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 (April 1, 2001- March 31, 2002)

SUBMITTED April 23, 2002

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1. Participants

1.A.   Primary Personnel

Participant's Name(s)	Project Role(s)	>160 Hours/Yr
Thomas A. DeFanti	Principal Investigator	Yes
Maxine Brown	Co-Principal Investigator	Yes
Andrew E. Johnson	Co-Principal Investigator	Yes
Daniel J. Sandin	Co-Principal Investigator	Yes

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

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

| Participant's Name(s)	Project Role(s)	>160 Hours/Yr
Jason Leigh	Senior Personnel/Professional Staff	Yes
Michael McRobbie	Senior Personnel/Professional Staff	Yes
Doug Pearson*	Senior Personnel/Professional Staff	No
Jim Williams	Senior Personnel/Professional Staff	Yes
Linda Winkler+	Professional staff	Yes
Bill Nickless+	Professional staff	Yes
Alan Verlo	Professional staff	Yes
Laura Wolf	Professional staff	Yes
Patrick Hallihan	Professional staff	Yes

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 He has been replaced by Jim Williams at Indiana University

+ Linda Winkler and Bill Nickless, while not compensated by the University of Illinois at Chicago, serve as part-time STAR TAP/Euro-Link engineers.

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

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

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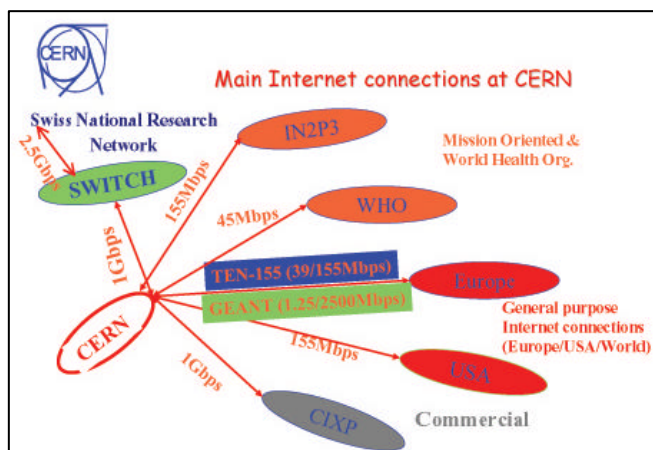
The European Laboratory for Particle Physics (CERN) [http://cern.ch], on the Franco-Swiss border near Geneva, provides experimental facilities for particle physics experiments, mainly in the domain of high-energy physics (HEP). CERN's current major facility is the Large Electron Positron (LEP) collider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

LEP experiments generate 25 TBs of data each year, which is stored on magnetic tapes. The LHC experiments are expected to produce several-orders-of-magnitude more data, namely tens of petabytes per experiment each year. The sheer volume of data combined with the complexity of the analysis to be performed, and the requirement that the processing of the data may also be done remotely, places heavy demands on the High Energy and Nuclear Physics

(HENP) computing and networking infrastructure, which can only be met by using leading-edge technology and services.

ISRAEL INTER-UNIVERSITY COMPUTATION CENTER (IUCC)
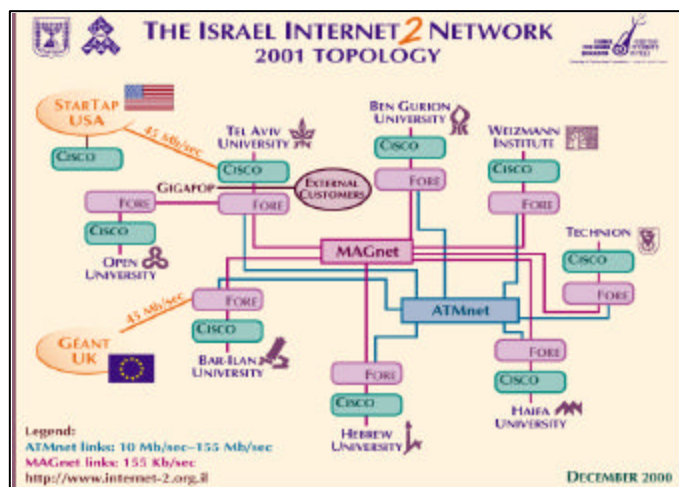
Israel's IUCC [http://www.internet-2.org.il] coordinates and advocates the computing needs of Israel's research and academic infrastructure. IUCC was created by eight Israeli universities, and is funded by the Committee for Planning and Budget of the Council for Higher Education.

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

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

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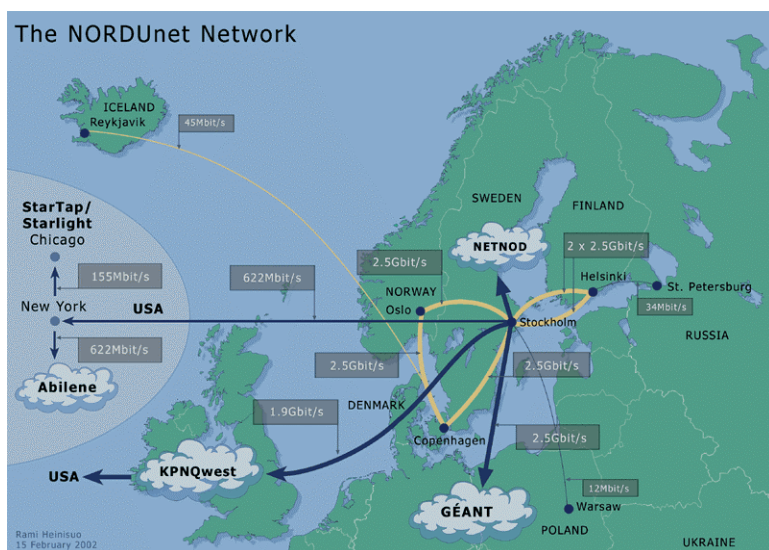
NORDUnet [www.nordu.net] serves the universities and publicly funded research institutions in Denmark, Finland, Iceland, Norway and Sweden. The national and international bandwidths are in the Gigabit range. The five national networks collaborate in the commonly owned NORDUnet to get international connectivity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

In October 2001, NORDUnet upgraded its backbone to 2.5Gb. This was a major upgrade of the previous Nordic backbone, which consisted of 2x155Mb connections to each of the countries. NORDUnet's core nodes in Stockholm, Oslo and Copenhagen form a network ring, giving the necessary resiliency in case of link failure. Iceland connects to NORDUnet at 45Mb. Denmark, Finland and Norway are all doubly connected to the NORDUnet backbone at 2.5G. The total international bandwidth connected to NORDUnet's central node at KTH in Stockholm is now approximately 10Gb.

NORDUnet also serves networks for research and education in Poland (NASK/12Mb), Estonia (EEnet/ 16Mb), Ukraine (UARnet/1Mb), and Russia (RUNNEt/34Mb).

In September 2001, NORDUnet located its US PoP at StarLight (initated by carrier delays in getting an OC-3 connection to STAR TAP).

RENATER2
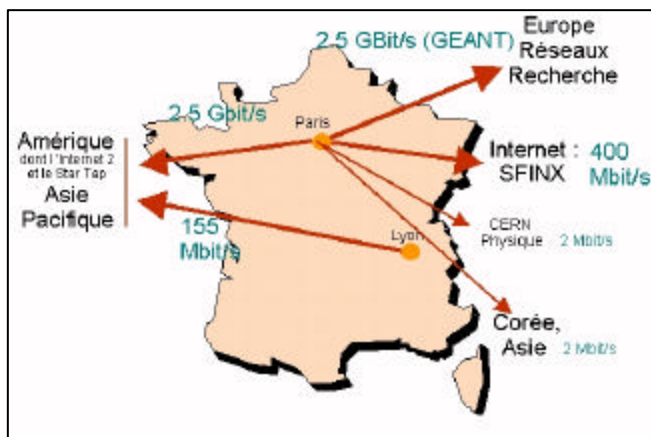
GIP RENATER [www.renater.fr] is a non-profit organization owned by five large research and education groups in France. Users of RENATER2, the national backbone of GIP RENATER, are advanced scientific laboratories and higher education institutions. RENATER2 is a nation-wide infrastructure connecting campuses, metropolitan and regional networks with IP and (optionally) ATM services, and has international linkages to other European countries and to STAR TAP. RENATER2 accesses the commodity Internet through the Open-Transit service of France Télécom.

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

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 enables connections with other national and international networks.

SURFnet promotes cooperation between Dutch research institutions and US NGI/Internet2 sites. In Year 3 of Euro-Link, SURFnet closed its New York PoP and brought up two OC-12 production links and a 2.5Gb research link between Amsterdam and StarLight.

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

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

1.C.2. US Management Team

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

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

INDIANA UNIVERSITY

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

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

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

AMERITECH ADVANCED DATA SERVICES (AADS)

The AADS Network Access Point (NAP) [www.aads.net] is an Internet Exchange Point where ISPs meet to exchange traffic with other attached ISPs. The NAP is a layer 2 switched service that is not directly involved with routing IP datagrams; only forwarding Asynchronous Transfer Mode (ATM) cells between ISPs. The NAP is a large ATM switch providing both high speed and a high degree of scalability. Interface speeds currently supported include: DS-3, OC-3c and OC-12c. Ameritech and STAR TAP have been models for next-generation NGI eXchanges (NGIXs).

MREN

The Midwest's Metropolitan Research and Education Network (MREN) [http://www.mren.org] is a regional network connecting Midwest-area research institutions. It is a model for GigaPoPs, or other regional networks. MREN is one of the world's most advanced high-performance broadband networks, developed to support a wide range of advanced research applications requiring high performance and high bandwidth. UIC is one of the founding members of MREN. Joe Mambretti, director of the iCAIR center at Northwestern University, is the director of MREN and Linda Winkler of ANL is MREN's technical director. Over the past year, MREN member institutions have been connected to the AADS NAP at 622Mb; in recent months, MREN is in the process of relocating to the StarLight facility and upgrading to 1Gb.

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

The goal of iCAIR [www.icair.org], under the leadership of Joe Mambretti, is to accelerate leading-edge innovation and enhanced global communications through advanced Internet technologies, in partnership with the international community. iCAIR was established to provide a focal point for leading-edge Internet research, innovation, and pre-production deployment. iCAIR is an international research and development center that creates large-scale, advanced digital communication systems based on Internet protocols, in part, by utilizing regional, national and international advanced research networks. iCAIR is very involved in the Digital Video Working Group of the Coordinating Committee for International Research Networks (DVWG, CCIRN) as well as the Internet2 Digital Video (I2-DV) Initiative, and works closely with several Euro-Link NRNs.

STAR TAP

STAR TAP [www.startap.net], managed by UIC/EVL and operated by AADS, is an NSF-funded persistent infrastructure to facilitate the long-term interconnection and interoperability of advanced international networking in support of applications, performance measuring, and technology evaluations. STAR TAP anchors the international NSF Connections program. It enables traffic to flow to international collaborators from the approximately 200 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.

