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

Euro-Link[SM]

http://www.euro-link.org

High Performance International Internet Services between Research and Education Institutions in the United States and Europe/Israel

NSF Cooperative Agreement No. ANI-9730202

Annual Report (April 1, 2000–March 31, 2001)

SUBMITTED March 27, 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
Andrew E. Johnson	Co-Principal Investigator	Yes
Daniel J. Sandin	Co-Principal Investigator	Yes

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
Jason Leigh	Senior Personnel/Professional Staff	Yes
Michael McRobbie	Senior Personnel/Professional Staff	Yes
Doug Pearson*	Senior Personnel/Professional Staff	No
Jim Williams	Senior Personnel/Professional Staff	Yes
Linda Winkler+	Professional staff	Yes
Alan Verlo	Professional staff	Yes
Laura Wolf	Professional staff	Yes
Patrick Hallihan	Professional staff	Yes

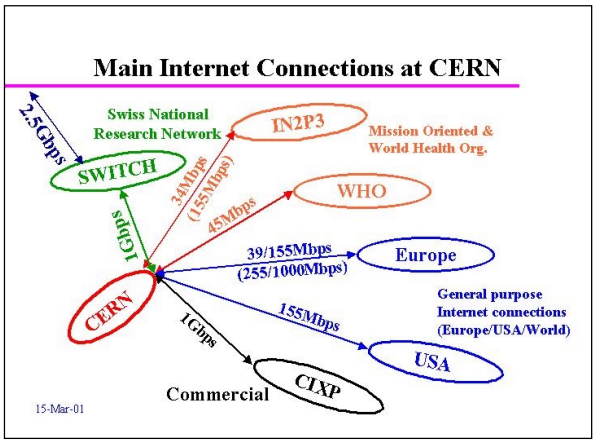
* Doug Pearson was listed as Senior Personnel on the proposal as he was in charge of the Euro-Link NOC at Indiana University. He has been replaced by Jim Williams at Indiana University

\+ It should be noted that Linda Winkler, while not compensated by the University of Illinois at Chicago, serves as part-time STAR TAP/Euro-Link engineer.

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

1.C.1. European National Research Networks (NRNs)

CERN (EUROPEAN LABORATORY FOR PARTICLE PHYSICS)



The European Laboratory for Particle Physics (CERN) [http://cern.ch], on the Franco-Swiss border near Geneva, provides experimental facilities for particle physics experiments, mainly in the domain of high-energy physics (HEP). CERN's current major facility is the Large Electron Positron (LEP) collider in a 27km tunnel, the largest machine of this type in the world; experiments are carried out by teams of hundreds of physicists from over 50 institutes spread across five continents. The next particle accelerator, to be completed in year 2005, is the 14 TeV (1 Tera electron volt = 1 billion electron volts) Large Hadron Collider (LHC); it is being built using high-powered 14-meter superconductor magnets and will be installed in the existing LEP tunnel.

All existing and future experiments produce large amounts of data. For example, LEP experiments generate 25 TBs of data each year, which are stored on magnetic tapes, whereas the LHC experiments are expected to produce several-orders-of-magnitude more data, namely tens of petabytes per experiment each year. The sheer volume of data combined with the complexity of the analysis to be performed, and the requirement that the processing of the data may also be done remotely, places heavy demands on the High Energy and Nuclear Physics (HENP) computing and networking infrastructure, which can only be met by using leading-edge technology and services.

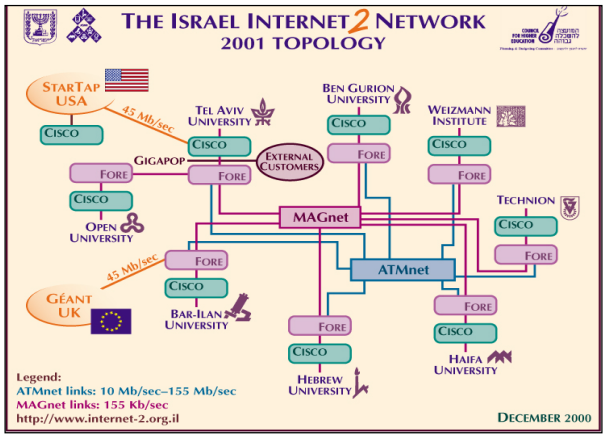
The CERN/STAR TAP connection also serves:

- National Institute of Nuclear and Particle Physics (IN2P3) [http://www.in2p3.fr], a CNRS (French National Center for Scientific Research) institute.
- The World Health Organization (WHO) [http://www.who.int].

ISRAEL INTER-UNIVERSITY COMPUTATION CENTER (IUCC)

Israel's IUCC [http://www.internet-2.org.il] coordinates and advocates the computing needs of Israel's research and academic infrastructure. IUCC receives funding from eight universities:

- Haifa University (Haifa)
- Technion (Haifa)
- Tel Aviv University (Tel Aviv)
- Open University (Tel Aviv)
- Bar-Ilan University (Tel Aviv)
- Weizmann Institute of Science (Tel Aviv)
- Hebrew University of Jerusalem (Jerusalem)
- Ben-Gurion University (Beersheva)



Israel's current national infrastructure is based on a dual ATM network. The primary network is an ATM OC-3 network running PNNI, which interconnects all eight Israeli universities. As a backup, all universities are connected to a slower, different ATM network at 10Mbps (UBR) [http://www.internet-2.org.il/ilanmap.html]. As an additional backup, there is a Frame Relay (FR) network (Access Rate=256, CIR=0), interconnecting all the universities. The two "heavy" sites with international access, Tel Aviv University and Bar-Ilan University, are using 2Mbps FR access trunks as backup. Internally, on-campus networks are ATM and/or Fast Ethernet based.

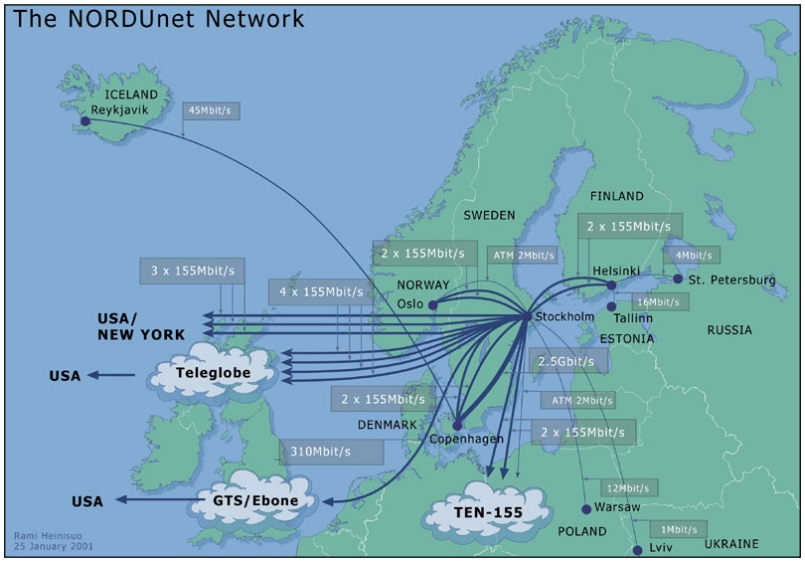
IUCC operates three supercomputers, an Origin2000 with 112 CPUs 400MHz (56 nodes); a Cray J932/32; and a Beowulf cluster with 66 CPUs (33 nodes SGI-1200L).

NORDUNET

NORDUnet [www.nordu.net] serves the universities and publicly funded research institutions in Denmark, Finland, Iceland, Norway and Sweden. The national and international bandwidths are in the Gigabit range. The five national networks collaborate in the commonly owned NORDUnet to get international connectivity among themselves and the rest of the world, including connections to the general purpose commercial Internet via gateways and peerings.

The universities and research institutions approved are:

- Center for Parallel Computers (Paralleldatorcentrum, PDC), Royal Institute of Technology (Kungliga Tekniska Högskolan, KTH) (Sweden)
- Niels Bohr Institute for Astronomy Physics and Geophysics, Copenhagen University (Denmark)
- Institut for Fysik og Astronomi, Århus Universitet (Denmark)
- Institut for Medier og Kommunikasjon, University of Oslo (Norway)
- University of Tromsø (Norway)
- University of Helsinki (Finland)
- Institutt for Informatikk (Norway)



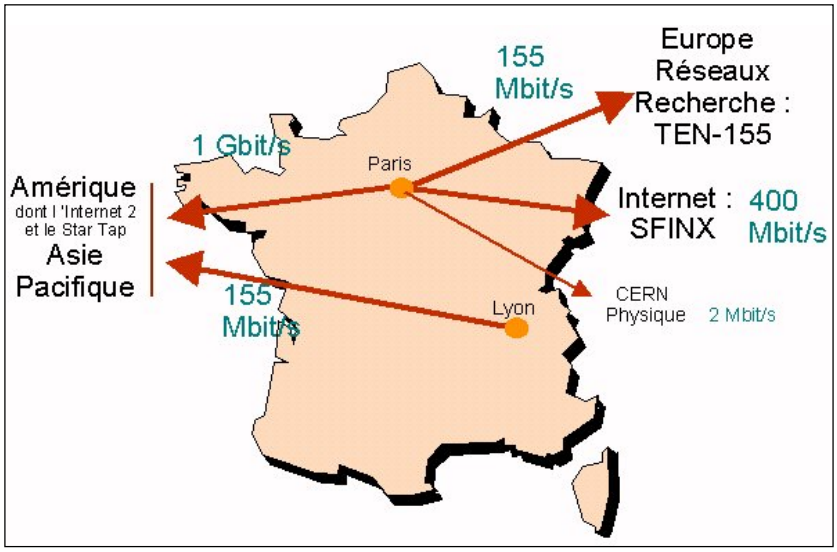
Currently, NORDUnet serves networks for research and education in Poland (NASK/12Mbps), Estonia (EEnet/ 16Mbps), Ukraine (UARnet/1Mbps), and Russia (RUNNEt/4Mbps−to be upgraded soon to 34Mbps); it gives these networks transit over NORDUnet to all other networks in the world, except those in America. Once the RUNNet upgrade is complete, NORDUnet will circulate a list of major institutions on the Central European networks (CEEC) served by NORDUnet to its US partners at STAR TAP, and propose that they be announced.

RENATER2

GIP RENATER [www.renater.fr] is a non-profit organization owned by five large research and education groups in France: Atomic Energy Agency (CEA), National Space Agency (CNES), National Center for Scientific Research (CNRS), National Institute for Research in Computing Sciences and Automatics (INRIA) and the Ministry for Education, Research and Technology (MENRT). Users of RENATER2, the national backbone of GIP RENATER, are advanced scientific laboratories and higher education institutions. RENATER2 is a nation-wide infrastructure connecting campuses, metropolitan and regional networks with IP and (optionally) ATM services, and has international linkages to other European countries and to STAR TAP. RENATER2 accesses the commodity Internet through the Open-Transit service of France Télécom.

RENATER2 has a mesh topology, with 2.5 Gbps, 155Mbps or 34Mbps links between its central switching node and the regional PoPs. The central loop in the Paris area has a throughput capacity of 80Gbps.

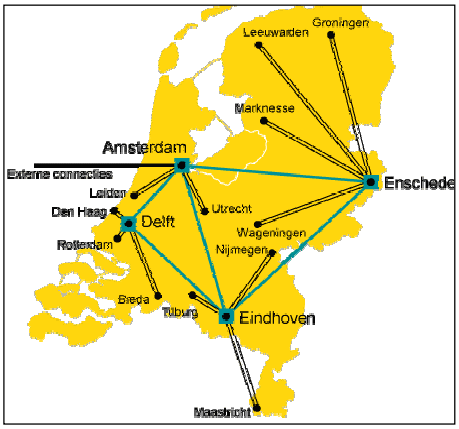
The research organizations in France with requirements for high-performance international Internet services to the US, which are already using STAR TAP or will in the near future, are:



- CDS (Strasbourg: astronomy)
- Centre de Sequencage (Evry)
- CETP (Versailles-Vélizy: CNRS: environmental science)
- CRISMAT (Caen)
- DAPNIA (Commissariat à l'Energie Atomique, Saclay: high energy physics)
- ENSL (Ecole Normale Supérieure de Lyon: high performance computing)
- IAP (Institut d'Astrophysique de Paris: space science)
- IAS (Institut d'Astronomie Spatiale, Orsay: astronomy and space sciences)
- INaLF (Nancy)
- Infobiogen (Villejuif)
- INRIA (Institut National de Recherche en Informatique et Automatisme: computer sciences)
- INSU (Insititut National des Sciences de l'Univers, CNRS: astronomy and space science)
- IN2P3 Laboratories connected to CERN
- IPG (Institut de Physique du Globe: earth sciences)
- IPSL (Institut Pierre Simon Laplace: climatology research)
- LHPC (Université Claude Bernard, Lyon: high performance computing)
- LIMHP (Université Paris 13: computational fluids dynamics)
- LIMSI (Université Paris Sud, Orsay: computer science)
- LMD (Ecole Polytechique, Palaiseau: climatology research)
- LOA (Laboratoire d'Optique Appliquée Palaiseau)
- LODYC (Paris/Jussieu campus: earth sciences)
- LPTHE (Université Paris Sud, Orsay: theoretical physics)
- OPM (Observatoire de Paris-Meudon: astronomy)

SURFNET

SURFnet [www.surfnet.nl] is the national computer network for research and education in The Netherlands. It connects the local networks of member institutions and also enables connections with other national and international networks.



SURFnet institutions connected to STAR TAP include:

- Stichting Academisch Rekencentrum Amsterdam (SARA)
- Utrecht University
- Twente University

SURFnet promotes cooperation between Dutch research institutions and US NGI/Internet2 sites. For this reason, the bandwidth capacity between the SURFnet PoP in New York and the STAR TAP in Chicago was upgraded to 155Mbps last year.

GigaPort [http://www.gigaport.nl] is a joint project of the Dutch government, trade and industry, educational institutions and research institutes. GigaPort's goal is to give the Netherlands a head start in the development and use of advanced, innovative technology. GigaPort Network, part of GigaPort, counts itself among the world's leading research networks and offers companies and institutions a state-of-the-art test environment for developing new (network) services. GigaPort is implemented under the authority of the GigaPort Steering Committee. The GigaPort Network is realized by SURFnet; GigaPort applications by the Telematica Instituut.

1.C.2. US Management Team

ELECTRONIC VISUALIZATION LABORATORY (EVL), UNIVERSITY OF ILLINOIS AT CHICAGO (UIC)

EVL [www.evl.uic.edu], over the past decade, has teamed with computer scientists and computational scientists at NCSA and Argonne National Laboratory to collect, maintain, develop, distribute, and evaluate VR tools and techniques for scientific computing. For Euro-Link, this expertise is being used to design, build, implement and maintain a new generation of sophisticated real-time network performance monitoring and persistent databases tuned to application uses of high-performance networks.

INDIANA UNIVERSITY

Indiana University [www.indiana.edu] received an NSF HPIIS award for the design and deployment of the TransPAC consortium [www.transpac.org], the high-speed backbone that interconnects research institutions in Japan, Korea, and other Pacific Rim countries that are part of the Asian Pacific Advanced Network (APAN) consortium with US institutions connected to the vBNS and Abilene. Indiana also provides Global NOC services for Abilene, TransPAC, MIRnet, Euro-Link and STAR TAP.

MATHEMATICS AND COMPUTER SCIENCE DIVISION (MCS), ARGONNE NATIONAL LABORATORY (ANL)

ANL [www.mcs.anl.gov] 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)

The AADS Network Access Point (NAP) [www.aads.net] is an Internet Exchange Point where ISPs 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 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 are the models for the next generation of NGI eXchanges (NGIXs).

MREN

The Midwest's Metropolitan Research and Education Network (MREN) [http://www.mren.org] 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 MREN's technical director.

INTERNATIONAL CENTER FOR ADVANCED INTERNET RESEARCH (iCAIR), NORTHWESTERN UNIVERSITY

The goal of iCAIR [www.icair.org], 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. iCAIR is very involved in the Digital Video Working Group of the Coordinating Committee for International Research Networks (DVWG, CCIRN) as well as the Internet2 Digital Video (I2-DV) Initiative, and works closely with several Euro-Link NRNs.

STAR TAP

STAR TAP [www.startap.net], managed by UIC/EVL and operated by AADS, is an NSF-funded persistent infrastructure to facilitate the long-term interconnection and interoperability of advanced international networking in support of applications, performance measuring, and technology evaluations. STAR TAP anchors the international vBNS connections program. Physically, it connects with the AADS NAP in Chicago, as does the vBNS and other high-speed Federal networks. It enables traffic to flow to international collaborators from the approximately 150 US leading-edge research universities, supercomputing centers, and national laboratories that are now, or will be, attached to the vBNS or Abilene. The primary advantage of STAR TAP is the ability to exchange traffic among networks, particularly international ones. STAR TAP is implementing a number of advanced layer 3 services that is of benefit to the Euro-Link community.

1.C.3. 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 or Abilene. Euro-Link, MIRnet and TransPAC are funded in part by the NSF's High Performance International Internet Services (HPIIS) program.

AMPATH

AmericasPATH, or AMPATH, [www.ampath.fiu.edu] 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.

MIRNET

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

TRANSPAC

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

1.D. Other Collaborators or Contacts

ALLIANCE AND NATIONAL CENTER FOR SUPERCOMPUTING APPLICATIONS (NCSA), UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

The NSF Partnerships for Advanced Computational Infrastructure (PACI) Cooperative Agreement to the National Computational Science Alliance (the "Alliance") [http://alliance.ncsa.uiuc.edu], whose lead institution is the National Center for Supercomputing Applications (NCSA), funds, in part, the UIC Electronic Visualization Laboratory (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.

