STAR TAP 2: Science, Technology And Research Transit Access Point
Award #ANI-9980480
Annual Report April 2001-August 2001

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1. Participants

1.A. Primary Personnel

Participant's Name(s)	Project Role(s)	>160 Hours/Yr
Thomas A. DeFanti	Principal Investigator	Yes
Maxine Brown	Co-Principal Investigator	Yes
John Jamison*	Co-Principal Investigator	Yes

* John Jamison worked at UIC on STAR TAP from Spring 1999-Spring 2000, but continues to act as consultant to the STAR TAP engineers, Linda Winkler, Andy Schmidt and Alan Verlo.

1.B. Other Senior Personnel (Excluding PI and Co-PI)

Additional people who contributed greatly to the project, and received a salary, wage, stipend or other support from this grant:

Participant's Name(s)	Project Role(s)	>160 Hours/Yr
Alan Verlo	Professional staff	Yes
Linda Winkler+	Professional staff	Yes
Laura Wolf	Professional staff	Yes
Michael McRobbie	Professional staff	Yes
Jim Williams*	Professional staff	Yes
Dana Plepys	Professional staff	Yes
Andy Schmidt	Professional staff	Yes

\+ It should be noted that Linda Winkler, while not compensated by the University of Illinois at Chicago, serves as part-time STAR TAP engineer with Alan Verlo and Andy Schmidt of EVL/UIC.

* Previously Doug Pearson was listed as Senior Personnel on the grant as he was in charge of the STAR TAP NOC at Indiana University. He has been replaced by Jim Williams at Indiana University.

1.C. Other Organizations That Have Been Involved as Partners

1.C.1. STAR TAP Management Team

ELECTRONIC VISUALIZATION LABORATORY, UNIVERSITY OF ILLINOIS AT CHICAGO (EVL/UIC). [www.evl.uic.edu]
EVL, over the past several years, has worked with computer scientists and computational scientists at NCSA and ANL to collect, maintain, develop, distribute, and evaluate tools and techniques for networked scientific computing. EVL is also the lead institution for the STAR TAP infrastructure.

MATHEMATICS AND COMPUTER SCIENCE DIVISION, ANL NATIONAL LABORATORY (ANL). [www.mcs.anl.gov]
ANL has been, and continues to be, a strong supporter of STAR TAP activities. Linda Winkler has facilitated STAR TAP engineering since its inception, and is the lead engineer today; her salary comes from ANL. Rick Stevens, director of the ANL Math and Computer Science Division, is the chair of STAR TAP's International Advisory Committee.

AMERITECH ADVANCED DATA SERVICES (AADS). [www.aads.com]
The AADS Network Access Point (NAP) is an Internet Exchange Point where ISPs can meet to exchange traffic with other attached ISPs. The NAP is a layer 2 switched service that is not directly involved with routing IP datagrams; only forwarding Asynchronous Transfer Mode (ATM) cells between ISPs. The Chicago NAP is a large ATM switch providing both high speed and a high degree of scalability. Interface speeds currently supported

include: DS-3, OC-3c and OC-12c. Ameritech and STAR TAP thus far have been the model for the next generation of NGI eXchanges (NGIXs).

MREN. [http://www.mren.org]
The Midwest's Metropolitan Research and Education Network (MREN) is a 622Mb regional network connecting Midwest-area research institutions. It is a model for "GigaPoPs," or other regional networks. MREN is one of the world's most advanced high-performance broadband networks, developed to support a wide range of advanced research applications requiring high performance and high bandwidth. UIC is one of the founding members of MREN. Joe Mambretti, director of the iCAIR Center at Northwestern University, is the director of MREN and Linda Winkler of ANL is the technical director.

INDIANA UNIVERSITY. [http://www.indiana.edu/~ovpit/]
Indiana provides NOC services for Abilene, TransPAC, EuroLink, MIRnet and, most recently, STAR TAP. Indiana's telecommunications infrastructure consists of central office class voice switches, state-of-the-art ATM and Fast Ethernet networks, a video network, inter-campus WAN, connections to the vBNS, Abilene and TransPAC, and multiple access points to the commodity Internet. Indiana has one of the largest multi-protocol networks among higher education institutions in the US.

INTERNATIONAL CENTER FOR ADVANCED INTERNET RESEARCH (iCAIR), NORTHWESTERN UNIVERSITY. [www.icair.org]
The goal of iCAIR, under the leadership of Joe Mambretti, is to accelerate leading-edge innovation and enhanced global communications through advanced Internet technologies, in partnership with the international community. iCAIR was established to provide a focal point for leading-edge Internet research, innovation, and pre-production deployment. iCAIR is an international research and development center that creates large-scale, advanced digital communication systems based on Internet protocols, in part, by utilizing regional, national and international advanced research networks.

1.C.2. STAR TAP International Research Networks

The following Research Networks are either connected to STAR TAP or will soon connect. A status report is given in Section 2.A.2: STAR TAP Connectivity Update.

ANSP. [www.ansp.br] São Paulo, Brazil, Academic Network

APAN. [www.apan.net] Asia-Pacific Advanced Network, OC-3

BELnet. www.belnet.be Belgium Research Network

CA*net3. [www.canet3.net] Canadian Network for the Advancement of Research, Industry and Education (CANARIE), OC-3

CERN. [http://cern.web.cern.ch] European Laboratory for Particle Physics, DS-3 and OC-3.

CERnet. [www.cernet.edu.cn] China Education and Research Network, DS-3

HEAnet. [www.heanet.ie/] Ireland National Education & Research Network

IUCC. [www.internet-2.org.il] Israel Inter-University Computation Center, DS-3

KOREN/KREONet2. [www.koren21.net, www.kreonet2.net] KOrean advanced REsearch Network (KOREN) and Korea Research Environment Open Network 2 (KREONet2), DS-3

MIRnet. [http://www.friends-partners.org/friends/mirnet/home.html] US-Russian High Performance International Internet Services, DS-3

NORDUnet. [www.nordu.net] Nordic Countries' National Networks for Research and Education (Denmark, Finland, Iceland, Norway, and Sweden), DS-3

RENATER2. [www.renater.fr] France Research and Education Network, DS-3

RNP. [www.rnp.br] Brazil National Research Network, DS-3

REUNA. [www.reuna.cl] Chile National University Network, DS-3

SingAREN. [www.singaren.net.sg] Singapore Advanced Research and Education Network, DS-3

SURFnet. [www.surfnet.nl] The Netherlands Research and Education Network, OC-3

TANet2. [www.tanet2.net.tw] Taiwan Academic Network, DS-3

1.C.3. STAR TAP "Affiliated" International Research Networks

These networks connect (or have connected) to the Ameritech NAP and peer with the STAR TAP Router. While these networks have not applied to NSF for official STAR TAP status, the STAR TAP Router is AUP-free and any participating STAR TAP member can receive their routes.

SINET. [www.sinet.ad.jp] Japan's Science Information Network.
SINET was connected to the STAR TAP Router until September 2000, and now peers with Abilene on the west coast of the USA.

GEMnet. [http://www-grd.rdh.ecl.ntt.co.jp/GEMnet/index.html] is an NTT Laboratory (Japan) research network provided to link Japanese universities to MREN and Abilene for specific networking research projects.

1.C.4. STAR TAP United States Advanced Networks

Abilene. [www.ucaid.edu/abilene] US University Corporation for Advanced Internet Development (UCAID), Internet2 Advanced Network, OC-12

DREN. [www.hpcmo.hpc.mil/Htdocs/DREN/index.html] US Dept. of Defense Research and Engineering Network, DS-3

ESnet. [www.es.net] US DOE Energy Sciences Network, OC-3

NISN. [www.nisn.nasa.gov] US NASA Integrated Services Network, OC-3

NREN. [www.nren.nasa.gov] US NASA Research and Education Network, OC-3

vBNS/vBNS+. [www.vbns.net] US NSF Very high-performance Backbone Network Service/MCI Research Network, OC-12

1.C.5. STAR TAP Consortia

Consortia of American universities and National Research Networks, which serve to facilitate connectivity to U.S. high-performance network service providers, such as the vBNS and Abilene. Euro-Link, MIRnet and TransPAC are funded in part by the NSF's High Performance International Internet Services (HPIIS) program.

AMPATH. [www.ampath.fiu.edu]
AmericasPATH, or AMPATH, is a Florida International University (FIU) and Global Crossing (GC) collaborative project to interconnect the Research and Education networks of South and Central America, the Caribbean, and Mexico, to networks in the US and other countries.

EURO-LINK. [www.euro-link.org]
Euro-Link is a HPIIS-funded consortium of UIC, the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden), the Netherlands, France, and Israel. Euro-Link, under the leadership of UIC, is a National Science Foundation-funded initiative that facilitates the connection of European and Israeli National Research Networks to the high-performance vBNS and Abilene networks via STAR TAP. EVL has an active research program with SARA (Academic Computing Services Amsterdam) in The Netherlands, and is developing application-level network performance/monitoring tools to help researchers better understand bandwidth and latency issues involved in transoceanic tele-immersion applications.

