VLBI Correlators in Kashima

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Abstract

Kashima Space Technology Center (KSTC) is making use of two kinds of software correlators, multi-channel K5/VSSP software correlator and the fast wide-band correlator 'GICO3', for geodetic and R&D VLBI experiments. Overview of the activity and future plan is described in this paper.

1. General Information

The Kashima Space Technology Center (KSTC) of the National Institute of Information and Communications Technology has developed two types of VLBI systems. Multi-channel VLBI system called 'K5/VSSP'[1, 2] and wide band data acquisition system 'K5/VSI' [3, 4] were developed for applications of geodesy and astronomy, respectively. Software correlators for each of the systems have been developed and used for geodetic observation and R&D VLBI experiments.

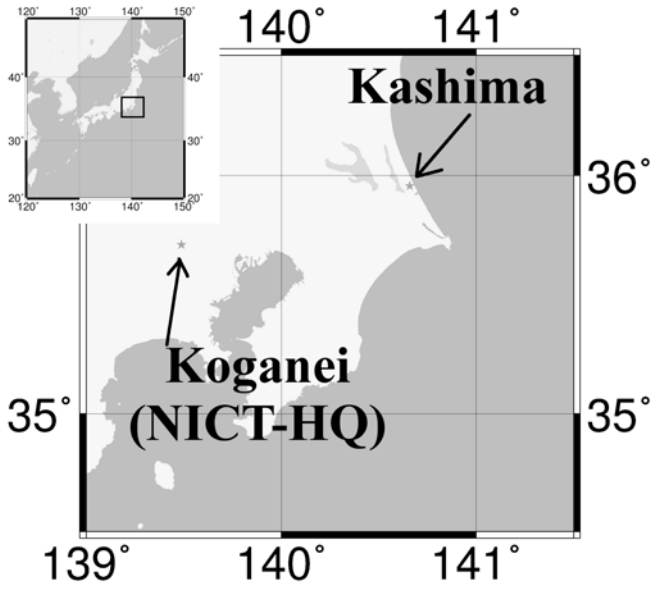

Figure 1. Locations of NICT Headquarters and KSTC.

Current main mission our group is development of transportable VLBI systems for frequency comparison over the intercontinental distance. To gain better sensitivity with small diameter antennas, wide-band observation system is employed in the system. Linear and dual polarizations observation for frequency range of 3-15 GHz are almost the same with VLBI2010 specification. The quantity of computation load of correlation processing is estimated to increase about 2 order of magnitude than the conventional VLBI system, thus new software correlator with distributed computation design named KFC is under the plan.

2. Component Description

Correlation center of the KSTC is mainly used for processing of geodetic and R&D VLBI experiments organized by NICT. Two types of software correlators have been used.

2.1. K5/VSSP Software Correlator

Correlation Type: Both FX-type and XF-type software correlators are available in the K5/VSSP software suite[2]. The FFT algorithm used in FX-type correlator has advantages in correlation with large lag (delay) window, thus it is mainly used for clock parameter

search in the beginning of routine processing. XF-type correlator is relatively faster than FX-type in processing of 1-bit quantization data with small lag number. Since small number of lag window is sufficient for geodetic application, thus the XF-type correlator is mainly used in routine 1-bit quantization data processing for geodesy. Except for the case above, the XF-type software is used.

Processing unit: The K5/VSSP32 DAS is designed with 1 or 4 channels inputs in one unit, thus four channels is designed as the maximum number of data stream fed to single correlation task. This is a benefit for distributed processing with this software correlator, because correlation tasks are divided by the unit of channels and can be processed independently with multiple CPUs.

Processing speed: Single 4-channel processing rate is 3-6 times slower the data acquisition rate, when single task run on a Intel(R) Core2 Due 3GHz processor, for example. The total processing rate is compensated by multiple run of the tasks on cluster of computers in routine operation. This software correlator code is compiled with gnu gcc compiler, and can work on any CPU.

Other functions: Correlation product include all the necessary information such as phase calibration information for further reduction of geodetic VLBI. In the next step, correlator output files are synthesized by bandwidth synthesis 'komb' software[5] to extract precise group delay from the data.

