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K5/VSSP Data Processing System of Small Cluster Computing at Tsukuba VLBI Correlator

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Abstract

A software correlation system at Tsukuba VLBI Correlator of Geographical Survey Institute (GSI) is in process of upgrading its architecture with using the K5/VSSP which is a PC-based software correlator package for geodetic VLBI developed by National Institute of Information and Communications Technology (NICT). Performing software correlation is based on a set of NICT's K5/VSSP kernel programs which cover calculating a priori delay and rate, correlation processing and bandwidth synthesis. As an initial step, we introduced one management computer, 24 data servers and eight rack mount correlation servers. The second step of upgrading K5/VSSP correlation system was building aid application "PARNASSUS" with graphical user interface to aid operating K5/VSSP kernel programs. K5/VSSP enables a distributed computing for software correlation since it provides data storage in Unix files for every four channels per scan. "PARNASSUS" serves to optimize operator's input into kernel program and to handle distributed correlation comprehensively.

As for GSI, there has been an increase in demand for intensive and domestic sessions in the last few years. For the Tsukuba VLBI Correlator it means that a larger amount of data had to be processed. However routine run of K5/VSSP correlator, which was operated in the distributed computing, did not take extra operational time for data processing so far in spite of the increased number of sessions. A hot debate, involving new-fasioned VLBI technology, has developed in the IVS community. For stations and correlators, a development of some kind of active system has been proposed by laboratories around the world. GSI opts for K5/VSSP.

1. Introduction

The topic of this presentation is involved in software correlation system for processing VLBI data using K5/VSSP. Firstly, general architecture and current form of K5/VSSP both at station and correlator sides are provided as background information. The process of distributed computing for treating a large amount of data in the software correlation system is demonstrated. Finally,future plans for the K5/VSSP software correlation system are presented.

2. System Upgrade at Tsukuba VLBI Correlator

Our recent work at the Tsukuba VLBI Correlator was shifting the correlation system toward K5/VSSP. Figure 1 is a photo of the K5/VSSP software correlation system which currently consists of 24 Linux computers as data servers, each of which can share a couple of disk cartridges at once through a drive unit with 16 drive slots, eight rackmount Linux computers with 3GHz Intel Xeon dual CPUs as correlation servers and one Linux computer for file handling and management.

The installation of the K5/VSSP recording system into the network stations of GSI was finished in early 2004. Station and Correlator should fit together in data format and data storing media.

Efforts to shift from the K4 to the K5/VSSP software correlation system had been made at the Tsukuba VLBI Correlator since autumn, 2004. The Tsukuba VLBI Correlator fully switched to K5/VSSP software correlation processing in April 2005. It became more efficient at processing data with distributed computing in K5/VSSP software correlation system. We have operated K5/VSSP in this fashion as a software correlator for IVS.

