TransLight / StarLight

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www.startap.net/translight

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1. Participants

1.A. Primary Personnel

Participant's Name(s)	Project Role(s)	>160 Hours/Yr
Thomas A. DeFanti (1)	Principal Investigator	Yes
Maxine Brown (2)	Co-Principal Investigator	Yes

(1) Tom DeFanti, PI, focuses on managing the link procurement process, network engineering, budgets and accounts payable, interfacing with personnel from Internet2, ESnet, NLR and DANTE/GÉANT2, coordinating project management and oversight activities with the NSF, and performing day-to-day project management. He participates in monthly IRNC phone calls and attends meetings as requested.
(2) Maxine Brown, co-PI, focuses on managing documentation and education and outreach activities, and is responsible for TransLight/StarLight quarterly and annual reports, web pages and events planning. She also participates in monthly IRNC phone calls and attends meetings as requested.

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

Additional people who contribute greatly to the project are listed below. While some receive a salary from this grant, others provide in-kind services:

Participant's Name(s)	Project Role(s)	>160 Hours/Yr
Alan Verlo (3)	Professional staff	Yes
Laura Wolf (4)	Professional staff	Yes
Steve Sander (5)	Professional staff	Yes
Pat Hallihan (6)	Professional staff	Yes
Lance Long (7)	Professional staff	Yes
Linda Winkler (8)	Professional staff	Yes
Rick Summerhill (9)	Professional staff	Yes
Roberto Sabatino (10)	Professional staff	Yes
Erik-Jan Bos (11)	Professional staff	Yes
Kees Neggers (12)	Other Senior Personnel	Yes
Joe Mambretti (13)	Other Senior Personnel	Yes

(3) Alan Verlo is the TransLight/StarLight network engineer, and is a member of the StarLight engineering team. For many years Verlo has also been a member of the SC conferences' SCinet committee, focusing on enabling international SC research demos that have connections in Chicago. He was also co-chair of the iGrid 2005 international cyberinfrastructure team, responsible for clusters and international networking. Verlo regularly participates in JET and GLIF GOLE meetings.
(4) Laura Wolf is responsible for TransLight/StarLight technical writing and web documentation.
(5) Steve Sander is the TransLight/StarLight budget, accounts payable and equipment procurement person.
(6) Pat Hallihan reports to Alan Verlo and is technical support staff.
(7) Lance Long reports to Alan Verlo and is technical support staff.
(8) Linda Winkler of Argonne National Laboratory, while not compensated by the University of Illinois at Chicago (UIC), serves as part-time StarLight engineer with Alan Verlo, and assists with TransLight/StarLight. For many years, Winkler has been a member of the SCinet committee, focusing on enabling international SC research demos that have connections in Chicago. She was also co-chair of the iGrid 2005 international cyberinfrastructure team, responsible for clusters and international networking.
(9) Rick Summerhill is the Internet2 Chief Technology Officer and, while not compensated by UIC, is one of the stewards of the TransLight/StarLight link that connects the Internet2 network at MAN LAN to the GÉANT2 POP at the Amsterdam Internet Exchange.
(10) Roberto Sabatino is the DANTE Chief Technology Officer and, while not compensated by UIC, is one of the stewards of the TransLight/StarLight link that connects the Internet2 network at MAN LAN to the GÉANT2 POP at the Amsterdam Internet Exchange.
(11) Erik-Jan Bos is a SURFnet Managing Director and, while not compensated by UIC, is one of the stewards of the TransLight/StarLight link connecting StarLight in Chicago to NetherLight in Amsterdam.
(12) Kees Neggers is a SURFnet Managing Director and a founder and current chair of GLIF. While not compensated by UIC, he does the tenders and procures both TransLight/StarLight links on UIC's behalf, and is one of the stewards of the TransLight/StarLight link connecting StarLight in Chicago to NetherLight in Amsterdam.

(13) Joe Mambretti is the StarLight managing director and head of the International Center for Advanced Internet Research (iCAIR) at Northwestern University. While not compensated by UIC, Joe has been a strong supporter and advisor regarding our IRNC efforts. Mambretti has assisted with connectivity issues, not only at StarLight, but also at MAN LAN.

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

Argonne National Laboratory
Argonne National Laboratory's Mathematics and Computer Science Division (MCS) <www.mcs.anl.gov> has been, and continues to be, a strong supporter of US international networking activities. Linda Winkler has facilitated STAR TAP/StarLight engineering since its inception, and is the lead engineer today; her salary comes from Argonne.

Northwestern University
Joe Mambretti, director of Northwestern's International Center for Advanced Internet Research (iCAIR) <www.icair.org>, also runs the StarLight facility <www.startap.net/starlight>, and assists with connectivity issues.

SURFnet
SURFnet, the national network for research and education in the Netherlands <www.surfnet.nl>, is a TransLight/StarLight "key institutional partner," responsible for negotiating, procuring and implementing the TransLight OC-192 circuit(s) between Open Exchanges in the US and in Europe, which UIC pays for upon receipt of an invoice from SURFnet, as has been our practice since our previous NSF HPIIS Euro-Link award.

1.D. Other Collaborators or Contacts

CANARIE
The Canadian Network for the Advancement of Research, Industry and Education (CANARIE) <www.canarie.ca> is Canada's advanced Internet development organization. It operates CA*net 4, a series of point-to-point optical wavelengths, most of which are provisioned at 10Gbps speeds, interconnecting Canada's provincial research networks with each other and international peer networks, and forming an innovative framework to support grids and e-Science.

DANTE
Owned by European NRENs, DANTE <www.dante.net> is an organization that plans, builds and operates pan-European networks for research and education. The GÉANT2 project is a collaboration among 26 National Research & Education Networks representing 30 countries across Europe, the European Commission, and DANTE. Its principal purpose is to develop the GÉANT2 network -- a multi-gigabit pan-European data communications network for research and education; see <www.geant2.net>. TransLight/StarLight funding provides a 10Gbps routed infrastructure to connect the Internet2 network, NLR PacketNet and DOE/ESnet with DANTE/GÉANT2. TransLight/StarLight also makes a 10Gbps switched infrastructure available for use.

ESnet
The Energy Sciences Network, (ESnet) <www.es.net> is funded by the DOE Office of Science to provide network and collaboration services in support of the agency's research missions, serving thousands of Department of Energy scientists and collaborators worldwide. ESnet provides direct connections to all major DOE sites with high-performance speeds, as well as fast interconnections to more than 100 other networks. TransLight/StarLight funding provides a 10Gbps routed infrastructure to connect the Internet2 network, NLR PacketNet and DOE/ESnet with DANTE/GÉANT2. TransLight/StarLight also makes a 10Gbps switched infrastructure available for use.

Global Lambda Integrated Facility (GLIF)
GLIF <www.glif.is> is an international virtual organization of NRENs, consortia and institutions that promotes lambda networking. GLIF provides lambdas internationally as an integrated facility to support data-intensive scientific research, and supports middleware development for lambda networking. It brings together premier networking engineers to develop an international infrastructure by identifying equipment, connection requirements, and necessary engineering functions and services.

GLORIAD

GLORIAD, the Global Ring Network for Advanced Applications Development, <www.gloriad.org> is currently constructing a dedicated lightwave round-the-world connecting scientific organizations in the United States, Russia, China, Korea, Canada, the Netherlands and the Nordic countries. GLORIAD currently has 3x1Gbps VLANs on the TransLight/StarLight CHI/AMS link to NetherLight, where Russia has a 10Gbps link to Moscow. (This will soon change, and Russia will connect from Moscow to Stockholm, and then to Amsterdam via NORDUnet.)

Internet2
Internet2 <www.internet2.edu> is a consortium of leading US research universities working in partnership with industry and government to develop and deploy advanced network applications and technologies. In Spring 2007, the new Internet2 network <www.internet2.edu/network/>, a hybrid optical and packet network, designed in collaboration with Level 3 Communications, came online. TransLight/StarLight funding provides a 10Gbps routed infrastructure to connect the Internet2 network, NLR PacketNet and DOE/ESnet with DANTE/GÉANT2. TransLight/StarLight also makes a 10Gbps switched infrastructure available for use.

National LambdaRail (NLR)
NLR <www.nlr.net> is a major initiative of US research universities and private sector technology companies to provide a national-scale infrastructure for research and experimentation in networking technologies and applications. TransLight/StarLight considers itself, in part, to be the international extension of NLR, and wants to encourage data-intensive e-science drivers needing gigabits of bandwidth to use NLR FrameNet and international links for schedulable production services not available with "best effort" networks. TransLight/StarLight funding provides a 10Gbps routed infrastructure to connect the Internet2 network, NLR PacketNet and DOE/ESnet with DANTE/GÉANT2. TransLight/StarLight also makes a 10Gbps switched infrastructure available for NLR FrameNet use.

TransLight/PacificWave
TransLight/PacificWave <www.pacificwave.net/participants/irnc> is developing a distributed exchange facility on the West Coast (currently in Seattle, Sunnyvale, and Los Angeles) to allow interconnection of international research and education networks with US research networks. TransLight/PacificWave is the sister project to TransLight/StarLight.

2. Activities and Findings

2.A. Research Activities

2.A.1. Goals and Objectives

The NSF International Research Network Connections (IRNC) TransLight/StarLight award is responsible for providing a minimum of OC-192 connectivity between the US and Europe. The goals of the IRNC program in general, and TransLight/StarLight specifically, are to:

- Fund international network links between US and foreign science and engineering communities
- Encourage the use of advanced architectures
- Support advanced science and engineering requirements
- Encourage the development and leveraging of deployed infrastructure to meet current and anticipated needs
- Enable network engineers to engage in system and technology demonstrations and rigorous experimentation

In cooperation with US and European national research and education networks, TransLight/StarLight is implementing a strategy to best serve established production science, including use by scientists, engineers and educators who have persistent large-flow, real-time, and other advanced application requirements.

2.A.2. Accomplishments and Milestones

In Year 3, TransLight/StarLight continues to fund two international links, which were both delivered July 2005: an OC-192 routed connection between MAN LAN in New York City and NetherLight at the Amsterdam Internet Exchange (AMS-IE) connecting GÉANT2 to the US Internet2, NLR and ESnet networks, and an OC-192 switched connection between StarLight in Chicago and NetherLight (also at the AMS-IE) that is part of the GLIF fabric.

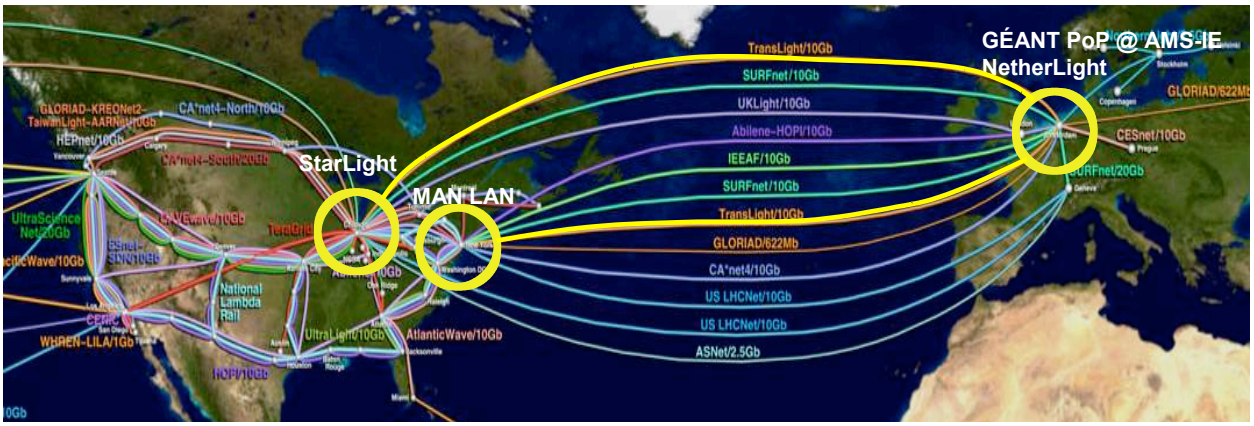
In Year 3, we worked with our IRNC and TransLight/StarLight partners on various activities, to:

- **Identify and develop production applications on both IRNC circuits**
  - Identify and support science and engineering research and education applications, and provide network engineering assistance for several demanding US/Asia/Europe demonstrations, at major events and activities, including research demonstrations at GLIF in Prague, Czech Republic, September 17-18, 2007, and at SC'07 in Reno, NV, November 10-16, 2007.
  - Plan and provision 1Gbps VLANs between Chicago and Amsterdam. Currently we have 3x1Gbps VLANs for GLORIAD (Greg Cole); 1Gbps VLAN for NOAA/Russia collaborations; 1Gbps VLAN for the Teraflow Testbed (Robert Grossman); 3 x 1Gbps VLANs for the OptIPuter and Global Lambda Visualization Facility (Jason Leigh); and 2 x 1Gbps VLANs (in progress) for high-energy physics between CERN and Tier2 institutions in Brazil (Harvey Newman and Julio Ibarra).
- **Enable state-of-the-art international network services similar to and interconnected with those offered or planned by domestic research networks, including the Internet2 network, NLR and ESnet.**
  - Assisted implementing "TransLight," a 10Gbps circuit donated by Cisco Systems and deployed by NLR between TransLight/StarLight in Chicago and TransLight/PacificWave in Seattle.
- **Share network engineering tools and best practices**
  - Learn about cybersecurity best practices of benefit to the IRNC community
  - Participate in JET, Joint Techs, and GLIF GOLE meetings
  - Participate in IRNC Measurement Group meetings (Matt Zekauskas and Matt Mathis)
- **Documentation and conference presentations**
  - Maintain the TransLight/StarLight website <www.startap.net/translight>
  - Contribute to the GLIF website <www.glif.is> and facilitate the design of a new GLIF world map
  - Give presentations at conferences (e.g., SC, ONT, GLIF, Internet2)

2.A.3. Infrastructure Topology

TransLight/StarLight consists of two international links, which were both delivered July 2005:

- **NYC/AMS:** OC-192 routed (L3) connection between MAN LAN in New York City and NetherLight at the Amsterdam Internet Exchange (AMS-IE) connecting GÉANT2 to the US Internet2, NLR and ESnet networks. *This link was originally provided by VSNL, but with an administrative change to Qwest, who assumed responsibilities for the lambda on the VSNL international cable systems as of December 30, 2007.*
- **CHI/AMS:** OC-192 switched (L2) connection between StarLight in Chicago and NetherLight in Amsterdam (also at the AMS-IE) that is part of the GLIF LambdaGrid fabric. This is configured as a 10GigE circuit, carved into VLANs, for data-intensive applications requiring lightpaths. *This link is provided by Global Crossing.*
- Note: SURFnet funds two complementary links from Amsterdam to New York (MAN LAN) and Chicago (StarLight), which leverages and complements the IRNC links. (Regarding overall US/European network leveraging, see Section 3.A.1: Leveraging to Date of IRNC Award Investment.)