CALIFORNIA INSTITUTE FOR TELECOMMUNICATIONS AND INFORMATION TECHNOLOGY [Cal-(IT)2], UNIVERSITY OF CALIFORNIA SAN DIEGO (UCSD)

Cal-(IT)2 [www.calit2.net], a new center founded by Larry Smarr, is a distributed center, conducting research at both the UCSD and UC-Irvine (UCI) campuses. UCSD and UCI will conduct research in core technologies needed to expand the reach and capacity of the global wireless Internet and its emerging all-optical core. Initially, it 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 the goals of STAR TAP.

CAVERNUS

The CAVE Research Network User's Society (CAVERNUS) [http://www.ncsa.uiuc.edu/VR/cavernus] gives the worldwide community of VR device users 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. 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, we conduct network and visualization experiments with international collaborators via STAR TAP.

EMERGE

EMERGE was initially a DoE funded effort to achieve and demonstrate Differentiated Services (DiffServ) over the Midwest Metropolitan Research and Education Network (MREN), ESnet and Abilene. [http://www.evl.uic.edu/cavern/EMERGE/] We have extended 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 Northwestern's iCAIR. (See Section 2.B: Research Findings.)

GLOBUS AND THE GLOBAL GRID FORUM

Globus [http://www.globus.org] 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 (Global GF) [www.globalgridforum.org], a community-initiated forum of individual researchers and practitioners working on distributed computing, or Grid, technologies; Global GF participants come from over 150 participating organizations, with financial and in-kind support coming from Global GF sponsoring companies and institutions.

GRID PHYSICS NETWORK (GriPhyN)

GriPhyN [www.griphyn.org] is a team of experimental physicists and information technology (IT) 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, the European Data Grid project.

NETWORK FOR EARTHQUAKE ENGINEERING SIMULATION

The NEESgrid integration project is being organized by NCSA and funded by the NEES program at NSF. [www.neesgrid.org, www.eng.nsf.gov/nees] 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.

2. Activities and Findings

2.A. Research Activities

2.A.1. Euro-Link Goals and Statement of Work

Euro-Link is a consortium of the University of Illinois at Chicago (UIC) and several National Research Networks (NRNs) in Europe and Israel, formed to assist the US and European research and education communities with High-Performance International Internet Services (HPIIS). The NSF, through its HPIIS program, encourages NRNs to connect to the vBNS and other recognized high-performance internet service providers, such as the University Corporation for Advanced Internet Development's UCAID's Abilene, via STAR TAP.[1]

This Euro-Link award presumes European NRNs have previously applied for and received NSF approval to connect to STAR TAP. Only European NRNs with NSF approval to connect to STAR TAP can become members of the Euro-Link consortium. When the Euro-Link proposal was submitted to NSF in January 1999, there were four Euro-Link *charter NRNs*, NORDUnet, SURFnet, RENATER2, and Israel's IUCC. In late-1999, CERN received NSF permission to connect to STAR TAP and to join the Euro-Link consortium.

The NSF "Euro-Link" Cooperative Agreement has a clear Statement of Work that defines the goals and objectives of this consortium. The activities that support this Statement of Work, as well as additional activities, are documented in this section; they are:

- ***Furnish, operate, and maintain a direct connection for high-performance traffic between the vBNS and Abilene and European NRNs via the STAR TAP (Section 2.A.2)***
- ***Ensure, to the extent supportable by prudent application of networking technology, that only approved institutions' traffic is permitted to use the high-performance connection (Section 2.A.3)***
- ***Monitor the network performance and use of the EuroLink connections (Section 2.A.4)***
- ***Develop a new generation of performance analysis tools (Section 2.A.5)***
- ***Provide engineering services, both testbeds and production implementations, of new networking protocols (such as IPv6, Multicast, cache services, QoS) (Section 2.A.6)***
- ***Establish a Euro-Link Network Operations Center (Section 2.A.7)***
- ***Maintain a publicly-accessible EuroLink-HPIIS web site (Section 2.A.8)***
- ***Support the use of EuroLink-HPIIS for high-performance applications (Sections 2.A.9)***

2.A.2. European NRN Connectivity to STAR TAP

Direct Connectivity to STAR TAP

Each NRN procures and operates its own transatlantic services as an extension of its national services. Euro-Link provides engineering support and helps defray the costs of connecting to STAR TAP. Each operates ~155Mbps network, an aggregate bandwidth of hundreds of Mbps.

CERN (OC-3)

On January 31, 2001, a new 155Mbps circuit to STAR TAP provided by KPNQwest became operational; the previous 45Mbps circuit (activated April 2000 by KPNQwest, an upgrade from CERN's original 20Mbps circuit to STAR TAP provided by Cable & Wireless) will be retained for several weeks to support some experiments and the 155Mbps will only be used to peer with Abilene. CERN is also preparing a Call for Tender for the provision of a 622Mbps circuit to the STAR TAP with circuit delivery during 1Q02.

CERN operates the CIXP (CERN Internet Exchange Point) GigaPoP for its academic and research partners, which connects to Abilene via STAR TAP. Most members link to the GigaPoP at DS3 or OC-3 speed. Towards the end of year 2000, a few Gbps circuits became operational, most notably an experimental circuit at 2.5Gbps speed between CERN and ETH Zurich.

[1] The Science, Technology And Research Transit Access Point (STAR TAP) is an infrastructure that supports the long-term interconnection and interoperability of advanced international networking in support of applications, performance measuring, and technology evaluations. [www.startap.net] Since 1997, NSF has funded Tom DeFanti, principal investigator, to create and manage STAR TAP. The original award #ANI-9712283, for the period April 1997-March 2000 was extended through March 2003 with award # ANI-9980480. STAR TAP, a Next Generation Internet Exchange Point (NGIX), is managed by UIC in collaboration with ANL, iCAIR, MREN and Indiana University, and is operated by Ameritech Advanced Data Systems.

In addition, CERN plans to exercise the option to split the SONET/SDH protected circuit into two independent circuits before the end of year 2001, which will provide new possibilities in terms of physical interconnection to STAR TAP and US research networks.

ISRAEL IUCC (DS-3)

IUCC connects internationally via QUANTUM (to European countries) and via STAR TAP (to non-European countries). IUCC connected to STAR TAP initially via a T3 satellite link, but upgraded this to an undersea fiber T3 link in December 2000, which reduced round-trip-times on the link from 560ms to 180ms. European connectivity is via an E3 fiber cable to QUANTUM[2] in Europe, which is being upgraded to a T3 fiber link in April 2001.

> ***"The Euro-Link project played a critical role in getting our local 'Next Generation Internet' project up and running in Israel…"***
>
> ***– Joe van Zwaren, Director for Exact Sciences, Ministry of Science, Culture and Sport, Jerusalem, Israel***

NORDUNET (DS-3)

NORDUnet research traffic uses a dedicated 155Mbps link between Stockholm and New York (to be increased to 2*155Mbps in April 2001), and a 45Mbps connection from New York to STAR TAP. (STAR TAP traffic is 45Mbps because NORDUnet/Abilene traffic is exchanged in New York City, giving adequate bandwidth to other research traffic.) NORDUnet has distributed a Call for Tender [http://www.nordu.net/tender/USA2001] that requests 467-622Mbps to the Abilene PoP in New York and 155Mbps to STAR TAP by July 1, 2001, out of a total transatlantic capacity of 2.5Gbps.

> ***"The Euro-Link connection to NORDUnet has served as a catalyst to new ways of pursuing science, as well as a great motivating factor for the rapid capacity growth of the NORDUnet transatlantic connectivity and the Swedish University Network, SUNET. Feasibility of transatlantic Collaborative Virtual Reality environments has been demonstrated and so has the feasibility of computational steering in a Grid-like setting with distributed computational and visualization resources. These feasibility projects have stimulated planning of telescience projects between the Karolinska Institute in Stockholm and NCMIR in San Diego, and discussions about collaborations between brain image projects supported by NPACI and a similar project at the Karolinska Institute and the lead academic computing center in Sweden, PDC at the Royal Institute of Technology in Stockholm. These and similar projects have been a great motivating factor for NORDUnet to increase its transatlantic capacity from 34Mbps when the first feasibility demonstration took place in April 1998, to a total of 2.5Gbps in 2001."***
>
> ***– Lennart Johnsson, Professor, University of Houston, Texas and co-director, Center for Parallel Computers (Parallelldatorcentrum, PDC) and the Royal Institute of Technology (Kungl Tekniska Högskolan, KTH)***

RENATER2 (DS-3)

RENATER2 carries its transatlantic traffic to five France Télécom NAPs over an Open-Transit capacity service provided by France Télécom from Paris to Pennsauken, Raleigh, Stockton, New York and Chicago. Between Paris and Chicago, a dedicated 45Mbps ATM link is used to carry STAR TAP traffic. RENATER hopes to upgrade this to a 155Mbps OC-3c circuit in February/March 2001.

Dany Vandromme is pressing France Télécom to upgrade the STAR TAP bandwidth in order to set up access to

[2] DANTE (Delivery of Advanced Technology to Europe, Ltd.), a collection of European NRNs, provides the principal international IP backbone service for the academic and research community in Europe. In April 1997 DANTE submitted the QUANTUM (QUAlity Network Technology for User-oriented Multimedia) project proposal to the European Commission (EC) in response to the Fifth Call under the EC's Telematics Applications Programme. The QUANTUM project is supported by a consortium of 16 NRNs with DANTE as the coordinating partner. QUANTUM is the implementation of improved QoS, particularly for multimedia applications, across a very high-speed (up to 155Mbps) pan-European network, the TEN-155 network. In addition to the operational TEN-155 network, the QUANTUM project will implement an advanced testing program called Quantum Test Programme (QTP), which has the objective of testing and validating new technologies, products, and services with a view of introducing them into the operational TEN-155 networks at some future date. QUANTUM is being replaced during 2001 with the Géant network.

6TAP and improve the capacity committed to active projects. PHYnet[3] uses about 30Mbps of RENATER2's link, leaving the remaining bandwidth for other research traffic. There is an urgent need to deliver an additional 30Mbps sustained capacity between IN2P3 in Lyon and Stanford Linear Accelerator Center (SLAC) in California for BABAR experiments. RENATER has other usage requirements as well, such as 6TAP and other existing projects.

SURFNET (OC-3)

SURFnet research traffic uses a dedicated 155Mbps Packet-over-SDH (POS) link to New York to exchange of traffic with STAR TAP peers and with Abilene; traffic to other destinations is all routed through external connections from the Amsterdam PoP. In New York, SURFnet has a direct connection to Abilene at 155Mbps, and a direct 155Mbps connection to STAR TAP (upgraded from 45Mbps last year). From its GigaPoP in Amsterdam, SURFnet also has a 622Mbps connection to TEN-155 for European NRN traffic.

SURFnet's national backbone consists of a core of four GigaPoPs, linked at 622Mbps, that connect 16 concentrator PoPs at up to 310Mbps speed. The Dutch universities connect to the SURFnet network at speeds of 155Mbps and 1 Gbps. Most universities connected are currently planning an upgrade to 1 Gbps based on Gigabit Ethernet.

On March 5, 2001, SURFnet announced its upgrade plans for the coming year. July 1, 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 (710 N. Lake Shore Drive on Northwestern University's campus) in Chicago. On September 1, 2001, SURFnet will bring a 2.5 Gbps lambda connection from SARA to StarLight (provided by Teleglobe) in order to be able to experiment with new types of technology for a completely optical Internet.

Direct Connectivity to STAR TAP: Inquiries

In the past year, we have consulted with the following European NRNs about connecting to STAR TAP.

Belgium (BELNET, the Belgian National Research Network) (Now connected through DANTE/Abilene in NYC)
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)
England (JANET) (Now connected through Abilene in NYC)
Europe (early inquiries from DANTE; recent 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)
Ireland (HEAnet, the National Research and Educational network of Ireland)
Switzerland (SWITCHng: Switzerland (SW) Information Technology (IT) Confederatio Helvetica (CH) next generation (ng)

Indirect Connectivity to STAR TAP via Abilene/CA*net ITN Services

As of October 2000, DANTE's TEN-155 [www.dante.org.uk] network connects to STAR TAP via the Abilene International Transit Network (ITN) service (See Section 2.A.6.g.). In January 2001, DANTE upgraded its New York connection to Abilene from 100Mbps to 622Mbps. The connection provides Abilene users access to and brings traffic from DFN (Germany), GARR (Italy) and TEN-155-connected networks, including Restena (Luxembourg), GRnet (Greece), HEAnet (Ireland), ARNES (Slovenia), RCCN (Portugal), IUCC (Israel), HUNGARNET (Hungary), CARNET (Croatia), CESnet (The Czech Republic), REDIRIS (Spain), POL34 (Poland), and SWITCH (Switzerland).

*Note: On April 11, 2000, as the first instance of the Abilene/CA*net ITN, CA*net3 carried DANTE's TEN-155 pan-European research network traffic from New York to STAR TAP. On April 13, the link was shut down because the bandwidth from DANTE's New York POP to CA*net's New York POP wasn't adequate (10Mbps). To get connectivity to DFN and JANET for iGrid 2000 applications at the INET conference in Yokohama in July, Abilene provided transit from its PoP in New York to STAR TAP.*

[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.

2.A.3. Compliance with NRN and NSF [vBNS] Acceptable Use Policies

To comply with the Acceptable Use Policies (AUPs) of the High-Performance Internet Service Providers that NSF approves (vBNS, Abilene), Euro-Link NRNs segregate their research and commodity traffic either at home or on the US East Coast prior to connecting to STAR TAP. Here is a description of the implementation, maintenance and updated routing and switching configurations consistent with the AUPs of networks the NRNs peer with.

CERN

CERN is in a rather special situation as it is a single institution so, in principle, there is no need to do special filtering and redirection of traffic. In addition, there is a very clear focus on providing, by whatever appropriate technological means possible, a near zero packet loss and a very low jitter communications channel between the CERN GigaPoP and the networks connected to STAR TAP. CERN's bandwidth to the commodity Internet (i.e. 21Mbps) is much smaller than the bandwidth of its transatlantic circuit (i.e., 155Mbps); therefore, there is very little interaction between research and commodity traffic.

ISRAEL IUCC

IUCC has created a system for providing Class of Service so that Israel's "Internet-2" traffic receives priority over commodity Internet traffic. IUCC purchases commodity Internet transit from Genuity via the AADS NAP, at a rate of 8Mbps, and similar bandwidth via DANTE in Europe. IUCC maintains a T3 link to STAR TAP and an E3 link to QUANTUM, and even though demand for Internet commodity traffic is much higher than for "Internet-2" traffic, the major bandwidth is reserved for "Internet-2" usage and cannot be used by commodity Internet traffic.

The current Internet routing tables stand at around 97,000 prefixes (February 2001), while the combined "Internet-2" and QUANTUM routing tables stand at around 5,200. This represents roughly 5% of the Internet that is accessible via Israel's "Internet-2" lines. The BGP routing tables, along with Cisco policy-based routing and GRE tunnels, play a major role in segregating the traffic into different classes. Therefore, 37Mbps of its overall 45Mb/sec bandwidth is dedicated to Euro-Link applications. IUCC maintains a publicly available AUP [http://www.internet-2.org.il/aup.html].

NORDUNET

In 2000, a dedicated 155Mbps link was allocated from Stockholm to Abilene/STAR TAP traffic. It will be increased to 2*155Mbps in April 2001 and further upgraded to 622Mbps in July 2001. The dedicated links alleviate the need for prioritization schemes as originally forecasted.

RENATER2

Using current ATM technology, RENATER2 makes a clear distinction between commodity and research traffic through its routing policy. RENATER2 does traffic engineering by monitoring the load of the various VCs from Paris to STAR TAP. Because of this monitoring and knowledge of research/commodity fluxes, no significant congestion is expected or observed on the France/US link that would prevent adequate QoS for high-performance traffic.

RENATER 2 also has in its strategy to experiment and develop, first nationally, then internationally, IPv6 and its associated QoS services. In support of its interest in IPv6, a dedicated VC has been set up on the STAR TAP link to extend the native nationwide IPv6 network to the 6TAP in Chicago. This enables research teams in Europe to cooperate with their partners in US through the 6TAP.

During 2000, RENATER2 issued a Call for Tender to upgrade its transatlantic link. Overall transatlantic capacity increased to 300Mbps in June 2000 and 600Mbps in September 2000. Capacity is increasing by 10% every month to an anticipated 2.5 Gbps in December 2001. This capacity includes an OC-3 path to STAR TAP. The previous circuit to STAR TAP was between Pennsauken and Chicago and is now a fully dedicated ATM service between Paris and Chicago. The current capacity of this circuit is 45Mbps, to be upgraded in the near future to 155Mbps, as soon as France Télécom can provide it.

"For the BABAR high energy physics experiment at SLAC (Stanford Linear Accelerator Laboratory), the computing requirements are such that the load is being shared at present between two computing centers, SLAC and CC-IN2P3 (Lyon, France). This puts a heavy load on the bandwidth requirements and QoS to transfer up to 1 Terabyte/week each way. The 30+Mbps VP link between the two centers through Euro-Link has been working amazingly well

since the beginning, two months ago. The load sharing can only continue with a good VP and perspectives for bandwidth increases in the future."

– Denis Linglin, Head of IN2P3 Computing Center, Lyon, France

SURFNET

SURFnet's research traffic connects to STAR TAP from its New York PoP at 155Mbps. Abilene traffic is peeled off in New York. Traffic to the commodity Internet is routed through the external connections out of Amsterdam.

2.A.4. Network Performance and Usage

CERN

CERN's Internet traffic statistics page is at [http://sunstats.cern.ch/mrtg].

CERN is very active in performance monitoring. CERN hosts three Internet probes – Surveyor, RIPE and NIMI – and is part of the Internet End-to-End Performance Monitoring (IEPM) PINGER project supported by DOE Mathematical, Information, and Computational Sciences (MICS) through the Stanford Linear Accelerator Center (SLAC). In addition, CERN provides its own set of statistics using a combination of public domain (e.g., MRTG, netperf, iperf, tcptrace, xplot) and in-house tools.

