Tsukuba VLBI Correlator

Kensuke Kokado, Shinobu Kurihara, Ryoji Kawabata, Kentaro Nozawa

Abstract

This report briefly summarizes activities at the Tsukuba VLBI Correlator in 2011. The Tsukuba VLBI Correlator processed 145 IVS Intensive sessions and eight Japanese domestic sessions via the K5/VSSP correlation system, which includes some K5/VSSP kernel software. We improved a software correlation system and succeeded in shortening the latency of VLBI sessions. All of the sessions performed after the improvement were correlated by the software correlation system.

Figure 1. Tsukuba VLBI Correlator.

1. Introduction

The Tsukuba VLBI Correlator is a part of VLBI facilities operated by the Geospatial Information Authority of Japan (GSI) as well as the Tsukuba 32-m VLBI station (TSUKUB32). A principal component of our correlation system is the K5/VSSP correlation software package developed by the National Institute of Information and Communications Technology (NICT). We can install the software on commercially-based computers operated by CentOS (Linux OS). We have processed IVS-INT2 sessions and domestic VLBI sessions (JADE sessions) with a number of computers on which the K5/VSSP software package was installed. The sessions we processed in 2011 are described in Section 4. The number of processed sessions was dramatically increased because additional INT2 sessions on the baseline between the Kokee and Wettzell stations were implemented after the 2011 earthquake off the Pacific coast of Tohoku.

2. Component Description

The system components of the Tsukuba VLBI correlator are described in Table 1. We have two systems to process the observed data from international sessions or domestic sessions.

System 1 is an old correlation system which was used for correlation of JADE sessions and JAXA sessions. It is operated by a management application "PARNASSUS" (Processing Application in Reference to NICT's Advanced Set of Software Usable for Synchronization) designed for distributed correlation processing.

System 2 is a new correlation system which is mainly used for correlation of INT2 sessions. We introduced distributed processing programs written in Perl script into the system. The programs have been developed by GSI since 2009 and routinely used since 2010. The framework of the programs is shown in Figure 2. We can correlate the VLBI data automatically with the new distributed processing programs. MK3TOOLS is a program to create Mark III databases from the output files of bandwidth synthesis program for K5/VSSP.

All of the hardware consists of commercially-based products operated on CentOS version 5.4 or 5.5. Now all of the servers work well.

For the INT2 sessions, we have transferred the data from the Wettzell or the Kokee station to the Tsukuba correlator via high-speed network. The Tsukuba Correlator has been connected to high-speed network "SINET4 (Science Information NETwork4)" operated by the National Institute of Informatics (NII). The effective network bandwidth was increased from 1 Gbps to 10 Gbps in October 2011. The network enables us to perform a real-time data transfer from the Wettzell or the Onsala station to the Tsukuba correlator.

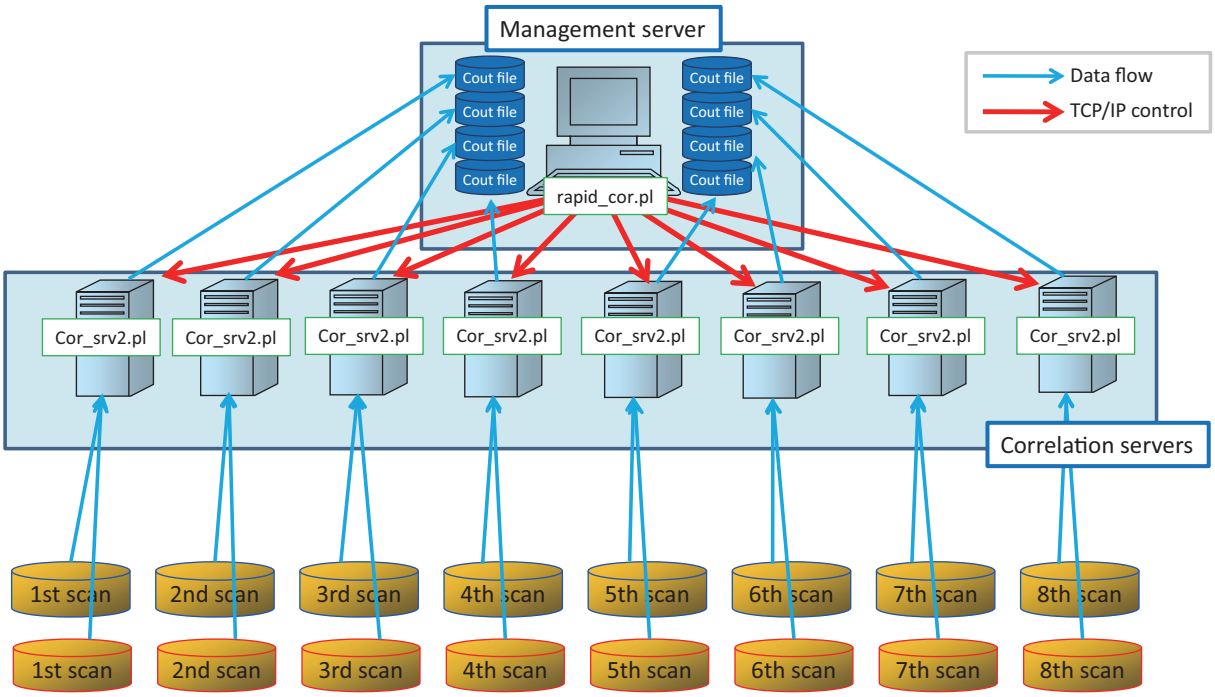

Figure 2. The framework of new distributed processing programs.