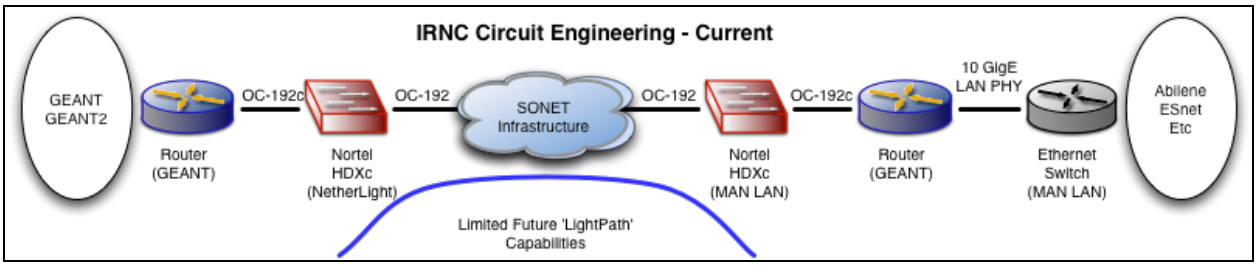
The GLIF Technical Engineering (TECH) Working Group has defined GLIF Open Lightpath Exchanges, or GOLEs. MAN LAN, StarLight and NetherLight are all GOLEs. The **NYC/AMS** and **CHI/AMS** links are, from an operating perspective, treated similarly, as permanent 10Gbps lightpaths that are either handed off to routers (NYC/AMS) or switches (CHI/AMS).

IRNC pays for links only. At MAN LAN, Internet2 pays for an HDXc and GÉANT2 pays for the router. At the AMS-IE, SURFnet pays for an HDXc and GÉANT2 pays for the router. At StarLight, CANARIE pays for an HDXc and StarLight provides a Force10. At NetherLight, SURFnet pays for an HDXc and Nortel ERS8600R switch (previously, until November 2007, we used a Force10 owned by University of Amsterdam).

2.A.4. NYC/AMS Network Operations and Engineering

PoP Connectivity and Peering – NYC/AMS

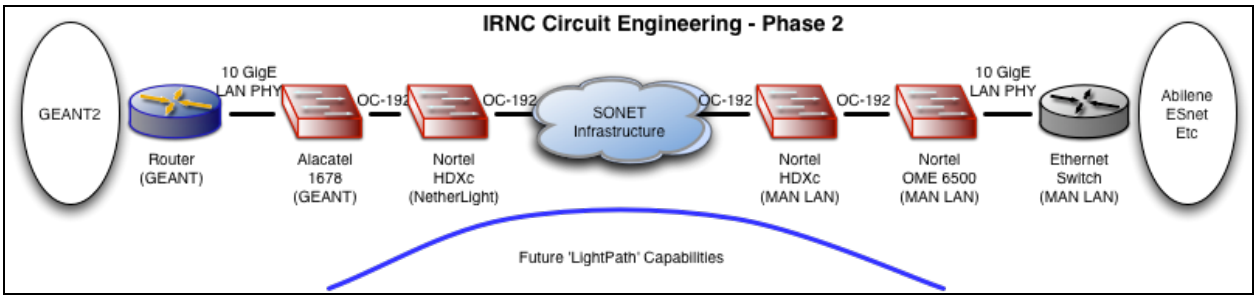
NYC/AMS…Currently, this OC-192 is connected between GÉANT2 owned-and-operated Juniper M160 routers located at the MAN LAN facility and the NetherLight facility at the AMS-IE (operated by SARA). At MAN LAN, the router connects to Internet2's HDXc; at NetherLight, the router connects to SURFnet's HDXc.



While Internet2 and DANTE wanted to replace DANTE's router at MAN LAN with an Alcatel MCC1678 switch to

enable more flexible connections to Internet2, NLR and ESnet, interoperability problems between the Alcatel and a Nortel OME6500 at MAN LAN have delayed this indefinitely. Internet2 and DANTE engineers did interoperability tests on the Nortel equipment (at MAN LAN) and Alcatel equipment (GÉANT2 POP in Amsterdam), but discovered issues with performance. Testing started again in January 2008 to determine whether these issues could be resolved.

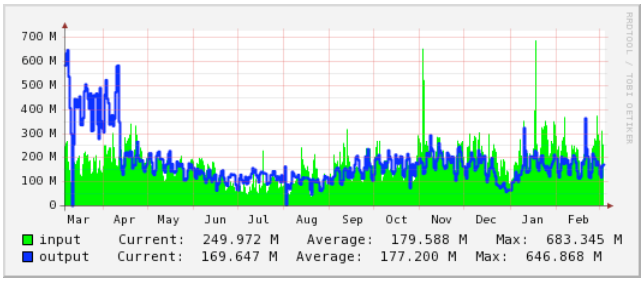
Internet2 and DANTE had wanted to engineer the TransLight/StarLight link to carry lightpaths as well as Layer 3 IP traffic, as illustrated below. However, because GÉANT2 has a NYC/Paris OC-192 link and Internet2 has a NYC/London OC-192 link that are provisioned exclusively as lightpaths, they do not see any urgency to upgrade the TransLight/StarLight link.

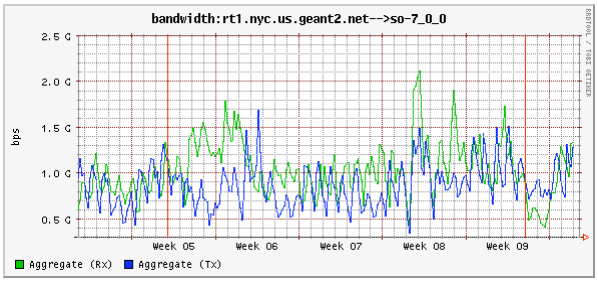


Usage

Internet2 makes MRTG traffic statistics of Internet2/GÉANT2 peering at MAN LAN available. Statistics are at: <http://dc-snmp.grnoc.iu.edu/i2net/show-graph.cgi?title=rtr.newy32aoa.net.internet2.edu--ge-4/0/0.102&rrdname=rtr.newy32aoa.net.internet2.edu--ge-4_0_0.102.rrd>.

In 2007, GÉANT2 migrated its measurement tools (stats.geant.net) to a new portal (stats.geant2.net) tied to web accounts. While GÉANT2 previously provided Maxine Brown with access to a password-protected website, they are not providing her with a new GÉANT2 account. However, they did provide a monthly utilization chart. *Note: The GÉANT2 charts show utilization of over 2.0Gbps on the link. Internet2 believes that the GÉANT2 traffic is the aggregate of Internet2, ESnet and NLR PacketNet traffic. In the coming months, we will try to obtain URLs for traffic usage for ESnet and NLR, as well as Internet2.*





On the left, is the Internet2's SNAPP 2007 utilization chart for TransLight/StarLight. On the right, is the GÉANT2 monthly utilization chart for 2008 (February/March), which shows the aggregate of Internet2, ESnet and NLR traffic.

Routing Policies

The NYC/AMS link is a routed, L3 connection providing connectivity among GÉANT2 in Europe and the Internet2, DoE ESnet, NLR and CANARIE's CA*net4 at the MAN LAN exchange point. While other links between Internet2 and GÉANT2 exist, this link is being preferred for traffic between Internet2 and GÉANT2.

Peering Policies

The Internet2 network and the GÉANT2 network follow their established peering policies with respect to accessing and transiting traffic that might flow over this link. A list of Internet2 direct peers (i.e., those for which Internet2 has BGP peering sessions set up) can be found at <www.internet2.edu/network/peers>. From the Internet2 network, one can reach ~80 research and education networks, many via transit over direct peer networks like GÉANT2.

GÉANT2 connects 30 European national research and education networks across 34 countries

<www.geant2.net/server/show/nav.00d009001>. GÉANT2 also benefits from connections to other world regions that have been achieved through other related research networking projects, notably:

- Southern and Eastern Europe through SEEREN <www.seeren.org>
- The Mediterranean through EUMEDCONNECT <www.eumedconnect.net/?PHPSESSID=a2d20eecaf68d1fabe8440d45378f62c>
- Latin America through ALICE <www.geant2.net/alice>
- The Asia-Pacific region under TEIN2 <www.tein2.net>

Security

Internet2 and GÉANT2 Security Information

Internet2 recently switched over from its Abilene network to the Internet2 IP Network, deployed on Level 3. DDOS and Transit security information can now be found at <https://wiki.internet2.edu/confluence/display/network/Forms%2C+Maps%2C+Policies%2C+and+Procedures>. GÉANT2 security information is documented at <www.geant2.net/server/show/nav.1822>.

Engineering

IRNC benefits from Internet2, ESnet, GÉANT2 and CANARIE collaboration efforts. Current issues being tackled include: an ESnet, GÉANT2, Internet2 interconnection in Washington DC; the development of hybrid network services; sharing of testbed capabilities; the management of end-to-end (e2e) services across networks; and, a joint network security exercise. Meetings and outcomes are documented at <www.geant2.net/server/show/nav.1227>.

NOC Operations

The Global NOC based at Indiana University handles Internet2 NOC operations: <http://noc.net.internet2.edu>.

The Global NOC at Indiana University also handles NOC operations for the MAN LAN facility (through which the Internet2 network, ESnet, NLR and GÉANT2 peer in New York): <http://noc.manlan.internet2.edu>.

The GÉANT NOC handles GÉANT2 NOC operations: <www.geant2.net/server/show/nav.759>.

RENOG: Global NOC-NOC Communications

RENOG, the Research & Education Network Operators Group <www.renog.org>, facilitates technical discussion among network operators in global research and education networks. StarLight, TransLight/StarLight and Internet2 network engineers are subscribed to the RENOG mailing list. *Note: GLIF facilitates international technical coordination of lambda networking.*

2.A.5. CHI/AMS Network Operations and Engineering

PoP Connectivity and Peering – CHI/AMS

CHI/AMS…In Chicago, the TransLight/StarLight OC-192 is connected to a CANARIE-owned HDXc box at StarLight and then to StarLight's Force10 switch. Via StarLight's Force10, this link peers with a number of advanced international networks, as well as the Internet2 network, NLR, ESnet, and regional optical networks.

In Amsterdam, the link is connected to a SURFnet-owned HDXc box at NetherLight. From there, the link had been plugged into the University of Amsterdam's (UvA) Force10, but was moved to a NetherLight Nortel NERS8600R switch just prior to SC07. However, during SC07, SURFnet experienced some hardware problems so moved the IRNC link back to the UvA Force10 for a few days.

SURFnet and TransLight/StarLight each have 10Gbps links between Chicago and Amsterdam. To offer diverse configurations and paths, the SURFnet link is configured into 1GbE channels, while the IRNC is configured as a full WAN PHY with shared VLANs. If we find that this arrangement is not optimal in the future, we can change it.

TransLight…As of June 30, 2006, TransLight/StarLight and TransLight/Pacific Wave are directly connected through a 10GigE lightpath connection donated by Cisco Systems and deployed on NLR. This network fabric between the two TransLight entities creates a way for participating networks to easily configure direct connections when needed, and can be used for peering/exchange and transit.

i2CAT L2 (Barcelona)…i2CAT's 10Gbps link to NetherLight became operational April 20, 2007. This link is

being used for several projects, including Phosphorus and CineGrid.

PERN (Pakistan) expressing interest in joining GLIF fabric…Pakistan's Higher Education Commission (HEC) is interested in high-speed connectivity, and HEC Chairman Atta-ur-Rehman was scheduled to visit NSF in February 2007 to discuss large-scale collaborative projects; HEC started to build PERN2, a high-speed interconnect among higher-education institutions in Pakistan. Subsequently, Anwar Amjad, consultant IT to HEC, and Arshad Ali (NIIT), met with NSF on April 25, 2007 and visited Joe Mambretti at StarLight on April 27, 2007.