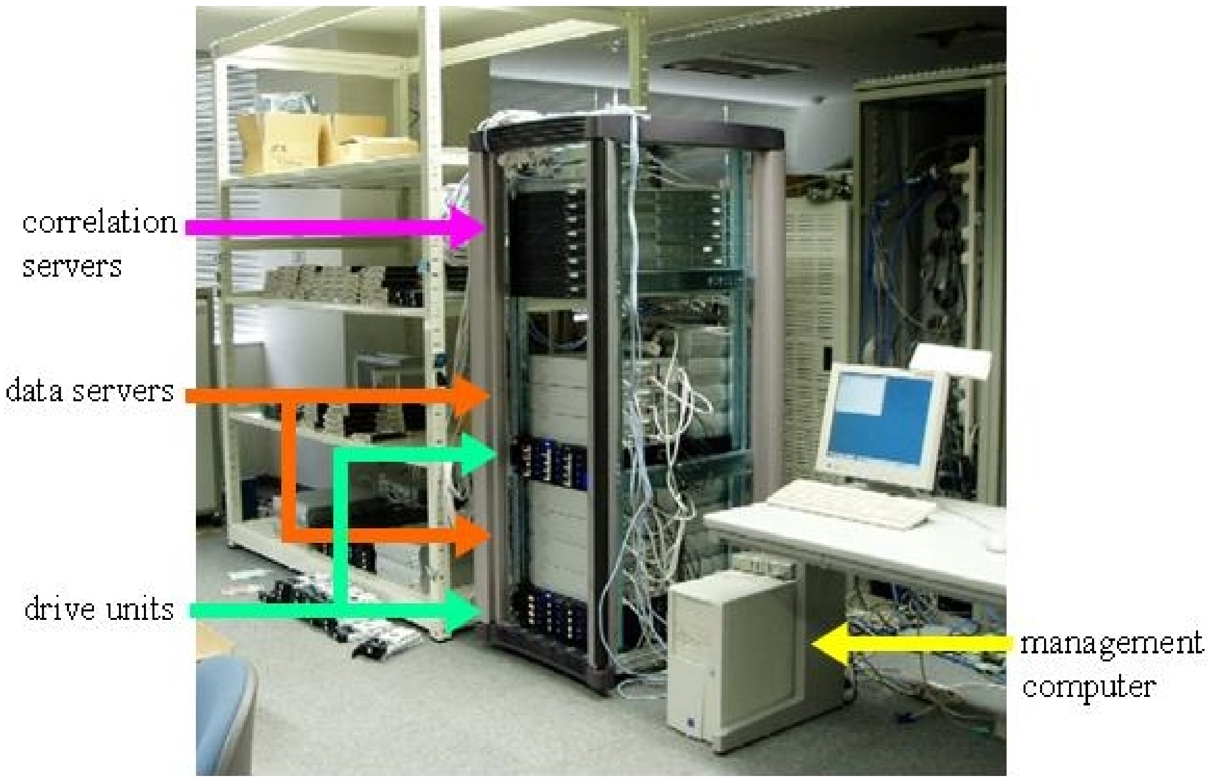

Figure 1. View of the K5/VSSP software correlation system at Tsukuba VLBI Correlator

2.1. K5/VSSP at a Station

Figure 2 is a simplified diagram of acquiring and recording data on K5/VSSP at GSI's network station. The left half of the figure shows the traditional block diagram of data acquisition. Emphasis in the figure is on the right half with the K5/VSSP recording system. The K5 acquisition system puts raw data from every four channels per scan into Linux files that are stored on removable disk cartridges (Figure 3) as formatted binary file.

K5/VSSP has eVLBI capability. In Intensive sessions (IVS-INT02) on the TSUKUB32-WETTZELL single baseline for monitoring UT1, data is recorded on K5/VSSP at TSUKUB32 and on Mark 5 at WETTZELL. Shortly after observation, recorded data at WETTZELL is transferred to Tsukuba VLBI Correlator through the Internet.

