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September 2001 Quarterly Status Report

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A. Significant Results or Events in the Past Quarter

- Direct BGP peering between UIC/EVL and CERN was established; preliminary Reliable Blast UDP (RUDP) bandwidth tests over CERN's 100Mbps underway.
- RENATER2's peering with the STAR TAP router was reestablished.
- The StarLight web site was launched.
- NORDUnet connected an OC-3 to StarLight
- Explanation/pointers related to the STAR TAP ITN project posted to the web site
- Working with SARA on network performance studies over long, fat networks using various transmission techniques (TCP, UDP, FEC, RUDP).
- Participated in tele-collaborative VR event in Austria networked to the US and various European sites.

- The first prototype of Unified Collaboratory for Analyzing Networks (uCAN) completed.

B. Expected Results or Events in the Coming Quarter

- SURFnet will connect a dedicated 2.5Gb research network to STAR TAP.
- HEAnet (Ireland) and BELNET (Belgium) will connect to STAR TAP
- Brazil's Sao Paulo Foundation for the Advancement of Research (FAPESP) and RNP networks will connect to STAR TAP
- A second IPv6 Router will be installed and operational at StarLight.
- The Global NOC will issue an online newsletter and quarterly reports using the Footprints system.
- A cluster-to-cluster data transfer (likely a stereo animation) will be sent over SURFnet's StarLight link, and displayed on LCD panel systems at both endpoints (EVL and Amsterdam)

C. Summary of Technical Activities

C.1. Euro-Link Network Status and Institutions

C.1.a. CERN

On September 28, Harvey Newman reported that the DOE/NSF High Energy Physics Transatlantic Network Working Group approved the following US/CERN production link timeline:

November 2001	Upgrade from OC-3 to two unprotected OC-3s; the second OC-3 dedicated to research
April 2002	Upgrade to OC-12 (622Mb), to support research production traffic between IN2P3 and CERN to vBNS, ESnet, Abilene, etc. (IN2P3 is the National Institute of Nuclear and Particle Physics, a CNRS (French National Center for Scientific Research) institute that currently sends traffic over the CERN link to STAR TAP.)
After 2002	Upgrade by a factor of ~2 each year, to reach 10Gbps by 2005 or 2006

The European Union (EU) funded "DataTAG" (Research and Technological Development of a Trans-Atlantic Grid) research link is planned for summer 2002; CERN will terminate an OC-48 (2.5Gb) at StarLight. This link will be purely for research, and will be used to carry out various network measurements, demonstrations and experiments. It will support a 2.5Gb trans-Atlantic link to StarLight with first year matching funds provided by the NSF HPIIS Euro-Link award. The project will last two years, with a starting date of January 1, 2002. DataTAG partners are CERN (prime contractor), Particle Physics And Astronomy Council (PPARC) in the United Kingdom, the Italian National Physics Network (INFN) and the University of Amsterdam in The Netherlands.

EVL currently collaborates with CERN on various network transfer protocol tests on its existing 155Mb circuit. In August, EVL student Eric He reported that direct BGP peering between UIC/EVL and CERN was up, and preliminary Reliable Blast UDP (RUDP) bandwidth tests over CERN's link were showing good results. In September, he reported comparative results of similar RUDP tests between EVL and SARA. See Section D.3.c.

C.1.b. IUCC

No activity to report.

C.1.c. NORDUnet

In spring 2001, NORDUnet completed a tender for USA connectivity that was to take effect July 1, 2001. NORDUnet contracted for an STM-4c (OC-12, 622Mbps) link between Stockholm and the Abilene PoP in New York, and an OC-3 (155Mbps) from New York to STAR TAP in Chicago. NORDUnet switched providers, from Teleglobe to KPNQwest. Because KPNQwest did not order a Chicago local loop for NORDUnet in a timely manner, we invited NORDUnet to locate at the StarLight facility.

A series of problems caused delays. By early August, the OC-3c circuit from Qwest's NY PoP to StarLight was finally working. NORDUnet had installation problems first with its New York router, and then transmission problems with its Chicago router. Because of the latter problem, and because NORDUnet formally terminated Teleglobe services on August 31, Abilene offered to provide transit between NORDUnet in NY and the US Federal research networks, as well as Abilene international peers (including those connected through STAR TAP), *on a*

temporary basis, until problems were resolved. The Chicago router problem was quickly fixed, and the new NORDUnet link was operational August 31.

C.1.d. Renater2

On September 20, RENATER2 peering with the STAR TAP router was reestablished after a protracted disruption due to France Telecom circuit problems. Technical information on the STAR TAP web site reflects the change.

