Haystack Observatory VLBI Correlator

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Abstract

This report summarizes the activities of the Haystack Correlator during 2008. Highlights include correlation of many broadband delay (VLBI2010) experiments and installation at WACO of the correlator run-time software that had been converted to Linux. Problems with bad disks and serial links were investigated. Real-time e-VLBI development for Mark 5B, non-real-time e-VLBI transfers, and engineering support of other correlators continued.

Figure 1. Partial view of the Haystack Mark IV correlator, showing five racks containing (left to right) four Mark 5A correlator playback units, the Mark IV correlator, three Mark 5A correlator playback units, and one Mark 5B correlator playback unit (bottom) with the associated correlator interface board unit, two Mark 5B correlator playback units with associated correlator interface board units, and three station units.

1. Introduction

The Mark IV VLBI correlator of the MIT Haystack Observatory, located in Westford, Massachusetts, is supported by the NASA Space Geodesy Program and by the National Science Foundation. The available correlator time is dedicated mainly to the pursuits of the IVS, with a small portion of time allocated to processing radio astronomy observations for the Ultra High Sensitivity VLBI (u-VLBI) project. The Haystack Correlator serves as a development system for testing new correlation modes, for e-VLBI, for hardware improvements such as the Mark 5C system, and for diagnosing correlator problems encountered at Haystack or at one of the identical correlators at the U.S. Naval Observatory and the Max Planck Institute for Radioastronomy. This flexibility is made possible by the presence on-site of the team that designed the correlator hardware and software. Additionally, some production correlator time is dedicated to processing geodetic VLBI observations for the IVS.

2. Summary of Activities

2.1. Broadband Delay Experiments

Several broadband delay development experiments using prototype VLBI2010 systems were conducted and correlated in a wide variety of configurations, including different frequency placements of the RF bands, different LO frequency offsets, and phase cal modifications of various types. These experiments were designed to explore the capabilities, and potential limitations, of the evolving VLBI2010 hardware. Most were interferometric observations between the Westford 18-m and the GGAO 5-m antennas, with the post-receiver hardware at each site including two digital back ends (DBEs) and four Mark 5B+ units. Many astronomical observations conducted by the u-VLBI program using DBEs and Mark 5B+ units were processed as well.

2.2. WACO Linux Correlator Run-time Software Conversion and IP Change

The Linux correlator run-time software conversion which was implemented at the Haystack and Bonn correlators in 2007 was carried out at WACO in early 2008. Later in the year a project to change all the IP addresses of networked devices on the WACO correlator was completed. This was needed in order to address security requirements for the Navy. This was a major project and involved setting up an independent network at Haystack in order to test the changes in advance.

2.3. Mark 5A/5B/5C Recording System Related Projects

Problems related to the handling of bad disks with Conduant SDK 7 software have been resolved with a special version of John Ball's Mark 5A code and SDK 8.1. A new release of the software specifically for the correlators is in beta testing. A Mark 5C record mode test was conducted to evaluate the ability of a Mark 5C system to record at 4 Gb/sec in Mark 5B mode. For information regarding the Mark 5C recording system, please refer to the "Haystack Observatory Technology Development Center" report. SATA disk testing was conducted so that newly purchased SATA disks could be used in the August CONT session. Those investigations and other Mark 5 related system testing continue.

2.4. Input Board Serial Link Tests

An extensive investigation into data corruption issues associated with new style serial links installed in correlator input boards was conducted this year. These new links were designed and built by the Bonn group at MPI in order to provide replacements (and expansion stock) for the original serial links, which contained obsolete parts. A problem with these links manifested itself in the course of expanding the number of playback units on the Mark IV correlator. The symptom was intermittent data corruption in single channels. The problem was found to be an incorrect component installed on the boards. The boards were subsequently modified and the problem solved. This issue was important to resolve, as it was preventing the expansion of the correlator with more Mark 5B data output modules (DOMs).