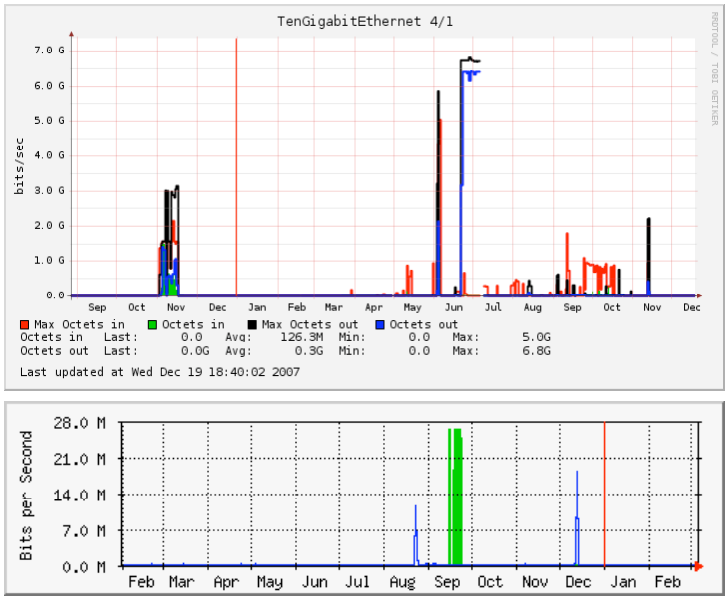
Usage

Multiple VLANs run over this lambda. The CHI/AMS link has proven popular as a vehicle for lightpaths required for short periods; for example, during Supercomputing events, where the usage of the link has to be scheduled.

L1 links cannot be monitored for usage; however, the CHI/AMS link goes from the StarLight HDXc into a Force10 switch, and from the NetherLight HDXc into a Nortel ERS8600R switch owned SURFnet, and a UvA Force10 prior to that. Bandwidth utilization can be measured on the switches.

StarLight makes MRTG traffic statistics of TransLight/StarLight available; statistics are at: <http://noc.startap.net/mrtg/206.220.240.222_tengigabitethernet_3_0.html>. *Note: Daily and weekly StarLight MRTG usage charts appear in this report to substantiate bandwidth for some of the heroic 1-2Gbps demonstrations and experiments that took place throughout the year. However, the MRTG annual chart does not reflect this usage in its Y-axis. Why this is the case is unknown, though one possibility is that MRTG charts, when averaging data to show annual usage, take data in bigger time steps, thereby bypassing the multi-gigabit spikes that occur for a few hours in a short timeframe. The StarLight network engineers agree, saying that without doing fine grained collection and analysis, the MRTG results are less than perfect.*

Meanwhile, UvA made TransLight/StarLight Cricket traffic statistics available from its Force10, through November 2007, when the link was moved to a Nortel ERS8600R. *Statistics for the Nortel switch are not yet available, though SURFnet is working on it.* UvA statistics appear below, and are available at: <http://trafficlight.uva.netherlight.nl/cricket/grapher.cgi?target=%2Ff10%2Ften_giga_eth_4_1;view=Octets;ranges=d%3Aw%3Am%3Ay>. *Note: The UvA chart shows several multi-gigabit spikes of traffic over the course of a year.*



The top diagram is the UvA Force10's Cricket yearly IRNC bandwidth utilization chart (Y axis is 7Gbps). The bottom diagram is the StarLight MRTG (Y axis is 28Mbps). While the discrepancy could be the way that the different systems do annual averaging, it is unknown at this time. We believe that the UvA chart more accurately reflects usage.

Routing Policies

The CHI/AMS link is a 10Gbps lambda implemented between StarLight and NetherLight. Since no IP routers are on

the lambda, there are no routing policies to report.

Peering Policies

Lightpaths are L1 point-to-point connections, so traditional peering policies don't apply. Instead, peering is based on the GLIF principle that resources are shared among collaborating participants; resource owners decide use.

Security

StarLight, NetherLight/SURFnet Security Information

Current StarLight and NetherLight security information is documented on the TransLight/StarLight website <www.startap.net/translight/pages/security.html>. StarLight security can be found at <www.startap.net/starlight/ENGINEERING/starlight%20security.html>. SURFnet/NetherLight security is documented at <www.surfnet.nl/info/en/services/security/home.jsp>.

It should be noted that both the carrier, Global Crossing, and the NetherLight facility located at the Amsterdam Internet Exchange in the SARA Computing and Networking Services building on the campus of the Science Park Amsterdam also maintain robust procedures to secure their cables and connections.

Adopting best practices…In the coming years, TransLight/StarLight will, pending budget, manpower and equipment, adopt best practices under NSF's guidance. In addition, Alan Verlo attended the Cybersecurity Summit 2007 for NSF Large Research Facilities, February 22-23, 2007, in Arlington, VA, and has distributed the URL for online proceedings and other relevant information to StarLight principals, notably:

- <www.educause.edu/Proceedings/12196> (Cybersecurity Summit proceedings)
- <www.educause.edu/ir/library/pdf/CYB07001d.pdf> (NSF security requirements for Cooperative Agreements for Large Facilities and FFRDCs)
- <www.educause.edu/security> (Educause/Internet2 Computer and Network Security Task Force website)

In addition, the National Academy of Sciences' Computer Science & Telecommunications Board (CSTB) published its findings on cybersecurity, "Toward a Safer and More Secure Cyberspace," in June 2007 <http://www7.nationalacademies.org/cstb/pub_safercyberspace.html>.

In general, lambda networking is considered a more secure way of networking as, in principle, shared packet devices are not located in the path, but only at the very edges.

Engineering

NDT, iperf, OWAMP, etc…StarLight has a NDT server <Network Diagnostic Tool: ndt.sl.startap.net>, an iperf server <iperf.sl.startap.net> with BWCTL software (Bandwidth Test Controller: bwctl.sl.startap.net) <Bandwidth Test Controller: http://e2epi.internet2.edu/bwctl/>, and an OWAMP server <One Way Active Measurement Protocol: owamp.sl.startap.net> <One-way Ping: http://e2epi.internet2.edu/owamp/>. These are connected to both routed R&E networks and to the CAVEwave lambda network and the TransLight/StarLight CHI/AMS link.

Pathdiag, PerfSONAR…Verlo is in the process of installing the network diagnostic tools Pathdiag and perfSONAR. Verlo recently installed an MRTG measurement host on an EVL-owned switch at StarLight that supports EVL-related activities and links, including CAVEwave, OptIPuter 10Gbps connections to EVL and NCSA, VLANs to Amsterdam and Moscow, and other circuits (NASA, CineGrid, LSU). The MRTG measurement host will be used for the IRNC PerfSONAR setup, and the MRTG data will be used by PerfSONAR to monitor GLIF lightpaths/VLANs that traverse CAVEwave and the other circuits mentioned.

TL1 Toolkit…TL1 Toolkit <http://nrg.sara.nl/TL1-Toolkit>, released by SARA and funded by SURFnet in The Netherlands, enables network engineers to execute TL1 commands without knowing the exact syntax and returns the output in a standard format. This library has specific retrieve functions for Nortel OME6500, Nortel DWDM CPL, Nortel HDXc and Cisco ONS15454, but can be used to execute TL1 commands on *any* TL1-capable device using the cmd() function. The TL1 Toolkit may prove useful for monitoring the StarLight/GOLE Nortel HDXc (and MAN LAN Nortel OME6500). On December 31, 2007, TL1 Toolkit version 1.3.1 was released.

Network Description Language (NDL)…NDL provides a way to describe computer networks in a meaningful way. This work is being spearheaded by University of Amsterdam in collaboration with the GLIF TECH Working Group <www.science.uva.nl/research/sne/ndl/>.

Measuring Lightpath Services…Much remains to be learned about how to measure and report traffic on hybrid networks, which deliver lightpath services as well as routed IP services. On February 6, 2007, SURFnet distributed a draft document describing the problem space of measurement in a hybrid network as a starting point for discussions among GLIF TECH Working Group participants. <http://www.glif.is/working-groups/tech/lightpath-measurement-0.9.pdf>.

Identifying Lightpaths…On December 6, 2007, SARA started a discussion among GLIF TECH Working Group participants on global identifiers for lightpaths. These identifiers need to ensure uniqueness, be maintenance free as much as possible (i.e. a name should not change when one of the characteristics of the lightpath changes), avoid any notion of a central authority or repository, and be able to generate a name on the spot by an organization (i.e., without going back and forth with one or more peer organizations).

LightPath Services…The following 1Gbps VLANs on the TransLight/StarLight CHI/AMS link are in place:

- **GLORIAD…** Per June 2006 discussions with Kevin Thompson of NSF, TransLight/StarLight provided 3 x 1Gbps VLANs on its CHI/AMS link to GLORIAD. Implementation was delayed due to installation of GLORIAD equipment at StarLight and Moscow delays, but was operational and in use by April 10, 2007.

  Note: The 10Gb Moscow-Amsterdam (and hence, Moscow-Chicago) connection will be temporarily suspended on January 1, 2008, due to recent management and financial issues within Russia. These problems will hopefully be resolved in short order so collaborations can continue.

- **NOAA…** A 1Gbps lightpath on the TransLight/StarLight-GLORIAD infrastructure was put in place from NOAA's National Geophysics Data Center (NGDC) in Boulder, CO, to Chicago (via NLR FrameNet), from Chicago to Amsterdam (via TransLight/StarLight), and from Amsterdam to Moscow (via RBnet) to the Center of Geophysical Data Studies of the Russian Academy of Sciences.

- **Teraflow Testbed…**Bob Grossman of the UIC National Center for Data Mining and the head of the Teraflow Testbed project requested a VLAN on the TransLight/StarLight-GLORIAD infrastructure for Teraflow research between Chicago and Moscow. This link was operational on March 28, 2007, and was first used to exchange SDSS data between NCDM's servers at UIC and StarLight with servers in Moscow. (In Section 2.B.3: e-Science Support, see the *Teraflow Testbed 2007: Sloan Digital Sky Survey* entry.)

- **OptIPuter/Global Lambda Visualization Facility (GLVF)…** The UIC Electronic Visualization Laboratory (EVL) founded the GLVF[1] at iGrid 2005, to develop and standardize on networked collaboration and scientific visualization tools and techniques for the benefit of e-science. Many GLVF partners are also OptIPuter partners, and are using OptIPuter-developed SAGE technologies as a platform for scientific collaborations. EVL has VLANs to SARA and University of Amsterdam in place for GLVF collaboration. EVL also has a VLAN on the TransLight/StarLight-GLORIAD infrastructure for OptIPuter/SAGE research with Moscow. (In Section 2.B.3: e-Science Support, see the *GLVF: OptIPuter SAGE Visualcasting @ GLIF 2007* and *GLVF: 50th Anniversary of Sputnik 2007* entries.)

- **Korea-NORDUnet Medical Imaging…**NORDUnet requested a 1Gbps VLAN on TransLight/StarLight for a Korea-Norway collaboration between the Department of Gynecologic Oncology, University Hospital, Trondheim, Norway, and YonSei Hospital in Seoul, Korea, who are collaborating on medical imaging (remote HDTV laparoscopy) <http://people.kreonet.net/medicalHD-pilot/index.html>. The application requires at least 800Mbps, low jitter. *(Note: Though a TransLight/StarLight VLAN was requested, a 1GE circuit on the SURFnet AMS-CHI link was configured, so TransLight/StarLight is not being used for transit. A VLAN over TransLight (the donated Cisco Research Wave between Chicago and Seattle) was configured, which carries traffic from Chicago to Seattle, where it peers with KREONet2.)*

LightPath Services…The following VLANs are pending:

- **DRAGON…**The DRAGON project (Jerry Sobieski) expressed interested in a VLAN between Amsterdam and Chicago for dynamic path computation and inter-domain provisioning. DRAGON is developing multi-domain authorization capabilities with UvA researchers, and is establishing a more persistent

[1] GLVF <www.evl.uic.edu/cavern/glvf> is a group of international researchers collaborating on the design and development of complementary, distributed visualization and collaboration technologies. GLVF's primary goals are to create de-facto international standards and integrated tools to enable advanced, real-time, interactive visualization and distance collaboration; to work with global scientific teams on the social science of collaboration; to both learn from and educate them on how to use these new technologies to transform the ways they do science; and, to globally train our students and junior faculty, the next-generation, globally-engaged workforce.

intercontinental lightpath capabilitiy for eVLBI activities. We are currently waiting for DRAGON to send equipment (a small switch and a PC) to StarLight.

- **Large Hadron Collider/CERN…** Tom DeFanti has been talking with Harvey Newman (Caltech), Don Petravick (Fermilab) and Bill Johnston (ESnet) about using a portion of TransLight/StarLight links for Large Hadron Collider (LHC) data grid production. On October 24, 2007, Newman contacted DeFanti, copying CERN network engineer Dan Nae, with technical questions to facilitate connectivity. Newman is designing a test phase where he will bring data to his LHC PoPs at NetherLight and CERN, and then work with Internet2 and GÉANT2 to do two things: (1) with GÉANT2, reach some of the European Tier1s who are willing, such as IN2P3, and (2) with Internet2, get some of the US Tier2s connected to the Internet2 Dynamic Circuit Network in the next several months. The IRNC link will be used to connect the European and US facilities. The first step is to do high-speed storage-to-storage among POPs at a few sites, including Caltech and CERN.
- **Large Hadron Collider/CERN/Brazil…** Tom DeFanti talked with Julio Ibarra (WHREN-LILA) and Harvey Newman (Caltech) about using IRNC to connect two Tier2 groups in Brazil – ***via Brazil's Rede Nacional de Pesquisa (RNP)/***HEPGrid network to Universidade do Estado do Rio de Janeiro (UERJ), and ***via the Academic Network at São Paulo (ANSP)*** to the São Paulo Regional Analysis Center (SPRACE), Universidade Estadual Paulista (UNESP)/ Universidade de São Paulo (USP) – to Tier1 sites and CERN at 1Gbps rates. Network engineers in Brazil, the US and CERN implemented 2 x 1Gbps VLANs to move traffic over WHREN (Brazil to Miami), AtlanticWave (Miami to Washington DC), CAVEwave (Washington DC to Chicago), TransLight/StarLight (Chicago to Amsterdam), and then over SURFnet and/or CERN links (Amsterdam to Geneva). These VLANs were completed in March 2008.

