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

Euro-Link℠

http://www.euro-link.org

NSF Cooperative Agreement No. ANI-9730202
Quarterly Status Report
October 1, 1999–December 31, 1999

Submitted January 10, 2000

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

Doug Pearson, Jim Williams
Indiana University

Principal Investigator
Thomas A. DeFanti
Electronic Visualization Laboratory (EVL)
University of Illinois at Chicago (UIC)
851 S. Morgan St., Room 1120
Chicago, IL 60607-7053
(312) 996-3002
(312) 413-7585 fax
tom@uic.edu

Table of Contents

A. Significant Results or Events in the Past Quarter **3**

B. Expected Results or Events in the Coming Quarter **3**

C. Summary of Technical Activities **3**

C.1. Euro-Link Network Peering Status 3

C.2. Engineering Services 4

C.3. NOC Services 5

C.4. Euro-Link Performance Analysis Tools 6

D. Accomplishments **6**

D.1. Meetings Attended 6

D.2. Publications 8

D.3. Software Releases 8

D.4. Other International Activities 8

E. Collaboration Activities **8**

F. Problems **9**

G. Any Proposed Changes in Future Plans **9**

H. Summary of Award Expenditures (October-December) **9**

I. Appendix: STAR TAP Direct Peering Matrices **10**

I.1. STAR TAP/International Direct Peering Matrix 10

I.2. STAR TAP/MREN Direct Peering Matrix 11

J. Appendix: CERN/Caltech TCP Tuning using vBNS and Abilene **12**

J.1. TCP tuning between Caltech and CERN 12

J.2. Results 13

K. Appendix: Teleglobe "Distributed STAR TAP" Press Release **14**

A. Significant Results or Events in the Past Quarter

- Current Euro-Link consortia members are:
  - CERN
  - IUCC (Israel)
  - NORDUnet (Nordic countries: Sweden, Finland, Iceland, Denmark, Norway)
  - RENATER2 (France)
  - SURFnet (The Netherlands)
- Euro-Link web site created: www.euro-link.org
- Continued work on network performance activities.
- Continued Euro-Link NOC discussions with Indiana University.
- Configured the STAR TAP router to peer with most of the National Research Networks at STAR TAP.
- Installed the Cisco 7507 DiffServ router at STAR TAP and have begun DiffServ tests between CERN and the International Center for Advanced Internet Research (iCAIR) at Northwestern University.
- Installed an AMP host at STAR TAP that may serve as a future platform for US-European performance monitoring.
- Installed an NLANR Web Cache at STAR TAP that will soon be integrated into NLANR's Global Caching Hierarchy (which includes caches in Europe).
- Installed a Test and Measurement UNIX PC at STAR TAP.
- Issued a "Distributed STAR TAP" press release with Teleglobe.
- Performed a packet-level Forward Error Correction Scheme between EVL and SARA (Amsterdam).
- Worked with CERN and Internet2 to allow Abilene to carry CERN's "transit traffic" from the New York POP to STAR TAP.

B. Expected Results or Events in the Coming Quarter

- Continue to develop the Euro-Link web site.
- Continue to work with Teleglobe, C&W, and other commercial carriers on a distributed STAR TAP topology.
- Continue to work with Internet2 to encourage international connectivity to STAR TAP.
- Continue to work with CERN, SARA (Amsterdam) and sites in Russia and Singapore on network performance studies.
- Continue to work with Indiana University on the Euro-Link NOC set up.

C. Summary of Technical Activities

C.1. Euro-Link Network Peering Status

C.1.a. CERN

CERN is confident that its 20Mbps bandwidth to STAR TAP will be upgraded to at least 45Mbps by April 2000 and is in the final stage of negotiations with vendors. Since the cost of the NY-to-Chicago link is a major part of the international end-to-end expense, CERN approached Abilene about the possibility of using it to transit from NY to the STAR TAP in Chicago. As an Internet2 member and Primary Participant on Abilene, CERN may transit to any of the networks peering with Abilene–at STAR TAP or elsewhere.

With the infrastructure now in place, CERN is focusing on applications and IPv6, and has been talking with Brian Carpenter, of IBM and the International Center for Advanced Internet Research (iCAIR) at Northwestern University, about developing a DiffServ testbed for experimentation and research. CERN has nearly finished provisioning a stable dedicated PVC. In mid-December, however, CERN engineers noticed that test traffic was interfering with production traffic, which they plan to fix before experiments can continue.

During the IDC '99 conference, CRC/Ottawa was connected through STAR TAP to CERN, and ultimately to the conference center in Madrid.

On December 1, Harvey Neuman notified STAR TAP and Internet2 that CERN performance tests showed network throughput over the vBNS was good, but very poor over Abilene (see Appendix J). On December 16, after many emails among Internet2, Abilene NOC, STAR TAP and NLANR staff, the situation mysteriously corrected itself. CERN's Philippe Galvez reported that performance between Caltech to CERN (via Abilene) appeared normal again, which meant that the maximum TCP throughput could resume between the two institutions; and that the current bottleneck was in the transatlantic line, as expected. [CERN performed a successful MPEG2 videoconference with CIT.] The bad news, according to Mr. Galvez, is that he can't pinpoint the exact reason why this improvement occurred over two days. He has already investigated at Caltech and CERN whether specific changes had been made on the network path (there were a few; a shortened connection between Caltech and CalREN2 was made the week previously and a router configuration changed at CERN), but nothing to explain the improvement. Guy Almes and the Abilene NOC staff are still investigating in order to prevent this problem from recurring.