STARLIGHT

Star Light [http://www.startap.net/starlight/], the optical STAR TAP, is managed by UIC/EVL, NU/iCAIR, and

ANL/MCS. It is located on the Northwestern University medical campus in downtown Chicago. StarLight is an advanced optical infrastructure and proving ground for network services optimized for high-performance applications. StarLight is being developed in partnership with Canada's CANARIE and Holland's SURFnet. StarLight connects to STAR TAP at the AADS NAP in Chicago via an OC-12 ATM link. The primary advantages of StarLight are space and collaboration opportunities for Gigabit-enabled applications, optical switching and, eventually, optical routing. Star Light is implementing a number of advanced layer 2 and layer 3 services of benefit to the Euro-Link community.

1.C.3. Consortia

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

AMPATH

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

NAUKA-NET (formerly FASTnet/MIRnet)

Nauka-Net [http://www.friends-partners.org/friends/fastnet/home.html] is a NSF HPIIS program with matching support from the Ministry for Science and Technology of the Russian Federation. The consortium includes National Center for Supercomputing Applications (NCSA) at the University of Illinois, the Russian Institute for Public Networks (RIPN), Moscow State University (MSU), Friends and Partners-Russia (F&P/R), the VUZTelecom Center of St. Petersburg, and other key Russian and US organizations.

TRANSPAC

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

1.D. Other Collaborators or Contacts

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

The NSF Partnerships for Advanced Computational Infrastructure (PACI) Cooperative Agreement to the National Computational Science Alliance (the "Alliance") [http://alliance.ncsa.uiuc.edu], whose lead institution is the National Center for Supercomputing Applications (NCSA), funds, in part, the UIC Electronic Visualization Laboratory (EVL) to deploy research results in virtual reality, networking, visual supercomputing, distributed computing and networked collaboration. (PACI does not fund basic research; it assumes partners already *have* research results and are funded by peer review in their disciplines.) NCSA and Alliance director Dan Reed is very supportive of STAR TAP.

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

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

CAVERNUS

The CAVE Research Network User's Society (CAVERNUS) [http://www.ncsa.uiuc.edu/VR/cavernus] gives the worldwide community of VR device users a place to share ideas, solutions and discoveries as they interconnect over high-speed networks. The universities, research laboratories and commercial R&D facilities supporting this web site are also the primary users of EVL's CAVERNsoft. CAVERNUS hosts an advanced CAVE workshop series that introduces advanced programming and visualization techniques to optimize the use of projection-based virtual-

reality display systems, and hosts Birds of a Feather (BoF) or Special Interest Group (SIG) meetings at major conferences. As EVL continues to enhance CAVERNsoft, we conduct network and visualization experiments with international collaborators via STAR TAP and StarLight.

EMERGE

EMERGE was initially a DoE funded effort to achieve and demonstrate Differentiated Services (DiffServ) over the Midwest Metropolitan Research and Education Network (MREN), ESnet and Abilene. [http://www.evl.uic.edu/cavern/EMERGE/] We have extended these QoS experiments to Europe and Asia via STAR TAP. (CERN has participated in EMERGE experiments, in part, by establishing a successful DiffServ testbed between its lab and Northwestern's iCAIR.)

GLOBUS AND THE GLOBAL GRID FORUM

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

GRID PHYSICS NETWORK (GriPhyN)

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

DataTAG

The DataGrid [www.eu-datagrid.org] is a European Union (EU) funded project to enable next-generation scientific exploration that requires intensive computation and analysis of shared large-scale databases across distributed scientific communities. The EU-funded DataTAG (Research and Technological Development of a Trans-Atlantic Grid) [www.eu-datagrid.org] initiative will support a 2.5Gb transatlantic link to StarLight to enable European and USA grid projects to collaborate.

This link, planned for July 2002, will be purely for research, over which various network measurements, demonstrations and experiments will run. The EU will support the transatlantic link with first-year matching funds provided by the NSF HPIIS Euro-Link award. The project will last two years, starting January 1, 2002. DataTAG partners are CERN (prime contractor), Particle Physics and Astronomy Council (PPARC) in the United Kingdom, the Italian National Physics Network (INFN) and the University of Amsterdam in The Netherlands.

NETWORK FOR EARTHQUAKE ENGINEERING SIMULATION

The NEESgrid integration project is being organized by NCSA and funded by the NEES program at NSF. [www.neesgrid.org, www.eng.nsf.gov/nees] The goal of NEESgrid is to design and integrate experimental and computing and communications facilities for use by the earthquake engineering community.

2. Activities and Findings

2.A. Research Activities

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

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

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

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

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

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

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/StarLight. Each operates ~155Mb network, an aggregate bandwidth of hundreds of Mb.

CERN (OC-3)

CERN plans to convert its current STAR TAP OC-3 service to an OC-12c connection terminating at the StarLight facility in Spring 2002. The European Union (EU)-funded "DataTAG" link, an OC-48 (2.5Gb) from CERN to StarLight, is planned for Summer 2002. By late 2002, CERN hopes to upgrade DataTAG to a 10Gbps connection to Chicago, and to connect to the TeraGrid at 2.5Gb. CERN hopes to have a 10Gb TeraGrid connection in 2003.

CERN's circuit upgrade to OC-12c will support research production traffic between IN2P3 and CERN to vBNS, ESnet, Abilene, etc. (IN2P3 is the National Institute of Nuclear and Particle Physics, a CNRS (French National Center for Scientific Research) institute that currently sends traffic over the CERN link to STAR TAP.) After 2002, the link will be upgraded by a factor of ~2 each year, to reach 10Gb by 2006.

ISRAEL IUCC (DS-3)

Israel will disconnect its STAR TAP connection on May 1, 2002 and no longer participate in Euro-Link

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

funding. Since the European Union's Géant project pays 50% of the cost of a transatlantic circuit, Israel plans to take advantage of its Géant connection in order to connect to New York and Abilene.

NORDUNET (OC-3)

NORDUnet upgraded its Chicago connection from DS-3 to OC-3 in September 2001 and moved to the StarLight facility. NORDUnet peers with Abilene in New York and brings non-Abilene research traffic to StarLight.

RENATER2 (DS-3)

In November 2001, RENATER2 upgraded its link to STAR TAP from a DS-3 to an OC-3. This link will soon be upgraded to an OC-12, and Dany Vandromme is considering connecting to StarLight. He is also considering bringing a 2.5Gb circuit to StarLight.

SURFNET (Two OC-12's; one 2.5Gbps)

SURFnet closed its New York PoP in July 2001 and brought two 622Mb connections to the StarLight facility in Chicago. SURFnet has now built its PoP at StarLight. A 2.5Gb lambda connection from Amsterdam to StarLight came up in late December 2001. SURFnet has a Cisco ONS 15454 (optical transport platform) at StarLight, which Kees Neggers invites others (e.g., CERN, MREN) to plug into, as needed.

The UIC National Center for Data Mining (NCDM) has clusters both at StarLight and at NetherLight (at SARA in Amsterdam). EVL and NCDM will begin testing applications from Chicago to Amsterdam at 2xGigE rates next quarter.

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

To comply with the Acceptable Use Policies (AUPs) of the High-Performance Internet Service Providers that NSF approves (vBNS, Abilene), Euro-Link NRNs segregate their research and commodity traffic either at home or on the US East Coast prior to connecting to STAR TAP/StarLight.

2.A.4. Network Performance and Usage

CERN

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

Israel IUCC

IUCC maintains a site of statistical information about all its connections [http://www.internet-2.org.il/stats.html].

NORDUNET

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

RENATER2

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

SURFNET

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

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

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

As they are developed, these tools are incorporated into EVL's CAVERNsoft, a cross-platform C++ toolkit for building tele-immersive applications with special emphasis on networking. CAVERNsoft is divided into two modules: the data-sharing module *and the* virtual-reality module. *The data-sharing module provides the most comprehensive set of networked data distribution tools currently available in a single tele-immersion library. It*

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consists of a broad variety of C++ classes to match almost every conceivable model for distributed processing? from distributed shared memory to message passing to remote procedure calls. It also provides features for high-throughput data transmission and network monitoring; every CAVERNsoft networking class has built-in network monitoring so that applications can easily profile their network resource utilization. CAVERNsoft is the main software infrastructure that supports our work in network performance metrics. CAVERNsoft is currently deployed at the OpenChannels [www.openchannelsoftware.org] website.

2.A.5.a. Network Monitoring Tools

BANDWIDTH UTILIZATION RADAR MAP

Under Jason Leigh's supervision, EVL student Brenda Lopez is working with STAR TAP engineer Linda Winkler to develop graphical radar maps for the STAR TAP and StarLight routers. Because of frequent equipment moves between the AADS NAP and StarLight, she is unable to gather usage statistics at this time. Work on the maps will resume once the environments are stable.

**UNIFIED COLLABORATORY FOR ANALYZING NETWORKS (UCAN)**

UCAN is an extendable integrated framework that lets network researchers and application developers monitor network utilization of applications and obtain network state information simultaneously. UCAN is also fully collaborative and helps participants view results and control remote experiments. EVL student Naveen Krishnaprasad, who received an MS degree under Jason Leigh for developing UCAN, plans to (a) incorporate UCAN into EVL's CAVERNsoft software, and (b) develop UCAN experimental testbeds between EVL and other STAR TAP/StarLight member networks. (In February 2002, Naveen sent the prototype version of UCAN to KISTI (Korea Institute of Science and Technology Information) for installation on its network. DiffServ tests between EVL and KISTI are planned for this summer.)

VITAL STATISTICS MONITOR (VitaMon)

EVL student Brenda Lopez is designing a vital statistics monitor (VitaMon) for collaborators to use while running networked applications. It will be a graphical optical traffic map that shows all incoming/outgoing bandwidth among StarLight sites. VitaMon may either employ RTPL or Globus' Network Weather Service to measure end-to-end bandwidth and delay between multiple points connected to STAR TAP.

2.A.5.b. Low-Latency State Transmission Over Long-Distance Networks

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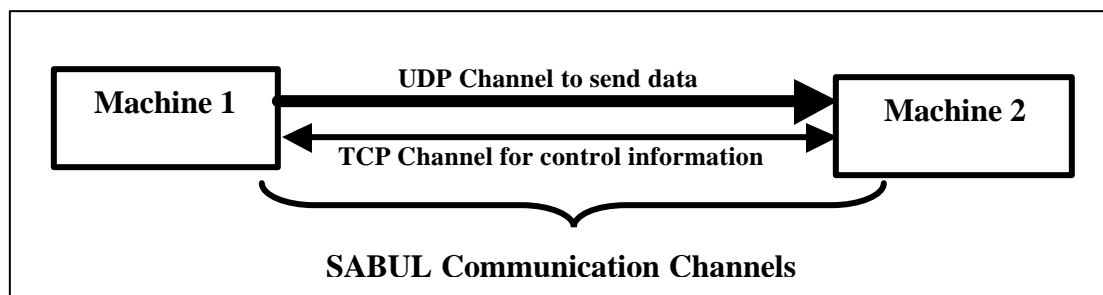
SABUL is a C++ library for large data transfers over high-speed wide-area networks. It is a rate-control-based protocol similar to NETBLT, but with two fundamental improvements over NETBLT and similar implementations of rate-controlled RUDP protocols: the use of both TCP and UDP channels in the protocol,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

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

PARALLEL SOCKET (PSockets) TOOLS

PSockets is a library that stripes data across multiple TCP sockets; it was developed by EVL in collaboration with UIC's Bob Grossman. Currently, in network performance studies between Chicago and Amsterdam, we are getting 400Mb throughput doing TCP experiments over SURFnet's 622Mb link. To achieve this level of throughput, 300 parallel sockets have to open.