  In an email to DeFanti dated December 26, 2007, Newman explains why this is of benefit to the US:

The use of the IRNC bandwidth by the Latin American Tier2s and their partners is of considerable benefit to US scientists involved in the LHC physics program, for the following reasons:

(1) In the context of the distributed computing model of the CMS experiment, each Tier2 center needs to contact and receive data from Tier1s throughout the experiment, in order to balance the use of Tier1 resources throughout the experimental collaboration. Without the use of the IRNC links, all the datasets needed by the Latin American Tier2s would need to be transported first to the Tier1 at Fermilab, thus increasing the burden on the US Tier1. This would have an impact on the computing and manpower resources provided jointly by the Department of Energy and the National Science foundation to the US CMS Research Program.

(2) The groups at UERJ (Rio de Janeiro) and USP/UNESP (Sao Paulo) are providing important manpower resources to the installation and commissioning of the CMS experiment. Without these resources, a greater share of the overall commissioning and installation burden (and costs) would fall to the US. Justification to support these activities by Brazilian physicists comes through the preparations for physics and in the potential discoveries that are expected once the LHC begins operation in the Summer of 2008. This relies in turn on the effectiveness of the Latin American Tier2 centers (where the majority of the data analysis will take place for the Latin American groups in CMS), for the reasons given above.

(3) In the context of the CHEPREO program, UERJ and UNESP are collaborating on multiple lines of data analysis with Caltech, the University of Florida (UF), Florida State University (FSU), and Florida International University (FIU), including searches for Higgs particles, supersymmetry and other signs of new physics. A central theme of this collaboration is precision measurements of leptons combined with jets and missing energy. As part of this collaboration, the seven US and two Latin American Tier2 centers are working together to share computing and storage resources. Without the use of part of the IRNC transatlantic link, the Tier2s at UERJ and USP/UNESP will not be effective, for the reasons given above, and a larger share of the US Tier2 resources for computing and storage, and the associated manpower, would need to be used to support these data analysis tasks.

(4) A central direction of development of US and transatlantic networking in support of the LHC and other major science programs is towards the use of dynamically provisioned, end-to-end network services. Combining this with state-of-the-art applications, TCP protocol stacks, custom Linux kernels and network interfaces, we expect, in NSF-funded projects such as UltraLight, PLaNetS and the recently proposed

VINCI project, to achieve full use of the available network bandwidth both nationally in the US, across the Atlantic between the US and Europe, and between the US and Latin America for the first time.

We are collaborating with USP/UNESP and the Kyatera project in Brazil, as well as the regional Sao Paulo grid led by Prof. Sergio Novaes, in these developments. In the second five-year round of CHEPREO, we have planned, and are budgeted for the same optical multiplexers supporting the emerging standards VCAT and LCAS (CIENA Core Directors) as are now being used in US LHCNet and in Internet2, to be used in collaboration with ESnet and the HEP labs involved in the LHC. The use of VLANs for Layer-2 dynamic provisioning, and from 2008 the Core Directors for Layer-1 dynamic provisioning (using VCAT and LCAS), will enable the CHEPREO collaborators at FIU and at Sao Paulo to participate directly in these developments.

Through the involvement of Prof. Novaes' group, and part of the IRNC link across the Atlantic, we thus expect to establish a tri-continent development and production testbed for high-speed dataset transfers. This testbed and initial production/experience will be of great benefit to the US scientists, indeed to all scientists in the LHC program. This also would make the Tier2s in Latin America more effective, which would once again (as described above) have attendant benefits for the high-energy physicists in the US.

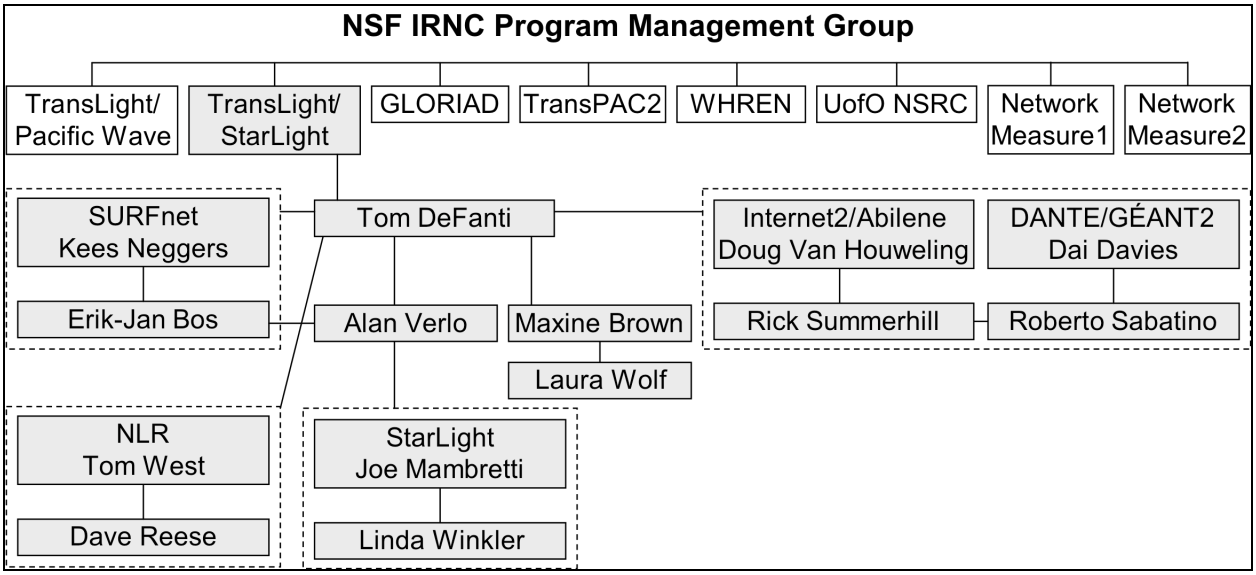
The broader impact of these developments, including use of the IRNC transatlantic links among the US, Latin America and Europe, will be to provide state-of-the-art applications and tools for high-speed data transport, and for managed full use of long-range networks up to the 100Gbps within the next few years. This would clearly be of great benefit to scientists throughout the US, and could hold important lessons for future major programs funded by NSF, including GENI.

NOC Operations

StarLight NOC operations are subcontracted to Argonne National Laboratory; see <www.startap.net/starlight/ENGINEERING/network_operations.html>.

SURFnet NOC operations are detailed on their website <http://noc.netherlight.net/>. Active monitoring of NetherLight and its links is done on a 24x7 basis.

2.A.6. Project Governance/Management and Oversight



TransLight/StarLight's governing structure is very simple and based on mutual cooperation among related groups. This structure can evolve, as necessary, to support all critical or significant project activities.

Tom DeFanti is principal investigator and project director of TransLight/StarLight, and serves as the primary point of contact with our NSF program officer. DeFanti is also steward, with Kees Neggers of SURFnet, of the CHI/AMS link, and has appointed Doug Van Houweling of Internet2 and Dai Davies of DANTE as stewards of the NYC/AMS

link. StarLight and NetherLight provide network engineering and operations support for the CHI/AMS link; Internet2 and GÉANT2 provide support for the NYC/AMS link.

On behalf of TransLight/StarLight, SURFnet negotiates and procures the OC-192 NYC/AMS and CHI/AMS links. SURFnet is a key institutional partner of this IRNC award. Tom DeFanti has been working with Kees Neggers and SURFnet since the beginning of the NSF HPIIS program, and UIC has longstanding procedures in place to pay invoices from SURFnet for transoceanic connectivity without charging any overhead to the grant.

DeFanti, in addition to overseeing the annual tendering, payment and installation of the links, is responsible for assuring annual project milestones are met; coordinating project management and oversight activities with the NSF; serving as the day-to-day project manager; and, serving as a member of the IRNC Program Management Group (of IRNC PIs). He also represents TransLight/StarLight at meetings and conferences, as requested.

Maxine Brown is co-principal investigator of TransLight/StarLight and is responsible for all documentation, including quarterly and annual reports and web-based materials. Brown has also given invited presentations at several meetings and conferences about TransLight/StarLight efforts. Editorial writer Laura Wolf assists Brown with writing and web development as well as coordinates meetings, visits, and participation at major conferences.

Alan Verlo is the TransLight/StarLight network engineer and a member of the StarLight engineering team, so is involved in all network engineering and operations support. For many years, Verlo has also been a member of the SCinet committee, focusing on enabling international SC research demos that have connections in Chicago.

2.A.7. Meeting and Conference Participation

TransLight/StarLight principals have participated in the following meetings and conferences to promote IRNC:

February 14-18, 2008. UIC/EVL, in cooperation with Calit2, brought an OptIPortable (30 Megapixel shippable OptIPortal tiled display) to the AAAS conference in Boston and staffed it for demonstrations of OptIPuter and IRNC activities. Shown here is the 2008 GLIF map (a draft version) on the OptIPortable.

January 20-25, 2008. Alan Verlo attended the Winter 2008 ESCC/Internet2 Joint Techs Workshop (Techs in Paradise) <www.hawaii.edu/tip2008/>. The GLIF TECH and Control Plane Working Groups held meetings January 19-20 <www.terena.org/events/details.php?event_id=1118>; Verlo gave a presentation on "VLANs & Lightpaths: CineGrid at GLIF 2007 Network Infrastructure." The JET met January 21, and Verlo and Winkler participated.

December 12, 2007. Tom DeFanti and Maxine Brown participated in the monthly NSF IRNC phone call.

December 2-5, 2007. Tom DeFanti and Alan Verlo attended the CineGrid Workshop at Calit2, as did Jason Leigh and Luc Renambot (EVL). Leigh participated in the panel "Streaming HD, 4K and Beyond," Renambot participated in the panel discussion "Compression Alternatives for HD and 4K," and Verlo participated in the panel "Successful CineGrid Projects 2007."

November 29, 2007. Thom Dunning of NCSA visited the UIC College of Engineering and toured EVL. As part of the Petascale initiative, he is interested in working with EVL on several areas: (1) enabling distance lecturing and hence visualization using HD between Great Lakes Consortium members as well as potential Petascale users, (2) coming up with a streaming visualization plan to get the results of Petascale out to the end users, and (3) ensuring that StarLight will be around when the Petascale comes up, as NCSA depends on it to enable access to users.

November 27, 2007. Calit2 (Larry Smarr) hosted a visit by representatives from KAUST (King Abdullah University of Science and Technology, Saudi Arabia), interested in future collaborations. Tom DeFanti showed them 4K streaming from remote locations (Amsterdam, Tokyo, Chicago) to show the value of high-performance networks. KAUST representatives included Majid F. Al-Ghaslan, Interim CIO; Sami A. Al-Maghlooth, IT; AbdalKareem M. Al-Jaziri, Aramco Researcher / KAUST Research; Ahmad Al-Ghamdi, Aramco Project Management Team; Nazeeh Hussaini, Aramco Project Management Team; Ron Killer, HOK. Alan Verlo, TransLight/StarLight network engineer, helped facilitate the demonstrations.

November 26-28, 2007. Representatives of the Russian Academy of Sciences' Space Research Institute visited EVL. They already built a tiled display and are running SAGE 3.0, and came to talk with Jason Leigh and Luc Renambot (EVL) about future collaborations. They also collaborate with Bob Grossman (UIC/NCDM) and Joe Mambretti (NU), and also talked with them about future collaborations.

November 14, 2007. Maxine Brown and Joe Mambretti attended an ONT-IV planning meeting at SC2007.

November 10-16, 2007. Tom DeFanti, Maxine Brown, Alan Verlo and Laura Wolf attended SC07 in Reno, NV. Alan Verlo participated in SCInet, supporting StarLight and IRNC international applications. On November 14, Verlo and Linda Winkler participated in the monthly JET meeting, held in conjunction with SC07.

October 26, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

October 23-25, 2007. NSF OCI sponsored an IRNC Workshop, organized by Alan Blatecky. Unfortunately, Tom DeFanti and Maxine Brown had unexpected emergencies and were unable to attend. Chip Cox represented TransLight/StarLight on a Workshop panel. The resulting IRNC Workshop report has been posted to the TransLight/StarLight website.

October 22, 2007. Fang-Pang Lin of the NCHC supercomputer center in Taiwan visited Jason Leigh and Maxine Brown (EVL) to learn more about OptIPuter technologies.

October 19, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

October 16, 2007. Alan Verlo and Linda Winkler participated in the monthly JET meeting at NSF.

October 9-10, 2007. Larry Smarr gave the presentation "New Applications of SuperNetworks and the Implications for Campus Networks" at the Fall 2007 Internet2 Member Meeting, Town and Country Resort and Convention Center, San Diego, CA. The next day, Tom DeFanti orchestrated demos for Internet2 attendees at Calit2; demos included iHDTV teleconferencing between Calit2 and U Washington; 4K streaming from EVL in Chicago to the Calit2 auditorium; stereo movies; and, 4K movies playing locally. Kevin Thompson, while he could not attend the Calit2 portion of the meeting, sent an email saying "…while I got tied up and sadly missed your demos yesterday afternoon, word among folks I've talked to at the I2 meetings is that people were 'blown away'."

October 8-12, 2007. APAC07, the biennial Australian Partnership for Advanced Computing (APAC) Conference and Exhibition on Advanced Computing, Grid Applications and eResearch <www.apac.edu.au/apac07>, was held in Perth. As part of this event, there was a workshop entitled "Driving eResearch Collaboration Across the Pacific (DeRCAP)" <www.apac.edu.au/apac07/dercap/> that was organized by John Silvester's TransLight/PacificWave Application group, with Maxine Brown representing TransLight/StarLight.