Because of the high-throughput requirements of Data Grid applications, CERN actively monitors throughput from CERN to US institutions, such as, Caltech, SLAC, FermiLab and UIC. Focus is on comparing the performance of multiple versus single streams. CERN is having difficulties reaching nominal throughput; i.e., closely approaching link speed for single stream TCP/IP file transfers, and is interested in exploring TCP/IP variants (e.g., VEGAS) or other techniques, such as RSVP tunnels with reliable UDP or conventional TCP/IP RENO stacks.

Today, TCP/IP protocols are the only solution for reliable file transfer over the Internet; they tend to favor short-life over long-life flows, and to penalize overall performance of high-performance flows more than lower-performance ones. Furthermore, today's high-performance routers do not deal well with the large window sizes necessary to achieve throughputs close to nominal circuit speeds, thus leading to packet losses and sometimes very disappointing end-to-end performances. CERN is interested in getting involved with projects that are directly tackling the issue of poor file transfer performance on high-speed long-distance networks (e.g., Web100 [www.web100.org]), as well as better TCP/IP instrumentation to ease or eliminate (auto-tune) application tuning.

Israel IUCC

IUCC maintains a site of statistical information about all its connections [http://www.internet-2.org.il/stats.html]; T3 Euro-Link statistics can be found at [http://noc.ilan.net.il/stats/TAU-GIGAPOP/tau-gp1-fe-i2.ilan.net.il.html] and STAR TAP peering statistics can be found at [http://noc.ilan.net.il/stats/ILAN-I2-uplinks/peers.html]. IUCC has, in addition, installed an NLANR passive monitor [http://moat.nlanr.net/] and is in the process of analyzing the data.

NORDUNET

NORDUnet participates in the ANS Surveyor measurement infrastructure with UNINETT operating a measurement station at the University of Oslo.

RENATER2

RENATER2 does not have a public web page of STAR TAP traffic; this information is available from the RENATER2 NOC (noc-r2@cssi.renater.fr)

SURFNET

SURFnet monitors traffic on its STAR TAP connection, as it does on all its connections (external connections, backbone links, and customer links). This information is put on the web using MRTG or RRDTool; it is protected by *userid/passwds* and access-lists.

2.A.5. Application-Level Network Performance Analysis Tools

EVL is developing a new generation of performance analysis tools. We are adopting and adapting emerging network performance monitoring technologies and developing advanced visualization, persistent databases and visualization/VR techniques to create new applications-oriented performance measuring tools for HPIIS.

Network Monitoring Tools

BANDWIDTH UTILIZATION RADAR MAP

Jason Leigh is supervising EVL student Brenda Lopez who created the iGrid 2000 STAR TAP network map, (which showed bandwidth utilization of networks participating in iGrid); the map has been enhanced to illustrate all country-to-country source and destination packets arriving at STAR TAP. This map is accessible from the STAR TAP web site; from [http://www.startap.net/ENGINEERING/], click on "Bandwidth Utilization Radar Map." This summer, Lopez will develop snapshots of network traffic spikes to STAR TAP, rather than just previous history.

uCAN: UNIFIED COLLABORATORY FOR ANALYZING NETWORKS

Jason Leigh is supervising EVL student Naveen Krishnaprasad on the development of uCAN software, which will enable remote network researchers and application developers to collaboratively execute an application and monitor network utilization, as well as other application-specific parameters. uCAN will enable users to correlate, in real time, how the actions taken by an application directly impact the underlying networks, and vice versa. A network researcher could also alter router configurations, such as a router's queuing algorithm, to determine how it might improve application throughput. Estimated completion of a usable version is end of Spring 2001. The prototype currently allows users to initiate bandwidth measurement experiments and perform SNMP queries of routers.

WEB100

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

Network Performance Studies for European/US Collaborative Art Project

EVL co-director Dan Sandin is assisting on the development of Yggdrasil, a script-based, authoring environment for networked virtual-reality applications by EVL PhD candidate Dave Pape. This tool will allow non-programmers to create effective, behavior-rich art and science virtual-reality environments. Sandin is extending the library for behaviors, performing network performance tests and developing applications. In coming months, Dan will supervise EVL student Joseph Tremonti in the development and execution of network performance tests to Austria, and later Sweden, Hungary and The Netherlands, in preparation for the Ars Electronica Center's Festival in Austria, September 1-6. [http://www.aec.at]

Low Latency State Transmission Over Long Distance Networks

PARALLEL SOCKET TOOLS

Jason Leigh, in network performance studies with SARA in The Netherlands, was getting 32-60Mbps throughput doing TCP experiments over SURFnet's 155Mbps link. The problem has been isolated to a bottleneck in CAVERNsoft's parallel socket code that was limiting it to 32Mbps transmission. In theory, the parallel socket code should achieve 70Mbps since EVL's internal 100 Base-T network connects to the campus' OC-3 network to STAR TAP. TCP normally provides about 70% throughput.

RELIABLE BLAST UDP (RUDP)

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

Initial RUDP results were encouraging. In November 2000, Eric reported that from EVL to SARA, he got 3.5Mbps using FTP, 32Mbps using parallel TCP, and 75Mbps effective bandwidth using RUDP when data size was 100 MB. On February 7, 2001, Eric conducted more RUDP experiments between EVL and SARA.

Since QoS is currently not available between the two sites, Eric chose to send data at rates well below the maximum available bandwidth of the network link; in essence, emulating a smaller, reserved QoS link. The table shows the

bandwidth at which RUDP data was transmitted, and the effective throughput of the total file transfer. Note that on an over-provisioned network, effective throughput is almost as high as the sending bandwidth. This is in contrast to TCP, which typically incurs a 30% bandwidth loss by requiring frequent acknowledgements.

Sending Bandwidth (Mbps)	Effective Bandwidth	Number of NAKs (Negative Ack's)
20	19.7	0
40	38.5	0
60	54-57	1
80	56-70	2
90	61-77	3

As we approach the bandwidth limit of the link, performance begins to decrease; however, performance is no poorer than what is expected of optimally tuned TCP. Because these experiments were conducted without the benefit of QoS, interference from competing traffic streams was both possible and likely. We predict that our results would yield even better performance with QoS. It would be very interesting to test this scheme using DiffServ between EVL and CERN. (For full report, see Section 3.A: Publications, "Adaptive Networking for Tele-Immersion.")

"EVL has been performing extensive high-throughput network experiments to SARA [Academic Computing Services Amsterdam, The Netherlands] and CERN. These experiments were performed to examine the performance of new application-level protocols, such as Forward-Error Corrected UDP, Parallel TCP, and Reliable Blast UDP, performed over high-bandwidth, long-distance links. This research would not have been possible without the collaboration with SARA and CERN via Euro-Link's SURFnet and CERN links. The paper 'Adaptive Networking for Tele-Immersion,' which summarizes performance results, was recently accepted for inclusion at the 5th Immersive Projection Technology/7th Eurographics Virtual Environments Conference, May 16-18, 2001, in Stuttgart, Germany."

– Jason Leigh, Senior Research Scientist, Electronic Visualization Laboratory, UIC

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.

Petri-Net Network Modeling

EVL evaluated Petri-Net models for UDP and TCP. Theoretical work is currently on hold, as more emphasis is being devoted to developing practical network performance tools.

2.A.6. Euro-Link/STAR TAP Engineering Services

STAR TAP/Euro-Link leadership continues to focus on providing high-level services to its constituents.

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 AADS. Once connected to STAR TAP, the NRNs can peer with 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. 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/]; Euro-Link peers are listed below.

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, peer with the STAR TAP Router. Direct peering between networks that exchange large amounts of traffic is encouraged.

Networks	North America										SA	Europe							Asia			
	Abilene	CA*net 2/3	DREN	ESnet	6TAP-IPv6 Router	MREN	NISN	NREN	STAR TAP Router	vBNS/vBNS+	REUNA (Chile)	CERN	Israel IUCC	NORDUnet	MIRnet	RENATER2	SURFnet	APAN	CERNET (China)	GEMnet (Japan)	SingAREN	TANet2
Europe																						
CERN	●	●		●	●	*		●	●	●			1	1		2	1	●				
Israel IUCC	●	●		●		*	●		●	●		1		1		1	1	●				●
NORDUnet	●/2	●		●		*	4	●	●	●		1	1		5	1	1	●			●	
MIRnet				0		*	●	●	●	●				5				0				
RENATER2	●	●	●	●	●	*		●	●	●		1	1	1			1	●			●	
SURFnet	●/2	●	●	●	●	*		●	●	●		1	1	1		1		●			●	●

* 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 ISP

STAR TAP/MREN Direct Peering Matrix

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

	MREN											
	Argonne Lab	U Chicago	Fermi Lab	UIC	UIUC/NCSA	U Iowa/ Iowa State U	Merit, Michigan, Michigan State	Northwestern U	U Notre Dame	Ohio State U (OARnet)	U Wisconsin Madison	U Wisconsin Milwaukee
Europe												
CERN[1]	●		●	●	●		●	●				
IUCC												
NORDUnet	●							●				
MIRnet	●											
RENATER2												
SURFnet				●	●			●				

1 CERN is considered a member of MREN.

IPv6 Tunnel Service at the 6TAP

The 6TAP [www.6tap.net] IPv6 service is run by ESnet and CANARIE and hosted by STAR TAP. 6TAP supports IPv6 over IPv4 tunnels and IPv6 performance measurement and statistics.

NLANR Web Cache

Duane Wessels of 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. 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 was installed at STAR TAP and 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 in December 1999. To date, CERN and iCAIR have used it to run DiffServ-aware video streaming experiments over a transatlantic tunnel [www.icair.org/inet2000] (See Section 2.B: Research Findings.); 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]; a draft report is available at [http://www.evl.uic.edu/cavern/papers/DiffServ12_12_2K.pdf]

EMERGE's goal is to build the teams and technology to help achieve guaranteed bandwidth across large distances. Follow-on efforts will involve testing Multi-Protocol Label Switching (MPLS) to manage DiffServ and other flows, extending the Grid Services Package (authentication/security software developed at NCSA) and incorporating visualization into monitoring tools, adding haptic and rendering flows to the tele-immersion network performance tests, creating a test suite for multi-resolution compressed digital video, continuing interoperability testing and tuning with ESnet and Abilene, and increasing international efforts.

Multicast

Many of the Euro-Link participants have Native Multicast enabled (including Israel IUCC, NORDUnet and SURFnet). These networks are documented at [http://www.startap.net/ENGINEERING/TECHINFO.html].

International Transit Network (ITN) Services

ITN service is now offered by STAR TAP, CANARIE and Internet2/Abilene to facilitate connectivity among international NRNs connecting to North American coasts. It became operational in October 2000. Further information is available on the Abilene [www.ucaid.edu/abilene/html/itnservice.html] and CA*net web sites [www.canet3.net/optical/documentation.html], as well as STAR TAP's [www.startap.net/CONNECT] page.

2.A.7. Euro-Link Network Operations Center (NOC)

The Euro-Link NOC can be accessed from [www.euro-link.org/ENGINEERING] or [http://noc.euro-link.org]. The NOC is operated by Jim Williams and Steve Peck of Indiana University. In addition to Euro-Link, Indiana's "Global NOC" operates the STAR TAP, TransPAC, MIRnet and Abilene networks as three logical NOCs inside one physical NOC. Each European NRN operates its own NOC as well; this information is maintained for all STAR TAP-connected networks at [www.startap.net/ABOUT/points.html].

Interaction between the Euro-Link NOC and the European NRN NOCs revolves around service. The Euro-Link NOC works hard to provide good service and information to its European counterparts. The Euro-Link NOC monitors NRN connections to STAR TAP, and when a particular network loses connectivity, troubleshooting begins. The Euro-Link NOC first looks at AADS to assess if there are any problems there; if so, it contacts the European NRNs to inform them of the problem. This happens through NOC-to-NOC email, as well as formal email notices to Euro-Link technical personnel. If the problem resides elsewhere, whether an NRN's network or a long-distance carrier's transoceanic network, then the NOC contacts its European NRN peers and offers assistance where necessary. Once again, formal email notification of an outage or a problem is sent to Euro-Link as a whole.

The Euro-Link NOC provides weekly reports of network availability (e.g., downtime, scheduled maintenance, etc.)

to the peering networks. The NOC also stays in close touch with the European NOCs in an effort to keep all relevant contact and engineering information up to date.

2.A.8. Documentation and Dissemination of Information

The Euro-Link web site [www.euro-link.org] was introduced in January 2000. We continually update Euro-Link information, including general information, network performance studies, engineering data, applications and publications. The contents of this report will be posted on the web site shortly after its completion.

2.A.9. Meetings Attended (April 2000–March 2001)

Because we also manage the NSF-funded STAR TAP initiative, many of the activities documented below overlap with those listed in our STAR TAP reports.

Euro-Link Annual Meetings

UIC organizes annual STAR TAP International Advisory Committee meetings, held in conjunction with the annual INET conferences. At INET 98, PI Tom DeFanti and co-PI Maxine Brown first met Peter Villemoes (NORDUnet), Kees Neggers (SURFnet), Ari Cohen (IUCC) and Christian Michau (CNRS/RENATER2) to discuss a HPIIS/Euro-Link connection. We currently do not hold separate Euro-Link meetings, due to the fact that each country procures and manages its own transoceanic link to the US. STAR TAP/Euro-Link meetings are documented on the web [http://www.startap.net/ABOUT/meetingsIndex.html].

- INET 2000 (July 17), Yokohama, Japan
- INET '99 (June 22), San Jose, CA
- INET '98 (July 21), Geneva, Switzerland

HPIIS Team Meetings

Euro-Link relies on the respected capabilities of the NSF HPIIS Team, comprised of UIC/Euro-Link, Indiana University/TransPAC and GNOC, University of Tennessee at Knoxville/MIRnet, AADS, and the STAR TAP management team. HPIIS awardees help each other by sharing experiences. We have a group email alias <hpiis-team@startap.net>. We have held the following meetings:

- In October 2000, NSF held a formal HPIIS Site Review at the San Diego Supercomputer Center. The report by the Review Committee is under development. Presentations and documentation from the Review are available at [http://www.euro-link.org/ABOUT/meetings.html#HPIIS00].
- In April 1999 we held a formal HPIIS meeting in conjunction with the opening of the International Center for Advanced Internet Research (iCAIR) at Northwestern University; minutes are posted on the STAR TAP web site [http://www.startap.net/ABOUT/MEETINGS.html].

Euro-Link Participation in International Conference Events

Past events we have organized include iGrid '98 at SC'98 and iGrid 2000 at INET 2000. The iGrid 2000 event at INET in Yokohama last July, organized by EVL, featured 24 collaborative projects from 14 nations [www.startap.net/igrid2000]. Of those involved, nine involved European countries (although some of the European countries connect to Abilene in New York via DANTE), and of these nine, four involved Euro-Link countries. iGrid '98 featured 22 demonstrations from 10 countries [www.startap.net/igrid98].) (Note: iGrid 2000 participation is detailed in Section 2.B: Research Findings.)

We are already involved in the SC'2001 conference [www.sc2001.org] in Denver, November 10-16, 2001; we are assisting ANL host 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; SARA in The Netherlands is one of these sites. Also, we are planning an optical networking demo (if possible, from SURFnet to Chicago to Denver) to promote the goals of StarLight.

Euro-Link Management Participation in European Events

ISRAEL IUCC

EVL staff Jason Leigh and Greg Dawe, and student Michael Lewis, remotely participated in Telecom 2000, Tel

Aviv, Israel's largest annual telecommunications conference, November 6-9, 2000. EVL's ImmersaDesk, however, was shipped to the site in Tel Aviv, and remotely deployed by Technion University engineers. A real-time collaboration among Israelis, EVL in Chicago, SARA in Amsterdam and EVL personnel in the Alliance booth at SC00 in Dallas, Texas, took place November 8-9. (Note: Telecom is detailed in Section 2.B: Research Findings.)

NORDUNET

Tom DeFanti and Maxine Brown of EVL attended NORDUnet 2000 in Helsinki, Finland, September 27-30, 2000. DeFanti gave a presentation "The Global Grid;" Brown presented "Global Tele-Immersion Applications."

SURFNET

EVL's Jason Leigh and student Chris Scharver attended the Eurographics Workshop in Amsterdam and did semi-public virtual-reality demonstrations in SARA's CAVE, June 1-2, 2000.

Euro-Link Meeting, Workshop and Conference Participation (April 2000-March 2001)

March 28-29, 2001. Tom Greene and Aubrey Bush of NSF ANIR visit Chicago (Northwestern University and UIC/EVL) to talk with Tom DeFanti, Joe Mambretti, Maxine Brown, Andy Schmidt, Linda Winkler, Bill Nickless, Ian Foster and Rick Stevens (Argonne National Laboratory) about STAR TAP and StarLight and tour the facilities.

March 22, 2001. StarLight meeting at EVL with Tom DeFanti (EVL et. al.), Joe Mambretti of Northwestern and Charlie Catlett and Linda Winkler of ANL.

March 16, 2001. Tom DeFanti and Maxine Brown had a conference call with Tom Greene at NSF and Julio Ibarra and Heidi Alvarez at Florida International University about issues that need to be resolved in order to connect AMPATH (South/Central America) to STAR TAP.

March 7, 2001. Tom DeFanti and Maxine Brown attended the Internet2 Spring Member Meeting in Washington DC. Brown gave a StarLight update at the International Task Force meeting. Kees Neggers of SURFnet gave an update on the SURFnet/Chicago lambda connection to take place this year. DeFanti and Brown also meet with John Jamison of Juniper about future router grants/donations.

March 6, 2001. Tom DeFanti and Maxine Brown met with Aubrey Bush, Tom Greene and Steve Goldstein at NSF about the future of international networking.

March 5, 2001. Bill St. Arnaud and René Hatem (CANARIE) and Kees Neegers (SURFnet) visit Chicago to talk with Tom DeFanti (EVL et. al.), Joe Mambretti of Northwestern and Linda Winkler of ANL about StarLight.

