

**PTV “Internet2 Next Generation” Project Activity Report**  
**CPB Contract #5319; WSU Subcontract #G000944**  
**(October 1, 1999 – June 30, 2000)**

Introduction

This interim report is submitted per the requirements of WSU Exhibit C (Page 4). It also meets the CPB Schedule C (Page 3) requirements for the second Interim Narrative Report. Activities described involve consultant project-related activities from **July 1, 2000 through August 31, 2000**.

The key activities during this period were related to the technology demonstrations over Internet2 (I2) held at the Higher Education Telecommunications Consortium (HETC) meeting in Madison, Wisconsin on July 12 and 13. These activities included vendor contacts for equipment loans, coordination of the technology and the content-production teams for the Madison event. Based on the success of these demonstrations, a “Public Television Next Generation Intranet” demonstration event is currently being planned for the Fall PBS Meeting in Washington, DC on October 23, 2000.

The successful transmission of PTV-based video from multiple locations for the demonstrations in Madison (and earlier in Nashville) involved support from numerous members of the Internet2 video community. Campus I2 coordinators and networking staff at the participating PTV sites and at I2 video centers outside of PTV (such as Northwestern University, the University of Washington, and Vanderbilt University), all contributed their talents to this effort. Their support will be critical for future demonstrations.

Project Activity Report

**1. The July HETC Meeting Demonstrations**

The bulk of activities in June and July were related to setting up a series of I2-enabled video delivery demonstrations as part of the July 12<sup>th</sup> meeting of the Higher Education Telecommunications Consortium (HETC). This gathering was one of the venues identified by the Principal Investigator (Dennis Haarsager) and CPB staff as meeting the criteria of a “national public television gathering” (per Task 8).

The production staff at WHA-Television and the computer and networking team at UW-Extension’s Instructional Communications Systems (ICS) unit provided significant on-site support for the demonstrations. UW-Madison’s Division of Information Technology (DoIT) staff provided additional content encoding, Videocharger support, Internet2 access and network control, technical support consultation to participating video providers at other campuses, and a campus

ATM link between the demonstration venue (the Pyle Center) and the I2 gateway.

Vendor outreach for this event included equipment loan agreements with Minerva Networks (for MPEG-2 codecs) and FutureTel (MPEG-2 encoding cards). Decoder cards were purchased from Sigma Designs. Technical assistance came from IBM (for their Videocharger server) and from Virage, Inc. (for assistance with setting up their Video Logger™ workstation).

IBM, while not being able to provide a direct link to the Virage indexing system in time for the event, was able to assist DoIT and ICS with the provision of appropriate “drivers” to allow the display of Videocharger content via a Netstream decoder card at S/Video quality. IBM’s director of Videocharger Content Management, William Belknap, has promised to assist the project with links to Virage and/or MediaSite video asset searching systems before the PBS Fall Meeting demonstration.

The technology demonstrations at the HETC meeting included the following:

- A Video-on-Demand PTV Portal, with “point and click” access to both stored and live PTV-related content. Live MPEG-1 content (at 1 mbps) was provided by WUSF-TV, C-SPAN, and WTIU. Stored video content – at both 1mpbs and 5.5 mpbs – was accessed on-demand from servers at the Research Channel (at the University of Washington), Argonne National Labs (Champaign, Illinois). Sample PTV content, organized by Wisconsin Public Television (WPT), was accessed from an IBM Videocharger server at UW-Madison. This demonstration was staffed by Marcell ### (from Northwestern University’s International Center for Advanced Internet Research) and Rebekah Irwin, Project Assistant for the CPB-supported *Reforging the Links* project.
- Live production-quality feeds from Penn State’s WPSX-TV (8 mbps) and Washington State’s KWSU-TV (at 5.5 mbps), were displayed using Minerva Networks codecs.
- Remote searching and playback of video assets were demonstrated using both Virage and MediaSite video search tools. WPT’s *Weekend* series was indexed using Virage tools, and Real Media Player. Programs were hosted on UW-Extension’s media server, and accessed over the ATM link between the Pyle Center and DoIT. While this was a local network demonstration at 300 kbps, we hope to upgrade this to 1 mpbs or higher data rates using I2 for transport between the video asset server and the demonstration site.

Documentation of these events is described in the *Reforging Links* website library <http://www.reforginglinks.uwex.edu/techdemo.html>.

