VLBI Correlators in Kashima

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Abstract

Software correlator systems developed at the Kashima Space Research Center are used for data processing of R&D VLBI experiments. Two major correlation tasks processed in 2009 were the MARBLE project for reference baseline evaluation and the time standard comparison project. The automatic data processing scheme with distributed processing has been extensively used for these VLBI data processing. A new software correlation system, which uses the high speed software correlator 'GICO3', has been completed for the VERA project.

1. General Information

The VLBI group of the Kashima Space Research Center (KSRC) of the National Institute of Information and Communications Technology (NICT: Fig.1) has been contributing to the VLBI community by developing the VLBI data acquisition system (DAS) and correlation systems.

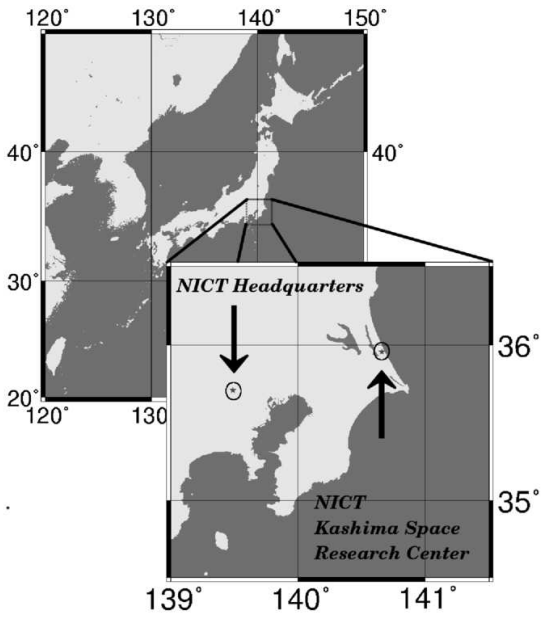


Figure 1. Location of NICT/KSRC.

The multi-channel DAS named K5/VSSP32 [1] has been used for geodetic and radio science observations. A corresponding software correlation package for K5/VSSP32 has been developed and maintained by T. Kondo. Another DAS system named K5/VSI [2], which captures the data stream from a VSI-H interface [4], has another software correlator called 'GICO3' [3]. The two software correlators have been developed in parallel.

The former K5/VSSP32 system is a multi-channel data acquisition system with four channel inputs per unit. One unit has sampling capability in the range of 40 kHz to 64 MHz, with quantization bits 1, 2, 4, and 8 under the limitation of a maximum output data rate of 256 Mbps. The geodetic K5 DAS system is composed of four K5/VSSP32 units. This system has been widely used for geodesy operationally. e-VLBI experiments for rapid UT1 measurements have been performed with this system within a collaboration among the Onsala, Metsähovi, Tsukuba, and Kashima stations.

The K5/VSI system was originally developed as a high sampling rate DAS system for astronomy. The K5/VSI system has become compatible with the Mark 5B DAS through the joint use of the multi-channel data sampler ADS2000, which has a VSI-H interface for data output. The Kashima station participated in an e-VLBI observation demonstration at the IYA2009 opening ceremony, using this Mark 5B emulation system. Now, the K5/VSI has been employed as the software correlation system of the VERA project by NAOJ (National Astronomical Observatory of Japan).

2. Staff

The names of the staff members who contribute to the Correlation Center at NICT/Kashima and their tasks are listed below in alphabetical order.

- HASEGAWA Shingo: maintenance and troubleshooting of K5 system computers, operation of the 34-m station for IVS sessions.
- HOBIGER Thomas: developer of a new VLBI database system that uses NetCDF, research on atmospheric delay calibration with the ray tracing technique.
- ICHIKAWA Ryuichi: VLBI Project Manager at Kashima, research on the MARBLE project, atmospheric delay with ray tracing.
- KAWAI Eiji: maintenance of the 34-m telescope, operation of the 34-m station for IVS sessions.
- KIMURA Moritaka: developer of the high speed Gigabit software correlator 'GICO3' and the K5/VSI DAS system.
- KONDO Tetsuro: development and maintenance of the software correlator package for K5/VSSP32 (working at Ajou University in Korea since April 2008).
- KOYAMA Yasuhiro: Group Leader of "Space-Time Application Group".
- SEKIDO Mamoru: e-VLBI development and observations, maintenance of the 34-m station.
- TSUTSUMI Masanori: maintenance of K5 system computers.

3. Component Description

The correlation of VLBI data was mainly performed by the K5/VSSP32 software correlator. VLBI experiments for the MARBLE project [5] and for the time standards comparison project [6] were the major focus of our correlation center in 2009. Table 1 shows a brief summary of the experiments. Ultra-rapid UT1 observations with e-VLBI technology have been performed by the Geographical Survey Institute (GSI) on the Onsala—Tsukuba baseline. We have supported these e-VLBI experiments, although actual correlation has been performed by GSI. Figure 2 shows the

Table 1. Major correlation tasks processed in 2009.