Also, based on conversations with Harvey Newman at Caltech last year, who is involved with GriPhyN and the design of Petascale Virtual Data Grids to deal with the results of Large Hadron Collider experiments, we have started performing networking experiments between Chicago and CERN using parallel TCP.

RELIABLE BLAST UDP (RUDP)

Jason Leigh is supervising EVL Ph.D. student Eric He to implement a RUDP transmission scheme to accelerate reliable data transmission over fat networks. In RUDP, the sender blasts all the data (each packet is identified by a sequence number) to the receiver. Upon receipt, the sequence numbers are checked and any lost packets are identified. The receiver then sends a lost packet report back to the sender through TCP. Upon receipt of the report, the sender retransmits the lost packets. The procedure continues until the receiver receives all packets. This technique is believed to be most effective when used in conjunction with QoS, since the guaranteed bandwidth will minimize transmission errors. The RUDP scheme exploits low transmission errors to maximize throughput. In October 2001, Eric's revised RUDP code was integrated into the new version of CAVERNsoft. The new classes allow application developers to transfer bulk data over high-speed networks. October RUDP experiments over the CERN/EVL OC-3 link showed that the throughput outperformed Parallel TCP (PTCP) ? 60Mb throughput from the testbed, as compared to 41Mb using PTCP.

FORWARD ERROR CORRECTION (FEC)

Eric rewrote the FEC code for future integration into CAVERNsoft. Since FEC protocol is mainly used to stream data, he created an interface specifically for streaming data between machines, and is ready to begin testing. The next steps are to conduct more FEC experiments based on the new code, to make RUDP responsive to network congestion, and to incorporate the protocols into the QUANTA framework.

2.A.5.c.   Ultra-High-Bandwidth Transmission Over Long Distance Networks (StarLight)

QUALITY OF SERVICE ADAPTIVE NETWORKING TOOLKIT (QUANTA)

In February 2002, NSF awarded a three-year, $540,000 grant to Jason Leigh and Oliver Yu to develop QUANTA. QUANTA is an applications-level API that translates high-level data distribution requirements into low-level optimized networking protocols and parameter settings. This work is specifically targeted for optical networks. EVL PhD students Naveen Krishnaprasad and Eric He expect to finish the first version of QUANTA by Summer 2002. This adaptive QoS middleware will include advanced high-performance network protocols such as Parallel TCP, RUDP and FEC. Eric He will develop a set of heuristic rules to make the best protocol selections based on the available resources and network conditions. The input of the engine is user QoS requirements; the output of the engine is the optimal strategy? the optimal transport protocol and suitable parameters.

INTERRUPT COALESCING AND JUMBO FRAMES

EVL currently has two 16-node Linux clusters on order; one for the StarLight facility and one for UIC. Engineers expect both to be installed by Summer 2002. The StarLight cluster will augment the four-node PC cluster currently used by EVL to run tests to Northwestern University. The new cluster will have three times the bus bandwidth (400MHz x 64bits=2.98GBytes/s) of the current four-node cluster. In the past, EVL was able to only achieve ~500Mb (local area) PC transmission rate out of the box. With appropriate tuning using *Interrupt Coalescing* and *Jumbo frames*, EVL has achieved bandwidth of 850Mbps.

EVL is working with Cees de Laat at University of Amsterdam and Paul Wielinga of SARA to perform tests over the 2.5Gb NetherLight/StarLight link. Tests include VNC for streaming of clustered desktops, WireGL for streaming OpenGL visualizations, and streaming stereoscopic visualizations.

TERA-VISION: ULTRA-RESOLUTION VISUALIZATION STREAMING

Tera-Vision, currently under development, will be a platform and software independent solution for real-time display distribution in advanced collaborative environments. Tera-Vision will be a real-time method to distribute visual imagery from any graphics platform over the Access Grid that requires no setup, software, or hardware changes to a user's computer. The goal is to provide one solution for what is commonly referred to as the "Docking

Problem/Display Pushing Problem" on the Access Grid; i.e., to provide a means for anyone on the Access Grid to plug-in their laptop and deliver a presentation without having to install or configure any software, or distribute any of the data files in advance.

EVL student Rajvikram Singh is working on the Tera-Vision project to stream high-resolution video streams between clusters using distributed servers and clients. He will begin testing jitter and bandwidth usage on clusters at EVL and at StarLight in Spring 2002. Our semester goal is to stream animation to University of Amsterdam. Raj is also porting the Tera-Vision code to Windows and integrating a video capture card. He also intends to test a version of the Tera-Vision code that can be used to stream video to EVL's Access Grid environment (which is augmented with stereo capability). A cluster-to-cluster streaming experiment between EVL and University of Amsterdam is expected in summer 2002.

TERA-SCOPE

Tera-Scope is a research project for the development of new algorithms and tools to interactively query, mine, correlate, visualize and display terabyte datasets on either high-resolution tiled displays or desktop workstations.

EVL MS student Rajvikram Singh is working with EVL PhD student Charles Zhang on the Message Passing Interface (MPI) programming to enable Tera-Scope code to run in parallel on clusters. Charles is incorporating visualization capabilities into the 3D user interface design, providing parallel pipelines between the user interface and large datasets (i.e., 10Gb), and making parallel the query, computation and display over high-speed networks.

2.A.5.d. Advanced Collaborative Environments (ACE) Grid Working Group

Progress toward a Global Grid Forum working document on the security requirements of advanced collaborative environments was reported by ACE co-chair Jason Leigh after attending the Global Grid Forum 4 (GGF4) in Toronto, Canada February 18-19, 2002. Leigh and Rick Stevens of ANL formed the ACE Working Group [http://calder.ncsa.uiuc.edu/ACE-grid/] at the Global Grid Forum in Amsterdam last March to complement other Grid Working Groups [http://www.gridforum.org/]. ACE will provide human-centered techniques and technologies for facilitating interactive, collaborative, and immersive access of Grid resources from anywhere, at any time.

2.A.5.e. Network Performance Studies for European/US Collaborative Art Project

EVL student Dave Pape received his PhD in Computer Science in June 2001 for developing "Yggdrasil (YG)," a script-based, authoring environment for networked virtual-reality applications. This tool allows non-programmers to create effective, behavior-rich art and science virtual-reality environments. YG and CAVERNsoft were used to develop tele-immersive art works for "EVL: Alive on the Grid," a virtual-reality experience demonstrated at the Ars Electronica Center (AEC) Festival in Austria, September 1-6, 2001 [http://www.aec.at]. Participants included artists from three US universities (UIC, Indiana University and SUNY-Buffalo) and four European countries (Austria's AEC; Hungary's C3 [http://www.c3.hu/]; The Interactive Institute of Sweden [http://www.interactiveinstitute.se/]; and, The Netherlands' SARA, Technische Universiteit Eindhoven, and V2 Organization Institute for the Unstable Media, Rotterdam [http://www.v2.nl/]) for the entire five-days of the Festival. Fourteen EVL students and two EVL faculty members attended.

EVL co-director Dan Sandin extended the YG library for behaviors and network performance tests. He supervised Pape and EVL student Joseph Tremonti in the development and execution of real-time network performance tests among the participating sites. There were two communication components measured between the networked VR systems: (1) audio tele-conferencing *(aconf)* and (2) a dynamic database representing the virtual worlds. Audio teleconferencing generated roughly 15 kilobytes of traffic per site, and was fairly constant. (*aconf* uses CAVERNsoft as its networking layer.) The VR worlds database was fairly complex, and included 1,188 objects, 363 sounds, ~1,200 dynamic nodes, ~14,000 database entries and 2.5 gigabytes of data. This represented the largest shared VR experience done by EVL in terms of shared virtual entities.

Network constraints among participants were as follows: maximum bandwidth measured out of AEC was 1.5Mb (using a 2Mb link). Connections among EVL (Chicago) to SARA (Amsterdam), SUNY (New York), Indiana University (Indiana) and the Interactive Institute (Umea, Sweden) were 8Mb. The Budapest connection went over Hungary's commodity network, measuring less than 1Mb, and frequently caused a bottleneck. During rehearsals, information was served from the AEC CAVE, on a system using caching repeaters for the database. One repeater at AEC was used initially to communicate to external sites, but a 1.5Mb bottleneck was found at AEC, and only able to handle two internal (at AEC) and one external site at any time. As more external sites were added, the applications

lurched and stuttered. To redistribute the data load over the network, and take advantage of other good connectivity, Pape ran a caching repeater at AEC linked to a caching repeater at EVL and all external sites except Budapest. This setup allowed up to seven sites to operate smoothly, with the exception of interruptions caused when sites joined the system. Once attached, a site would download the system and it would even out. Seven sites connected with bandwidth measured by Netstat ？ 1.5 Mb from AEC and 4 Mb of outgoing traffic from EVL. Surprisingly, audio was able to survive at modest levels even during peak periods.

General network test results: In the morning (Linz time), bandwidth was normally 1.5-1.6Mb each way. In the afternoon, as the US woke up, it would decrease, sometimes dipping as low as 200Kb. The routing, and often the afternoon bandwidth, was asymmetric. At times, we would get 1+ Mb one way, and 250 Kb the other way (the US-to-Austria direction being faster). Round trip times were fairly consistent, averaging 140-150 ms. All of the ping tests reported 0% packet loss. The highest bandwidth recorded on the EVL repeater machine was when seven host sites connected on the third day (AEC CAVE, AEC ImmersaDesk, EVL, Sweden, New York, Indiana, and Hungary). At that point, Netstat reported roughly 550 KBytes/second (~4.4Mb) of outgoing traffic; we did notice a little bit of audio breakup. This would have been on EVL's "Kona" Onyx computer, with a 10Mb network interface. One possibility for the audio breakup is that the reflector program couldn't keep up with the number of packets, or that the EVL reflector to AEC connection lost packets in the afternoon. The event was a success despite stability problems when multiple sites were attached (which caused the repeaters to crash).