CERN peering information can be found in Appendix I; this information will soon be available at www.startap.net/ENGINEERING.

C.1.b. IUCC (Israel)

Technical contact Hank Nussbacher's email address has changed <hank@att.net.il> and Danny Dolev, IUCC administrative head, has completed his term at IUCC and been replaced by Raphi Rom <rom@ee.technion.ac.il>. *(Dolev is still currently on the STAR TAP International Advisory Committee, and we will be discussing changes to that group this spring.)*

IUCC peering information can be found in Appendix I; this information will soon be available at www.startap.net/ENGINEERING. NISN, which currently shares a connection to STAR TAP with ESnet and NREN, is in the process of designing and implementing a separate Chicago (AADS) connection. Israel is eager to peer with NISN once this connection is established. The order for the circuit was recently received by Lee Grimes, the Ameritech Project Manager who brought up most of the original Euro-Link circuits. The exact date of circuit delivery is pending.

C.1.c. NORDUnet (Nordic Consortium)

NASA was involved in various demonstrations at the CEOS'99 conference in Stockholm in early November. NORDUnet facilitated network connectivity for NASA by peering with NREN using the STAR TAP Router.

NORDUnet peering information can be found in Appendix I; this information will soon be available at www.startap.net/ENGINEERING.

C.1.d. RENATER2 (France)

RENATER2 began peering with the STAR TAP router January 7, 2000. We are still waiting to receive additional peering information from RENATER2. Information received to date is listed in Appendix I; soon to be available at www.startap.net/ENGINEERING.

C.1.e. SURFnet (The Netherlands)

SURFnet is increasing its trans-Atlantic bandwidth to 2x OC-3 sometime in January 2000. It is also adding two more OC-3s worth of non-European connectivity from an ISP out of Amsterdam; one of which should be delivered in January. The second OC-3 will be put in service during the first half of 2001, yielding OC-12 speed, non-European connectivity dedicated to SURFnet. SURFnet is also upgrading its connection to STAR TAP from its PoP in New York from DS-3 to OC-3; Ameritech is still in the provisioning process.

SURFnet peering information can be found in Appendix I; this information will soon be available at www.startap.net/ENGINEERING.

C.2. Engineering Services

C.2.a. STAR TAP Router

On November 3, we brought up the STAR TAP Router to facilitate peering among the 20 National Research Networks (NRNs) connected to STAR TAP. Due to individual policy restrictions, the vBNS, Abilene, and ESnet are currently not planning to peer with the STAR TAP Router. Currently peering are: CA*net 2, NREN, DREN, MREN

(Argonne National Lab, Northwestern University), APAN, CERN, UICC, NORDUnet, RENATER2, SingAREN, SURFnet and TANet2. Peering with NISN is expected soon. On December 14, the STAR TAP Engineering team upgraded the interfaces on this router to enable it to support higher-speed throughput and handle more traffic.

C.2.b. IPv6 Tunnel service at the 6TAP

The 6TAP [www.6tap.net], an IPv6 service run by ESnet and hosted by STAR TAP, is up and running. ESnet is currently purchasing an additional router and two PCs for the 6TAP project [www.6tap.net], to support IPv6 over IPv4 tunnels and IPv6 performance measurement and statistics. Once ESnet acquires and configures all of the equipment, we will install it in STAR TAP rack space at the Ameritech NAP. We are currently working with Ameritech to find co-location space.

C.2.c. STAR TAP Web Caches

*NLANR Caching project…*Duane Wessels has built and tested a Web Cache, running the Squid caching software, for STAR TAP. The cache PC was installed at Ameritech on December 14. NAP.NET has agreed to donate ISP service over a 1 MB connection. Once NAP.NET is in place (expected in early January), Duane will integrate the cache into NLANR's Global Caching Hierarchy.

*Internet2 Distributed Storage Initiative/Novell…*We are working with Jamshid Mahdavi of Novell and Micha Beck of Internet2 to deploy an Internet2/Novell cache system at STAR TAP. At the December NLANR/Internet2 Tech Meeting in Miami, Micha reported that difficulties in acquiring hardware would delay the installation of the cache system at STAR TAP.

C.2.d. STAR TAP Performance Measurement Systems

*NLANR AMP (Active Measurement Platform) box…*An AMP box was installed at STAR TAP and information is now accessible from the STAR TAP web pages (click on "Engineering" and then "Performance Measurements").

*Advanced Network & Services' Surveyor box…*At present, the Surveyor-required GPS feed used for timing is not available within the Ameritech NAP. Matt Zekauskas of Advanced Network & Services is currently exploring the possibility of using a card that takes clock readings off CDMA broadcasts sent out by Mobile Phone Service Providers instead of using a GPS receiver card. If this proves successful, it may be a good solution for STAR TAP.

