Cover Page

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

Euro-Link℠

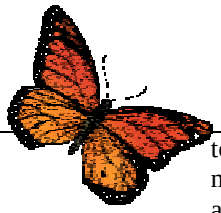
http://www.euro-link.org

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 and Program Plan

For the period April 1, 2000–March 31, 2001

Submitted April 1, 2000



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The butterfly represents CERN's MONARC (Models of Networked Analysis at Regional Centers) project accessing and analyzing Large Hadron Collider experiment data. See Section I.1.

Euro-Link Annual Report and Program Plan
Certification Statement

I certify that to the best of my knowledge, (1) the statements herein are true and complete, and (2) text in this report as well as in any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or individuals working under their supervision. I understand that the willful provision of false information or concealing a material fact in this report or any other communication submitted to NSF is a criminal offense (U.S. Code, Title 18, Section 1011).

Thomas A. DeFanti, Principal Investigator — Date
University of Illinois at Chicago

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A. Executive Summary

Euro-Link's successful first year can be directly attributed to the strong and enthusiastic support of its NRN leadership. Initially comprised of four charter National Research Networks (NRNs): the Nordic countries, The Netherlands, France and Israel (CERN joined mid-year as the fifth member), Euro-Link's *modus operandi* is to promote global applications and collaborations by connecting to STAR TAP.

This report documents the connectivity of each NRN. It also describes in detail the engineering support, network technologies and services that the staff and members of Euro-Link and STAR TAP, in concert with HPIIS counterparts TransPAC and MIRnet, are facilitating to establish a permanent global computing and communications infrastructure.

While the physical links constantly change due to ongoing reductions in bandwidth costs, the logical "links" of people-to-people and people-to-machines is ever growing interdependently. NSF HPIIS Euro-Link funding is encouraging connectivity sooner, rather than later, and stimulating network-dependent research collaborators to develop an international testbed that delivers both quantity and quality of service.

One major outcome of Euro-Link funding, as evidenced by this Annual Report and Program Plan, is the evolving synergistic relationship among its participants. As a team, we are working to optimize physical connectivity, while encouraging and developing a persistent, interdependent human infrastructure.

B. Introduction

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 (or 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 previously applied for and received NSF approval to connect to STAR TAP. As part of their individual proposals, they agreed to satisfy NSF's requirements to identify universities with meritorious applications. They also agreed to implement their own high-performance-versus-commodity traffic segregation. 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, UIC worked with four *charter NRNs*, NORDUnet (Nordic countries: Denmark, Finland, Iceland, Norway and Sweden), SURFnet (The Netherlands), RENATER2 (France), and Israel's Inter University Computation Center (IUCC). In the past year, CERN received NSF permission to connect to STAR TAP and to join the Euro-Link consortium.

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 ~45 Mbps network (those with East Coast PoPs are upgrading to 155 Mbps; Israel's satellite connection is 37 Mbps), an aggregate bandwidth of hundreds of Mbps.

[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. 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 recently extended through March 2003 with award # ANI-9980480. STAR TAP, a Next Generation Internet Exchange Point (NGIX), is managed by the University of Illinois at Chicago and operated by Ameritech Advanced Data Systems. International networking connections range from about 10-90 Mbps, with 155 Mbps connections on the way, all dedicated to high-performance collaborations. Research networks that currently peer at STAR TAP are: CA*net 2/3 (Canada), CERN, IUCC (Israel's Inter-University Computation Center), MIRnet (Russia), NORDUnet (Nordic countries: Sweden, Denmark, Norway, Iceland and Finland), SURFnet (The Netherlands), RENATER2 (France), SingAREN (Singapore), APAN (Asia-Pacific: Japan, Korea, Australia, Singapore (second connection) and Thailand), and TANet2 (Taiwan). Also connected are all of the USA's Next Generation Internet backbones – NSF's vBNS, NASA'S NREN and NISN, the Department of Defense's DREN and Department of Energy's ESnet – as well as Abilene, the Internet2 initiative of the University Corporation for Advanced Internet Development (UCAID).

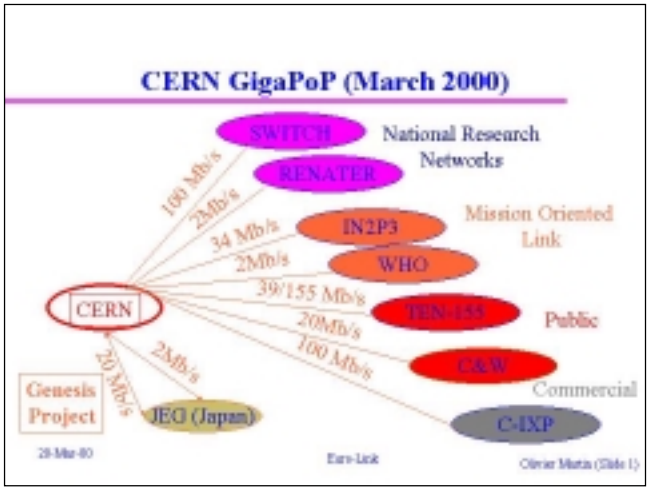
C. Euro-Link Organization and Management

C.1. NRN Members and Services

C.1.a. CERN

The European Laboratory for Particle Physics (CERN) [http://www.cern.ch], located 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 27 km tunnel, the largest machine of this type in the world; experiments are carried out by teams of several hundred physicists from more than 50 institutes spread over 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 superconducting magnets and will be installed in the existing LEP tunnel. All existing and future CERN experiments produce large amounts of data. For example, the LEP experiments generate 25 terabytes of data each year, which are stored on magnetic tape cartridges, whereas the LHC experiments are expected to produce several-orders-of-magnitude more data. 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 connects:



- The National Institute of Nuclear and Particle Physics (IN2P3) [http://www.in2p3.fr], a CNRS (French National Center for Scientific Research) institute whose mission is to promote and federate research activities of its member laboratories in the field of nuclear and particle physics.
- The World Health Organization (WHO) [http://www.who.int], which is heavily involved in research activities related to all health issues, including cancer, cardiovascular diseases, diabetes, environmental health, HIV/AIDS, human reproduction, immunology, malaria control, mental health, tropical diseases, tuberculosis, etc. WHO works with many top research institutions worldwide, officially designated as "WHO Collaborating Centers." In the US, WHO has 200 Collaborating Centers, many of which are major medical and public health research centers and universities, including the National Institute of Health, the Centers for Disease Control and Prevention, centers of the Environmental Protection Agency and Food and Drug Administration agencies. In addition, WHO has its own research arms that are directly involved in specific fields of research, such as the International Agency for Research on Cancer (IARC) and the WHO Center in Kobe, Japan (WCK) for Health Development, Aging and Urbanization Research.

C.1.b. Israel IUCC

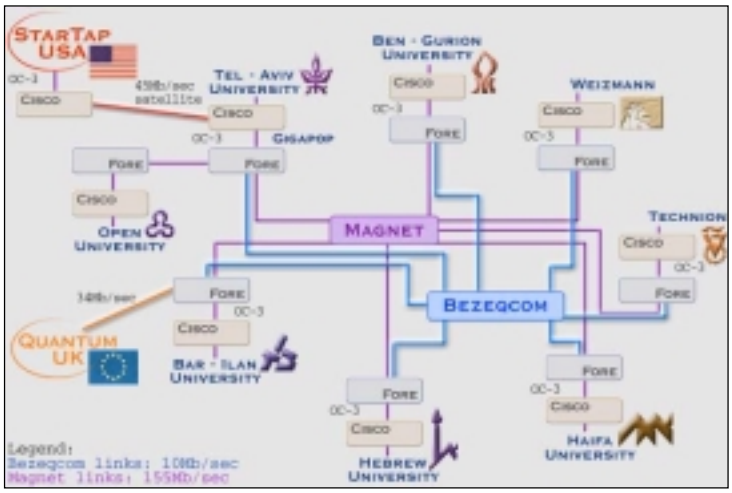
Israel's Inter University Computation Center (IUCC) [http://www.internet-2.org.il] coordinates and acts as an advocate for the computing needs of Israel's research and academic infrastructure.

The IUCC is completely funded by Israel's 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)

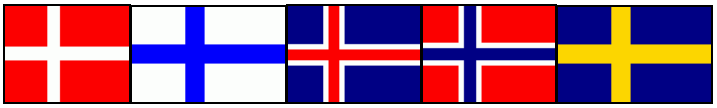
Israel's current national infrastructure is based on a dual ATM network. The primary network is an ATM OC-3 network running PNNI, which interconnects all eight Israeli universities. As a backup network, all universities are also connected to a slower, different ATM network at 10Mbps (UBR) [http://www.internet-2.org.il/ilanmap.html]. As an additional backup network, there is a Frame Relay 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 2 Mbps FR access trunks as backup.



Internally, all the on-campus networks are either ATM based and/or Fast Ethernet based.

The IUCC network operates two supercomputers, an IBM SP-2/64 and a Cray J932/32. Both are located at Tel Aviv University and researchers access them remotely via the Internet. In addition, IUCC purchased a 64-node SGI Origin machine.

C.1.c. NORDUnet



NORDUnet [www.nordu.net], the Nordic country (Denmark, Finland, Iceland, Norway, and Sweden) national networks for research and education, cover all institutions for higher education and publicly funded research in the Nordic countries. The national and international bandwidths are in the 155 Mbps 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.

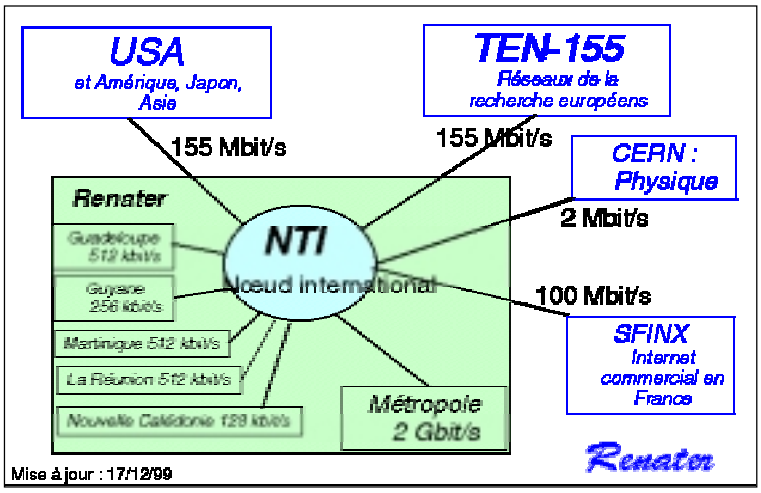
The universities and research institutions approved are:

- 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)

C.1.d. 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). RENATER 2, the national backbone of GIP RENATER, is used by all advanced scientific laboratories

and higher education entities. RENATER2 is a nation-wide infrastructure connecting campus, metropolitan, and regional networks with IP and (optionally) ATM services as well as international linkages within Europe and to the STAR TAP in Chicago.