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

STAR TAP/StarLight/Euro-Link leadership continues to focus on providing high-level services to its constituents.
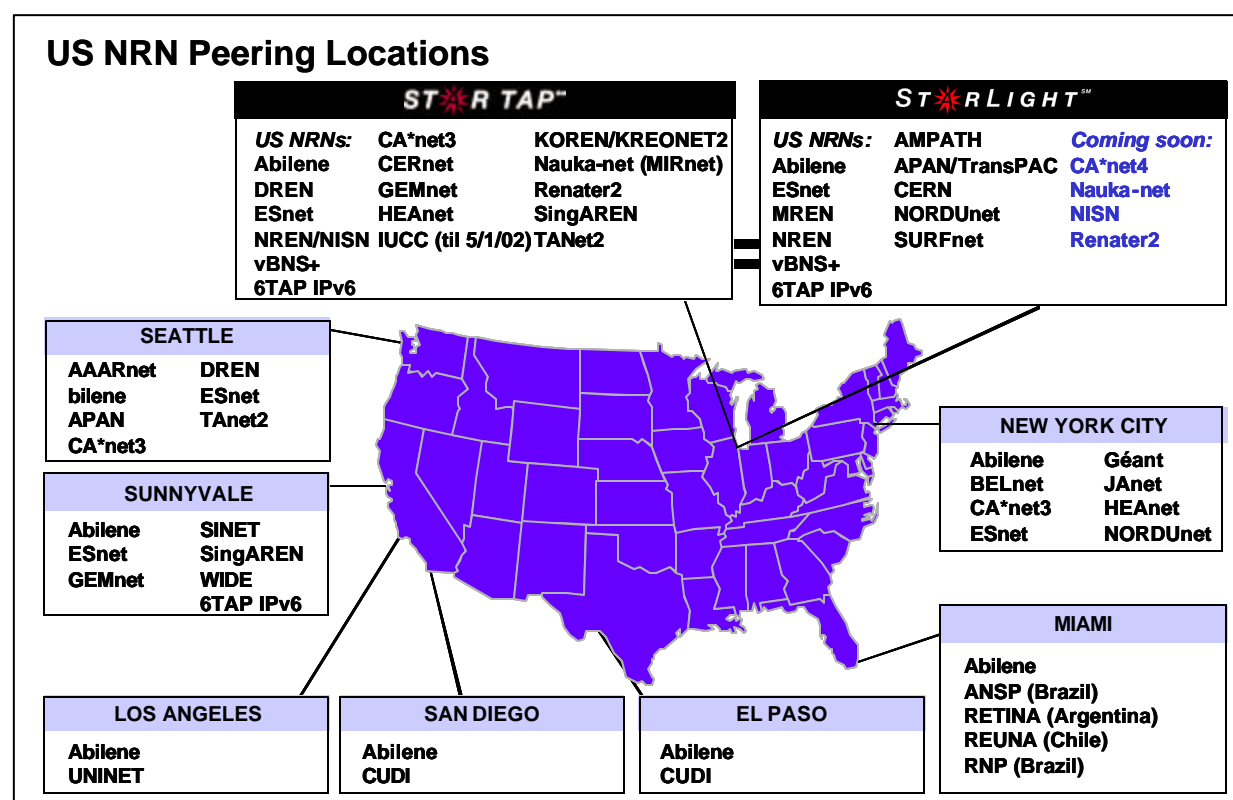
2.A.6.a. Peering: Bi-Lateral Agreements

STAR TAP and StarLight run in an Acceptable Use Policy (AUP)-free mode; that is, connecting networks must agree pair-wise regarding acceptable use. For STAR TAP relies on mature ATM switching as provided by AADS; for StarLight, we use a Cisco 6509 switch/router. Once connected, the NRNs can peer with US Next Generation Internet networks, UCAID's Abilene, and advanced networks from other countries. They can peer by bilateral agreement, which is functionally implemented at AADS with a full-mesh ATM Private Virtual Circuit (PVC) layer-2 service at the switch. Or, they can do level-3 peering using the STAR TAP/StarLight Router. They may also

connect to one or more ISPs at the AADS facility, which is outside the scope of STAR TAP and StarLight, but a useful capability nonetheless.

The list of STAR TAP and StarLight peers (both level 2 and level 3 peering) is currently in flux as NRNs move from STAR TAP to StarLight. As soon as the connections become stable, we will update the current peering matrix on our websites [www.startap.net/ENGINEERING, www.startap.net/starlight/ENGINEERING].

STAR TAP/StarLight Connections: Who Connects Where?																									
Updated April 21, 2002																									
	US Networks										Foreign Networks														
Peering Locations	Abilene	DREN	ESnet	MREN	NISN	NREN	vBNS+	STAR TAP Router	StarLight Router	6TAP: IPv6 Router	AMPATH	APAN/TransPAC	CA*net3/4	CERN	CERnet	GEMnet	HEAnet	IUCC	KOREN/KREONet	Nauka-net	NORDUnet	Renater2	SingAREN	SURnet	TANet2
STAR TAP	•	•	•		•	•	•	•		•		•		•		•	•	2	•		•		•	•	•
StarLight	•	3	•	1	3	•	•		•	•	•	•	3	•							3	•	3		•

1: MREN sites in transition from STAR TAP to StarLight

2: To disconnect May 1, 2002 and connect to Abilene via Geant in New York City

3: Coming soon

2.A.6.b. IPv6 Service at the 6TAP

Two 6TAP [www.6tap.net] IPv6 services are run by ESnet and CANARIE ？ one at STAR TAP and one at StarLight. 6TAP supports IPv6 over IPv4 tunnels and IPv6 performance measurement and statistics.

2.A.6.c. NLANR Web Cache

In December 2001, NLANR moved its Web Cache from STAR TAP, where it has been operational since December 1999, to StarLight. The cache is integrated into NLANR's Global Caching Hierarchy.

2.A.6.d. NLANR Performance Measurement

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

2.A.6.e. EMERGE Differentiated Services (DiffServ) Testbed

iCAIR/NU and CERN have used the STAR TAP EMERGE Testbed in the past, and Jason Leigh is talking with CERN about future tests. Note: EMERGE was initially a DoE-funded effort to achieve and demonstrate DiffServ over MREN, ESnet and Abilene <http://www.evl.uic.edu/cavern/EMERGE/>. We extended these QoS experiments to Europe and Asia via STAR TAP.

2.A.6.f. Multicast

Many of the Euro-Link participants have Native Multicast enabled (including Israel IUCC, NORDUnet and SURFnet). These networks are documented at [http://www.startap.net/ENGINEERING/TECHINFO.html]. We are also interested in creating an AUP-free IP multicast exchange point at StarLight; our interest is driven by ANL's Access Grid effort, which requires solid IP multicast service.

2.A.6.g. International Transit Network (ITN) Services

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

2.A.6.h. StarLight/Abilene Connectivity

Abilene's OC-48 core router, located at the Chicago Qwest PoP, connects to StarLight via two 1Gbps connections

using I-WIRE fiber; one connection is for StarLight (inter)National Research Network traffic (e.g., SURFnet) and one connection is for MREN traffic. (Note: TransPAC peers with Abilene both in Chicago and in Seattle. NORDUnet peers with Abilene in New York. AMPATH peers with Abilene in Miami.)

2.A.6.i. StarLight/STAR TAP Connectivity

There are two OC-12 connections from the StarLight facility to STAR TAP (at the AADS NAP) for non-Abilene research traffic. One OC-12 is for SURFnet's use, which will be terminated as soon as possible. The other is shared among other StarLight customers, and will be maintained in Year 4.

2.A.6.j. StarLight/Fednet Connectivity

ESnet and NREN, both located at the Chciago Qwest PoP, now connect to StarLight via 1Gb connections using I-WIRE fiber.

2.A.6.k. STAR TAP/StarLight Routers

In our distributed STAR TAP/StarLight environment, there is a STAR TAP Router at the AADS NAP (Cisco 7505), a StarLight Router at 710 N. Lake Shore Drive (Juniper M10), and an MREN Router at 710 (Juniper M5). A Cisco 6509 serves as an additional MREN Router as well as the StarLight Gigabit Ethernet Exchange Point switch.

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

The Euro-Link NOC can be accessed from [www.euro-link.org/ENGINEERING] or [http://noc.euro-link.org]. Indiana University's Jim Williams and Steve Peck operate the NOC. In addition to Euro-Link, Indiana's "Global NOC" operates the STAR TAP/StarLight, TransPAC, Nauka-Net (formerly MIRnet), AMPATH and Abilene networks as five logical NOCs inside one physical NOC. Each European NRN operates its own NOC as well; this information is maintained for all STAR TAP-connected networks at [www.startap.net/ABOUT/points.html]. In addition to the BGP session and syslog monitoring tools, the NOC recently added a new router proxy that allows users to submit show commands to a STAR TAP/StarLight core node router. <http://loadrunner.uits.iu.edu/~routerproxy/startap/>.

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

The Euro-Link NOC provides weekly reports of network availability (e.g., downtime, scheduled maintenance, etc.) to the peering networks. The NOC also stays in close touch with the European NOCs in an effort to keep all relevant contact and engineering information up to date.

2.A.8. Euro-Link Documentation and Dissemination of Information

The Euro-Link web site [www.euro-link.org] is continually updated with Euro-Link information, including general information, network performance studies, engineering data, applications and publications. This report will be posted on the web site shortly after its completion.

2.A.9. Euro-Link Applications Documented

Active US/Euro-Link collaborations are documented on the Euro-Link web site. [http://www.euro-link.org/APPLICATIONS/]. They also appear in the Appendix of this document.

2.B.   Research Findings

2.B.1.   StarLight

StarLight has been operational since September 2001, with proposed expansion plans through 2006. Euro-Link members CERN, SURFnet and NORDUnet have already been connected, as well as AMPATH and APAN/TransPAC, US-based advanced networks Abilene, I-WIRE/MREN, ESnet, NREN and vBNS+, and the 6TAP IPv6 testbed. RENATER2, CA*net3/4, Nauka-net and NISN are expected to connect later in 2002. See <http://www.startap.net/starlight/NETWORKS/>

2.B.2.   Application-Level Network Performance Analysis Tools

Preliminary results are reported in Section 2.A.5 along with descriptions of the tools. Research papers and MS/PhD degrees are currently in progress.

2.B.3.   Network Performance Analysis Software Releases

CAVERNsoft G2, a C++ toolkit for building collaborative, networked applications is available for download. It has low- and mid-level networking classes to support general collaborative applications building, and high-level modules to support tele-immersion (or collaborative virtual reality.) The distribution includes full source for SGI/Irix, Linux and Win9x/NT/2000. Currently, graphics support is only supported on the SGI through IRIS Performer. The distribution comes with the full source of Globus 1.1, and allows the user to generate both Globus and non-Globus versions of CAVERNsoft. CAVERNsoft is currently deployed at the OpenChannels <www.openchannelsoftware.org> website.

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

QUANTA, in Spring 2002, will replace CAVERNsoft. (QUANTA v1.0 will be backwards compatible with CAVERNsoft.)

2.B.4.   Collaborations (April 2001- March 2002)

2.B.4.a.   SC Global at SC 2001

EVL had a major organization/design role in the SC Global <http://www.scglobal.org/> event at the SC'2001 conference in Denver, November 10-16, 2001. SC Global linked the conference site in Denver with locations in Europe, Asia, Australia, South America, and the South Pole using Access Grid technology <http://www.accessgrid.org>. Thirty-six sites participated in SC Global, 28 of which contributed content to the conference. These included sites all across the US and in Beijing, China; Juelich, Germany; Tsukuba, Japan; Toronto, Canada; Manchester, England; Stuttgart, Germany; Bologna, Italy; Sydney, Australia; Porto Alegre, Brazil; and the National Science Foundation's South Pole Research Center.