MIRNET. [http://www.friends-partners.org/friends/mirnet/home.html]
MIRnet is a HPIIS-funded consortium of the University of Tennessee and Russia

TRANSPAC. [www.transpac.org]
TransPAC is a HPIIS-funded consortium of Indiana University and the Asian-Pacific Advanced Network Consortium (APAN, which includes Australia, Japan, Korea, and Singapore)

1.D. Other Collaborators or Contacts

1.D.1. STAR TAP Collaborators

ALLIANCE and NATIONAL CENTER FOR SUPERCOMPUTING APPLICATIONS (NCSA), UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN. [http://alliance.ncsa.uiuc.edu]
The NSF Partnerships for Advanced Computational Infrastructure (PACI) Cooperative Agreement to the National Computational Science Alliance (the "Alliance"), whose lead institution is the National Center for Supercomputing Applications (NCSA), funds, in part, the UIC/EVL to deploy research results in virtual reality, networking, visual supercomputing, distributed computing, and networked collaboration. (PACI does not fund basic research; it assumes partners already *have* research results and are funded by peer review in their disciplines.) NCSA and Alliance director Dan Reed is very supportive of STAR TAP. STAR TAP and its successor, StarLight, are already working to connect to the Distributed Terascale Facility (DTF).

CALIFORNIA INSTITUTE FOR TELECOMMUNICATIONS AND INFORMATION TECHNOLOGY [Cal-(IT)2], UNIVERSITY OF CALIFORNIA SAN DIEGO. [www.calit2.net]
Cal-(IT)2, a new institute founded by Larry Smarr, is a distributed center, conducting research at both the UCSD and UC-Irvine (UCI) campuses. UCSD and UCI conduct research in core technologies needed to expand the reach and capacity of the global wireless Internet and its emerging all-optical core. Initially, Cal-(IT)2 will use the new telecommunications infrastructure to advance applications important to California's economy, including education, environmental monitoring, health care delivery, transportation, and new media arts, but has ambitions to expand collaborations internationally. Cal-(IT)2 fully encourages and supports the goals of STAR TAP.

CAVERNUS. [www.cavernus.org]
The CAVE Research Network User's Society (CAVERNUS) gives the worldwide community of virtual-reality developers a place to share ideas, solutions and discoveries as they interconnect over high-speed networks. The universities, research laboratories and commercial R&D facilities supporting this web site are also the primary users of EVL's CAVERNsoft collaboration library. CAVERNUS hosts an advanced CAVE workshop series that introduces advanced programming and visualization techniques to optimize the use of projection-based virtual-reality display systems, and hosts Birds of a Feather (BoF) or Special Interest Group (SIG) meetings at major conferences. As EVL continues to enhance CAVERNsoft, EVL conducts network and visualization experiments with international collaborators via STAR TAP.

CORPORATION FOR EDUCATION NETWORK INITIATIVES IN CALIFORNIA (CENIC).
[www.cenic.org]
CENIC represents the common interests of California's higher education academic and research communities in achieving robust, high-capacity, next-generation Internet communications services. CENIC's membership is drawn from California higher education institutions and information technology industries. Tom DeFanti is an Alternate for Larry Smarr, who serves as an Outside Director on CENIC's Board of Directors. DeFanti and Smarr are very interested in getting California connected to StarLight via the DTF backbone.

DataTAG (A EUROPEAN UNION-FUNDED PROJECT FOR RESEARCH AND TECHNOLOGICAL DEVELOPMENT OF A TRANS-ATLANTIC GRID)
Several major international Grid development projects are underway, both in the US and the European Community. All these projects have a common goal of providing transparent access to the massively distributed computing infrastructure that is needed to meet the challenges of modern experiments, including data-intensive Large Hadron Collider (LHC) applications, Earth Sciences research and Bioinformatics research. The DataTAG project will create a large-scale intercontinental Grid testbed focused on advanced networking issues and interoperability among these various intercontinental Grid domains, extending the capabilities of each and enhancing the worldwide Grid development program. The project will address issues that arise with high-performance inter-Grid networking, including sustained and reliable high-performance data replication, end-to-end advanced network services, and novel monitoring techniques. It will also address interoperability issues between Grid middleware layers, such as information and security services. The advances made will be disseminated to each of the associated Grid projects. Participants include CERN, INFN (Istituto Nazionale di Fisica Nucleare, Italy), Particle Physics and Astronomy Research Council (PPARC, UK) and University of Amsterdam (Netherlands).

EMERGE. [http://www.evl.uic.edu/cavern/EMERGE/]
EMERGE was a DoE funded effort (1999-2000) to achieve and demonstrate Differentiated Services (DiffServ) over the Midwest's Metropolitan Research and Education Network (MREN), ESnet and Abilene. Several universities that connect to MREN, notably UIC, NU, UC/ANL, UIUC/NCSA and UWisconsin-Madison, have substantial DoE research grants for networked collaborative problem solving. One immediate goal of EMERGE was to get these labs DiffServ-enabled with routers, Grid middleware and application test suites that verified the benefits of the DiffServ approach to Quality of Service (QoS). Another goal was to explore MREN interoperability with ESnet (an IP-over-ATM network) and Internet2/Abilene (an IP-over-SONET network) when DiffServ was enabled. A more ambitious inter-agency and international goal was to extend these QoS experiments to Europe and Asia via STAR TAP. (CERN has already participated in EMERGE experiments, in part, by establishing a successful DiffServ testbed between its lab and NU's iCAIR. EVL is talking with CERN about doing DiffServ tests; meanwhile, EVL has done Reliable Blast UDP (RUDP) network bandwidth performance tests between Chicago and CERN.)

GLOBUS/ GLOBAL GRID FORUM. [http://www.globus.org, www.globalgridforum.org]
Globus is a joint project of ANL and the University of Southern California's Information Sciences Institute, with significant contributions from NCSA, NASA Ames, the Aerospace Corporation, and other partners. The Globus project is developing basic software infrastructure for computations that integrate geographically distributed computational and information resources. CAVERNsoft uses Globus I/O software to tie geographically distributed virtual environments together for collaborative sessions. The Globus leadership recently founded the Global Grid Forum (GGF), a community-initiated forum of individual researchers and practitioners working on distributed computing, or Grid, technologies; GGF participants come from over 150 participating organizations, with financial and in-kind support coming from GGF sponsoring companies and institutions.

GRID PHYSICS NETWORK (GriPhyN). [www.griphyn.org]
GriPhyN is a team of experimental physicists and information technology researchers who plan to implement the first Petabyte-scale computational environments for data-intensive science in the 21st century. Driving the project are unprecedented requirements for geographically dispersed extraction of complex scientific information from very large collections of measured data. To meet these requirements, GriPhyN will deploy computational environments called Petascale Virtual Data Grids (PVDGs) that meet the data-intensive computational needs of a diverse community of thousands of scientists worldwide. While GriPhyN is an NSF-funded program under the leadership of Paul Avery of the University of Florida and Ian Foster of ANL, the focus is on accessing data generated from CERN experiments. Hence, STAR TAP is of utmost importance to GriPhyN, and the European Union-funded counterpart, DataTAG.

NATIONAL LABORATORY FOR APPLIED NETWORK RESEARCH (NLANR). [www.nlanr.net].
NLANR provide technical, engineering, and traffic analysis support of NSF High Performance Connections sites, including STAR TAP and HPNSP (high-performance network service providers), such as the vBNS and Abilene. Funded by NSF, NLANR is a distributed organization with three parts: Application/User Support, Engineering Services, and Measurement and Analysis.

NATIONAL PARTNERSHIP FOR ADVANCED COMPUTATIONAL INFRASTRUCTURE (NPACI) and SAN DIEGO SUPERCOMPUTER CENTER (SDSC), UNIVERSITY OF CALIFORNIA, SAN DIEGO (UCSD) [www.sdsc.edu, www.npaci.edu]
Tom DeFanti is on sabbatical AY01-AY02. His sabbatical goal is to research optical networking technologies (hardware, software, grid middleware), as well as network policy and national and international funding opportunities, and to work with current STAR TAP partners to design a seamless global optical infrastructure. For 2001-2002, SDSC has appointed DeFanti as Strategic Advisor on issues related to Networking and Visualization with respect to SDSC, the DTF and Cal-(IT)2.

NETWORK FOR EARTHQUAKE ENGINEERING SIMULATION (NEES). [www.neesgrid.org, www.eng.nsf.gov/nees].
The NEESgrid integration project is being organized by NCSA and funded by the NEES program at NSF. The NEESgrid project is a six-month scoping study, with the goal of developing a systems design for the integration of experimental and computing and communications facilities for use by the earthquake engineering community.

1.D.2. STAR TAP Contacts

STAR TAP has consulted with the following International Research Networks about connecting to Chicago. An asterisk (*) precedes the names of those networks whose connections are imminent.