## 2. Potential I2 Demonstrations at the Fall PBS Planning Meeting

Based on the response to the demonstrations conducted for the HETC, the Project steering committee was asked to recommend which of the above should be repeated at the PBS Fall Planning Meeting in October. It was agreed that (1) a Video Assets Management demonstration (searching and accessing indexed video segments/programs), (2) a collaborative editing or multi-site live video demonstration, and (3) access to remote video content on-demand, would all be of interest to other PBS Managers.

With the assistance of CPB Project Officer Jerry Ostertag, possible facilities for a Washington, DC demonstration site were investigated. *Highway One* [www.highwayone.org](http://www.highwayone.org), located near the White House, appears to offer the best location for a PBS event. This site was the location of the demonstrations associated with the University Corporation for Advanced Internet Development (UCAID) Internet2 Spring, 2000 membership meeting <<http://www.internet2.edu/html/spring00.html>>, and is equipped with both open display space and, most importantly, an OC-3 (155 mpbs) link to both Abilene and vBNS via an ATM connection to New York City.

Ms. Narrissa Johnson at Highway One has agreed to “pencil in” the afternoon and evening of Monday, October 23<sup>rd</sup> for a “PTV-Internet2 reception.” Mr. Jerry Sobieski, of the MaxgigaPOP at the University of Maryland, has also agreed to assist us with network connectivity support.

## 3. Report Preparation

In addition to the task-related activities associated with this project, the consultant has also prepared both this and the previous Interim Reports during the period of July 1<sup>st</sup> through August 31<sup>st</sup>.

### Documentation of Demonstrations/Results to date:

#### (1) Inventory of Existing Servers, etc.

Washington State University consultant, John Gray, conducted this research activity during the late winter of 1999-2000. He was able to visit the majority of participating station sites. In summary, he concluded that:

- There was no consistent approach to server and related equipment at the stations and little access to MPEG encoding equipment.
- With some exceptions, there was generally a low level of awareness of each other’s technologies between the broadcast and IT organizations.

Despite this lack of equipment and knowledge of IP-based video technologies at the station level, support was not only available at, but eagerly offered by, most campus IT units.

- University IT departments were universally welcoming of public television use of Internet2 connectivity.
- None of the universities were using their I2 connectivity at levels that would preclude public television use for high quality video.
- Universities were at varying stages of becoming connected with the Abilene Internet2 backbone, though all had either an Abilene or vBNS connection.

Based on these findings, the project team chose not to rely on station-based digital video equipment to pursue any of the project demonstrations. Instead, major equipment vendors were approached for equipment loans (e.g., for video codecs), and existing university-based digital video storage capacity (e.g., Videocharger servers) was identified and access requested. Technology support was also sought from within the university Internet2 video community. This outreach made it possible for the project to conduct its first demonstrations (in Madison and Nashville). It also helped bridge the gap between station-based IT personnel and campus networking departments.

## (2) Server-to air broadcasting

The current grant has supported a series of live, real-time MPEG-2 video transmissions to remote viewing locations. The results of these trials will be evaluated, and will lead to a server-to-air demonstration before the end of the grant period.

- The first of these live video feeds originated from WHA-TV in Madison to a gathering of PBS Managers attending the Annual Meeting in Nashville, TN. Wisconsin Public Television's *Weekend* program was fed directly to a Minerva Networks VNP codec as serial digital video, compressed and encoded as an IP-based MPEG-2 stream, and sent to Vanderbilt University over the Abilene Network. A videocassette of this broadcast was made, and is available upon request.
- During the HETC Meeting in Madison (July 13, 2000), two live Abilene video feeds – one from KWSU (at 5 mbps), the other from WPSX-TV (at 8 mbps), were received in the Pyle Center. These were decoded and displayed on large video monitors.
- A similar display is planned for the next public event demonstration at the

PBS Fall Planning Meeting (see #8, below).

- Research is now underway to identify a potential segment for the *Weekend* program that would accommodate a live (or server-based) broadcast of a video segment originating at a remote location and delivered via Internet2.

(3) Server-to Air Across International Networks

Through the good offices of Dr. Joe Mambretti, Director of the International Center for Advanced Internet Research (iCAIR) at Northwestern University, contacts have been made with university-based IP video centers in Israel, the United Kingdom, Canada, and the Netherlands. These organizations are currently assisting iCAIR in demonstrating streaming of MPEG-1 level video (1.5 mpbs) across international peered networks. The potential of receiving at least one of these streams at the PBS Fall Planning Meeting is being explored. Following a successful MPEG-1 trial, a “broadcast-level” feed (at MPEG-2) will be attempted before the end of the Project term.