March 4-7, 2001. Jason Leigh attended the Global Grid Forum in Amsterdam, The Netherlands. 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.

February 28, 2001. StarLight meeting at EVL with Tom DeFanti (EVL et. al.), Joe Mambretti of Northwestern and Charlie Catlett and Linda Winkler of ANL.

February 13, 2001. Olivier Martin of CERN visited Chicago to talk with Tom DeFanti and Maxine Brown of EVL and Joe Mambretti of Northwestern University about StarLight.

January 28-31, 2001. The APAN/TransPAC/NLANR/Internet2 Joint Techs Workshop was held in Hawaii. Linda Winkler, representing STAR TAP, attended. Steve Peck and the Global NOC held a BOF session on NOC services and interaction between engineering groups. Participants included the Global NOC, APAN, and CA*net3. Special emphasis was placed on sessions relating to Asian networks.

January 21-23, 2001. Joint Workshop on Virtual Intelligent Environments and Technology, Universidad Veracruzana, Veracruz, Mexico. Tom DeFanti and Maxine Brown attended this NCSA/Alliance Education, Outreach and Training (EOT) workshop. DeFanti gave a presentation titled, "Virtual Reality over Gigabit Networks." *[Note: While not Euro-Link specific, we continue our efforts to get Central/South America connected to STAR TAP to provide our Euro-Link partners with the best access to researchers worldwide.]*

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

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

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

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

Optical STAR TAP was discussed. DeFanti presented, "StarLight: Applications-Oriented Optical Wavelength Switching for the Global Grid at STAR TAP."

The day before the conference started, DeFanti gave a lecture at McGill University titled, "3D Telephony: Virtual Reality and the Ten Gigabit Telephone Call." He addressed the 3rd meeting of the Canadian Working Group on Virtualized Reality.

DeFanti, Brown, Mambretti and Goldstein met Teleglobe's Yves Poppe to discuss future STAR TAP plans.

DeFanti, Winkler, Mambretti and Neggers met representatives of Level3 about transatlantic wavelengths.

DeFanti, Brown, Winkler, Mambretti and Goldstein met Joerg Micheel, WAND and NLANR MOAT, The University of Waikato, New Zealand, about developing Passive Monitoring Analysis (PMA) boxes for wavelengths; Hans-Werner Braun subsequently expressed strong interest.

DeFanti, Brown, Winkler, Mambretti and Goldstein met Brian Pratt of edgeflow Inc. in Canada, about products based on OBGP and STAR TAP's (specifically Star Light's) potential interest.

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

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

November 6-9, 2000. SC'2000, attended by Maxine Brown, Alan Verlo, Chris Scharver and Eric He (UIC), and Linda Winkler (ANL). Tele-immersive demonstrations were run between Israel and Chicago; also a real-time demonstration by UIC's Bob Grossman with Europe and Australia. Brown and Winkler attended an organizational meeting for SC Global, to be held at SC'2001 in Denver, November 10-16, 2001, to link Denver with dozens of SC constellation sites distributed throughout the world, all of which support the Access Grid real-time, Internet-based videoconferencing system.

November 6-9, 2000. A US State Department-issued warning advising against travel to Israel caused Jason Leigh, Greg Dawe and Michael Lewis (UIC) to cancel plans to attend Telecom 2000 in Tel Aviv, Israel's largest annual telecommunications conference. EVL's ImmersaDesk, however, was shipped to the site in Tel Aviv, and remotely deployed by Technion University engineers. Using a Polycom system to conduct real-time remote training, the EVL and Technion teams conducted a tele-collaborative session on November 5. EVL researchers used CAVERNsoft-based applications to remotely debug ImmersaDesk hardware. A real-time collaboration among Israelis, EVL in Chicago, SARA in Amsterdam and EVL personnel in the Alliance booth at SC00 in Dallas, Texas, took place November 8-9. On December 7, Joe van Zwaren, Israeli Ministry of Science, reported the following about the

Telecom 2000 conference: "The ImmersaDesk made a tremendous impact. Many people got the full impact of the technology. I am now exploring the possibility of getting a museum to buy an ImmersaDesk to give a real-time 3D view produced by an electron microscope (the company that might sponsor this is in the electron microscope business). This would provide a permanent exhibition of the technology in Israel."

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

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

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

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

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

September 27-30, 2000. Tom DeFanti and Maxine Brown of EVL attended NORDUnet 2000 in Helsinki, Finland [http://www.csc.fi/nordunet2000/program.phtml]. DeFanti gave a presentation "The Global Grid;" Brown presented "Global Tele-Immersion Applications." Also represented at NORDUnet 2000 were Bill St. Arnaud (CANARIE), Kees Neggers (SURFnet), Peter Villemoes (NORDUnet) and David Williams (CERN). DeFanti, Brown, St. Arnaud, Neggers and Williams had meetings on our future "StarLight" project, as both SURFnet and CERN are interested in installing wavelengths across the Atlantic Ocean.

September 14, 2000. Tom DeFanti, Joe Mambretti, Andy Schmidt, Linda Winkler, Alan Verlo, Oliver Yu, Akihiro Tsutsui, Cliff Nelson and Ameritech's Anthony Haeuser met to discuss (1) the status of dark fiber available between UIC/Goldberg, NU campuses and Bell Nexxia, (2) co-location space available at Ameritech, and (3) I-WIRE and MREN (StarLight) plans for GigE, 10GigE, DWDM/CWDM.

September 7, 2000. Bill St. Arnaud, Rene Hatem (CANARIE), Charlie Catlett, Linda Winkler, Bill Nickless (ANL), Cliff Nelson (UIC), Tom DeFanti, Alan Verlo, Akihiro Tsutsui, Oliver Yu, Jason Leigh (EVL) met at EVL to discuss Optical STAR TAP. Discussion included goals, and hardware, middleware and fiber needs.

August 23, 2000. StarLight meeting, EVL. Tom DeFanti and Joe Mambretti of Northwestern attended.

August 2, 2000. Networking people from STAR TAP, TransPAC, Internet2 and CANARIE met to discuss the issues and procedures for an International Transit Network (ITN).

July 21, 2000. Hank Nussbacher gave a presentation at an EPSCoR (Experimental Program to Stimulate Competitive Research) meeting in San Diego, CA, on the matter of satellite networking, which was based mainly on the knowledge gained via IUCC's satellite link to STAR TAP. The EPSCoR workshop dealt with methods to reduce costs for high-speed connectivity to academic sites in the USA that do not have sufficient funds or necessary fiber to connect. [www.internet-2.org.il/epscor/index.htm]

July 18-21, 2000. iGrid 2000 at INET 2000 in Yokohama, Japan. The International Grid (iGrid) special event showcased 24 demonstrations, featuring the latest in technological innovations and application advancements supporting global community networking [www.startap.net/igrid2000]. iGrid 2000 was jointly sponsored by EVL/UIC, the Office of the Vice President for Information Technology at Indiana University, University of Tokyo and Keio University. Via STAR TAP, it provided global connectivity to 14 countries: Canada, CERN (Switzerland),

Germany, Greece, Japan, Korea, Mexico, Netherlands, Singapore, Spain, Sweden, Taiwan, United Kingdom and the USA. Technical innovations demonstrated included tele-immersion, large datasets, distributed computing, remote instrumentation, collaboration, streaming media, human/computer interfaces, digital video and high-definition television, and grid architecture development. Applications represented the fields of science, engineering, cultural heritage, distance education, media communications, and art and architecture.

July 17, 2000. Annual meeting, STAR TAP International Advisory Committee, INET 2000, Yokohama, Japan. Minutes posted to [http://www.startap.net/ABOUT/MEETINGS.html].

July 16, 2000. Tom DeFanti, Maxine Brown and Laura Wolf met with SURFnet's Kees Neggers to discuss SURFnet's DWDM network, now under construction, and future plans to connect it to STAR TAP and Canada.

June 28, 2000. Euro-Link representatives Tom DeFanti and Maxine Brown participated in a conference call with MIRnet, TransPAC and NSF people to discuss plans for the upcoming HPIIS Review meeting.

June 1-2, 2000. EVL Senior Research Scientist Jason Leigh and student Chris Scharver attended the Eurographics Workshop in Amsterdam and demonstrated a semi-public VR walkthrough of Amsterdam architect Rem Koolhaas' new Illinois Institute of Technology (IIT) building, as well as "TIDE: The Tele-Immersive Data Explorer." TIDE [www.evl.uic.edu/cavern], developed by EVL in collaboration with UIC National Center for Data Mining (Bob Grossman, director) and DOE ASCI researchers, is a CAVERNsoft-based collaborative, immersive environment for querying and visualizing data from massive and distributed datastores. The fully immersive demo, shown in SARA's CAVE, was a huge success. Leigh reported both demos went off without a single problem, and noted, "We got a lot of positive reaction from the audience, especially of TIDE. Many were as impressed by our work as with the quality of the networking supporting the collaboration." He referred those interested in the networking aspect to Tom DeFanti and Maxine Brown, and to the STAR TAP web site. Leigh met with Laurent Grizon of Institut Francais du Petrole to discuss a possible future collaboration.

While at the conference, they met with a student of Ralf Schaefer, the Head of the Image Processing Department at Heinrich-Hertz-Institut in Berlin, Germany, to discuss their participation in N*VECTOR, EVL's collaborative effort with researchers at University of Tokyo and NTT.

Also, while at SARA in Amsterdam, Jason and Chris met with Ed Breedveld, a SARA researcher with whom they have been collaborating on "Saranav"–a Performer-based CAVE application to load and view 3D polygonal datasets in the CAVE–as well as QoS experiments.

May 31-June 2, 2000. Maxine Brown, Tom DeFanti and Linda Winkler met with Hiroshi Esaki of University of Tokyo and researcher Gorochan Kunito to discuss iGrid 2000 and international networking. There is great concern about transiting Germany's applications to Yokohama, since DANTE (which brings German DFN traffic to the USA) wants to only let limited IP addresses through to STAR TAP, due to bandwidth constraints on their Atlantic links.

May 22-23, 2000. Tom DeFanti and Maxine Brown attended the DoE's Mathematical, Information, and Computational Sciences (MICS) division review of its network research program at the Dulles Hyatt in Herndon, Virginia.

May 20, 2000. Tom DeFanti met with George Strawn at O'Hare airport to give an update on STAR TAP in preparation for a trip to Portugal by President Clinton and NSF CISE Associate Director Ruzena Bajcsy.

May 16, 2000. Linda Winkler presented "STAR TAP ITN International Transit Network" to Internet2/NLANR Joint Techs meeting in Minneapolis, MN. Met with Jim Williams, Steve Peck and Kazunori Konishi (APAN) to discuss Euro-Link/STAR TAP/TransPAC network issues. Discussion focused on the coming iGrid 2000 demonstrations at INET 2000.

May 11, 2000. Maxine Brown, staff Laura Wolf and student Brenda Lopez held a meeting with Linda Winkler on the Access Grid to discuss visualizing STAR TAP international traffic for iGrid 2000 in July. STAR TAP Router traffic is posted on the STAR TAP web site [www.startap.net/ENGINEERING].

March 27-29, 2000. Hank Nussbacher gave a presentation on "The Asymmetry of Internet-2 Traffic" at the Internet2 International Task Force Meeting, Washington DC. [www.internet-2.org.il/i2-asymmetry/index.htm]

2.B. Research Findings

2.B.1. StarLight

Euro-Link NRNs are doubling bandwidth every year. This trend is serving as a prime impetus for the development of StarLight, the next-generation Optical STAR TAP. We plan to have StarLight operational in 2001, with expansion plans running until 2006. StarLight expects to handle wavelengths from Canada and Holland this year, CERN and Japan next year, as well as, of course, I-WIRE/Indiana. Asian and European connectivity would be greatly facilitated by donated wavelengths to the coasts, which we are investigating. South American connectivity depends on Miami's AMPATH.

The StarLight facility will be located at Northwestern University's downtown campus, at 710 N. Lake Shore Drive, and managed and operated by iCAIR. StarLight will provide a mechanism for (university) customer-controlled 10 Gigabit network flows to be switched and routed to research networks and commercial networks. Its architecture is designed to be distributable among opportune points of presence, university campuses, carrier meet points, and so on. StarLight will enable ways, via grid middleware, for bandwidth to be scheduled, allocated, and delivered for use by high-performance computational, data and visualization grids. StarLight is leveraging the intellectual lead of CA*net4, the Canadian optically switched network planned to stretch coast-to-coast, connecting to the US in Chicago, Seattle and New York City.

Harvey Newman, Caltech researcher and CERN collaborator, when recently asked to forecast GriPhyN and CERN data grid bandwidth requirements, said:

"The CMS (Compact Muon Solenoid) detector is being designed to measure the signatures of new physics, to be generated by CERN's LHC (Large Hadron Collider), expected to come online in 2005. In the first full year of operation, the CMS will require 11 PB of tape and 4 PB of disk storage, and 80 Teraops computing power. These numbers will increase over subsequent years.

The [bandwidth] baseline will be OC-48 to OC-192 for a national center's terrestrial links, and OC-192 for the major transoceanic links. Since we foresee about 1 Tbyte/sec internal data flow at CERN, you might guess we could build a tightly coupled system with up to 0.1-1 Tbps on the cross-ocean links. Of course I am talking about data transfer using light protocols that have little to do with TCP.

These estimates are for the CMS alone. For the whole LHC program, one would need more bandwidth links and 2-4 times more computing power and data storage."

2.B.2. Network Performance Analysis Software Releases

CAVERNsoft G2, a C++ toolkit for building collaborative, networked applications is available for download. It has low- and mid-level networking classes to support general collaborative applications building, and high-level modules to support tele-immersion (or collaborative virtual reality.) The distribution includes full source for SGI/Irix, Linux and Win9x/NT/2000. Currently, graphics support is only supported on the SGI through IRIS Performer. The distribution comes with the full source of Globus 1.1, and allows the user to generate both Globus and non-Globus versions of CAVERNsoft. In January, CAVERNsoft was deployed at [openchannelsoftware.org]. The latest version of CAVERNsoft G2, version 1.2.1, released December 2000, is available at [http://www.evl.uic.edu/cavern/cavernG2/].

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

2.B.3. Collaborations

EVL continues to work with SARA in Amsterdam. In the past year:

- EVL upgraded SARA's SARAnav software to CAVERNsoft G2
- EVL demonstrated a virtual walk-through of architect Rem Koolhaas' IIT design on June 2, 2000 at SARA
- EVL is testing SARA's SARASim, a Python/CAVELib program that allows users to build script-based virtual-reality applications that uses CAVERNsoft for networking

- EVL continues to jointly conduct network performance studies over long, fat networks using various transmission techniques (TCP, UDP, FEC, RUDP)

> ***"In 1998, while designing a new building for Illinois Institute of Technology (IIT) in Chicago, renowned Dutch architect Rem Koolhaas heard he could view his designs in virtual reality (VR) using the CAVE at the Electronic Visualization Laboratory (EVL) at the University of Illinois at Chicago. EVL people, in turn, put him in touch with people at SARA in Amsterdam, where they were doing scientific visualization with radiosity--using supercomputers for real-time illumination of architectural images; however, the actual presentation of the final designs to IIT management in Chicago never happened. The goal of this project was to give the architect the ability to present and examine his design with his team both locally and internationally. The integration of SARA's SARAnav application with EVL's CAVERNsoft library enables an architect to have a collaborative design and presentation tool. Even though this particular architectural tool hasn't been used yet (because of the late integration of the technology in the design process), the request to use this collaborative technology has been made for new projects, including the design for a new Library in Seattle. Rem Koolhaas and his Office for Metropolitan Architecture are very interested in using this, and other forms of this technology, because his is a global architectural firm with 90% of its projects outside The Netherlands. Without the Euro-Link/SURFnet/STAR TAP connection, these applications would not be possible, and it shows that tele-immersion research and high-bandwidth networks has produced a worthy tool for all types of applications, including architecture."***
>
> ***– Edward J. Breedveld, Marketing Manager, Virtual Reality and High-end Visualization, Stichting Academisch Rekencentrum Amsterdam (SARA) Computing Services, The Netherlands***

2.B.4. Euro-Link Applications Documented

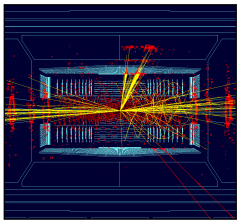
Active US/European collaborations utilizing high-performance research networks continue to be documented for CERN, IUCC, RENATER2, SURFnet and NORDUnet and appear on the Euro-Link web site. [http://www.euro-link.org/APPLICATIONS/]. These applications are documented here, in the Appendix of this document.

> ***"The Computational Physics Group at the Technion works with other computational physicists in a US/Israel Binational Science Foundation project (with Dennis Rapaport of Bar Ilan and David Landau at the University of Georgia (UGA), and a German Israel Foundation project with Kurt Binder in Mainz and Wolfhard Janke in Leipzig, amongst several others). Our main interest is Atomistic Computer Simulations, and my group's expertise is visualizing these systems in collaboration with experimental researchers. Our collaborators' expertise is in algorithmic aspects of the simulation; therefore, intensive collaboration is beneficial to all of us…With STAR TAP/Euro-Link/IUCC, we can now exchange animated visualizations in real time with US, European and even Australian associates…This intensive collaboration was not possible other than in face-to face meetings until recently…On a recent visit to UGA, we videoconferenced to the Technion, enabling seven people to participate in discussions at the UGA Workshop for the price of one plane ticket…"***
>
> ***– Joan Adler, Professor, Physics Department, Technion, Haifa, Israel***
>
> ***"STAR TAP/Euro-Link connectivity between US research networks and Israel's IUCC (Inter-University Computation Center) advanced network brings atmospheric research, in general, and weather prediction, in particular, into a new era. It certainly enables Israeli/US research that was impossible in the past due to data accessibility difficulties…"***
>
> ***– Pinhas Alpert, Head, ISA-MEIDA, and Professor, Department of Geophysics and Planetary Sciences, Tel-Aviv University, Israel***

2.B.5. iGrid 2000 Demonstrations

The iGrid 2000 event during INET 2000 in Yokohama, Japan, July 18-21 was an overwhelming success. It featured 24 high-speech collaborative research applications from 14 regions around the world. iGrid connected to the JGN,

the WIDE Project Network (in cooperation with NTT, TTNet and PNJC), APAN and the APAN/TransPAC (100Mbps) link to STAR TAP. Nine iGrid applications involved European countries (although some connect to Abilene in New York via DANTE), and of these nine, four involved Euro-Link countries. These applications are highlighted below, listed in the Appendix, and on the Euro-Link web site.