RENATER2 has a star topology, with 2.5 Gbps, 155 Mbps or 34 Mbps links between its central switching node and the regional PoPs. The central node has a throughput capacity of more than 5 Gbps. Thanks to a recent RENATER2 upgrade, there are four major improvements for users:

- A bandwidth increase ratio of 5 for the national backbone
- QoS, native ATM service, and PVCs as well as best-effort IP service
- CoS IP service
- Nationwide VPN offer

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:

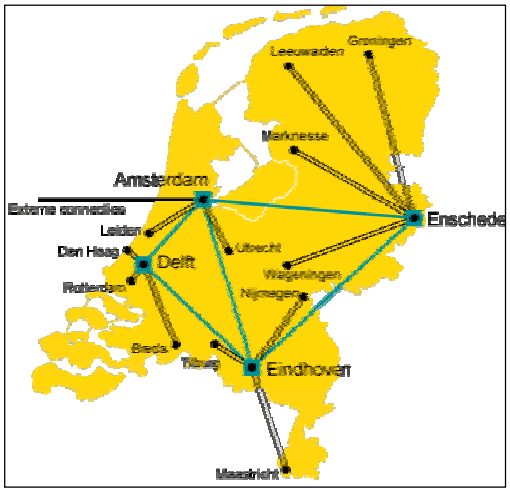
- CDS (Strasbourg : astronomy)
- Centre de Sequencage (Evry)
- CETP (Versailles-Vélizy: CNRS: environmental science)
- CRISMAT (Caen)
- DAPNIA (Commissariat à l'Energie Atomique, Saclay: high energy physics)
- ENSL (Ecole Normale Supérieure de Lyon: high performance computing)
- IAP (Institut d'Astrophysique 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)

Researchers at the above institutions not only need STAR TAP access for collaboration with peers in the US, but for various collaborations outside the US:

- *Singapore* — An agreement between CNRS and National University of Singapore
- *Canada and US* — Canada-France-Hawaii Telescope (CFHT)
- *Japan* — Agreements between CNRS and the Japan Society for the Promotion of Science, Monbusho, Agency of Industrial Science and Technology

C.1.e. 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.



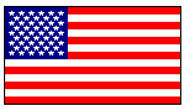
SURFnet institutions using the STAR TAP link for advanced research networking include:

- 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 will soon be upgraded from 45 Mbps to 155 Mbps. Supported activities include:

- IPv6
- IP Multicast
- Classes of Service
- Audio and video broadcast streaming servers
- Video-on-demand servers

C.2. US Partners and Collaborations



In addition to the NRNs, Euro-Link brings together a diverse group of US institutions and people to focus on transatlantic collaborations over high-performance networks. The lead institution is the University of Illinois at Chicago (UIC), which provides overall intellectual, reporting, and financial supervision, and applications-oriented performance monitoring. Indiana University houses and staffs the NOC services. Ameritech operates the STAR TAP/Euro-Link Network Access Point (NAP). MREN and Argonne National Laboratory provide resources on an informal basis through long-term relationships with the people involved in this initiative. The NSF "HPIIS Team," comprised of UIC (Euro-Link), Indiana University (TransPAC) and University of Tennessee (MIRnet), collaborate on issues of mutual interest. These institutions all see great value in developing high-bandwidth global networking.

C.2.a. UIC Electronic Visualization Laboratory

The UIC Electronic Visualization Laboratory (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.

C.2.b. Ameritech Advanced Data Services (AADS) NAP

The AADS [www.aads.net] NAP is an Internet Exchange Point where ISPs can meet to exchange traffic with other attached ISPs. The NAP is a layer 2 switched service that is not directly involved with routing IP datagrams; only forwarding Asynchronous Transfer Mode (ATM) cells between ISPs. The NAP is a layer 2 service because it will not restrict inter-networking protocol or routing policy selection. The fabric of the Chicago NAP is an ATM switch providing both high speed and a high degree of scalability. There are currently 99 customers connected to the NAP. Interface speeds currently supported include: DS-1, DS-3, OC-3c (155 Mbps), and OC-12c (622 Mbps).

C.2.c. 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.

C.2.d. 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 on the vBNS and Abilene. Indiana also provides NOC services for Abilene, TransPAC, Euro-Link, and, starting in April 2000, STAR TAP.

C.2.e. MREN

The Metropolitan Research and Education Network (MREN) [www.mren.org] is a 155Mbps regional network connecting Chicago-area research institutions managed by Ameritech and is a model for "GigaPoPs," or other regional networks. It came into being as part of the SC'95 I-WAY experiment and a desire for the University of Chicago, Argonne National Laboratory, University of Illinois at Chicago, Fermi National Accelerator Laboratory, Northwestern University, NCSA, and Ameritech to create a regional high-bandwidth ATM network. MREN now connects MERIT, University of Michigan, Michigan State University, University of Minnesota, University of Illinois at Champaign-Urbana, University of Wisconsin at Madison and at Milwaukee, Notre Dame, Purdue University, Iowa State University, and University of Iowa. The Department of Energy's ESnet, DARPA's DREN and CAIRN networks, and NASA's NREN and NISN networks connect with MREN and vBNS authorized institutions. Since its inception, MREN has supported a wide range of advanced networking projects and applications. MREN's technical committee undertakes projects focused on network operations and advanced technologies. MREN is scheduled for an upgrade to 622Mbps.

C.2.f. iCAIR, Northwestern University

The International Center for Advanced Internet Research (iCAIR) at Northwestern University [http://www.icair.org] was formed in 1999 by Joe Mambretti, who is also the director of MREN. iCAIR has an Emerging Technologies and Testbed Laboratory (for digital video traffic modeling and measurement, IP-over-SONET, and ATM/IP network performance measurement), an Advanced Internet Services Facility (based on an IBM SP supercomputer), and a networking R&D facility based on another SP supercomputer. The campus has two other SP computers (a fifth will soon be ordered). The iCAIR supercomputers are housed within 7x24 environmentally controlled machine rooms, operated by professional systems staff. The campus has fiber connections to approximately 150 buildings on Northwestern's Chicago and Evanston campuses. The campus backbone is based on an OC-12 ring. An inter-campus' Wide Area Network OC-12 SONET ring connects the Chicago and Evanston campuses. This new network infrastructure supports not only the campus production network, but network research as well. Researchers have access to a collection of network and computing resources, such as software tools and servers, OC-12 connections, high-speed ATM and IP switch network, HP OpenView for traffic monitoring, digital video/audio servers, voice over IP gateways, and routers and switches from Cisco, IBM, Lucent and others.

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.

C.2.g. HPIIS Team

EuroLink relies on the respected capabilities of the NSF HPIIS Team, comprised of:

- UIC/Euro-Link
- Indiana University/TransPAC and NOC teams
- University of Tennessee at Knoxville/MIRnet
- AADS, which operates the switching center

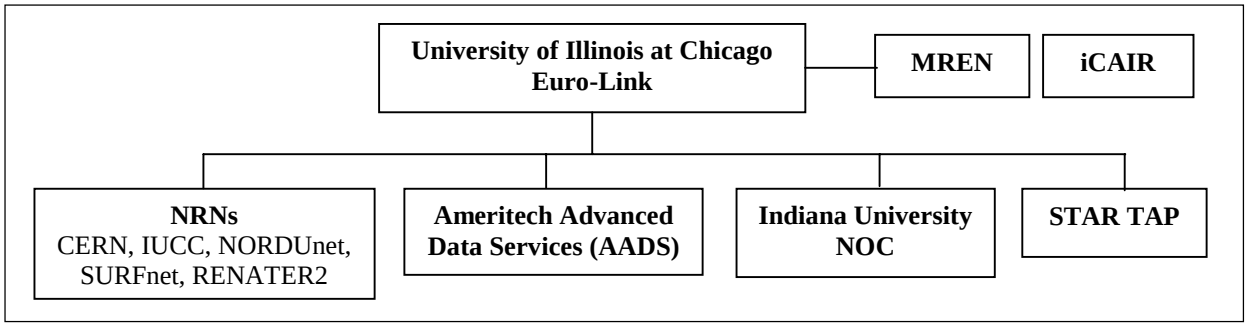
- STAR TAP team
- MREN

HPIIS awardees help each other by sharing experiences. We have a group email alias <hpiis-team@startap.net>. 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; documentation from the meeting is posted on the STAR TAP web site [http://www.startap.net/ABOUT/MEETINGS.html].

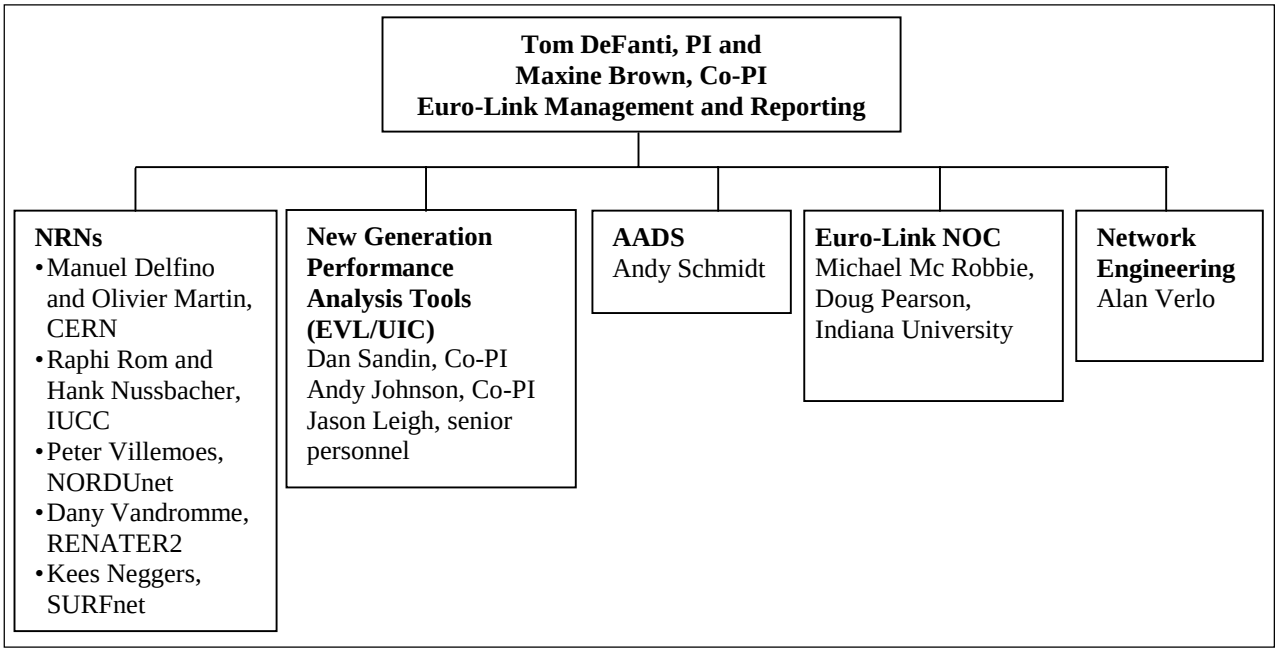
C.3. Management

UIC has primary responsibility for ensuring the quality, timeliness and effective management and delivery of services provided under the Euro-Link Cooperative Agreement.

