National Science Foundation, Directorate for Computer Information Science and Engineering
Division of Advanced Networking Infrastructure & Research (ANIR)

NSF Cooperative Agreement No. ANI-9730202
December 2000 Quarterly Status Report

Submitted January 9, 2001

Tom DeFanti, Maxine Brown, Andy Johnson, Dan Sandin, Jason Leigh, Laura Wolf
Electronic Visualization Laboratory
University of Illinois at Chicago

Linda Winkler
Argonne National Laboratory

Jim Williams, Stephen Peck
Indiana University

Table of Contents

A. Significant Results or Events in the Past Quarter

- An NSF-convened Review Committee formally met for a mid-term review of the High Performance International Internet Services (HPIIS) program, notably the US/international scientific applications enabled.
- RENATER2's transatlantic and local loop was upgraded from DS3 to OC3.
- IUCC connectivity to STAR TAP switched from satellite to fiber.
- EVL scientists ran real-time, collaborative demonstrations between Telecom 2000 in Israel, SC'00 in Dallas, SARA in Amsterdam, and EVL in Chicago to showcase scientific collaboration over high-speed networks to Israeli scientists.
- CAVERNsoft was used to remotely debug equipment in Israel using both an ImmersaDesk-to-ImmersaDesk collaborative demonstration and a Polycom system.
- Plans for STAR TAP International Transit Network moved forward.

- Brazil's Sao Paulo Foundation for the Advancement of Research (FAPESP) request to connect to STAR TAP was approved by NSF's Steve Goldstein.
- CAVERNsoft G2, version 1.2 was released in November;
- CAVERNsoft G2, version 1.2.1 was released in December.

B. Expected Results or Events in the Coming Quarter

- CERN's transatlantic and local loop will be upgraded from DS3 to OC3.
- An explanation and pointers related to the STAR TAP ITN project will appear on the web site.
- RENATER2 will upgrade its dedicated bandwidth to STAR TAP.
- The replacement STAR TAP NLANR web cache machine will be installed at AADS.
- Connection of Brazil's Sao Paulo Foundation for the Advancement of Research (FAPESP) network to STAR TAP, expanding collaborative opportunities for Euro-Link members
- Release of a new CAVE simulator GUI to provide a graphical user interface for compiled CAVE Simulator applications

C. Summary of Technical Activities

C.1. Euro-Link Network Status and Institutions

C.1.a. CERN

The annual ThinkQuest conference will be held near CERN this year. (ThinkQuest honors high school students who win scholarships for designing educational web sites). Caltech's Harvey Newman and Al Weis are discussing using prototypical Grid systems for workshops and competitions by the ThinkQuest teams. Newman also proposed holding a global ThinkQuest event at SC'2001, using the Access Grid and/or VRVS for video participation and shared applications.

CERN technicians continue to work on a capacity upgrade of their transatlantic line from 45Mb to OC-3/STM-1. Olivier Martin and Paolo Moroni began working with Ameritech on their 45Mb to 155Mb OC-3/STM-1 upgrade in October, originally scheduled for completion December 1. Personnel changes at Ameritech delayed approval of a UIC subcontract to Ameritech enabling payment of local loop charges for the past year, and subsequently, installation. New Ameritech STAR TAP account manager Tony Haeuser expedited the subcontract approval.

C.1.b. IUCC

On December 7, STAR TAP engineers changed the IUCC multicast configuration in response to a trouble report from IUCC's Hank Nussbacher. An improvement was noted.

