Developments of the K5 VLBI System

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Abstract

At Kashima Space Research Center of National Institute of Information and Communications Technology, developments of the K5 VLBI system have been continuing based on conventional PC systems to realize e-VLBI observations and data processing over the Internet. By using the the K5 system, various geodetic VLBI experiments have already been performed and interoperability with the other VLBI observation systems such as Mark-5 and PC-EVN have been demonstrated.

1. Concept of the K5 System

The K5 VLBI system is designed to perform real-time or near-real-time VLBI observations and correlation processing using Internet Protocol over commonly used shared high speed networks. Various components are being developed to realize the target goal in various sampling modes and speeds. The entire system will cover various combinations of sampling rates, number of channels, and number of sampling bits. All of the conventional geodetic VLBI observation modes will be supported as well as the other applications like single-dish spectroscopic measurements or pulsar timing observations will also be supported. The concept as the family of the K5 system is show in the Figure 1.

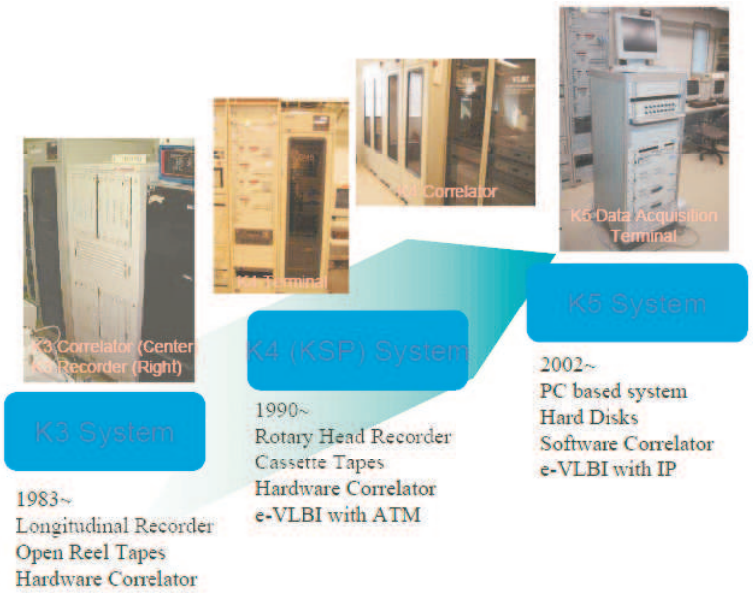

Figure 1. Concept of the entire K5 System.

As shown in the Figure 1, if the ADS1000 or ADS2000 sampler units are used, the PC-VSI board is used to interface the VSI (VLBI Standard Interface) compliant signal from the

sampler unit and the PCI bus of the PC. Both of the sampler units, ADS1000 and ADS2000, are equipped with two VSI compliant connectors which can support data rates up to 1024Mbps. In addition, ADS2000 unit supports 64MHz clock signalling specified as the option of the VSI specification to support the data rates up to 2048Mbps with a single VSI connector. Whereas the ADS1000 is designed as a single channel high speed sampler unit, the ADS2000 is designed for geodetic VLBI observations by supporting 16 channels at the sampling rates up to 32Msps for each channel. When the ADS1000 or ADS2000 sampler unit is used, the PC-VSI board is connected with the sampler unit by using VSI specified data signalling. Although the function is not fully supported at present, the same PC-VSI board will be used to extract data from the K5 system by using VSI.

When relatively low sampling rates are required, PC systems with the IP-VLBI boards are used as shown in the bottom of the Figure 1. The IP-VLBI board is consist of a main board and a daughter board, and it occupies two board slots in the PCI bus of the PC system. Each board is equipped with four BNC connectors from which the base-band signal is supplied and sampled at the Nyquist frequency of the signal. In this configuration, A/D sampling capability is embedded in the board and the PC can be directly connected to the base band converter units. This configuration is called as K5/VSSP and has been used for various geodetic VLBI sessions including IVS routine VLBI sessions and rapid UT1-UTC estimation demonstrations[1].

2. K5/VSSP System

Figure 2 shows the evolution of the VLBI observation and data processing systems developed at the Kashima Space Research Center of the National Institute of Information and Communications Technology (NICT). The K5 system is characterised by the use of conventional PC systems. The data correlation will be performed on the PC systems using software correlator programs. Similarly, the K4 system can be characterised by the use of rotary-head, cassette type magnetic tape recorders, and the K3 system can be characterised by the use of open-reel magnetic tape recorders.

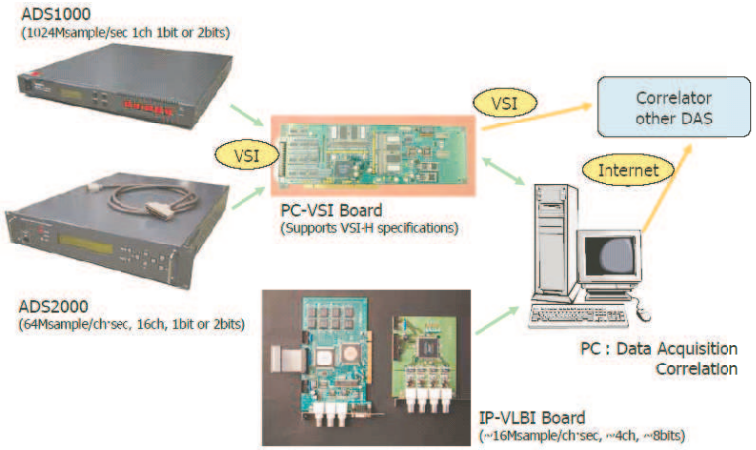

Figure 2. Developments of K3, K4 and K5 VLBI systems.