Africa (interest expressed by NIH and other US research institutions)
* Argentina (RETINA)
Australia (AAIREP, the Australian Advanced Internet Research and Education Program) (NOTE: Australia is both connected to STAR TAP via APAN, and its AARNet network is connected to the Northwest GigaPoP in Seattle, where it takes advantage of Abilene and CA*net3's International Transit Network services to connect to other research networks in the USA and foreign countries.)
* Belgium (BELNET, the Belgian National Research Network)
* Brazil (ANSP, the Academic Network at Sao Paulo)
* Brazil (RNP, the Brazilian National Research and Education Network)
Central and Eastern Europe (CEESat.net Satellite Network), in collaboration with the Central and Eastern Europe (CEENet) organization that represents the national academic network administrations of 27 CEE and some Asian countries, including a number of former USSR countries; also received an inquiry from Eastern European university network ZENWA. (Now connected through DANTE/Abilene in NYC)
Costa Rica (CRnet)
England (JANET) (Now connected through Abilene in NYC)
Europe (early inquiries from DANTE; interest from FLAG Telecom) (Now connected through DANTE/Abilene in NYC)
Germany (BelWue, the Baden-Wuerttemberg Extended LAN scientific regional network); in early days of STAR TAP, also had discussions with DFN. (DFN is now connected through Abilene in NYC)
Hong Kong (HARNET, Hongkong Academic and Research Network)
* Ireland (HEAnet, the National Research and Educational network of Ireland)
Philippines (PREGINET, the Philippines Research, Education, and Government Information Network)
Puerto Rico (Connecting via Abilene through AMPATH in Miami)
Romania (Romanian Academic Network)
Saudi Arabia (King Fahd University of Petroleum and Minerals)
Spain (While connected via DANTE to Abilene in New York, a group in Barcelona is following StarLight developments with great interest.)
Switzerland (SWITCHng: Switzerland (SW) Information Technology (IT) Confederatio Helvetica (CH) next generation (ng)
Thailand (UniNet, the Thai Inter-University Network)
United Kingdom (While connected via DANTE to Abilene in New York, the JANET network is following StarLight developments with great interest.)
US JOI/CORE network (Joint Oceanographic Institutions, Inc., a consortium of 14 US oceanographic institutions. [www.joi-odp.org], and Consortium for Ocean Research and Education [http://core.ssc.erc.msstate.edu]

2. Activities and Findings

2.A. Research Activities

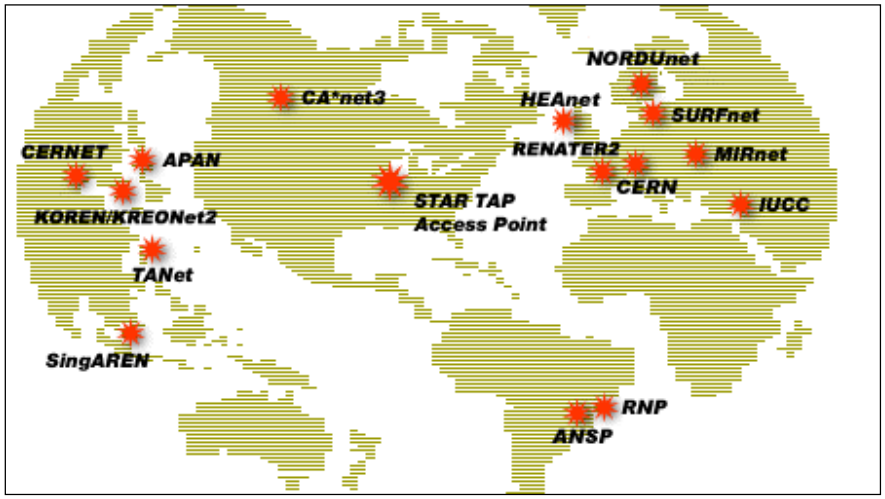
2.A.1. STAR TAP Goals

NSF created the Science, Technology and Research Transit Access Point (STAR TAP) initiative in 1997 (NSF award ANI-9712283 to UIC) to provide a persistent infrastructure to facilitate the long-term interconnection and interoperability of advanced international networking in support of applications, performance measuring, and technology evaluations. Over the years, we have worked hard to successfully position STAR TAP has become a model for next-generation global NGI eXchanges (NGIXs).

Beginning in 2000, STAR TAP funding was renewed (NSF award ANI-9980480 to UIC, and called *STAR TAP 2* for the purposes of the proposal) for an additional three years, to implement advanced network engineering solutions to maintain and improve functionality. STAR TAP continues to be a global-scale laboratory in support of applications, performance measuring, and technology evaluations. STAR TAP's role in providing persistent services as a global exchange point for the Nation demands meeting these engineering challenges. Our users expect STAR TAP to grow in capacity and sophistication.

STAR TAP continuously reinforces the importance of advanced digital communication services for worldwide scientific research communities. However, recent activities, such as the iGrid 2000 demonstration at INET 2000 and iGrid 98 at SC'98,[1] and the assessment of future *cyber-infrastructure* needs,[2] clearly indicate that the next-generation of global scientific research will require networking services that are significantly more sophisticated, with much higher capacity potential and substantially higher performance, than the services available today. Optical networks allow for a far greater degree of network configuration flexibility than existing networks; hence, over the past several months we have started focusing on the development of StarLight, the Optical STAR TAP.

2.A.2. STAR TAP Connectivity Update



[1] EVL has organized major demonstration events, including iGrid '98 at SC'98 and iGrid 2000 at INET 2000. The iGrid 2000 event at INET in Yokohama, organized by EVL, featured 24 collaborative projects from 14 countries [www.startap.net/igrid2000]. iGrid '98 featured 22 demonstrations from 10 countries [www.startap.net/igrid98]. iGrid 2000 featured 24 applications from 14 countries, with emphasis on tele-immersion, large datasets, distributed computing, remote instrumentation, collaboration, human/computer interfaces, streaming media, digital video and high-definition television.

[2] Grid-intensive applications are evolving that require *cyber-infrastructure;* that is, large-scaled distributed storage and networked computing facilities. The NSF Major Research Equipment (MRE) program <http://www.nsf.gov/bfa/bud/fy2001/mre.htm> funds the construction and acquisition of major research facilities to provide scientists with access to geographically distributed, shared-use, next-generation, experimental research equipment installations, with tele-observation and tele-operation capabilities. Over the next decade, as we evolve towards distributed petascale computing and exabyte storage, so must our networks evolve, from megabits to gigabits to terabits.

2.A.2.a. International Networks

ANSP. [www.ansp.br] São Paulo, Brazil, Academic Network
Connection is imminent. A DS-3 was due July 12, 2001, but Ameritech has been experiencing inter-office congestion problems. There is no turn up commitment from Ameritech; however, our best guess is late August.

APAN. [www.apan.net] Asia-Pacific Advanced Network, OC-3
Connected.

BELnet. www.belnet.be Belgium Research Network
Connection is imminent. Ameritech is processing an order for OC-3c ATM connectivity. We anticipate the circuit being turned up in mid-August.

CA*net3. [www.canet3.net] Canadian Network for the Advancement of Research, Industry and Education (CANARIE), OC-3
Connected.

CERN. [http://cern.web.cern.ch] European Laboratory for Particle Physics, DS-3 and OC-3.
As of January 31, 2001, CERN's new 155Mbps circuit to STAR TAP became operational. Initially, it will only be used to peer with Abilene. The old 45Mbps circuit will be retained a few more months to support ongoing experiments.

CERnet. [www.cernet.edu.cn] China Education and Research Network, DS-3
Connected.

HEAnet. [www.heanet.ie/] Ireland National Education & Research Network
Connection is imminent. Ameritech is processing an order for OC-3c ATM connectivity. We anticipate the circuit being turned up in mid-August.

IUCC. [www.internet-2.org.il] Israel Inter-University Computation Center, DS-3
Connected.

KOREN/KREONet2. [www.koren21.net, www.kreonet2.net] KOrean advanced REsearch Network (KOREN) and Korea Research Environment Open Network 2 (KREONet2), DS-3
Ameritech is processing to upgrade to OC-3c. We anticipate the circuit being turned up in mid-August.

MIRnet. [http://www.friends-partners.org/friends/mirnet/home.html] US-Russian High Performance International Internet Services, DS-3
Connected.

NORDUnet. [www.nordu.net] Nordic Countries' National Networks for Research and Education (Denmark, Finland, Iceland, Norway, and Sweden), DS-3
Connected. Note: NORDUnet recently completed a tender to upgrade their USA connectivity with KPNQwest, to take effect July 1, 2001. NORDUnet requested an STM-4c (OC-12, 622Mbps) link directly between Stockholm and the Abilene PoP in New York, and 155Mbps from New York to STAR TAP in Chicago. We recently learned, however, that the Chicago local loop was never ordered for NORDUnet (NORDUnet switched providers, from Teleglobe to KPNQwest), and an OC-3 from the Qwest POP in Chicago to the NAP, if ordered immediately, would not be ready until late October. Instead, NORDUnet will now come to the StarLight facility using QwestLink fiber recently installed as part of the State of Illinois I-WIRE initiative, and then use an OC-3 from StarLight to backhaul traffic to the NAP. (NORDUnet traffic to Abilene and ESnet can be peeled off at the Qwest POP in Chicago, so the traffic to the NAP should be minimal.) Only a week ago we learned that KPNQwest was having problems with the local loop in Stockholm, so this upgrade has been delayed several weeks.

RENATER2. [www.renater.fr] France Research and Education Network, DS-3
Connected. RENATER currently has a dedicated 45Mbps ATM link between Paris and Chicago to carry STAR TAP traffic. They hope to upgrade this to a 155Mbps OC-3c circuit soon in order to access 6TAP and improve capacity

committed to active projects, but to our knowledge, France Télécom is having provisioning problems. PHYnet[3] uses about 30Mbps of RENATER2's link, leaving the remaining bandwidth for other research traffic.

RNP. [www.rnp.br] Brazil National Research Network, DS-3
Connection is imminent. Ameritech and Cable & Wireless builds in Chicago for a DS-3 are complete. The customer's router is not ready in New York. RNP anticipates its New York router will be ready in mid-August.

REUNA. [www.reuna.cl] Chile National University Network, DS-3
Chile connected to STAR TAP and then disconnected several months later due to costs. They currently peer with Abilene in Miami.

SingAREN. [www.singaren.net.sg] Singapore Advanced Research and Education Network, DS-3
Connected.