C.1.e. SURFnet

The past quarter was spent moving SURFnet's PoP from New York to StarLight, and bringing up one of two OC-12 (622Mb) production networks. In addition, I-WIRE fiber was installed between the Qwest PoP in Chicago and StarLight, and Abilene installed an OC-48 core router at the Qwest PoP. Using I-WIRE fiber, Abilene now has a 1GbE connection at StarLight, enabling Abilene to peer with SURFnet and exchange traffic. [Note: All these activities were finally completed in November 2001.]

Teleglobe provided the OC-12 currently in production and is also providing the 2.5Gb link from Amsterdam to StarLight, due to be operational in November. Global Crossing is providing their second OC-12 production link.

C.2. Engineering Services

C.2.a. StarLight/Abilene Connectivity

Abilene placed an OC-48 core router at the Qwest PoP in Chicago and has ordered an OC-48c backbone circuit to Indianapolis. Abilene uses two pairs of I-WIRE fiber to connect to StarLight, one for StarLight participants (e.g., SURFnet) and one for MREN participants. NORDUnet peers with Abilene in New York and TransPAC peers with Abilene in Seattle.

C.2.b. StarLight/STAR TAP Connectivity

STAR TAP pays for two OC-12 connections from StarLight to STAR TAP (at the Ameritech NAP). One OC-12 connection is for SURFnet's use; the other OC-12 connection carries non-Abilene traffic from other research networks located at StarLight.

C.2.c. StarLight/STAR TAP Documentation

On October 17, the StarLight web site was launched. <http://www.startap.net/starlight/>

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

Several STAR TAP members, new and old, are opting to peer with Abilene at one of the US coasts, where they can pass traffic to US universities and can use the Abilene ITN service to transmit traffic to other international research networks. They are then bringing smaller DS-3 circuits to Chicago to continue to peer at STAR TAP.

- SingAREN, in September, began migrating to a new telco for its international and US domestic circuits. SingAREN now comes to California where it peers with Abilene and takes advantage of its ITN service. A new circuit to STAR TAP will be available sometime between mid-October and early November.

- Taiwan's TANet2 will soon transition to Abilene's ITN via the Pacific Northwest GigaPoP "Pacific Wave" peering service, while maintaining a DS-3 link to STAR TAP (scheduled for completion November 21). Asia Global Crossing-Taiwan Fixed Network Alliance is the new contractor.

- RNP2, the network that serves universities and research centers in Brazil, connected via AMPATH in Miami to Abilene's ITN service; they are also connecting to STAR TAP. Participation in CERN high-energy physics experiments was among a list of expected uses of the new connection. RNP2 was having trouble with its New York router, so connectivity has been delayed. Note: Cable & Wireless has DS-3 local loops ready for both RNP2 and ANSP (another Brazilian R&E network) in Chicago.

In August, a list of International Transit Network participants were added to the STAR TAP networks web page and map. <http://www.startap.net/NETWORKS/>

C.2.e. STAR TAP Router and Peering

In September, a link to CAIDA's Monitoring Multicast on a Global Scale (MANTRA) project [http://www.caida.org/tools/measurement/mantra/] was added to the STAR TAP/Engineering web page. Snapshots of the STAR TAP router's multicast activities appear at: [http://www.caida.org/tools/measurement/Mantra/routers/STARTAP/processed/index.html].

In early August, STAR TAP engineer Linda Winkler began running Caimis' RouteReporter software on the STAR TAP router <www.caimis.com/products/te_manager/routereporter.shtml>. The software monitors and reports on all BGP routing activity, and provides real-time and off-line analysis of routing performance. If it proves useful, a page displaying the data will be added to the STAR TAP and Euro-Link websites.

Four new OC-3 circuits are being delivered by Teleglobe to STAR TAP Belgium's BELNET, Ireland's HEAnet, Korea's KISTI and Thailand's UniNet. (Note: KISTI previously shared a DS-3 link with CERNET and Teleglobe is moving them to a 45Mb PVC on a new OC-3 into AADS.) HEAnet submitted a proposal to NSF requesting permission to connect to STAR TAP, and it was approved; see <http://www.heanet.ie/Heanet/projects/nat_infrastruct/nsf-star-tap.html>. HEAnet's connection is expected in early October. To our knowledge, BELNET and UniNet have not yet submitted proposals to NSF requesting permission to connect to STAR TAP; Tom DeFanti will contact them to submit proposals, but in the meantime we will work with them to minimize connectivity delays.

Brazil's RNP network's DS-3 is ready for testing on the Ameritech end; however, RNP's New York router isn't yet available. The original July 12 connection date of Brazil's Sao Paulo research network FAPESP-ANSP has been pushed back due to FAPESP inter-office delays. The FAPESP 155 Mbps link to Miami has been operational since December 2000. NSF approved the FAPESP connection to STAR TAP on December 21, 2000; RNP2 did not submit a proposal to NSF, but in the meantime we are working with them to minimize connectivity delays. Cable & Wireless is expected to connect both RNP and FAPESP in October.