C.2.e. DiffServ

The UIC DOE/NGI EMERGE project [http://www.evl.uic.edu/cavern/EMERGE/], initially targeting MREN sites, will be extended internationally over the next several months to include CERN, Russia, Singapore and Amsterdam. The STAR TAP Cisco 7507 DiffServ router, to be used for EMERGE experiments, was installed at Ameritech on December 14. (See Section C.1.a for the iCAIR/CERN collaboration to date. Note that iCAIR is part of the EMERGE project.)

C.2.f. Renting Co-Location Space at Ameritech

The STAR TAP project currently has access to 1-1/2 racks, which are co-located at the Ameritech NAP and leased by Indiana University and Merit. Along with MREN, we are in the process of leasing two additional racks to handle the additional equipment we plan to install at the NAP. Progress with Ameritech has been slow, but temporary accommodations for the project will be made until a permanent space is found.

C.2.g. Contact Information

Administrative, technical and NOC contacts for Euro-Link countries are now posted on the STAR TAP web site, at [http://www.startap.net/ABOUT/points.html] and on the Euro-Link site at [http://www.euro-link.org/ENGINEERING/POC.html].

C.2.h. SC'99

We worked with several SC'99 participants to help them set up routing between SC'99 in Portland, Oregon, and sites attached to Euro-Link networks.

C.3. NOC Services

Doug Pearson and Jim Williams of Indiana University are in the process of implementing a STAR TAP/Euro-Link/TransPAC NOC, in which the three logical NOCs will be maintained inside one physical NOC. Problem reporting, activity tracking and documentation will be maintained individually for STAR TAP, Euro-Link and TransPAC. Immediate action items and task assignments are on the web at [http://www.transpac.org/startapnoc.html]. They have begun development of a Euro-Link "weather map" modeled after the Abilene weather map, and a BGP monitoring tool for BGP session monitoring across Euro-Link.

A part-time web developer began work January 5, 2000 at Indiana University; responsibilities include populating (and updating) TransPAC, STAR TAP, Euro-Link and Abilene web pages with individual project information (e.g., VC/VP information, L3 information, equipment lists, and technical contacts); and producing tools, reports and informational pages for the NOCs.

The STAR TAP engineering team has sent several pages of documentation on various STAR TAP components to the IU NOC, and will work with the NOC team to integrate it into the NOC web pages. A noc@euro-link.org email alias has been created.

C.4. Euro-Link Performance Analysis Tools

C.4.a. Network QoS of Real-Time Multimedia

An alpha version of EVL's CAVE-based Netlogger visualization tool (QoSIMoTo: QoS Internet Monitoring Tool) is complete. This tool visualizes historic as well as real-time Netlogger data consisting of bandwidth, latency and jitter. The QoSIMoTo website is expected to launch next month. [www.evl.uic.edu/cavern/qosimoto]

C.4.b. Petri-Net Network Modeling

Based on EVL's summer evaluations of its Petri-Net models for UDP and TCP, we are now building higher-level Petri-Net models of the audio and video data sent over networks during typical tele-immersive sessions. As a test case to determine if these models can accurately predict network utilization and behavior, EVL wants to apply these models to the AccessBot, a data-intensive, high-bandwidth and high-fidelity video-streaming application, which is currently maintaining a persistent connection between Chicago and the NCSA ACCESS Center in Washington DC.

C.4.c. Network Monitoring

There are no results at this time. Performance monitoring is being postponed until Netlogger is re-integrated into the next-generation CAVERNsoft code (currently under development). [www.evl.uic.edu/cavern/cavernG2]

C.4.d. Low Latency State Transmission Over Long Distance Networks

We are implementing a packet-level Forward Error Correction scheme; both parity-based and XOR-based. The goal is to develop an alternative to TCP for transmitting real-time data, which has substantial latency over international links.

Our first implementation and experiments between EVL and SARA showed an encouraging 20% reduction in latency over TCP. We were also able to observe a significant reduction in packet loss on overloaded networks. Over the next two quarters, we plan to engage in a systematic exploration of the conditions under which these improvements remain sustainable (as well as exploring other algorithms), especially in QoS-enabled routers.

D. Accomplishments

D.1. Meetings Attended

December 14-18, 1999. "Simulation and Visualization on the Grid" PDC Annual Conference 1999, Parallelldatorcentrum (PDC), Kungl Tekniska Högskolan (Royal Institute of Technology), Stockholm, Sweden. [http://www.pdc.kth.se/conference/1999/] Tom DeFanti and Maxine Brown, presented papers: "The Global Technology Grid: Its Role in Virtual Reality" (DeFanti) and "Global Tele-Immersion: Working in CyberSpace" (Brown). Also met with Karl-Einar Sjödin of the Swedish National Board for Industrial and Technical Development (NUTEK) and Hans Wallberg, the head of SUNET, the Swedish University NETwork.

Conference topics included computational simulations; hardware and software for visualization and virtual reality; collaborative simulation; distributed virtual reality systems; and digital libraries. In addition to DeFanti and

Brown, invited speakers included Nicolle Bordes (San Diego Supercomputer Center); Andrew Chien (University of California San Diego); Henry Fuchs (University of North Carolina Chapel Hill); Carl Kesselman (University of Southern California, Information Sciences Institute); Bernard Pailthorpe (San Diego Supercomputer Center); and Thierry Priol (INRIA). The conference proceedings, available on the web, will be published in Springer-Verlag's "Lecture Notes in Computational Science and Engineering" series.