Relationships of Organizations involved in Euro-Link



Euro-Link Management Reporting Structure



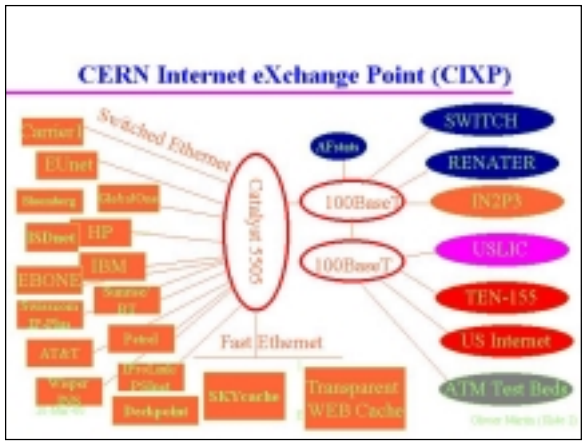
D. Annual Report

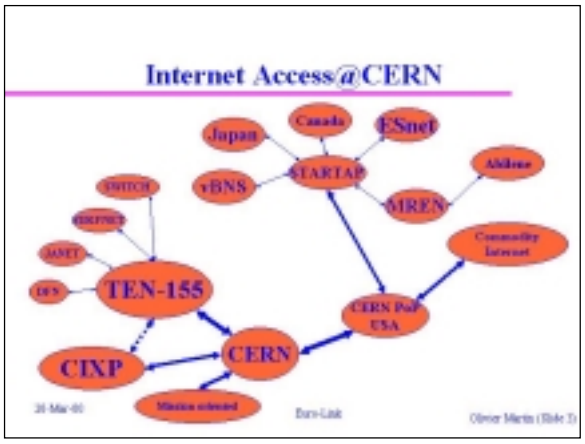
D.1. STAR TAP Connectivity and Peering

D.1.a. CERN

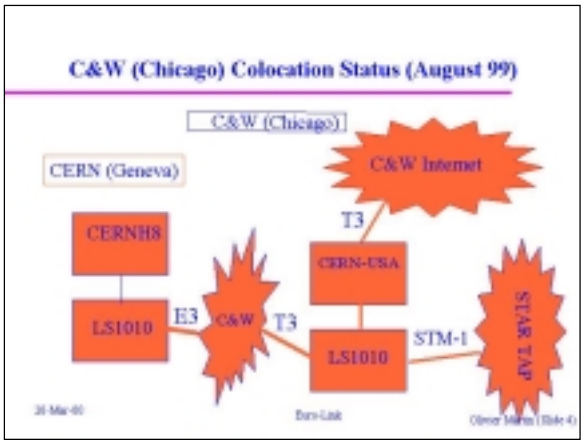
CERN provides its research community with an uncongested "bearer" service that provides reasonable assurance there will be adequate bandwidth for advanced networked applications. In accordance with vBNS objectives, this link will progress from a "best-effort" service to a differentiated communications service, as technology improves.

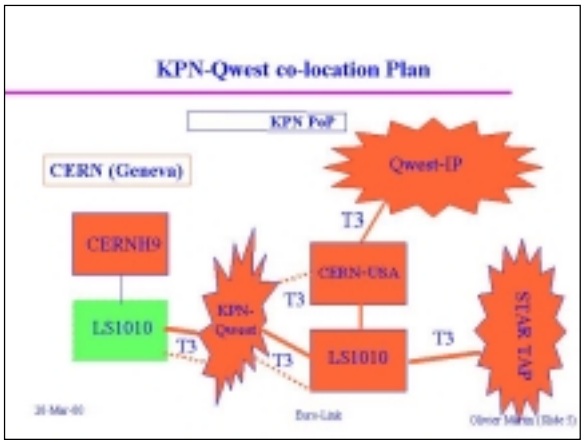
CERN operates the CIXP (CERN Internet eXchange Point) GigaPoP for its academic and research partners, which connects to the vBNS via STAR TAP. Some members link to the GigaPoP at OC-3 speed from their ATM production networks. Smaller members who don't have an ATM network link up at a minimum of E1.





In August 1999, CERN connected to STAR TAP via an STM-1 connection from a Cable & Wireless (C&W) PoP in Chicago, where the 20 Mbps transatlantic ATM VP to CERN terminates. Following a call for tender won by KPNQwest, CERN will upgrade the transatlantic circuit to 45 Mbps (T3) on April 1, 2000, then 155 Mbps (OC-3c) on October 1, 2000. In addition, CERN has been given the option to split the SDH-protected circuit into two independent circuits, at small incremental cost, which will provide new possibilities in terms of physical interconnection to STAR TAP and US research networks.





The new transatlantic service is based on native SDH circuits, and CERN has not yet decided whether to continue using ATM on top of it, which would provide excellent ways to guarantee bandwidth through STAR TAP and to allow native IPv6 connection to the 6TAP router. For simplicity, CERN will probably start with a native T3 connection between the CERN routers in Chicago and Geneva.

Support for the use of advanced networking protocols and services like RSVP and MPLS can be expected progressively as technology transfer takes place. In addition, there will be other advanced services that commercial

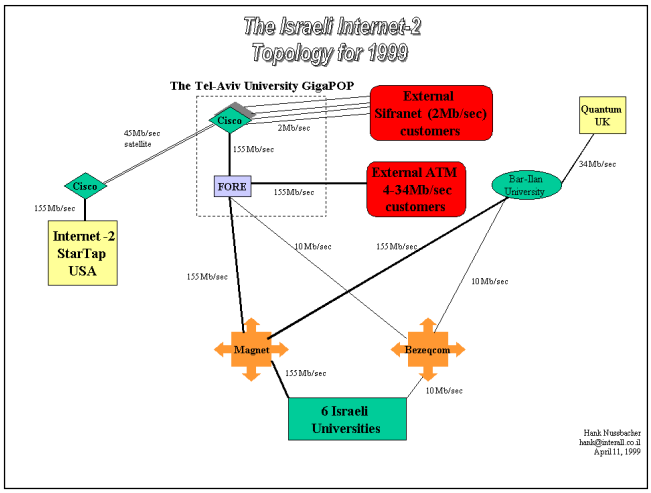
ISPs may not be able provide, including:

- Hierarchical web proxy caching servers
- Audio and video broadcast streaming servers
- Video-on-Demand servers
- Other multimedia servers
- 6-Bone tunneling (although CERN does native IPv6 today, it might have to revert to tunneling in the future)

CERN maintains its own Network Operations Center (NOC) for its GigaPoP, with adequate provision for backup power supply, climate control and security, and with appropriate staffing levels for around-the-clock support. Network security is also emphasized through active participation in CERT.

D.1.b. Israel IUCC

IUCC's international connectivity is via a T3 satellite link to STAR TAP and an E3 fiber cable to QUANTUM[2] in Europe. In addition, a 10 Mbps backup ATM VC has been purchased from DANTE (UK) that creates redundancy in the event that either the satellite link or the undersea fiber link goes down. The entire IUCC network is run as a single ASN (AS378). Most of Israel's 20 academic colleges are connected via slow-speed lines to one of its eight universities. These eight universities have been selected for vBNS/IUCC connectivity. (See Section C.1.b.)



The design of Israel's satellite connectivity was presented at the UCAID Internet2 Fall workshop in Seattle (October 1999) and can be found at [http://www.internet-2.org.il/i2-satellite/index.htm].

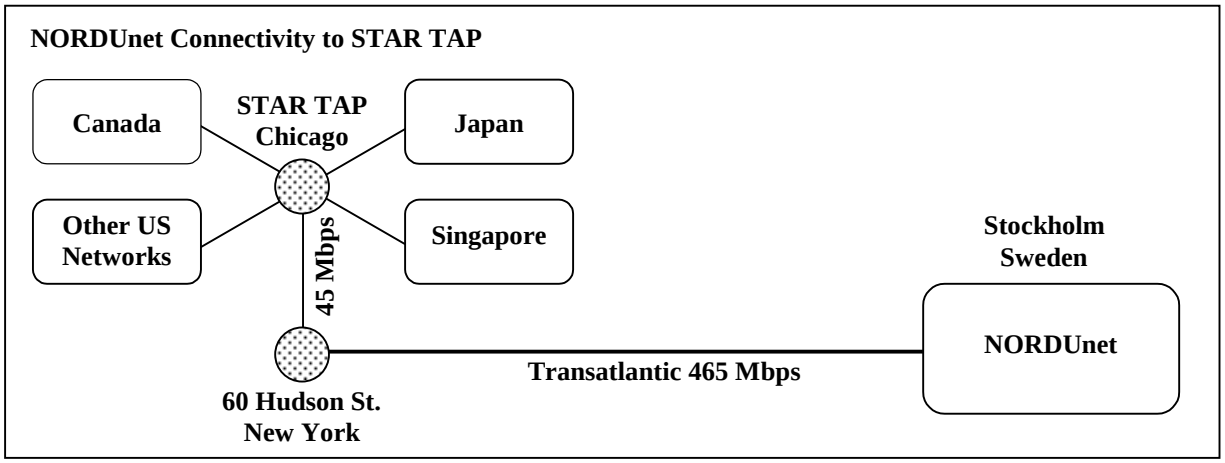
Network management is distributed among the eight universities. System administrators at each university monitor the network and correct problems as they occur. A smaller team manages international connections. Netview/AIX is used to provide trend analysis and monthly accounting reports. IUCC also maintains a **24x7** NOC. The first-level NOC is outsourced to AT&T and when a problem occurs, AT&T phones the IUCC second-level NOC.

D.1.c. NORDUnet

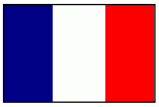
NORDUnet research traffic shares bandwidth with commodity traffic between Stockholm and New York. The shared capacity was upgraded from 155 Mbps to 465 Mbps in 1999 to assure that sufficient bandwidth was available to research traffic. The connection between New York and Chicago, which is for STAR TAP traffic only, was maintained at 45 Mbps because NORDUnet/Abilene traffic was exchanged at the NORDUnet PoP in New York City, giving enough headroom on the link.

[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 155 Mbps) 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.

NORDUnet maintains its own NOC at the Royal Institute of Technology in Stockholm.

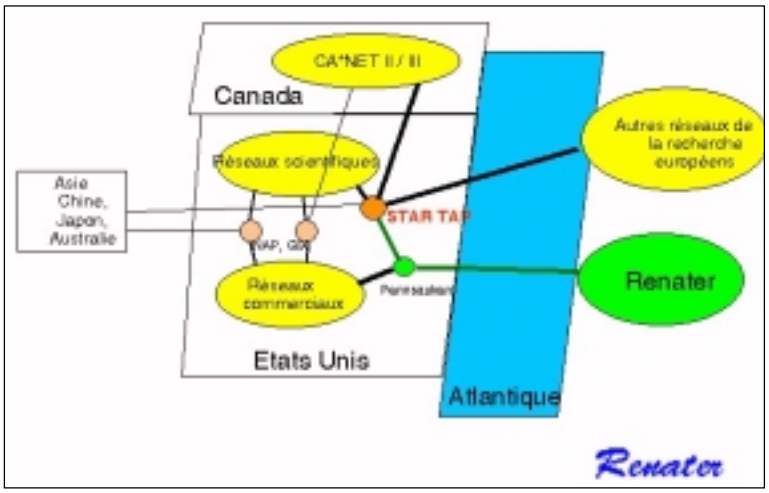


D.1.d. RENATER2



RENATER2, the GIP RENATER backbone, carries its transatlantic traffic to two SPRINT NAPs over a 155 Mbps ATM link provided by France Télécom between Paris and Pennsauken, New Jersey. Between Pennsauken and Chicago, a dedicated 34 Mbps link is used to carry STAR TAP traffic.

RENATER2 maintains its own Network Operations Center [noc-r2@cssi.renater.fr].



D.1.e. SURFnet

SURFnet's national backbone consists of a core of four GigaPoPs, linked at 622 Mbps, that connect 16 concentrator PoPs at 155 Mbps speed. The Dutch universities connect to the SURFnet network at speeds of 34 Mbps and 155 Mbps. Most universities connected at 34 Mbps are currently planning an upgrade to 155 Mbps.