Throughout July and August, STAR TAP engineer Linda Winkler worked with Juniper to resolve intermittent stability problems associated with the M5 STAR TAP/TransPAC router installed last May at the AADS/NAP. Note: In October 2001, TransPAC moved to the Juniper M10 at StarLight, so the M5 STAR TAP Router is no longer shared.

C.2.f. 6TAP

ESnet staff has provided a second IPv6 router for StarLight. Once installed, the StarLight community will be able to participate in the national IPv6 testbed operated from Lawrence Berkeley National Laboratory. Eventually, Linda Winkler will remove the one at STAR TAP and backhaul IPv6 traffic from the NAP to the StarLight facility.

C.2.g. DiffServ

No updates to report.

C.3. NOC Services

Publication of the first Euro-Link quarterly NOC report using the new Footprints trouble ticket system has been postponed to next quarter. Although data has been collected, the Global NOC reported its software engineering group is in the process of automating and improving its reporting mechanisms.

In August, the NOC added a 24x7 NOC staffing chart to its "Contacts" section of the Euro-Link NOC web page, listing technician schedules. In July, the NOC announced its new Footprints trouble ticket reporting system. Online "snapshot" reports of open trouble tickets are available for each NOC-supported network (TransPAC, STAR TAP, Euro-Link, AMPATH, and Abilene). The report is updated twice an hour, and details ticket title and number, priority and status, date created, and a short summary of the ticket's information. <http://noc.euro-link.org>

Ongoing activities: The Global Research NOC is preparing to issue a regular, online newsletter.

D. Euro-Link Performance Analysis Tools

D.1. Network Monitoring Tools

D.1.a. Bandwidth Utilization Radar Map

No progress due to previous M5 router problems.

D.1.b. uCAN: Unified Collaboratory for Analyzing Networks

In September, EVL student Naveen Krishnaprasad completed the first prototype of the Unified Collaboratory for Analyzing Networks (uCAN). uCAN enables remote network researchers and application developers to collaboratively execute an application and monitor network utilization, as well as other application-specific parameters. uCAN also allows users to correlate, in real time, how the actions taken by an application directly impact the underlying networks, and vice versa. A network researcher can also alter router configurations, such as a router's queuing algorithm, to determine how it might improve application throughput.

The current prototype contains capabilities for active testing, visualization and router management, and is fully collaborative. It has a proxy to mediate router queries using SNMP, providing ubiquitous access to authorized users on a network. In the future, specific permissions will be assigned to specific users so network operators can filter out sensitive information. uCAN has a collaborative widget interface that enables the development of a wide range of collaborative desktop applications. This interface will eventually be integrated into a library for CAVERNsoft. The next step is to package uCAN for alpha testing between EVL and users of StarLight and STAR TAP.

D.2. Network Performance Studies for European/US Collaborative Art Project

EVL PhD graduate Dave Pape developed Yggdrasil (YG), a script-based, authoring environment for networked VR applications, which enables non-programmers to create effective, behavior-rich art and science virtual-reality environments. EVL co-director Dan Sandin extended the library for behaviors, and worked with EVL students Dave Pape, Alex Hill and Joseph Tremonti on the development and execution of network performance tests to Austria, Sweden, Hungary and The Netherlands, throughout the Ars Electronica Festival in Austria, September 1-6. [http://www.aec.at] This is an international, large-scale art festival held annually in Linz, Austria, and sponsored by the Ars Electronica Center (AEC).

AEC commissioned the VR experience, "EVL: Alive on the Grid," to demonstrate both shared and tele-immersive applications based on EVL software YG and CAVERNsoft. This demonstration connected five remote and two internal participants for the entire five-days of the Festival. Fourteen EVL students and two EVL faculty members attended.

There were two measured components of the communication between the networked VR systems: (1) audio tele-conferencing *(aconf)* and (2) a dynamic database representing the virtual worlds. Audio teleconferencing generated roughly 15 kilobytes of traffic per site, and was fairly constant. (*aconf* uses CAVERNsoft as its networking layer.) The VR worlds database was fairly complex, and included 1,188 objects, 363 sounds, ~1,200 dynamic nodes, ~14,000 database entries and 2.5 gigabytes of data. This represents the largest shared VR experience done by EVL in terms of shared virtual entities. The largest number of international collaborators (17) simultaneously working in a virtual environment was done by Jason Leigh and Andrew Johnson at Supercomputing 1996.