December 9-14, 1999. Conferència: International Collaborative Networking and Virtual Reality, Universitat de les Illes Balears, Palma, Mallorca. Tom DeFanti and Maxine Brown, presenters. Meeting hosted by Prof. Joan Masso. Also met with Bartomeu Serra Cifre, computer center director, and Francisco José Perales, computer science professor at Universitat, as well as the Minister of Science and Technology for the Balearic Islands. (Note that Joan Masso serves as technology advisor to the Minister.)

December 5-8, 1999. NLANR/Internet2 Tech Meeting, Miami, Florida. John Jamison attended. John gave a "STAR TAP Update" presentation, and met with project collaborators from AMP, the Internet2/Novell Web Cache, and Surveyor.

November 29-30, 1999. CANARIE's 5th Annual Advanced Networks Workshop, "Optical Internet: From Information Highway to Information Main Street" [http://www.canarie.ca/frames/workshop.html]. Tom DeFanti and John Jamison attended. DeFanti gave presentations "The EMERGE QoS Testbed" and "STAR TAP Progress Report." Over 300 people attended; European attendees included:

- Kees Neggers, SURFnet
- Jeremy Sharp, UKERNA
- Roland Trice, UKERNA
- Dirk Hetzer, Deutsche Telekom
- Monika Jaeger, Deutsche Telekom
- J.P. Lavado, Deutsche Telekom

November 15-19, 1999. Supercomputing '99 (SC'99), Portland, Oregon. Tom DeFanti, Maxine Brown, Jason Leigh, Andy Johnson and four EVL students attended. EVL did CAVERNsoft demos in the Alliance, Argonne, DOE ASCI, and UIC National Center for Data Mining booths. STAR TAP blinkie pins were distributed by the Alliance and NLANR.

November 1-2, 1999. Industrial Virtual Reality Symposium, sponsored by the National Institute of Standards and Technology (NIST), UIC and the American Society of Mechanical Engineers (ASME), held at UIC, Chicago, IL. Tom DeFanti was keynote speaker. This conference attracted an international audience of virtual-reality/mechanical engineering users. International attendees included:

- Ceri Pritchard, British Aerospace PLC, Bristol, England
- The Tuan Ann, Temasek Polytechnic, Singapore
- Brian Corrie, National Research Council/Integrated Manufacturing Technology Institute, Ontario, Canada
- Benoît Ozell, Centre de Recherche en Calcul Appliqué (CERCA) Montreal, Canada
- Jae Won Lee, INHA University, Korea

October 28, 1999. Visit to EVL by France Telecom (FT), to discuss ways in which FT can better support members of the STAR TAP community. (They currently bring RENATER2 to STAR TAP.) Maxine Brown and John Jamison attended; Jason Leigh supervised CAVE demonstrations. FT attendees:

- Daniel Mayer, Manager Carrier Services, FT, NY
- Patrick Jamin, Internet Technical Director, FT Branche Reseaux, France
- Christopher Chaillot, Internet Backbone Engineering, FT Branche Reseaux, France
- Jean-Claude Bourgoint, VP Internet Carrier Services, FT Branche Reseaux, France

October 20, 1999. Visit to Cable & Wireless offices in Chicago, to discuss ways in which C&W can better support members of the STAR TAP community. (They currently bring CERN to STAR TAP.) Tom DeFanti, Maxine Brown and John Jamison from UIC/EVL attended. C&W attendees:

- Mark Luptak, International Account Manager
- Heather Lence, Major Account Representative

- John (Iain) McFadyen, Global Services Special Programs Office
- Chris Altman, Technical Sales Consultant
- Amy Meldgin, District Sales Manager

October 10-13, 1999. UCAID/Internet2 Meeting, Seattle, Washington. Tom DeFanti and Maxine Brown attended. An International Dinner (Sunday, October 10); International Task Force Meeting chaired by Tom DeFanti (Monday, October 11); GigaPoP/International meeting (Tuesday, October 12).

October 4-5, 1999. DOE NGI Meeting, Washington, D.C. Tom DeFanti, Jason Leigh, Alan Verlo and John Jamison attended.

D.2. Publications

Steven N. Goldstein, Maxine D. Brown, Thomas A. DeFanti, "The Science, Technology and Research Transit Access Point (STAR TAP)," La Recherche, Paris, France, February 2000 (to appear). [See http://www.startap.net/PUBLICATIONS/pubs.html#Application Papers].