SURFnet. [www.surfnet.nl] The Netherlands Research and Education Network, OC-3
Connected. In August 2001, SURFnet will close its New York PoP and bring two 622Mbps connections (one provided by Teleglobe and the other by Global Crossing) to the StarLight facility in Chicago. SURFnet is now building its PoP at 710 N. Lake Shore Drive (StarLight). Equipment shipped from the Netherlands arrived in Chicago in May. Initially, SURFnet will have one Cisco 12008 router installed at StarLight, plus one Cisco 2620 for out-of-band access to the Cisco 12008. The 12008 will have OC-12c POS connections to both Teleglobe and Global Crossing, and an OC-12c ATM connection from StarLight to STAR TAP. Between the 12008 and STAR TAP they will install a small ATM switch to access 6TAP. This will also involve a router dedicated to IPv6, which SURFnet will connect to a IPv6-exchange facility at the StarLight location as soon as it becomes available.

TANet2. [www.tanet2.net.tw] Taiwan Academic Network, DS-3
Connected.

2.A.2.b. STAR TAP "Affiliated" International Research Networks

These networks connect to the Ameritech NAP and currently peer with the STAR TAP Router. While these networks have not applied to NSF for official STAR TAP status, the STAR TAP Router is AUP-free and any participating STAR TAP member can receive their routes.

SINET. [www.sinet.ad.jp] Japan's Science Information Network.
SINET was connected to the STAR TAP Router until September 2000, and now peers with Abilene on the west coast of the USA.

GEMnet. [http://www-grd.rdh.ecl.ntt.co.jp/GEMnet/index.html] is an NTT Laboratory (Japan) research network provided to link Japanese universities to MREN and Abilene for specific networking research projects.

2.A.2.c. United States Advanced Networks

Abilene. [www.ucaid.edu/abilene] US University Corporation for Advanced Internet Development (UCAID), Internet2 Advanced Network, OC-12
Because of I-WIRE and DTF and a growing interest in an Optical MREN, Abilene will put an OC-48 router in the Qwest POP at the NBC Tower building in Chicago in the September timeframe, and will connect to the StarLight facility using I-WIRE fiber.

DREN. [www.hpcmo.hpc.mil/Htdocs/DREN/index.html] US Dept. of Defense Research and Engineering Network, DS-3

ESnet. [www.es.net] US DOE Energy Sciences Network, OC-3

NISN. [www.nisn.nasa.gov] US NASA Integrated Services Network, OC-3

[3] PHYnet is France's High-Energy Physics community network; it is a VPM tailored onto the RENATER2 infrastructure. PHYnet peers with ESnet in order to connect to SLAC, FermiLab, CERN, etc.

NREN. [www.nren.nasa.gov] US NASA Research and Education Network, OC-3

vBNS/vBNS+. [www.vbns.net] US NSF Very high-performance Backbone Network Service/MCI Research Network, OC-12

2.A.3. STAR TAP Engineering Services

Peering: Bi-Lateral Agreements and STAR TAP Router

STAR TAP runs in an Acceptable Use Policy (AUP)-free mode; that is, connecting networks must agree pair-wise regarding acceptable use. STAR TAP relies on mature ATM switching as provided by Ameritech. Once connected to STAR TAP, the NRNs, in addition to connecting to the vBNS, can peer with other US Next Generation Internet networks, UCAID's Abilene, and advanced networks from other countries. They can peer by bilateral agreement, which is functionally implemented with a full mesh ATM Private Virtual Circuit (PVC) layer-2 service at the switch. Or, they can do level-3 peering using the STAR TAP Router. They may also connect to one or more ISPs at the AADS facility, which is outside the scope of STAR TAP, but a useful capability nonetheless.

The STAR TAP Router was introduced in November 1999 to facilitate peering among the ~20 National Research Networks (NRNs) connected to STAR TAP. Due to individual policy restrictions, the vBNS, Abilene and ESnet do not peer with the STAR TAP Router. A current list of STAR TAP peers (both level 2 and level 3 peering) can be found on the STAR TAP site, at [http://www.startap.net/ENGINEERING/].

In May 2001, an M5 router donated by Juniper Networks to the STAR TAP project was installed. This router now serves as STAR TAP's layer 3 peering point for the exchange of IPv4 traffic (STAR TAP was previously sharing a Cisco router with APAN).

IPv6 Tunnel Service at the 6TAP

The 6TAP [www.6tap.net], an IPv6 service run by ESnet and CANARIE and hosted by STAR TAP, is up and running. 6TAP supports IPv6 over IPv4 tunnels and IPv6 performance measurement and statistics. 6TAP is currently talking to STAR TAP/StarLight engineering about placing equipment at 710 N. Lake Shore Drive.

NLANR Web Cache

NLANR built and tested a Web Cache, running the Squid caching software, for STAR TAP. The cache PC was installed at Ameritech in December 1999. GENUiTY (formerly NAP.NET) donated ISP service over a 1 Mb connection. The cache is integrated into NLANR's Global Caching Hierarchy.

NLANR Performance Measurement

An NLANR AMP (Active Measurement Platform) box is installed at STAR TAP; information is accessible from the STAR TAP web pages [http://www.startap.net/ENGINEERING/PERFORM.html].

Differentiated Services (DiffServ) EMERGE Testbed

A STAR TAP Cisco 7507 DiffServ router, used for international EMERGE experiments, was installed at Ameritech in December 1999. To date, CERN and iCAIR have used it to run experiments [www.icair.org/inet2000]; Russia, Singapore and Amsterdam have expressed interest in running experiments as well. This router is an extension of UIC's EMERGE project [www.evl.uic.edu/cavern/EMERGE]. The goal of EMERGE is to build the teams and technology to help achieve guaranteed bandwidth across large distances.

Multicast

Many of the STAR TAP participants have Native Multicast enabled. These networks are documented at [http://www.startap.net/ENGINEERING/TECHINFO.html].

Distributed STAR TAP

STAR TAP management has designated several international carriers as "Distributed STAR TAP" providers. These carriers not only carry transoceanic or cross-continent NRN traffic to the US, but can make sure the connections come in a timely and efficient manner to Chicago and the Ameritech NAP. This designation is for the convenience of our NRN partner networks, to assure them there won't be connectivity delays because a carrier is unfamiliar with Chicago's telecommunications infrastructure. Current "Distributed STAR TAP" providers are Teleglobe, Cable & Wireless and IMPSAT. [www.startap.net/CONNECT]

International Transit Network (ITN)

In October 2000, the CA*net3 ITN and Abilene ITN services were offered by CANARIE and Internet2 to facilitate connectivity among NRNs that now connect to one of the coasts of North America. [www.startap.net/CONNECT]

2.A.4. STAR TAP NOC Services

The Global NOC web site ties together all NOC-supported network services for Abilene, STAR TAP, TransPAC, Euro-Link, MIRnet and AMPATH [http://globalnoc.iu.edu/]. The STAR TAP-specific NOC web site is [http://noc.startap.net]. The NOC provides network management and problem management/reporting services.

2.A.5. STAR TAP International Advisory Committee and Annual Meeting

On June 5, 2001, we held our annual STAR TAP International Advisory Committee meeting in conjunction with the INET 2001 conference in Stockholm, Sweden. The agenda and PowerPoint presentations from each of the speakers are posted on the STAR TAP web site. [http://www.startap.net/ABOUT/MEETINGS.html]. The meeting was held at the Center for Parallel Computers (Parallelldatorcentrum or PDC), on the campus of the Royal Institute of Technology (Kungl Tekniska Högskolan or KTH). It was sponsored by Global Crossing Europe, the International Center for Advanced Internet Research (iCAIR) at Northwestern University, PDC, Qwest and Teleglobe USA.

The STAR TAP International Advisory Committee (IAC) consists of representatives of the international and HPIIS networks connected to STAR TAP. The group serves as an external advisory body to the STAR TAP Principal Investigator, Tom DeFanti, to assure that the international groups connected to STAR TAP make decisions that affect the policies and operations of STAR TAP. For the first three years of STAR TAP, the IAC chair was Larry Smarr. Rick Stevens became chair in July 2000. As of June 2001, the IAC consisted of the following members:

- Rick Stevens, ANL/USA (Chair)
- Tomonori Aoyama, JGN/Japan
- Natasha Bulashova, Russia/MIRnet
- Greg Cole, NCSA/MIRnet
- Manuel Delfino, CERN
- Shigeki Goto, APAN
- Michael McRobbie, IndianaU/TransPAC
- Kees Neggers, SURFnet/Netherlands
- Bill St. Arnaud, CANARIE
- Dany Vandromme, RENATER/France
- Peter Villemoes, NORDUnet
- Jer-Nan Juang, NCHC/TANet2
- Ralphi Rom, IUCC/Israel
- Ngoh Lek Heng, SingAREN, Singapore
- Heather Boyles, Internet2 International Transit Service (ITN)
- Florencio I. Utreras, REUNA (Chile)**
- Xing Li, CERNET (China)
- Ok-Hwan Byeon, KOREN/KREONet2 (Korea)
- Victor Reijs, HEAnet (Ireland)*
- Alexandre L. Grojsgold, RNP (Brazil)*
- Hartmut Richard Glaser, ANSP (Sao Paulo, Brazil)*

* Connection is imminent
** Connection subsequently terminated

STAR TAP Engineering staff is on the Advisory Committee; the following people ex-officio members.

- Alan Verlo, STAR TAP Engineering (Ex Officio)
- Linda Winkler, STAR TAP Engineering (Ex Officio)
- Akihiro Tsutsui, STAR TAP Engineering (Ex Officio)*
- John Jamison, STAR TAP consultant (Ex Officio)**
- Andy Schmidt, STAR TAP Engineering (Ex Officio)

* Akihiro Tsutsui works for NTT Optical Network Laboratory and was on loan to EVL for 9 months to assist on optical networking. Although he recently returned to Japan, he has asked to remain a consultant to the StarLight project.
** John Jamison was STAR TAP Engineer from 1999-2000 and now works for Juniper Networks, but remains a consultant to STAR TAP.