October 5, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

October 1, 2007. Russia's Space Research Institute used EVL's SAGE to stream 4K animations from EVL and StarLight to Moscow as part of the October 1, *50th Anniversary of Sputnik* celebrations, to show government officials how they were using Moscow's 10Gbps connection from Moscow to Amsterdam. Bob Grossman's NCDM/TeraFlow/SDSS project was also part of the demonstrations.

September 27-28, 2007. Jason Leigh (EVL) attended the NSF Workshop "Enabling Science Discoveries Through Visual Exploration" in Arlington, VA <www.visualizingscience.org>. Maxine Brown provided NSF OCI program manager Lucy Nowell with copies of the 1987 NSF-funded report *Visualization in Scientific Computing,* edited by Bruce McCormick, Tom DeFanti and Maxine Brown, as Nowell was interested in providing this document to attendees to show what progress has taken place over the past 20 years. Note: This report mentioned networking.

September 26, 2007. Maxine Brown attended the PRAGMA-13 Workshop, at the Advanced Computing Applications and Technologies Institute, UIUC/NCSA, Champaign, IL.

September 22, 2007. Tom DeFanti is a member of the SURFnet Scientific Advisory Committee and attended the annual meeting in Utrecht, The Netherlands.

September 17-18 2007. Tom DeFanti, Maxine Brown, Alan Verlo, Joe Mambretti and Linda Winkler participated in the 7th Annual Global Lambda Grid Workshop (GLIF), Prague, Czech Republic.

- *Streaming 4K at GLIF 2007*…During GLIF 2007, CineGrid participants streamed 4K digital cinema material "on demand" in real time from seven playback servers in Japan, Europe and North America to both audiences at Charles University in central Prague, and then at CinePOST, a cinema post-production facility within Barrandov Studios, one of the largest and oldest film production centers in Europe. Playback nodes were located at: Keio University (Japan); University of Amsterdam/SARA (The Netherlands); Calit2/UCSD; UIC/EVL; UIUC/NCSA; USC/School of Cinematic Arts; and, U Washington/ResearchChannel.
- *4K Remote Production & Color Correction*…On September 18, CineGrid members demonstrated a prototype workflow for remote color-grading of digital rushes from a 4K digital camera shoot in Prague to a specialized

rendering processor located nearly 10,000 km away in San Diego, and a 4K color correction system in Prague operated by a colorist working 7000 km away in Toronto. Calit2 and EVL participated.

- Maxine Brown chaired the GLIF Applications Working Group sessions. Jason Leigh and Luc Renambot of EVL gave a presentation on the OptIPuter "SAGE Visualcasting" experiment between Chicago, Amsterdam and the Czech Republic the week prior to the GLIF event. Laurin Herr of CineGrid gave a presentation on the CineGrid experiments taking place in Prague during the GLIF meeting (for which Alan Verlo provided major network engineering support).
- Joe Mambretti, Cees de Laat, Michel Savoie, et. al., demonstrated "International Dynamic Optical Multicast and the HPDM Testbed."

September 16, 2007. Joe Mambretti, Tom DeFanti, Maxine Brown, Alan Verlo and Linda Winkler participated in the GLIF-North America (NA) meeting, held in Prague, Czech Republic.

August 25-26, 2007. The Chinese-American Network Symposium (CANS 2007) was held in Xi'an, China. Although she did not attend, Maxine Brown was on the program committee and recommended several presentations describing advanced networking applications.

August 24, 2007. Tom DeFanti (Calit2) met with Dr. Velikhov of the Russian Academy of Sciences regarding future Calit2/EVL collaborations.

August 21, 2007. Alan Verlo and Linda Winkler participated in the monthly JET meeting at NSF.

August 16, 2007. Tom DeFanti and Maxine Brown participated in the monthly NSF IRNC phone call.

August 14, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

August 13-14, 2007. Joe Mambretti and Maxine Brown participated in the ONT-4 Planning Meeting, FermiLab, Batavia, Illinois

August 9, 2007. Maxine Brown (EVL) hosted a tour of EVL for representatives from the University of Electronic Science and Technology of China (UESTC), a leading university in China on communication and networking.

August 3, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

July 20-21, 2007. EVL hosted the WIDE/CAIDA measurement workshop, and treated attendees to demonstrations of OptIPuter technologies. Alan Verlo and Matt Zekauskas participated.

July 15-19, 2007. Alan Verlo and Linda Winkler attended the Summer 2007 ESCC/Internet2 Joint Techs Workshop <http://jointtechs.es.net/Illinois2007>, held at Fermilab in Batavia, IL. The JET meeting was held July 17.

July 10, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

July 9-11, 2007. Maxine Brown attended the NSF CI-TEAM Community Building Workshop in Arlington, VA.

June 29, 2007. Tom DeFanti and Maxine Brown participated in the monthly NSF IRNC phone call.

June 26, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

June 21, 2007. The first successful demonstration of transatlantic streaming over photonic IP networks of 4K digital motion pictures and 5.1 surround sound was achieved by the international research consortium, CineGrid. The CineGrid @ Holland Festival 2007 project transmitted the live performance of the opera "Era la Notte" in Amsterdam's concert hall, part of the Holland Festival, nearly 10,000 kilometers, in real time, to UCSD where it was viewed in 4K (which is four times the resolution of HDTV) in the Calit2 auditorium, delivering an audience experience of unprecedented quality across long distances over photonic networks. Calit2, EVL, SARA, UvA and SURFnet participated.

June 20-22, 2007. Natasha Bulashova (GLORIAD) visited Jason Leigh and Maxine Brown at UIC/EVL on June 20, Joe Mambretti (NU/StarLight) on June 21 and Robert Grossman (UIC/NCDM) on June 22, to discuss US/Russia research collaborations, particularly with the Russian Academy of Sciences' Space Research Institute. Her report is available on the web <www.gloriad.org/gloriad/news/chicago-meeting-2007.html>.

June 19, 2007. Alan Verlo and Linda Winkler participated in the monthly JET meeting at NSF.

June 18, 2007. Tom DeFanti and Joe Mambretti participated in the GLIF North America (GLIF-NA) Meeting, Denver, Colorado. Mambretti gave the presentation "Next Generation Network Services."

June 12, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

June 9, 2007. Joe Mambretti presented "Next Generation Advanced Networks," SingAREN, Singapore.

June 5-8, 2007. Joe Mambretti presented "21st Century Communications, Services, Architecture and Technology" at GridAsia 2007, Singapore.

June 4-8, 2007. Maxine Brown attended the TeraGrid '07 conference in Madison, WI.

June 4, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

June 2007. Larry Smarr gave the presentation "Why Researchers are Using Advanced Networks" remotely, over HDTV, from Calit2 in La Jolla, CA, to participants at the *Building KAREN Communities for Collaboration Forum,* sponsored by the KIWI Advanced Research and Education Network at University of Auckland, New Zealand.

May 31, 2007. Joe Mambretti presented "Major Networking Research Themes, US Testbeds, and the GENI Initiative" to NICT, Tokyo, Japan.

May 30, 2007. Tom DeFanti and Maxine Brown participated in the monthly NSF IRNC phone call.

May 22, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

May 16, 2007. Bernard Pailthorpe of the University of Queensland, Australia, visited EVL and gave a presentation on HPC and cyberinfrastructure developments and applications in Australia.

May 15, 2007. Alan Verlo and Linda Winkler participated in the monthly JET meeting at NSF.

May 15, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

May 2, 2007. Alan Verlo and Linda Winkler participated in a phone call of network engineers from the major GLIF Open Lightpath Exchanges (GOLEs) worldwide.

May 1, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

April 27, 2007. Anwar Amjad, consultant IT to Pakistan's Higher Education Commission (HEC) and Arshad Ali (NIIT) met with Joe Mambretti at StarLight. HEC has started to build PERN2 (Pakistan Education & Research Network), a high-speed interconnect among higher-education institutions in Pakistan, and is interested in funding an extension from Islamabad to Amsterdam in order to be part of the GLIF fabric.

April 22-27, 2007. John Silvester represented TransLight/StarLight at the Internet2's Spring Member Meeting, in Arlington, VA. In particular, he participated in the International group's Breakfast Roundtable session on April 23.

April 17-18, 2007. Alan Verlo attended the *Internet2 IPv6 Workshop – Merit* in Ann Arbor, MI <http://events.internet2.edu/2007/ipv6/unicast4-07/index.html>.

April 17, 2007. Linda Winkler participated in the monthly JET meeting at NSF.

March 26-April 2, 2007. To ensure utilization of its 10Gbps link from Barcelona to NetherLight (and then to the US via IRNC TransLight/StarLight and/or SURFnet), the i2CAT Foundation sent engineer Francisco Iglesias to learn more about EVL's SAGE software (developed under OptIPuter). i2CAT is interested in combining SAGE with the Ultragrid system to create a new system: V3 (Visualization, Video and HD Videoconferencing).

March 23, 2007. Joan Frye, NSF MRI program manager, visited EVL to review accomplishments from MRI funding, particularly EVL's "LambdaVision" award CNS-0420477. LambdaVision is a high-resolution tiled display that is multi-gigabit network enabled, so there was much discussion of applications using/requiring these displays, particularly international applications being developed by the Global Lambda Visualization Facility <www.evl.uic.edu/cavern/glvf>.

March 21, 2007. Maxine Brown and Alan Verlo met with Randy Shelton and John Sharkey of Force10 about UIC/EVL/StarLight hosting an educational meeting for potential and existing Force10 customers, describing some of the advanced applications and international networking that takes place at StarLight. Specifics to be determined.

March 20, 2007. Alan Verlo and Linda Winkler participated in the monthly JET meeting at NSF.

March 20, 2007. Alan Verlo participated in the IRNC Measurement Group phone call.

March 20, 2007. Laura Wolf organized a Taipei visit to UIC/EVL. *(Note: Taiwan's National Center for High-*

performance Computing, NCHC, is located at the Hsinchu Industrial Park and responsible for the country's R&E national and international networking. Taiwan connects to Pacific Wave in Seattle, but then connects to StarLight via CANARIE and UCLP.) Taiwanese visitors included:

- Chin-Tay Shih, Dean, College of Technology Management, National Tsing Hua University
- Kung Wang, Institute of Industrial Economics, National Central University, former Director General of Hsinchu Science-based Industrial Park
- Paul Lin, Computer Communications Laboratories of ITRI, the Industrial Technology Research Institute
- Ian C. Hsu, Department of Biomedical Engineering and Environmental Science, NTHU
- Yi-Ling Wei, Industrial Researcher, Industrial Economics and Knowledge Center, Industrial Technology Research Institute (IEK/ITRI)

March 15, 2007. Tom DeFanti participated in the monthly NSF IRNC phone call.

February 26-27, 2007. Tom DeFanti and Maxine Brown were co-organizers, with others, of the 6th Annual Photonics Workshop, sponsored by NTT, in San Diego. Tom DeFanti and Alan Verlo attended. Several IRNC members and national/international collaborators attended and participated.

February 22-23, 2007. Alan Verlo attended the Cybersecurity Summit 2007 for NSF Large Research Facilities in Arlington, VA. <http://www.educause.edu/cyb07>

February 19, 2007. Maxine Brown participated in a planning meeting with TransLight/PacificWave, AARNet and the Australian Partnership for Advanced Computing (APAC) for a US-Australia Workshop, tentatively planned to be held at APAC '07, October 8-12, 2007 in Perth.

February 11-15, 2007. Alan Verlo attended the Winter 2007 ESCC/Internet2 Joint Techs Workshop, Minneapolis (February 11-13). He (and Linda Winkler) also participate din the JET meeting on February 13. They attended GLIF TECH meetings (February 14-15).

February 2, 2007. Tom DeFanti participated in the monthly NSF IRNC phone call.

2.B. Research Findings

2.B.1. Year 3 Outcomes vs. Stated Year 3 Goals

TransLight/StarLight has not deterred from the overall mission of IRNC, which is to continually implement a strategy to best serve established production science, including usage by scientists, engineers and educators who have persistent large-flow, real-time, and other advanced application requirements. International networking is now ubiquitous, and while we cannot track every application, this report documents several large-scale, multi-continent activities that require connectivity as well as special advanced services afforded by optical networks.

More specifically, in last year's Program Plan we stated that attention be paid to capacity planning and circuit upgrades, together with our partners Internet2, NLR, ESnet, SURFnet, and DANTE/GÉANT2, and we have been successful in doing so. As explained in Section 3.A.2.2, one unavoidable problem is that our IRNC transatlantic links have "competition" from links paid for by SURFnet, UKLight, CESNET, GÉANT2, US LHC (DOE/CERN), Internet2, and others; however, IRNC also leverages greatly from these links (see Section 3.A.1).

Another goal stated in last year's Program Plan was to advance networking technologies and services, and TransLight/StarLight has successful worked with its partners and peers to help support and provide leading-edge technologies and services, as possible. TransLight/StarLight network engineer Alan Verlo is actively involved in the IRNC Measurement Committee, the JET, Joint Techs, the GLIF TECH Working Group and SCInet. We have also been paying attention to security, and are committed to adopting best practices under NSF's guidance, pending available budget, manpower and equipment.

As application folks, TransLight/StarLight principals have successfully focused on the third and final goal described in last year's Program Plan, which was to assure community support and satisfaction. We have worked with Internet2, NLR, ESnet, SURFnet/NetherLight, DANTE/GÉANT2, the JET, GLIF members, and relevant regional entities to identify and encourage lambda usage among US/European computer scientists and discipline scientists who have ongoing large-flow, real-time, and other advanced application requirements at Layer 1/2 and Layer 3. We have worked with our partners to connect scientists with GigE circuits end-to-end. We continue to document our activities on the TransLight/StarLight website. And, we continue to be actively involved in national and international network meetings, including IRNC, JET, ONT, Internet2, NLR, GLIF and SC meetings.