Jason Leigh, Andy Johnson, Maxine Brown, Dan Sandin, Tom DeFanti, "Tele-Immersion: Collaborative Visualization in Immersive Environments," IEEE Computer, December 1999, pp. 66-73. (Features a description of the work being done with SARA in Amsterdam.)
[See http://www.startap.net/PUBLICATIONS/pubs.html#Application Papers]

Ian Foster, Joseph Insley, Gregor von Laszewski, Carl Kesselman, and Marcus Thiebaux, "Distance Visualization: Data Exploration on the Grid," IEEE Computer, December 1999, pp. 36-43.
[See http://www.startap.net/PUBLICATIONS/pubs.html#Application Papers]

Gabrielle Allen, Tom Goodale, Gerd Lanfermann, Thomas Radke, Edward Seidel, Werner Benger, Hans-Christian Hege, Andre Merzky, Joan Masso and John Shalf, "Solving Einstein's Equations on Supercomputers," IEEE Computer, December 1999, pp. 52-58. [See http://www.startap.net/PUBLICATIONS/pubs.html#Application Papers]

D.3. Software Releases

EVL worked with SARA's Anton Koning to incorporate CAVERNsoft into Saranav–a Performer-based CAVE application to load and view 3D polygonal datasets in the CAVE. It has numerous command-line options to control various visualization and navigation parameters, as well as an extensible menu system to control the application. Koning has made this software freely available to the CAVE Research Network User's Society (CAVERNUS) at [http://www.ncsa.uiuc.edu/VR/cavernus/shared.html]. CAVE-to-CAVE network performance tests between Chicago and The Netherlands commenced in mid-November.

D.4. Other International Activities

Tom DeFanti, member of the External Advisory Committee, Center for Parallel Computers (Parallelldatorcentrum, PDC) at the Royal Institute of Technology (Kungl Tekniska Högskolan, KTH), 1999-present.
[http://www.pdc.kth.se]

E. Collaboration Activities

- Ongoing with SARA in Amsterdam. We will upgrade their Saranav software (see section D.3) to the new version of CAVERNsoft (CAVERNsoft G2) once it is available.
- Supporting 6TAP, an IPv6 service run by ESnet and hosted by STAR TAP (see Section C.2.b).
- Working with NLANR to deploy a web cache running Squid software at STAR TAP (see Section C.2.c).
- Working with Internet2 to deploy an Internet2/Novell Cache system at STAR TAP (see Section C.2.c).
- Worked with NLANR to provide AMP-based STAR TAP performance statistics (see Section C.2.d).
- Working with Advanced Network & Services on providing Surveyor-based STAR TAP performance statistics (see Section C.2.d).

- Working with the DOE/NGI EMERGE project to extend DiffServ tests internationally over the next several months to CERN, Russia, Singapore and Amsterdam (see Section C.2.e)
- Working with SARA in The Netherlands to experiment with an EVL-designed packet-level Forward Error Correction scheme (see Section C.4.d)
- Worked with Teleglobe on a “Distributed STAR TAP” press release (see Appendix K).

F. Problems

No significant problems were encountered this quarter.

G. Any Proposed Changes in Future Plans

No changes to date.

H. Summary of Award Expenditures (October-December)

The spending rate is within budget. Notable activities for this quarter include:

- Continuing to work with Indiana University to complete paperwork in order to execute the UIC subcontract. (Indiana University staff is still processing the paperwork, *but it’s close to completion!)*

Euro-Link Expenditures			
Itemized Expenses	**Year 1 Budget**	**Current Quarter Expenses**	**Year to Date**
Salaries and Fringe Benefits	212,923.00	35,975	68,494
Travel	50,000.00	14,354	15,358
Computer Equipment and Supplies	100,000.00	71,202	84,814
Subcontracts/Services (Ameritech and Indiana U)	96,780.00	0	0
Other (HPIIS services to NRNs)	1,600,000.00	0	1,600,000
Indirect Costs	159,221.00	34,167	61,215
Total Expenditures	**2,218,924.00**	**155,698**	**1,829,881**

I. Appendix: STAR TAP Direct Peering Matrices

I.1. STAR TAP/International Direct Peering Matrix

Even if an NRN is not peering directly with other STAR TAP-connected networks, they can exchange routes and traffic with one another via the STAR TAP Router. NRNs, except for vBNS, Abilene, and ESnet, will peer with the STAR TAP Router. Direct peering between networks that exchange large amounts of traffic is encouraged.

STAR TAP/International Direct Peering Matrix																				
Networks	**North America**										**Europe**						**Asia**			
	Abilene	**CA*net 2/3**	**DREN**	**ESnet**	**6TAP-IPv6 Router**	**MREN**	**NISN**	**NREN**	**STAR TAP Router**	**vBNS/vBNS+**	**CERN**	**Israel IUCC**	**NORDUnet**	**MIRnet**	**RENATER2**	**SURFnet**	**APAN**	**SINET**	**SingAREN**	**TANet2**
North America																				
Abilene		•	•	•	0	*	•	•		•	•	•	•		•	•	•	•	•	•
CA*net 2/3	•				•	*	•	•	•	•	•	•	•			•	•		•	•
DREN	•					*	2	•	•	•						•				
ESnet	•				•	*	2	•		•	•	•	•	0		•	•	•	•	•
6TAP-IPv6 Router	0	•		•		*				•	0					0	•		0	
MREN	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
NISN	•	•	2	2		*		2		•			4	•			•	0		
NREN	•	•	•	•		*	2		•	•	•		•	•		•	•			
STAR TAP Router		•	•			*		•			•	•	•		•	•	•		•	•
vBNS/vBNS+	•	•	•	•	•	*	•	•			•	•	•	•	•	•	•		•	•
Europe																				
CERN	•	•		•	0	*		•	•	•		1	1		2	1	0			
Israel IUCC	•	•		•		*			•	•	1		1		1	1	•			•
NORDUnet	•	•		•		*	4	•	•	•	1	1		5	1	1	•	•	•	
MIRnet				0		*	•	•		•			5				0			
RENATER2	•					*			•	•	2	1	1							
SURFnet	•	•	•	•	0	*		•	•	•	1	1	1				•	•	•	•
Asia																				
APAN	•	•		•	•	*	•	•	•	•	0	•	•	0		•			3	0
SINET	•			•		*	0						•			•				
SingAREN	•	•		•	0	*			•	•			•			•	3			•
TANet2	•	•		•		*			•	•		•				•	0		•	