SURFnet's external connectivity can be divided in three categories:

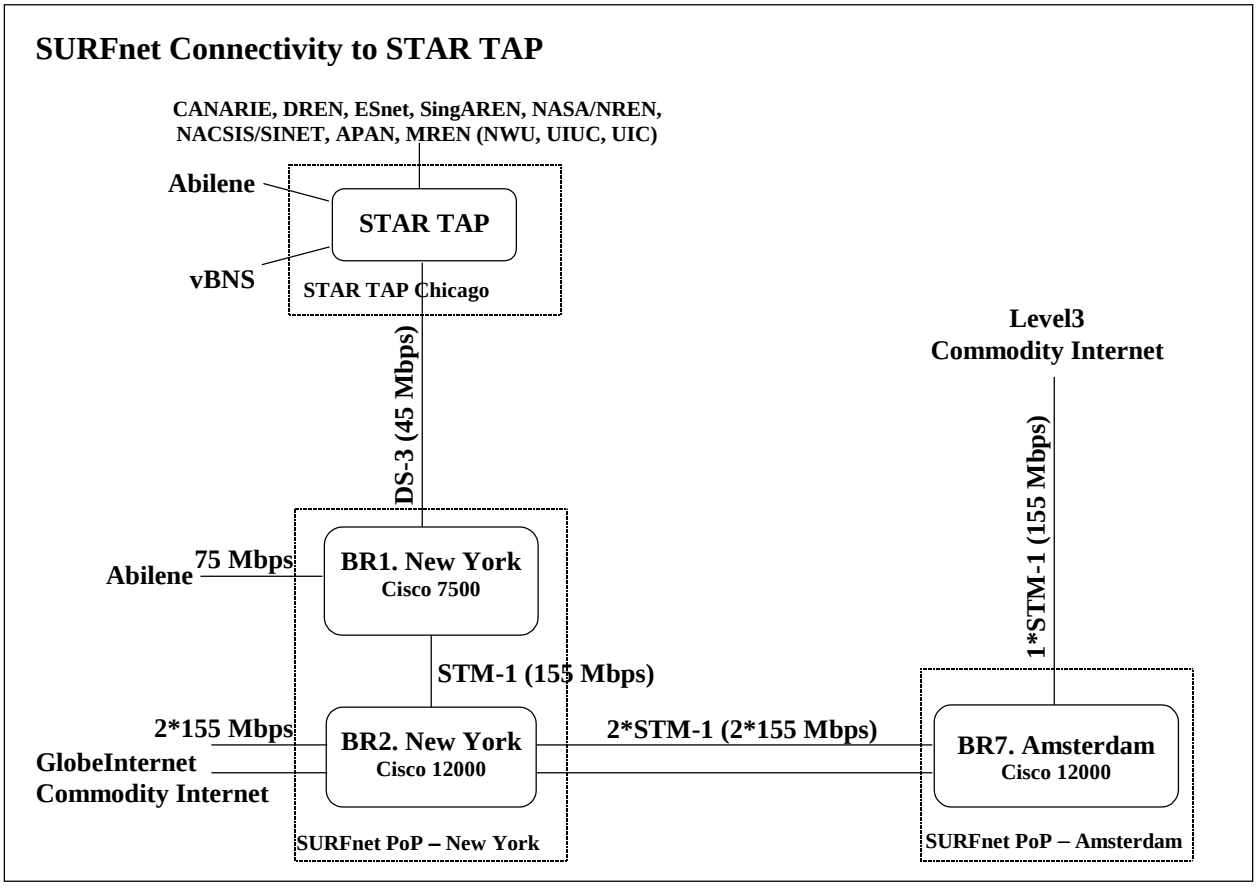
- Transatlantic, which consists of 310 Mbps + 155 Mbps capacity (for commodity Internet traffic) to SURFnet's PoP in New York provided from Amsterdam. The 155 Mbps capacity will be upgraded to 310 Mbps in the second quarter of 2000, bringing the total US capacity to 622 Mbps.
- Intra-European, which is SURFnet's 155 Mbps connection to the TEN-155 network. SURFnet plans to upgrade the connection to TEN-155 to 622 Mbps in the second half of 2000.

- Other, implemented as a Gigabit Ethernet connection and a Fast Ethernet connection to the Amsterdam Internet Exchange (AMS-IX) over which many peerages are running with national and international Internet Service Providers (ISPs).

SURFnet connects to STAR TAP from its New York PoP at 45 Mbps. This capacity is currently being upgraded to 155 Mbps. The New York PoP is connected to the GigaPoP in Amsterdam at 2* 155 Mbps using Packet-over-SDH (POS) technology. Apart from the STAR TAP connection, the New York PoP also has a direct connection to Abilene at 75 Mbps (soon to be upgraded to 155 Mbps) and to Teleglobe for commodity Internet traffic.

The routing policies for commodity Internet traffic are being set up in such a way that as much traffic as possible will be routed through Amsterdam, ensuring that as much bandwidth as possible is available to the New York PoP for research traffic. SURFnet peers with other research networks via the STAR TAP Router as well as via bilateral peerings.

Last year, native IP multicast was implemented on the SURFnet backbone using the PIM sparse-mode, MBGP and MSDP protocols. Connections to Abilene, vBNS and others have been set up in such a way that the exchange of IP multicast traffic is done natively, meaning that it is the same connection used to exchange unicast traffic. Video-over-IP projects have been using this multicast connectivity over the past year.



D.1.f. Peering: Bi-Lateral Agreements and STAR TAP Router

Once connected to STAR TAP, the NRNs, in addition to connecting to the vBNS, can peer with other US Next Generation Internet networks, the Internet2, and advanced networks from other countries. They can peer using the STAR TAP Router or by bilateral agreement. They may also connect to one or more ISPs at the AADS facility, which is outside the scope of Euro-Link, but a useful capability nonetheless.

STAR TAP/International Direct Peering Matrix

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

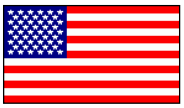
* MREN institution direct peering information detailed below.
0 Planned or under consideration
1 European "peering" via TEN-155
2 Direct peering at a location other than STAR TAP
3 Peering with APAN via a direct physical link to Japan and Korea
4 Temporary
5 Exchange traffic via a commercial European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

STAR TAP/MREN Direct Peering Matrix

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

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

D.1.g. Euro-Link Network Operations Center (NOC)



The Euro-Link NOC is up and operational; web pages can be found at [noc@euro-link.org]. Doug Pearson, Jim Williams and Steve Peck of Indiana University have created a STAR TAP/Euro-Link/TransPAC NOC, in which three logical NOCs are maintained inside one physical NOC. They have begun development of a Euro-Link "weather map" modeled after the Abilene weather map, and a BGP monitoring tool for BGP session monitoring across Euro-Link.

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 STAR TAP (the Ameritech NAP) to assess if there are any problems there. If so, the Euro-Link NOC contacts the European NRNs to inform them of the problem. This happens through NOC-to-NOC email, as well as formal email notification to all Euro-Link technical personnel. If the problem resides elsewhere, whether an NRN's network or a long-distance carrier's transoceanic network, then the Euro-Link 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.

D.2. Compliance with NRN and NSF vBNS Acceptable Use Policies

Most of the NRNs have a policy to connect all the universities in their countries without discrimination as to research need; however, to comply with the NSF AUP, they segregate traffic either at home or on the US East Coast prior to connecting to STAR TAP.

D.2.a. CERN

CERN is in a rather special situation as it is a single institution connecting to the vBNS, so, in principle, there is no need to do special filtering and redirection of traffic; however, there is a 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.

In the near future, CERN's bandwidth to the commodity Internet (i.e., 21 Mbps) will be much smaller than the bandwidth of its transatlantic circuit (i.e., 45 Mbps, then 155 Mbps, and possibly 2*155 Mbps within the next 12 months); therefore, there should be very little interaction between research and commodity traffic.

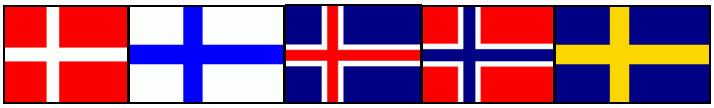
D.2.b. Israel IUCC

IUCC has created a system for providing Class of Service so that Israel's "Internet-2" traffic receives priority over commodity Internet traffic. IUCC has purchased commodity Internet transit from NAP.NET (BBN/GTE) via the AADS NAP, at a rate of 8 Mbps, and similar bandwidth via DANTE in Europe. IUCC maintains a satellite T3 link to STAR TAP (operational since July 1999) and an E3 link to QUANTUM (operational since May 1999), 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 71,000 prefixes (February 2000), while the combined "Internet-2" and QUANTUM routing tables stand at around 3,600. This represents roughly 5% of the Internet that is accessible via Israel's "Internet-2" lines. The BGP routing tables play a major part along with Cisco policy-based routing and GRE tunnels in segregating the traffic into different classes. Therefore, 37 Mbps of its satellite bandwidth is dedicated to Euro-Link applications.

IUCC maintains a publicly available AUP [http://www.internet-2.org.il/aup.html].

D.2.c. NORDUnet



In 1999 NORDUnet transatlantic capacity was upgraded from 155 Mbps to 465 Mbps to assure that sufficient bandwidth was available to research traffic. During 2000, NORDUnet will dedicate an entire transatlantic STM-1 to research traffic, alleviating the need for prioritization schemes as originally foreseen.

D.2.d. RENATER2

Segregation between STAR TAP authorized traffic and commodity Internet fluxes are made according to specific rules to announce vBNS-RENATER and RENATER-vBNS routes, and similarly for other networks for which peering is installed. Classes of service are being tested on the Paris/Chicago link, before being installed on the main 155 Mbps link, to insure the correct prioritization of high performance traffic. Emerging techniques like CAR and WRED will be fully validated after six months of operation, and then installed. Tests are currently going on. Meanwhile, there is no significant congestion expected on the France/US link that would prevent adequate QoS for this HPIIS traffic.

RENATER 2 also has in its strategy to experiment and develop, first nationally, then internationally, IPv6 and its associated QoS services.

At present, RENATER2 is in the process of a call for tender process concerning the upgrade of this transatlantic link. The transatlantic capacity should be increased above 622 Mbps, including an OC-3 path to STAR TAP.

D.2.e. SURFnet

SURFnet connects to STAR TAP from its New York PoP at 45 Mbps and is upgrading to 155 Mbps. Abilene and commodity Internet traffic is peeled off in New York. Effort is being made to route as much commodity Internet traffic through Amsterdam as possible, thus ensuring that maximum bandwidth is available to the New York PoP for research traffic.

D.3. Network Performance and Usage

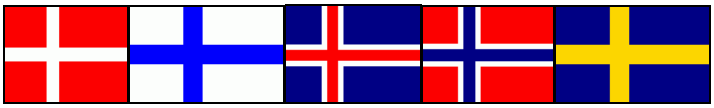
D.3.a. CERN

CERN is very active in performance monitoring. CERN hosts three Internet probes – Surveyor, RIPE and NIMI – and is also part of the Internet End-to-end Performance Monitoring (IEPM) PINGER project, supported by DOE MICS through the Stanford Linear Accelerator Center. In addition, CERN is providing its own set of statistics using a combination of public domain (e.g., MRTG, netperf, iperf, tcptrace, xplot) and in-house tools. CERN's Internet traffic statistics page is at [http://sunstats.cern.ch/mrtg]. In the future, CERN plans to install Netlogger and to study alternatives to TCP-based file transfer in order to reduce the problems linked to error recovery on high-bandwidth delay paths.