Project	Exp code	Date	Stations	baseline x scans	Data rate (Mbps)
MARBLE	mb9155	4-5 Jun.	Ts32, Ks11, Mb1	2x300	512
MARBLE	mb9176	25-26 Jun.	Ts32, Ks11, Mb1	2x300	512
MARBLE	mbc240	28-30 Aug.	Ks34, Ks11, Kg11	3x1400	256
MARBLE	mb9358	24-25 Dec.	Ts32, Ks34, Mb1, Mb2	2x240, 3x140	512
Time Comp.	k09158	7-9 Jun.	Ks34, Ks11	1x1568	256
Time Comp.	k09239	27-28 Aug.	Ks34, Ks11	1x1680	256
Time Comp.	k09351	17-19 Dec.	Ks34, Ks11	1x11160	256

Ts32:Tsukuba-32m, Ks34:Kashima-34m, Ks11:Kashima-11m, Kg11:Koganei-11m, Mb1:Marble-1, Mb2:Marble-2

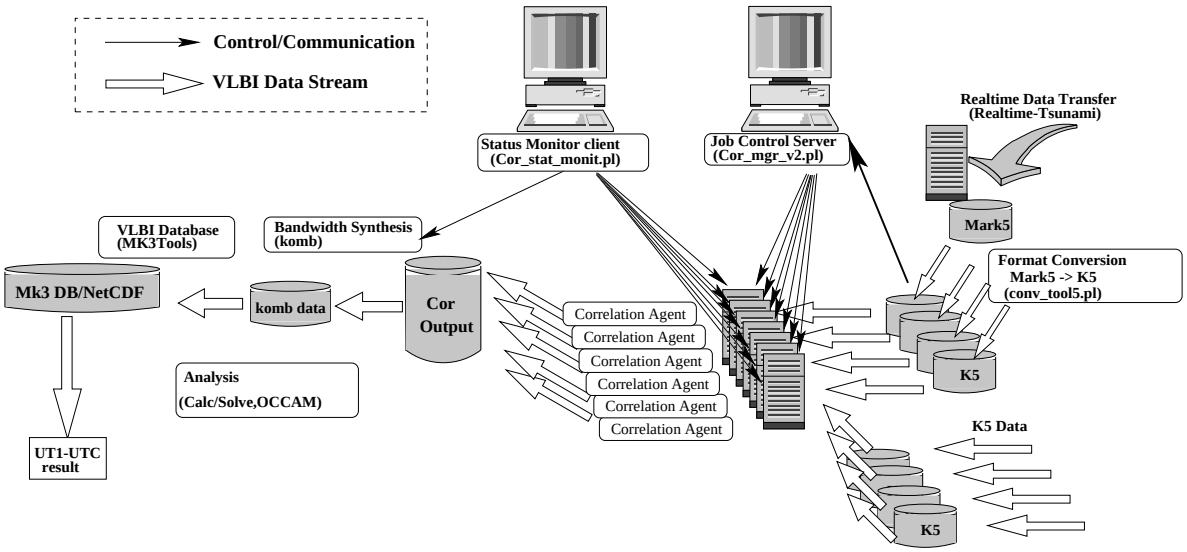


Figure 2. Distributed software correlation system with a cluster of PCs.

schematic view of the correlation data processing scheme with software correlator. A subsidiary software package for distributed correlation processing has been written in the Perl script programming language. The software modules written in Perl scripts communicate with each other, and they accomplish the distributed data processing. The data conversion (Mark IV→K5/VSSP32) and correlation processing tasks are invoked from these scripts.

4. Development and Future Plans

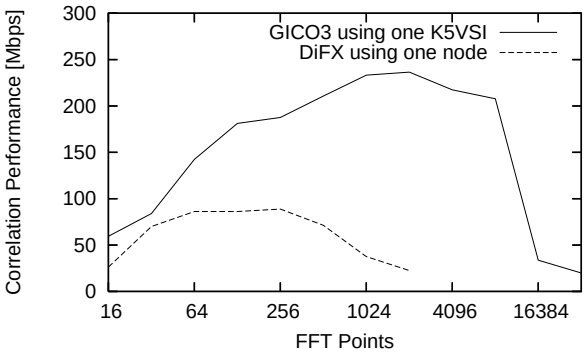
4.1. e-VLBI Development

The K5/VSI DAS became compatible with the Mark 5B DAS through the joint use of the ADS2000 multi-channel sampler. A software package for real-time data stream transmission with UDP/IP was developed, and successful participation in international e-VLBI experiments organized by JIVE and ATNF was achieved. A specification of the standard VLBI data interchange format (VDIF) [7] was ratified at the e-VLBI workshop held in Madrid in 2009. By taking advantage of the VDIF for a format of UDP packet, we have developed new K5/VSI data transmission software. This new software is going to be used to speed up the UT1 measurements in Intensive sessions that use the Wettzell—Tsukuba baseline.

4.2. Fast Software Correlator 'GICO3'

The high speed GICO3 correlation software has been adopted for the VERA project [8]. This correlation system has been developed with the goal of simultaneous five station, ten baseline correlation capability [9]. The maximum data rate is one Gbps per station. A fascinating characteristic of GICO3 is that the processing rate per station does not depend on the number of stations. Thus, the total processing performance is scalable by the designated number of stations. The left part of Table 2 compares the performance under the same conditions of the GICO3 software correlator and the DiFX software correlator [10], which is being widely used in the international VLBI

Table 2. Performance comparison of the GICO3 and DIFX software correlator(left) and specification of software correlation system of the VERA Project (right).



Stations	5
Baselines	10
Processing Rate	512 - 1024 Mbps/station
Lags Number	64 - 65536 points
Output	10 cross and 5 auto correlations
Output rate	1 - 100Hz
Output format	CODA, FITS

community. The plot clearly shows that GICO3 has 2-4 times higher performance than DiFX. See [3] for details on the architecture of GICO3. The software code of the GICO3 correlator will be available to the public and will become freely available from the Internet soon. The right table lists the specification parameters of VERA's software correlator, which uses GICO3. Development of the GICO software correlator for geodetic applications is in progress.

References

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[2] http://www2.nict.go.jp/w/w114/stsi/ivstdc/news-index.html