Tsukuba VLBI Correlator

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Abstract

This is a report of the activities at the Tsukuba VLBI Correlator in 2006.

1. General Information

The Tsukuba VLBI Correlator is situated at the Geographical Survey Institute (GSI) in Tsukuba, Ibaraki Pref., Japan. It is a part of VLBI components operated by GSI, together with the Tsukuba 32-m VLBI station (TSUKUB32). The K5/VSSP correlator system has been in operational use since April 2005. In addition to the daily work, the Tsukuba VLBI Correlator also served as a K5/VSSP correlator system for development purposes in August 2006. Intensive sessions (IVS-INT2) performed on Saturday and Sunday on the TSUKUB32–WETTZELL baseline for monitoring UT1-UTC have been correlated at the Tsukuba VLBI Correlator. Processing of JADE series (geodetic sessions with domestic VLBI network of GSI, run for 24-hour) is also a major task for the Tsukuba VLBI Correlator.

2. Component Description

2.1. Correlation Systems

Software correlation processing at the Tsukuba VLBI Correlator has been done on K5/VSSP. It is based on the K5/VSSP technology that has been developed at NICT (National Institute of Information and Communications Technology, Japan). There are two K5/VSSP correlators at the Tsukuba VLBI Correlator. The first K5/VSSP correlation system, which is now abbreviated "system 1", has been operational since April 2005 as described above. The installation of a second K5/VSSP correlation system, abbreviated "system 2", was completed in August 2006. "system 2" has continued operation, dedicated mainly to processing Intensive sessions so far, while processing of JADE series is usually subject to "system 1".

The equipment for the K5/VSSP software correlation "system 1" has not changed with respect to the component description given in the 2005 report. The equipment for the K5/VSSP software correlation "system 2" currently consists of eight Linux computers with 3.4GHz Intel Pentium 4 as the data servers—each of which can share a couple of disk cartridges at once through a drive unit with 16 drive slots, eight rack mount Linux computers with 3.4GHz Intel Xeon dual CPUs as the correlation servers, and one Linux computer for file handling and multi-task control as the management computer. Each data servers can perform distributed computing as well as function as correlation servers.

The K5/VSSP acquisition system puts raw data from every four channels per scan into Linux files that could amount to, for example, 250 to 300 Gbytes in total during a 24-hour session. These files are stored as formatted binary files on four or eight 250 Gbytes removable disk cartridges, then transported to the correlator. Each disk cartridge from stations is connected to a data server in an external mounting mode.

2.2. File Sharing Logic

It is assumed that each data server should share auxiliary and raw data files with the management computer and correlation servers when distributed computing is going to be performed on the system. Each data server (host name:serv??) has directories /disk/serv??/sd1 and /disk/serv??/sd2 where two removable disk cartridges are mounted as /dev/sda1 and /dev/sdb1 of local disk partitions respectively. As NFS (network file system) server, a setup for /etc/exports on each data server allows these directories to be shared with the management computer and correlation servers. Meanwhile, the management computer should have directory /home/vlbi/ipvlbi where auxiliary files such as schedule, session log and a priori delay&rate calculation are copied to. Setting up NFS server on the management computer allows auxiliary files to be accessible with data and correlation servers. Instead of NFS client setup, there is automounting setup for /etc/auto.master and /etc/auto.misc, allowing servers to mount disk partitions on a remote server. Setting up NFS and automounting appropriately makes ready for control of distributed computing.

2.3. K5/VSSP Correlation Package and Aid Application

To make software correlation from raw data within the cluster of servers, the most essential elements are four kernel programs: "apri_calc", "cor", "sdelay" and "komb". They have been originally designed and developed by NICT. Based on an agreement of research cooperation between GSI and NICT, the Tsukuba VLBI Correlator is allowed to take advantage of these products which are licensed under NICT. "apri_calc" calculates a priori delay&rate for each scan per single baseline. "cor" executes software correlation. "sdelay" makes coarse fringe directly from correlator output. "komb" is a bandwidth synthesis program to obtain multi-band delay. The kernel programs have the ability to process only one scan data of single baseline.

These four kernel programs alone were supposed to do the software correlation, but they could not keep up with the demands for processing many scans for multi-baselines. Besides, our preliminary way of distributed computing sometimes did not work properly. There might be a conflict between correlation servers to get a task because of lacking access control to a list of tasks waiting to be correlated. As a solution, we developed an aid application software, "PARNASSUS" (Processing Application in Reference to NICT's Advanced Set of Softwares Usuable for Synchronization), to handle multi-baseline sessions. This application serves the operator as a tool, providing a graphical user interface and facilitating multi-task control.

There were some steps toward a full combination of "PARNASSUS". The latest version PARNASSUS 1.3, released March 2006, covers a priori delay&rate calculation, correlation execution, bandwidth synthesis and creating Mark III database. The application succeeds in optimizing operator's input into kernel program and comprehensively handling distributed computing of software correlation.

2.4. Primary Solution

CALC/SOLVE developed by NASA/GSFC is installed on an HP workstation to produce primary solution.

2.5. Machinery Room

Many computers are together in a machinery room now. The operator's room was set up in a different room to avoid subjection to a continuously low frequency audio noise, which might affect the operators working in close proximity.