D.3.b. Israel IUCC

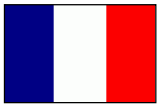
IUCC maintains a site of statistical information about all its connections [http://www.internet-2.org.il/stats.html]; T3 Euro-Link statistics can be found at [http://noc.ilan.net.il/stats/TAU-GIGAPOP/tau-gp1-fe-i2.ilan.net.il.html] and STAR TAP peering statistics can be found at [http://noc.ilan.net.il/stats/ILAN-I2-uplinks/peers.html].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

D.3.c. NORDUnet



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

D.3.d. RENATER2

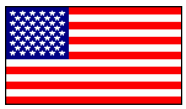


RENATER2 does not presently have a web page regarding STAR TAP traffic. Hopefully this will change at some time this year, once the current call for tenders is completed. A higher transatlantic link, along with associated services, will improve performance.

D.3.e. SURFnet

SURFnet monitors traffic on its STAR TAP connection, as it does on all its connections (external connections, backbone links, and customer links). Results are put on the web using MRTG or RRDTool. This information is typically protected by userid/passwds and access-lists; however, STAR TAP traffic monitoring can be found at [http://www.surfnet.nl/surfnet/persons/bos/startap-traffic/].

D.3.f. 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 QoS of Real-Time Multimedia

An alpha version of EVL's CAVE-based Netlogger visualization tool (QoSIMoTo: QoS Internet Monitoring Tool) was recently completed [www.evl.uic.edu/cavern/qosimoto]. This tool visualizes historic as well as real-time Netlogger data consisting of bandwidth, latency and jitter.

Petri-Net Network Modeling

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

Network Monitoring

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

Low Latency State Transmission Over Long Distance Networks

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

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

D.4. Engineering Advancements

D.4.a. CERN

CERN is focusing on applications as well as several engineering projects:

- Participating in the Internet2 Distributed Storage Initiative, and will soon install a Novell ICS cache
- IPv6 (with Lawrence Berkeley Labs via the 6TAP router)
- Working with Brian Carpenter, of IBM and the International Center for Advanced Internet Research (iCAIR) at Northwestern University, on the Virtual Room Videoconferencing System (VRVS) DiffServ testbed for experimentation and research [http://vrvs.cern.ch/About/VRVS_Paper.pdf]. CERN has nearly finished provisioning a stable dedicated PVC. In mid-December, however, CERN engineers noticed that test traffic was interfering with production traffic, which they plan to fix before experiments can continue.
- High-speed file transfer (Caltech/SLAC/Fermilab).

If CERN moves away from ATM on its transatlantic circuit (Section D.1.a), CERN will make extensive use of DiffServ mechanisms in order to deliver the required grade of service to its various applications/users.

D.4.b. Israel IUCC

IUCC has set itself a target to benchmark and test solutions that can negate the influence of large satellite delays that influence TCP throughput. IUCC selected two products to test at the Intelsat laboratory in Washington DC and then picked the one with the best potential for further testing. Results of that benchmark can be found at [http://www.internet-2.org.il/satellite-testing.html].

IUCC installed Mentat XH45 boxes [http://www.mentat.com/skyx/xh45.html], installing one box in Israel and one box at its co-location site in Chicago. IUCC began testing and found instances of a 160-fold performance increase for TCP streams. Previously, IUCC had attempted to work with researchers to TCP tune their systems; for details, see [http://www.psc.edu/networking/perf_tune.html].

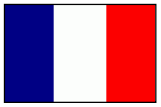
However, Israel discovered that their test conditions were not scalable. Therefore they are pursuing the "black box" solution. Interestingly enough, NASA also tested the Mentat boxes [http://www.mentat.com/skyx/skyx-nasa.html] and found that they help not only high-latency links but low-latency (70 ms) links as well, which would be applicable for all of the Internet-2 infrastructure in the USA.

IUCC maintains a high-bit-rate Video on Demand listing for all VoD servers in Internet-2 at [http://www.internet-2.org.il/vod.html]. IUCC has been testing all the VoD servers in the US and has uncovered problems relating to use of these servers. IUCC is working with these institutions to correct their problems.

D.4.c. NORDUnet

NORDUnet has set up native multicast connectivity with most of the STAR TAP-connected networks.

D.4.d. RENATER2



In the coming year, RENATER2 will focus on the following engineering enhancements:

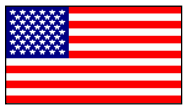
- Increase available transatlantic bandwidth. A call for tender is in progress. The transatlantic capacity should be increased above 622 Mbps, including an OC-3 path to STAR TAP.
- Experiments with QoS services, aiming at a more efficient (in terms of performance and of bandwidth allocation and usage) use of the costly transatlantic infrastructure, and make them operational as soon as possible.
- Experiment with IPv6 as part of the 6Bone activity.
- If possible, experiment with end-to-end (campus to campus) QoS services, to answer demanding criteria from some specific scientific communities (astronomy, particle physics). Typical applications are: reliable

bulk data transfer, interactive remote access to data acquisition and control computers, cooperative workgroup (broadband videoconferencing etc.).

D.4.e. SURFnet

The UIC Electronic Visualization Laboratory is collaborating with SARA in The Netherlands on network performance tests (see Section D.3.f).

D.4.f. Euro-Link/STAR TAP Engineering Advancements



General Overview

STAR TAP leadership is focusing on improved performance by providing higher level services to its constituents. Specifically, STAR TAP is working with Ameritech and its national and international partner NRNs to co-engineer advanced layer 3 services and new technologies, such as:

- A policy-free IPv4 router that simplifies the ability of STAR TAP-connected networks to exchange routes and traffic with other STAR TAP-connected networks with whom they do not peer directly
- Dense Wave Division Multiplexing (DWDM) efforts with CANARIE and MREN
- IPv6 efforts with ESnet
- Web caching with the NSF-sponsored National Laboratory for Applied Network Research (NLANR) and the Internet2 Distributed Storage Working Group
- Performance measuring using the NLANR Active Measurement Platform (AMP) instrument, as well as the possible addition of Advanced Network & Services' Surveyor system
- Use of Multi-Protocol Label Switching (MPLS) Quality-of-Service (QoS)
- DiffServ experiments with the DOE NGI-supported EMERGE testbed
- Unicast/multicast digital video QoS efforts with iCAIR at Northwestern University
- QBone QoS efforts with Internet2

STAR TAP works with HPIIS awardees TransPAC, MIRnet and Euro-Link to assure continued services in the post-vBNS era, and to continue/improve connectivity to US backbones such as Abilene, vBNS+, ESnet, DREN, NREN and NISN, as well as to anticipated interconnecting GigaPoPs and emerging state-funded R&E networks.

STAR TAP Router

On November 3, 1999, we brought up the STAR TAP Router to facilitate peering among the 20 National Research Networks (NRNs) connected to STAR TAP. Due to individual policy restrictions, the vBNS, Abilene, and ESnet are currently not planning to peer with the STAR TAP Router. Currently peering are: CA*net 2, NREN, DREN, MREN (Argonne National Lab, Northwestern University), APAN, CERN, UICC, NORDUnet, RENATER2, SingAREN, SURFnet and TANet2. Peering with NISN is expected soon. On December 14, 1999, the STAR TAP Engineering team upgraded the interfaces on this router to enable it to support higher-speed throughput and handle more traffic.

IPv6 Tunnel service at the 6TAP

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

STAR TAP NLANR Web Cache

Duane Wessels of NLANR has built and tested a Web Cache, running the Squid caching software, for STAR TAP. The cache PC was installed at Ameritech on December 14, 1999. NAP.NET donated ISP service over a 1 MB connection. Once NAP.NET is in place (expected in February 2000), Duane will integrate the cache into NLANR's Global Caching Hierarchy.

STAR TAP Performance Measurement Systems

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

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

DiffServ

The UIC DOE/NGI EMERGE project [http://www.evl.uic.edu/cavern/EMERGE/], initially targeting MREN sites, will be extended internationally over the next several months to include CERN, Russia, Singapore and Amsterdam. The STAR TAP Cisco 7507 DiffServ router, to be used for EMERGE experiments, was installed at Ameritech on December 14, 1999.

D.5. Documentation and Dissemination of Information

D.5.a. www.euro-link.org

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

D.5.b. Accomplishments, Meetings Attended, Publications

See Appendix I.

D.5.c. Applications

See Appendix II. This information will soon be posted to the Euro-Link web site.

D.6. Euro-Link Annual Meeting

For the past two years, UIC has organized annual STAR TAP International Advisory Committee meetings, held in conjunction with the INET conference. At INET 98, PI Tom DeFanti and co-PI Maxine Brown met Peter Villemoes (NORDUnet), Kees Neggers (SURFnet), Ari Cohen (IUCC) and Christian Michau (CNRS/RENATER2) to discuss a HPIIS/Euro-Link connection. At INET 99, DeFanti and Brown met with Euro-Link *charter NRN* representatives Villemoes, Neggers, Cohen and Danny Dolev (IUCC), and Dany Vandromme (RENATER2), as well as hosted a full day of STAR TAP meetings. 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. The STAR TAP meetings held at INET 99 are documented on the web [http://www.startap.net/ABOUT/MEETINGS_individual.html#INET99].

E. Program Plan

In Year 2 of Euro-Link, in addition to the functional and administrative activities necessary to fulfill the Cooperative Agreement, the Euro-Link team will pursue the following activities. Above all, we will continue to encourage other European networks (e.g., DFN, UKERNA) to connect to STAR TAP and we will continue to promote meritorious applications, provide engineering support and encourage the development and use of new networking technologies and services. In addition, we will continue to pursue more cost-effective ways for Europeans to connect to STAR TAP, whether via the STAR TAP International Transit Network or a consolidated EuroPoP connecting several countries in Europe (see Section E.1 below).

E.1. Euro-Link Connectivity and Peering

E.1.a. STAR TAP International Transit Network (ITN) development

A major activity of Year 2 will be making sensible and timely use of offers of free transit for Euro-Link NRNs from the *telco co-location hotel* (a meet point for local, regional, and global telecommunications carriers) at 60 Hudson Street in New York City to STAR TAP. Both Abilene and CA*net3 are offering IP transit, details to be worked out. Issues of concern are router placement, AUPs and related policy issues, and timing of circuit switchover.

The ITN has broader implications that extend to other countries besides the Euro-Link NRNs. South American countries like Chile, Brazil, Venezuela, Argentina, Costa Rica, and Colombia are likely to connect to the US via Miami. Abilene currently plans to carry transit from Miami for these countries to relevant telco hotels (e.g., 1 Wilshire, 60 Hudson) and STAR TAP. Some Asian traffic (e.g., China) may be carried by CA*net3 from Vancouver to STAR TAP, New York, and Seattle. And, Mexico's CUDI network, which connects to the US in Los Angeles, may connect to STAR TAP either by Abilene via CalREN or by CA*net3 via NTON.

In addition, several active GigaPoPs (e.g., those serving Miami, Seattle, Los Angeles, and Houston) want active roles in planning the consolidation and transit of international traffic, which STAR TAP engineering welcomes. The 60 Hudson Street location has no local authoritative GigaPoP, which makes the arrangements somewhat more of a business deal than when a university-led GigaPoP is in charge. Euro-Link will pursue the most advantageous course within its range of possibilities, and with the concurrence of NSF.