Distributed Particle Physics Research

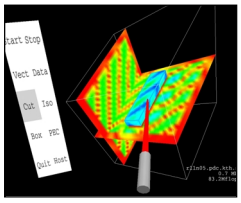
- **CERN**
- Caltech, USA

This application demonstrates remote viewing and analysis of particle physics events. The application is the front end to an engineered object-oriented global system that incorporates grid middleware for authentication and resource discovery, a distributed object database containing several terabytes of simulated events, and a component that enables queries issued by the front-end application to be matched to available computing resources in the system.

ALIVE: Architectural Linked Immersive Environment

- SARA Academic Computing Services Amsterdam, **The Netherlands**
- Office of Metropolitan Architecture, Rotterdam, Netherlands
- Electronic Visualization Laboratory (EVL), University of Illinois at Chicago, USA

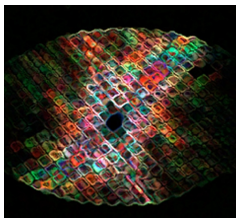
ALIVE is used to evaluate the usability of collaborative virtual reality for architectural design.



Steering and Visualization of a Finite-Difference Code on a Computational Grid

- Royal Institute of Technology, **Sweden**
- University of Houston, USA

This application enables computational steering of electromagnetic simulations across distributed resources using interactive visualization in a virtual-reality environment.



GiDVN: Global Internet Digital Video Network

- Digital Video Working Group, Coordinating Committee for International Research Networks (DVWG, CCIRN)
- CANARIE Inc., Canada
- **CERN, Switzerland**
- APAN, Japan
- KDD, Japan
- APAN-KR and Seoul National University, Korea
- SURFnet, **Netherlands**
- DGSCA-UNAM, Mexico
- SingAREN, Singapore
- Universitat Politecnica de Catalunya, Spain
- Royal Institute of Technology, **Sweden**
- iCAIR, Northwestern University, USA

GiDVN projects are enhancing media capabilities for the next-generation Internet, enabling new applications to interoperate throughout the world.

Note: Abilene provided temporary transit from New York to STAR TAP, DANTE researchers from Germany's Fraunhofer Institut Graphische Datenverarbeitung (Darmstadt), Albert-Einstein-Institute (Potsdam), Konrad-Zuse-Zentrum fur Informationstechnik (Berlin), the High Performance Computing Center Stuttgart, and Brandenburg University of Technology at Cottbus remotely collaborated in four research application demonstrations.

2.B.6. Telecom 2000: Israel, Amsterdam, Chicago and Dallas Collaboration

Telecom 2000, Israel's largest annual telecommunications conference, was held in November 2000. EVL was invited to participate at the request of the Israeli Ministry of Science's Jo van Zwaren, who wanted universities in the IUCC network to acquire virtual-reality equipment for scientific collaborative research. A US State Department-issued warning advising against travel to Israel caused Jason Leigh, Greg Dawe and Michael Lewis to cancel plans

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

2.B.7. Ars Electronica Festival in Austria

EVL's Dan Sandin is organizing a large, shared VR environment for the Ars Electronica Festival, September 1-6, 2001, in Austria. Participants include artists from Hungary's C3 [http://www.c3.hu/], The Netherlands' V2 [http://www.v2.nl/], The Interactive Institute of Sweden [http://www.interactiveinstitute.se/], and the United States (UIC, Chicago and SUNY, Buffalo).

2.B.8. Trans-Atlantic DiffServ iCAIR/CERN Testbed

CERN peering with the STAR TAP EMERGE (DiffServ) Router enabled CERN and iCAIR to conduct STAR TAP Router-enabled QoS DiffServ over a trans-Atlantic testbed that they provisioned. DiffServ-enabled digital video (DV) was streamed between the two organizations over the testbed. These tests were conducted, in part, in preparation for DiffServ-enabled streaming tests during iGrid 2000 in Yokohama. A variety of experiments were conducted, involving *mgen* UDP flows, with BE baseline streams and contending traffic streams, and with measurements for throughput, delay and jitter. Because of the limited number of routers available, the full EMERGE model was not implemented. Instead, the CERN iGrid link was established as a dedicated broadband 5Mbps PVC. A constant UDP flow was established with a Poisson distribution of 2.4Mbps, which was preserved because of the a) ingress control b) link control and c) congestion control at the APAN-JP NOC and the network control points established for iGrid. The delay results showed a desirable consistency. On a scale of 100ms, equal service was delivered to every part of the flow. Jitter variations (closely clustered average jitter of 1.65ms) resulted from variations in flow source. The success of these tests has led to plans for a more complex series of experiments. (Another set of DiffServ-based experiments for the GiDVN was conducted by the APAN group in Korea in conjunction with collaborators at Korean universities.)

2.B.9. International Transit Network (ITN) Services

ITN service is now offered by CANARIE/CA*net3 and Internet2/Abilene to facilitate connectivity among international NRNs connecting to North American coasts. It became operational in October 2000. Further information is available on the Abilene [www.ucaid.edu/abilene/html/itnservice.html] and CA*net web sites [www.canet3.net/optical/documentation.html], as well as STAR TAP's [www.startap.net/CONNECT] page.

2.C. Research Training

There is clearly a fine team of professors, staff and engineers from UIC, ANL, NCSA, MREN, iCAIR and Indiana University involved with Euro-Link (and 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 Euro-Link, not just the management team in the Chicago area, the involvement extends nationally (NLANR, NGI networks, Internet2) and internationally. All the people working on Euro-Link (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

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 also participated in NRN conferences, including the annual NORDUnet Workshop, Israel's Internet-2 and Telecom conferences and the Eurographics conference held in 2000 in Amsterdam. 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.euro-link.org/PUBLICATIONS/].

Past events we have organized include iGrid '98 at SC'98 and iGrid 2000 at INET 2000. (The iGrid 2000 event at INET in Yokohama last July, organized by EVL, featured 24 collaborative projects from 14 nations [www.startap.net/igrid2000]. iGrid '98 featured 22 demonstrations from 10 countries [www.startap.net/igrid98].) We are already involved in the SC'2001 conference [www.sc2001.org] in Denver, November 10-16, 2001; we are both assisting ANL host 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, and we are planning an optical networking demo (if possible, from Chicago to Denver) to promote the goals of StarLight. SARA in The Netherlands has an Access Grid, so will participate in the former and, when SURFnet's 2.5 Gbps lambda is installed at StarLight, SARA will participate in the latter as well. 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) (see Section 1.D: Other Collaborators or Contacts).

3. Publications and Products

3.A. Journals/Papers

In addition to overseeing the growth and development of Euro-Link, the faculty, staff and students of EVL/UIC are users of Euro-Link. 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.

Jason Leigh, Oliver Yu, Dan Schonfeld, Rashid Ansari, Eric He, Atul Nayak, Jinghua Ge, Naveen Krishnapasad, Kyoung Park, Yong-joo Cho, Liujia Hu, Ray Fang, Alan Verlo, Linda Winkler, Thomas DeFanti, "Adaptive Networking for Tele-Immersion," Proceedings of the 5th Immersive Projection Technology/ 7th Eurographics Virtual Environments Conference, May 16-18, 2001, Stuttgart, Germany, (accepted for publication).

J. Leigh, Yu, O., Schonfeld, D., Ansari, R., He, E., Nayak, A., Ge, J., Krishnaprasad, N., Park, K., Cho, Y., Hu, L., Fang, R., Verlo, A., Winkler, L., DeFanti, T., "Adaptive Networking for Tele-Immersion," Proceedings of the 5th Immersive Projection Technology/7th Eurographics Virtual Environments Conference, May 16-18, 2001, Stuttgart, Germany. http://www.evl.uic.edu/cavern/papers/jleigh_EGVEIpt2001.pdf

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.

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

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

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

Jason Leigh, Maggie Rawlings, Javier Girado, Greg Dawe, Ray Fang, Muhammad-Ali Khan, Alan Cruz, Dana Plepys, Daniel J. Sandin, Thomas A. DeFanti, "AccessBot: An Enabling Technology for Telepresence," INET 2000 Proceedings, The 10th Annual Internet Society Conference, 18-21 July 2000, Yokohama, Japan, CD ROM. http://www.evl.uic.edu/cavern/papers/Inet2000AccessBot.pdf

Tomoko Imai, Zhongwei Qiu, Sowmitri Behara, Susumu Tachi, Tomonori Aoyama, Andrew Johnson, Jason Leigh, "Overcoming Time-Zone Differences and Time Management Problem with Tele-Immersion," INET 2000 Proceedings, The 10th Annual Internet Society Conference, 18-21 July 2000, Yokohama, Japan, CD ROM. [http://www.startap.net/images/timezone.pdf]

D. He, F. Liu, D. Pape, G. Dawe, D. Sandin, "Video-Based Measurement of System Latency," Proceedings of the 4th International Immersive Projection Technology Workshop, Ames IA, June 19-20, 2000.

N. Sawant, C. Scharver, J. Leigh, A. Johnson, G. Reinhart, E. Creel, S. Batchu, S. Bailey, R. Grossman, "The Tele-Immersive Data Explorer: A Distributed Architecture for Collaborative Interactive Visualization of Large Datasets," Proceedings of the Fourth International Immersive Projection Technology Workshop 2000, June 19-20, Ames, Iowa.

A. Johnson, “Creating Tele-Immersion Environments,” Tutorial presentation at the 11th Annual Workshop on Interconnections Within High Speed Digital Systems, Santa Fe NM, May 21-24, 2000.

3.B. Books/Publications

A. Johnson, J. Leigh, “Tele-Immersive Collaboration in the CAVE Research Network,” chapter to appear in the: Collaborative Virtual Environments: Digital Places and Spaces for Interaction, edited by Churchill, Snowdon and Munro, March 2001, pp.225-243.

3.C. Internet Dissemination

www.euro-link.org

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

Euro-Link, by its very nature, is interdisciplinary. There is clearly a fine team of computer scientists, computational scientists and networking engineers involved with Euro-Link, facilitating greater advances in global networking than unconnected single-investigator efforts could produce. Euro-Link 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, Euro-Link is a necessary and integral part of application advances and technological innovations. Euro-Link also impacts the network community by providing an infrastructure to study long-distant, high-bandwidth networks. NLANR is working with Euro-Link/STAR TAP on network measurement and web caching. ESnet and CANARIE are working with Euro-Link/STAR TAP on 6TAP. Networking companies, such as Cisco and Juniper, have given Euro-Link/STAR TAP router donations.

EVL not only manages the Euro-Link and STAR TAP facilities, but the Lab is also one of Euro-Link'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 Euro-Link 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.

Euro-Link and NSF's companion HPIIS programs have helped change the way international science is done, by providing a persistent infrastructure for global collaboration. The HPIIS programs, through STAR TAP, have 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 200x sometime in the future.

While we have no quantitative metrics to evaluate Euro-Link's role in education/human resources development, we cite throughout this report testimonials from American and European users and NRN managements. We have documented more than 80 applications on the Euro-Link web site, implying that hundreds of networking engineers, application programmers and discipline scientists are involved in Euro-Link-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 Euro-Link 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. Euro-Link is a major – and unique – resource for Science and Technology. Euro-Link/STAR TAP is an infrastructure and proving ground in which to implement new network engineering solutions to advance the state of the art. The majority of Euro-Link funds in this Cooperative Agreement (see Section 8: FY02 Budget Narrative) go for five $320,000 annual payments to the Euro-Link NRNs (a total of $1,600,000 annually) to help offset the high costs of transatlantic networking. Additional Euro-Link funds are used to cover local loop fees for these NRNs in Chicago. NSF's funds are leveraged at least 4:1 and up to 10:1 through this effort, providing US scientists ever-increasing access to Euro-Link connected facilities at a very reasonable cost.

4.E. Contributions Beyond Science and Engineering

Because of Euro-Link/STAR TAP's interest in QoS, IPv6 and lambda switching, we have recently gotten 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. (See "StarLight" in Section 2.B: Research Findings.) 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 (and Euro-Link) is evolving into 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 (and Euro-Link) 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.
N/A

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?
See Section 7: Euro-Link Program Plan. In FastLane, this is included in the attached PDF file.

5.D. Animals, Biohazards, Human Subjects

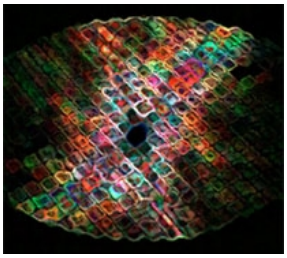
Has there been any significant change in animal care and use, biohazards, or use of human subjects from what was originally approved (or approved later)?
No.

6. Appendix: Euro-Link Applications

This appendix represents a major UIC/EVL effort to compile a list of meritorious applications involving US/Euro-Link researchers. The data was gathered from documents submitted by NRN's, news lists and independent research. This information appears on the Euro-Link and STAR TAP web sites. Applications are organized here (and on the Euro-Link web site) by NRN; organization by scientific discipline appears on the STAR TAP web site.

6.A. CERN

GiDVN: Global Internet Digital Video Network



International Center for Advanced Internet Research (iCAIR), Northwestern, USA; Digital Video Working Group, Coordinating Committee for International Research Networks (DVWG,CCIRN), worldwide membership

Joe Mambretti, iCAIR, Northwestern University, j-mambretti@nwu.edu

GiDVN projects are enhancing media capabilities for the next-generation Internet, enabling new applications to interoperate throughout the world.

Peter Marshall, CANARIE Inc., Canada
Olivier Martin, Paolo Moroni, Philippe Galvez, Joop Joosten, CERN
Kazunori Konishi, APAN, Japan
Shuichi Matsumoto, Masahiro Wada, Shigeyuki Sakazawa, Yasuhiro Takishima, Tetsusi Yamashita, KDD, Japan
Jaehwa Lee, Seungmo Choe, APAN-KR, Korea
Yung Yi, Yanghee Choi, Wang Lijing, Seoul National University, Korea
Sungkwan Youm, Korea University, Korea
Egon M. Verharen, SURFnet, The Netherlands
Cesar Olvera, DGSCA-UNAM, Mexico
Manjeet Singh, Francis Lee, SingAREN, Singapore
Artur Serra, Sebastia Sallent, Joan Borràs, Universitat Politecnica de Catalunya, Spain
Björn Pehrson, Daniel Forsgren, Royal Institute of Technology, Sweden
Joe Mambretti, Jim Chen, Jeremy Weinberger, Tim Ward, Northwestern University, USA

http://www.icair.org/inet2000, http://iumrs.ms.nwu.edu

Authenticated Quality of Service (QoS)

CERN; University of Michigan, USA; Argonne National Laboratory, USA; Pittsburgh Supercomputing Center, USA

William A. (Andy) Adamson, University of Michigan, andros@umich.edu

This project provides the next step toward providing authenticated, authorized network QoS guarantees. The collaborators are mainly concerned with the signaling for the set-up of network QoS, specifically the design and transmission of authentication and authorization information. They will test with UDP-based applications for which current Cisco QoS configurations work, and will experiment with TCP-based applications.

The UDP traffic generator from University of Michigan's Center for Information Technology Integration (CITI) is being used to test QoS capabilities of network components. The basic form of these initial results will be followed when verifying network resource reservation at the end-point Bandwidth Broker networks.

This project aims to integrate the PKI-based Akenti authorization system into Argonne National Lab's Globus-based bandwidth broker and the Internet2 Middleware working group's LDAP directory schema, to provide a scalable, authenticated means to request network QoS.

http://www.citi.umich.edu/projects/qos/

GriPhyN: Grid Physics Network

CERN, Switzerland; 17 US research laboratories and universities, led by University of Chicago, USA and University of Florida, USA

Paul Avery, University of Florida, avery@phys.ufl.edu
Ian Foster, University of Chicago and Argonne National Laboratory, foster@cs.uchicago.edu
Harvey B. Newman, CERN and Caltech, newman@hep.caltech.edu

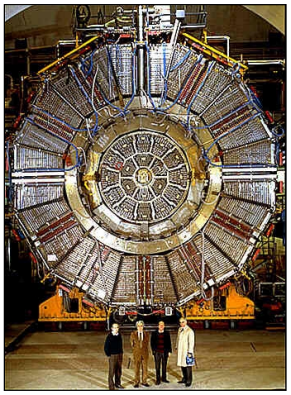
The GriPhyN collaboration is a team of experimental physicists and information technology (IT) researchers who plan to implement the first Petabyte-scale computational environments for data intensive science in the 21st Century. Driving the project are unprecedented requirements for geographically dispersed extraction of complex scientific information from very large collections of measured data: CMS (Compact Muon Solenoid), ATLAS (A Toroidal LHC Apparatus), LIGO (Laser Interferometer Gravitational-wave Observatory), and SDSS (Sloan Digital Sky Survey).

CMS and ATLAS experiments will use the Large Hadron Collider (LHC) at CERN to search for the origins of mass and probe matter at the smallest length scales; LIGO will detect the gravitational waves of pulsars, supernovae and in-spiraling binary stars; and, SDSS (Sloan Digital Sky Survey) will carry out an automated sky survey enabling systematic studies of stars, galaxies and large-scale structure.