These remote participants? or SC Constellation Sites? not only tuned in to the technical program and keynote addresses in Denver, but served up their own presentations, participated in panel discussions, and conducted remote workshops, educational sessions, and birds of a feather meetings. Moreover, SC Global content extended beyond high-performance computing and networking, with many Constellation Sites offering sessions in telemedicine, social sciences, and the arts.

Specifically, EVL (Dana Plepys, Greg Dawe) did a great deal of planning for the SC Global "Showcase" venue, a large-format Access Grid node on the Denver Convention Complex exhibit floor that featured specialized sessions geared toward large audience participation, interaction and collaboration.

2.B.4.b.   iGrid 2002

Maxine Brown, Tom DeFanti, Alan Verlo, Linda Winkler, Jason Leigh, Laura Wolf, and Greg Dawe are working with people in the Netherlands' GigaPort Project and SURFnet to organize an iGrid event in Amsterdam, September 23-26, 2002, to showcase multi-gigabit applications. iGrid 2002 information is available at <www.startap.net/starlight/igrid2002>.

2.B.4.c.   Application-Level Network Performance Studies

Jason Leigh is working with SARA in Amsterdam to do network performance studies over long, fat networks using various transmission techniques (TCP, UDP, FEC, RUDP). Leigh has also worked with CERN on RUDP tests and is talking to them about DiffServ experiments. These collaborations are documented in Section 2.A.5.

2.B.4.d.   Network Performance Studies for European/US Collaborative Art Project

Dan Sandin organized a major "EVL: Alive on the Grid" tele-immersive art demonstration for the Ars Electronica Center (AEC) Festival in Austria, September 1-6, 2001. Participants included artists from three US universities (UIC, Indiana University and SUNY-Buffalo) and four European countries (Austria's AEC; Hungary's C3; The Interactive Institute of Sweden; and, The Netherlands' SARA, Technische Universiteit Eindhoven, and V2 Organization Institute for the Unstable Media, Rotterdam. The demonstrations were instrumented, and real-time network performance tests were executed during the event. Results are documented in Section 2.A.5.e.

2.B.5.   Meetings Attended (April 2001- March 2002)

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

2.B.5.a.   Euro-Link Annual Meetings

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

- INET 2002 (June 21-22 with CCIRN), Washington, D.C.
- INET 2001 (June 5), Stockholm, Sweden
- INET 2000 (July 17), Yokohama, Japan
- INET '99 (June 22), San Jose, CA
- INET '98 (July 21), Geneva, Switzerland

2.B.5.b.   HPIIS Team Meetings

Euro-Link relies on the respected capabilities of the NSF HPIIS Team, comprised of UIC/Euro-Link, Indiana University/TransPAC and GNOC, University of Illinois at Urbana-Champaign[2]/MIRnet, AADS, and the STAR TAP management team. HPIIS awardees help each other by sharing experiences. We have a group email alias <hpiis-team@startap.net>. We have held the following meetings:

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

2.B.5.c.   Euro-Link Participation in International Conference Events

Past events that we organized include iGrid '98 at SC'98 and iGrid 2000 at INET 2000. The biennial iGrid

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[2]   "MIRnet" Cooperative Agreement was formerly with the University of Tennessee at Knoxville, but the PI, Greg Cole, relocated to UIUC.

(International Grid) event showcases application advancements and middleware innovations enabled by globally connected, high-performance networks. The iGrid 2002 event to be held this September 23-26 in Amsterdam challenges scientists and technologists to optimally utilize 2.5-10Gb experimental networks, with special emphasis on e-Science, Grid and Virtual Laboratory applications <http://www.startap.net/igrid2002/>. An dedicated event website is also under construction <http://www.igrid2002.org/>. To date, organizer Maxine Brown has received 28 submissions for collaborative projects from 14 nations/locations, 20 of which involve European countries.

We were involved in the SC'2001 conference [www.sc2001.org] in Denver, November 10-16, 2001, assisting ANL host the SC Global event with technical and planning support. SC Global used Access Grid technology [www.accessgrid.org] to link the SC "core" at the Denver Convention Center with dozens of Access Grid nodes or "constellation sites" throughout the world, including SARA in The Netherlands. We also sent staff and students to run "Tera Wide Data Mining" optical networking demonstrations, to promote the goals of StarLight.

2.B.5.d.   Euro-Link Management Participation in European Events

NORDUNET

The annual STAR TAP meeting was held during the INET 2001 conference in Stockholm, Sweden, at the Center for Parallel Computers at the Royal Institute of Technology, June 5, 2001. The agenda and Power Point presentations appear at <http://www.startap.net/ABOUT/meetingInet2001.html>

SURFNET

On September 11-13, 2001, Tom DeFanti, Maxine Brown, Linda Winkler and Joe Mambretti attended two TERENA meetings in Amsterdam. September 11-12, TERENA hosted discussions with StarLight, NetherLight, CA*net4, CERN, UKERNA and UCAID/Internet2 stakeholders. On September 12-13, TERENA hosted an International Lambda Workshop to discuss future research and education opportunities. DeFanti gave a technical overview of lambda networks and the StarLight project. Winkler talked about I-WIRE experience in procuring lambdas and Mambretti talked about Chicago's CivicNet and OMNInet metro initiatives. <http://www.terena.nl/conf/lambda/>

2.B.5.e.   Euro-Link Meeting, Workshop and Conference Participation (April 2001-March 2002)

March 27, 2002. Leo Grebot visited EVL to talk to Jason Leigh and EVL art professor Franz Fischnaller about a possible wavelength connection to Barcelona and potential applications.

March 21-26, 2002. Sylvain Ravot of Caltech and Paolo Moroni of CERN visited StarLight to install the new 622Mb circuit between CERN and Starlight.

March 20, 2002. Erik-Jan from SURFnet visited StarLight.

March 11, 2002. Maxine Brown attended the first Workshop of the Pacific Rim Applications and Grid Middleware Assembly (PRAGMA), organized by Phil Papadopoulos and Peter Arzberger of UCSD. It was held at SDSC. Brown gave a presentation on iGrid 2002, as there is much interest from the Pacific Rim countries about participating in the Amsterdam-based event.

March 4-5, 2002. Jason Leigh attended the Access Grid Retreat in San Diego, California <http://www-fp.mcs.anl.gov/fl/accessgrid/ag-retreat-2002/index2002.htm>. One of the two papers he presented was about Tera-Vision, the high-bandwidth networking platform and applications being developed at EVL.

February 27-29, 2002. Seven researchers from NTT (Network Innovation Laboratories) and five from University of Tokyo (Todai) attended the ON*VECTOR workshop hosted at EVL and moderated by Pacific Interface's Laurin Herr. EVL directors and select students attended. Day one and two were dedicated to network management and middleware issues, and included progress reports on EVL's UCAN (Unified Collaboratory for Analyzing Networks) and a presentation of NTT's Computer Services Protocol (CSP) and FACE prototype. The Photonic Networking Workshop portion included representatives from Glimmerglass Networks, CANARIE, Argonne and Northwestern. Attendees heard progress reports on UIC's optical network build-out, characterization and evaluation of dark fiber, and Gigabit Ethernet mux field tests. There was an update on plans for GENIE GBIC and a presentation of NTT's measurement plan for long-haul optical fiber characteristics. The guests also visited the StarLight facility and Joe Mambretti provided a technical explanation of its physical/logical infrastructure.

February 21-22, 2002. Cees de Laat (University of Amsterdam), Olivier Martin (CERN) and Richard Hughes-Jones (University of Manchester, England) visited EVL to learn more about StarLight. Attendees included Jason Leigh, Oliver Yu, Mitch Theys, Alan Verlo, Maxine Brown (EVL/UIC); Bill Nickless, Caren Litvanyi (Argonne National Laboratory); and, Joe Mambretti, Tim Ward (Northwestern University). Among the items discussed were lambda switching, routing issues to Caltech, Gigbit NICs, 10 Gigabit experiences, iGrid 2002, and EVL's Reliable Blast UDP (RUDP) and Parallel TCP. Cees presented "The Road to Optical Networking," which addressed different operating models and usage scenarios for optical networking technology under the network and grid layers. de Laat explained the architecture of the dedicated research lambda from the NetherLight facility in Amsterdam to the StarLight facility in Chicago as well as his early experiences using it. Guests also visited the StarLight facility.

February 18-19, 2002. Jason Leigh attended Global Grid Forum 4 (GGF4) in Toronto, Canada. Leigh chairs the Advanced Collaborative Environments Research Group. Progress was made toward a GGF working document on the security requirements of advanced collaborative environments.
http://www.globalgridforum.org/Meetings/GGF4/Default.htm

January 21-22, 2002. Tom DeFanti, Maxine Brown, Alan Verlo, Jason Leigh, Linda Winkler and Laura Wolf attended the first iGrid 2002 planning meeting at the WTCW on the University of Amsterdam campus. Present from The Netherlands were Jan Langelaar, Paul Wielinga, Ed Mos, Cees de Laat, Mieke van den Berg and Erik-Jan Bos. A site and computer facilities tour was followed by discussions concerning the scientific program, organizational and budgetary issues, and sponsorship.

January 17-18, 2002. Tom DeFanti and Maxine Brown attended an Optical Networking meeting in London with UKERNA and academic representatives. Attending was David Williams of CERN and Tony Hey, Director of the UK's Core e-Science Programme, which is part of the Engineering and Physical Sciences Research Council (EPSRC), the largest of the seven UK Research Councils. DeFanti, Brown and Cees de Laat gave presentations on StarLight, iGrid 2002 and NetherLight, with the intent of encouraging UKERNA to provide a wavelength to either NetherLight and/or StarLight.

January 16-17, 2002. Florida International University's Julio Ibarra and Heidi Alvarez (FIU networking and AMPATH) and Joyce Elam (dean, FIU College of Business Administration) met with Jason Leigh, Dan Sandin, Laura Wolf and Steve Jones to learn more about STAR TAP/StarLight and MREN (GigaPoP). Ibarra and Alvarez were seeking input for an NSF CISE Minority Research Infrastructure grant they were writing. Elam's interest was to meet peers who used high-performance networking applications to enhance their programs and research.

January 16, 2002. Tom DeFanti, Maxine Brown Jason Leigh, Dan Sandin, Laura Wolf, and Joe Mambretti hosted Leo Grebot from Expaces in Barcelona. Grebot is working with Artur Serra of the University Politecnica de Catalunya who runs an advanced Internet project (i2CAT). Artur has been involved with a major networking conference in Barcelona for the past two years (EVL student Javier Girado and Joe Mambretti attended in 2000 and Maxine Brown in 2001). Artur is interested in STAR TAP/StarLight and is seeking ways for Barcelona to bring a wavelength to Chicago. Leo is helping him by contacting telecom operators, such as Cable and Wireless, about Gigabit international connectivity. Leo toured the StarLight facility and discussed collaborative technologies.