STAR TAP Administrative staff is on the Advisory Committee; the following people ex-officio members.

- Tom DeFanti, UIC/STAR TAP/EuroLink (Ex Officio)
- Maxine Brown, UIC/STAR TAP/EuroLink (Ex Officio)
- Laura Wolf, UIC/STAR TAP/EuroLink (Ex Officio)
- Steve Goldstein, NSF (Ex Officio)

2.A.6. STAR TAP Meetings, Conferences and Workshop Participation (May 2001-August 2001)

August ~27, 2001. Tom DeFanti, in his role as Strategic Advisor to SDSC and Cal-(IT)2 during his sabbatical year, is meeting with Tom West of CENIC to discuss California's DTF and StarLight connectivity.

August 23-24, 2001. Tom DeFanti, Maxine Brown and Linda Winkler are attending the HPIIS NLANR Workshop at SDSC in San Diego, California. Metrics for usage for international links will be discussed.

August 21, 2001. Tom DeFanti is host to visitors from Japan's Multimedia Virtual Laboratory (MVL) Conference. This group, visiting EVL, consists of individuals from private companies, academic institutions and government organizations interested in the advancement of worldwide R&D activities in the fields of science and technology.

August 20, 2001. Jason Leigh is host to visitors to EVL from the University of Tokyo Robotics Laboratory with whom EVL is collaborating.

August 16-17, 2001. Tom DeFanti and Maxine Brown are attending the FIU AMPATH Workshop, being held to identify areas of scientific collaboration between researchers in the US and Central/South America.

August 13, 2001. NSF ANIR program manager Chip Cox visited EVL and StarLight. In attendance were Tom DeFanti, Maxine Brown, Linda Winkler, Joe Mambretti, Andy Schmidt, Jason Leigh and Bob Grossman.

August 6-9, 2001. The Tenth IEEE International Symposium on High Performance Distributed Computing (HPDC-10) was held in San Francisco, California. In conjunction with HPDC, there was a Workshop on Advanced Collaborative Environments. Jason Leigh participated in the Workshop as well as the conference.

July 23-24, 2001. Maxine Brown attended an NSF RI Workshop at NSF headquarters in Arlington, VA. She spoke with Rick Adrion of CISE EIA about EVL plans to submit an RI focused on optical networking. She also met with Steve Goldstein.

July 15-18, 2001. Jason Leigh and PhD student Kyoung Park attended the 2nd international Global Grid Forum (GGF-2) workshop in Washington DC. The GGF workshops are aimed at designing, building, and using grids and grid technologies. Leigh and Rick Stevens of ANL are co-chairs of the GGF's ACE Working Group [http://calder.ncsa.uiuc.edu/ACE-grid/]. ACE will provide human-centered techniques and technologies for facilitating interactive, collaborative, and immersive access of Grid resources from anywhere, at any time.

June 28, 2001. Joe Mambretti and Andrew Schmidt met with SBC representatives Anthony Haeuser, Caitlin Brown and Gary Misner to discuss better support of STAR TAP and MREN in the future. Points of discussion included a general network status review, points of contacts between the organizations, and setting an agenda to work together in coming months. Also discussed were current and future network architectures, gigabit Ethernet Metro service and how it fits into STAR TAP's future plans, updated pricing reflecting higher education discounts, and connectivity to the Abilene network. Attendees concluded the most likely direction for the networks would be gigabit Ethernet based, and Ameritech would work with us to extend their gigabit Ethernet capabilities. Ameritech agreed to create a billing structure to facilitate dividing the OC-12 Abilene connection charge among the MREN participants.

June 22-27, 2001. Tom DeFanti, Maxine Brown and Jason Leigh met with collaborators at NTT and University of Tokyo in Japan. In addition to EVL research projects, the possibility of an iGrid 2002 event in Amsterdam was discussed. Tomonori Aoyama, EVL's collaborator at University of Tokyo, is chairman of the recently established Photonic Internet Forum (PIF), supported by the Japanese government. While Aoyama is interested in bringing a lambda to StarLight, funding isn't yet allocated. We discussed the possibility of NTT or another telecommunications company donating a lambda for the iGrid 2002 event so Japanese applications could be represented.

June 21, 2001. EVL's Andy Schmidt and Alan Verlo and Northwestern's Tim Ward and Joe Mambretti met to discuss OMNInet and StarLight optical networking plans and how they intended to interface cluster computers.to the optical backbone being created at StarLight.

June 13, 2001. Jason Leigh presented his current work on Euro-Link, STAR TAP and protocols for high throughput data transmission in tele-immersion at the Undersea Weapon Simulation Based Design Workshop in Baltimore, Maryland. <http://sbdonr.umd.edu/>

June 11-14, 2001. Maxine Brown attended a SC'2001 Paper Committee meeting in Denver, which was held at the same time as other SC meetings. While there, she talked with Wes Kaplow of Qwest, who was attending the SC SCInet (Supercomputing networking committee) meetings, about Qwest's bringing an OC-192 from Chicago into Baltimore for SC'2002 to promote StarLight demonstrations.

June 3-7, 2001. A series of STAR TAP and StarLight meetings were held during INET 2001 in Stockholm, Sweden. (June 3) A dinner was organized that included Bill St. Arnaud, Kees Neggers, Larry Smarr, Joe Mambretti, Tom DeFanti, Maxine Brown, Linda Winkler, Andy Schmidt, Laura Wolf, Jason Leigh, Bob Grossman and others involved in StarLight. (June 4) Tom DeFanti met informally with Tom Greene and Chip Cox of NSF to discuss STAR TAP meeting presentations. (June 5) The annual STAR TAP meeting was held at the Center for Parallel Computers (Parallelldatorcentrum or PDC), Royal Institute of Technology (Kungl Tekniska Högskolan or KTH); the agenda and Power Point presentations appear at <http://www.startap.net/ABOUT/meetingInet2001.html>. (June 5) Tom DeFanti, Bob Grossman, Laura Wolf and Maxine Brown had dinner and discussed setting up data mining servers at both StarLight and SARA in Amsterdam for future lambda-effort applications. (June 6) Larry Smarr, Tom DeFanti, Maxine Brown and Kees Neggers continued discussions on StarLight, meeting later with Tom Greene and Yves Poppes (Teleglobe). (June 7) Tom DeFanti, Maxine Brown, Kees Neggers and Karel Vietsch of TERENA met to discuss a Lambda Workshop in Amsterdam, September 12-13; see <http://www.terena.nl/conf/lambda/>. They also discussed holding an iGrid 2002 event in Amsterdam in September 2002 to showcase advanced applications over optical networks. Maxine is to follow up with Jacqueline Tammenoms Bakker who heads up Holland's GigaPort project, as she would help provide funding for this event. (June 7) Tom DeFanti and Maxine Brown had dinner with Lennart Johnsson, a professor at University of Houston and director of PDC in Stockholm, as well as members of PDC's Board of Directors to discuss future trends in high-performance computing.

May 31, 2001. Tom DeFanti and Oliver Yu of EVL/UIC and Joe Mambretti of Northwestern University met with representatives of the Photonics Internet Forum (PIF), which was recently established by Japan's Ministry of Post & Telecommunications to make recommendations to the government to establish national policies and obtain research funds for photonic networking technologies for the IT industries and IT users in Japan. The PIF sent a delegation to North America, headed by Professor Aoyama, in order to see how US and Canadian governments and public sectors are handling photonic network testbeds, and how they provide research funding to research groups involved with photonic networking. The group visited STAR TAP/ StarLight, as well as NSF (Aubrey Bush) and CANARIE (Bill St. Arnaud). PIF representatives who visited STAR TAP/StarLight were:

- Tomonori Aoyama, University of Tokyo and Japanese Gigabit Networks
- Ken-ichi Kitayama, Osaka University

- Ken-ichi Sato, Photonic Transport Network Laboratory, NTT Network Innovation Laboratories
- Wataru Chujo, Ultrafast Photonic Network Group, Communications Research Laboratory,
- Masahiro Ojima, Telecommunication Systems Division, Hitachi, Ltd.
- Akira Hakata, Advanced Photonic Network Systems Development Div., Fujitsu Ltd.
- Shingo Inoue, Information Technology Research Department, Mitsubishi Research Institute, Inc.
- Sumiyasu Hidaka, Research Div., Support Center for Advanced Telecommunications Technology Research

May 30, 2001. Jason Leigh presented his current work on Euro-Link, STAR TAP and protocols for high throughput data transmission in tele-immersion at AT&T Visualization Days in New Jersey. [www.visdays.com]

May 29, 2001. Tom DeFanti, Maxine Brown and others from EVL/UIC, Joe Mambretti and Tim Ward of Northwestern, and Linda Winkler and Bill Nickless of ANL met with Internet2's Doug Van Houweling, Heather Boyles, Steve Corbató and Greg Wood to discuss increasing Abilene bandwidth in Chicago for Euro-Link networks. Abilene agreed to put an OC-48 router in the Qwest POP at the NBC Tower building in the September timeframe, and will connect to 710 with I-WIRE fiber once it's installed.

May 23-25, 2001. Tom DeFanti, Maxine Brown and Jason Leigh participated in the NCSA/Alliance All Hands Meeting (AHM). Leigh and 4 EVL students hosted a poster session describing EVL development and deployment activities, including Euro-Link network performance monitoring efforts and StarLight. DeFanti was the AHM general chair, and as part of the program, invited Bill St. Arnaud to talk about optical networks and Bob Grossman to talk about large-scale data mining.