2.B.2. IRNC Projects Interactions

SC 2007

Together with our IRNC siblings, we supported scientific and engineering research and education applications at major events and activities, including SC07 in Reno, NV, November 10-16, 2007. Alan Verlo partipates in SCInet, and one of his primary duties is to support international connections at StarLight, particularly TransLight/StarLight.

Internet2/GÉANT2 and StarLight/NetherLight Compatibilities

TransLight/StarLight seamlessly connects the routed NYC-AMS link that connects Internet2, ESnet, NLR and GÉANT2, and the switched CHI-AMS link that connects StarLight and NetherLight, thereby assuring that international network services conform to those currently offered or planned by domestic research networks.

Global Lambda Integrated Facility (GLIF)

TransLight/StarLight principals are leading organizers of GLIF <www.glif.is>, an international virtual organization that supports persistent data-intensive scientific research and middleware development on LambdaGrids.. Tom DeFanti, Maxine Brown, Alan Verlo, Linda Winkler, Joe Mambretti, Kees Neggers and Erik-Jan Bos attended the GLIF meetings held in Prague, September 17-18, 2007, as well as John Silvester (representing NLR), Heather Boyles (representing Internet2) and Hans Doebbeling (representing DANTE/GÉANT2).

A major GLIF engineering activity is to define GLIF Open Lightpath Exchanges (GOLEs) that enable interoperability and interconnectivity of L1, L2 and L3 links. TransLight/StarLight's hubs in MAN LAN/New York, StarLight/Chicago and NetherLight/Amsterdam are GOLEs, connecting our 2 x 10Gbps lambdas as either permanent or configurable links.

E-Science Application Identification and Support

Maxine Brown has been involved with the following organizations and conferences throughout the past year, whose

goals are to find and encourage application and middleware development.

- **TransLight/PacificWave's Applications group (ongoing)**, organized by John Silvester, stimulates application development. This group meets occasionally via telephone and at conferences. Maxine Brown is a member of this group, representing TransLight/StarLight. This group has provided advice and support to several of the projects listed below.
- **NCO Optical Networking Testbed 4 (ONT-4) Workshop** will tentatively be held March 31-April 2, 2008 at FermiLab in Batavia, IL, though there was discussion about postponing it until October so it takes place around the GLIF meeting in Seattle, October 1-2. Maxine Brown, Tom DeFanti, Joe Mambretti and Kees Neggers are members of the planning committee.
- **Cyberinfrastructure (CI) Days** is an effort for groups providing CI resources to educate campuses about what is available; this ongoing effort is organized a consortium consisting of TeraGrid, Educause, Internet2, Open Science Grid, National LambdaRail and IRNC. Maxine Brown represents IRNC. There was one event at UC Davis several months ago, prior to NLR and IRNC participation <http://vpiet.ucdavis.edu/cyberinfrastructure.cfm>. There was one held October 3, 2007, at the ND/SD EPSCoR 6th Biennial Joint Conference <www.ndsu.edu/epscor/news/NDSDJointEPSCoRConf2007.htm>. The Educause 2007 conference held a seminar "CyberInfrastructure: What, Why, How, and Who's Already Doing It" at its annual meeting in Seattle on October 23 <www.educause.edu/E07/Program/11073?PRODUCT_CODE=E07/SEM03A>. A presentation about CI Days took place at the Internet2 Fall Member Meeting in San Diego on October 9 <http://events.internet2.edu/2007/fall-mm/sessionDetails.cfm?session=3531&event=273>. A New York State Grid (NYSG) CI Days was held at University of Albany on December 4-5, 2007 <www.nysgrid.org/main/news/workshop-12-2007>. Most recently, a New Mexico CI Days was held at New Mexico Highlands University <www.nmhu.edu/nmci>. A CI Days website is currently under development <http://cidays.org/>.
- **Workshop on Driving eResearch Collaboration Across the Pacific (DeRCAP)** was held at the Australian Partnership for Advanced Computing (APAC) 2007 Conference in Perth, October 8-12, 2007, designed to stimulate e-science usage of AARNet links to the US <www.apac.edu.au/apac07/dercap/>. Given that science is global, this workshop included collaborators from the US, Asia and Europe. Organized by John Silvester's TransLight/PacificWave Applications group, with Maxine Brown representing TransLight/StarLight, the group worked with John O'Callaghan, APAC Executive Director, and Chris Hancock, Chief Executive Officer of AARNet, on this US-Australia Workshop. The TransLight/PacificWave Applications group is now discussing follow-on workshops for 2008/2009.
- **Australasia e-Research Workshop 2008**, currently in the planning stages due to the success of DeRCAP (above), is looking at the DeRCAP outcomes, to develop action plans for each of the main scientific discipline areas and associated collaboration tools. Maxine Brown is a member of the working group.
- **PRAGMA-13 Workshop** was held at NCSA, September 23-25, 2007. Maxine Brown was a member of the Technical Program Committee <www.ncsa.uiuc.edu/Conferences/PRAGMA13>.
- **PRAGMA-14 Workshop** was held at NCHC in Taiwan, March 11-12, 2008. Maxine Brown was a member of the Technical Program Committee <www.nchc.org.tw/event/2008/pragma/>.
- **The Chinese-American Network Symposium (CANS) 2007** took place August 25-26, 2007, in Xi'An, China <www.canscouncil.net/cans2007>. Maxine Brown was a member of the program committee.
- **The annual eVLBI Network Technologies Workshop** was hosted by the CSIRO Australia National Telescope Facility <www.atnf.csiro.au/research/workshops/2007/eVLBI>. It was held at the QUESTnet (Queensland Education Science & Technology Network) 2007 conference, July 10-13, 2007, in Cairns. Jerry Sobieski attended. The TransLight/PacificWave Applications group was kept aware of activities.
- **A New Zealand-US Workshop "Building KAREN Communities for Collaboration"** was hosted by Charles Jarvie, Development Manager of REANNZ, in New Zealand, July 2-4, 2007 <www.karen.net.nz/recordings>. TransLight/PacificWave's Ron Johnson and John Silvester participated.

2.B.3. E-Science Support (Quantified Science Drivers)

For many years, we documented international applications on the StarLight website <www.startap.net/starlight/APPLICATIONS> and, more specifically, US/European applications on the Euro-Link website <www.startap.net/euro-link/APPLICATIONS>. However, as international collaborations become more prevalent, as collaborations expand from two to three to four continents, and as more transoceanic links become operational, it is impossible to identify and document these applications − they are ubiquitous. Of more interest to us, is to identify and serve high-end applications − that is, data-intensive e-science applications requiring advanced networking capabilities − for they are the drivers for new networking tools and services to advance the state-of-the-art of production science.

Below is a list of recent applications we are tracking; more are documented on the TransLight/StarLight website <www.startap.net/translight/pages/applications.html>. Applications utilizing GLIF links are publicized at <www.glif.is/apps>.

US/European Applications 2007

ALMA

www.alma.nrao.edu/

Collaborators:

- National Science Foundation via the National Radio Astronomy Observatory and the North American ALMA Science Center; US
- National Research Council of Canada; Canada
- European Southern Observatory and the European Regional Support Center; Europe
- Spanish Ministry of Science and Technology; Spain
- National Astronomical Observatory of Japan (NAOJ) under the National Institutes of National Sciences (NINS)
- ALMA-Taiwan, Academia Sinica Institute of Astronomy & Astrophysics; Taiwan
- Republic of Chile

The Atacama Large Millimeter Array (ALMA) is an international astronomy facility. ALMA is a gigantic radio telescope array consisted of up to 64 12m antennas and the ACA system (4 12m antennas and 12 7m antennas), under construction on an Andean plateau at 5,000m above sea level in Chile. ALMA is a partnership among Europe, Japan and North America, in cooperation with the Republic of Chile, with its full operation expected in 2012. Taiwan is also contributing to ALMA as a partner of Japan.

ALMA will be the forefront instrument for studying the cool universe – the relic radiation of the Big Bang, and the molecular gas and dust that constitute the building blocks of stars, planetary systems, galaxies, and life itself. This material typically resides at temperatures of 3-100 K, resulting in spectral energy distributions peaking at submillimeter through to far-infrared wavelengths. Most of the energy in the Universe lies in two thermal components – the cosmic background and the far infrared background – whose Earth-accessible spectrum lies within the ALMA frequency coverage. Indeed, the peak of the spectral energy distribution for dusty objects in the distant universe becomes redshifted entirely to submillimeter wavelengths. While a number of current and future telescopes will operate at submillimeter wavelengths in order to exploit the wealth of information available in this part of the electromagnetic spectrum, none will have the combination of sensitivity, resolution, and frequency coverage of ALMA.

ARGO-YBJ 2007

http://argo.na.infn.it/
www.ihep.ac.cn/english/YBJ-E/index.htm

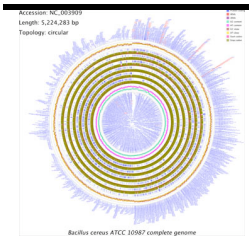
Collaborators:

- Chinese Academy of Sciences (CAS) Institute of High Energy Physics; CAS Center for Space Science and Applied Research; Shandong University; Southwest Jiaotong

University; Tibet University; Yunnan University; China
- INFN and Lecce University; INFN and Napoli University; INFN Section of Napoli and University of Salerno; INFN Section of Napoli and University of Sonnio, Benevento; INFN and University Roma "Tor Vergata"; INFN and University "Roma Tre" Roma; INFN and Institute of Cosmogeo Physics of CNR, Torino; INFN Section of Catania and Institute of Physics of Cosmic and IFCA/CNR, Palerno; INFN Section of Pavia; Italy
- GLORIAD, CANARIE, SURFnet

The YBJ International Cosmic Ray Observatory is located in the Yangbajing (YBJ) valley of the Tibetan highland. The Sino-Italian ARGO (Astrophysical Radiation with Ground-based Observatory) experiment studies cosmic rays, mainly cosmic gamma-radiation, at an energy threshold of ~100 GeV, by means of the detection of small size air showers.

Greg Cole, in an email to Maxine Brown on June 19, 2007, says, "YBJ is a huge emerging application. Already, we [GLORIAD] are seeing daily transfers in excess of 0.8 Terabytes."

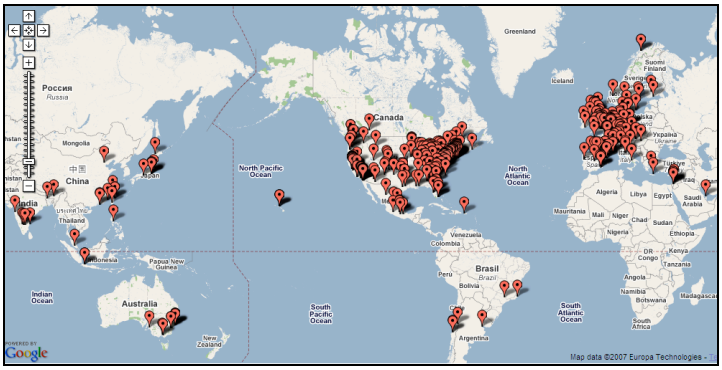


CAMERA 2007

http://camera.calit2.net

Collaborators:
- Calit2/UCSD and J. Craig Venter Institute; USA
- CAMERA has 1300 registered users from 48 countries, with major users in the UK, Germany, Canada, France and Brazil.

The Community Cyberinfrastructure for Advanced Marine Microbial Ecology Research and Analysis (CAMERA) is a Gordon and Betty Moore Foundation-funded project under the leadership of the UCSD division of the California Institute for Telecommunications and Information Technology (Calit2). Calit2 works with the J. Craig Venter Institute, UCSD Scripps Institution of Oceanography's Center for Earth Observations and Applications, and Scripps Genome Center. CAMERA partners with the DOE Joint Genome Institute and works with CAMERA Science Advisory Board members from U Washington, MIT, UC-Davis, U Wisconsin-Madison, Discovery Biosciences Corp, U Georgia, San Diego State U, Michigan State U and U Miami. CAMERA has 1300 registered users from 48 countries.



USA	761
United Kingdom	64
Germany	54
Canada	46
France	44
Brazil	33

CAMERA is accelerating the field of environmental metagenomics by creating a globally accessible community resource of microbial metagenomic data. CAMERA builds on pioneering efforts in metagenomics to sequence the genomes of entire microbial communities, often comprising thousands of species. Because of the use of the shotgun sequencing techniques on the community of microbial, viral and pico-eukaryotic species in ocean water, CAMERA will include metagenomic data of hundreds to thousands of microbial and other species at a single location. The move from traditional organism genome databases to CAMERA-based metagenomics data storage and computational analysis requires the development of a complex cyber-architecture to enable researchers to retrieve and simultaneously view many sub-components of living organisms and their environments – their genes, gene mappings, genomes, metagenomes, partial genomes,

proteins, synthetic genes, bacteria, atmospheric maps, and oceanographic maps – and have high-definition teleconferencing with remote colleagues as they examine the same datasets.