In November, a US State Department-issued warning advising against travel to Israel caused Jason Leigh, Greg Dawe and Michael Lewis to cancel plans to attend Telecom 2000 – Israel's largest annual telecommunications conference. EVL's ImmersaDesk, however, was shipped to the site in Tel Aviv, and remotely deployed by Technion University engineers. Using a Polycom system to conduct real-time remote training, the EVL and Technion teams conducted a tele-collaborative session on November 5. EVL researchers used CAVERNsoft-based applications to remotely debug ImmersaDesk hardware. A real-time collaboration among Israelis, EVL in Chicago, SARA in Amsterdam and EVL personnel in the Alliance booth at SC00 in Dallas, Texas, took place November 8-9. On December 7, Joe van Zwaren, Israeli Ministry of Science, reported the following about the Telecom 2000 conference held November 6-9 in Tel Aviv: "The ImmersaDesk made a tremendous impact. Many people got the full impact of the technology. I am now exploring the possibility of getting a museum to buy an ImmersaDesk to give a real-time 3D view produced by an electron microscope (the company that might sponsor this is in the electron microscope business). This would provide a permanent exhibition of the technology in Israel."

In October, IUCC began the changeover from satellite connectivity to terrestrial links to STAR TAP, resulting in sporadic connectivity and multicast peering interruptions.

C.1.c. NORDUnet

NORDUnet's Peter Villemoes reported NORDUnet issued an Invitation to Tender for Network Connections to the USA. [http://www.nordu.net/tender/USA2001] Initially (July 1, 2001) asking for 467-622Mbps to the Abilene PoP in NYC and 155Mbps to STAR TAP in Chicago, out of a total transatlantic capacity of 2.5Gbps.

NORDUnet's original plan to terminate its service to STAR TAP in January 2001 and take advantage of the Internet2/Abilene ITN service has been changed. The connection to STAR TAP will be maintained, as NORDUnet wants access to other US federal agency networks (to which Abilene will not carry transit traffic) and UIC will continue to assume the cost of NORDUnet's local loop.

Further discussions with Abilene have made NORDUnet consider its connection to US and international research networks to be only via STAR TAP after July 1, 2001. The initial capacity into STAR TAP would be 622Mb.

C.1.d. Renater2

In November, France Telecom upgraded its DS3 link to Ameritech to two OC-3s (primarily for commodity Internet traffic); France Telecom assigned its former 45Mbps DS-3 link to Renater/PHYnet. Despite a provisioning freeze, Kevin Peterson (AADS) configured new VCs for ESnet, PHYnet, Abilene, vBNS and 6TAP. Renater hopes to upgrade to a 155Mbps OC-3c circuit in February/March 2001.

On December 6, Renater's Dany Vandromme told Tom DeFanti that France Telecom is only able to provide a 45 Mbps ATM VP between Paris and STAR TAP for research traffic; there is an apparent temporary shortage of *dedicated* ATM bandwidth for Chicago. Vandromme hopes to upgrade to 155Mbps in early 2001 (February or March). He is pressing France Telecom to upgrade the STAR TAP bandwidth ASAP in order to set up access to 6TAP and improve the capacity committed to active projects. Meanwhile, commodity traffic bandwidth is expected to be 2.5Gbps by December 1, 2001.

PHYnet uses about 30 Mbps of the traffic, leaving the remaining bandwidth for Renater. There is an urgent need to deliver 30 Mbps sustained capacity between SLAC (in Stanford) and IN2P3 in Lyon for BABAR experiments; Renater has other usage requirements, such as 6TAP and other existing projects. Note: PHYnet is France's High-Energy Physics community network; it is a VPM tailored onto the Renater infrastructure. PHYnet peers with ESnet in order to connect to SLAC, Fermilab, CERN, etc.

C.1.e. SURFnet

Jason Leigh, in network performance studies with SARA in The Netherlands, is getting 32Mbps throughput over SURFnet's 155Mbps link to STAR TAP. Leigh and Linda Winkler are still working to solve this puzzle.

Meanwhile, SURFnet is interested in upgrading their link to STAR TAP to 622Mbps, and is also putting out a Call for Proposal for a transatlantic lambda; i.e., multi-gigabit global connectivity. (Note: On December 8, the Publications Office of European Communities published SURFnet's Call for Proposal announcement; interested bidders should contact <admin@gigasurf.nl> or (phone) +31 30 2305305.