December 10, 2001. Linda Winkler, Andy Schmidt and Tom DeFanti met with CERN's Sylvain Ravot to discuss CERN's plans to convert its current NAP based OC-3 service to OC-12 service terminating at StarLight. They also discussed plans for the 2.5Gbps DataTAG link to StarLight <http://www.datatag.org>.

December 5-6, 2001. The NSF ANIR Workshop on "Grand Challenges in e-Science" was held at EVL to discuss the challenges, applications and funding needs of emerging experimental and commodity networks <http://www.evl.uic.edu/activity/NSF/final.html>.

November 1, 2001. Tom DeFanti met with EVL scientists and affiliated faculty and Northwestern's Joe Mambretti to discuss visualization cluster location, shipping, networking and software issues.

November 1, 2001. Tom DeFanti discussed changes to the Global NOC service model with IU's Jim Williams.

October 30, 2001. Tom DeFanti gave a presentation via the Access Grid about StarLight to a French delegation visiting NSF in Washington DC. Dany Vandromme, head of RENATER2, was a member of the delegation. Vandromme discussed his intention to increase Renater's bandwidth by bringing in a 622Mb to STAR TAP (perhaps via StarLight), primarily for ESnet and CA*net connectivity. <http://www.france-science.org/presentationppt/fichiers_powerpoint.htm>

October 18-19, 2001. Linda Winkler attended the 10 Gigabit Ethernet Workshop, supported by the NSF and hosted by the San Diego Supercomputer Center. <http://www.sdsc.edu/10GigE>

October 10, 2001. Tom DeFanti, an alternate CENIC Board of Directors (Larry Smarr is the member), attended CENIC board meeting in Los Angeles. Of particular interest was discussion of their Optical Network Initiative (ONI) for the State of California, with interest in connecting to the Pacific Northwest and StarLight.

October 2, 2001. EVL student Atul Nayak attended the CAVE Programming Workshop organized by the Center for Parallel Computing (PDC), Royal Institute of Technology (KTH), in Stockholm, Sweden. He presented a tutorial on CAVERNsoft titled, "Creating Collaborative Virtual Environments (CVE)," in which he described CAVERNsoft G2, a toolkit for high performance tele-immersive collaboration applications for creating CVEs. See: http://www.pdc.kth.se/projects/vr-cube/workshop.html

October 2, 2001. Tom DeFanti and Maxine Brown attended morning plenary sessions of Internet2's Austin-based Fall 2001 Member Meeting via the Access Grid.

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

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

September 5-7, 2001. Jason Leigh met with networking researchers at KISTI (Korea) to discuss future research ideas for KREONET. The plan is to reinstate and extend past experiments on Parallel TCP, RUDP and DiffServ. Jason also met with KISTI's visualization group and trained them on CAVERNsoft and tele-immersion. [*Note: While not Euro-Link specific, the similar testbed experiments will soon be initiated between EVL and University of Amsterdam over SURFnet's new 2.5Gbps link*.]

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

photonic networking. The group visited STAR TAP/ StarLight, as well as NSF (Aubrey Bush) and CANARIE (Bill St. Arnaud).

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

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

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

May 18, 2001. Maxine Brown presented, "StarLight: In Support of Global Scientific Research Communities," at the Advanced Internet Session at the Internet Global Conference in Barcelona <http://www.igconference.net/>. The session was organized by Artur Serra of Universitat Politecnica de Catalunya (UPC), and also included speakers Latif Ladid (Vice President of Ericsson and President of the IPv6 Forum), Pascal Drabik (Scientific Officer, European Commission) and Xavier Kirchner (Director Centre de R&D, Nortel Networks, Barcelona).

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

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

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

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

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

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

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

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meeting was set to occur on May 29 at EVL.

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

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

2.C.   Research Training

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

2.D.   Education/Outreach

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

Since 1986, EVL has partnered with NCSA, ANL, and more recently NU/iCAIR, in ongoing efforts to develop national/international collaborations at major professional conferences, notably ACM SIGGRAPH, ACM/IEEE Supercomputing (SC), IEEE High Performance Distributed Computing (HPDC) and INET, as well as Internet2 meetings. We have participated in European conferences (e.g., TERENA's Lambda Workshop and INET 2001 in Stockholm), NORDUnet annual meetings and a UKERNA seminar on optical networking. Our success has been in the development of teams, tools, hardware, system software, and human interface models on an accelerated schedule to enable multi-site collaborations for complex problem solving. We have received a great deal of media attention for our work; news articles are posted at [www.euro-link.org/PUBLICATIONS/].

Past events we have organized include iGrid '98 at SC'98 and iGrid 2000 at INET 2000. We participated in the SC'2001 conference [www.sc2001.org] in Denver, November 10-16, 2001; assisting ANL to host the SC Global event with planning support and on-site staff. (SARA in Amsterdam participated.) EVL also participated in Tera Wide Data Mining project demos to promote the goals of StarLight. We also encourage our international collaborators to develop conference events (such as iGrid) to showcase meritorious applications among their own researchers.

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

3.   Publications and Products

3.A.   Journals/Papers

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

J. Leigh, J. Girado, R. Singh, A. Johnson, K. Park, T.A. DeFanti, "TeraVision: A Platform and Software Independent Solution for Real Time Display Distribution in Advanced Collaborative Environments," Proceedings of the Access Grid Retreat, La Jolla, California, 2002.

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

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

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

Jason Leigh, Oliver Yu, Dan Schonfeld, Rashid Ansari, Eric He, Atul Nayak, Jinghua Ge, Naveen Krishnapasad, Kyoung Park, Yong-joo Cho, Liujia Hu, Ray Fang, Alan Verlo, Linda Winkler, Thomas DeFanti, "Adaptive Networking for Tele-Immersion," Proceedings of the 5th Immersive Projection Technology/ 7th Eurographics Virtual Environments Conference, May 16-18, 2001, Stuttgart, Germany <http://www.evl.uic.edu/cavern/papers/jleigh_EGVEIpt2001.pdf>.

3.B.   Books/Publications

DeFanti, T., Sandin, D., Brown, M., Pape, D., Anstey, J., Bogucki, M., Dawe, G., Johnson, A., Huang, T., "Technologies for Virtual Reality/Tele-Immersion Applications: Issues of Research in Image Display and Global Networking," *Frontiers in Human-Centered Computing, Online Communities and Virtual Environments* (Earnshaw, Van Dam, Vince and Guedj, Springer-Verlag), London, April 2001, pp 137-159.

Johnson, A., Leigh, J., "Tele-Immersive Collaboration in the CAVE Research Network," *Collaborative Virtual Environments: Digital Places and Spaces for Interation*, (Churchill, Snowdon and Munro), March 2001, pp. 225-243. <http://www.evl.uic.edu/aej/papers/CVEchapter.pdf>

3.C.   Internet Dissemination

www.euro-link.org

3.D.   Other Specific Products

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

4.   Contributions

4.A.   Contributions within Discipline

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

4.B.   Contributions to Other Disciplines

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

EVL not only manages the Euro-Link and STAR TAP facilities, but the Lab is also one of Euro-Link's major users. EVL's networking interest is a natural outgrowth of its focus on visualization; i.e., EVL is not only interested in producing graphic images and display technologies, but is interested in moving visualizations over networks. In the early '90s EVL focused on distributed computing (connecting visualization/virtual-reality technologies to vector and parallel remote supercomputers), and by the mid-90s EVL focused on tele-immersion (collaborative virtual reality over networks, an extension of the "human/computer interaction" paradigm to "human/computer/human collaboration"). Now, at the beginning of a new decade, EVL is focusing on latency issues in tele-immersion, particularly over ultra-high-speed networks. While today's tele-immersion sessions typically have little going on besides collaborative 3D interactive graphics, transoceanic tele-immersion software and middleware must provide

for latency-tolerant and time-shifted usage as well as archival storage and content-based retrieval of multi-flow, multi-participant virtual-reality sessions. EVL is examining the problems of managing these flows in real time and creating adaptive latency-tolerant solutions for international distances.

4.C.   Contributions to Human Resource Development

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

Euro-Link and NSF's companion HPIIS programs have helped change the way international science is done, by providing a persistent infrastructure for global collaboration. The HPIIS programs, through STAR TAP, and now StarLight, have enabled a worldwide community of application scientists, computer scientists, networking engineers and artists. STAR TAP has a mailing list of ~600 <stars@startap.net> individuals, from academia, government and industry, interested in information about international networking developments. The success of iGrid '98 and iGrid 2000 sparked the interest of the Europeans to sponsor iGrid 2002.

While we have no quantitative metrics to evaluate Euro-Link's role in education/human resources development, we have many testimonials from American and European users and NRN management. We have documented more than 80 applications on the Euro-Link web site, implying that hundreds of networking engineers, application programmers and discipline scientists are involved in Euro-Link-related international high-performance networking and applications development.

4.D.   Contributions to Resources for Research and Education

In Section 4.B (Contributions to Other Disciplines), we note that Euro-Link is a necessary and integral part of application advances and technological innovations for the Computational Science and Engineering and the Computer Science communities, as well as of major interest to research network engineers. Euro-Link is a major -- and unique -- resource for Science and Technology. Euro-Link/STAR TAP is an infrastructure and proving ground in which to implement new network engineering solutions to advance the state of the art.

About half of Euro-Link funds in this Cooperative Agreement (see Section 7: FY02 Budget Narrative) will go for four $320,000 annual payments to the Euro-Link NRNs (a total of $1,280,000 in Year 4) to help offset the high costs of transatlantic networking. Additional Euro-Link funds are used to cover local loop and rack space fees for these NRNs in Chicago. NSF's funds are leveraged at least 4:1 through this effort, providing US scientists ever-increasing access to Euro-Link connected facilities at a very reasonable cost.

4.E.   Contributions Beyond Science and Engineering

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

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

5.   Special Requirements

5.A.   Objectives and Scope

A brief summary of the work to be performed during the next year of support if changed from the original proposal.

See Euro-Link Program Plan, Section 6 of this report (uploaded in FastLane as a supplemental PDF file).

5.B.   Special Reporting Requirements

Do special terms and conditions of your award require you to report any specific information that you have not yet reported?

No.

5.C.   Unobligated Funds

Do you anticipate that more than twenty percent of the funds under your NSF award will remain unobligated at the end of the period for which NSF currently is providing support?

No. See Euro-Link Program Plan, Section 7 of this report (uploaded in FastLane as a supplemental PDF file).

5.D.   Animals, Biohazards, Human Subjects

Has there been any significant change in animal care and use, biohazards, or use of human subjects from what was originally approved (or approved later)?

No.