E.1.b. EuroPoP discussions

IUCC, RENATER2, and SURFnet have suggested ways of consolidating traffic at some location in Europe and then bringing a single circuit to STAR TAP. This was the original Euro-Link plan and is, indeed, the model that TransPAC developed, but the complex issues of tenders and international circuit costs within Europe caused us to adopt the currently operating design of independent circuits.

Now that commodity Internet traffic is better handled in Europe, and internal European circuit costs are being driven down by deregulation, it is possible to enter into discussions that could eventually result in a EuroPoP. We will use the STAR TAP International Advisory Committee, or at least the European subset, to develop a long-term strategy.

E.1.c. CERN Funding and Connectivity

For Year 2, CERN has been added to the Euro-Link consortium, making our fixed annual $1,600,000 payments for HPIIS telecommunications services divisible by 5 NRNs (not 4, as was done in the first year of this Cooperative Agreement). In year 2, each NRN will receive a payment of $320,000 to offset the costs of transoceanic connections to STAR TAP. Invoice documents will be prepared and executed.

CERN has been connected to STAR TAP since August 1999 using C&W circuits. Recently, following a call for tender won by KPNQwest, CERN is upgrading its transatlantic circuit and will switch providers April 1. (See Section D.1.a.) Originally KPNQwest was to connect at 60 Hudson in New York City and Abilene was to carry CERN traffic (CERN is a member of Internet2 and is regarded as a US university) to STAR TAP, all Federal networks, and any countries with which Abilene has an MOU. However, rack space and power issues at 60 Hudson have delayed this plan, so KPNQwest will instead temporarily bring a circuit to Chicago to connect to STAR TAP. Euro-Link and STAR TAP engineers are working with all parties to assure relatively uninterrupted connectivity.

E.1.d. NOC Activities

Indiana University will have an integrated and fully functioning STAR TAP/Euro-Link/TransPAC/Abilene NOC.

E.2. Application-Level Network Performance Collaborations

E.2.a. NORDUnet

EVL has, in the past, worked with PDC in Stockholm. They have an old version of CAVERNsoft that they use in their "Steering and Visualization of a Finite-Difference Code on a Computational Grid" electromagnetic simulation application (see Section I.3). We recently contacted PDC and asked that they review the new release of CAVERNsoft G2 (see Section H.3) to see if they want to incorporate it in their application codes. If they use CAVERNsoft G2, we can do application-level performance monitoring (Section D.3.f).

Another potential collaboration would be for them to install a DiffServ router at PDC and participate in the international EMERGE testbed (Section D.4.f).

E.2.b. SURFnet

We will continue to work with SARA in The Netherlands on network performance analysis (Sections D.3.f and H.3). Now that EVL's QoSIMoTo: QoS Internet Monitoring Tool has been developed, and now that CAVERNsoft G2 has been released (with Netlogger integrated), UIC/EVL can actually do performance monitoring and analysis.

E.3. Engineering Advancements

E.3.a. IPv6 Activities

CERN and SURFnet are actively involved in the ESnet/CANARIE sponsored 6TAP project located at STAR TAP. In the coming year, ESnet/CANARIE have plans to develop IPv6 route server technology, network tools for network measurement, analysis and display, and experience in supporting, provisioning and operating IPv6 Internet exchange points. STAR TAP and Euro-Link engineers are very involved in helping make this project successful.

E.3.b. DiffServ Collaborations

CERN will continue to work with iCAIR on the Virtual Room Videoconferencing System (VRVS)/EMERGE DiffServ testbed (Section D.4.a). We also hope to add new countries/NRNs to the EMERGE testbed.

Note: Some interest has been expressed in an MPLS testbed, and this will be explored further in the coming year.

E.3.c. Native Multicast to Euro-Link Universities

The STAR TAP IPv4 router is multicast enabled. Following the lead of TransPAC, we will continue to make native multicast available to NRNs and others peering at the IPv4 router.

E.3.d. Euro-Link Access Grid Deployment

The Access Grid [www.mcs.anl.gov/fl/accessgrid/] is the ensemble of computer, network and display resources used to support human interaction across the Computational Grid3. It consists of multimedia display, presentation and interaction environments, interfaces to grid middleware and interfaces to visualization environments. The Access Grid, when fully realized, will support large-scale distributed meetings, collaborative work sessions, seminars, lectures, tutorials and training. The Access Grid's fundamental contribution is group-to-group communication, thus differentiating it from desktop-to-desktop-based tools that are focused on individual communication. The Access Grid environment affords both formal and informal group interactions. Large-format displays integrated with intelligent or active meeting rooms are a central feature of the Access Grid nodes. Access Grid nodes are "designed spaces" that explicitly contain high-end audio and visual technology needed to provide a compelling user experience.

[3] The Computational Grid (a.k.a. The National Technology Grid or the Information Power Grid) is a plan to tie together the US's computer, data, instrument, and visualization technologies with networks and advanced middleware (e.g., Globus) [http://alliance.ncsa.uiuc.edu].

VALinux is packaging Access Grid hardware for distribution. Euro-Link will assist its partner NRNs to bring up Access Grids in Europe and Israel as desired, and use them to enhance group communication.

E.3.e. GriPhyN Activities with CERN and Others

The GriPhyN (Grid Physics Network) collaboration[4] proposes to design, develop, prototype, deploy and field-test a new generation Petascale Virtual Data Grid (PVDG) instrumented with a Virtual Data Toolkit, that will meet the data-intensive computational needs of a diverse community of thousands of scientists spread across the globe. The new generation Grid-based systems to be developed, although initially focused on four frontier physics experiments, will be applicable to large-scale data-intensive problems in many fields of science, engineering, and industry and commerce. Although no information systems of this scope currently exist, systems of similar size and complexity providing transparent access to massive sets of raw and processed data will be needed in the coming decades, as a central element of our information-centric society.

The four NSF-funded physics experiments involved in the initial PVDG development are about to enter a new era of exploration of the four fundamental forces of nature and the structure of the universe. The Compact Muon Solenoid (CMS) and ATLAS (A Toroidal LHC ApparatuS) experiments at the Large Hadron Collider (LHC) will search for the origins of mass and probe matter at the smallest length scales; the Laser Interferometer Gravitational-wave Observatory (LIGO) will detect the gravitational waves of pulsars, supernovae and inspiraling binary stars; and, the Sloan Digital Sky Survey (SDSS) will carry out an automated sky survey enabling systematic studies of stars, galaxies, nebula, and large-scale structure. (See Section I.)

The data analysis for these experiments presents unprecedented challenges in information technology. Communities of thousands of scientists, distributed globally and served by networks of varying bandwidths, need to extract small signals from enormous backgrounds via computationally demanding analyses of datasets that will grow from the 100 terabyte to the 100 petabyte scale over the next decade. These analyses will use distributed CPU resources, from teraflops (2000 AD) to petaflops (2010 AD), that must be supported, for each experiment, at four different levels: Tier 1, a US national center; Tier 2, regional centers; Tier 3 university computing centers; and Tier 4, individual scientists' workstations. STAR TAP/Euro-Link has offered to help coordinate the international networking aspects of GriPhyN.

E.4. Documentation and Dissemination of Information

E.4.a. Web Documentation

In the coming year, we will have a fully functioning Euro-Link web site with engineering and applications well documented for all our NRNs.

E.4.b. iGrid 2000

UIC/EVL is currently organizing an iGrid 2000 research demonstration at INET 2000 in Yokohama, Japan, July 18-21, 2000. A web site describing the event is being updated as the event takes shape [www.startap.net/igrid2000]. Several European countries are participating.

E.4.c. Conference Participation

UIC/EVL is participating in the Eurographics' Workshop on Virtual Environments to be held in Amsterdam in June [http://www.euro-link.org/PUBLICATIONS/news-eurograph_wkshp.html]. A highlight of the event will be a live tele-immersion demonstration by co-PI Andrew Johnson and Jason Leigh between the CAVE at EVL and the CAVE at SARA, the Academic Computing Center in Amsterdam. Johnson, Leigh and their students will also be giving a tutorial on CAVERNsoft.

PI DeFanti and co-PI Brown have been invited to participate in the 19th Nordic Networking Conference, organized by NORDUnet, to be held at Finlandia Hall, Helsinki, Finland in September 2000. [http://www.euro-link.org/PUBLICATIONS/news-NORDUnet2000.html].

[4] GriPhyN is currently the subject of an NSF ITR proposal under development; Tom DeFanti is listed as Senior Personnel, advising on advanced international networking.

F. Performance Review

Euro-Link, TransPAC and MIRnet are talking with Steve Goldstein, the NSF HPIIS Program Manager, about a HPIIS Review meeting at the NCSA ACCESS Center in Arlington, Virginia, in September 2000. The Review will consist of a report and a presentation, and will focus on the coordination/integration of work among the HPIIS Team members and STAR TAP. The purpose of the Review is to evaluate the performance of the HPIIS team members in accordance with the goals of the HPIIS program. The ultimate goal is to promote the continuation of HPIIS and all its parts, and show that the need for this program persists.

G. Budgets

(Available upon request.)

H. Appendix I: Accomplishments (April 1999–March 2000)

H.1. Meetings Attended

February 24-25, 2000. Linda Winkler and John Jamison attended I2 Routing and Multicast working group meetings at University of California, Santa Barbara, to coordinate international activities with Abilene and CA*net3.

February 18, 2000. Hosted Chris Greenhalgh, School of Computer Science and IT, University of Nottingham, United Kingdom, at UIC. Gave a presentation on "Collaborative Virtual Environments at the University of Nottingham," and is interested in doing tele-immersion with EVL at UIC.

February 3-4, 2000. Tom DeFanti and Maxine Brown were in Paris, France. DeFanti gave a presentation on Global Research Networks to ~150 people at Atelier [www.atelier.fr], a group of financial and technical people who meet regularly for information sharing and lectures on the economics of the internet and computer technologies. The director general of Atelier.fr is Jean-Michel Billaut. DeFanti and Brown also met with:

- Philippe Quéau, director of the Information and Informatics Division, UNESCO (United Nations Educational, Scientific and Cultural Organization)
- John B. Rose, program specialist, Information and Informatics Division, UNESCO
- Henrikas Yushkiavitshus, Undersecretary General for Communication, Information and Informatics
- Alain Giffard, Minister of Culture and Communication, France
- Xavier Dalloz, consultant

January 31-February 2, 2000. Tom DeFanti and Maxine Brown attended Imagina 2000 in Monte Carlo, Monaco. DeFanti gave a keynote ("carte blanche") talk on Global Networking and Tele-Immersion.

January 27-28, 2000. Tom DeFanti, Maxine Brown and John Jamison met with Steve Goldstein at NSF.

January 20-21, 2000. EVL doctoral student Javier Girado presented "Global Tele-Immersion: Working in CyberSpace," as a keynote speaker at the "Science and Technology and Companies: A Vision for the 21st Century" workshop and plenary sessions, held in Barcelona, Spain. The event was sponsored by Barcelona University (UB) and the Technical University of Catalunya (UPC), and reflected the interest of both institutions to foster joint research projects and a technology exchange, and to promote the new Scientific and Technological Park Barcelona 2000 (PCTB2000).

January 18, 2000. Tom DeFanti, Joe Mambretti and Linda Winkler attended a meeting at Argonne National Laboratory, where representatives of the company Akamai [www.akamai.com] discussed their interest in working with universities and research laboratories on web caching products. Mambretti offered to have MREN serve as its initial partner.

