converted to K5 data format then they were correlated with Kashima data using software correlator. At both team sites, good fringes were successfully detected. Fig.5 shows fringes detected by Kashima team.

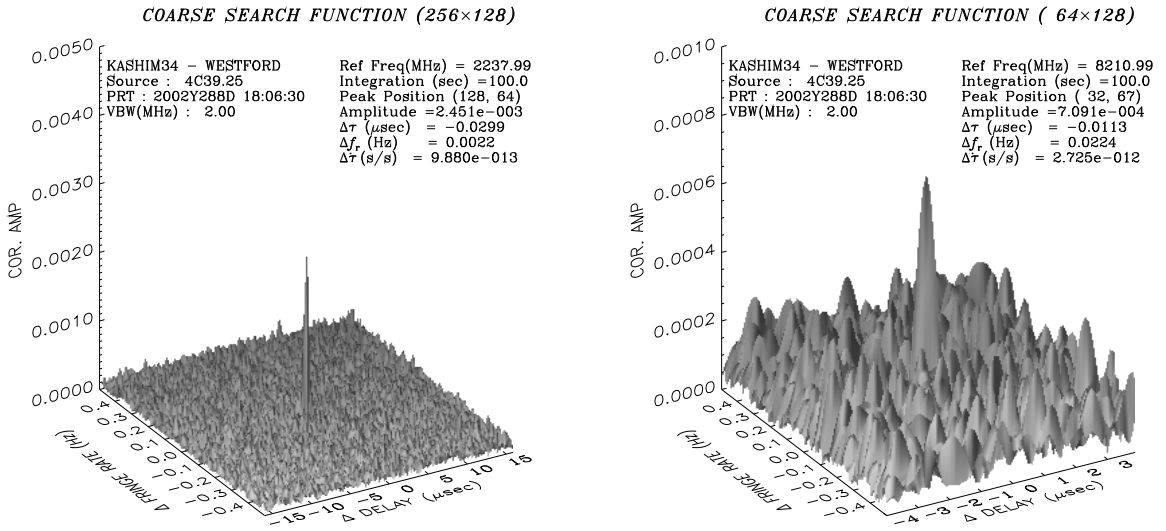

Figure 5. First US-Japan e-VLBI fringes. Left panel is for S band and right is for X band. Observation is made on October 15, 2002.

Acknowledgements. The first US-Japan e-VLBI was conducted in collaboration with MIT Haystack Observatory team. The Finland-Japan PC-VSI experiment was conducted in collaboration with the Metsähovi Radio Observatory team. We would like to acknowledge the continuing effort of all staff members of Haystack Observatory and Metsähovi Radio Observatory to lead an experiment to success. We also wish to thank all staff members of NTT and Internet2 involved in the international e-VLBI experiment for their efforts to establish the necessary network connection.

References

[1] Kimura, M. and J. Nakajima, The implementation of the PC based giga bit VLBI system, *Technical Development Center News CRL*, No.21, 31-33, 2002.

[2] Kondo, T, Y. Koyama, M. Sekido, J. Nakajima, H. Okubo, H. Osaki, S. Nakagawa, and Y. Ichikawa, Development of the new real-time VLBI technique using the Internet Protocol, *Technical Development Center News CRL*, No.17, 22-24, 2000.

[3] Osaki, H., Kondo, T, and M. Kimura, Development of versatile scientific sampling processor (VSSP) – A practical approach, *Technical Development Center News CRL*, No.20, 7-9, 2002.

[4] Ritakari, J. and A. Mujunen, The Metsähovi solution for gigabit VLBI, *Technical Development Center News CRL*, No.20, 2-3, 2002.

[5] Yonezawa, I., J. Nakajima, H. Ohkubo, M. Tsuboi, and T. Kasuga, Development of compact VLBI system, *Technical Development Center News CRL*, No.21, 29-30, 2002.