Technology Coordinator Report

Alan Whitney

Abstract

The efforts of the Technology Coordinator in 2002 were primarily in the following areas: 1) completion of the VSI-S specification, 2) preliminary international e-VLBI efforts using heterogeneous and the beginning of the development standardized e-VLBI data formats (VSI-E), 3) beginning of an initiative to create a vision for VLBI in 2010 and 4) organization of the first international e-VLBI workshop. We will describe each of these briefly.

1. VLBI Standard Interface Software (VSI-S)

The VSI Technology Coordination Committee has completed Version 1.0 of the VSI-S specification, which is the software part of the VSI specification. Version 1.0 of VSI-H, the hardware part of the VLBI Standard Interface, was completed in August 2000 and published in the IVS 2000 Annual report.

The goal of the VSI-S specification is to specify a robust, reliable communication protocol to control a VSI-H-compliant VLBI Data Transmission System (DTS). In this regard, VSI-S addresses the following issues:

1. Specifies a communications structure and protocol.

2. Specifies a generalized command and response syntax model to be used by the DTS.

3. Specifies a base set of commands to configure and operate a generic DTS adhering to the VSI-H specification.

Already, several groups worldwide have developed, or are developing, VLBI data systems and components that adhere to the VSI-H and VSI-S standards. We expect this trend to broaden and accelerate.

I believe that it is quite commendable that a diverse international committee has been able to agree to a standard specification for both hardware and software interfaces for VLBI. Special thanks is extended to all the members of the VSI Technology Committee for their efforts to bring the VSI specification to successful result:

- Wayne Cannon; York University, Canada

- Brent Carlson; DRAO, Canada

- Dick Ferris; ATNF, Australia

- Dave Graham; MPI, Germany

- Ed Himwich; NASA/GSFC, U.S.

- Tetsuro Kondo; CRL, Japan

- Nori Kawaguchi; NAO, Japan

- Ari Mujunen; Metsahovi, Finland

- Misha Popov; ASC, Russia

- Sergei Pogrebenko; JIVE, Netherlands

- Jon Romney; NRAO, U.S.

- Ralph Spencer; Jodrell, England

Both the VSI-S and VSI-H specifications are available at *http://dopey.haystack.edu/vsi/index.html*.

2. VSI-H Rev 1.1

The original VSI-H Revision. 1.0 specification has been updated to Revision 1.1 to more clearly define and specify 'multi-port' VLBI Data Terminal Systems (DTSs). Multi-port VSI systems may be constructed to support multi-Gbps applications.

3. VSI-E

The need for a standardized data format for e-VLBI interchanges is now very evident and the first steps are now being taken to tackle this issue. Based on an extension of the e-VLBI data format already adopted by the Japanese K5 system, a draft VSI-E proposal has been created and circulated for comment. We hope to be able to agree on international e-VLBI data format within the next few months.

4. VLBI 2010 Initiative

At the October 2002 IVS Directing Board meeting, the Technology Coordinator was given the charge of organizing a working group to explore the vision for VLBI in 2010. This group is just now beginning to get organized and hopes to have a preliminary report by fall 2003.

Among the factors encouraging VLBI 2010 initiative:

- Continuing RFI problems at many sites

- DSN moving to X/Ka (32 GHz) band observations. Advantage: eliminates S-band RFI

- Aging antennas

- Technology advances in disks and e-VLBI

- Concerns in the US:

    1. Retirement of current practitioners

    2. Reduced support for VLBI technology development by sponsoring agencies

Goals of VLBI2010:

- Unattended observing

- Global coverage

- Electronic data transfer, near real-time correlation.

- Smaller antennas? ($\sim$12m for expected to be available for $\sim$\$150k)

- Spanned bandwidth 4 GHz

5. International e-VLBI Workshop

Approximately 70 attendees representing 15 institutions worldwide participated in a 2-day workshop held at MIT Haystack Observatory on 8-9 April 2002. The purpose of this workshop was to explore the current state of high-speed astronomy data transmission, concentrating on the transmission of pre-correlation VLBI data, dubbed 'e-VLBI'. Among the topics discussed were:

- International networking facilities - now and future

- User requirements for high-speed networking

- Networking protocols for real-time data transmission

- Public vs. dedicated networks

- International standards for e-VLBI data transfer

The program committee consisted of Yasuhiro Koyama of CRL, Steve Parsley of JIVE, Jon Romney of NRAO and Alan Whitney of Haystack Observatory. Presentations from the workshop are available on-line at *http://web.haystack.mit.edu/e-vlbi/abstract.html*.

