The Software Correlator Status of Chinese VLBI Network

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Outline

◆ The history of CVN software correlator.
◆ The development status of CVN software correlator.
◆ The future work.
The history of CVN software correlator

• Development was begun in 2007.

• The early version implement parallel using Pthread.
  - It took part in CE-1, CE-2 mission as a primary equipment and did good jobs in 2007 and 2010.

• The newer version implement parallel and distributed computing using MPI and OpenMP.
  - It executed the CE-2 extended mission of flying over the second Solar-terrestrial Lagrange point. Last year, the real-time parallel version software correlator completed the CE-3 task successfully based on e-VLBI technology.
The development status of CVN software correlator

Get the data over network by TCP/IP protocol
Enables real-time (applied in the Chinese lunar exploration).

People’s Republic of China (PRC):
Administrative Divisions & Territorial Disputes
Data Flow Diagram in Chang’E 3 Mission based on e-VLBI technology
## Specifications

### Specifications of CVN software correlator

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing Mode</td>
<td>Real-time &amp; post-processing</td>
</tr>
<tr>
<td>Station number</td>
<td>1~20</td>
</tr>
<tr>
<td>Real-time fast fringe search</td>
<td>4 stations</td>
</tr>
<tr>
<td>IF number</td>
<td>1,2,4,8,16</td>
</tr>
<tr>
<td>Frequency channel</td>
<td>24~16384/IF</td>
</tr>
<tr>
<td>Integration period</td>
<td>0.1~60 second</td>
</tr>
<tr>
<td>Maximum data speed</td>
<td>About 1.9Gbps/station, totally 4 stations</td>
</tr>
</tbody>
</table>

Test method of maximum data speed: read the data from Mark5 and write to the hard disk. Use 128 cores totally. The following powerpoint will introduce the performance of the computing platform which the test was done on.
Computing platform

Standard Linux cluster
- Five I/O nodes
  - E7-4820*4/ 128GB/ 300GB+12TB
- 32 compute nodes, 12 cores/node
  - E5-2640*2/ 32GB/ 300GB
- 2 manage nodes
  - E5-2620*2/ 24GB/ 900GB+214GB
- Management network
  - 10G Ethernet
- Compute network
  - InfiniBand
Input and output data format

• Input data format
  - Mark 5A, Mark 5B
  - Now adding VDIF
  - Adding the new input data format is easy

• Output data format
  - CVN specific data format
  - Converted into FITS-IDI
  - can be loaded by AIPS directly
The structure and algorithm

- FX correlator
- Parallization
  By time
  Based on MPI and OpenMP
- Runs on standard linux clusters

Algorithm

- Station 1
  - Delay compensation
- Station 2
  - Delay compensation
  - Correlation
  - Integration

The Software Correlator Status of CVN
Software Engineer

• Written in C
  - with Python scripts
  - with Matlab to show the intermediate result

• Optionally uses Intel IPP library

• GPU version is in development
Compared to the DIFX’s result

The Software Correlator Status of CVN
Clean RR map. Array: KSTU
4C39.25 at 8.476 GHz 2013 Nov 07

It’s nearly the same!
The development of GPU version

This result is based on monitoring and control signals. Currently, this version can only run on the single GPU development board.

GPU: C2070(compute ability 2.0)

Raw Data: 4 Stations, 2Bit Sampling, 64Mbps/Station, FFT points: 1024

Speed: about 300Mbps/Station
Functions

- For spacecraft tracking: Chinese lunar exploration
  - Phase calibration tone extraction
    PCAL tones are injected at the front end of a VLBI antenna in order to provide a convenient means to estimate instrumental delays
  - Fast fringe search
    In general, during orbital maneuver phases, the accurate orbit cannot be provided in advance, so the correlator cannot work properly in such conditions. Fast fringe search module firstly extracts the main carrier frequencies from the signals of different stations, produces the delay-rate, and then compensates the delay and delay-rate.
  - Real-time visibility monitoring
The result of CVN software correlator using the fast fringe search function. The show tool is real-time monitoring tool developed by ourselves.

Fast fringe search is closed!

Fast fringe search is opened!
• For geodesy
  - Used in Crustal Movement Observation Network of China
• For astronomy
  - Pulsar
    be in the experimental stage.
The future work

• Develop the high speed GPU-based software correlator for VGOS

• Add new functions
  - the pulsar function
  - the multiple phase centers function
  - the polarization function
Thanks you very much!