Network constraints among participants were as follows: maximum bandwidth measured out of Ars Electronica Center (AEC) was 1.5Mbps (using a 2Mb link). Connections among EVL (Chicago) to SARA (Amsterdam), SUNY (New York), Indiana University (Indiana) and the Interactive Institute (Umea, Sweden) were 8Mbps. The Budapest connection went over Hungary's commodity network, measuring less than 1Mbps, and frequently caused a bottleneck.

During the rehearsal, information was served from the AEC CAVE, on a system using caching repeaters for the database. One repeater at AEC was used initially to communicate to external sites, but a 1.5Mbps bottleneck was found at AEC, and only able to handle two internal (at AEC) and one external site at any time. As more external sites were added, the applications lurched and stuttered. To redistribute the data load over the network, and take advantage of other good connectivity, Pape ran a caching repeater at AEC linked to a caching repeater at EVL and

all external sites except Budapest. This setup allowed up to seven sites to operate smoothly, with the exception of interruptions caused when sites joined the system. Once attached, a site would download the system and it would even out. Seven sites connected with bandwidth measured by Netstat 1.5 Mbps from AEC and 4 Mbps of outgoing traffic from EVL. Surprisingly, audio was able to survive at modest levels even during peak periods.

General network test results: In the morning (Linz time), bandwidth was normally 1.5-1.6 Mbps each way. In the afternoon, as the US woke up, it would decrease, sometimes dipping as low as 200Kbps. The routing, and often the afternoon bandwidth, was asymmetric. At times, we would get 1+ Mbps one way, and 250 Kbps the other way (the US-to-Austria direction being faster). Round trip times were fairly consistent, averaging 140-150 ms. All of the ping tests reported 0% packet loss.

The highest bandwidth recorded on the EVL repeater machine was when seven host sites connected on the third day (AEC CAVE, AEC ImmersaDesk, EVL, Sweden, New York, Indiana, and Hungary). At that point, Netstat reported roughly 550 Kbytes/second (~4.4 Mbps) of outgoing traffic; we did notice a little bit of audio breakup. This would have been on EVL's "Kona" Onyx computer, with a 10 Mbps network interface. One possibility for the audio breakup is that the reflector program couldn't keep up with the number of packets, or that the EVL reflector to AEC connection lost packets in the afternoon.

The event was a success although we had some stability problems when multiple sites were attached, which caused the repeaters to crash (but never with few sites). An investigation of the stability problems is underway. Presumably, congestion at the repeaters is the culprit, but Pape is setting up automatic robot clients and servers to confirm it. We will continue testing this large application in both national and international contexts, including a public show at EVL on October 27.

D.3. High-Bandwidth Transmission Over Long Distance Networks

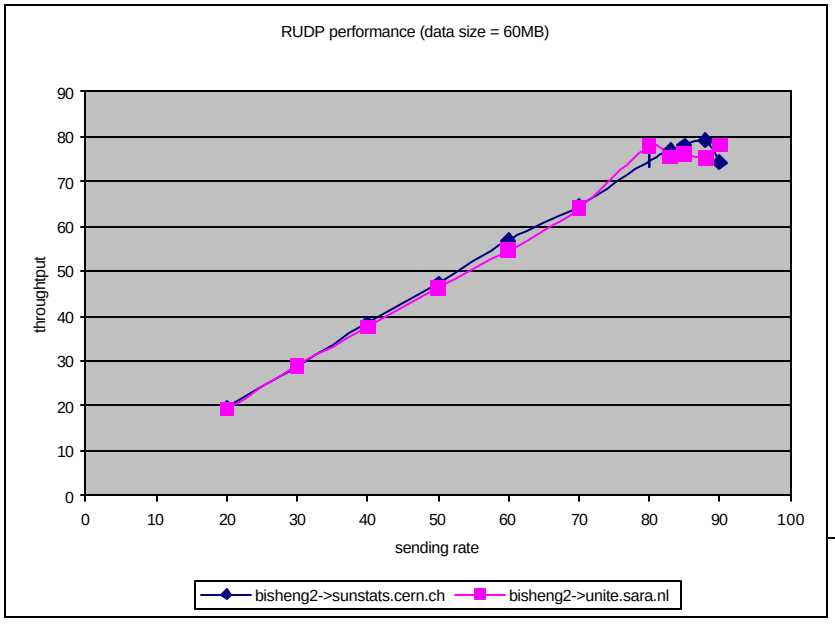
D.3.a. TeraVision: Streaming Video Over Gigabit Networks

EVL student Brenda Lopez is working on a stereo animation as part of Jason Leigh's AGAVE-based Teravision project. She is modifying and sequencing a series of Dan Sandin's fractal visualizations that will be streamed through an EVL cluster to SARA in Amsterdam over SURFnet's new 2.5Gb StarLight link. Images will be output to a tiled LCD display.