To meet these requirements, which arise initially from the four physics experiments involved in this project but will also be fundamental to science and commerce in the 21st Century, GriPhyN will deploy computational environments called Petascale Virtual Data Grids (PVDSs) that meet the data-intensive computational needs of a diverse community of thousands of scientists spread across the globe. GriPhyN is a US National Science Foundation Information Technology Research (ITR) initiative led by the University of Chicago and the University of Florida.

http://www.griphyn.org

Networked Experiments of the European Laboratory for Particle Physics



CERN; Argonne National Laboratory, USA; California Institute of Technology, USA; Cornell University, USA; Fermilab, USA; Harvard University, USA; Lawrence Berkeley National Laboratory, USA; Massachusetts Institute of Technology, USA; Princeton University; USA; ESnet, USA.

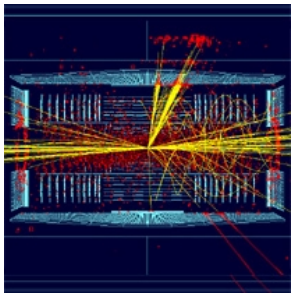
Harvey Newman, Caltech, newman@hep.caltech.edu

CERN provides experimental facilities for particle physics experiments, mainly in high-energy physics (HEP). CERN's current major facility is the Large Electron Positron (LEP) collider in a 27-km tunnel, the largest machine of this type in the world. Four very large experiments in man-made caverns intersect the LEP tunnel, constituting half of CERN's total experimental program for the 1990s. Each of the experiments is carried out by teams of several hundred of physicists from over 50 worldwide institutes.

LEP experiments generate 25 terabytes of data each year, which is stored on magnetic tape cartridges, whereas the Large Hadron Collider (LHC) experiments, expected to commence in 2005, are expected to produce several order of magnitude more data. The sheer volume of the data combined with the complexity of the analysis to be performed, and the requirement that the processing of the data may also be done remotely, places heavy demands on the High Energy & Nuclear Physics (HENP) computing and networking infrastructure, which can only be met by using leading edge technology and services.

http://www.cern.ch

Distributed Particle Physics Research



CERN; Caltech, USA

Harvey Newman, Caltech and CERN, newman@hep.caltech.edu
Julian Bunn, Caltech, julian@cacr.caltech.edu

This application demonstrates remote viewing and analysis of particle physics events. The application is the front end to an engineered object-oriented global system that incorporates grid middleware for authentication and resource discovery, a distributed object database containing several terabytes of simulated events, and a component that enables queries issued by the front-end application to be matched to available computing resources in the system (the matchmaking service).

http://pcbunn.cacr.caltech.edu, http://cmsdoc.cern.ch/orca, http://iguana.web.cern.ch/iguana, http://vrvs.cern.ch

Large Hadron Collider (LHC) project

CERN; Caltech, USA; Others.

Harvey Newman, Caltech, newman@hep.caltech.edu

The LHC is an accelerator that brings protons and ions into head-on collisions at higher energies than ever before, enabling scientists to penetrate still further into the structure of matter, and recreate the prevailing conditions of the early post-"Big Bang" universe.

The LHC is a remarkably versatile accelerator. It can collide proton beams with energies around 7-on-7 TeV and beam crossing points of unsurpassed brightness, providing the experiments with high interaction rates. It can also collide beams of heavy ions such as lead with total collision energy in excess of 1,250 TeV−about 30 times higher than at the Relativistic Heavy Ion Collider (RHIC) under construction at the Brookhaven Laboratory in the US. Joint LHC/LEP operation can supply proton-electron collisions with 1.5 TeV energy, some five times higher than presently available at HERA at the DESY laboratory in Germany. The research, technical and educational potential of the LHC and its experiments is enormous.

http://www.cern.ch/LHC/

ATLAS (A Toroidal LHC ApparatuS)

CERN; Caltech, USA; Others.

Harvey Newman, Caltech and CERN, newman@hep.caltech.edu

1850 collaborators in 150 institutions around the world are constructing the ATLAS experiment. It will study proton-proton interactions at the Large Hadron Collider (LHC) at CERN. The detector is due to begin operation in the year 2005. ATLAS is designed to improve our fundamental understanding of matter and forces. A prime physics goal of ATLAS is to understand the nature of mass.

http://atlasinfo.cern.ch/Atlas/Welcome.html

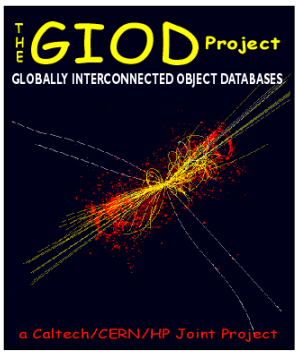
Compact Muon Solenoid (CMS)

CERN; Caltech, USA; Others.

Harvey Newman, Caltech and CERN, newman@hep.caltech.edu

The CMS detector is designed to cleanly detect the diverse signatures of new physics at the Large Hadron Collider (LHC). It will do so by identifying and precisely measuring muons, electrons and photons over a large energy range; by determining the signatures of quarks and gluons through the measurement of jets of charged and neutral particles (hadrons) with moderate precision; and by measuring missing transverse energy flow, which will enable the signatures of non-interacting new particles as well as neutrinos to be identified.

The Globally Interconnected Object Databases (GIOD) Project



Caltech, USA; CERN; Hewlett Packard; Others.

Harvey Newman, Caltech, newman@hep.caltech.edu

Particle physicists are engaged in large international projects to address a massive data challenge, with special emphasis on distributed data access. The data is overwhelming. Even though data from the CMS detector will be reduced by a factor >107, over a petabyte (1015 bytes) of data per year will accumulate for scientific analysis.

The task of finding rare events resulting from the decays of massive new particles in a dominating background is even more formidable. Particle physicists have been at the vanguard of data-handling technology, beginning in the 1940s with eye scanning of bubble-chamber photographs and emulsions, through decades of electronic data acquisition systems employing real-time pattern recognition, filtering and formatting, and continuing on to the petabyte archives generated by modern experiments. In the future, CMS and other experiments now being built to run at CERN's Large Hadron Collider expect to accumulate of order of 100 petabytes within the next decade.

The scientific goals and discovery potential of the experiments will only be realized if efficient worldwide access to the data is made possible. Particle physicists are thus engaged in large national and international projects that address this massive data challenge, with special emphasis on distributed data access. There is an acute awareness that the ability to analyze data has not kept up with its increased flow. The traditional approach of extracting data subsets across the Internet, storing them locally, and processing them with home-brewed tools has reached its limits. Something drastically different is required. Indeed, without new modes of data access and of remote collaboration we will not be able to effectively "mine" the intellectual resources represented in our distributed collaborations.

http://pcbunn.cithep.caltech.edu

MONARC (Models of Networked Analysis at Regional Centers) for LHC Experiments

CERN; Caltech, USA; Others.

Harvey Newman, Caltech, newman@hep.caltech.edu

LHC experiments have envisaged computing models (CM) involving hundreds of physicists doing analysis at institutions around the world. Regional Centers are intended to facilitate access to the data with more efficient and cost-effective data delivery to the groups in each world region, using high-speed national networks. This project intends to study network-distributed computing architectures, data access and data management systems that are major components of the CM, and the ways in which the components interact across networks.

http://www.cern.ch/MONARC/

Virtual Room Videoconferencing System (VRVS)

CERN; Caltech, USA; Others.

Harvey Newman, Caltech, newman@hep.caltech.edu

The VRVS was introduced in early 1997, to provide a low cost, bandwidth-efficient, extensible tool for videoconferencing and collaborative work over networks within the High Energy and Nuclear Physics (HENP) communities, and to some extent, research and education at large.

Since it went into production, deployment of the Web-based system has expanded to include 100s of registered hosts running VRVS software in more than 28 countries. There are now 19 "reflectors" that create the interconnections and manage the traffic flow, at HENP labs and universities in the US and Europe. Virtual Room videoconferencing is regularly employed as part of ATLAS and CMS, and increasingly for other DOE-supported programs. The system is managed by the Caltech L3/CMS group working in collaboration with the CERN IT Division, under a joint project approved by the LHC Computing Board (LCB) in July 1997. Future plans for the system include deployment of additional reflectors to Asia and the spawning of other sets of "Virtual Rooms" in Russia.

http://VRVS.cern.ch/

6.B. Israel IUCC

The Israeli Ministry of Science has identified 35 Israeli "Internet-2" projects that have an express need for high-bandwidth Internet-2 connections. All have US partners on Abilene or other NGI networks, unfortunately, the project summaries do not always explicitly name them. See [http://www.internet-2.org.il/startap/st6app.html].

TelePresence Microscopy (TPM)

Argonne National Laboratory, USA; Technion, Israel

Wayne D. Kaplan, Technion, kaplan@tx.technion.ac.il
Mike Lieberthal, Technion, mtmike@tx.technion.ac.il

TelePresence Microscopy (TPM) enables on-line cooperation between scientists, utilization of unique instrumentation by researchers who may not have access to such resources, and training of students of different levels. Video signals from the microscope (specimen view, detectors or peripheral instrumentation) are fed into a server, and can be directly accessed via a web browser capable of server push technology (such as Netscape).

Remote control is possible by sending instructions for magnification, movement of the specimen and focus using the web page interface. A control server sends this information into the microscope and the remote user can get instant feedback. Additionally, video conferencing allows for discussion between local and remote parties. The local user determine whether the microscope session is open or closed to the general public for viewing, and if the remote user may have remote control. Sharing of data is also possible on-line.

http://www.technion.ac.il/technion/materials/TPM/index.html

The Israel Space Agency - Middle East Interactive Data Archive (ISA-MEIDA)

NASA/GSFC, USA; Tel Aviv University, Israel

Pinhas Alpert, Tel Aviv University, pinhas@cyclone.tau.ac.il

ISA-MEIDA is an Earth observing data center available to the research community and general public through the Internet. It is one of nine international data centers, or nodes, participating in NASA's Earth Observing System Data Information System (EOSDIS).

NASA EOSDIS nodes outside of the US interconnect Canada, Japan, England, Russia and Europe to eight data centers within the US. By 2002, the EOSDIS global archives will contain more than 260 data products, occupying over 3 petabytes (1 petabyte = 10^9 megabytes).

ISA-MEIDA enables Israeli users to access Earth data from the US and other participating data centers. Similarly, international users have access to complementary datasets archived at the Israeli node. These datasets include detailed assessments and forecasts of atmospheric variables such as temperature, wind, humidity, clouds, dust, ozone, other aerosols and gases over the Middle East, as well as earth surface fields like land cover, soil moisture and vegetation. The full data from GEOS-1 and AVHRR is available through the ISA-MEIDA's connection to the global EOSDIS system. The Israel meteorological observations are the property of the Meteorological Service, which gave ISA-MEIDA permission to relay requests for this information.

http://www.nasa.proj.ac.il/

Israeli Mirror of the Los Alamos E-Print Server (ePrint arXiv)

Los Alamos National Laboratory, USA; Tel Aviv University, Israel

Marek Karliner, School of Physics and Astronomy, Tel Aviv University, marek@proton.tau.ac.il

Several theoretical problems in high-energy physics can only be solved using the most powerful computers available. One example is working out, in detail, the consequences of quarks – the force that holds together the most basic constituents of matter. Protons and neutrons are made out of quarks, and the basic theory describing their interactions is known as the Quantum Chromodynamics (QCD).

The most promising approach of solving QCD involves extremely large computer calculations, on the scale of many Terraflops over a period of a year or more. Such calculations produce very large amounts of intermediate data, which then need to be processed to obtain the final results, i.e., scientific visualization.

Research results in theoretical high-energy physics are nowadays disseminated mostly through a system of electronic distribution of articles (e-prints), based in the Los Alamos National Laboratory, and run by Paul Ginsparg.

The Los Alamos server was initially set up in 1991 for distribution of articles in theoretical high-energy physics, but has grown rapidly over the last few years to encompass all fields of physics and mathematics. An Israeli mirror has been set up to ensure access to the e-print archive, with technical support provided by the Tel Aviv University computer center staff and Los Alamos server staff, working together via the Internet. The mirror server uploads a large amount of new articles from the Los Alamos server daily, and maintains a large archive (several Gbytes) of articles from the past seven years.

http://xxx.tau.ac.il/

Collaborative Learning Over Broadband Internet: "Dialog Through Music"

Israel; Canada

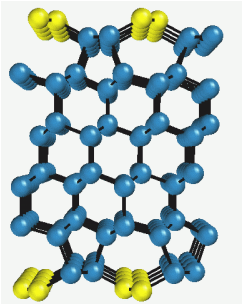
Martin Brooks, National Research Council of Canada, Canada, Martin.Brooks@nrc.ca
Peter Marshall, CANARIE Inc., Canada, marshall@canarie.ca

Maestro Pinchas Zukerman and the National Arts Center partnered with the National Research Council of Canada (NRC), Communications Research Centre Canada (CRC), CANARIE (Canada's Advanced Internet Development Organization) and the Canada-Israel Industrial Research and Development Foundation, in an exploratory application of tomorrow's Internet for international learning.

On October 4, 2000, while the National Arts Centre Orchestra was in the Middle East, Maestro Zukerman led "Dialog Through Music," where Israeli, Palestinian, and Canadian youth shared their emotional and creative responses to Beethoven's famous melody "Ode to Joy." Three groups of ten high school students connected by live video, with Israeli students and Maestro Zukerman in Tel Aviv, Palestinian students in Jerusalem, and Canadian students in Ottawa.

Maestro Zukerman's extensive experience with live video violin teaching, and the potential for the National Arts Center to use broadband learning technologies to build passion for the arts among all Canadians, makes this partnership between Arts and Sciences an exciting opportunity to explore our future.

Computer Alchemy Using Virtual Reality



Israel; Others

Joan Adler, Technion, Israel, phr76ja@phjoan.technion.ac.il
Wayne D. Kaplan, Technion, kaplan@tx.technion.ac.il

Computational Condensed Matter Physics and Material Science is a rapidly growing field, fueled in part by the advent of computer alchemy. As computers have become more powerful and algorithms more robust, this practical research tool models molecularly dynamic systems in virtual reality–notably, atomistic material simulations up to several million particles.

Especially suitable for discussing simulation results with experimental collaborators, visualization is also essential for teaching quantum mechanics and condensed matter physics, since most effects on the atomic scale cannot be demonstrated in the usual way.

Current work at Technion involves atomic-level modeling of diamond and aluminium/alumina interfaces. Computational physics and experimental research faculty are collaborating to produce the 3D computer visualization models. High-bandwidth networks are used to transfer the visualizations, and developing protocols for interactive conferencing and discussion.

http://phycomp.technion.ac.il/

Israel One – A Broadband High School Network

North Carolina School of Science and Mathematics, USA; Tel Hai College, Israel

Iris Raviv, Israel's Ministry of Education, Culture and Sports, irisraviv@hotmail.com
Hamutal Hameiri, North Carolina Israel Partnership, hamutalm@netvision.net.il
Itzhak Yuli, Tel Hai College, tzachy@telhay.co.il
Peggy Manring, North Carolina School of Science and Math, manringp@academic.ncssm.edu

Israel One is a high school educational network. It uses distance learning technology and videoconferencing to reach remote schools, especially in the periphery where English and math teachers are scarce. Sixteen schools are expected to participate, representing the cultural diversity of Israel.

This project serves as a testbed for current broadband technology and ATM protocol, and utilizes voice, audio and data. The project provides teacher training to assist students in the use of the broadband technologies, and adopts a student empowerment program. The multi-cultural model of the project encourages cooperation among schools of different geographical locations (Galilee, Negev), old Israelis and new immigrants, Arab, Druze and Jews; secular and religious; development towns, kibbutzim and moshavim.

The program builds upon the experience of the North Carolina Information Highway (NCIH) and the North Carolina School of Science and Mathematics (NCSSM). It is carried out in cooperation with the Israel Internet II program and industrial partners Bezeq (Telecom), Motorola Israel, Bynet, TNN and Accord. International corporate partners include VTEL, PictureTel and GTE.

ProtoMap–A Map of Protein Space: Interactive Web Site for Biological and Biomedical Investigations

Hebrew University, Jerusalem, Israel; Mirror sites: Stanford University, USA; Cornell University, USA

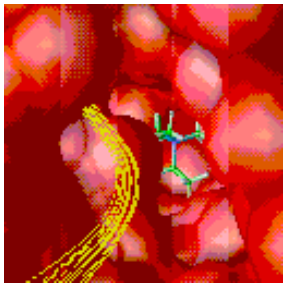
Michal Lineal, Hebrew University, Jerusalem, michal@keonardo.is.huji.ac.il
Nathan Lineal, Hebrew University, Jerusalem, nati@cs.huji.ac.il

This site classifies and groups all of the proteins in the Swiss-Prot and TrEMBL databases. Transitivity is used to identify homologous proteins, and within each group, every two members are either directly or transitively related. Transitivity is applied restrictively in order to prevent unrelated proteins from clustering together. The classification is done at different levels of confidence, and results in a hierarchical organization of all the proteins.

The resulting classification splits the protein space into well-defined groups of proteins, most of them closely correlated with natural biological families and superfamilies. The hierarchical organization may help to detect finer subfamilies that make up known families of proteins, as well as interesting relations between protein families.

http://www.protomap.cs.huji.ac.il/

Visualization of Acetylcholinesterase: Nature's Vacuum Cleaner



Cornell University, USA; Weizmann Institute of Science, Israel

Richard Gillilan, Cornell University, richard@tc.cornell.edu
Joel L. Sussman, Weizmann Institute of Science, Joel.Sussman@weizmann.ac.il
Israel Silman, Weizmann Institute of Science, Israel.Silman@weizmann.ac.il

Acetylcholinesterase (AcChoEase) is an enzyme that plays a key role in the human nervous system. In vertebrates, nerve impulses travel from cell to cell by means of chemical messenger. When an electrical impulse reaches the end of one cell, messenger molecules–acetylcholine (AcCho), in this case–are released to diffuse though the fluid-filled, intercellular, synaptic gap. Upon reaching the destination cell, AcCho molecules dock into special receptors triggering a new electrical impulse. Like a vacuum cleaner, the enzyme AcChoEase is constantly sweeping up and hydrolyzing AcCho during this process, so that the whole cycle can begin again.