January 14, 2000. Tom DeFanti and Maxine Brown met with Cable & Wireless representatives at UIC:

- Mark Luptak, Account Manager, IP Special Markets (including STAR TAP)
- Todd Bullington, International Account Manager
- Chris Altman, Technical Sales Consultant

We discussed Mark Luptak's new job, in which he will continue to work on STAR TAP; C&W's "Distributed STAR TAP" press release (which Tom/Maxine have approved; release is still pending); the news that CERN has changed providers; and the potential that C&W will connect Hong Kong to STAR TAP.

January 13, 2000. John Jamison attended two meetings in Miami. At the first, JJ and Julio Ibarra of FIU discussed possible designs and strategies for implementing a Miami GigaPoP, which could serve as a convergence point for Latin American Research Networks. At the second meeting, JJ and representatives of IMPSAT discussed the technical details of connecting Chile's REUNA network to STAR TAP.

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

Conference topics included computational simulations; hardware and software for visualization and virtual reality; collaborative simulation;

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

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

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

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

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

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

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

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

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

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

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

- Mark Luptak, International Account Manager
- Heather Lence, Major Account Representative
- John (Iain) McFadyen, Global Services Special Programs Office
- Chris Altman, Technical Sales Consultant
- Amy Meldgin, District Sales Manager

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

October 4-6, 1999. Alan Goodall, Director of AV Media Services at the University of Strathclyde, Glasgow, and a recipient of the Winston Churchill Fellowship, visited EVL and Argonne National Laboratory. The Fellowship enabled him to travel around the world researching the whole range of VR technologies, and to see who is doing what and where. Specifically, he was researching the potential of VR in education and training.

October 4-5, 1999. DOE NGI Meeting, Washington, D.C. T. DeFanti, J. Leigh, A. Verlo and J. Jamison attended.

September 29, 1999. International Internet2 meeting at NCSA/ACCESS Center, Washington DC. Tom DeFanti, Maxine Brown, John Jamison from EVL; Heather Boyles and Guy Almes from Internet2; and, Steve Goldstein, Bill Decker and Aubrey Bush from NSF attended. The goal was to agree upon a common Internet2/STAR TAP strategy for international groups desiring Abilene connectivity. UCAID/Internet2 endorses international connectivity to STAR TAP; exact wording still needs to be determined.

September 27, 1999. Meeting with Mark Luptak of Cable & Wireless (C&W). Tom DeFanti and Maxine Brown attended. C&W is seeking ways of assisting their international customers connect to STAR TAP. (Discussions similar to those with Teleglobe at September 14 meeting. See below.)

September 23, 1999. Network Performance meeting at EVL. See Section C.4.

September 17, 1999. Meeting with Henry Bienan, Northwestern University president and a member of the UCAID Board of Trustees. Tom DeFanti, Joe Mambretti and Mort Rahimi attended, to bring Bienan up-to-date on STAR TAP and its activities. One specific discussion item, which is not Euro-Link-centric, was APRU (Association of Pacific Rim Universities) and their interest in creating APRUnet (an advanced Internet capability among APRU universities and APEC economies).

September 14, 1999. Meeting with Andre Choo of Teleglobe at EVL. Tom DeFanti and Maxine Brown attended. Teleglobe is seeking ways of assisting their international customers connect to STAR TAP. DeFanti explained our interest in developing a distributed STAR TAP, with certain key places like 60 Hudson in New York becoming "STAR Nodes," and carriers providing "STAR Links" to Chicago. We are waiting to hear back from Teleglobe.

September 13-17, 1999. Russia trip. JJ traveled to Russia with an NSF delegation headed by Bob Borchers to consult with them about the MIRnet/STAR TAP connection. (See Section E.)

August 31, 1999. EVL/Indiana U meeting at EVL. Tom DeFanti, Maxine Brown, Michael McRobbie and Karen Adams attended. We discussed (a) the Euro-Link NOC subcontract, (b) an applications-focused iGrid 2000 event at INET 2000 in Yokohama, Japan in July 2000 (EVL would encourage European participation), and (c) an NSF HPIIS Review, which we shall propose take place in September 2000.

August 9-11, 1999. NASA's "Bridging the GAP Workshop" in San Jose. JJ Jamison attended. This meeting provided updated information on multicast, QoS and security efforts of NASA and other US Agency networks.

August 3-6, 1999. Eighth IEEE International Symposium on High Performance Distributed Computing in Redondo Beach, California. Jason Leigh and Oliver Yu of EVL/UIC attended. They took the tutorial "Distributed Systems Performance Analysis Using Net Logger and Pablo" taught by Brian Tierney of Lawrence Berkeley National Laboratory and Ruth Aydt of UIUC.

July 30, 1999. Internet2 Routing Registry training class held at Merit in Ann Arbor, Michigan. JJ Jamison and Alan Verlo attended. Skills will be used to register Euro-Link routes in the Internet2 Routing Registry.

July 28, 1999. Ameritech meeting, to discuss the delays in connecting CERN, NORDUnet and IUCC and how to prevent this from happening in the future. Ameritech made it clear they were in the process of reorganizing in order to better serve the STAR TAP community. Attendees from UIC: Tom DeFanti, Maxine Brown, JJ Jamison. From Ameritech: William Cannon, VP Sales Strategy and Network Services; Kimberly Price, VP New Product/Business Development; Jay Zollinger, VP Operations; Christina Fulton, Director of New Products-IP Networking; John Christensen, NAP Sales Engineer; David Savage, Sr. Acct Manager, government and education; and, Andy Schmidt, Business Development, STAR TAP.

July 20, 1999. JET (Joint Engineering Team) meeting, National Science Foundation, Arlington, Virginia. JJ Jamison attended and represented the interests of both the STAR TAP and Euro-Link projects.

June 29-30, 1999. Measurement and Analysis Collaborations Workshop Among Measurement Host Sites, San Diego Supercomputer Center, San Diego, CA, sponsored by NLANR/MOAT. JJ Jamison and Alan Verlo attended. JJ gave presentation entitled "Planned Performance Measurement @ STAR TAP."

June 22, 1999. STAR TAP International Advisory Committee and Technical Advisory Committee meetings, INET'99, San Jose, CA. Tom DeFanti, Maxine Brown, JJ Jamison, and Alan Verlo attended. Also attended by Danny Dolev and Ari Cohen (Israel IUCC), and Dany Vandromme (RENATER2). Tom DeFanti chaired the morning session (International Advisory Committee meeting) and JJ chaired the afternoon session (Technical Advisory Committee meeting). Meetings and agenda organized by Maxine Brown, and hosted by Teleglobe.

June 15-17, 1999. Academic School of Computing and Imaging '99 (ASCI '99) conference, Boxmeer, Heijen, The Netherlands. Jason Leigh gave keynote presentation "A Tele-Immersive Environment for Collaborative Exploratory Analysis of Massive Data Sets."

June 14, 1999. Jason Leigh visited the Academic Computing Services Amsterdam (SARA) center to discuss collaborative research. (See Section C.4)

June 10, 1999. JET (Joint Engineering Team) meeting, Pittsburgh, PA. JJ Jamison attended.

June 7-10, 1999. TERENA NORDUnet Networking Conference TNNC99. Maxine Brown attended and presented "CAVERN: The CAVE Research Network."

June 6-10, 1999. NLANR/Internet2 Techs Workshop, Carnegie Mellon University, Pittsburgh, PA. JJ Jamison attended and gave the presentation "STAR TAP Engineering Update."

June 1-4, 1999. First Joint European Commission/National Science Foundation Advanced Research Workshop on "Research Frontiers in Virtual Environments and Human-Centered Computing," Chateau de Bonas, France. Tom DeFanti participated. Organized by Andy van Dam (Brown University, USA) and Rae Earnshaw (University of Bradford, UK).

May 3-4, 1999. USA/Israel NGI Workshop, Tel Aviv, Israel. Hosted by the Israeli Ministry of Science. Tom DeFanti attended and presented two lectures, "The CAVE and Virtual Reality," and "The Internet2, Next Generation Internet, and STAR TAP."

April 26-28, 1999. Internet2 Spring Member Meeting, Washington DC. Internet2 International Task Force Meeting attended by Tom DeFanti and Maxine Brown.

April 14, 1999. STAR TAP Connectivity/ Internet2 MOU meeting with CERN at Fermi National Accelerator Laboratory, Chicago, IL. Attendees: David Williams, Harvey Newman, Manuel DelFino, CERN; Matthias Kasemann, FermiLab; Michael Ernstein, DESY; Tom DeFanti, Maxine Brown, STAR TAP/EuroLink; Linda Winkler, STAR TAP/TransPAC; Heather Boyles, UCAID Internet2.

April 6, 1999. HPIIS Team Meeting, Chicago, IL. Status reports of STAR TAP, TransPAC, MIRnet and EuroLink where presented. Tom DeFanti, Maxine Brown, Alan Verlo, and J. Jamison attended. Tom DeFanti chaired. Meeting organized by Maxine Brown.

H.2. Publications

Ray Fang, "Forward Error Correction for Multimedia and Teleimmersion Streams," EVL internal technical report. February. [http://www.evl.uic.edu/cavern/FEC/RayFangFEC1999.pdf]

Steven N. Goldstein, Maxine D. Brown, Thomas A. DeFanti, "The Crossroads of Advanced Networks," La Recherche, Paris, France, No. 328, February 2000, pp. 50-51. [http://www.startap.net/PUBLICATIONS/pubs.html#Application Papers].

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

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

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

Hank Nussbacher, D.C. Palter, "Internet-2 Takes to the Air", Satellite Communications, November 1999, pp. 36-39.

Y. Zhou, T. Murata, T. DeFanti; "Modeling and Analysis of Collaborative Virtual Environments by Using Extended Fuzzy-Timing Petri Nets," IEEE Transactions on Systems, Man and Cybernetics, special issue on Discrete Systems and Control, submitted for publication.

Tom DeFanti, Dan Sandin, Maxine Brown, Dave Pape, Josephine Anstey, Mike Bogucki, Greg Dawe, Andy Johnson, Tom Huang, "Technologies for Virtual Reality/Tele-Immersion Applications: Issues of Research in Image Display and Global Networking," European Commission/National Science Foundation Advanced Research Workshop on "Human-Centered Computing, Online Communities, and Virtual Environments" (editors Judy Brown, Andy van Dam, Rae Earnshaw, Jose Encarnacao, Richard Guedj, Jennifer Preece, Ben Shneiderman, John Vance), Chateau de Bonas, France, June 1-4, 1999, (to be published by Springer Verlag).

Tom DeFanti, (contributor), "Special Report on Human-Centered Computing, Online Communities and Virtual Environments," Judy Brown, Andy van Dam, Rae Earnshaw, Jose Encarnacao, Richard Guedj, Jennifer Preece, Ben Shneiderman, John Vance (editors), ACM SIGGRAPH Computer Graphics, Vol. 33, No. 3, August 1999, pp. 42-62.

Jason Leigh, Andrew Johnson, Tom DeFanti, Stuart Bailey, Robert Grossman, "A Tele-Immersive Environment for Collaborative Exploratory Analysis of Massive Data Sets," ASCI 99, pp. 3-9, Heijen, the Netherlands, June 15-17, 1999, http://www.evl.uic.edu/cavern/TIDE/tide.pdf

Maxine Brown, "CAVERN: The CAVE Research Network" (abstract), TERENA NORDUnet Networking Conference 1999: The Challenge of Gigabit Networking, Lund, Sweden, June 7-10, 1999, http://www.terena.nl/tnnc

H.3. Software Releases

CAVERNsoft G2, a C++ toolkit for building collaborative networked applications or "logistical networking" applications, is now available on the web. 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, 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. For more info and download, visit [www.evl.uic.edu/cavern/cavernG2]; for more info on Globus visit [www.globus.org].