2.2. GICO3 Software Correlator

Correlation Type: FX-type correlator by using FFT algorithm. Optimum lag window is around 1024 lags, which is determined by overhead of function call and size of fast access cash memory[6].

Processing unit: Processing with arbitrary number of channels is possible by the initial configuration.

Processing speed: Processing rate of 2 Gbps data is a few times slower than real-time data acquisition rate in case of processing with Intel(R) Xeon(R) CPU of 2.33GHz clock, for example.

Other functions: Cross correlation and auto-correlation results are obtained at the same time, so that it is suitable for astronomical applications. Extraction of precise delay observable and creation of Mk3 database is available by using Mk3Tools[7].

3. 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 (Kashima): in charge of maintenance and troubleshooting of K5 system computers, tasks of the data conversion from K5/VSSP format to Mark5 format in IVS-sessions.

- HOBIGER Thomas (Koganei,Tokyo): development of a new VLBI database system based on NetCDF, research on atmospheric delay calibration with the ray tracing technique, and development of new software correlator KFC for wide-band VLBI system.
- KONDO Tetsuro (Bangkok/Thailand): maintaining the software correlator package and documentation of the K5/VSSP32 system.
- KOYAMA Yasuhiro (Koganei,Tokyo): the Leader of the International Cooperation Office of NICT. Conducting VLBI experiments for frequency comparison.
- SEKIDO Mamoru (Kashima): Coordinating VLBI experiments and development of the new VLBI system for frequency comparison.
- TAKEFUJI Kazuhiro (Kashima): Development of the new wide-band VLBI system with small diameter antenna MARBLE and processing of experiment data with GICO3 software correlator.
- TSUTSUMI Masanori (Kashima): maintenance of K5 system computers and the network.

4. Current Status and Activities

Table 1 shows a list of the experiments processed by K5 software correlator. Since Time and Frequency comparison is the main project, some experiments for feasibility test were made with 11m antennas. These data were processed with software correlator K5/VSSP running on multi-core PCs (e.g., CPU Intel Core i7 920 2.67 GHz cache 8192 KB, Processor 4 (Hyper Threading Total Core8), Memory 12 GB).

Table 1. Correlation tasks processed with K5/VSSP correlator in 2012.

Project	Exp code	Date	Stations	baseline x scans x days	Data rate (Mbps)
Freq. Comp.	K1203x	2-6 Feb.	K1,Kg	1 x 4723 (4 days)	512
Freq. Comp.	K12050	19-21 Feb.	K1,Kg	1 x 2295 (2 days))	512
Freq. Comp.	K12052	21-22 Feb.	K1,Kg	1 x 1349 (1 day)	512
Freq. Comp.	K122nx	28-31 Jul.	K1,Kg	1 x 4723 (3 days)	512
Freq. Comp.	K122wx	31 Jul.-4 Aug.	K1,Kg	1 x 3593 (3 days)	512
Sgr-A*	sg1218x	28 Jun.-8 Jul.	K1, Kg	1 x 35 x 10 days	512
Sgr-A*	sg1228x	11-15 Oct.	K1, Kg	1 x 35 x 6 days	512
Sgr-A*	sg12362	27 Dec.	K1, Kg	1 x 35 x 1 day	512

K1:Kashima-11m, Kg:Koganei-11m

Except for the frequency comparison, monitoring of Sgr-A* with S/X-band was organized with K5/VSSP32. Since it is predicted that a bunch of material will fall into the massive black-hole at the center of our galaxy by the summer in 2013, huge energy is expected to be emitted in the form of electromagnetic radiation in wide frequency range. This monitoring observation will be continued in 2013 under the collaboration with Keiou University, Ibaraki University, and National Astronomy Observatory of Japan.

Except for these experiments, fringe test and performance test experiments for small diameter antenna with K5/VSI (ADS3000+) data acquisition system were conducted. GICO3 software correlator was used for these processing.

5. Future Plans

Project mission of the VLBI group in NICT is to establish a VLBI system for Time and Frequency comparison. For this purpose, we are developing the transportable wide-band VLBI system, which is semi-compliant with the VLBI2010 specification. A new software correlator with distributed computation design is under the plan[8] for this project.

References

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