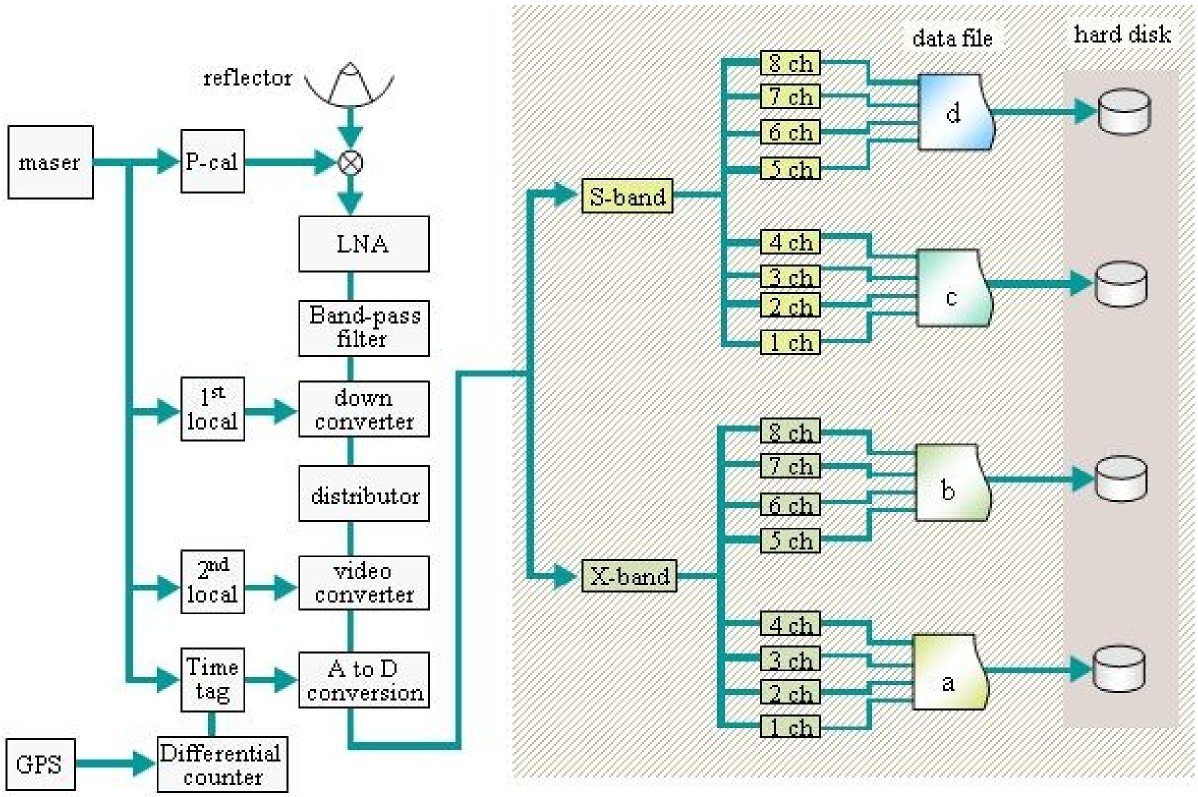

Figure 2. Simplified diagram of K5/VSSP at a station

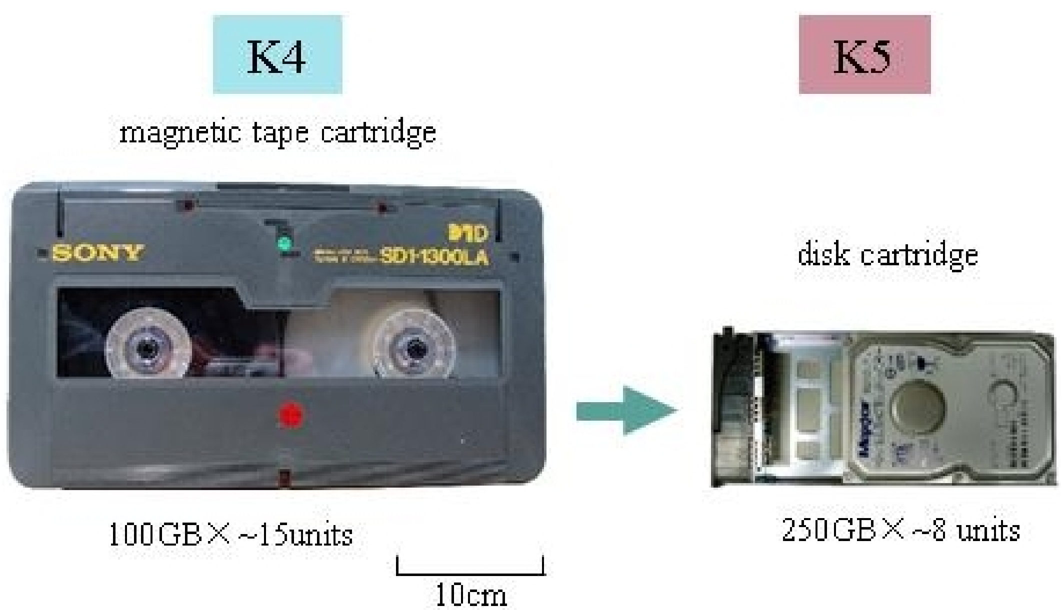

Figure 3. Media for storing data: from MT (magnetic tape) to disk

2.2. K5/VSSP at the Correlator

As described, K5/VSSP enables data file handling on Linux computers, which leads to processing data on software correlator. Figure 4 shows the components of the K5/VSSP software correlation system in its current form. Each data server can share a couple of disk cartridges at once through a drive unit with 16 drive slots where disk cartridges from stations are put into for use. We prepare three drive units for 24 data servers. The brief procedure for mounting data files on the system is to insert the disk cartridge into the drive slot (Figure 6) and to execute the mount command. Directories are shared among computers by Network File System (Figure 7). Once the operator enters in a management computer, raw data and auxiliary files such as schedule, session log and a priori are accessible since they are transparent to the operator by NFS. Accessing a data disk on a data server is distributed, as is the processing of the data.

When we started with the K5/VSSP software correlation system, it was operated in a preliminary form (Table 1). Figure 8 gives a simplified flow chart of the data processing with the K5/VSSP software correlation system. Four kernel programs, "apri_calc", "cor", "sdelay" and "komb" are the most essential elements to make software correlation from raw data within the equipment. "apri_calc" calculates a priori delay and rate for each scan per single baseline. "cor" executes software correlation. "sdelay" makes rough fringe directly from correlator output. "komb" is a bandwidth synthesis program to obtain multi-band delay. These programs come from NICT's K5/VSSP software correlator package, which was originally developed by T. Kondo, Y. Koyama and their co-workers at 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.