6. Appendix: Euro-Link Applications

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

6.A. CERN

European DataGrid

Led by CERN, European Organization for Nuclear Research, five main and fifteen associated partners. European research agencies include the European Space Agency (ESA), France's Centre National de la Recherche Scientifique (CNRS), Italy's Istituto Nazionale di Fisica Nucleare (INFN), the Dutch National Institute for Nuclear Physics and High Energy Physics (NIKHEF) and UK's Particle Physics and Astronomy Research Council (PPARC). Associated partners include the Czech Republic, Finland, France, Germany, Hungary, Italy, the Netherlands, Spain, Sweden and the United Kingdom. (Note: DataGrid funding will support a CERN transatlantic link to StarLight in 2002.)

Fabrizio Gagliardi, CERN, Fabrizio.Gagliardi@cern.ch

The European DataGrid project, funded by the European Union, aims to set up a computational and data-intensive grid of resources for the analysis of data coming from scientific exploration. Next-generation science will require coordinated resource sharing, collaborative processing and analysis of huge amounts of data produced and stored by many scientific laboratories in several institutions.

The project will devise and develop scalable software solutions and testbeds in order to handle many PetaBytes of distributed data, tens of thousand of computing resources (processors, disks, etc.), and thousands of simultaneous users from multiple research institutions. The project spans three years, from 2001 to 2003, with over 200 scientists and researchers involved. The first and main challenge facing the project is the sharing of huge amounts of distributed data over the current network infrastructure. The DataGrid project will rely upon emerging computational Grid technologies that are expected to make a giant computational environment out of a distributed collection of files, databases, computers, scientific instruments and devices.
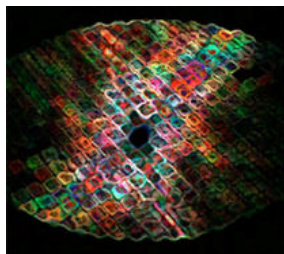
http://www.eu-datagrid.org

GEANT 4

CERN (primary), Bulgaria, Canada, Finland, France, Germany, Hungary, India, Italy, Japan, Netherlands, Russia, Spain, Switzerland, United Kingdom, United States

See website for contact names (click Support, click Contacting Geant4)

Geant4 (GEometry ANd Tracking) is a toolkit for the simulation of the passage of particles through matter. It was designed for the next-generation of High Energy Physics (HEP) experiments, with primary requirements from the LHC, the CP violation and heavy ion experiments. Its application areas include HEP and nuclear experiments, medical, accelerator and space physics studies. Geant4 exploits advanced software engineering techniques and object-oriented technology to achieve the transparency of the physics implementation, and hence provide the possibility of validating the physics results. It was developed by RD44, a worldwide collaboration of about 100 scientists from over 40 institutions and laboratories participating in more than 10 experiments in Europe, Russia, Japan, Canada and the United States.

http://geant4.web.cern.ch/geant4/

GiDVN: Global Internet Digital Video Network

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

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

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

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

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

Authenticated Quality of Service (QoS)

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

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

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

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

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

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

GriPhyN: Grid Physics Network

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

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

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

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

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

http://www.griphyn.org
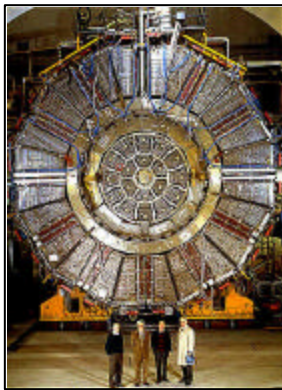
Networked Experiments of the European Laboratory for Particle Physics

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

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

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

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

http://www.cern.ch
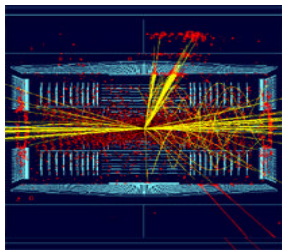
Distributed Particle Physics Research

CERN; Caltech, USA

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

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

enables queries issued by the front-end application to be matched to available computing resources in the system (the matchmaking service).

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

Large Hadron Collider (LHC) project

CERN; Caltech, USA; Others.

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

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

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

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

ATLAS (A Toroidal LHC ApparatuS)

CERN; Caltech, USA; Others.

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

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

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

Compact Muon Solenoid (CMS)

CERN; Caltech, USA; Others.

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

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

The Globally Interconnected Object Databases (GIOD) Project

Caltech, USA; CERN; Hewlett Packard; Others.

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

Particle physicists are engaged in large international projects to address a massive data challenge, with special emphasis on distributed data access. The data is overwhelming. Even though data from the CMS detector will be reduced by a factor >107, over a

petabyte (1015 bytes) of data per year will accumulate for scientific analysis.

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

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

http://pcbunn.cithep.caltech.edu

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

CERN; Caltech, USA; Others.

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

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

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

Virtual Room Videoconferencing System (VRVS)

CERN; Caltech, USA; Others.

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

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

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

http://VRVS.cern.ch/

6.B.   Israel IUCC

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

TelePresence Microscopy (TPM)

Argonne National Laboratory, USA; Technion, Israel

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

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

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

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

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

NASA/GSFC, USA; Tel Aviv University, Israel

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

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

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

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

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

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

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

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

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

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

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

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

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

Collaborative Learning Over Broadband Internet: "Dialog Through Music"

Israel; Canada

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Peter Marshall, CANARIE Inc., Canada, marshall@canarie.ca

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

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

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

Computer Alchemy Using Virtual Reality

Israel; Others

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

Computational Condensed Matter Physics and Material Science is a rapidly growing field, fueled in part by the advent of computer alchemy. As computers have become more powerful and algorithms more robust, this practical research tool models molecularly dynamic systems in virtual reality–notably, atomistic material simulations up to several million particles.
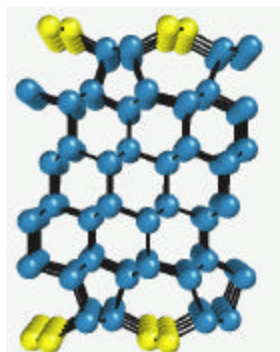
Especially suitable for discussing simulation results with experimental collaborators, visualization is also essential for teaching quantum mechanics and condensed matter physics, since most effects on the atomic scale cannot be demonstrated in the usual way.

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

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

Israel One – A Broadband High School Network

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

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Hamutal Hameiri, North Carolina Israel Partnership, hamutalm@netvision.net.il
Itzhak Yuli, Tel Hai College, tzachy@telhay.co.il
Peggy Manring, North Carolina School of Science and Math, manringp@academic.ncssm.edu

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

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

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

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

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

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

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

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

http://www.protomap.cs.huji.ac.il/
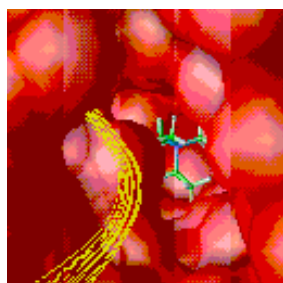
Visualization of Acetylcholinesterase: Nature's Vacuum Cleaner

Cornell University, USA; Weizmann Institute of Science, Israel

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Joel L. Sussman, Weizmann Institute of Science, Joel.Sussman@weizmann.ac.il
Israel Silman, Weizmann Institute of Science, Israel.Silman@weizmann.ac.il

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

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

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

Interactive Simulation in the Field of Plant Nutrition

Penn State University, USA; Tel Aviv University, Israel

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Amram Eshel, Tel Aviv University, amram@post.tau.ac.il

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

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

SeaWiF Data for the Eastern Mediterranean and the Middle East Image

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

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

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

NASA documentation. Subsequently, each image is transferred from receiving stations to NASA/GSFC, to create a global image based on several HRPT stations across the globe.

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

Large-Scale Atomistic Modeling of Semiconductors and Ceramics

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

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Dennis Rapaport, Bar-Ilan University, rapaport@mail.biu.ac.il
David Landau, University of Georgia, Athens, dlandau@uga.edu

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

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

Video of Demand (VoD)

Israel; Internet2, USA.

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

VoD is a new technology that is enabled using advanced Internet capabilities. There are a select number of VoD servers located in Israel, Europe and the USA. This site documents all the various high-bit rate VoD servers located on advanced networks worldwide. A VoD system is one that allows a user to start the playback when he/she wishes, as well as pause, rewind and fast-forward that playback. High-bit rate is anything above 1Mbps. 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
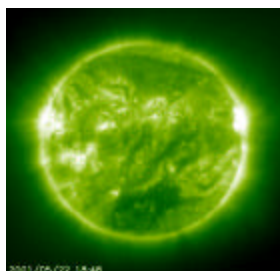
EVL: Alive on the Grid

University of Illinois at Chicago, Indiana University, State University of New York (SUNY), Buffalo, USA; Stichting Academisch Rekencentrum Amsterdam (SARA), Technische Universiteit Eindhoven (TU/e), V2 Lab/V2 Organization Institute for the Unstable Media, Rotterdam, The Netherlands; Interactive Institute - Tools for Creativity Studio, Umea, Sweden; C³ Center for Culture & Communication Foundation, Hungary

Dan Sandin, University of Illinois at Chicago, dan@evl.uic.edu

The Ars Electronica Festival, sponsored by the Ars Electronica Center (AEC), is an international, large-scale annual art festival held annually in Linz, Austria. In 2001, the AEC festival commissioned the University of Illinois at Chicago's Electronic Visualization Laboratory to produce an original virtual reality art application for the CAVE®. The resulting work—EVL: Alive on the Grid—is a collection of shared and tele-immersive virtual reality environments linked by the Grid (a collection of networks, computers and virtual reality displays spanning the globe). During the five-day event, participants from three American and five European sites interacted in the virtual worlds.
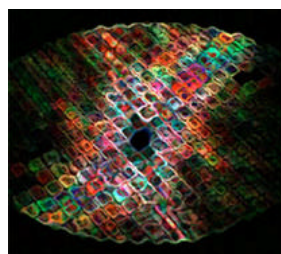
http://www.aec.at/festival2001/
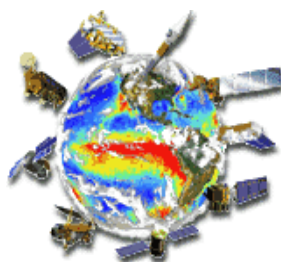
Earth Observing System (EOS)

NASA ,USA; worldwide collaborators. Euro-Link NRN-linked institutions in Denmark, Finland, France, Norway, Sweden

Michael King, Goddard Space Flight Center, king@climate.gsfc.nasa.gov

The Earth Observing System (EOS) is the centerpiece of NASA's Earth Science Enterprise (ESE). It consists of a science component and a data system supporting a coordinated series of polar-orbiting and low inclination satellites for long-term global observations of the land surface, biosphere, solid Earth, atmosphere and oceans. The EOS Project Science Office (EOSPSO) is committed to helping bring program information and resources to program scientists and the general public alike.

http://eospso.gsfc.nasa.gov

GiDVN: Global Internet Digital Video Network

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

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

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

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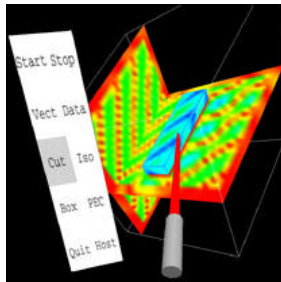Egon M. Verharen, SURFnet, The Netherlands
Cesar Olvera, DGSCA-UNAM, Mexico
Manjeet Singh, Francis Lee, SingAREN, Singapore
Artur Serra, Sebastia Sallent, Joan Borràs, Universitat Politecnica de Catalunya, Spain

Björn Pehrson, Daniel Forsgren, Royal Institute of Technology, Sweden
Joe Mambretti, Jim Chen, Jeremy Weinberger, Tim Ward, Northwestern Univ., USA

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

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

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

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

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

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

WITAS Multi-Modal Conversational Interface

University of Stanford, USA; Linköping University, Sweden

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

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

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

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

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

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

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

The 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) will be established and deployed in a series of actual courses.