(4) Transfer of ATSC High-Definition Digital Television

The delivery of broadband digital video streams over Internet2 is a very demanding application. To date the only demonstrations of this application have occurred outside of the public television community. The University of Washington [UW-S]) has been the most active in this area.

- With support from Sony Electronics, two HDTV streams were sent simultaneously from Stanford University to UW-S, one of them at 40 mpbs and the other at 200+ mpbs. These feeds were displayed at the fall 1999 Internet2 members' meeting in Seattle.
- At the April, 2000 National Association of Broadcasters (NAB) Convention in Las Vegas, five production-level (200 mpbs) video streams from KING5 Television in Seattle were sent to the convention, switched on the show floor, and streamed back to Seattle to be broadcast directly off the Internet by KING-DT.  
See <http://www.researchchannel.com/special/NAB2000/press.html> for a detailed press release from U.W.

These demonstrations have been widely promoted. Many of the attendees (including a CPB Project Officer) at the PBS Engineering Conference, held in conjunction with the NAB, attended the DTV event. While these demonstrations succeeded in showing the potential of IP video delivery, the majority of PBS station managers participating in Internet2 activities feel that HD is “too far ahead in the future” in the minds of most of their peers. They have recommended that

the project focus its next set of demonstrations on *server-to-air* and *server-to-editor* applications using current NTSC video formats.

While “DTV over IP” has not received the same degree of attention by the Project Consultant, contacts have been made with the Center for Advanced Video Network Engineering Research (CAVNER) at the University of North Carolina. This organization is evaluating various HD-to-IP conversion systems. They have expressed a willingness to attempt a HD feed from Research Triangle Park to a PBS station once they have successfully tested an intrastate IP HD-video feed in North Carolina. WGBH-TV is currently establishing a direct LAN connection to Harvard University. Once this link is established, it may be possible to have WGBH originate a DTV feed to CAVNER via Abilene.

(5) IP Multicasting

This technology protocol involves the transmission of one originating signal across the entire IP network. The original signal is replicated at multiple routers, allowing receiving sites to find a serving location anywhere on the network. This arrangement avoids the need to send out dozens or even hundreds of individually addressed streams from one location. Like satellite transmissions, there is need for only one “uplinked” signal. However, in order to preserve network capacity, multicast broadcasts must be prearranged: servers and routers must be authorized to duplicate the incoming signal and serve it to others, receiving sites must be “multicast-enabled.”

Because of the complex requirements of network routing for multicast transmissions, the project will have to work very closely with the Internet2 technical community to arrange a demonstration of IP multicast using MPEG-2 video from a single source to multiple destinations. These contacts are now being made with the support of the UCAID (University Corporation for Advanced Internet Development) staff in Ann Arbor, MI.

Because public television has its own successful “multicast” delivery service – the PBS satellite system, it is unlikely that a future PTV interconnect would completely abandon satellite-based feeds for bringing real-time program feeds to multiple receive locations. IP-multicast may still have a place in the future interconnect, primarily for its ability to support the real-time creation of smaller, ad-hoc, networks.

(6) Automation Systems Integration

Given the lack of compatible digital automation systems at the participating stations (and within PTV as a whole), this demonstration is not likely to be completed by the end of the project term. The “good news” is that this task has

been successfully demonstrated in the commercial broadcast arena by such organizations as The New York Times station group. WLIW and WNYE in New York City are also investigating Master Control integration over terrestrial IP and ATM networks. The project team will monitor these applications and include an update in the project's Final Report.

While a demonstration of full-scale automation system integration will not happen under this project, a simulation of how stations could use IP networks to preview programs on remote servers and "drag and drop" the selected program into their local scheduling grid will be created. In addition, the concurrent Northwest Advanced Digital Distribution Entity (ADDE) project will also be addressing regional interconnection and integration of station Master Control systems.