D.3.b. Vital Statistics Monitor (VitaMon)

Lopez is designing a vital statistics monitor (VitaMon), a graphical optical traffic map that shows all incoming/ outgoing bandwidth among StarLight sites. VitaMon will employ RTPL to measure end-to-end bandwidth and delay between multiple points connected to StarLight, and will be used by collaborators running networked applications. Alan Verlo, Jason Leigh, and Cees De Laat are in the process of setting up a machine at EVL to serve as EVL's RTPL server.

D.3.c. Reliable Blast UDP (RUDP)



In September 2001, after some code revisions, EVL student Eric He performed RUDP experiments over the OC-3 link between EVL and SARA (in Amsterdam), and EVL and CERN. Available bandwidth is constrained by the 100Mbps NICs on both ends. This graph shows that throughput reaches almost 80Mbps.

RUDP tests were also performed over a 1Gbps link between EVL, Northwestern University and StarLight. In this case, RUDP was only able to reach 450Mbps, whereas raw UDP was able to reach 800Mbps.

The cause of the poorer performance is due to a lack of bus bandwidth on our current PC cluster (133MHz x 64bits = 0.99GBytes/sec). Our new PC cluster has three times the bus bandwidth (400MHz x 64bits=2.98GBytes/s), and we believe this will solve the problem.

D.3.d. Simple Available Bandwidth Utilization Library (SABUL) for High-Speed Wide Area Networks

In July 2001, UIC/EVL and UIC Laboratory for Advanced Computing (LAC, Bob Grossman, director) performed parallel TCP and RUDP tests between EVL and SARA; a UIC Technical Report is available; see Section E.2. Findings are summarized below.

SABUL is a C++ library for large data transfers over high-speed wide-area networks. It is a rate-control-based protocol similar to NETBLT, but with two fundamental improvements over NETBLT and similar implementations of rate-controlled Reliable UDP protocols: the use of both TCP and UDP channels in the protocol, and continuous updating of communication state information, which helps control the data transfer rate to reduce packet loss.

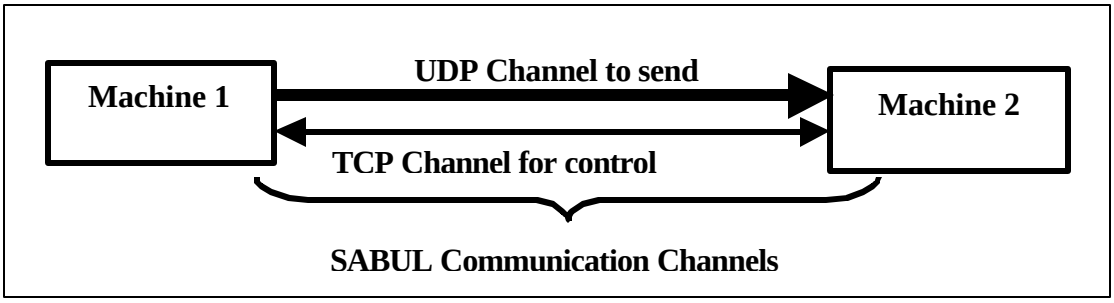


Figure 1: The UDP channel is used to transfer large amounts of data from Sender to Receiver. The Receiver sends state information of the packet loss and the list of lost packets to the Sender using the TCP channel. The Sender dynamically updates its sending rate based on packet loss and thereby reaches a data rate that minimizes packet loss. The SABUL library has been implemented in C++ on a Linux operating system. It has now been ported to various Unix platforms (Solaris, AIX, Irix, and Free BSD).

Experimental Results. The SABUL library was utilized for data transfer between two Linux nodes at University of Michigan in Ann Arbor and NCAR, Boulder, Colorado. Each node had 256MB of RAM and fast Ethernet cards. The machines were connected through Internet2's Abilene network at OC-3 (155 Mbps). Table 1 shows the results of our tests along with results obtained using *Iperf*, a network performance tool, and *PSockets*, a library that stripes data across multiple TCP sockets. When using Iperf the network was tuned to an optimal TCP window size of 512.5KB. SABUL was tuned to have a maximum packet loss of one percent.

Node Location	Library/Utility used	Throughput in Mbps	Packet loss %
Boulder to Ann Arbor	Iperf with network tuning	83.3	0.0
	PSockets (19 sockets)	85.27	0.085
	SABUL	92.65	0.032
Ann Arbor to Boulder	Iperf with network tuning	10.1	0.11
	PSockets (19 sockets)	40.68	0.57
	SABUL	63.87	1.1

Table 1: Performance of SABUL over Abilene network

Table 1 shows that SABUL was able to achieve higher throughput than Iperf with TCP window tuning (a specific kind of network tuning at the application level) and PSockets. At the same time, SABUL was able to maintain packet loss to be less than 1%. Figures 2 and 3 show the change in data rate as well as packet loss rate as SABUL tunes itself to have a packet loss of 1%. These graphs are results of runs between Ann Arbor and Boulder.