* MREN institution direct peering information detailed below.
0 Planned or under consideration
1 European "peering" via TEN-155
2 Direct peering at a location other than STAR TAP
3 Peering with APAN via a direct physical link to Japan and Korea
4 Temporary
5 Exchange traffic via a commercial European IPS

I.2. STAR TAP/MREN Direct Peering Matrix

Even if an NRN is not directly peering with these MREN institutions, they can receive their routes via US peers, such as ESnet and vBNS.

The MREN institutions all peer with one another because they are each part of a full PVC mesh. See MREN Peering Information: http://www-fp.mcs.anl.gov/mren/mren-peers.html

STAR TAP/MREN Direct Peering Matrix															
	MREN														
	Argonne Lab	**U Chicago**	**Fermi Lab**	**Indiana U**	**UIC**	**UIUC/NCSA**	**U Iowa**	**Iowa State U**	**Merit, Michigan, Michigan State**	**U Minnesota**	**Northwestern U**	**U Notre Dame**	**Ohio State U (OARnet)**	**U Wisconsin Madison**	**U Wisconsin Milwaukee**
North America															
Abilene	●	●			●	●			●						●
CA*net 2/3															
DREN															
ESnet															
6TAP-IPv6 Router															
MREN	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
NISN														●	●
NREN	●	●				●			●	●	●			●	
STAR TAP Router	●										●				
vBNS/vBNS+	●	●	●	●	●	●	●	●		●	●	●		●	●
Europe															
CERN			●								●				
IUCC															
NORDUnet	●										●				
MIRnet	●														
RENATER2															
SURFnet					●	●					●				
Asia															
APAN	●														
SINET															
SingAREN															
TANet2															

J. Appendix: CERN/Caltech TCP Tuning using vBNS and Abilene

J.1. TCP tuning between Caltech and CERN

Test performed December 1, 1999, approximately 4 PM Geneva time, using IPERF Version 1.0 (http://dast.nlanr.net/Projects/iperf/doc/index.html)

Machine at CERN: sunstats.cern.ch, SunOS 5.6, connected with 100BaseT to External network.
Machine at Caltech: Jasper.cacr.caltech.edu , SunOS 5.7, connected with 100BaseT.

J.1.a. Traceroute from CERN to Caltech

traceroute to jasper.cacr.caltech.edu (131.215.145.33), 20 byte packets

1 r513-c-rci47-2-ip13.cern.ch (192.16.165.1)	1 ms 12 ms 1 ms
2 cgate1.cern.ch (128.141.200.10)	2 ms 2 ms 3 ms
3 cgate2-dmz.cern.ch (192.65.184.94)	3 ms 2 ms 4 ms
4 cernh9.cern.ch (192.65.185.9)	4 ms 3 ms 3 ms
5 ar1-chicago.cern.ch (192.65.184.165)	124 ms 115 ms 113 ms
6 chi-vbns.cern.ch (192.65.184.185)	115 ms 117 ms 122 ms
7 jn1-at1-0-0-23.rto.vbns.net (204.147.135.237)	162 ms 161 ms 162 ms
8 CIT-vBNS.Calren2.net (198.32.251.26)	203 ms 207 ms 196 ms
9 media-converter.caltech.edu (192.41.208.50)	191 ms 191 ms 192 ms
10 * * *	
11 SFL-border.dmz.caltech.edu (192.12.19.252)	194 ms 194 ms 194 ms
12 Booth-RSM.ilan.caltech.edu (131.215.254.253)	194 ms 192 ms 195 ms
13 jasper.cacr.caltech.edu (131.215.145.33)	213 ms * 205 ms

