Junichi Nakajima et al.: VSI Interface Implementation, Performance Enhancement of Gbps VLBI Instruments, IVS 2002 General Meeting Proceedings, p.123–127
http://ivscc.gsfc.nasa.gov/publications/gm2002/nakaji

VSI Interface Implementation, Performance Enhancement of Gbps VLBI Instruments

Junichi Nakajima, Yasuhiro Koyama, Tetsuro Kondo, Mamoru Sekido, Moritaka Kimura, Hiroshi Okubo, Hiroo Osaki

Kashima Space Research Center, Communications Research Laboratory
Contact author: Junichi Nakajima, e-mail: nakaji@crl.go.jp

Abstract

Communications Research Laboratory had intensively performed implementation of the VSI (VLBI Standard Interface) and popularization. As a Technology Development Center of the IVS (International VLBI Service), this is the first attempt to adapt the VSI to existing VLBI system. The VSI modifications of the former CRL VLBI system proved the Gbps performance both in tape based observation and real-time observation. The VSI functional block concept also enabled flexible system integration and future enhancement to PC-based VLBI. Realization of the VSI compatibility in telescopes will bring further strength to the worldwide VLBI observation network which used in astrometry and geodesy. As well as several astronomy dedicated VLBI systems, the VSI-based VLBI will increase the network potential. In other words, Gbps compatibility between different systems will be difficult without VSI.

1. Introduction

After the endorsement of VSI-H (VLBI Standard Interface - Hardware) [8] in August 2001 by the International VLBI Service, VLBI is promised further evolution in this decade through the VSI interface. In former VLBI systems, the hardware is almost isolated from each other since each VLBI system had been designed for its own scientific objective and technology prepared by the each group. Thus the interface specification is satisfied internally. However, to realize the VLBI observation using a different system, the whole particular system installation at the telescope is required. This strongly limits the flexibility of VLBI telescope resources. The first step to solve this inconvenience, VSI-H allows researchers to connect multi-national and multi-vendor instruments. Second step VSI-S (VLBI Standard Interface- Software) which will control DAS (Data Acquisition System), DIM (Data Input Module), DOM (Data Output Module) and DPS (Data Processing System), and DTS (Data Transmission System; kind of media or fiber) in same manner. Here the DAS, DIM, DOM, DPS and DTS are the abstracted system in the VSI. The researcher can make the best use of VSI instruments in the target station and minimum effort is needed in preparation. For example, if the target VLBI station is using different VLBI acquisition system and recorder. VSI based media conversion will enable correlation between the stations playback. If a special sampling mode is needed in a planned observation only the DAS part sent to the target station will satisfy the VLBI objective.

2. VSI Popularization

VSI popularization is one important role of the Technology Development Center (TDC) [2] and contribution of VLBI development to the scientific communities. Since VLBI has been thought

of as a technology which uses specially designed high speed hardware and original software to process data, the promotion of the VSI concept and simple introduction are important to increase the popularity of VSI. Otherwise, it is difficult to let other researchers use VSI as a convenient interface. CRL has prepared short presentations and education material introducing the VSI trends to domestic engineers, scientists and graduate students. Distribution of sample VSI cables and brochures about VSI have attracted attentions [6]. Since VSI is becoming the de-facto standard, we also aim for formal standardization in the JIS (Japan Industrial Standardization) as a step to ISO standard.

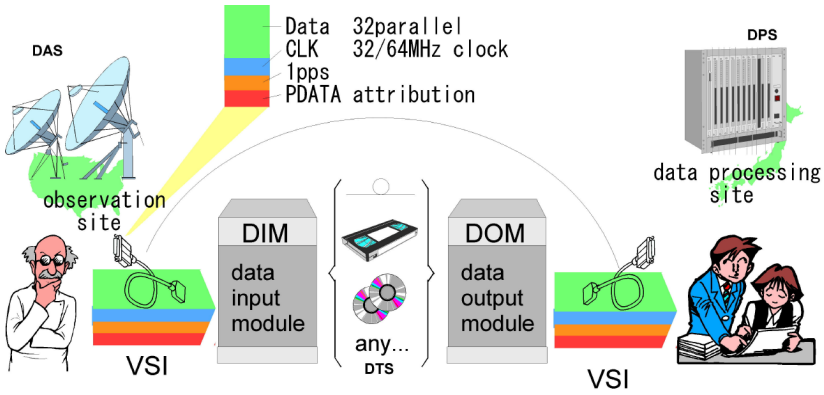

Figure 1. Pictorial drawing to introduce VSI-H to beginners

Figure 2. GBR-1000 (right) VSI adapted Gbps recorder and GBR2000D(left), the VSI native data recorder and related VSI components (AD sampler, Burst memory and Switcher) are shown.