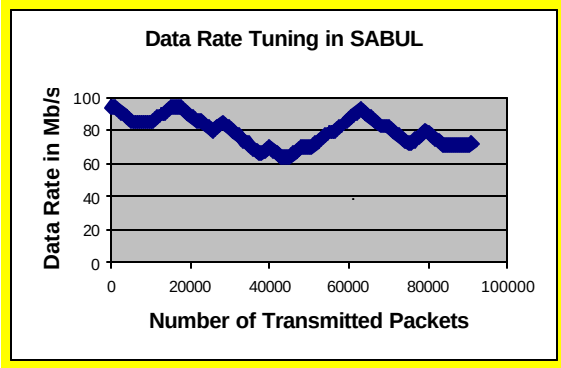


Figure 2: SABUL date rate tuning

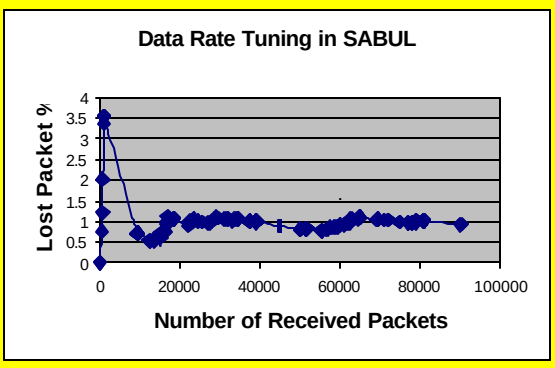


Figure 3: Packet loss percentage in SABUL

Node Location	Library/Utility Used	Throughput (Mbps)	Packet Loss %
Amsterdam to Ann Arbor	Iperf with network tuning	39.4	0.27
	SABUL	90.47	0.01
Ann Arbor to Amsterdam	Iperf with network tuning	20.0	0.62
	SABUL	39.0	0.6
UIC (EVL) to Amsterdam	Iperf with network tuning	58.04	0.12
	SABUL	70.66	0.15
Amsterdam to UIC (EVL)	Iperf with network tuning	14.88	0.68
	SABUL	16.83	2.26

Table 2: Performance of SABUL over an OC-3 link

Table 2 compares the results of throughput and packet loss obtained while sending or receiving data from nodes at Ann Arbor or Chicago to a node in Amsterdam. It can be clearly seen that the throughput performance of SABUL is much superior to that of a single TCP socket tuned with appropriate TCP window size.

Conclusion. We are not proposing that the days of TCP are numbered. Due to its widespread acceptance and many refinements over the years, it should still serve well as a general-purpose reliable transport protocol. We see SABUL as a more specialized protocol serving the needs of applications that require large data transfers on high-bandwidth networks over long distances.

D.3.e. Ultra-High-Bandwidth Transmission Over Long Distance Networks

In September, EVL students Eric He and Rajvikram Singh tested various transport protocols over a 1GigE link, sending data from EVL to StarLight to Northwestern University (Evanston campus). They were able to achieve 850Mbps over UDP, 300Mbps via TCP, 400Mbps via Parallel TCP and 500Mbps via RUDP.

Over the 1G link between EVL and Starlight two 1024x768 animation sequences were streamed in parallel (using TCP) achieving a frame rate of 15 frames per second. The two animation sequences were generated by two nodes of a cluster at Starlight and streamed to two nodes of a PC cluster at EVL. In a same experiment within EVL nearly 30 frames per second was achieved. They reported a noticeable "glitch" every minute into the animation, which they believe is a network glitch, and the likely cause of the poor throughput. Investigations are underway.

Last July, in anticipation of SURFnet's 2.5Gb connection to STAR TAP, Jason Leigh began talking with Cees de Laat, Paul Weilinga (SARA) and Henri Bal (Vrje University, Amsterdam) to develop ideas for testing bandwidth-intensive applications over SURFnet. SARA and SURFnet are both interested in attempting to stream compressed CAVE video. EVL obtained GigE cards for its CAVE Onyx in preparation for this. Vrje University is interested in testing parallel cluster-to-cluster simulation and visualization codes. EVL shared information about its cluster with Vrje to maximize compatibility between systems. In September, Cees DeLaat (SURFnet and University of Amsterdam) reported that a cluster in Amsterdam would be ready for use by the end of October, at which time we can begin throughput and graphics streaming tests overseas.