Table 1. Improvement of K5/VSSP software correlation system

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preliminary form	current form
single task control	multi-task control
manually input	graphical user interface
kernel program	kernel program
——	aid application "PARNASSUS"

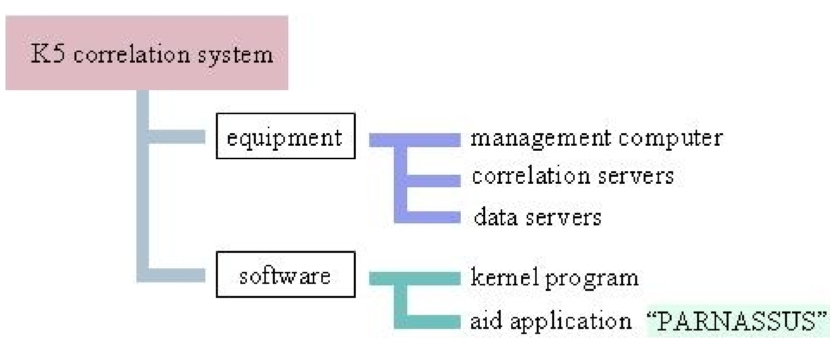

Figure 4. Components of K5/VSSP software correlation system

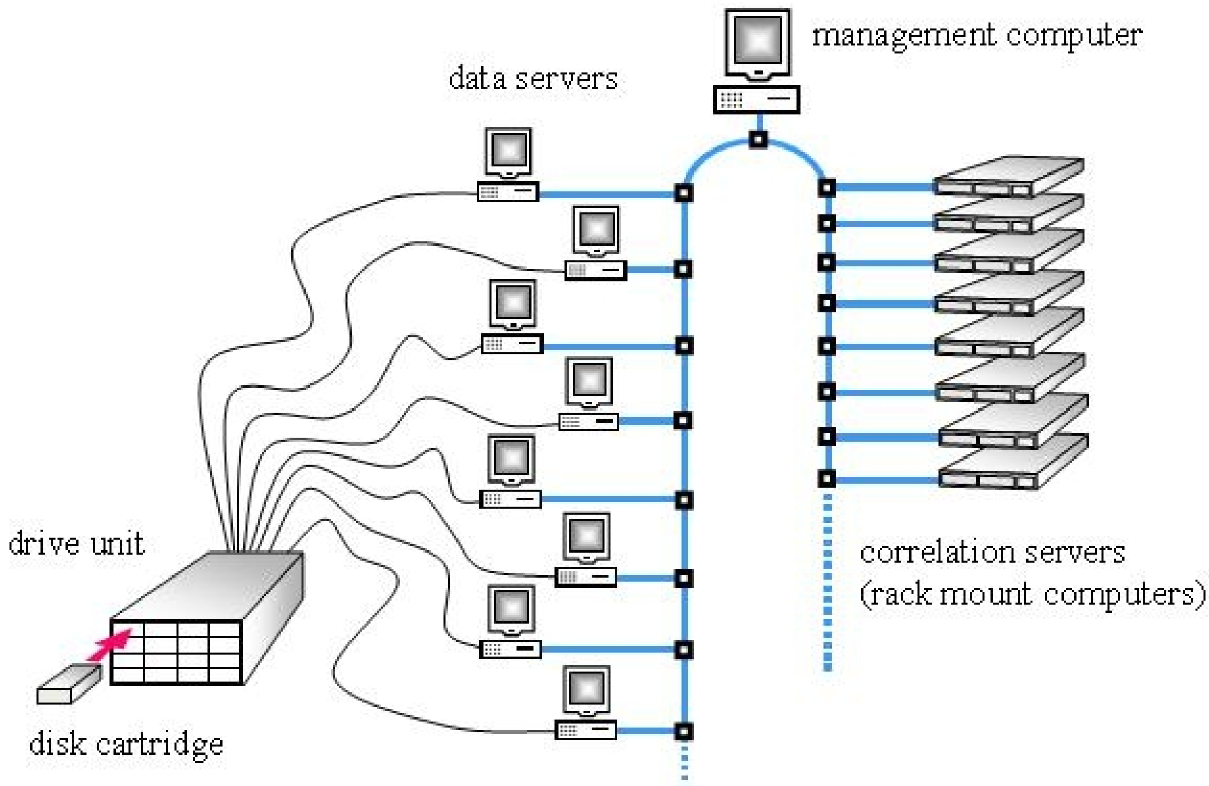

Figure 5. Equipment level of K5/VSSP software correlation system

Figure 6. Disk cartridge and drive unit

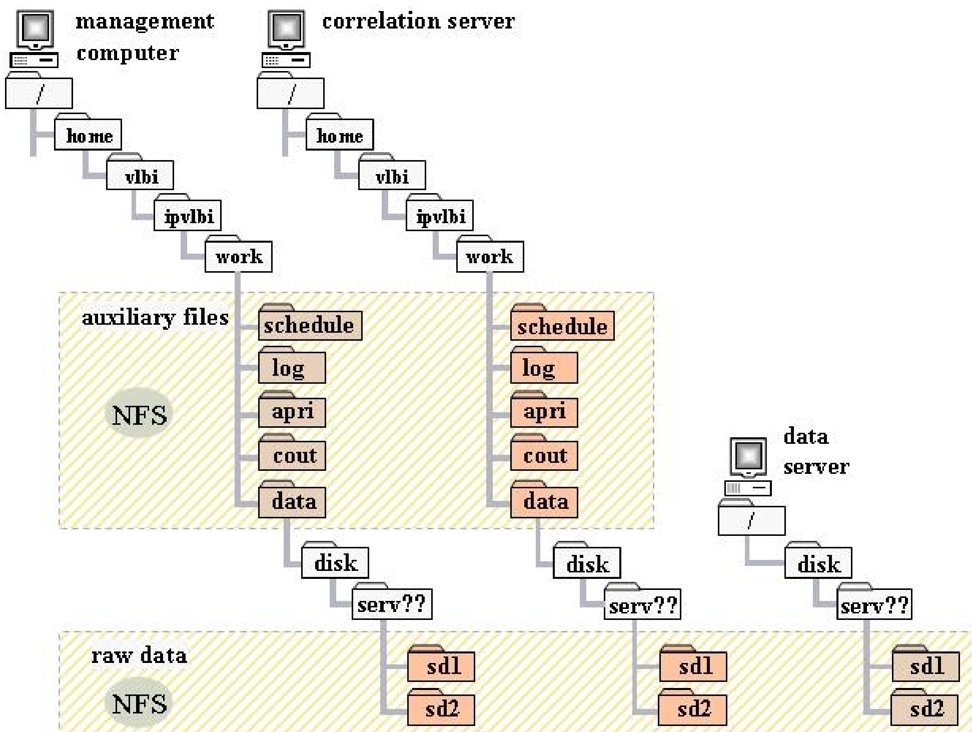

Figure 7. File sharing logic

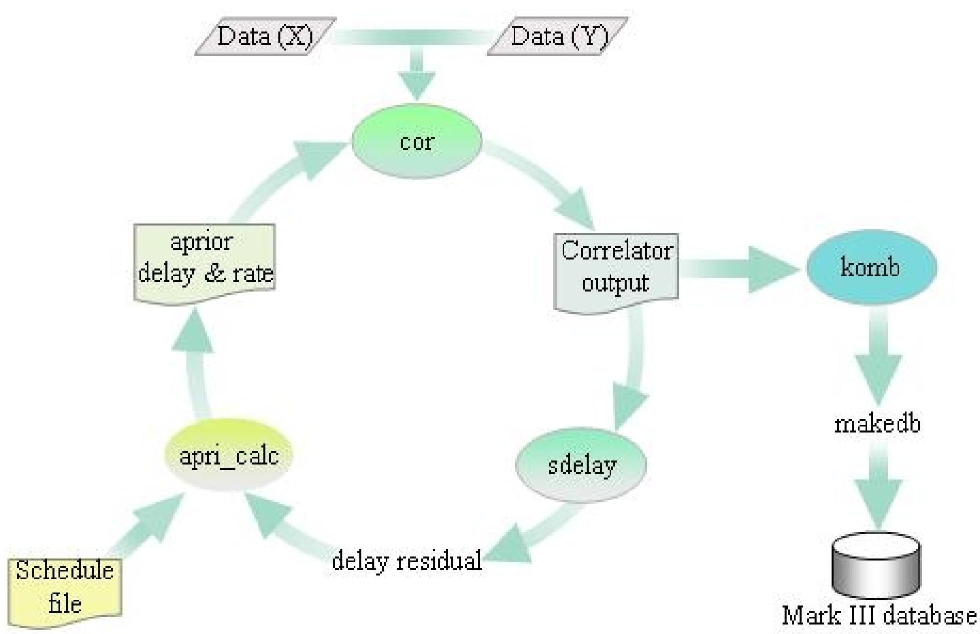

Figure 8. Data processing flow

2.3. Aid Application "PARNASSUS"

The kernel programs have the ability to process only one scan of a single baseline. There was an increase in the number of sessions to be processed at the Tsukuba VLBI Correlator(Figure 9). The only use of four kernel programs in the software correlation was too simple to meet the demands for processing many scans for multi-baselines. As a solution, we have developed an aid application software, "PARNASSUS" (Processing Application in Reference to NICT's Advanced Set of Softwares Usuable for Synchronization), to handle with sessions of multi-baselines, creating the operator's workbench by providing a graphical user interface and facilitating multi-task control. The application succeeds in optimizing operator's input into kernel program and comprehensively handling distributed correlation.

There were some steps toward a full combination of "PARNASSUS". The idea of developing an application to aid the operator's input occurred to us in autumn, 2004. As a private advisory group, K. Takashima, M. Ishimoto and M. Machida were in charge of planning, primary design, requirements definition and functional specification to the application. K. Takano (Advanced Engineering Services Co., Ltd) mainly took control of structual design, coding, programming, testing and installation as a developer.