QoSIMoTo (QoS Internet Monitoring Tool) [www.evl.uic.edu/cavern/qosimoto] has been released on the web for IRIX and Linux. QoSIMoTo is a program to view, in real-time, latency, bandwidth and jitter of multiple flows in Netlogger format. The program runs in the CAVE, and on SGI desktop workstations and Linux PCs running in CAVE-simulator mode.

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

H.4. Other International Activities

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

I. Appendix II: Euro-Link Applications

This appendix represents a major UIC/EVL effort to compile a list of meritorious applications involving US/Euro-Link researchers. This information will soon be put on the Euro-Link and STAR TAP web sites. Applications are organized here by NRN; the web version will have the applications further organized by scientific discipline.

I.1. CERN

CERN applications are documented in their proposal to NSF requesting permission to connect to STAR TAP; it can be found at http://nicewww.cern.ch/~omartin/cern-nsf.html

Networked Experiments of the European Laboratory for Particle Physics (CERN)

CERN; Argonne National Lab, 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 and CERN, 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 form more than 50 institutes spread over the five continents.

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

Large Hadron Collider (LHC) project

CERN; USA; Others.

Harvey Newman, Caltech and CERN, 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; 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

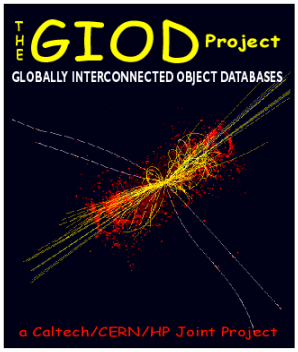
Compact Muon Solenoid (CMS)

CERN; 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 and CERN,
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 the data from the CERN CMS detector will be reduced by a factor >107, it will amount to over a petabyte (1015 bytes) of data per year accumulated 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; USA; Others.

Harvey Newman, Caltech and CERN,
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; USA; Others.

Harvey Newman, Caltech and CERN,
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 hundreds of registered hosts running the VRVS software in more than 28 countries. There are currently 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 now 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, among others, and the spawning of other sets of "Virtual Rooms" in Russia.

http://VRVS.cern.ch/

I.2. Israel IUCC

The Israeli Ministry of Science is funding 14 Israeli "Internet-2" projects [http://www.internet-2.org.il/most-apps.html]. All these applications have US partners who are on Abilene, vBNS or other NGI networks. (Unfortunately, this web site does not always specify who the US partners are, although we are trying to find out.) Additional applications are documented at [http://www.machba.ac.il/I2/applications.html].

Routing & Scheduling for Large Scale Broadband Networks

Technion, Israel.

Raphael Rom, Technion, Haifa, rom@ee.technion.ac.il
Ariel Orda, Technion, Haifa, ariel@ee.technion.ac.il
Adrian Segall, Technion, Haifa, segall@ee.technion.ac.il

Servers & Protocols for Complex Internet Auctions

Hebrew University, Israel.

Daniel Lehman, Hebrew University, Jerusalem, lehmann@cs.huji.ac.il
Noam Nisan, Hebrew University, Jerusalem, noam@cs.huji.ac.il

Interleaved QoS-based Management for Wide Bandwidth Communication Protocols

Hebrew University, Israel.

Danny Dolev, Hebrew University, Jerusalem, dolev@cs.huji.ac.il

Algorithm & Protocols for the New Generation IP (IPv6)

Technion, Israel.

Reuven Cohen, Technion, Haifa, rcohen@cs.technion.ac.il

Telepresence Microscopy

Technion, Israel.

Wayne Kaplan, Technion, Haifa, kaplan@tx.technion.ac.il

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

Hebrew University, Israel.

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

Bioinformatics Internet Server: Protein Annotation Understanding of Gene Expression Patterns

Hebrew University, Israel.

Nir Friedman, Hebrew University, Jerusalem, nir@cs.huji.ac.il
Naftali Tishby, Hebrew University, Jerusalem, tishby@cs.huji.ac.il

Computer Alchemy using Virtual Reality on Internet2

Technion, Israel.

Joan Adler, Technion, Haifa, phr76ja@phjoan.technion.ac.il
Rafi Kalish, Technion, Haifa, kalish@ssrc.technion.ac.il
Wayne Kaplan, Technion, Haifa, kaplan@tx.technion.ac.il

Interactive Process Design Studio

Technion, Israel; University of Pennsylvania, USA; University of Utah, USA.

Daniel Lewin, Technion, Haifa, lewin@tx.technion.ac.il
Warren D. Seider, University of Pennsylvania, seider@sas.upenn.edu
J.D. Seader, University of Utah, seader@ute.cc.utah.edu

Applying Near Real Time 1-km AVHRR Satellite Data for Examination of Vegetation Conditions & Related Human Health Concerns in Northeastern Africa (BGU/IDR/RSL-NASA/GSFC Collaboration)

Ben Gurion University of the Negev, Israel.

Arnon Karnieli, Ben Gurion University of the Negev,

karnieli@bgumail.bgu.ac.il

Development of GeneDis–Human Genetic Disease Database

Tel Aviv University, Israel.

Nir Ben-tal, Tel Aviv University, bental@ashtoret.tau.ac.il
Rachel Kreisberg-Zakarin, Tel Aviv University, racheli@post.tau.ac.il

World Wide Waves-Global Solution of Multidimensional Wave Equations on a Distributed Net

Technion, Israel.

Uri Peskin, Technion, Haifa, uri@chem.technion.ac.il
Ilan Bar-On, Technion, Haifa, baron@chem.technion.ac.il

Challenges in Emerging Learning Technologies using Intenet2: Developing WEB based Teaching & Real-Time Consultation Program for Prenatal Sonographic Examinations

Technion, Israel; Rambam Hospital, Israel.

Shai Linn, Technion and Rambam Hospital, Haifa, linn@tx.technion.ac.il
Etan Zimmer, Technion and Rambam Hospital, Haifa, etan@tx.technion.ac.il
Moshe Bronstein, Technion and Rambam Hospital, Haifa

The 21st Century School

Israel; North Carolina University, USA.

Hamutal Hameiri, North Carolina/Israel Project, ncip@netvision.net.il

Video of Demand (VoD)

Israel; 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

Application title: Interactive Simulation in the Field of Plant Nutrition

Tel Aviv University, Israel; Penn State University, USA.

Amram Eshel, Department of Plant Sciences, Tel Aviv University, Israel, amram@post.tau.ac.il
J.P. Lynch, Department of Horticulture, Penn State University, USA, jpl4@psu.edu

This US-Israel Bi-national Agricultural Research and Development (BARD) Foundation project involves hypotheses testing and result evaluation, using *SimRoot*, a 3D interactive graphic model that visualizes 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.

I.3. NORDUnet

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

University of Oslo, Norway.

Gunnar Liestol, Institut for Medier og Kommunikasjon, University of Oslo, gunnar.liestol@media.uio.no

The LEARN2 project develops 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) is being 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

NORDUnet Supports Global Observation Information Network Demonstration in Stockholm

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

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.nordu.net/news/index.html#goin, 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:

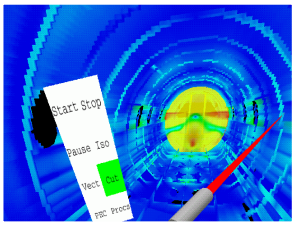
- PDC participates in the Globus/GUSTO testbed [www.globus.org]. At SC'97, PDC contributed with a computational electromagnetic application running across a number of sites.
- At the NCSA/Alliance'98 conference, PDC participated in a global virtual environment demonstration. Together with 4 US sites (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. The testbeds will put high demand on the transatlantic links, 155-622 Mbps.

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

Center for Parallel Computers (PDC), Royal Institute of Technology, Stockholm; University of Houston, USA; Argonne National Laboratory, USA.



This project investigates computational steering of finite difference code for electromagnetic simulation using virtual reality to control the computation. To handle the large computational requirements of both simulation and visualization, the system is distributed across multiple machines using Globus.

I.4. RENATER2

RENATER2 applications relying on STAR TAP are documented at [http://www.renater.fr/International/STARTAP-en.htm]. For security reasons, the web documentation does not include IP addresses. For French legal reasons, it does not include names of contacts, but in most cases, they can be obtained upon specific request from RENATER.

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

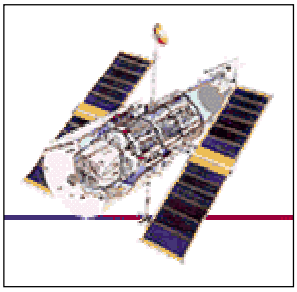
Fluctuations de Brillance de Surface

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.

Study of the LICs.

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/

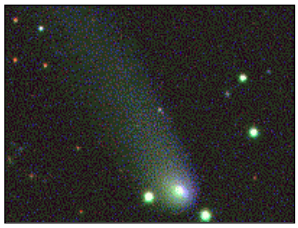
Serveur d'Éphémérides MPC/CBAT de l'U.A.I.

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

HESSI

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

X/Gamma spectro-imagery of solar flares.

http://www.obspm.fr,

http://spacelink.nasa.gov/NASA.Projects/Space.Science/ SunEarth.Connection/HESSI/index.html

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), University 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

INDOEX

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

California, San Diego, USA.

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/

I.5. SURFnet

iCAIR Consortium QBone Proposal

iCAIR, Northwestern University, USA; MREN, USA; TransPAC, Indiana University, USA; Centre for Telematics and Information Technology, University of Twente, The Netherlands; Utrecht University, The Netherlands.

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QBone is an Internet2 initiative to build a testbed for new IP quality of service (QoS) technologies. New advanced network applications like remote instrument control, scientific collaboratories, and virtual classrooms will give universities the tools needed to fulfill their teaching and research missions of the 21st Century – but only if the demands that these new applications place on the network can be met. The QBone testbed will initially implement the differentiated services (DiffServ) approach to QoS that is now taking shape within the IETF.

http://qbone.ctit.utwente.nl/,
http://www.internet2.edu/qos/qbone/

Architectural Walk-Through Coupled with a Parallel Lighting Simulation

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

SARA and EVL/UIC are investigating tele-immersion visualization techniques inside networked CAVES. In architectural design, the lighting of a room can be simulated accurately using a technique called radiosity, which is computationally intensive. If architectural designs are reviewed in virtual reality, the images must be generated in real-time–but real-time lighting conditions are calculated using an empirical shading model that is inadequate. At the SC'98 iGrid event, SARA researchers showed an architectural walk through in which lighting conditions were computed with a parallel radiosity simulation running on a remote supercomputer. When lighting conditions were changed (e.g., switching lights on or off, changing colors) the simulation computed new room shading and sent the data to a virtual-reality-display over a high-speed network. Within seconds, a new lighting of the room can be evaluated.

In 1999, Amsterdam architect Rem Koolhaas used SARA's CAVE and the collaborative software Saranav to visualize and review his 1998 award-winning design of the new Campus Center at Illinois Institute of Technology's historic Mies van der Rohe campus in Chicago. Collaborative Saranav was built in cooperation with the Electronic Visualization Laboratory (see Section G.5).

http://www.sara.nl/hec

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