Chemicals that inhibit the action of AcChoEase are being used in the treatment of glaucoma, myasthenia gravis and, experimentally, Alzheimer's disease. In spite of the ability to exploit the enzyme, its precise mechanism of operation is still a mystery.

The recent solution of the X-ray structure for AcChoEase, places the active catalytic site deep within a gorge-like fold of the protein. Electrostatic computations reveal the enzyme to be a single massive dipole. Such a configuration of charge suggests an electrostatic mechanism for directing the positively charged AcCho into the gorge and towards the active site.

Interactive Simulation in the Field of Plant Nutrition

Penn State University, USA; Tel Aviv University, Israel

Jonathan P. Lynch, Penn State University, JPL4@psu.edu
Amram Eshel, Tel Aviv University, amram@post.tau.ac.il

This US-Israel Bi-national Agricultural Research and Development (BARD) Foundation project involves hypotheses testing and result evaluation, using an interactive graphic model. *SimRoot*, a 3D model developed at Penn State, graphically describes the 3D deployment of plant root systems in soil. The model follows plant development and will predict the performance of plants under various environmental conditions, depending on their physiological characteristics.

Results are displayed graphically in 3D dynamic images that can be rotated by the viewer. This work was limited until now to users working at the console or on local-area networks. This application will require high-speed computer communication to allow real-time responses between Israel and the US. If successful, a whole new area of applications in cooperative ecological and physiological research and teaching will evolve.

Collection of SeaWiF Data for the Eastern Mediterranean and the Middle East Image

Goddard Space Flight Center, NASA, USA; Ben Gurion University, Israel

Gene Carl Feldman, NASA/GSFC, gene@seawifs.gsfc.nasa.gov
Arnon Karnieli, J. Blaustein Institute for Desert Research, Ben Gurion University, karnieli@spamergsfc.nasa.gov

SeaWiFS is a newly developed satellite, integrating advanced technology that acquires multi-channel data over land and sea. Daily SeaWiFS images over the Eastern Mediterranean and the Middle East are received at the J. Blaustein Institute in HRPT format (1.1 km resolution) using a PC-based receiving station. The volume of daily images will range from 30-130Mb, depending on the area of acquisition. These PCs receive raw HRPT-type data and convert it to level-0 to match the specifications of NASA documentation. Subsequently, each image is transferred from the receiving station to NASA/GSFC, to create a global image based on several HRPT stations across the globe.

http://seawifs.gsfc.nasa.gov/SEAWIFS.html

Large-Scale Atomistic Modeling of Semiconductors and Ceramics

University of Georgia, Athens, USA; Technion, Israel; Bar Ilan University, Israel

Joan Adler, Technion, Israel, phr76ja@phjoan.technion.ac.il
Dennis Rapaport, Bar-Ilan University, rapaport@mail.biu.ac.il
David Landau, University of Georgia, Athens, dlandau@uga.edu

The field of computational atomistic modeling is a research area of considerable importance and interest. In particular, the quantitatively accurate atomistic modeling of solids is a rapidly developing discipline with many practical applications. In this project we plan to use various kinds of molecular dynamics and Monte Carlo simulation techniques to explore a range of phenomena associated with semiconductors and ceramics.

The kinds of behavior that will be studied include the interfaces in mixtures of silicon, germanium and carbon, and

the processes responsible for generating defects and the subsequent graphitization of diamond; the complexity of these phenomena is such that a detailed atomistic modeling approach is essential. The simulations will be closely coordinated with ongoing experimental studies. Because of the heavy computational requirements and the detailed data analysis involved, the work entails the development of algorithms to support parallel processing together with specialized visualization techniques.

Video of Demand (VoD)

Israel; Internet2,USA.

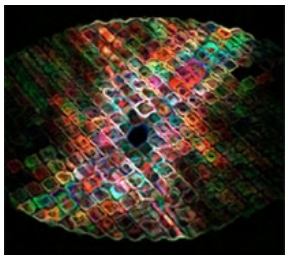
Hank Nussbacher, IUCC, hank@interall.co.il

VoD is a new technology that is enabled using advanced Internet capabilities. There are a select number of VoD servers located in Israel, Europe and the USA. This site documents all the various high-bit rate VoD servers located on advanced networks worldwide. A VoD system is one that allows a user to start the playback when he/she wishes, as well as pause, rewind and fast-forward that playback. High-bit rate is anything above 1Mb/sec. This site links to other worldwide VoD web sites, including: ViDe (Video Development Initiative), Digital Video for the next Millennium, Internet2's Digital Video Network and Internet2's Digital Video Initiative.

http://www.internet-2.org.il/vod.html

6.C. NORDUnet

GiDVN: Global Internet Digital Video Network



International Center for Advanced Internet Research (iCAIR), Northwestern, USA; Digital Video Working Group, Coordinating Committee for International Research Networks (DVWG,CCIRN), worldwide membership

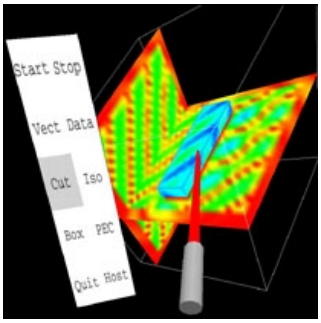
Joe Mambretti, iCAIR, Northwestern University, j-mambretti@nwu.edu

GiDVN projects are enhancing media capabilities for the next-generation Internet, enabling new applications to interoperate throughout the world.

Peter Marshall, CANARIE Inc., Canada
Olivier Martin, Paolo Moroni, Philippe Galvez, Joop Joosten, CERN
Kazunori Konishi, APAN, Japan
Shuichi Matsumoto, Masahiro Wada, Shigeyuki Sakazawa, Yasuhiro Takishima, Tetsusi Yamashita, KDD, Japan
Jaehwa Lee, Seungmo Choe, APAN-KR, Korea
Yung Yi, Yanghee Choi, Wang Lijing, Seoul National University, Korea
Sungkwan Youm, Korea University, Korea
Egon M. Verharen, SURFnet, The Netherlands
Cesar Olvera, DGSCA-UNAM, Mexico
Manjeet Singh, Francis Lee, SingAREN, Singapore
Artur Serra, Sebastia Sallent, Joan Borràs, Universitat Politecnica de Catalunya, Spain
Björn Pehrson, Daniel Forsgren, Royal Institute of Technology, Sweden
Joe Mambretti, Jim Chen, Jeremy Weinberger, Tim Ward, Northwestern University, USA

http://www.icair.org/inet2000, http://iumrs.ms.nwu.edu

Steering and Visualization of a Finite-Difference Code on a Computational Grid



University of Houston, USA; Royal Institute of Technology, Sweden

Lennart Johnsson, University of Houston, johnsson@cs.uh.edu
Erik Engquist, Royal Institute of Technology, erike@pdc.kth.se
Per Öster, Royal Institute of Technology, per@pdc.kth.se

This application enables computational steering of electromagnetic simulations across distributed resources using interactive visualization in a virtual-reality environment. To handle the large computational requirements of both simulation and visualization, the system is distributed across multiple machines using Globus.

http://www.pdc.kth.se/projects/GEMSviz

WITAS Multi-Modal Conversational Interface

University of Stanford, USA; Linköping University, Sweden

Oliver von Klopp Lemon, Stanford University, lemon@csli.stanford.edu
Erik Sandewall, Linköping University, erisa@ida.liu.se

The WITAS Unmanned Aerial Vehicle (UAV) under development at Sweden's Linköping University is an autonomous mobile helicopter with onboard AI, adjustable with respect to the operating environment and operator decisions. A team at Stanford University's Center for the Study of Language and Information (CSLI) is collaborating to build a multi-modal communication interface to this robot, capable of complex dialogues about the UAV's tasks and state, and about situations as they unfold on the ground.

The interface supports dialogues between the operator and the UAV using natural conversational language. The multi-modal aspects of the interface derive from the ability to combine speech, text, graphics, gestures, live video, and sensor data in the same communication. The interface is also designed to be "conversational," in the sense that the multi-modal dialog is planned and managed, and that different display and communication strategies are activated in different dialog and resource/time-bounded contexts. Currently, the team is using the Open Agent Architecture to manage communicating processes, Nuance for speech recognition, and Gemini for NL parsing.

http://www-csli.stanford.edu/semlab/witas.html, http://www.ida.liu.se/ext/witas/

Learn 2: A Network of Incubator Spaces for Developing & Designing Environments for Lifelong Learning

Stanford University, USA; University of Oslo, Norway; Royal Institute of Technology (KTH), Sweden; Uppsala University, Sweden; Roskilde University, Denmark

Gunnar Liestol, University of Oslo, gunnar.liestol@media.uio.no

The purpose of the LEARN2 project is to develop resources, procedures, conventions and production methods for high-bandwidth multimedia learning, and its related knowledge distribution on the Web. An optimal format for lifelong learning of cross-disciplinary topics (based in the humanities) will be established and deployed in a series of actual courses.

The project takes into account that further progress in the field of multimedia learning environments must consider the formal shaping–the rhetoric and design–of the medium, and appropriate additional and closely-related pedagogical strategies to achieve optimal exploitation of the continued technological improvements.

The three goals of the project are: (1) Establishing an optimal network of 'incubator sites,' or high-bandwidth multimedia learning environments, (2) Focus on the development and design of high capacity multimedia courses, conventions and genres for learning within these spaces, and (3) Conduct research and evaluation of the technological, rhetorical and pedagogical solutions employed.

http://www.media.uio.no/learn2

Global Observation Information Network (GOIN) Demonstration in Stockholm

NORDUnet, Norway; NASA NREN, USA; APAN, Asia

Peter Villemoes, NORDUnet, Peter.Villemoes@adm.nordu.net

The Global Observation Information Network (GOIN) is a USA/Japan effort to strengthen bilateral cooperation in Earth observation information networks, involving both satellite and in-situ data.

In 1999, NORDUnet cooperated with NASA/NREN and APAN to support live demonstrations of the GOIN in Stockholm during the Committee on Earth Observation Satellites (CEOS) Plenary, hosted by the European Meteorological Satellite (EUMETSAT) organization, with the support of the Swedish Space Corporation (SSC). CEOS [www.ceos.org] is the worldwide technical coordination body for all agencies that develop and operate satellites that observe the earth from space.

http://www.nnic.noaa.gov/GOIN/GOIN.html

Tromsø And COrnell Moving Agents (TACOMA)

University of Tromsø, Norway; Cornell University, USA; University of California, San Diego, USA

Dag Johansen, Faculty of Science, University of Tromsø, Norway, dag@cs.uit.no

The TACOMA project focuses on operating system support for agents, and how agents can be used to solve problems traditionally addressed by other distributed computing paradigms; e.g., the client/server model. A series of TACOMA distributed systems have been completed where agents can be moved about in the Internet.

An agent in TACOMA is a piece of code that can be installed and executed on a remote computer. Such an agent

may explicitly migrate to other hosts in the network during execution. We are currently focusing on fault-tolerance, security, applicability and management issues. The TACOMA platform has also been ported to new operating system architectures, in particular Windows NT, Windows CE and the PalmOS.

Several TACOMA applications are under construction. One example is a wide-area network weather monitoring system accessible over the Internet. This distributed application is StormCast. We are also investigating whether agents can be useful in extensible file system architectures.

http://www.tacoma.cs.uit.no/

Scalable High-performance Really Inexpensive Multi-Processor (SHRIMP)

University of Tromsø, Norway; Princeton University, USA

The SHRIMP project investigates how to construct high-performance servers with a network of commodity PCs and commodity operating systems. The cost of a multi-computer server is substantially less than a commercial, custom-designed multi-computer. The goal is to study how to build a system that delivers performance competitive with or better than the commercial multi-computer servers. Research consists of several components: user-level, protected communication, efficient message-passing, shared virtual memory, distributed file system, performance measurement, scalable 3D graphics, and applications.

Princeton's Computer Science department is building a parallel computer using PCs running Linux as the processing elements. The first was a simple two-processor prototype that used a dual-ported RAM on a custom EISA card interface. A recent prototype will scale to larger configurations, using a custom interface card to connect to a "hub" that is essentially the same mesh routing network used in the Intel Paragon [http://www.ssd.intel.com/paragon.html]. Considerable effort has gone into developing low overhead "virtual memory mapped communication" hardware and support software.

http://www.CS.Princeton.EDU/shrimp/

European Incoherent SCATter (EISCAT)

University of Tromsø (Norway); US institutions involved in Upper Atmosphere Facilities and KDI.

C.M. Hall, University of Tromsø, Norway, chris.hall@phys.uit.no

The EISCAT Scientific Association operates radars and receivers in several Nordic cities. Several Incoherent Scatter facilities are distributed about the world, such as Millstone Hill Observatory (MHO), in Westford, Massachusetts. EISCAT studies the interaction between the Sun and the Earth as revealed by disturbances in the magnetosphere and the ionized parts of the atmosphere (these interactions also give rise to the spectacular aurora, or Northern Lights).

The Incoherent Scatter Radar technique requires sophisticated technology and EISCAT engineers are constantly involved in upgrading the systems.

http://www.eiscat.uit.no/

Distributed Virtual Reality

Center for Parallel Computers (PDC), Royal Institute of Technology, Stockholm; NCSA/University of Illinois, USA; University of Illinois at Chicago, USA; University of Utah, USA; University of Houston, USA.

Johan Ihren, Parallel Computing Center, RIT, Stockholm, johani@pdc.kth.se

PDC's Cube is a fully immersive visualization environment that displays images on all surrounding surfaces, including the floor and the ceiling. Virtual environments can be used for everything from science to art, and from industrial simulations to education. Examples of projects at PDC in this area include EnVis, a tool for CFD (Computational Fluid Dynamics) visualization.

PDC has been involved in a number of activities:

- PDC participates in the Globus/GUSTO testbed [www.globus.org]. At SC'97, PDC contributed with a computational electromagnetic application running across a number of sites.
- At the NCSA/Alliance'98 conference, PDC participated in a global VR demonstration. Together with 4 US sites (University of Utah, University of Houston, University of Illinois at Chicago, and University of Illinois at Urbana/Champaign) a collaborative application designed by Caterpillar was demonstrated.
- PDC is an international affiliate partner to the US National Partnership for Advanced Computing Infrastructure (NPACI). The general areas for collaboration are grid computing, advanced scientific visualization, mass storage and computational chemistry.
- As an experienced IBM SP sites, PDC has agreed with University of Houston to take care of IBM SP related systems management and training at UH. This is partly an experiment in remote (transatlantic) systems work. The IBM SP with mass storage system at UH is working as a data cache within NPACI. An activity similar activity will take place at PDC.

PDC will participate in the following, future activities:

- PDC works as data cache for the Swedish Space Corporation. Data from satellite-based experiments are transferred to PDC from the down-link point and made globally accessible. An example is the ODIN experiment with researchers from Sweden, Finland, France and Canada accessing the data.
- Within NPACI, Mark Ellisman is leading a project on federating brain data. PDC is a partner in similar Swedish and European projects. Planning is underway on how to integrate results of these projects, a task that will put very high demands on the transatlantic link.
- Within the NPACI project, the Telescience ALPHA project would like to do some experiments with digital video between the Karolinska Institute, Stockholm, and UCSD, and possibly some other US sites. The use of IPv6 is high on the list of features for this application.
- Plans are being made for a global data analysis grid for the forthcoming experiments at the Large Hadron Collider at CERN. Full-scale experiments will start in 2005-2006, producing petabytes of data. Testbeds are planned to start in 2000-2001 and PDC plans to participate on behalf of the Swedish particle physicists. Coordination with the US HEP project is also planned. Testbeds will put high demand on the transatlantic links.

6.D. RENATER2

BABAR

DAPNIA/SPP, Saclay, France; Stanford Linear Accelerator Center (SLAC), USA; CERN.

Roy Aleksan, DAPNIA/SPP, Saclay, aleksan@hep.saclay.cea.fr, aleksan@dapnia.cea.fr, roy@slac.stanford.edu

The BaBar detector was built at SLAC to study the millions of B mesons produced by the PEP-II storage ring. The BaBar collaboration consists of around 600 physicists and engineers from 85 institutions in 9 countries.

http://www.slac.Stanford.edu/BFROOT, http://www-dapnia.cea.fr, http://www.SLAC.Stanford.edu

The DØ Experiment

Worldwide collaborations, including CERN, based at Fermilab, Illinois. French institutions include: DAPNIA/SPP, SACLAY; Centre de Physique des Particules de Marseille; Institut des Sciences Nucleaires de Grenoble; LPNHE, Universités Paris VI and VII; and Laboratoire de L'Accelerateur Lineaire

Armand Zylberstejn, azylber@fnald0.fnal.gov, azylber@hep.saclay.cea.fr

The DØ Experiment is a worldwide collaboration of scientists conducting research on the fundamental nature of matter. The experiment is located at the world's premier high-energy accelerator, the Tevatron Collider, at Fermilab.

Worldwide collaborations include Fermilab, Brookhaven National Lab; CERN; Cornell University; DESY, Germany; KEK, Japan; Lawrence Berkeley Lab and Stanford Linear Accelerator Center; several French institutions (DAPNIA/SPP, Centre de Physique des Particules de Marseille, Institut des Sciences Nucleaires de Grenoble, LPNHE, Universites Paris VI and VII, and Laboratoire de L'Accelerateur Lineaire.

http://www-d0.fnal.gov, http://www-dapnia.cea.fr

iMAGIS: Models, Algorithms, Geometry for Graphics and Image Synthesis

INRIA, France; MIT, USA.