3. Development

In developments through 2001, all present Gbps VLBI system had adapted to VSI interfaces. Most of the Gbps VLBI system interfaces designed in 1990s are using ECL interfaces [4] [5]. Simple VSI level converters between the ECL and LVDS (Low Voltage Differential Signal) were developed. For convenience, a VSI switcher is produced too. New 1 Gsps (1ch, 2bit) VSI AD samplers are fully operational. A brand new VSI native Gbps data recorder GBR-2000D in Figure 2 has started operation too. These VSI functional units are summarized in Table 1 and 2. Although the slow speed IP-VLBI board is not VSI-compatible, the onboard AD PCI card, which becomes popular, is

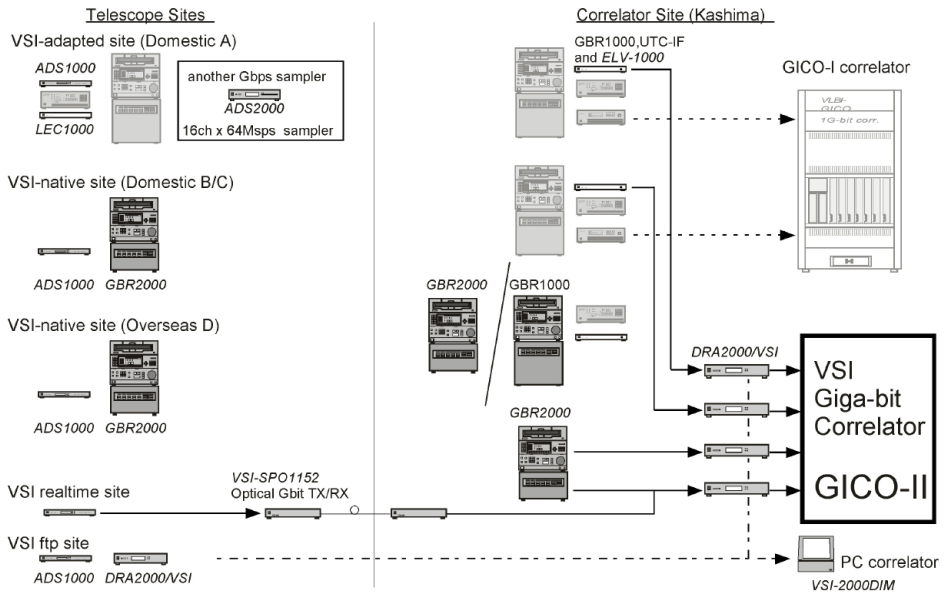

Figure 3. Integrated VSI Gbps VLBI system, including VSI adaptation of ECL interfaces. A new VSI correlator GICO-II (GIgabit COrrelator-2) is being produced. VSI instruments are indicated by slanted fonts

presented as an exception. As for the 256 Mbps conventional system, an S2-to-VSI converter and VSI-to-K4 converter were developed to achieve data conversion from S2 to K4 VLBI systems. In Table 2, PC-VSI2000-DIM will be a tool to confirm multi-national compatibility of VSI interface. The VSI-bench system with high performance PC can receive and inspect conformity of VSI Gbps data directly.

A new VSI correlator of four stations are in the final stage of hardware completion. A Gbps VLBI system in 2002 will be completed as shown in Figure 3. Without BBC (Base Band Converters) the simple Gbps VLBI system is easily adapted to any telescope's IF and enable high sensitivity observation. VLBI survey of faint sources as an expansion of previous VLBI source monitoring technique [3] is planned with a related institute. In the future, PC based VLBI system will also handle Gbps data with emerging high density media (holographic storage device for example).

4. Recent Achievement

A Gbps system installation on the Japanese domestic network [7] had been carried out three times. Astronomical results focusing on survey and Hi-z quasars are processed.

On July 23, 2001, the first Gbps real-time VLBI between Usuda 64 m and Kashima 34 m was successfully performed by collaboration of National Astronomical Observatory, Institute of Space and Astronautic Science, Nippon Telegraph and Telecommunications, and CRL. Between the telescopes, the 208 km baseline was connected by NTT's ATM network and an ATM-to-parallel VLBI interface developed by NAO. These telescopes are connected by fibers and the telescope network is named GALAXY (Gigabit Astronomical Large Array Xross connected) [1]. In the

Table 1. Recent VSI compliant (conventional speed) instruments developed by CRL. Contributing Manufactures are N:Nittsuki Co. Ltd., D:digitallink Co. Ltd., Y:YEM Co. Ltd., C: Cosmo Research.