5.1. National and International Networking Facilities

Representatives from several major research networks outlined their current status and future plans. Within the U.S., the Internet2 research network provides backbone connections spanning the country at 10 Gbps, primarily between major research institutions and universities, but 'last-mile' connections to most antennas remain a major hurdle. In Europe, the Geant network is in the process of establishing a similar network; again, 'last-km' problems pose a major cost obstacle for direct connections. In Japan, several dedicated high-speed networks, as well as the research network Scinet, have already been used for e-VLBI at data rates to 2 Gbps. For the short term most global e-VLBI usage will have to share bandwidth with other users on research networks.

A number of international research links exist, but the only truly high-speed links are between Japan, U.S. and Europe. TransPAC, jointly sponsored by Japan and the U.S., links Chicago and Tokyo at ~600 Mbps, while Surfnet, the national research network of The Netherlands, links Chicago and Amsterdam at ~2.4 Gbps, with connections to other high-speed European networks. A new high-speed network links Japan and Korea. High-speed network connections between other international geographical areas do not yet appear to be available.

Though there exists a well-advertised excess capacity of installed national and international fiber, most of this fiber remains unlit and will likely continue to be unlit until commercial demand is sufficient. The time scale for such demand is unclear. Research uses of this excess capacity remain problematical at best, though there has been some success in some instances of fiber and communications companies allowing access to research users at low cost. That being said, most government-supported research networks are developing rapidly and are looking for users to fill their available bandwidth. *It was made quite clear that these networks are not likely to expand significantly unless there is sufficient usage and demand to justify such expansion.*

5.2. Protocols for e-VLBI

Based on current usage statistics, most shared high-speed research networks operate, on average, at only a small fraction of their available capacity. Usage tends to be 'bursty', with average

length high-speed bursts ranging from seconds to minutes. e-VLBI has the potential to fill a significant fraction of this unused capacity, but it must do so in a non-obtrusive manner that does not significantly affect other users. This suggests that special protocols might be developed which keep e-VLBI as a lower-priority 'background' usage; but it also suggests that large buffers may be required at the correlators in order to accommodate large time 'jitter' (seconds, minutes, hours?) in data return.

5.3. e-VLBI Experiments Done or in Progress

Several networks have already been established and demonstrated in Japan capable of data rates as high as 2 Gbps. Primarily, these have been over dedicated non-IP links, but work is now in progress to use shared IP networks as well. The Merlin array in England is in the process of developing and installing a multi-Gbps dedicated network. Haystack Observatory is preparing a Gbps e-VLBI demonstration experiment between Haystack and NASA/GSFC in Maryland using IP over shared networks.

The general consensus at the meeting among networking experts was that 1 Gbps over a WAN is now 'possible, but difficult', requiring special skills. However, it is the goal of the networking community to make 1 Gbps connections easy in the near future.

5.4. Networking Technology

The advent of relatively inexpensive wavelength-division multiplexing (WDM) on optical fibers is having a huge impact on the telecommunications industry and promises to considerably expand available bandwidths at a reasonable cost. 'Private' e-VLBI wavelengths on existing lit fibers are a future possibility.

The development of COTS-based VLBI/e-VLBI data systems makes transfer of e-VLBI data to/from high-speed networks relatively straightforward using standard network interfaces.

5.5. 'Last-mile' problems

The connection of telescopes to high-speed nodes, dubbed the 'last-mile' problem, remains a high barrier for many sites. For almost all cases, the cost of fiber installation is the dominant cost and is not likely to fall significantly. A cost of several tens of thousands of dollars per km is expected to be typical, though in some special cases it may be a low as a few thousand dollars per km. Lighting the fiber with the bandwidths needed by e-VLBI is becoming quite affordable, the cost usually being small compared to fiber-installation costs.

A provisional working group consisting of Jon Romney, Richard Schilizzi and Alan Whitney was established to draft a white paper to set e-VLBI goals, determine current observatory connectivities, provide the beginnings of a master global e-VLBI development plan, and establish the tasks of a permanent e-VLBI working group. Among the tasks of the permanent working group will be:

- Coordinate standardization of e-VLBI data formats
- Identify continuing goals, both scientific and technical
- Coordinate international e-VLBI efforts and proposals
- Maintain current state of connectivity of global VLBI observatories

- Maintain e-VLBI as a visible user of global high-speed networks

- Promote continued interactions with networking specialists

5.6. Follow-on e-VLBI Workshop

Follow-on e-VLBI workshops are planned for Dwingeloo in 2003 and Japan in 2004, perhaps with a rotation back to the U.S. in 2005.