Bob Grossman, director of UIC's National Center Data Mining (NCDM), wants to install a data mining server in Amsterdam and performing tera-mining queries among sites in Chicago, Amsterdam and Canada. EVL is in the process of building and optimizing its Linux cluster to maximize throughput over GigE networks. In the past, EVL was able to only achieve ~500Mbps (local area) PC transmission rate out of the box. With appropriate tuning using Interrupt Coalescing and Jumbo frames, EVL has been able to achieve bandwidth of 850Mbps. Other applications that EVL would like to test over SURFnet include VNC for streaming of clustered desktops, WireGL for streaming OpenGL visualizations and streaming stereoscopic visualizations.

D.3.f. Quality of service Adaptive Networking Toolkit (Quanta)

Eric He and Jason Leigh are combining their past work on Parallel TCP, RUDP, and Forward Error Correction into a system called Quanta, which will provide an intelligent API for application programmers to translate high-level data distribution requirements into low-level optimized networking protocols and parameter settings. This work is being especially targeted for future high-speed optical networks.

E. Accomplishments

E.1. Meetings

September 11-13, 2001. Tom DeFanti, Maxine Brown, Linda Winkler and Joe Mambretti attended two TERENA meetings in Amsterdam. September 11-12, TERENA held a "closed" meeting for those groups running international lambdas (or who will soon announce their firm plans and time schedule to do so); StarLight, CANARIE, SURFnet, UKERNA and Internet2 were represented. The purpose of this meeting was to let these groups have an opportunity to discuss practical, technical and tactical matters. September 12-13, TERENA hosted an International Lambda Workshop to discuss future research and education opportunities. DeFanti gave a technical overview of lambda networks and the StarLight project. Winkler talked about I-WIRE experience in procuring lambdas and Mambretti talked about Chicago's CivicNet and OMNInet metro initiatives. <http://www.terena.nl/conf/lambda/>

September 10, 2001. Tom DeFanti, Maxine Brown, Joe Mambretti and Tom Greene (NSF) visited SARA to talk about iGrid 2002 with Jacqueline Tammenoms Bakker (head of the GigaPort project) and Jan Langelaar (director of the WTCW-Amsterdam Science & Technology Centre, which is where SARA and University of Amsterdam are located). The meeting went very well, with WTCW agreeing to host and support iGrid 2002. Note: Additional meetings were held with Cees de Laat of University of Amsterdam on September 14.

September 5-7, 2001. Jason Leigh met with networking researchers at KISTI (Korea) to discuss future research ideas for KREONET. The plan is to reinstate and extend past experiments on Parallel TCP, RUDP and DiffServ. Jason also met with KISTI's visualization group and trained them on CAVERNsoft and tele-immersion.

September 4, 2001. A StarLight Media Announcement brainstorming meeting was held at EVL. Joe Mambretti (NU) and Andy Schmidt (EVL) gave Tom Garritano (NSF) and Paul Francuch (UIC) a tour of the StarLight facility before the meeting. Also present were EVL's Tom DeFanti, Maxine Brown, Laura Wolf and Andy Schmidt, and Argonne's Linda Winkler.

August 27, 2001. Jason Leigh, University of Amsterdam's Cees de Laat, Joe Mambretti, Linda Winkler and Andy Schmidt met at StarLight to discuss StarLight application requirements and future network research ideas.

August 23-24, 2001. Tom DeFanti, Maxine Brown and Linda Winkler attended the NLANR HPIIS Workshop <http://moat.nlanr.net/Workshops/HPIIS-2001/>.

August 15-17, 2001. Tom DeFanti and Maxine Brown attended the FIU AMPATH Workshop to Identify Areas of Scientific Collaboration between the US and the AMPATH Service Area, held at the Florida International University Kovens Conference Center at Biscayne Bay Campus <http://www.ampath.fiu.edu/events.htm>. DeFanti was one of several interviewed by Discovery Channel Latin America for the television documentary *Vida @ Linea*.

August 13, 2001. Chip Cox of NSF ANIR visited EVL to learn more about current STAR TAP, Euro-Link and StarLight activities. Those attending this meeting included Tom DeFanti, Maxine Brown, Jason Leigh, Andy Schmidt, Linda Winkler, Bob Grossman and Joe Mambretti.

August 10, 2001. Tom DeFanti and Bob Grossman discussed StarLight equipment needs for an upcoming NSF RI proposal we wish to submit.

August 2, 2001. EVL's Jason Leigh hosted the Canadian Communications Research Centre's John Spence and Eric Tsang to discuss possible VR/tele-immersion and Access Grid collaborations. The Centre, a Canadian federal government laboratory, is one of the main testbeds in Canada supporting CANARIE and CA*net3.

July 26, 2001. Maxine Brown hosted Tom Prudhomme of NCSA, Peter Ranelli of University of Southern Mississippi's Center of Higher Learning (located at the Stennis Space Center) and Mississippi state senators Terry Burton and Scott Cuevas to discuss EVL's tele-immersion and global networking efforts. The state senators were most impressed by the State of Illinois' I-WIRE initiative.