Mbps	Instrument Name	Function	Purpose, Research Objective	Product
128	IP-VLBI board, Model 9820	Real-time IP VLBI PCI interface board. 32 Msps, 4 ch on-board AD converter (Non-VSI)	Initial network VLBI as moderate speed. Parallel operation will replace ATM or tape-based 256 Mbps system	N
256	VSI-K4-DIM	Data Protocol Converter, VSI to K4	S2 to K4 copier, K4 adaptation to VSI sampler	C
256	VSI-S2-DOM	Data Protocol Converter, S2 to VSI	S2 to K4 copier, S2 to other VSI instruments	C
256-2048	LEC-1000	Level converter, LVDS (VSI) to ECL (conventional)	Simple level converter for the predecessor ECL system	D
256-2048	ELV-1000	Level converter, ECL (old system) to LVDS (VSI)	Simple level converter. Receive data from ECL system	D
256-2048	VSI-SW-22	VSI switcher	2 input, 2 output data selector distributor	D
256-2048	DRA-2000VSI	1 Gbps (128 MB) FIFO Data memory unit, remote observing data ftp extraction tool	Portable VLBI w/o standard signal. Data freezing and ftp access from remote site.	Y
256-2048	MCG-2000	Master VSI clock for off-line environment (ex. Correlator).	Multi port LVDS, ECL, 1PPS, DPS source and test TVG generator.	Y
-	VSI cables	High reliable VSI connection	0.5, 1, 2, 5, 10m length	D

observation, VSI Gbps samplers and a Gbps correlator (GICO-I) adapted to VSI were used. In the first real-time observation, data of Usuda 64 m telescope data was recorded in front of the GICO correlator at Kashima in case of no fringe analysis. This complex configuration is enabled by the transparent VSI concept and identical interface.

Another achievement was the first-ever 2 Gbps VLBI between Koganei 11 m and Kashima 11 m telescopes. On December 22, 2001, 1-Gbps 2-bit sampling observation were carried out between the telescopes and 1.4 times sensitivity was confirmed by 2-bit correlation.

5. Conclusion

VSI-based VLBI development and achievements were reported. VSI provides easy integration environment of VLBI system by functional treatment of units. As the first trial of the VSI-H adaptation, the system worked perfectly both in real-time VLBI and tape-based VLBI up to 2 Gbps. Further effort will be needed after the endorsement of VSI-S is finalized in the IVS discussion.

In CRL, the development fund for the VSI standardization is partially supported by Telecommunications Advancement Organization (TAO).

Table 2. Gbps VSI compliant (high speed) instruments developed by CRL. Manufactures are N:Nittsuki Co. Ltd., D:digitallink Co. Ltd., T: Toshiba Corporation, Y:YEM Co. Ltd.

Mbps	Instrument Name	Function	Purpose, Research Objective	stat.
1024-2048	ADS-1000	AD sampler, 1 ch, 1024 M sample, 2 bit	High-speed AD sampler up to 2 GHz analog input. 0.3 ps jitter. Bit distribution monitoring.	D
256-2048	ADS-2000	AD sampler, 16 ch, 64 Msample, 2 bit	Wide-band enhancement of multi-channel conventional VLBI. AGC control and module channel expansion.	N
2048-4096	ADS-4000	AD sampler, 1 ch, 2048 Msample, 2 bit	Ultimate high-speed AD sampler for VLBI sensitivity.	2002
1024-2048	VSI-SPO1152-TX/RX	VSI optical digital serial transmitter and receiver	Optical fiber VSI connection. For interferometer and telescope VLBI avoid analog transmission	Y+D
1024-2048	GBR-2000D	New Generation Data Recorder, Skip-back (No start-up time) and direct data access by ftp	Gbps VLBI observation with a cart robot. Data transfer with out tape shipping. Production	T
2048-8096	PC-VSI2000-DIM	VSI data analyzer, Burst VLBI (PC-VSI perspective)	Inspect VSI data and burst storage with emerging IT media.	2001-2002
2048-8096	PC-VSI2000-DOM	VSI data generator	Generate complex VLBI data with delay and rate with a PC	2002-2003

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