- March 2005, PARNASSUS 1.0 covered calculating apriori delay&rate
- September 2005, PARNASSUS 1.1 covered executing correlation
- December 2005, PARNASSUS 1.2 covered bandwidth synthesis

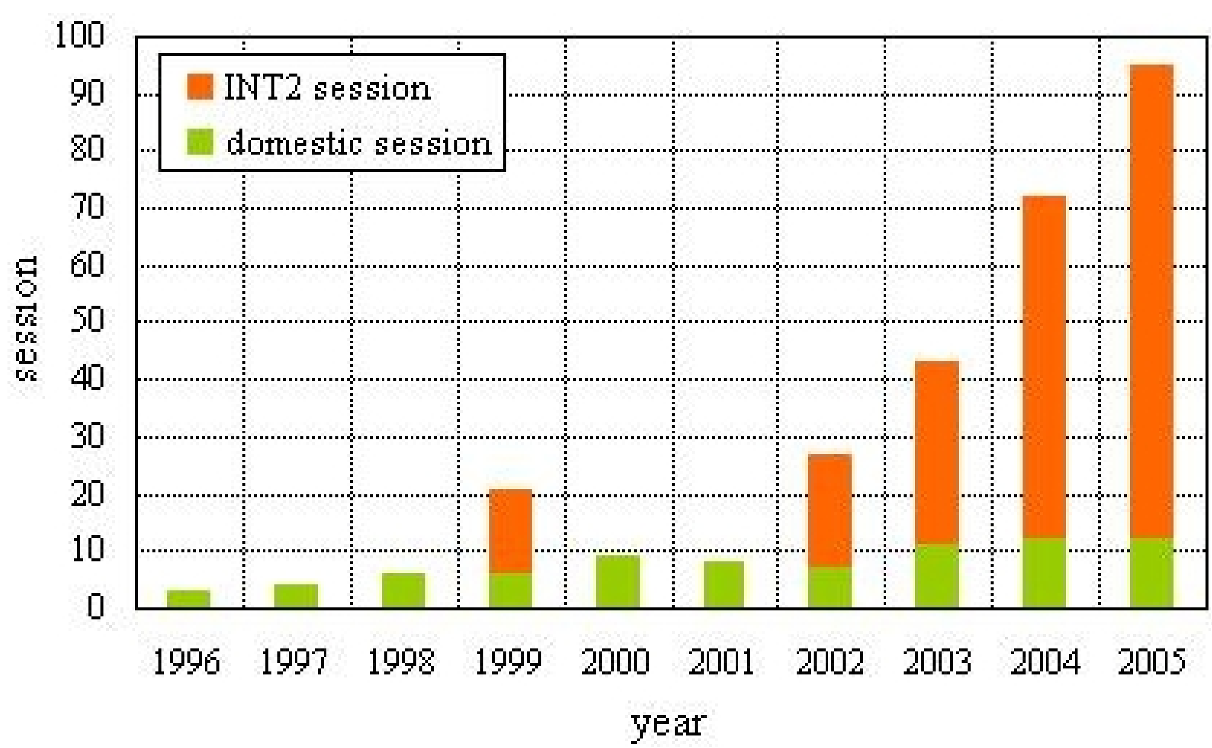

Figure 9. Demand for intensive and domestic sessions at Tsukuba VLBI Correlator

2.4. Distributed Computing

The difference between preliminary and current forms is explained here. Figure 10 is a simplified explanation of distributed computing in a preliminary form. Each image of horses and carrots represents correlator servers and data set, respectively. Correlator servers keep watching a task information. Once there is an uncorrelated data set, the task is accessible from any correlator server that is not occupied by processing another task. Sometimes the correlation system in the preliminary form did not work properly. There might be a conflict between correlator servers to get a task because of lacking access control to tasks in this form.

In current form (Figure 11), aid application "PARNASSUS" on a management computer keeps watch on the tasks. Once there is a uncorrelated data set, the task is distributed to any of the vacant correlator servers under control of "PARNASSUS".

