Shanghai VLBI Correlator

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Abstract

This report summarizes the activities of the Shanghai VLBI Correlator during 2012.

1. Introduction

The Shanghai VLBI Correlator is hosted and operated by the Shanghai Astronomical Observatory, Chinese Academy of Sciences. It is dedicated to the data processing of the Chinese domestic VLBI observing programs, inclusive of the CMONOC project for monitoring the Chinese regional crustal movement and the Chinese deep space exploration project for tracking spacecraft. As shown in Figure 1, the VLBI stations near Shanghai, Kunming, and Urumqi participate in some domestic geodetic sessions on an annual basis, while the Beijing station is mainly used for spacecraft data downlinks and VLBI tracking.

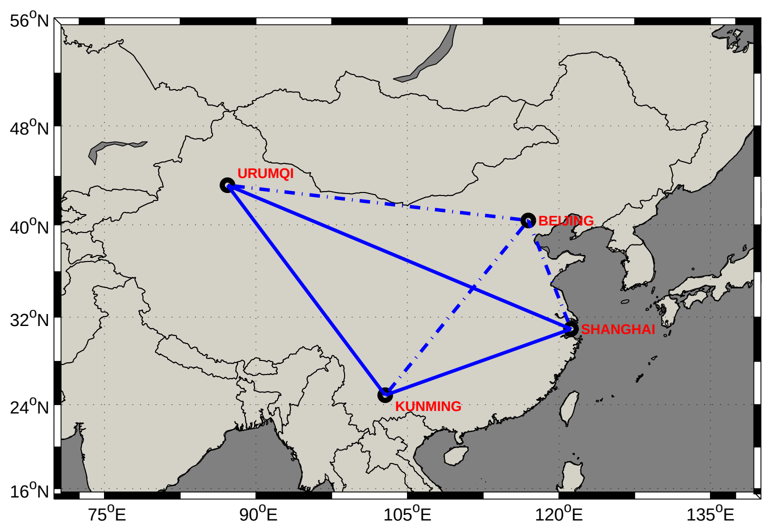

Figure 1. Distribution of the VLBI stations in China.

2. Component Description

Based on the FX type VLBA correlator, we began to design two correlators in 2003. One is the hardware correlator using the FPGA technology. The other one is the software correlator. The first version of our software correlator has been operational since 2006, and it was installed on an AMD Opteron 2200 CPU and later on an Intel X5400 CPU. The software correlator worked much better than the hardware correlator in the VLBI spacecraft tracking sessions. Because it was much easier to be modified, we adopted the second version of software correlator for geodetic applications. By using Message Passing Interface (MPI) and the POSIX thread APIs, the software correlator has been migrated to a computer cluster based on blade servers to get better performance since 2010 (see Figure 2). It has been formally accepted as an IVS correlator in March 2012.

Features of the software correlator cluster are listed below.

- IBM HS22 Blade Server, six computing nodes
- Each computing node: two socket Intel X5570 CPU (2.93 GHz), 12 GB Memory
- Two I/O nodes, with 48 TB raw storage capacity
- One management node with Rocks cluster software
- 10G Ethernet for blade internal network connection.

Figure 2. Shanghai VLBI Correlator.

A summary of the capabilities of the software correlator is presented in Table 1.

Table 1. Correlator capabilities.

Number available	five Mark 5B
Playback speed	1.8 Gbps
Input data formats	Mark 5B
Sampling	1 bit, 2 bits
IF channels	≤ 16
Bandwidth/channel	(2, 4, 6, 8, 32) MHz
Spectral points/channel	≤ 65536
Geometric model	supports plane wave front and curved wave front
online averaging time	0.1s$\sim$4s
Phase cal extraction	yes
Output	CVN matrix format. NGS card file.

3. Staff

The people involved in the development and operation of the Shanghai Correlator are listed below.

- Weimin Zheng: group head, software correlator development
- Xiuzhong Zhang: CDAS and other technique development
- Fengchun Shu: scheduler, experiment oversight, CDAS evaluation
- Zhong Chen: e-VLBI, cluster administration
- Weihua Wang: lead correlator operator, automatic correlation process development
- Juan Zhang: correlator software development and maintenance
- Yun Yu: operator, experiment support
- Wu Jiang: operator, experiment support
- Wenbin Wang: media library, computer services
- Renjie Zhu: CDAS development
- Zhijun Xu: FPGA programming, hardware correlator development
- Yajun Wu: FPGA programming.

4. Summary of Activities

4.1. Correlator Software

The correlator model calculations for Quasars or spacecraft, driven by VEX file, have been implemented in the software in 2006. In order to improve the accuracy of differential VLBI observations to the level of better than 0.1 ns, we have incorporated more corrections such as tidal station motion and gravitational delay.

A great effort has been made to shorten the data latency for the navigation of spacecraft. After adjustment of the software structure in the whole chain of data processing, we aim to produce the final delay observables within one minute after data acquisition.

4.2. CDAS

The Chinese VLBI Data Acquisition System (CDAS) is a type of digital backend designed to replace the traditional analog BBCs. In order to solve the irregular integer bit jumps when CDAS is working at 1 Gbps or higher output data rate, we upgraded the VSI interface cards of CDAS which had been deployed at the four stations since 2010. A three-hour fringe test showed that the delay residuals had become stable on all baselines. In addition to the currently used DDC version, we also developed a PFB version of CDAS with much more compact design.

4.3. e-VLBI

The data link between the Shanghai VLBI center and Seshan25 has been upgraded to 10 Gbps. The data link to other stations is reduced to 20 Mbps data rate for now and can be up to 155 Mbps for domestic e-VLBI observations.

Supported by Chinese Next Generation Network Scientific Research Information Demonstration Project, we established an experimental IPv6-based network connection from the Shanghai VLBI center to Seshan25, Kunming, and Urumqi. e-VLBI application will be demonstrated as an example to push forward the extensive usage of the next generation network.

4.4. Experiments Correlated

In 2012, five domestic geodetic VLBI experiments were carried out at 256 Mbps data rate using 16 channels. The data correlations were done after the Mark 5 modules were shipped to the Shanghai VLBI center. The differential VLBI observations continued to support the navigation of the Chang'E-2 spacecraft from the probe orbiting around the Earth-Sun L2 Lagrangian point to flying by the asteroid Toutatis. Data processing were performed largely in e-tranfer mode.

5. Future Plans

We will continue to support the data correlation of Chinese domestic VLBI observations. As many efforts have been devoted to the development of the realtime correlation technique for differential VLBI observations of spacecraft, we plan to install a DiFX software correlator to meet the requirements of more astronomical VLBI experiments and VLBI2010 technique development in China.