J.1.b. Traceroute from Caltech to CERN

traceroute to sunstats.cern.ch (192.65.185.20), 40 byte packets

1 BBMR-RSM.cacr.caltech.edu (131.215.145.252)	0.893 ms 0.641 ms 0.660 ms
2 SFL-border.ilan.caltech.edu (131.215.254.252)	2.451 ms 1.225 ms 0.770 ms
3 Converter.dmz.caltech.edu (192.12.19.250)	0.864 ms 0.847 ms 1.093 ms
4 10.26.3.1 (10.26.3.1)	0.747 ms 0.997 ms 1.085 ms
5 c2-gsr.caltech.edu (192.41.208.49)	1.043 ms 1.129 ms 1.272 ms
6 UCR--CIT.POS.calren2.net (198.32.248.10)	2.567 ms 2.757 ms 2.763 ms
7 UCI--UCR.POS.calren2.net (198.32.248.14)	3.833 ms 3.996 ms 4.026 ms
8 USC--UCI.POS.calren2.net (198.32.248.18)	5.337 ms 5.125 ms 5.023 ms
9 abilene--USC.ATM.calren2.net (198.32.248.86)	5.782 ms 5.931 ms 5.850 ms
10 scrm-losa.abilene.ucaid.edu (198.32.8.17)	16.258 ms 15.921 ms 16.037 ms
11 denv-scrm.abilene.ucaid.edu (198.32.8.2)	37.938 ms 37.631 ms 37.845 ms
12 kscy-denv.abilene.ucaid.edu (198.32.8.14)	82.331 ms 82.496 ms 82.202 ms
13 ipls-kscy.abilene.ucaid.edu (198.32.8.6)	91.658 ms 91.557 ms 91.497 ms
14 cern-abilene.cern.ch (192.65.184.190)	79.114 ms 79.235 ms 79.415 ms
15 cernh9-ar1-chicago.cern.ch (192.65.184.166)	193.045 ms 189.714 ms 189.986 ms
16 sunstats.cern.ch (192.65.185.20)	190.498 ms * 190.134 ms

Remarks:
The routing is clearly asymmetric, crossing vBNS to reach Caltech from CERN, and crossing Abilene on the way back. This asymmetry is probably the reason the TCP performance is dependent on the direction of the TCP transfer session, as shown in the graph below.

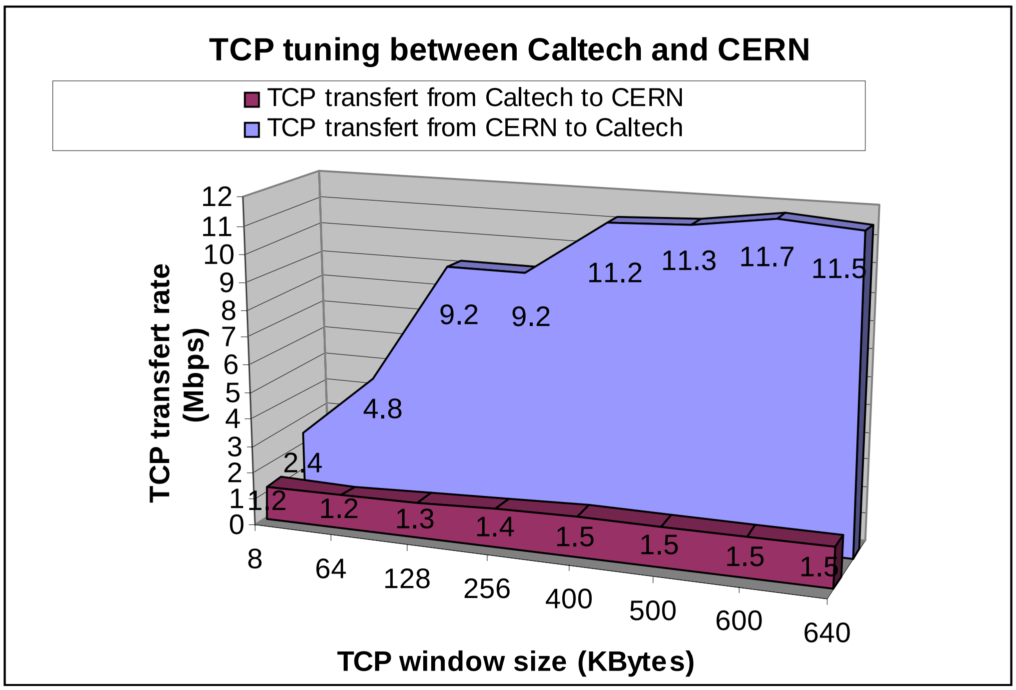
J.2. Results

On the following graph, we see that the TCP performance from CERN to Caltech can go up to 11.7 Mbps. If we add the background traffic on the transatlantic line of around 4.5 Mbps, we are close to the limit of the 20 Mbps ATM link (20 Mbps – 20% = 16Mbps).
In the same time, we see that the formula to find the minimum TCP window size to have maximum throughput is verified:
Best Windows Size = Network bottleneck on the path (in Mbps) **X** The round trip delay.
We have in our case:
- Network bottleneck on the path (in Mbps) is the transatlantic: 20 Mbps – 20% = **16Mbps**
- The round trip delay is around **190 ms**

We obtain optimum Windows size = 16 Mbps x 190ms = **370 Mbytes**

The TCP performance from Caltech to CERN does not greatly improve with the augmentation of the window size. The only possible reason seems to be the path used to reach CERN from Caltech. It does not appear optimal. Also, this bad performance does not prevent the ping and similar tools to show some correct results (good RTT, no packet losses). It is, therefore, difficult to know what in the chain perturbs the throughput in a dramatic way.

As more general comment, it appears that the best throughput could be obtained with a good tuning from the entire elements in the network path, however, it is very sensitive to external events (reconfiguration of the router, low percentage packet losses). The throughput could go from 12Mbps to 1.5 Mbps in a few seconds.