In October, the IOS code was upgraded on SURFnet 12000 routers to correct bugs and increase operating stability.

C.2. Engineering Services

C.2.a. International Transit Network (ITN)

CA*net3 ITN and Abilene ITN are new services offered by CANARIE and Internet2 to facilitate connectivity among National Research Networks (NRNs) that now connect to one of the coasts of North America. We will soon update the STAR TAP web page with information and pointers to the CANARIE and Internet2 web pages that contain more information.

C.2.b. STAR TAP Router Peering

On December 29, the Saõ Paulo/Brazil Foundation for the Advancement of Research (FAPESP) 155 Mbps link to Miami became operational. FAPESP engineers expect the connection to Chicago to be complete by late January. It signed with C&W to provide service to STAR TAP, pending NSF approval. FAPESP desires ATM PVC from

Miami to STAR TAP, going into C&W Chicago PoP and using the existing local connection vacated by CERN several months ago.

In October, NII (SINET/NACSIS) peering with STAR TAP was removed. An updated STAR TAP logical map was posted to [http://www.startap.net/ENGINEERING/].

Hyoung Soo Kim, of KOREN (Korea Research Network), contacted Tom DeFanti in late October to request technical information about connecting to STAR TAP. He was advised about prices and procedures, and is developing a proposal for the NSF.

A current list of STAR TAP peers appears on the STAR TAP site, at [http://www.startap.net/ENGINEERING/].

C.2.c. 6TAP

In December, SURFnet's Wim Biemolt reported SURFnet recently connected to 6TAP, joining Euro-Link partners CERN and RENATER. See [http://www.6tap.net/]

C.2.d. STAR TAP NLANR Web Cache

Alan Verlo reports EVL has completed testing of the replacement web cache machine, and expects to install it at AADS in January. A problem with the existing machine was diagnosed in October, and in November, Duane Wessels prepared a replacement machine, and sent it to EVL for final testing prior to installation at AADS.

C.2.e. DiffServ

DiffServ experiments between EVL and Argonne National Laboratory have been completed. One major finding is that while DiffServ is able to provide bandwidth guarantees to applications, it is unable to provide latency recovery. A report is being drafted for submission to a journal.
A draft report is available at [http://www.evl.uic.edu/cavern/papers/DiffServ12_12_2K.pdf]
See also http://www.evl.uic.edu/cavern/EMERGE/ and http://www.icair.org/inet2000

C.3. NOC Services

The Global Research NOC is preparing to issue a regular, online newsletter in the next few months.

On November 5-7, Ameritech Advanced Data Services (AADS) and SBC Advanced Services Inc. (ASI) performed a software upgrade on its NAP ATM network causing all STAR TAP peers to lose connectivity. All peering was reestablished November 7. The NOC reported that Ameritech was not very forthcoming with information, so it had a hard time keeping users abreast of the situation, especially since this was the weekend of SC'2000 setup, and several of the applications were disabled (see Section C.1.b). The interactions with AADS have been documented and will be presented (when we find a sympathetic ear).

The NOC continues to seek permission from STAR TAP peers to gather host router network statistics for a planned STAR TAP animated traffic map. No accurate or useful statistics beyond MRTG graphs can be gathered for Euro-Link without closer cooperation and coordination among Euro-Link NRN members and the NOC.

John Hicks is looking into adapting MIRnet-type traffic graphs for the Euro-Link and TransPAC projects.

The NOC plans to post an edited half-hour streaming video program of iGrid 2000 by mid-November (still pending). [http://www.indiana.edu/~video/igrid2000/home.html#litton]

In early October, the Global NOC launched newly designed Euro-Link and STAR TAP NOC web pages [http://noc.startap.net and http://noc.euro-link.org]. The Global NOC web site ties together all NOC-supported network services [http://globalnoc.iu.edu/]. The Global NOC's new email address is <globalnoc@iu.edu>.