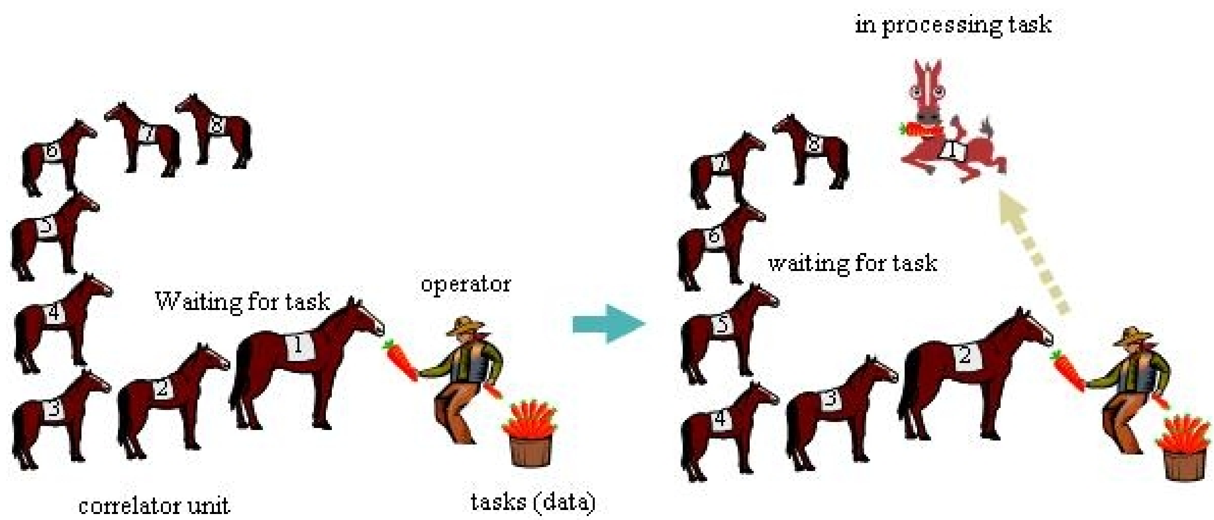

Figure 10. Data handling in preliminary form

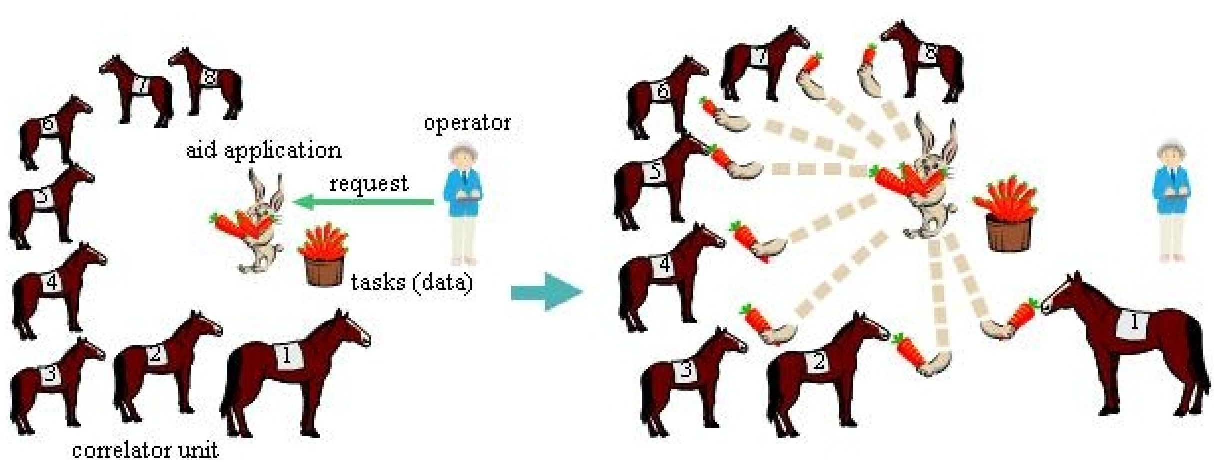

Figure 11. Data handling in current form

2.5. Fringe Search in Distributed Computing

Another issue for the K5/VSSP software correlation system is the fringe search in distributed computing. Ordinarly, a fringe is found within a few microseconds. But in the case of a gross clock offset of the time tag, it takes a lot of time to detect a fringe. K5/VSSP software correlation system can give a solution to that problem. Firstly, we have a wide range divided into some subsiduary range (Figure 12:left). W denotes the lag window size in the subsiduary range. A and B are end points in a whole search range. Then "PARNASSUS" starts the fringe search in each subsiduary range by distributed computing (Figure 12:right).