K. Appendix: Teleglobe "Distributed STAR TAP" Press Release

FOR IMMEDIATE RELEASE

TELEGLOBE'S HIGH SPEED ATM BACKBONE PROVIDES INFRASTRUCTURE TO CONNECT ASIAN AND EUROPEAN RESEARCH AND EDUCATION NETWORKS TO MORE THAN 100 US-BASED RESEARCH AND EDUCATION INSTITUTIONS

ATM-Based "Distributed STAR TAP" Access Services to Result in Improved Access and Lower Costs For R&E Networks Conducting Internet Technology Research

RESTON, Va., October 18, 1999 - Teleglobe Communications Corporation has established an ATM-based service that connects Asian and European Research and Education (R&E) networks directly to more than 100 R&E institutions that are part of the U.S.-based STAR TAP(sm) (Science, Technology and Research Transit Access Point) initiative. This direct connection -- called "Distributed STAR TAP(sm)" -- benefits the world's academic community by providing faster and more cost-effective access to Internet research capabilities over Teleglobe's global ATM backbone network.

STAR TAP, established as part of a National Science Foundation award to the University of Illinois at Chicago, provides a common interconnection point between U.S. R&E networks and their foreign counterparts for collaborative applications and for the development and testing of new Internet technologies. The advantage of a common interconnection point is that a participating network can connect with any other network without having to pass through a third party's network and without being subject in any way to a third party's networking policies.

Because STAR TAP's location (Chicago, U.S.) is far from most international cable landings and satellite teleports, the high-bandwidth international connections required to conduct advanced research have been relatively inconvenient.

Teleglobe's 'Distributed STAR TAP' access service, already deployed at the company's east and west coast ***GlobeSystem(sm)*** network access points in New York City and Los Angeles, greatly reduces the cost and effort to connect to STAR TAP. Teleglobe also plans on establishing access sites in Miami and at Teleglobe's three North American teleports in the near future.

"Teleglobe is grateful for the opportunity to collaborate more closely with the NSF and the University of Illinois at Chicago and to offer our base of PTT and carrier Internet Service Providers the means to better serve their national institutions of learning and higher education with access to America's leading edge research and education activities," said Bob Collet, vice president and general manager, Internet and Data Services, Teleglobe Communications Corporation.

'Distributed STAR TAP' Access Service

Through its east and west coast access points, Teleglobe will provide its R&E network customers with an Internet routing and ATM network service for interconnection with STAR TAP-connected networks. STAR TAP networks include the NSF very High Speed Backbone Network Service (vBNS), the DoE Energy Sciences Network (ESnet) and the NASA Research and Education Network (NREN). Teleglobe also provides access to Abilene, the high performance backbone service of the University Corporation for Advanced Internet Development (UCAID), at its east and west coast access points as well as at STAR TAP. The Distributed STAR TAP service also is available to the R&E networks supported by Teleglobe's wholesale carrier and ISP customers, as well as to other U.S. and Canadian research and education institutions, thus opening up significant new potentials of collaboration.

"STAR TAP management has been talking with a number of providers about extending the STAR TAP service connection points for the convenience of our international partner networks," said Steve Goldstein, program director for International Networking, National Science Foundation. "We are all delighted that Teleglobe is the first one to provide such a service to its customers. This continues Teleglobe's responsiveness to the needs of the advanced research community that was evidenced early on when they made a 155 Mbps link between North America and Europe available to Canadian researchers using CA*net and later extended its availability to U.S. researchers."

“The Distributed STAR TAP access service should provide for a significantly more effective means for U.S. networks to meet their international counterparts. This will be a catalyst for much more collaborative activity around the world,” said Tom DeFanti, STAR TAP Principal Investigator.

Teleglobe already directly provides a variety of Internet access services for non-U.S. R&E networks, including CERnet (China), DANTE (European Commission), MIMOS (Malaysia), MIRnet (Russia), NACSIS (Japan), the National University of Seoul (Korea), NORDUnet (Nordics), RosNIIROS (Russia), SingAREN (Singapore), SUPERJanet (UK), SURFnet (Netherlands), the University of Costa Rica and the University of Kuwait.

About Teleglobe

Teleglobe Inc. (NYSE, TSE, ME: TGO) is a recognized leader in global telecommunications. Through its subsidiary Teleglobe Communications Corporation, the company develops and supplies global connectivity services to carriers, Internet service providers, business customers and content providers worldwide. Through Excel Communication’s proven marketing and distribution channels, Teleglobe also caters to an expanding international consumer customer base. According to TeleGeography, the company is the fourth-ranked long distance provider in the United States and, according toa recent KMI Corporation study, the third largest owner of undersea fiber optic cable systems. Teleglobe has a 50% interest in ORBCOMM, the world’s first commercial low-earth-orbit, satellite-based, data communications system. Additional information is available at www.teleglobe.com.

About STAR TAP

STAR TAP, the Science, Technology And Research Transit Access Point, is a persistent infrastructure to facilitate the long-term interconnection and interoperability of advanced international networking in support of applications, performance measuring, and technology evaluations. The STAR TAP anchors the international vBNS connections program. STAR TAP is made possible by major funding from the National Science Foundation, award ANI-9712283, to the University of Illinois at Chicago. For more information, see http://www.startap.net