D. Euro-Link Performance Analysis Tools

Note: *The academic semester break in December suspended network performance testing and monitoring research.*

D.1.a. Network QoS of Real-Time Multimedia

Design is underway to combine CAVERNsoft's network monitoring and EVL's QoSIMoTo (QoS Internet Monitoring Tool) [www.evl.uic.edu/cavern/qosimoto] visualization, to form an integrated problem solving collaboratory (collaborative laboratory) that supports network management, monitoring, visualization and active testing. The goal is to create the equivalent of the "Microsoft Office" suite for applications developers, network students and researchers to collectively solve network problems.

D.1.b. Network Monitoring

Jason Leigh contacted NLANR's Basil Irwin to get an alpha release of Web100 software to test over international networks.

EVL is currently developing iCAN, the integrated Collaboratory for Analyzing Networks, which is software to enable several remote network researchers and application developers to collaboratively execute an application and monitor network utilization and other application-specific parameters. This will allow them to correlate, in real time, how the actions taken by an application directly impact the underlying networks, and vice-versa. The network researcher may also alter router configurations, such as a router's queuing algorithm, to determine how it may improve application throughput. Estimated completion of a usable version is end of Spring 2001. The prototype currently allows users to initiate bandwidth measurement experiments and perform SNMP queries of routers.

D.1.c. Low Latency State Transmission Over Long Distance Networks

In the area of high-throughput networking, Jason Leigh has performed experiments using CAVERNsoft's parallel socket library between EVL and SARA, and EVL and CERN. Parallel sockets performed extremely well in maximizing bandwidth utilization. He also found that overuse of parallel sockets did not have a significant detriment on throughput. We are now examining a network bottleneck between EVL and SARA that is limiting TCP bandwidth to 32Mbps over the 155Mbps link (see Section C.1.e).

Leigh has also begun work on a ***Reliable Blast UDP (RUDP)*** transmission scheme designed to accelerate reliable data transmission over fat networks. Caltech's Harvey Newman has expressed interest in employing this technology. In RUDP, the sender blasts all the data (each packet is identified by a sequence number) to the receiver. Upon receipt, the sequence numbers are checked, and any lost packets identified. The receiver then sends a lost packet report back to the sender through TCP. Upon receipt of the report, the sender retransmits the lost packets. The procedure continues until the receiver receives all packets. This technique is believed to be most effective when used in conjunction with QoS, since the guaranteed bandwidth will minimize transmission errors. The RUDP scheme exploits low transmission errors to maximize throughput.

The first results of the RUDP scheme have been gathered and are encouraging. The student doing the tests reports that from EVL to SARA (in Netherlands), we got 3.5Mbps using FTP, 32Mbps using parallel TCP, and 75Mbps effective bandwidth using RUDP when data size is 100MB. A more thorough analysis of the data is underway.

E. Accomplishments

E.1. Meetings

December 19, 2000. John Jamison of Juniper Systems, who is donating a router to STAR TAP, visited EVL to videotape Tom DeFanti and the CAVE for a promotional video for his company.

December 13, 2000. Indiana University hosted a STAR TAP/Euro-Link/TransPAC engineering meeting. The budding ITN was discussed, as were other projects involving STAR TAP, CA*net3, and the Global NOC. Extracts from Steve Peck's report follows:

- STAR TAP Juniper Router Deployment – Linda Winkler expects to receive and become familiar with the router by the end of December. IU engineers will do the same in January. STAR TAP router tools need to be modified.
- AADS Issues – Recent outages and lack of response continues to be documented.
- Network Tools – Due to the NSF's urging to report TransPAC traffic flow, Linda Winkler has turned on the CFLOWD data. IU engineers are currently choosing an appropriate visualization tool, possibly MADAS from UTK, to analyze this data.

December 12-13, 2000. John Jamison and Steve Peck held a Juniper Networks-sponsored JUNOS class at IUPUI. The main focus was to learn the IOS in preparation for the deployment of a Juniper router for STAR TAP and Euro-Link in 2001. Networking personnel from STAR TAP, IU, CA*net3, and Argonne National Laboratory attended.