CineGrid @ Holland Festival 2007

www.cinegrid.org
www.hollandfestival.nl/#festival/voorstelling/9043 (Click British flag for ENGLISH)

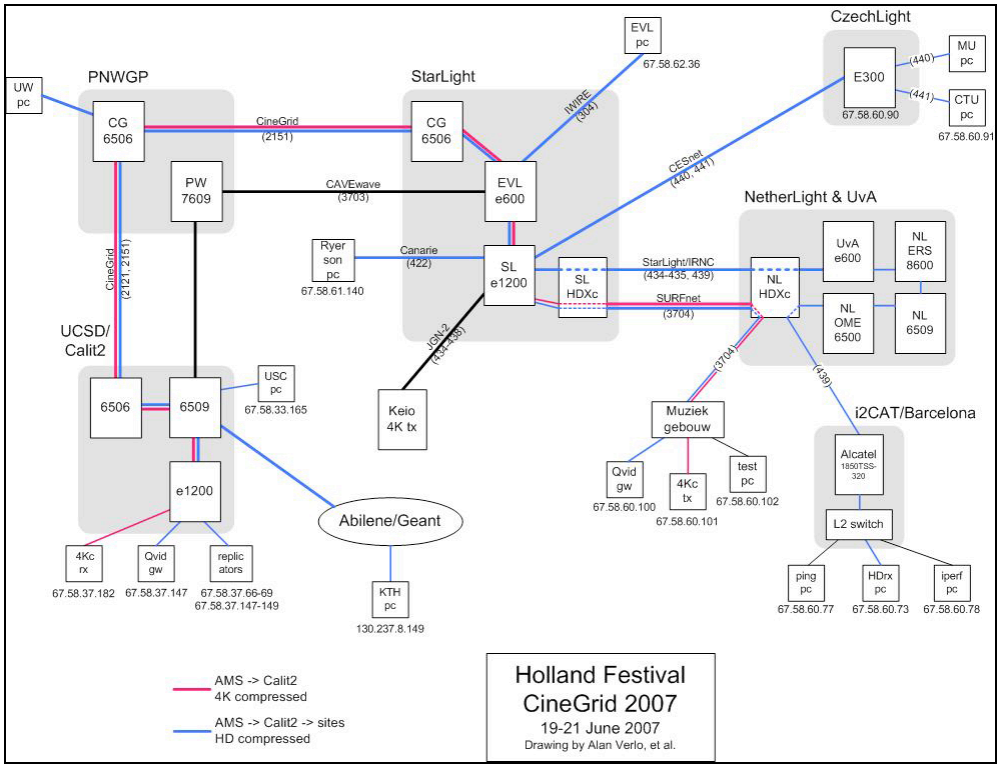
Collaborators

- Pacific Interface; Calit2/UCSD; UIC/EVL; StarLight; Pacific Wave; CENIC; US
- Keio University/Research Institute for Digital Media and Content (Keio/DMC); Japan
- Holland Festival; University of Amsterdam; SARA Computing and Networking Services; SURFnet; Waag Society; BeamSystems; Cultuurfabriek; The Netherlands

On June 20, 2007, the international research consortium, CineGrid, conducted the first successful transatlantic demonstration of streaming 4K digital motion pictures and 5.1 surround sound over photonic IP networks. The CineGrid @ Holland Festival 2007 project transmitted a live performance of the opera "Era la Notte" in Amsterdam's concert hall, part of the Holland Festival, nearly 10,000 kilometers, in real time, to UCSD where it was viewed in 4K (four times HDTV resolution) in the Calit2 auditorium, delivering an audience experience of unprecedented quality across long distances using advanced networks.

Three streaming tests were done, as the following diagram shows:

- (June 20, 2007) 4K point-to-point JPEG2000 compressed, at a rate of 500Mbps, between Amsterdam and San Diego
- (June 21, 2007) HD compressed coming at ~135Mbps from Amsterdam to Calit2, where it was replicated by Calit2 servers with Qvidium software into at least 6 streams going to USC, U Washington, UIC/EVL, Ryerson U (Toronto), Stockholm, Prague, and Barcelona.
- (June 22, 2007) 4K uncompressed (~8Gbps) from Amsterdam to Japan via Chicago.



CineGrid @ GLIF 2007

www.cinegrid.org
www.cinegrid.org/news/GLIF_demo1_oct07.php
www.cinegrid.org/news/GLIF_demo2_oct07.php

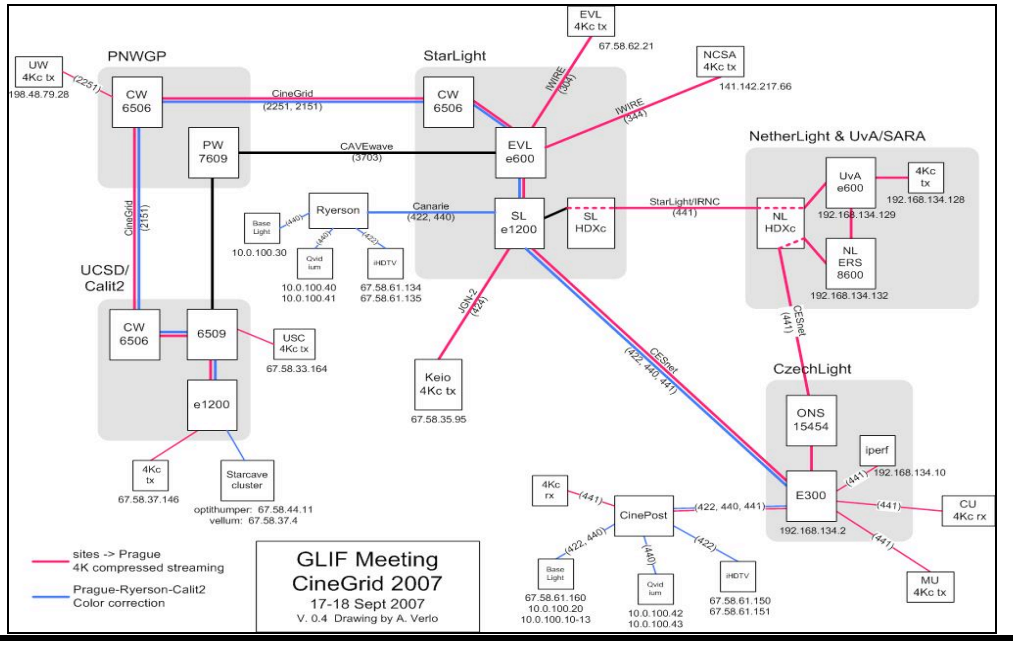
Collaborators:

- CineGrid; Calit2/UCSD; UCSD/Center for Computing and the Arts; UIC/EVL; UIUC/NCSA; University of Southern California, School of Cinematic Arts; U Washington, ResearchChannel; Pacific Interface, Inc; US
- Keio University/ Research Institute for Digital Media and Content; NTT Network Innovation Laboratories; Japan
- University of Amsterdam; SARA; The Netherlands
- Special thanks to CiscoWave, Cisco waves deployed over National LambdaRail; CENIC; CESNET; CzechLight; Global Lambda Integrated Facility (GLIF); I-WIRE; JGN2; Pacific Northwest GigaPoP; Pacific Wave; StarLight; CANARIE

Streaming 4K at GLIF 2007… (September 17-18, 2007) During GLIF 2007, 4K digital content (four times the resolution of HDTV) was streamed "on demand" in real time from seven playback servers in Japan, Europe and North America to audiences at Charles University in central Prague, and to CinePOST, a cinema post-production facility within Barrandov Studios, one of the largest and oldest film production centers in Europe. Playback nodes were located at: Keio (Japan); University of Amsterdam and SARA (Netherlands); Calit2/UCSD; UIC/EVL; UIUC/NCSA; USC/School of Cinematic Arts; and, U Washington/ResearchChannel.

4K Remote Production & Color Correction… (September 18, 2007) CineGrid demonstrated a prototype workflow for remote color grading of digital rushes from a 4K digital camera shoot in Prague to a specialized rendering processor located nearly 10,000 km away in San Diego, and a 4K color correction system in Prague operated by a colorist working 7000 km away in Toronto.

In the following network diagram, TransLight/StarLight was a "backup" link in case the transatlantic CESNET failed. TransLight/StarLight leverages networking investments from other countries, like the Czech Republic, for international connectivity.



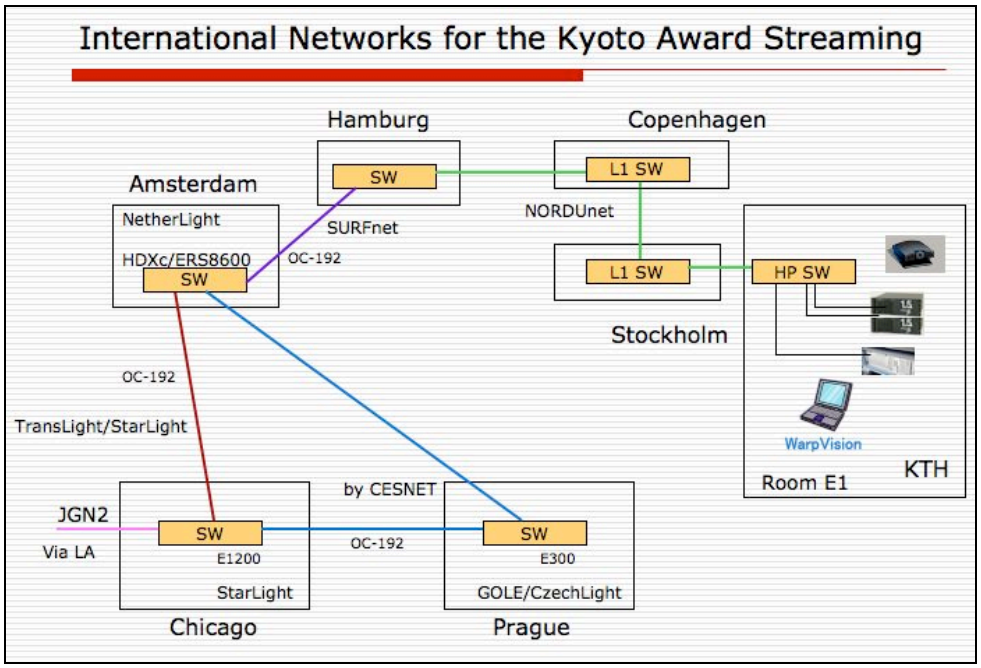
CineGrid: Kyoto Prize 2007

www.cinegrid.org

Collaborators:
- CineGrid; Calit2/UCSD; UIC/EVL; Pacific Interface, Inc; USA
- Keio University/ Research Institute for Digital Media and Content; Japan
- Royal Institute of Technology, KTH; Sweden
- Special thanks to TransLight/StarLight; CESNET; CzechLight; T-LEX; JGN2; NORDUnet; StarLight; NetherLight; SURFnet

On November 10-11, 2007, CineGrid streamed 4K uncompressed and compressed live video from Kyoto to Stockholm. This was the world's first 4K uncompressed transmission and the first 4K live streaming over both the Atlantic and Pacific oceans. The Kyoto Prize ceremony was held at the Kyoto International Conference Hall and streams were sent to KTH in Stockholm.

Two paths were setup; one was primary and one was for backup:
- *Primary:* Kyoto-Tokyo-JGN2-StarLight (Chicago)-IRNC-Netherlight (Amsterdam)-SURFnet/NORDUnet-Stockholm-KTH.
- *Backup:* Kyoto-Tokyo-JGN2- StarLight (Chicago)-CESNET-Prague-CESNET-Netherlight (Amsterdam)-SURFnet/NORDUnet-Stockholm-KTH.



CLASS: Comprehensive Large-Array Stewardship System 2007

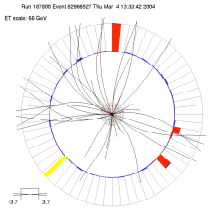
www.class.noaa.gov

Collaborators:
- National Oceanic & Atmospheric Administration (NOAA)/National Geophysics Data Center (NGDC); Boulder, CO, USA
- Russian Academy of Sciences/Space Research Institute/Center of Geophysical Data Studies; Moscow, Russia

CLASS is NOAA's premier on-line facility to distribute NOAA and US Department of Defense Polar-orbiting Operational Environmental Satellite (POES) data, NOAA Geostationary Operational Environmental Satellite (GOES) data, and derived data. CLASS is an electronic library of NOAA environmental data. The website provides capabilities to

find and obtain that data.

A 1Gbps VLAN from NOAA to StarLight (via NLR), from StarLight to NetherLight (via TransLight/StarLight-GLORIAD), and from NetherLight to MoscowLight and Russia's Space Research Institute (via RBnet) was configured on August 1, 2007 for CLASS collaboration. The goal is the ongoing exchange of satellite data.