May 18, 2001. Maxine Brown gave a presentation, "StarLight: In Support of Global Scientific Research Communities," in the Advanced Internet Session at the Internet Global Conference in Barcelona <http://www.igconference.net/>. The session was organized by Artur Serra of UPC, and also included speakers:

- Latif Ladid, Vice President of Ericsson and President of the IPv6 Forum
- Pascal Drabik, Scientific Officer, European Commission
- Xavier Kirchner, Director Centre de R&D, Nortel Networks, Barcelona

May 16-17, 2001. At the invitation of Artur Serra of the Universitat Politecnica de Catalunya (UPC), Maxine Brown visited the school to meet with networking and virtual-reality faculty and staff, as well as faculty at related schools and local government officials responsible for university research funding initiatives. Serra and Sebastia Sallent run the i2CAT program <http://www.i2-cat.net>, a university/commercial/government initiative that focuses on funding collaborative projects requiring advanced networking. Serra has been closely monitoring Kees Neggers' efforts to lead the optical Internet in Europe. People that Brown met with include:

- Jordi Domingo-Pascual, Computer Architecture Department (runs the GigaPoP), UPC
- Pere Brunet, Industrial Design Department (runs a CAVE-like facility, funded by Volkswagen), UPC
- Montserrat Meya I Llopart, Catalunya Government (University research)
- Josep Blat, Escola Superior Politecnica

May 16, 2001. Jason Leigh presented his current work on Euro-Link, STAR TAP and protocols for high throughput data transmission in tele-immersion at the Fifth Immersive Projection Technology Workshop in Stuttgart, Germany. [http://vr.iao.fhg.de/ipt-egve]

May 11, 2001. Tom DeFanti and Maxine Brown met with Bob Grossman of UIC about his placing a data warehouse at StarLight and at SARA in Amsterdam to stress-test the optical links once they are in place.

May 8, 2001. Anne Richeson of Qwest and representatives of QwestLink (the local company) visited the StarLight facility at 710 and then visited EVL to discuss opportunities in advanced networking with Tom DeFanti, Maxine Brown and Joe Mambretti.

May 3, 2001. Lazaros Efraimoglou, president of the Foundation for the Hellenic Worlds (FHW) in Athens, Greece, visited EVL with his wife to learn more about future virtual-reality and networking research activities. EVL graduate Maria Roussou works for the FHW, where she is responsible for their virtual-reality activities (they have a CAVE-like display and an ImmersaDesk, and develop cultural heritage applications of Greek temple ruins for

educational purposes). FHW participated in iGrid 2000 in Yokohama that EVL organized. Tom DeFanti and Maxine Brown impressed upon Efraimoglou the importance of high-speed interconnectivity for remote collaboration.

April 27, 2001. Tom DeFanti gave a presentation to the Computer Science Department at Northwestern University on, "StarLight: Optical Switching for the Global Grid." Maxine Brown and Laura Wolf, as well as others from EVL, met with Ian Foster and his staff about SC Global, a major international event at SC'2001 in Denver in November.

April 24-27, 2001. Dan Sandin of EVL visited Umeå University in Stockholm, Sweden. He attended the Umeå Forum, gave a presentation entitled "Interaction Design in the CAVE," and participated in the "Life in Networked Society" panel. Sandin visited Umea's HPC2N lab and presented a talk on the networking research at EVL. He met with Umeå's Kenneth Homlund to discuss setup for the upcoming tele-immersive art event in conjunction with the Ars Electronica Center festival in Austria in September. Sandin conducted a real-time, collaborative test between EVL and HPC2N. He intends to develop an on-going persistent collaborative relationship. Sandin also spoke at the Tools for Creativity Studio at the Interactive Institute of Sweden, another partner in the Ars Electronica event.

April 22, 2001. Tom DeFanti attended the UCAID Board of Trustees meeting in Washington DC, where he spoke with Doug Van Houweling, Heather Boyles and Steve Corbató about upgrading Abilene's 622 Mb link to Chicago, primarily to accommodate SURFnet and other internationals, such as NORDUnet or CERN, as well as MREN customers, as bandwidth increases. It was decided that we would hold a meeting in Chicago to discuss this issue, as well as share information on future plans under non-disclosure. For Internet2, this involves Abilene evolution and a next generation backbone network as well as DTF. For STAR TAP, it involves information on Star Light. The meeting is set to occur on May 29 at EVL.

April 19, 2001. Olivier Martin of CERN visited EVL and toured the StarLight facility in downtown Chicago. Met with Tom DeFanti, Maxine Brown and Joe Mambretti about a possible high-speed research link between CERN and StarLight, in addition to the existing link CERN plans to upgrade to 622Mbps by March/April 2002.

April 17, 2001. Joe Mambretti hosted an OMNInet technical meeting at Northwestern University. OMNInet, the Optical Metropolitan Network Initiative network, is co-located with StarLight at the 710 facility. Tom DeFanti, Maxine Brown, Jason Leigh, Linda Winkler, Alan Verlo and Andy Schmidt attended.

April 4-6, 2001. EVL deployed an ImmersaDesk in Valparaiso, Chile as part of REUNA's "Science, Culture and Education over Internet2 Networks" meeting. Real-time, tele-immersive collaborative demonstrations between Chile, UIC and University of Michigan featured geological earthquake data and medical models. REUNA director Florencio Utraras invited EVL to showcase tele-immersive virtual reality to stimulate interest among the Chilean scientific community for future collaborations with North America and Europe via the REUNA link to STAR TAP. *[Note: Subsequently, due to funding issues, REUNA disconnected from STAR TAP but continues to maintain its connection to AMPATH; we are working on ways to connect AMPATH with STAR TAP.]*

2.B. Research Findings

In a research context, "findings" are the outcomes of experiments. Because STAR TAP is an infrastructure grant, we interpret "findings" to be new infrastructure outcomes caused by (or an outgrowth of) the current infrastructure design. STAR TAP's StarLight, with a focus on optical networking, and is a direct outcome of our working with the international research community to architect the networking component of a 21st century advanced computational infrastructure.

2.B.1. StarLight: The Optical STAR TAP

Motivation

StarLight [www.startap.net/starlight] is an advanced optical infrastructure and proving ground for network services optimized for high-performance applications. StarLight is under development by EVL/UIC, iCAIR/NU and ANL's Mathematics and Computer Science Division, in partnership with CANARIE and SURFnet.

StarLight, in collaboration with the academic and commercial communities, is creating a global proving ground for grid-intensive e-Science applications, network performance measurement and analysis, and computing and networking technology evaluations. StarLight provides space and collaboration opportunities for advanced data mining, video streaming, caches, network monitoring and analysis, as well as optical switching and, eventually, optical routing.

StarLight Facility

StarLight will initially provide the applications-centric network research community with a Chicago-based co-location facility with enough space, power, air conditioning and fiber to engage in next-generation optical network and application research and development activities. The facility will also have ATM links back to STAR TAP, located at the SBC/Ameritech Network Access Point, a 1GigE and 10GigE switch/router facility for high-performance access to participating networks and, ultimately, a true optical switching facility for wavelengths.

StarLight's first connection is imminent. SURFnet is bringing two production 622Mb lines from Amsterdam to StarLight on July 1, 2001 and an additional 2.5 Gb lambda to StarLight on September 1. Canada's CA*net3 network will soon connect, as will Illinois institutions participating in I-WIRE, a State-of-Illinois-funded effort involving UIC, NU, ANL, NCSA, University of Chicago and Illinois Institute of Technology. CERN intends to bring a 2.5 Gb lambda to StarLight in July 2002; GigE connections from other countries are also anticipated next year. Several carriers also have or are in the process of installing fiber into StarLight.

StarLight's architecture is designed to be distributable among opportune carrier points of presence, university campuses, carrier meet points, and so on. Also, StarLight will provide multiple autonomous peering light-paths for its community, using a common set of protocols, and will provide interconnections to distributed OC-x services. Because not all researchers will have access to these advanced services, StarLight will also provide mechanisms to establish gateways for a variety of additional services, such as Asynchronous Transfer Mode (ATM), Synchronous Optical Network (SONET), Packet Over SONET (POS), high-performance Internet Protocol (IP), GigE and 10GigE. StarLight expects GigE services to be production quality and compatible with the existing STAR TAP facility. Optical switching services are viewed as experimental and will be managed as such for the foreseeable future.

RACK SPACE. StarLight currently has five cabinets, two of which have equipment. NU is in the process of building out additional floor space that can be used for significant cabinet growth.