2.5. e-VLBI

Development of real time software for Mark 5B continued. A version of the code was exported to JIVE this year. Non-real-time transfers have continued. Data from 30 experiments were transferred to Haystack this year from five stations, all in Japan: Kashima, Tsukuba, Chichijima, Shintotsukawa, and Aira.

2.6. Other Projects

General support of the other Mark IV correlators continued. Examples of the various fixes and enhancements were enabling the use of byte positions for Mark 5B modules that have lost their directories, and enabling the processing of 16 phase cal tones. Support continues for day-to-day problems and occasional bug fixes.

3. Experiments Correlated

In 2008, thirty-one geodetic VLBI experiments, consisting of ten R&Ds, two T2s, and nineteen test experiments, were processed at the Haystack correlator. The test experiments cover the broadband development and a wide assortment of other projects, some of which were mentioned in the summary above. As usual, there was also a large number of smaller tests that are not included in the above count because they were too small to warrant individual experiment numbers.

4. Current/Future Hardware and Capabilities

As of the end of 2008, functioning hardware installed on the system included 2 tape units, 7 Mark 5A units, 7 station units, 4 Mark 5B units (DOMs) with their associated correlator interface boards (CIBs), 16 operational correlator boards, 2 crates, and miscellaneous other support hardware. We have the capacity to process all baselines for 11 stations simultaneously in the standard geodetic modes, provided the aggregate recordings match the above hardware matrix.

The only change in the above described matrix compared to last year is the addition of one Mark 5B unit. We temporarily had a total of six Mark 5B units installed for the processing of u-VLBI project experiments but had to relinquish two of them later for other projects. One retired tape drive was removed from the equipment line in order to make rack space for the additional Mark 5B unit mentioned above. Installation and organization of the Mark 5B units were revised extensively at this time and at various other times during the year. The electrical circuit distribution for the correlator rack was re-wired this year in order to better distribute its load.

In 2009, we hope for an expansion of stations recording on Mark 5B units, which would allow for the retirement of station units and thus an increase in the use of Mark 5B playback units on the correlator. This will improve processing reliability and provide the opportunity to process more stations simultaneously.

5. Staff

Staff who participated in aspects of Mark IV, Mark 5, and e-VLBI development and operations include:

5.1. Software Development Team

- John Ball - Mark 5A/5B; e-VLBI
- Roger Cappallo - real-time correlator software and troubleshooting; system integration; post processing; Mark 5B/5C; Linux conversion; e-VLBI
- Kevin Dudevoir - correlation; maintenance/support; Mark 5A/5B/5C; e-VLBI; Linux conversion
- Chester Ruszczyk - e-VLBI; Mark 5A/5B/5C
- Jason SooHoo - e-VLBI; Mark 5A/5B/5C
- Alan Whitney - system architecture; Mark 5A/5B/5C; e-VLBI

5.2. Operations Team

- Peter Bolis - correlator maintenance
- Brian Corey - experiment correlation oversight; station evaluation; technique development
- Dave Fields - playback drive maintenance; Mark 5 installation and maintenance; general technical support
- Glenn Millson - correlator operator
- Arthur Niell - technique development
- Don Sousa - correlator operator; experiment setup; tape library and shipping
- Mike Titus - correlator operations oversight; experiment setup; computer services; software and hardware testing
- Ken Wilson - correlator maintenance; playback drive maintenance; general technical support

6. Conclusion/Outlook

Migration of additional correlator run-time programs to the Linux platform is expected in the coming year. Expansion of the use of Mark 5B units at all correlators will continue as more field stations convert to Mark 5B. Mark 5C testing is beginning. e-VLBI testing should resume this year with the restoration of the high speed link. Further use of DBEs will continue, with the intent of transforming standard observing techniques to higher data rates in the coming years. This is an exciting time at the Haystack correlator, as much of the testing and development of new equipment in previous years is now coming to fruition, resulting in larger and more extensive experiments.