Claude Puech, INRIA, Claude.Puech@inria.fr

This project develops new visualization techniques to enable the interactive manipulation of urban data. To achieve this goal, efficient image caching and interpolation techniques are combined with traditional 3D techniques. This is important for applications such as project review, civil and military simulators, virtual tourism, education, and climate/environmental studies.

http://www.inria.fr/Equipes/IMAGIS-fra.html, http://www.inria.fr/Unites/RHONE-fra.html, http://graphics.lcs.mit.edu/

Image/Video Transmission, Storage and Manipulation of 3D Images

LIMSI-CNRS, Orsay, France; Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign, USA.

3D interactive modeling, with real-time constraints, in a strongly reactive context, constitutes the main collaboration between these two laboratories.

http://www.renater.fr/International/STARTAP_Peerings/Projets/LIMSI_1.htm, http://www.LIMSI.fr

Network Computing

LIP, Ecole Normale Superieure de Lyon, France; Région Rhône-Alpes, France; INRIA, France; CNRS, France; Innovative Computing Laboratory, University of Tennessee, USA.

This research involves setting up metacluster computing with SCILab and NetSolve, organizing videoconferencing for project meetings, developing and testing a distributed web cache, and installing IBP. The LHPC project is a common laboratory for studying parallel computers; it was created by LIP and Matra Systèmes & Information. The first parallel computer of LHPC was installed in March 1995. This machine has evolved and is now made up of around 100 processors.

http://www.ens-lyon.fr/LIP/

Accélération de Particules par Ondes de Choc

Institut Astrophysique de Paris, France; North Carolina State University, USA.

Development of hydrodynamic models for the acceleration of particles in Supernovae remains.

http://www.IAP.fr

Catalogue des Étoiles au Beryllium

Institut Astrophysique de Paris, France; Limber Observatory, Texas, USA.

Catalogue of Beryllium stars.

http://www.IAP.fr

Détection des Étoiles Doubles par Haute Résolution Angulaire

Institut Astrophysique de Paris, France; Center for High Angular Resolution Astronomy, Georgia State University, USA.

Detection of binary stars.

Etude d'Amas de Galaxies en Ultraviolet

Institut Astrophysique de Paris, France; University of Alabama, USA.

Analysis of observations of galaxy clusters with the EUVE satellite.

http://www.IAP.fr

Etude de l'Amas ZWICKY 3146

Institut Astrophysique de Paris, France; CFA, Cambridge, Massachusetts, USA.

Studies of properties of clusters observed with X telescopes.

http://www.IAP.fr

Etude des Disques de Gaz

Institut Astrophysique de Paris, France; Yerkes Observatory, University of Chicago, USA.

Study of gaz disks around young planetary systems such as Beta Pictoris.

http://www.IAP.fr

Etude des Effets de la Poussière dans les Galaxies

Institut Astrophysique de Paris, France; Space Telescope Science Institute (STSCI), Maryland, USA.

Theoretical prediction of observations with new telescopes in the infrared.

http://www.IAP.fr

Etude Théorique et Expérimentale des Profils de Raies

Institut Astrophysique de Paris, France; University of Louisville, Kentucky, USA.

Theoretical computation of ray profiles and comparison with experimental spectra.

http://www.IAP.fr

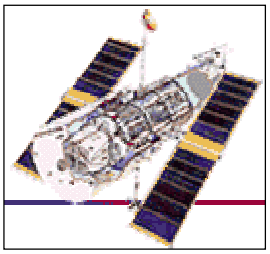
Fluctuations de Brillance de Surface

Institut Astrophysique de Paris, France; University of California at Berkeley, USA.

Theoretical predictions and observations of signal fluctuations in infrared imaging of galaxies.

http://www.IAP.fr

Hubble Space Telescope: Recherches de Raies d'Absorption



Institut Astrophysique de Paris, France; Space Telescope Science Institute (STSCI), Maryland, USA.

Search for absorption rays in spectra from the Hubble Space Telescope, in the framework of the "Absorption Line Systems in Quasars" program.

http://www.stsci.edu/

Large Scale Structure and Cluster Formation

Institut Astrophysique de Paris, France; CFA Cambridge, Massachussetts , USA; NASA, USA.

A long-term NASA project of combined analysis in optical, X-ray and radio.

Local Interstellar Cloud

Institut Astrophysique de Paris, France; LPL-WEST, Tucson, Arizona, USA.

The study of local interstellar clouds.

Modèles de Formation d'Etoiles avec Vent Galactique

Institut Astrophysique de Paris, France; University of Illinois at Urbana-Champaign, Dept. of Astronomy, USA.

Models for formation and evolution of galaxies with loss of mass. Consequences for the chemical evolution of elements D, He, O, Fe and others.

Nucléosynthèse du Big Bang dans le Modèle Cosmologique Standard

Institut Astrophysique de Paris, France; University of Minnesota Theoretical Physics Institute School of Physics and Astronomy, USA.

Development of a model for the primordial nucleosynthesis. Study of cosmologic parameters and comparison with observational constraints.

Origine et Evolution du Lithium, du Beryllium et du Bore dans la Galaxie

Institut Astrophysique de Paris, France; University of Chicago, USA.

The observation of Lithium, Beryllium and Bore elements in halo stars and the development of astrophysics models that detail the chemical evolution of these elements in the galaxy.

Photochimie des Enveloppes Circumstellaires

Institut Astrophysique de Paris, France; Physics Dept., New York University, USA.

Theoretical computation dealing with distribution of gaseous components of circumstellar shells.

FUSE (Far Ultraviolet Spectroscopic Explorer)

NASA, USA; The Johns Hopkins University, USA; The University of Colorado at Boulder, USA; The University of California at Berkeley, USA; Canadian Space Agency (CSA), Canada; French Space Agency (Centre National d'Etudes Spatiales, or CNES), France; Institut Astrophysique de Paris (IAP), France.

FUSE is a NASA-supported astronomy mission that was launched on June 24, 1999 to explore the universe using the technique of high-resolution spectroscopy in the far-ultraviolet spectral region.

http://www.iap.fr/ProgrammesCollaboration/Fuse/, http://fuse.pha.jhu.edu/

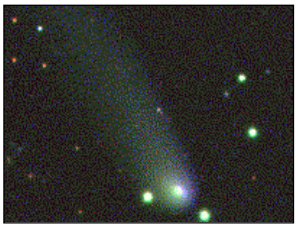
Serveur d'Éphémérides MPC/CBAT de l'U.A.I.

Institut Astrophysique de Paris, France; Smithsonian Astrophysical Observatory, Cambridge, Massachussetts, USA.

Using a server for computation of asteroids and comets ephemeredes.

http://cfa-www.harvard.edu/newtop/saohome.html

SLOAN Digital Sky Survey (SDSS)



Institut Astrophysique de Paris, France; Johns Hopkins University, Dept. of Astronomy, USA; CFHT Corp. (Hawaii); University of Hawaii Institute for Astronomy, Honolulu.

The SDSS enables the automatic, systematic study and exchange of data of stars, galaxies, nebula, and large-scale structure.

http://www.sdss.org/sdss.html

Surveys Radio

Institut Astrophysique de Paris, France; National Radio Astronomy Organization (NRAO), Virginia , USA.

Properties of deep radio surveys.

TERAPIX (Traitement Elementaire Reduction et Analyse des PIXels)

Institut Astrophysique de Paris, France; C.F.H.T. Corp., Kamelua, Hawaii, USA; University of Hawaii Institute for Astronomy, Honolulu, USA.

Data analysis of images form MEGAGAMMA/PRIME. TERAPIX is an astronomical data processing center at the Institut d' Astrophysique de Paris dedicated to very large CCD images and massive data flow provided by the MEGACAM camera. TERAPIX organizes the MEGACAM image processing and provides images and catalogues to the Canada-France-Hawaii-Telescope (CFHT) users community.

http://terapix.iap.fr

CASSINI-HUYGENS Cluster 2 WBD

CETP (IPSL,Vélizy), France; Dept. of Physics and Astronomy, University of Iowa, USA.

Transfer and real-time visualization of data from the Radio and Plasma Wave Science on board the spacecraft.

http://despa.obspm.fr/plasma/cluster/cluster.html, http://despa.obspm.fr/

CASSINI-HUYGENS Cluster 2 WEC

CETP (IPSL, Vélizy), France; University of California at Berkeley Space Science Lab, USA; Dept. of Physics and Astronomy, University of Iowa, USA.

Technical coordination of the WEC consortium of the CLUSTER-2 project.

http://despa.obspm.fr/plasma/cluster/cluster.html, http://despa.obspm.fr/, http://www.CETP.IPSL.fr

GALILEO

CETP (IPSL, Vélizy), France; Dept. of Physics and Astronomy, University of Iowa, USA.

Study of the environment of Jupiter.

http://www.CETP.IPSL.fr

GALILEO / NIMS

DESPA (Observatoire de Paris Meudon), France; NASA Jet Propulsion Laboratory, USA.

Infrared spectro-imagery of Jupiter with the GALILEO spacecraft.

http://despa.obspm.fr, http://www.jpl.nasa.gov/

CASSINI-HUYGENS DISR

DESPA (Observatoire de Paris Meudon), France; University of Arizona Lunar Planetary Lab, USA.

Analysis of cloud particles from TITAN: Electronic maps set up at DESPA

http://despa.obspm.fr/planeto/disr.html, http://www.jpl.nasa.gov/cassini/, http://despa.obspm.fr/planeto/cassini.html

High Energy Solar Spectroscopic Imager (HESSI)

DESPA (Observatoire de Paris Meudon), France; University of California at Berkeley/Space Science Laboratory, USA

Robert Lin, University of California, Berkeley, boblin@ssl.berkeley.edu
Nicole Vilmer, Observatoire de Paris-Meudon, vilmer@obspm.fr

The HESSI mission consists of a single spin-stabilized spacecraft in a low-altitude orbit inclined 38 degrees to the Earth's equator. The only instrument on board is an imaging spectrometer with the ability to obtain high fidelity color movies of solar flares in X rays and gamma rays. It uses two new complementary technologies: fine grids to modulate the solar radiation, and germanium detectors to measure the energy of each photon very precisely.

http://hesperia.gsfc.nasa.gov/hessi/, http://www.obspm.fr

IRON

DESPA (Observatoire de Paris Meudon), France; Dept. of Astronomy, Ohio State University, USA.

Computation of collision and radiative atomic data for astrophysics

http://www.obspm.fr

VIMS

DESPA (Observatoire de Paris Meudon), France; Lunar and Planetary Laboratory, Dept. of Planetary Science and Astronomy, University of Arizona, USA.

Infrared spectro imagery on the Cassini spacecraft: observations of Jupiter, Saturn, Titan between 2000 and 2006; transmission of camera images.

http://www.obspm.fr

ASTRAIA

CETP (IPSL, Vélizy), France; NCAR, USA.

Doppler meteorological airborne radar with two beams.

http://www.CETP.IPSL.fr

Capteur Spatial SEAWIFS: Ameliorations

Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA Saclay, France; Rosenstiel School of Marine and Atmospheric Science (RSMAS), University of Miami, USA.

Enhance atmospheric corrections for the space measurement system SEAWIFS for sea color.

CLIMSERV-CDC

(Note: il ne s'agit pas d'un projet, mais d'une activité de service effectuée par l'IPSL)

LMD (IPSL, Ecole Polytechnqiue-Palaiseau), France; Climate Diagnostic Center (CIRES), U of Colorado, USA

Data transfers from the NOAA Climate Diagnostic Center database to the French database CLIMSERV.

http://perceval.polytechnique.fr, http://www.lmd.jussieu.fr

CLIMSERV-EOSDIS / LARC

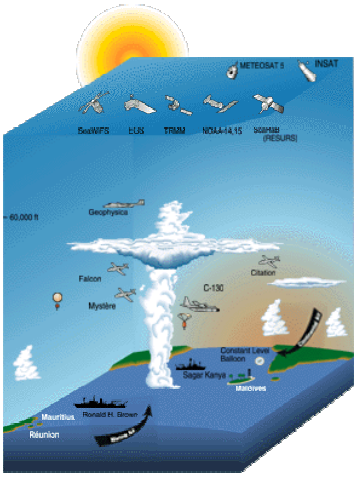
(Note: il ne s'agit pas d'un projet, mais d'une activité de service effectuée par l'IPSL)

LMD (IPSL, Ecole Polytechnqiue-Palaiseau), France; EOSDIS/LARC, NASA Langley Atmospheric Sciences Data Center, Virginia, USA.

Data transfers from the EOSDIS database to the French database CLIMSERV.

http://perceval.polytechnique.fr, http://www.lmd.jussieu.fr

International Field Experiment in the Indian Ocean (INDOEX)



LMD (IPSL, Ecole Polytechnqiue-Palaiseau), France; Center for Clouds, Chemistry and Climate, Scripps Institute for Oceanography, University of California, San Diego, USA

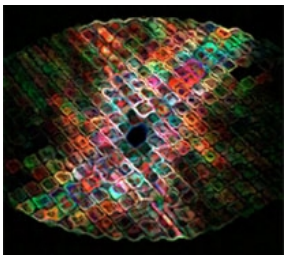
V. Ramanathan, Scripps Institution of Oceanography of the University of California, San Diego, vramanathan@ucsd.edu

INDOEX addresses questions of climate change that are of high priority and great value to the US and the international community. The project's goal is to study natural and anthropogenic climate forcing by aerosols and feedbacks on regional and global climate.

http://www-indoex.ucsd.edu/, http://www.lmd.ens.fr/INDOEX/

6.E. SURFnet

GiDVN: Global Internet Digital Video Network



International Center for Advanced Internet Research (iCAIR), Northwestern, USA; Digital Video Working Group, Coordinating Committee for International Research Networks (DVWG,CCIRN), worldwide membership

Joe Mambretti, iCAIR, Northwestern University, j-mambretti@nwu.edu

GiDVN projects are enhancing media capabilities for the next-generation Internet, enabling new applications to interoperate throughout the world.

Peter Marshall, CANARIE Inc., Canada
Olivier Martin, Paolo Moroni, Philippe Galvez, Joop Joosten, CERN
Kazunori Konishi, APAN, Japan
Shuichi Matsumoto, Masahiro Wada, Shigeyuki Sakazawa, Yasuhiro Takishima, Tetsusi Yamashita, KDD, Japan
Jaehwa Lee, Seungmo Choe, APAN-KR, Korea
Yung Yi, Yanghee Choi, Wang Lijing, Seoul National University, Korea
Sungkwan Youm, Korea University, Korea
Egon M. Verharen, SURFnet, The Netherlands
Cesar Olvera, DGSCA-UNAM, Mexico
Manjeet Singh, Francis Lee, SingAREN, Singapore
Artur Serra, Sebastia Sallent, Joan Borràs, Universitat Politecnica de Catalunya, Spain
Björn Pehrson, Daniel Forsgren, Royal Institute of Technology, Sweden
Joe Mambretti, Jim Chen, Jeremy Weinberger, Tim Ward, Northwestern University, USA

http://www.icair.org/inet2000, http://iumrs.ms.nwu.edu

Application-Level Network Performance Analysis Tools

Stichting Academisch Rekencentrum Amsterdam (SARA), The Netherlands; University of Illinois at Chicago, USA.

Jason Leigh, University of Illinois at Chicago, USA spiff@uic.edu
Ed Breeveld, SARA, The Netherlands, edward@sara.nl

The UIC Electronic Visualization Laboratory and SARA collaborate on a number of network performance projects. Specifically, in fulfillment of the goals of the Euro-Link project, the two sites have been working various networking QoS schemes to improve transmission rates, notably TCP, UDP, FEC and RUDP. (See Sections 2.A.5 and 2.B.3.)

ALIVE: Architectural Linked Immersive Environment

Stichting Academisch Rekencentrum Amsterdam (SARA), The Netherlands; University of Illinois at Chicago, USA.

Jason Leigh, University of Illinois at Chicago, USA spiff@uic.edu
Ed Breeveld, SARA, The Netherlands, edward@sara.nl
Frans Blok, Office of Metropolitan Architecture, Rotterdam, The Netherlands

ALIVE is used to evaluate the usability of collaborative virtual reality for architectural design.

The ALIVE project started February 1999 at SARA in cooperation with EVL and the Office for Metropolitan Architecture. In February 1998, architect Rem Koolhaas won the Richard H. Driehaus Foundation International Design Competition for the new Campus Center at Illinois Institute of Technology's historic Mies van der Rohe campus. A walkthrough of the plan has been modeled for the CAVE®.

http://www.sara.nl, http://www.archfonds.nl

The MegaConference

Hosted at Ohio State University. Augmented by other organizations as needed. SURFnet is one provider of MCU capacity, and broadcasts The Megaconference via RealVideo and MPEG1

Malik Amer Khan, OARnet, mkhan@oar.net
Bob Dixon, Ohio State University, Bob_Dixon@osu.edu

The Megaconference is a permanent, ongoing multipoint H.323 Internet videoconference. It is free and open to anyone with adequate equipment to provide good quality Internet video at the speed of 384 Kbps. SURFnet has participated in H.323 videoconferences/demos between Ohio State University, University of South Carolina, NYSERnet, Buffalo University, Rochester University and Syracuse University.

http://www.mega-net.net/megaconference

6TAP

The Netherlands; CANARIE (Canada); ESnet (USA).

The 6TAP project provides native and tunneled IPv6 interconnections at STAR TAP to early IPv6 production networks to enable them to build and demonstrate IPv6-based applications. 6TAP will develop: IPv6 route server technology, network tools for network measurement, analysis and display, and experience in supporting, provisioning and operating IPv6 Internet exchange points.

6TAP is co-sponsored by ESnet and CANARIE, with participation from vBNS, Abilene/Internet2, SURFnet, APAN, CERN, SingAREN, four US national labs (ANL, LBNL, ORNL, SLAC), U. Wisconsin, UCSD and Sun Microsystems.

http://www.6tap.net