July 16, 2001. The Advanced Collaborative Environments Working Group met at the Global Grid Forum 2 in Washington, D.C. Meeting minutes and slides to be posted to <http://calder.ncsa.uiuc.edu/ACE-grid/>.

July 10, 2001. Jason Leigh hosted Tor Langeland and Kåre P. Villanger from Christian Michelson Research Laboratory, in Norway, who are interested in working with EVL on research in collaborative virtual environments over Euro-Link. They are also interested in hosting an EVL student as an intern next summer.

E.2. Publications

R.L. Grossman, M. Mazzucco, Y. Pan, H. Sivakumar, Q. Zhang, "Simple Available Bandwidth Utilization Library (SABUL) for High-Speed Wide Area Networks," University of Illinois at Chicago, Department of Mathematics, Statistics and Computer Science, Laboratory for Advanced Computing, Technical Report, 2001.

Dave Pape, Ygdrasil, PhD Dissertation, Department of Computer Science, Electronic Visualization Laboratory, University of Illinois at Chicago, 2001.

Naveen Krishnaprasad, Unified Collaboratory for Analyzing Networks, Master's Thesis, Department of Computer Science, Electronic Visualization Laboratory, University of Illinois at Chicago, 2001.

E.3. Software Releases

No new software upgrades or releases.

F. Collaboration Activities

Tom DeFanti and Maxine Brown are working with people in the Netherlands's GigaPort Project and SURFnet5 to plan an iGrid event in Amsterdam next September 2002, to showcase 10Gigabit applications. In July, Maxine sent an iGrid 2002 *Invited* Call for Participation to computational scientists and engineers whose sites will be connected to I-WIRE, the TeraGrid and StarLight. This resulted in four proposals and several expressions of interest. A general Call for Participation will soon be distributed.

Working with SARA to do network performance studies over long, fat networks using various transmission techniques (TCP, UDP, FEC, RUDP).

Working with CERN on RUDP tests. EVL is talking to CERN about DiffServ tests.

Fourteen EVL students and two EVL faculty members (including Dan Sandin) participated in a major shared VR event during the Ars Electronica Festival, September 1-6, 2001, in Austria. Participants include artists from Hungary's C3 [http://www.c3.hu/], The Netherlands' V2 [http://www.v2.nl/], The Interactive Institute of Sweden [http://www.interactiveinstitute.se/], and the United States (UIC, Chicago and SUNY, Buffalo).

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 (July-September)

FY01 Euro-Link Expenditures – Y ear 3							
Itemized Expenses	**Year 3 Budget**	**Year 3 1st Q**	**Year 3 2nd Q**	**Year 3 3rd Q**	**Year 3 4th Q**	**Year 3 $ Spent**	**Balance**
Salaries and Fringe Benefits	252,990	174,682	78,308	0	0	252,990	0
Travel	50,000	13,393	6,898			20,291	29,709
Computer Equipment and Supplies	30,000	0	0			0	30,000
Subcontracts/Services (Ameritech and Indiana U)	340,988	72,850	72,850			145,700	195,288
Other (HPIIS Services to NRNs)	1,600,000	0	0			0	1,600,000
Indirect Costs	167,552	104,005	47,119			151,124	16,428
Subtotal for Year 3 Budgets/Expenses	**2,441,530**	**364,930**	**205,175**	**0**	**0**	**570,105**	**1,871,425**
(Year 3 Amendments)						0	0
(Year 3 Amendments)						0	0
Total Year 3 Budget/Expenses	**2,441,530**					**570,105**	**1,871,425**

FY01 Euro-Link Expenditures Cumulative					
	Year 1 Spent	**Year 2 Spent**	**Year 3 Spent**	**Year 4 Spent**	**Cumulative**
Salaries and Fringe Benefits	212,923	233,074	252,990		698,987
Travel	50,000	50,000	20,291		120,291
Computer Equipment and Supplies	100,000	40,278	0		140,278
Subcontracts/Services (Ameritech and Indiana U)	96,780	332,581	145,700		575,061
Other (HPIIS Services to NRNs)	1,600,000	1,600,000	0		3,200,000
Indirect Costs	159,221	167,621	151,124		477,966
Subtotal of Expenses to Date	**2,218,924**	**2,423,554**	**570,105**	**0**	**5,212,583**
(Year 3 Amendments)			0		0
(Year 3 Amendments)			0		0
Amendment #001 REU Supplement		10,000			10,000
Amendment #002 HPIIS Review Documentation		44,234			44,234
Total Expenses	**2,218,924**	**2,477,788**	**570,105**	**0**	**5,266,817**