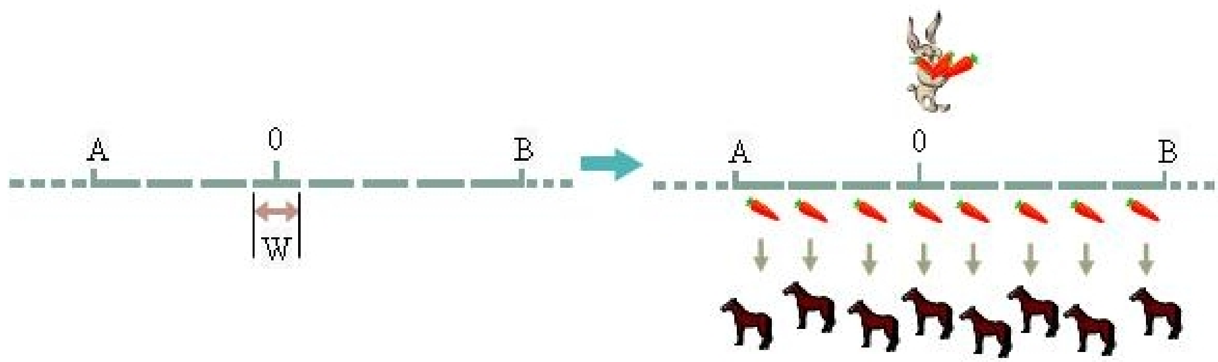

Figure 12. Fringe search in distributed computing

2.6. Performance

Figure 13 shows an efficiency comparsion between K4 and K5/VSSP correlation systems using the processing factor (PF). Black points come from PF of IVS-INT02 sessions which were processed on K4. White points are PF of IVS-INT02 sessions which were processed on K5/VSSP software correlation system. The average PF in the depicted period is 1.82 for K4 and 0.83 for K5/VSSP. There is a decrease of PF from KT to K5/VSSP. As mentioned earlier, we upgraded from K4 to K5/VSSP in April 2005. The improvement of PF in processing the intensive sessions results from introducing K5/VSSP. We did not have to extend our duty time for processing data despite of increased number of intensive and domestic sessions. It was efficient to process data with K5/VSSP software correlation system.

3. Future Plans

One of our goals in order to speed up processing is to work on the expansion of our K5 software correlation system. We will add eight correlation servers and eight data servers to the existing K5/VSSP correlation system.

The developement and testing of interactive "PARNASSUS 1.3", covering the range from calculating a priori to creating a database, is one of the priorities in the first half of 2006. Implementation plans for "PARNASSUS 2" running in batch mode will be discussed in the advisory group of the VLBI team of GSI.

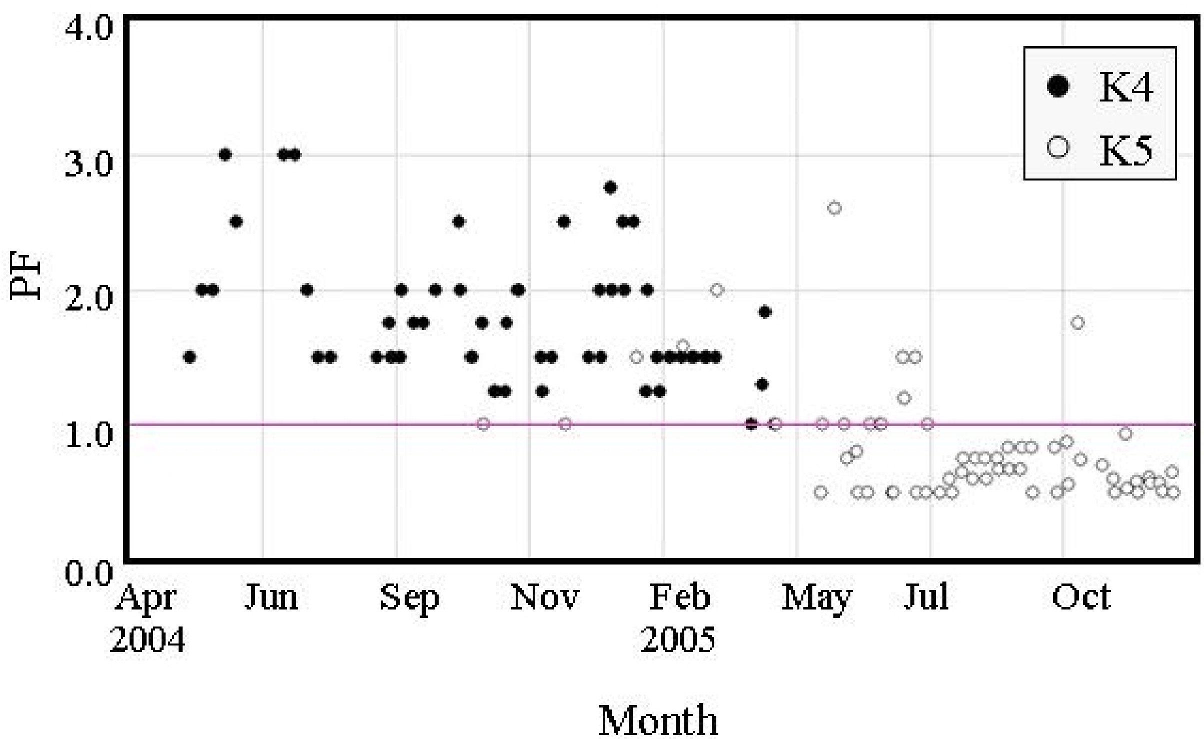

Figure 13. Efficiency comparsion with PF from Intensive session