EQUIPMENT. The following equipment is located at the StarLight facility:

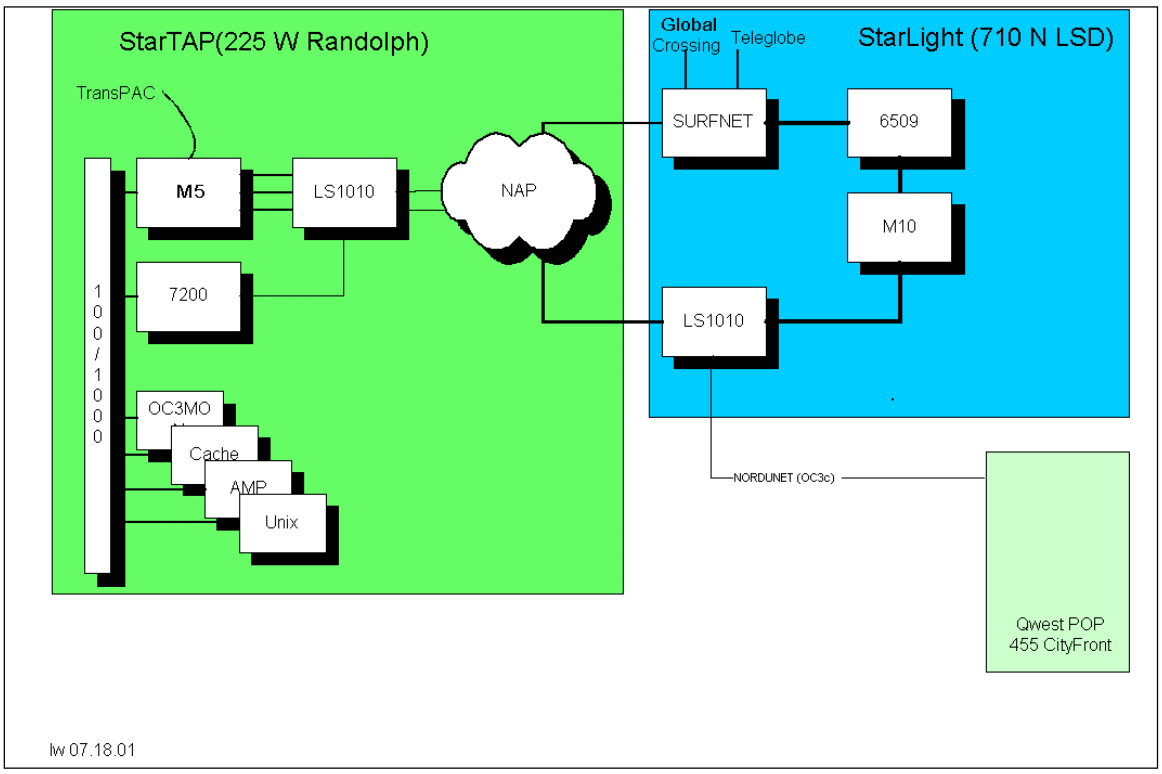
- Cisco LS1010 ATM switch with OC-12c and OC-3c ports, to serve as the gateway to the STAR TAP ATM network and as a local ATM hub.
- Cisco 6509 Gigabit Ethernet switch, to serve as STAR TAP's high-speed packet-based exchange point.
- Juniper M10 router, to serve as the gateway between the LS1010 and the 6509.
- Cisco 12000 router, to be used to terminate SURFnet's OC12s (soon to be installed)

StarLight Networking

STARLIGHT/STAR TAP CONNECTIVITY. STAR TAP contracted for two OC-12 connections from the StarLight facility to the Ameritech NAP. [Ameritech does not yet offer OC-48 service.] One of these OC-12s will be dedicated to SURFnet/Abilene traffic. The second link is to be shared by SURFnet (for non-Abilene traffic) and other NRNs that co-locate at StarLight. These connections were operational on July 1.

STARLIGHT/ABILENE CONNECTIVITY. In May, a meeting between STAR TAP (Tom DeFanti, Maxine Brown, Linda Winkler, Joe Mambretti) and Internet2 (Heather Boyles, Steve Corbató and Doug Van Houweling) was held to discuss increasing Abilene's bandwidth in Chicago to meet the needs of Euro-Link networks. Abilene agreed to put an OC-48 router in the Qwest PoP at the NBC Tower building in September, and connect to 710 N. Lake Shore Drive with I-WIRE fiber once it's installed.

STARLIGHT/ESNET CONNECTIVITY. ESnet is investigating collocating some equipment at StarLight, subject to availability and reasonable costs. They would like to use I-WIRE fiber to connect to StarLight from the Qwest POP in the NBC Tower building.



CARRIER AND SERVICE PROVIDER FIBER. The following telecommunications carriers and service providers either currently have fiber into the StarLight facility or have plans to bring fiber into the facility.

- Currently present:
  - AT&T has voice lines to NU
  - Ameritech has installed two OC-12s as well as an existing OC-3 ATM from StarLight to STAR TAP (the Ameritech NAP)
  - Focal has voice links to NU
  - Qwest is bringing an OC-3c for NORDUnet into StarLight from their downtown Chicago facility
- Short-term pending installations:
  - Global Crossing OC-12 for SURFnet
  - Teleglobe OC-12 for SURFnet
  - Teleglobe OC-48 for SURFnet
- Long-term pending installations:

- AT&T plans to install an OC-192 SONET ring
- Ameritech plans to install additional dark fiber
- Level(3) plans to install SONET facility
- Telseon plans to establish a Gigabit Ethernet POP

EXTERNAL PARTNER CIRCUITS. The following circuits are either functional or on order

- Functional
  - 2 OC-12s from the LS1010 to STAR TAP
  - 1 OC-3c for NORDUnet to the LS1010
- On order
  - OC-12s for SURFnet. The carrier is Teleglobe (anticipated August 15)
  - OC-12c for SURFnet. The carrier is GlobalCrossing (anticipated September 15)
  - OC-48 for SURFnet. The carrier is Teleglobe (anticipated September 15)

OPTICAL MREN. MREN's growth includes plans to incorporate MERIT, Wisconsin, Abilene, and Minnesota at StarLight.

StarLight Proposed Services

Optical networks allow for a far greater degree of network configuration flexibility than existing networks. StarLight will provide the required tools and techniques for (university) customer-controlled 10 Gigabit network flows to be switched and routed to research networks and commercial networks, empowering applications to dynamically adjust and optimize network resources.

A general control mechanism will be derived from emerging toolkits, such as Globus, which provides Grid resource access and allocation services, including network resources. In addition, StarLight will host a range of new tools, based, in part, on Layer 3 IP control, including General Multiprotocol Label Switching (GMPLS) and Optical Border Gateway Protocol (OBGP) signaling, for designing, configuring and managing optical networks and their components; e.g., optical links, light-path meshes, etc. These mechanisms will include the implementation of a new generation of tools for appropriate monitoring and measurements at multiple levels—device, light-path, physical link, etc.—regionally, nationally, and internationally.

Current services under discussion:
(1) StarLight management is talking with MERIT about providing route services and network operations to equipment at StarLight (in lieu of providing these services to Ameritech for MREN).
(2) StarLight Engineering has been talking with Bob Fink and Mike Collins of ESnet and Marc Blanchet of Viagenie about placing an IPv6 Router at StarLight. Collins will pre-configure a router and send it to StarLight so that down time is minimal.
(3) Meanwhile, SURFnet plans to put a Cisco 7204VXR router at StarLight, to be used as a dedicated IPv6 router. It will be connected with a frame relay PVC to SURFnet's PoP in Amsterdam and to the 6TAP. However, SURFnet is interested in having an IPv6 exchange at StarLight.

2.B.2. STAR TAP Applications Documented

Active US/International collaborations utilizing high-performance research networks continue to be documented on the STAR TAP web site [www.startap.net/APPLICATIONS].

2.B.3. Advanced Collaborative Environments (ACE) Grid Working Group

At the Global Grid Forum in Amsterdam, March 4-7, 2001, Jason Leigh and Rick Stevens of ANL formed the ACE Working Group [http://calder.ncsa.uiuc.edu/ACE-grid/] to complement other Grid Working Groups [http://www.gridforum.org/]. ACE will provide human-centered techniques and technologies for facilitating interactive, collaborative, and immersive access of Grid resources from anywhere, at any time.

2.B.4. TERENA International Lambda Workshop

As a result of the successful STAR TAP Annual Meeting (Section 2.A.5) which focused on StarLight (Section 2.B.1), others are realizing the importance of optical networking for enabling future e-Science applications. On September 12-13, 2001, TERENA is sponsoring an International Lambda Workshop in Amsterdam, to provide information to managers of research networks and research network users with advanced requirements on how to develop their own strategy towards optical networking [www.terena.nl/conf/lambda/index.html]. The day before this Workshop, the international team designing StarLight will use the opportunity of being in one location to meet and have face-to-face engineering discussions.

2.B.5. iGrid 2002

In recent years, EVL has organized two iGrid (or international grid) events, one in Orlando, Florida in 1998 [www.startap.net/igrid98] and one in Yokohama, Japan in 2000 [www.startap.net/igrid2000]. ***Five iGrid 2000 applications running in parallel completely consumed the 100Mb transoceanic link from Chicago to Yokohama; we then understood that we needed to go optical.*** Another iGrid is planned in Amsterdam in September 2002; the theme is grid-intensive application control of lambda-switched networks. We have already sent invitations to participate to key researchers with insatiable bandwidth appetites whose sites will be connected to I-WIRE, DTF and StarLight (although funding for the event still needs to be determined). "iGrid" is the international extension of the Alliance's National Technology Grid.

Jacqueline Tammenoms Bakker, head of The Netherland's GigaPort project, has expressed interest in hosting and funding this event. Maxine Brown and Tom DeFanti will have further discussions with her when they visit Amsterdam in September 2001 for the TERENA Lambda Workshop.

2.B.6. SC'2002

Roscoe Giles, SC'2002 chair, and Dennis Duke, SCinet chair, approached Tom DeFanti about organizing some sort of conference event to showcase high-end networked applications of global significance. One idea/opportunity will be to refocus the iGrid 2002 applications for the SC community. Tom has started discussions with Dan Reed and Rick Stevens about whether this is a worthwhile PACI/Alliance activity.