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

The three goals of the project are: (1) Establishing an optimal network of 'incubator sites,' or high-bandwidth multimedia learning environments, (2) Focus on the

development and design of high capacity multimedia courses, conventions and genres for learning within these spaces, and (3) Conduct research and evaluation of the technological, rhetorical and pedagogical solutions employed.

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

Global Observation Information Network (GOIN) Demonstration in Stockholm

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

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

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

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

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

Tromsø And COrnell Moving Agents (TACOMA)

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

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

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

An agent in TACOMA is a piece of code that can be installed and executed on a remote computer. Such an agent may explicitly migrate to other hosts in the network during execution. We are currently focusing on fault-tolerance, security, applicability and management issues. The TACOMA platform has also been ported to new operating system architectures, in particular Windows NT, Windows CE and the PalmOS.

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

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

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

University of Tromsø, Norway; Princeton University, USA

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

Princeton's Computer Science department is building a parallel computer using PCs

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

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

European Incoherent SCATter (EISCAT)

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

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

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

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

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

Distributed Virtual Reality

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

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

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

PDC has been involved in a number of activities:

- PDC participates in the Globus/GUSTO testbed [www.globus.org]. At SC'97, PDC contributed with a computational electromagnetic application running across a number of sites.
- At the NCSA/Alliance'98 conference, PDC participated in a global VR demonstration. Together with 4 US sites (University of Utah, University of Houston, University of Illinois at Chicago, and University of Illinois at Urbana/Champaign) a collaborative application designed by Caterpillar was demonstrated.
- PDC is an international affiliate partner to the US National Partnership for Advanced Computing Infrastructure (NPACI). General areas of collaboration are grid computing, advanced scientific visualization, mass storage and computational chemistry.
- As an experienced IBM SP site, 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 tas k that will put very high demands on the transatlantic link.
- Within the NPACI project, the Telescience ALPHA project would like to do some experiments with digital video between the Karolinska Institute, Stockholm, and UCSD, and possibly some other US sites. The use of IPv6 is high on the list of features for this application.
- Plans are being made for a global data analysis grid for the forthcoming experiments at the Large Hadron Collider at CERN. Full-scale experiments will start in 2005-2006, producing petabytes of data. Testbeds are planned to start in 2000-2001 and PDC plans to participate on behalf of the Swedish particle physicists. Coordination with the US HEP project is also planned. Testbeds will put high demand on the transatlantic links.

6.D. RENATER2

BABAR

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

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

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

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

The DØ Experiment

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

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

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

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

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

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

INRIA, France; MIT, USA.

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

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

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

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

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

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

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

Network Computing

LIP, Ecole Normale Superieure de Lyon, France; Région Rhône-Alpes, France; INRIA,

France; CNRS, France; Innovative Computing Laboratory, Univ. 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, Univ. 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, MA, USA; NASA, USA.

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

Local Interstellar Cloud

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

The study of local interstellar clouds.

Modèles de Formation d'Etoiles avec Vent Galactique

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

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

Nucléosynthèse du Big Bang dans le Modèle Cosmologique Standard

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

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

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

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

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

Photochimie des Enveloppes Circumstellaires

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

Theoretical computation dealing with distribution of gaseous components of circumstellar shells.
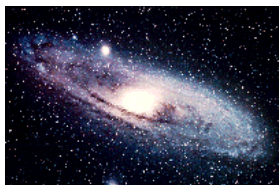
FUSE (Far Ultraviolet Spectroscopic Explorer)

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

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

ultraviolet spectral region.

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

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

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

Using a server for computation of asteroids and comets ephemeredes.

http://cfa-www.harvard.edu/newtop/saohome.html
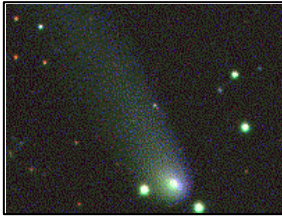
SLOAN Digital Sky Survey (SDSS)

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

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

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

Surveys Radio

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

Properties of deep radio surveys.

TERAPIX (Traitement Elementaire Reduction et Analyse des PIXels)

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

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

http://terapix.iap.fr

CASSINI-HUYGENS Cluster 2 WBD

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

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

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

CASSINI-HUYGENS Cluster 2 WEC

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

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

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

GALILEO

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

Study of the environment of Jupiter.

http://www.CETP.IPSL.fr

GALILEO / NIMS

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

Infrared spectro-imagery of Jupiter with the GALILEO spacecraft.

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

CASSINI-HUYGENS DISR

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

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

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

High Energy Solar Spectroscopic Imager (HESSI)

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

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

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

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

IRON

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

Computation of collision and radiative atomic data for astrophysics.

http://www.obspm.fr

VIMS

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

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

http://www.obspm.fr

ASTRAIA

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

Doppler meteorological airborne radar with two beams.

http://www.CETP.IPSL.fr

Capteur Spatial SEAWIFS: Ameliorations

Laboratoire des Sciences du Climat et de l'Environnement (LSCE), CEA Saclay, France;

Rosenstiel School of Marine and Atmospheric Science (RSMAS), Univ. of Miami, USA.

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

CLIMSERV-CDC

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

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

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

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

CLIMSERV-EOSDIS / LARC

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

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

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

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

International Field Experiment in the Indian Ocean (INDOEX)

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

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

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

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

6.E. SURFnet

Project DataSpace and the Terra Mining Testbed

Project DataSpace: University of Illinois at Chicago, USA; University of Pennsylvania, USA; Caltech, USA; *NCAR, USA; University of California Davis, USA; Magnify Research, Inc., USA; Imperial College, England; ACYys, Canberra, Australia*

Terra Mining Testbed: University of Illinois at Chicago, USA; SARA, The Netherlands; Dalhousie University, Canada, Imperial College of Science, Technology and Medicine, England; Virginia Tech and ACCESS DC, USA, Internet2, USA; University of California Davis, USA; University of Pennsylvania, USA.

Robert Grossman, University of Illinois at Chicago, grossman@uic.edu

The web today provides an infrastructure for working with distributed multimedia documents, but not for remotely exploring data. Project DataSpace is an attempt to provide such an infrastructure. It contains protocols for mining distributed data and is effective for distributed workstation clusters connected with high performance networks (super-clusters) and commodity networks (meta-clusters). The Terabyte Challenge, the testbed for Project DataSpace, will link 12 sites on five continents and demonstrate a variety of applications which will publish, access, analyze, correlate and manipulate remote and distributed data.

The Terra Mining Testbed is an infrastructure built on top of DataSpace for remote analysis, distributed data mining and real-time interaction with large, complex data sets. In a demonstration at SC'02, the DataSpace team accessed, correlated and then visualized data from the National Center for Atmospheric Research (NCAR), National Oceanic and Atmospheric Administration (NOAA) and World Health Organization (WHO)—a CERN linked institution—to study the correlation between El Nino and cholera outbreaks. Terra Mining applications are designed to exploit the capabilities of emerging domestic and international optical networks so that gigabyte and terabyte datasets can be remotely explored in real time.

The demonstration also showcased PC-based clusters called TeraNodes, now being deployed throughout the world, which will be dedicated to massive computation, data mining or visualization over national and international high performance networks. In coming years, as optical technology transforms networking capabilities, TeraNodes will become the building blocks for an optically connected web of data.

Transatlantic Broadband Videostream Using Motion JPEG-over-IP

Univ. of California, Berkeley, USA; Univ. of Tennessee, USA; SURFnet, The Netherlands

Lawrence Rowe, BMRC, University of California at Berkeley, rowe@cs.berkeley.edu
Chris Hodges, SunSITE, University of Tennessee, hodge@ns.utk.edu
Bart Kerver, SURFnet, bart.kerver@surfnet.nl

UC-Berkeley, Univ. of Tennessee and SURFnet have implemented the first live transatlantic broadband audio and video streams using Motion JPEG-over-IP. The implementation of this technology demonstrates how full-screen, near-TV quality video can be delivered over the Internet using simple, inexpensive hardware and freely available, open source software. The technology provides significantly better video quality than those relying on the H.323 standard—the current standard governing interactive audio, video and data communications in a networked environment.

High-quality real-time video, video-on-demand and videoconferencing are critical for applications such as distance education, telemedicine, and remote scientific collaboration. Based on initial success of trials run in December 2001, collaborators will continue to explore ways it can be used to strengthen and expand academic instruction and research.

http://www.bmrc.berkeley.edu/

SC Global

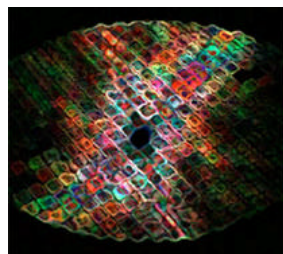Ian Foster, Argonne National Laboratory, foster@mcs.anl.gov

The annual SC conference is the premiere technical and industrial meeting for high-end networking and computing and computational science. The showcase event at SC'2001 held in Denver, Colorado was SC Global—the first truly global technical conference held on the Grid.

SC Global employed Access Grid technology to link the SC Core at the Denver Convention Center with dozens of SC Constellation Sites throughout the world. The event became a multi-national meeting place for demonstrations and discussions related to high-end computing and communications, and featured real time panels, workshops, and birds-of-a-feather sessions.

Disclaimer: Thirty-six sites participated in SC Global, 28 of which contributed content to the conference. These included sites all across the US and in Beijing, China; Juelich, Germany; Tsukuba, Japan; Toronto, Canada; Manchester, England; Stuttgart, Germany; Bologna, Italy; Sydney, Australia; Porto Alegre, Brazil; and the National Science Foundation's South Pole Research Center. The SARA supercomputer center in Amsterdam subsequently purchased an Access Grid. While they did not participate in SC'2001, they are now able to participate in other global projects.

http://www.accessgrid.org
http://www-fp.mcs.anl.gov/scglobal/default.htm

GiDVN: Global Internet Digital Video Network

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

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

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

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

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

Application-Level Network Performance Analysis Tools

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

Jason Leigh, University of Illinois at Chicago, USA spiff@uic.edu
Paul Wielinga, SARA, The Netherlands, wielinga@sara.nl

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

ALIVE: Architectural Linked Immersive Environment

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

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

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

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

The MegaConference

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

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

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

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

6TAP

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

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

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

http://www.6tap.net