December 14, 2000. Networking personnel from STAR TAP, AADS, Argonne, MREN and UIC met at EVL to resume discussion of I-WIRE, fiber co-location and optical STAR TAP configurations. Equipment has been ordered, a co-location site has been determined (Northwestern University's Chicago campus), and fiber build negotiations are progressing. Tom DeFanti and Joe Mambretti agreed that an optical STAR TAP would focus on international and big science project wavelength connectivity, rather than broader concepts like connecting US GigaPoPs.

December 4-5, 2000. Tom DeFanti attended an NSF-sponsored Workshop on the Future Revolution in Optical Communications and Networking, held at the DoubleTree Hotel in Crystal City, Virginia. The meeting was sponsored by the NSF Division on Electronics, Photonics and Device Technologies, and chaired by Alan Willner of University of Southern California.

December 1, 2000. Tom DeFanti attended an NSF Division of Advanced Networking Infrastructure and Research (ANIR)-sponsored Working Group on Middleware meeting in Berkeley, California. The meeting was chaired by David G. Messerschmitt of UC-Berkeley.

November 27-29, 2000. Tom DeFanti and Maxine Brown attended "The Networked Nation" CANARIE's 6th Advanced Networks Workshop. In attendance were NSF's Steve Goldstein, ANL's Linda Winkler, NU's Joe Mambretti, SURFnet's Kees Neggers, NORDUnet's Peter Villemoes and host Bill St. Arnaud.

- Optical STAR TAP was discussed.
- DeFanti presented, "StarLight: Applications-Oriented Optical Wavelength Switching for the Global Grid at STAR TAP."
- The day before the conference started, DeFanti gave a lecture at McGill University titled, "3D Telephony: Virtual Reality and the Ten Gigabit Telephone Call." He addressed the 3rd meeting of the Canadian Working Group on Virtualized Reality.
- DeFanti, Brown, Mambretti and Goldstein met Teleglobe's Yves Poppe to discuss future STAR TAP plans.
- DeFanti, Winkler, Mambretti and Neggers met representatives of Level3 about transatlantic wavelengths.
- DeFanti, Brown, Winkler, Mambretti and Goldstein met Joerg Micheel, WAND and NLANR MOAT, The University of Waikato, New Zealand, about developing Passive Monitoring Analysis (PMA) boxes for wavelengths; Hans-Werner Braun subsequently expressed strong interest.
- DeFanti, Brown, Winkler, Mambretti and Goldstein met Brian Pratt of edgeflow Inc. in Canada, about products based on OBGP and STAR TAP's (specifically Star Light's) potential interest.

November 21, 2000. Networking personnel from STAR TAP, AADS, Argonne, MREN and UIC met at EVL to resume discussion of I-WIRE, fiber co-location and Star Light configuration specifications. Ameritech fiber loans in Chicago are progressing up the chain of command at SBC. Joe Mambretti is in charge of negotiations. Charlie Catlett continues to work on I-WIRE fiber. Co-location issues persist; considering alternative co-lo spaces. Discussion of procuring/adding to Cisco 6509s properly configured for NU, UIC Goldberg and EVL, the Star Light co-lo facility and Argonne.

November 17, 2000. John Jamison (JJ) of Juniper Networks gave a presentation at UIC/EVL to representatives from UIC, NCSA, Argonne and Northwestern on MPLS.

November 16-17, 2000. Tom DeFanti, UIC, was keynote speaker at a symposium celebrating the 25th anniversary of the Fraunhofer-Institut fuer Graphische Datenverarbeitung in Darmstadt, Germany. Presented "3D Telephony: Virtual Reality and the Ten Gigabit Telephone Call."

November 6-9, 2000. SC'2000, attended by Maxine Brown, Alan Verlo, Chris Scharver and Eric He (UIC), and Linda Winkler (ANL). Tele-immersive demonstrations were run between Israel and Chicago (see C.1.b); also a real-time demonstration by UIC's Bob Grossman with Europe and Australia. Talks about SC Global, to be held at

SC'2001 in Denver, November 10-16, 2001, to link Denver with dozens of SC constellation sites distributed throughout the world, all of which support the Access Grid real-time, Internet-based videoconferencing system.