Following are some issues with running K5/VSSP correlation systems in daily work:

- It consumes a lot of electric power in total. Most of the power supply cables are busy.
- Some correlation servers went down due to overload of cooling CPU fan. Our solution was a CPU fan (9200 rpm) replacement.

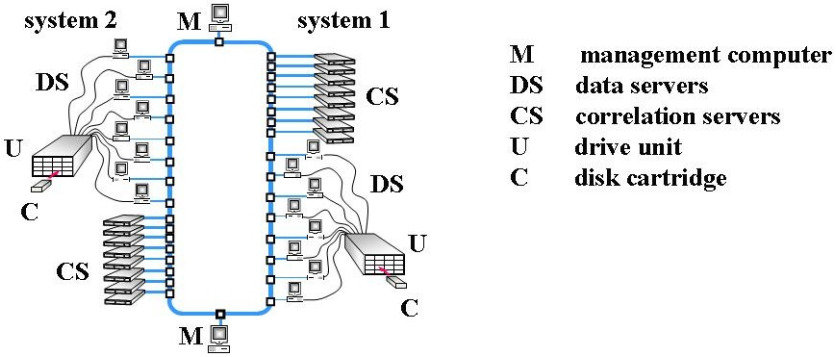

Figure 1. Simplified figure of the K5/VSSP correlation system.

3. Staff

List of the staff at the Tsukuba VLBI Correlator in 2006 is as follows. Staff in the observation domain are listed in the report of the Tsukuba 32-m VLBI station in the Network Stations section of this volume. M. Ishimoto, technical expert of the Tsukuba VLBI Correlator for three years, has left for a new career in April. In his stead, E. Iwata and H. Shigematsu took over the responsibility of maintaining and upgrading the correlation system. S. Fujiwara has left for a new career in August. Routine operations were mainly performed under contract with Advanced Engineering Services Co., Ltd (AES) over 200 days in the 2006 fiscal year (April 2006 through March 2007). AES was asked for 24 additional days of routine operations which were funded by National Astronomical Observatory of Japan. T. Nakajima from the Institute of Japanese Union of Scientists & Engineers worked for us. In particular, many addition in development of "system 2" should profit from his capacity as a system engineer and network administrator.

- S. Matsuzaka : Supervisor, Head of Space Geodesy Division (GSI)
- K. Takashima : Operations manager (GSI)
- E. Iwata : technical staff (GSI), system development and consultant
- H. Shigematsu : technical staff (GSI), correlation chief, media library and shipping
- M. Machida : technical staff (GSI), data evaluation, primary analysis

- K. Nozawa : main operator in routine correlation processing (Advanced Engineering Services Co., Ltd)
- K. Takano : sub-operator in routine correlation processing, software engineer for "PARNASSUS 1.3"(Advanced Engineering Services Co., Ltd)

4. Current Status and Activities

During 2006, 84 Intensive sessions (IVS-INT2) on TSUKUB32-WETTZELL single baseline for UT1, 12 geodetic sessions of domestic network for 24-hour (JADE series) were processed at the Tsukuba VLBI Correlator. One geodetic session for 24-hour (S06174 session) was processed using K5/VSSP correlator.

Most of the former K4 correlator equipment was removed in March 2006. After shifting correlation from K4 to K5/VSSP, one of our plans was due to add some more servers to the existing K5/VSSP correlation system ("system 1") as expansion. Eight rackmount-type Linux computers and eight Linux computers were available for this work. However, the development turned to preparing another correlation system, "system 2". This was triggered by "GSI internship 2006", which was a short-term stay program by GSI's Policy Board for the purpose of self-advertisement. Its goal was that students should learn GSI's activities through this program. This was an opportunity, as one program item, "VLBI Data Processing", required the use of a correlator, and the Tsukuba VLBI Correlator needed another correlation system. In particular, installing "system 2" brought us capacity building for running and maintaining the K5/VSSP correlator system on a regular basis.

S06174 session, conducted under GSI's initiative, aimed at the improvement of the USUDA64 (Ud) site position. USUDA64 of 64 m in diameter is mainly a navigation antenna for deep space missions belonging to JAXA (Japan Aerospace Exploration Agency). Excluding two good sessions in 1990 and 2003, some geodetic sessions in the past have not met accurate solutions for USUDA64's position so far. Processing of S06174 was funded by JAXA.

5. Plan for 2007

- It is planned to continue to process the TSUKUB32/WETTZELL Intensive sessions (IVS-INT2) with the K5 system. The sessions are to be performed on both Saturday and Sunday with K5 (TSUKUB32) and Mark 5 (WETTZELL) systems. The Tsukuba VLBI Correlator is also expected to be responsible for processing 12 geodetic sessions (JADE) of the domestic VLBI network of GSI.
- One of our aims to speed up the processing is to work on an expansion of our K5 correlation system. We will add some more correlation servers and data servers to the existing K5/VSSP correlation systems.
- Some implementation plans for the next version of "PARNASSUS" will be discussed in the advisory team of VLBI correlation domain.
- The previously described plan for estimating antenna thermal deformation using finite element method was initiated in 2006. Body temperature measurements will be continued at 11 points of the antenna mounting frame every minute.