2.C. Research Training

There is clearly a fine team of faculty, staff and engineers from UIC, ANL, NCSA, MREN, iCAIR and Indiana University involved with STAR TAP, as indicated in this report, facilitating greater advances in global networking than a single-investigator effort would afford. Moreover, if we count all the people involved in STAR TAP, not just the management team in the Chicago area, the involvement extends nationally (NLANR, NGI networks, Internet2) and internationally. All the people working on STAR TAP and STAR TAP-related projects are involved in furthering its goals, either within their respective disciplines, or by helping us better understand the limitations and future directions of long, fat networks.

2.D. Education/Outreach

Because we also manage the NSF HPIIS-funded Euro-Link project, many of the European-related activities listed below overlap with those listed in our Euro-Link reports.

Our primary education and outreach activities include web documentation, journal articles, and conference presentations and demonstrations. We also provide videotapes, PowerPoint presentations, and other teaching materials to collaborators to give presentations at conferences, government briefings, etc.

Since 1986, EVL has partnered with NCSA, ANL, and more recently iCAIR, in ongoing efforts to develop national/international collaborations at major professional conferences, notably ACM SIGGRAPH, ACM/IEEE Supercomputing (SC), IEEE High Performance Distributed Computing (HPDC) and INET, as well as Internet2 meetings. We have participated in NRN conferences, including the annual CANARIE Workshop, the NORDUnet annual conference, Israel's Internet-2 and Telecomm conferences and Chile's Internet-2 meeting. Our success has been in the development of teams, tools, hardware, system software, and human interface models on an accelerated schedule to enable multi-site collaborations for complex problem solving. We have received a great deal of media attention for our work; news articles are posted at [www.startap.net/PUBLICATIONS].

Past events we have organized include iGrid '98 at SC'98 and iGrid 2000 at INET 2000. We are involved in the SC'2001 conference [www.sc2001.org] in Denver, November 10-16, 2001; we are assisting with the SC Global event, which will use Access Grid technology [www.accessgrid.org] to link the SC "core" at the Denver Convention Center with dozens of Access Grid nodes or "constellation sites" throughout the world. We also encourage our international collaborators to develop conference events (such as iGrid) to showcase meritorious applications among their own researchers.

EVL also collaborates with the NSF-funded GriPhyN and NEES initiatives, as well as the CAVE Research Network Users' Society (CAVERNUS).

3. Publications and Products

3.A. Journals/Papers

In addition to overseeing the growth and development of STAR TAP, the faculty, staff and students of EVL/UIC are users of STAR TAP. Specifically, EVL/UIC develops tele-immersion tools and applications with collaborators worldwide. In addition, EVL/UIC studies the effects of long, fat networks on application performance. To this end, EVL is building tools into its CAVERNsoft communications library to facilitate optimal use, and is developing applications-level network performance analysis tools to help next-generation networks meet the high-bandwidth, quality-of-service (QoS) and connectivity needs of academic researchers running high-performance scientific applications. The publications listed below are relevant to all these activities.

J. Leigh, Yu, O., Schonfeld, D., Ansari, A., He, E., Nayak, A., Ge, J., Krishnaprasad, N., Park, K., Cho, Y., Hu, L., Fang, R., Verlo, A., Winkler, L., DeFanti, T. A., "Adaptive Networking for Tele-Immersion," presented at Immersive Projection Technologies/Eurographics Virtual Environments (IPT/EGVE), Stuttgart, Germany, May 16-18, 2001.

Jason Leigh, Greg Dawe, Jonas Talandis, Eric He, Shalini Venkataraman, Jinghua Ge, Dan Sandin, Thomas A. DeFanti, "AGAVE: Access Grid Augmented Virtual Environment," Proceedings of the Access Grid (AG) Technical Retreat, Argonne National Laboratory, Argonne, IL, January 30-31, 2001.

3.B. Books/Publications

Tom DeFanti, Dan Sandin, Maxine Brown, Dave Pape, Josephine Anstey, Mike Bogucki, Greg Dawe, Andy Johnson and Thomas S. Huang, "Technologies for Virtual Reality/Tele-Immersion Applications: Issues of Research in Image Display and Global Networking," Frontiers of Human-Centred Computing, Online Communities and Virtual Environments, Rae Earnshaw, Richard Guedj, Andries van Dam and John Vince (editors), Springer-Verlag London, 2001, pp. 137-159. (Report from the European Commission/National Science Foundation Advanced Research Workshop on Human-Centered Computing, Online Communities, and Virtual Environments, Chateau de Bonas, France, June 1-4, 1999.)

A. Johnson, J. Leigh, "Tele-Immersive Collaboration in the CAVE Research Network" (chapter), Collaborative Virtual Environments: Digital Places and Spaces for Interaction, edited by Churchill, Snowdon and Munro, January 2001, pp.225-243.

3.C. Internet Dissemination

www.startap.net

3.D. Other Specific Products

Other than the information reported here, we have not developed any other specific product of significance.

4. Contributions

4.A. Contributions within Discipline

STAR TAP, by its very nature, is interdisciplinary. There is clearly a fine team of computer scientists, computational scientists and networking engineers involved with STAR TAP, facilitating greater advances in global networking than unconnected single-investigator efforts could produce. STAR TAP developed its management team in the Chicago area (EVL/UIC, ANL, MREN, iCAIR, Indiana), and leveraged the efforts of national networking groups (NLANR, NGI networks, Internet2) and international NRN technical and administrative contacts.

4.B. Contributions to Other Disciplines

Within the Computational Science and Engineering and the Computer Science communities, STAR TAP is a necessary and integral part of application advances and technological innovations. STAR TAP also impacts the networking community by providing an infrastructure to study long-distant, high-bandwidth networks. NLANR is working with STAR TAP on network measurement and web caching. ESnet and CANARIE are working with STAR TAP on 6TAP. Networking companies, such as Cisco and Juniper, have given STAR TAP router donations.

EVL not only manages the STAR TAP facility, but the Lab is also one of STAR TAP's major users. EVL's networking interest is a natural outgrowth of its focus on visualization; i.e., EVL is not only interested in producing graphic images and display technologies, but is focusing on moving visualizations over networks. In the early '90s EVL focused on distributed computing (connecting visualization/virtual-reality technologies to vector and parallel remote supercomputers), and by the mid-90s EVL focused on tele-immersion (collaborative virtual reality over networks, an extension of the "human/computer interaction" paradigm to "human/computer/human collaboration"). Now, at the beginning of a new decade, EVL is focusing on latency issues in tele-immersion. While today's tele-immersion sessions typically have little going on besides collaborative 3D interactive graphics, transoceanic tele-immersion software and middleware must provide for latency-tolerant and time-shifted usage as well as archival storage and content-based retrieval of multi-flow, multi-participant virtual-reality sessions. EVL is examining the problems of managing these flows in real time and creating adaptive latency-tolerant solutions for international distances.

4.C. Contributions to Human Resource Development

We promote the power of STAR TAP through web documentation, journal articles, demonstrations and presentations at major networking conferences (e.g., Supercomputing, INET and Internet2), videotapes, PowerPoint presentations and other instructional material. We teach the infrastructure, the grid advancements, the technological innovations and the application advancements that global connectivity enables.

STAR TAP has helped change the way international science is done, by providing a persistent infrastructure for global collaboration. STAR TAP has enabled a worldwide community of application scientists, computer scientists, networking engineers and artists. STAR TAP has a mailing list of ~600 <stars@startap.net> individuals, from academia, government and industry, interested in information about international networking developments. The success of iGrid '98 and iGrid 2000 has sparked interest from the Europeans about sponsoring an iGrid 2002 in Amsterdam in September 2002.

While we have no quantitative metrics to evaluate STAR TAP's role in education/human resources development, there were 300 people actively involved in iGrid 2000 – from academia, government research laboratories and companies – to develop 24 applications from 14 countries. We have documented more than 150 applications on the STAR TAP web site, meaning that thousands are involved in STAR TAP-related international high-performance networking and applications development.

4.D. Contributions to Resources for Research and Education

In Section 4.B (Contributions to Other Disciplines), we note that STAR TAP is a necessary and integral part of

application advances and technological innovations for the Computational Science and Engineering and the Computer Science communities, as well as of major interest to research Network Engineers. STAR TAP is a major—and unique—resource for Science and Technology. STAR TAP is more than a switch for traffic exchange; it is an infrastructure and proving ground in which to implement new network engineering solutions to advance the state of the art.

4.E. Contributions Beyond Science and Engineering

Because of STAR TAP's interest in QoS, IPv6 and lambda switching, we receive inquiries from network equipment manufacturers and optical networking providers about partnering with us to create and showcase a marketplace for wavelength-based network services and products. We look forward to working with these companies and introducing them to the Nation's foremost university and Federal laboratory networking engineers, computer programmers and applications scientists, who are developing and using today's evolving grid technologies.

STAR TAP is evolving into StarLight—a national/international optical-networking proving ground, to demonstrate an entirely new information architecture whereby bandwidth becomes the *enabling,* rather than gating, technology. Our research colleagues will showcase new optical networking capabilities to their collaborators as well as Federal and corporate sponsors, thereby building new opportunities. Our users expect STAR TAP to grow in capacity and sophistication, and we look forward to the engineering challenges ahead.

5. Special Requirements

5.A. Objectives and Scope

A brief summary of the work to be performed during the next year of support if changed from the original proposal.
Our scope of work has not changed.

5.B. Special Reporting Requirements

Do special terms and conditions of your award require you to report any specific information that you have not yet reported?
No.

5.C. Unobligated Funds

Do you anticipate that more than twenty percent of the funds under your NSF award will remain unobligated at the end of the period for which NSF currently is providing support?
No.

5.D. Animals, Biohazards, Human Subjects

Has there been any significant change in animal care and use, biohazards, or use of human subjects from what was originally approved (or approved later)?
No.