November 2, 2000. Networking personnel from STAR TAP, AADS, Argonne, MREN and UIC met at EVL to discuss I-WIRE, fiber co-location space possibilities and configuration specifications for Optical STAR TAP (Star Light). ANL's Charlie Catlett is working on securing I-WIRE fiber bids and UIC's Will Marcyniuk (UIC) is exploring a possible Cisco donation. SBC/Ameritech, who is donating fiber, wants to be designated as "official" administrative operators of endpoints.

October 29-30, 2000. Tom DeFanti and Maxine Brown attended the International Task Force and Application Strategy Council meetings at Internet2. Maxine gave presentations on iGrid 2000. During the week of the Fall meeting, Joel Mambretti gave a talk on iGrid 2000 in one of the conference sessions focused on applications. In all cases, the presentation was well received.

October 25, 2000. HPIIS Performance Review meeting was held in San Diego, CA to review the merits of the High Performance International Internet Services (HPIIS) program, notably the US/international scientific applications enabled, in order to recommend the program's continued support. PI's from TransPAC, Euro-Link and MIRnet presented data and fielded questions before a multi-disciplinary review panel chaired by UCSD's Larry Smarr.

October 24, 2000. Tom DeFanti gave a presentation describing the Star Light switching state concept and international science-oriented wavelengths, to NSF officers and networking experts assembled for the October 24 HPIIS Performance Review Meeting in San Diego, CA. In attendance were Steve Goldstein, Aubrey Bush, Tom Greene and Karen Sollins form NSF. Harvey Newman (Caltech), Larry Smarr (UCSD), Ian Foster (Argonne) and Kim Mish (NTON) were also in attendance.

October 5, 2000. Networking people fro STAR TAP, Ameritech, Argonne National Laboratory, MREN and UIC met at EVL to discuss I-WIRE, fiber co-location possibilities and configuration specifications for Optical STAR TAP.

E.1.a. Future Meetings

January 2001. Discussions are underway about the Joint Techs conference in Hawaii, sponsored by NLANR/Internet2/APAN/TransPAC. A BOF session on NOC services and interaction between engineering staffs, is tentatively planned. Invited participants are the Global NOC, APAN, and CA*net3.

E.2. Publications

Y. Zhou, T. Murata, T. DeFanti, and H. Zhang, "Fuzzy-Timing Petri Net Modeling and Simulation of a Networked Virtual Environment – NICE," Institute of Electronics, Information and Communication Engineers (IEICE) Transactions, Fundamentals, Special Section on Concurrent Systems Technology, Vol. E83-A, No. 11, November 2000. [http://www.euro-link.org/PUBLICATIONS/FuzzyTiming_IEICE_Murata_June00.pdf]

K. Park, Y. Cho, N. Krishnaprasad, C. Scharver, M. Lewis, J. Leigh, A. Johnson, "CAVERNsoft G2: A Toolkit for High Performance Tele-Immersive Collaboration," Proceedings of the ACM Symposium on Virtual Reality Software and Technology 2000, October 22-25, 2000, Seoul, Korea, pp. 8-15.

Y. Zhou, T. Murata, T. DeFanti, "Modeling and Performance Analysis Using Extended Fuzz-Timing Petri Nets for Networked Virtual Environments," IEEE Transactions on Systems, Man and Cybernetics, Part B, Vol. 30, No. 5, pp. 737-756, October 2000. [http://www.euro-link.org/PUBLICATIONS/Yi_CollabVirtualEnv_IEEE.pdf]

E.3. Software Releases

On December 22, CAVERNsoft G2, version 1.2.1, was released. [http://www.evl.uic.edu/cavern/cavernG2/] CAVERNsoft is an open source C++ toolkit for building collaborative, networked VR applications. Its main strength is in providing networking capabilities for supporting high-throughput collaborative applications. These applications need not be CAVE applications. CAVERNsoft also provides modules for accelerating the construction of collaborative virtual reality applications.