Table 1. Specifications of the K5/VSSP correlation system components.

	System 1	System 2
Management Server (CPU)	1 server (Intel Pentium 4, 3.0 GHz)	2 servers (Intel Xeon 3.4 GHz dual CPU)
Correlation Servers (CPU)	16 servers (Intel Xeon 3.06 GHz dual CPU)	8 servers (Intel Xeon 3.4 GHz dual CPU)
Data Servers (CPU)	24 servers (Intel Pentium 4, 3.0 GHz)	8 servers (Intel Xeon 3.07 GHz quad CPU)
File system	NFS	Luster File System
Main application	PARNASSUS 1.3	Perl Programs
Operating System	CentOS version 5.4, version 5.5	
Processing Sessions	JADE sessions Additional domestic sessions (until July, 2011)	IVS-INT2 sessions JADE sessions JAXA sessions

3. Staff

The technical and engineering staff of the Tsukuba VLBI Correlator is as follows. Most of our staff members are subcontract engineers from private companies, the Advanced Engineering Service Co., Ltd (AES) and the Institute of Japanese Union of Scientists and Engineers (I-JUSE).

- Kensuke Kokado (GSI): Correlation Chief, Management of overall activity
- Kentaro Nozawa (AES): Main operator of the correlation work
- Takashi Nishikawa (AES): Sub-operator of the correlation work
- Toshio Nakajima (I-JUSE): System Engineer for computers and network

4. Current Status and Activities

4.1. Processing of JADE Sessions

JADE sessions are domestic 24-hour VLBI sessions scheduled by GSI. The participating stations in the session are four GSI stations (TSUKUB32, SINTOTU3, CHICHI10, and AIRA) and two VERA stations (VERAMZSW and VERAISGK) of the National Astronomical Observatory of Japan (NAOJ). The TSUKUB32 and VERAISGK stations are connected to broad-band network, so we can transfer the data via network. However, the other stations' network transfer rates are too slow to transfer the data to the correlator. Therefore, we have to send the data by shipment of hard disk. We have more than 100 hard disks for shipment, because we need more than four disks per station for each JADE session.

The JADE and JAXA sessions processed at the Tsukuba correlator in 2011 are described in Table 2. The JAXA series was registered by IVS in March 2011, and we submitted all of the databases that had been observed since 2006. The processing factor of each session is described in the rightmost column of Table 2. Although the processing times depend on the number or the performance of the correlation servers, we succeeded in shortening the processing times by installing the "Lustre File System" and the new distributed processing programs. As a result, the processing factor per baseline of sessions after September 2011 is smaller than that of the sessions before that.

Table 2. JADE sessions processed in 2011.

Session	Stations	Processed Baseline #	Processing Factor
JADE-1101	TsAiCcVmVs	10	4.00
JAXA-1101	TsAiCcUd	6	1.61
JADE-1104	TsAiCcS3	4	1.68
JADE-1105	TsS3	1	0.59
JADE-1106	TsAiCcS3Vm	4	0.77
JADE-1109	TsK1KgCcS3VmVs	16	3.38
JADE-1110	TsS3	1	0.42
JADE-1111	TsS3	1	0.07
JADE-1112	TsS3	1	0.06
Ts:TSUKUB32, Ai:AIRA, S3:SINTOTU3, Cc:CHICHI10, Vm:VERAMZSW Vs:VERAISGK, Ud:USUDA, K1:KASHIM11, Kg:KOGANEI			

4.2. Processing of IVS-INT2 Sessions

The Tsukuba correlator also processes the data of IVS-INT2/INT3 sessions. Usually, the INT2 sessions are observed on the Tsukuba-Wettzell baseline twice a week (Saturday and Sunday). However, a number of additional INT2 sessions on the Kokee-Wettzell baseline were implemented after the 2011 earthquake off the Pacific coast of Tohoku, so the number of INT2 sessions processed by the Tsukuba correlator was dramatically increased. The number of the processed sessions is shown in Table 3.

We have transferred all of the data via high-speed network. Especially, the data observed at Wettzell station is transferred and converted from VDIF to K5 format in real-time (during the observing session). For the data transfer for the Kokee station, we transferred the data with UDP-based protocol "TSUNAMI" after the observing sessions. The average achieved rate of the data transfer was up to 300 Mbps. As most of the INT2 sessions on the Tsukuba-Wettzell baseline are processed in real-time, the processing factors of the session are about 1.00. If we process all of the data with the new processing programs on the Lustre File System after the observing session, the processing factor could be under 0.2.

Table 3. IVS-INT2/INT3 sessions processed in 2011.

Session	Stations	Processed session #	AVG. Processing Factor
IVS-INT2(K)	Ts-Wz	78	0.73
IVS-INT2(I)	Kk-Wz	66	0.54
IVS-INT3(K)	Ts-Wz-Ny	1	1.5
Ts:TSUKUB32, Wz:WETTZELL, Kk:KOKEE, Ny:NYALES20			

5. Plans for 2012

The Tsukuba VLBI correlator will process eight JADE sessions, 112 IVS-INT2 sessions and one IVS-INT3 session. We plan to correlate all of the INT2 and INT3 sessions on the Tsukuba-Wettzell baseline with the real-time correlation system.