(7) Sizing Requirements for PTV Interconnection

Because the current configuration of the Internet2 does not allow for "bandwidth reservation," the only way to ensure error-free transport of live video streams is to have excess "headroom" on the network connections. This requirement is to protect the video packets from contention with other high-bandwidth users of the network. In practice, this has meant adding excess capacity to the access links to the Internet2 backbone. The Abilene "backbone" itself has more than enough capacity to support the project demonstrations; the weak link has been the connections from the television station to the campus network center, and from the campus to Internet2.

Project participants have discovered that in order to take full advantage of Internet2 for multiple MPEG-2 streams they need at least a 100 mbps "switched" (i.e., dedicated) Ethernet connection to their campus network. The campus, in turn, needs an OC-3 (155 mbps) connection to the Abilene backbone. These are the minimum configurations for stations considering near-term use of Internet2-based video transport.

In the mid-term (next 2 years) the Internet2 system will be developing better "video reservation" protocols. In addition video compression schemes will continue to improve, requiring less capacity for the same quality levels. In addition to these "upgrades" to the research-based university Internet2 network, other "video dedicated" networks are coming to the marketplace. Some are based on reserved service video internet-protocol (IP); others are using dedicated ATM circuits. In either case, future connection requirements are expected to drop.

KWSU's Northwest Advanced Digital Distribution Entity (ADDE) project has found that where dedicated access circuits are used (either ATM or a 'closed' IP cloud), stations could expect to be adequately served by either a DS-3 or OC-3 connection.

In somewhat oversimplified terms, if a station chooses to take its DTV program feeds at the ATSC 19.39 mbps data rate, a station could be interconnected for both DTV and analog purposes at a DS-3 (45 mbps) data rate. If for internal distribution reasons it chooses to receive digital feeds at 45 mbps, then it would need to be connected at an OC-3 (155 mbps) level (actually, it could be connected with two DS-3s, but commercial pricing gives you an OC-3 for the price of two DS-3s).

While the issue of whether DTV distribution feeds should take place at 19.39 mbps or 45 mbps is still controversial within the industry, the planning of a “hybrid” PTV interconnect – and its sizing requirements, is now “on the table” of the PBS Engineering Committee. This Committee’s “Interconnection Working Group” is now discussing a model which would support both satellite-based real-time delivery and terrestrial-based video file transfers between and amongst station and PBS servers. The fact that this working Group has identified terrestrial distribution as having a role in the next generation interconnect is a strong indication of the success of this project in raising the visibility of this emerging technology.

(8) Outreach and Education

This has been the major focus of the Project Consultant to date. These activities are described in Project Activity Report items #1 and #2, above. A successful demonstration event took place at the HETC Summer Meeting in Madison; a large-scale demonstration is being planned for the PBS Fall Planning Meeting in October. Elements of this demonstration will include:

- Multiple real-time video streams from participating stations – feeds will be at both 1 mpbs and 6 mbps rates, and will be selected from a web-based preview interface.
- Video program search, preview and scheduling – this is a *server-to-air* simulation. A program database is being developed at KWSU-TV that will allow users to select programs by title, subject, running time, etc. Selected programs will be previewed via Internet2 connections to Videocharger servers in Wisconsin, Indiana, Maryland and Pennsylvania. Ancillary program materials such as photographs, press kits and video promos will also be accessible via IP connections.
- Collaborative editing demonstration – working with IBM, the project will demonstrate the ability to search and select video segments from *The News Hour* and integrate the selected video into a production editing system.

(9) “Planning Guide”

*This task will be addressed in the later phases of the Project.*

(10) Collaborative Program Streams

The core members of the Project have been polled as to their interest in providing locally produced content for distribution via one or more Internet2-connected video servers. Issues to be resolved include:

- how such programs will be indexed (simple database of title, subject, running time, featured speakers, rights, etc. versus more detailed segment-based searching using Virage, MediaSite and other emerging tools)
- what formats will be used for digitization (MPEG-1 at 1.5 mbps can be decoded by software, at more locations, by more users than MPEG-2, yet the latter format is more suitable for broadcast/cablecast)
- who will do the digitization, indexing and file preparation; and once prepared,
- where the search database and the video assets will be housed.

These issues are further complicated by the efforts of the Research Channel at the University of Washington to create a national network of university-based video producers. They are soliciting memberships from universities interested in distributing campus lectures, arts events, and science/research documentaries. How a CPB-supported pilot of “collaborative program streams... from university lectures and distance learning programs” will relate to the already-underway Research Channel activities will be investigated during the next phase of the Project.