Version 1.2.1 contains the following features:

- New, easier installation and compilation procedure for CAVERNsoft programs
- Bug fixes for the networking modules
- Separation of CAVERNsoft and Globus downloads
- Enhanced CAVERNsoft G2 higher-level modules, including Linux support

What to expect in the future:

- CAVERNsoft on PC-based graphics clusters
- More networking protocol support for low latency, reliable transmission
- More networking protocol support for high bandwidth, bulk data transfer

CAVERNsoft G2, version 1.2 was released in time for the October 17-19 CAVERNUS workshop at Old Dominion University (broadcasted over the Access Grid). Version 1.2 contains the following features:

- Graphical modules now all work under Linux as well, with Linux version of Performer. All other modules work in Windows, IRIX, Solaris, Linux and FreeBSD
- Inverse kinematic articulated avatars with two-arm support (provided the user has an additional tracker)
- Update of coanim (collaborative animator/flip-book program) and LIMBO (application shell) with new inverse kinematic articulated avatars
- Bug fixes to networking modules
- Remote File IO classes with the ability to read the contents of remote directory trees
- CAVERNsoft Database class now supports UDP data reflection as well as TCP
- Performance monitoring added to the parallel TCP classes
- TCP client class provides setsockopt to give more user control of underlying networks
- The networking module can be downloaded separately from higher level graphical modules so that updates can progress independently of each other.

The following features, to be added, are now in the testing phase; details at http://www.evl.uic.edu/cavern/cavernG2/changes.html

- Generic network-aware Performer manipulators to make shared object manipulation easier to code. Provides both scale, rotate and translate support.
- Performer background file loader - downloads models off remote sites and loads them into a Performer scene graph in the background.
- TIDE 2 will ultimately replace the collaborative flipbook animator (coanim), and CAVERNsoft will run on a Linux cluster (future goal)

QoSIMoTo (QoS Internet Monitoring Tool) [www.evl.uic.edu/cavern/qosimoto] is available on the web for IRIX and Linux.

F. Collaboration Activities

- Working with SARA in The Netherlands to experiment with an EVL-designed packet-level Forward Error Correction scheme.
- Working with Harvey Newman at Caltech and Olivier Martin at CERN on DiffServ tests.
- Working with Hank Nussbacher and associates at the Technion University on Telecom 2000.

G. Problems

No significant problems were encountered this quarter.

H. Any Proposed Changes in Future Plans

No changes to date.

I. Summary of Award Expenditures (October-December)

Euro-Link Expenditures – Year 2			
Itemized Expenses	**Year 2 Budget**	**Current Quarter Expenses**	**Year 2 to Date**
Salaries and Fringe Benefits	228,112	24,508	109,740
Travel	50,000	8,855	12,470
Computer Equipment and Supplies	50,000	0	22,373
Subcontracts/Services (Ameritech and Indiana U.)	327,821	1,410	51,410
Other (HPIIS services to NRNs)	1,600,000	0	1,600,000
Indirect Costs	167,621	16,680	80,658
Total Expenditures	**2,423,554**	**51,453**	**1,876,651**

Euro-Link Expenditures – Cumulative			
Itemized Expenses	**Year 1 Spent**	**Year 2 to Date**	**Cumulative (Years 1+2) Spent**
Salaries and Fringe Benefits	212,923	109,740	322,663
Travel	50,000	12,470	62,470
Computer Equipment and Supplies	100,000	22,373	122,373
Subcontracts/Services (Ameritech and Indiana U.)	96,780	51,410	148,190
Other (HPIIS services to NRNs)	1,600,000	1,600,000	3,200,000
Indirect Costs	159,221	80,658	239,879
Total Expenditures	**2,218,924**	**1,876,651**	**4,095,575**