Figure 3 is one of the combined set of the K5 system and it is specified as the K5/VSSP system. VSSP is an acronym of the Versatile Scientific Sampling Processor. This name is used because the system is designed to be used for general scientific measurements. The system has a

capability to sample analog data stream by using the external frequency standard signal and the precise information of the sampled timing. The system is also used to process the sampled data. For geodetic VLBI observations, software correlation program runs on the K5/VSSP system. Therefore, it can be said that the functions of the formatter, the data recorder, and the correlator are combined into the single system. It is consist of four UNIX PC systems. Each UNIX PC system has one IP-VLBI data sampling board on its PCI interfacing bus. Table 1 shows the specifications of the K5/VSSP system. Each board can sample 4 channels of base-band signals at various sampling rates ranging from 40kHz to 16MHz. The timing of the sampling is controlled by the externally provided 10MHz and 1PPS reference signals so that precise timing information can be reproduced from the sampled data. Quantisation bits can be set from 1, 2, 4, and 8. Because the board has these many sampling modes, it has many possibilities to be used not only for VLBI observations but also for various other scientific researches which require precise timing information in the data. Device driver software of the board has been developed on LINUX, FreeBSD, and Windows2000 operating systems, and FreeBSD is used in the K5/VSSP data acquisition terminals. Four PC systems are mounted in the lower part of the 19-inch standard rack. A signal distributor unit for 1-PPS and 10 MHz signals and 16-channel base-band signal variable amplifier unit are mounted in the upper part of the rack. The LCD monitor and the keyboard on the top of the rack are connected to the four PC systems by using a four-way switch. Each PC system is equipped with four removable parallel ATA 3.5 inch hard disk drives. The sampled data can be transferred to the network by using TCP/IP protocol or can be recorded to internal hard disks as ordinary data files. The maximum recording speed is currently restricted by the speed of the CPU and the speed of the PCI internal bus. Currently, the total recording speed of 512 Mbps has been achieved. To process the data sampled with the K5 data acquisition system, software correlation processing program is also under development on conventional PC systems[2]. The correlation processing program receives data from K5 data acquisition systems over the network using TCP/IP protocol and then calculates cross correlation functions without any specially designed hardware. It can also read data files on internal hard disks. These capabilities allow to transfer observed data in real-time if the connecting network is fast enough, or in near real-time if data buffering is required. Since easily re-writable software programs and general PC systems are used, the processing capacity and the function of the correlator can be easily expanded and upgraded. Figure 4 shows the schematic diagram of the data flow of the K5 system.

Table 1. Specifications of the K5/VSSP system.

Reference Signals	10MHz (+10dBm) and 1PPS
Number of Channels	16
A/D bits	1, 2, 4, or 8
Sampling Frequency	40kHz, 100kHz, 200kHz, 500kHz,
(for each channel)	1MHz, 2MHz, 4MHz, 8MHz, or 16MHz
Maximum Data Rate	512Mbps

3. Concluding Remarks

By using the the K5 system, various geodetic VLBI experiments have already been performed and interoperability with the other VLBI observation systems such as Mark-5 and PC-EVN have

Figure 3. Picture of the K5/VSSP system.

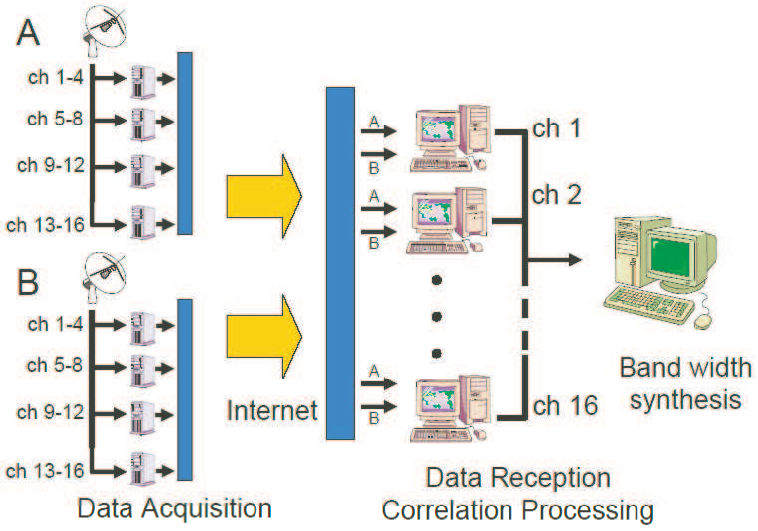

Figure 4. Data flow of the K5/VSSP system in typical geodetic VLBI observations.

been demonstrated. Currently, K5/VSSP system is routinely used as a main observing terminal at five IVS stations, i.e. 34m and 11m station at Kashima, 32m station at Tsukuba, 11m station at Koganei and 11m station at Syowa. The system is also used at other astronomical VLBI stations in Japan and is currently planned to be used at 32m station in Huancayo, Institute of Geophysics in Peru. On the other hand, the K5 software correlator program is used at Joint Institute for VLBI in Europe, Australia Telescope National Facility and MERLIN in England based on free software license agreements between these institutes and NICT. We are hoping that the K5 VLBI observation system and Software Correlator programs are widely used by as

many applications and institutes as possible.

4. Acknowledgements

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References

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