DØ (DZero) 2007

http://www-d0.fnal.gov
www.isgtw.org/?pid=1000434

Collaborators:

- Universidad de Buenos Aires; Argentina
- CBPF/LAFEX; Universidade do Estado do Rio de Janeiro; Universidade Estadual Paulista; Brazil
- McGill U; Simon Frazer U; U of Alberta; York University; Canada
- IHEP, Beijing; U of Science and Technology of China; China
- Universidad de Los Andes; Colombia
- Charles University/Center for Particle Physics, Prague; Czech Technical University; Czech Academy of Sciences/ Institute of Physics; Czech Republic
- Universidad San Francisco de Quito; Ecuador
- Centre de Physique des Particules de Marseille; DAPNIA/SPP, SACLAY; Institut de Physique Nucleaire de Lyon; IPHC Strasbourg; Laboratoire de I Accelerateur Lineaire; LPC, Univ Blaise Pascal, Clermont-Ferrand; LPNHE, Universites Paris VI and VII; LPSC, Grenoble; France
- University of Wuppertal/Fachbereich Physik; Institut fuer Physik, Mainz; LMU Munich; Bonn University/Physikalisches Institut; Universitaet Freiburg/Physikalisches Institut; Rheinisch-Westfälische Technische Hochschule (Aachen); Ill. Phys. Institute; Germany
- Delhi U; Panjab U; Tata Institute of Fundamental Research; India
- University College Dublin; Ireland
- Korea U; Kyungsung U; Seoul National U; SungKyunKwan U; Korea
- CINVESTAV; Mexico
- NIKHEF; Radboud University Nijmegen; Netherlands
- Institute for High Energy Physics; Institute for Theoretical & Exp. Physics; Joint Institute for Nuclear Research; Moscow State University; Petersburg Nuclear Physics Institute; Russia
- Royal Institute of Technology/KTH; Lund U; Stockholm U; Uppsala U; Sweden
- U Zurich; Switzerland
- Imperial College, London; Lancaster University; U Manchester; UK
- Boston U; Brookhaven National Laboratory; Brown U; California State U, Fresno; Columbia U; FermiLab; Florida State U; Indiana U; Iowa State U; Kansas State U; Langston U; Lawrence Berkeley National Laboratory; Louisiana Tech U; Michigan State U; Northeastern U; Northern Illinois U; Northwestern U; Oklahoma State U; Princeton; Purdue; Purdue U Calumet; Rice; Southern Methodist U; SUNY Buffalo; SUNY Stony Brook; Texas A&M U; U Arizona; U California, Davis; U California, Riverside; U Hawaii; U Illinois, Chicago; U Kansas; U Maryland; U Michigan; U Mississippi; U Nebraska; U Notre Dame; U Oklahoma; U Rochester; U Texas, Arlington; U Virginia; U Washington; US
- Ho Chi Minh City Institute of Physics; Vietnam

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 in Batavia, IL. The research focuses on precise studies of interactions of protons and antiprotons at the highest available energies. It involves an intense search for subatomic clues that reveal the character of the building blocks of the universe.

In Summer 2006, the DZero detector had a substantial upgrade, including the addition of new components. After any significant change to a detector, a precise calibration is required to properly quantify subsequent data. DZero's recalibration, completed in January 2007, involved measuring, reconstructing and comparing millions of data events.

The events used in calibration do double duty: in order to be used in physics analyses, they must first be "reprocessed" using the new calibration values. In other words, during the calibration, this data was used to refine the reconstruction "recipe"; subsequently, this same (raw) data was reprocessed using the new-and-improved recipe.

The experiment itself also did double duty – DZero's local computing farm was busy with incoming data and unable to accommodate all the needed calculations. Part of the needed computing power came from DZero's internationally distributed computing resources, DZero-SAM, and the Worldwide Large Hadron Collider Computing Grid. However, the bulk of reprocessing took place on 12 shared Open Science Grid (OSG) sites via opportunistic access. On OSG, DZero sustained execution of over 1,000 simultaneous jobs, and consumed and produced hundreds of gigabytes of data.

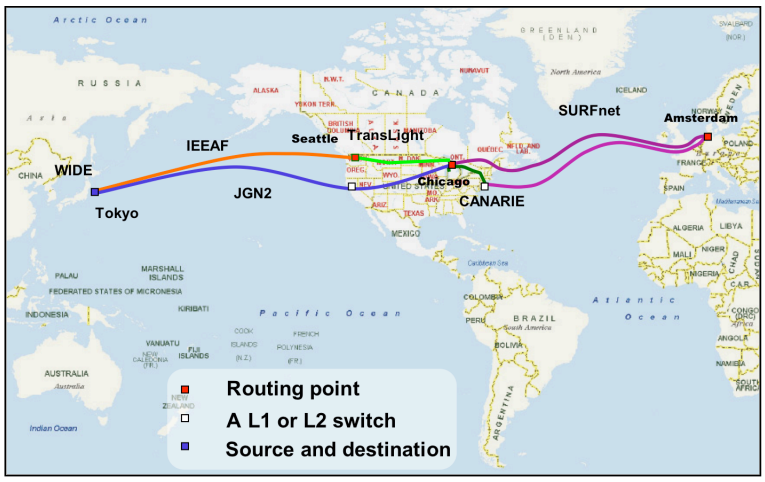
Data Reservoir 2007

http://data-reservoir.adm.s.u-tokyo.ac.jp
https://mail.internet2.edu/wws/arc/i2-news/2007-04/msg00003.html

Collaborators – 2006-2007 Land Speed Record participants:

- University of Tokyo; WIDE; JGN2; APAN; Fujitsu Computer Technologies; NTT Communications; Japan Chelsio Communications; Japan
- Major support from StarLight, Pacific Northwest GigaPoP, IEEAF, CANARIE, SURFnet, SARA and University of Amsterdam

At the Internet2 Spring 2007 meeting, April 2007, the Data Reservoir project won two consecutive new Land Speed Records (LSRs) in the IPv6 single and multi-stream categories. For the first set of IPv6 records, the Project created a network path over 30,000 kilometers in distance, crossing 6 international networks – over ¾ the circumference of the Earth. The team successfully transferred data in the single and multi-stream categories at a rate of 7.67Gbps, which is equal to 230,100 terabit-meters per second (Tb-mps). This record setting attempt leveraged standard TCP to achieve the new mark. The next day, the team used a modified version of TCP to achieve an even greater record. Using the same 30,000 km path, the network achieved a throughput of 9.08Gbps, which is equal to 272,400 Tb-mps for both the IPv6 multi and single stream categories. The team surpassed the current IPv4 records, proving that IPv6 networks can provide the same, if not better, performance as IPv4. These performance studies were conducted between Christmas and New Year's in December 2006.



The IRNC TransLight/StarLight link would have been used, but the Project wanted a completely dedicated network during the test period, which TransLight/StarLight could not provide, so SURFnet links were used instead.

DICE (DANTE-Internet2-CANARIE-ESnet) Collaboration 2007

www.geant2.net/server/show/nav.1227

Collaborators:
- DANTE/GÉANT2 members; Europe
- Internet2 members; ESnet members; DRAGON project members; US
- CANARIE members; Canada
- University of Amsterdam (UvA); The Netherlands

CANARIE, ESnet, GÉANT2 and Internet2 are building a strategic initiative on transatlantic cooperation within the framework of the GÉANT2 technical program. Regular technical meetings provide an opportunity to discuss issues of common interest, helping to build a more complete picture of the international context in which we operate. In particular, UvA is working with DICE to integrate its Token Based AAA mechanism inside OSCARS (ESnet domain controller development) and DRAGON (GMPLS based control plane/ routing/resource brokering functions). This work will also be embedded into Phosphorus.

Enlighten Your Research 2007: High-throughput Genome-wide Analyses in ALS

www.surfnet.nl/info/en/artikel_content.jsp?objectnumber=191487
http://lichtpad.surfnet.nl/info/attachment.db?191507
www.isno.nl/sorteer/ziekten/?id=26

Collaborators:
- University Medical Center Utrecht (UMCU); The Netherlands
- UCLA David Geffen School of Medicine/ Department of Human Genetics; UCLA Neuroscience and Genetics Research Center; US

On June 21, 2007, five research projects in the Netherlands were awarded the main prize in the "Enlighten Your Research" lightpath competition organized by SURFnet and NWO. Dutch scientists received a lightpath to their research lab and the sum of 20,000 Euros to integrate the use of a lightpath in their research.

A lightpath for the high-throughput genome-wide analyses in Amyotrophic Lateral Sclerosis (ALS) was awarded to UMCU to work with UCLA. The genome-wide analysis of ALS using microarray detection produces data files of up to 20GBytes in size. Analyzing the data is complex and requires highly specialized expertise. Moreover, new data is continuously added to these files, and advancing insight requires that the analysis be repeated regularly. The necessary expertise is available at the UCLA Department of Human Genetics, with whom UMCU has initiated collaboration. Up until now, researchers have had to travel to exchange knowledge and data in person. The researchers will now establish a lightpath in order to create a virtual organization, to share large data files and especially share expertise.

This proposal was a joint effort between UMCU and UCLA researchers. The SURFnet lightpath is awarded for the duration of the research (up to 4 years). CENIC has fiber into the UCLA campus from their 818 W. 7th St. PoP in downtown Los Angeles. If SURFnet can get a wave to the edge of the campus, UCLA will get it to the medical center, as this was already discussed with the UCLA folks. SURFnet is talking with Cisco about using a CiscoWave from Chicago to Los Angeles. SURFnet may use their link from AMS to CHI for this effort, though TransLight/StarLight is available and has offered bandwidth.

EnLIGHTened Computing 2007

http://enlightenedcomputing.org

Collaborators:

- MCNC; Louisiana State University/ Center For Computational Technology; North Carolina State University; Renaissance Computing Institute, Chapel Hill; US
- G-Lambda project; Japan
- Phosphorus; Europe
- Also collaborate with NSF-funded projects OptIPuter, UltraLight, WAN-in-LAB, DRAGON and Cheetah
- Global Lambda Integrated Facility (GLIF)

The EnLIGHTened Computing project focuses on the development of dynamic, adaptive, coordinated and optimized use of networks connecting geographically distributed high-end computing resources and scientific instrumentation. A critical feedback loop consists of resource monitoring for discovery, performance, and SLA compliance, and feedback to co-schedulers for coordinated adaptive resource allocation and coscheduling. The research carried out, the developed tools, and the applications that use them will be deployed across regional, national and international 10Gbps testbeds, connected via all-photonic Calient switches, all using GMPLS control plane technologies. The project consists of a global alliance of partners to develop, test, and disseminate advanced software and underlying technologies that provide generic applications with the ability to be aware of their network, Grid environment and capabilities, and to make dynamic, adaptive and optimized use of networks connecting various high-end resources.

EnLIGHTened has a 10Gb Cisco research wave on the NLR, which it uses for data transfer. Prior to May 2007, control signaling (i.e., the control plane) between the optical switches was done over Abilene, which was not desirable from a security and reliability standpoint. Optical devices don't have robust and secure enough software and control interfaces, and the control signaling, when sent on a public network, is subject to potential congestion, etc. A private control circuit is much more secure and reliable and is how big carriers control their networks (though this solution is costly). In May 2007, the EnLightened control plane was moved onto a new, separate FrameNet circuit that NLR donated. *(At StarLight, Alan Verlo assisted with this cutover.)* By having a nationwide infrastructure, similar projects, such as Phosphorus, can take advantage of this NLR infrastructure, and can connect at one place (e.g., StarLight) and can have interconnectivity to the EnLIGHTened testbed as well as to other projects that also connect there.

ESSE: Environmental Scenario Search Engine 2007

http://esse.wdcb.ru/
http://ideas.ngdc.noaa.gov/ideas/

Collaborators:

- National Oceanic & Atmospheric Administration (NOAA)/ National Geophysics Data Center (NGDC), Boulder, CO; National Centers for Environmental Prediction (NCEP); USA
- Russian Academy of Sciences/ Space Research Institute/ Center of Geophysical Data Studies; Russia *(This group is part of the Russian Data Intensive Grid (RDIG) consortium that works with the European Union's Enabling Grids for E-SciencE [EGEE] project.)*
- Microsoft Research Cambridge; UK

Environmental informatics is the integrated and authoritative representation of the natural environment in data management, access and analysis. The natural environment includes elements from multiple domains, such as space, terrestrial weather, oceans and terrain. The Environmental Scenario Search Engine **(**ESSE) is a flexible, efficient and easy-to-use "natural language" search engine for mining environmental data archives; it is unique in that

it searches inside numeric datasets. With ESSE, scientists can find specific parameter values, conditions, and scenarios among the huge amount of available environmental data. ESSE is currently used to search the National Centers for Environmental Prediction (NCEP) weather reanalysis data archive, and provides basic visualization capabilities, including time-series plots, 3D animations, and remote-sensing satellite images.

IDEAS, the Investigation of Distributed Environmental Archives System, is a networked, distributed software system that enables users to interact with archives of environmental data for the purpose of scenario extraction, data analysis and integration with existing models that require environmental input. IDEAS uses the ESSE search tool to enable users to look for specific environmental scenarios in vast archives.

A major goal of the international geoscience community is to develop a predictive Earth science system to help sustain Earth habitability, improve environmental quality, safeguard human health, and reduce the impacts of natural disasters. Using cyberinfrastructure, the geosciences have the capability to produce comprehensive information systems for decision markers in the government, public and private sectors that can reduce vulnerability of countries, economies, and individuals to climate changes, severe weather, and space weather hazards, and can support efficient operation and effective resource management.

A 1Gbps VLAN from NOAA to StarLight (via NLR), from StarLight to NetherLight (via TransLight/StarLight-GLORIAD), and from NetherLight to MoscowLight and Russia's Space Research Institute (via RBnet) was configured on August 1, 2007 for IDEAS/ESSE collaboration.

eVLBI: First e-VLBI Data from China-Australia, China-Europe and Australia-Europe Baselines 2007

www.expres-eu.org/ShAuEu_fringes.html
www.expres-eu.org

Collaborators:

- Mopra, Australia Telescope National Facility (ATNF); Australia
- Sheshan, Chinese Academy of Sciences/ Shanghai Astronomical Observatory; China
- Darnhall, part of the MERLIN Jodrell telescope array at Darnhall in Cheshire; University of Manchester/ Jodrell Bank Observatory; UK
- Medicini, Institute of Radio Astronomy (IRA), Medicina; Italy
- Torun, Nicolaus Copernicus University; Poland
- Westerbork, Netherlands Foundation for Research in Astronomy; JIVE; The Netherlands
- Special thanks to AARNet, CANARIE, CERNET, CSTNet, GARR, JANET, PIONIER, SURFnet, DANTE (GÉANT2, ORIENT and TEIN2)

On August 28, 2007, collaborators in the EXPReS project (Express Production Real-time e-VLBI Service, a three-year project coordinated by the Joint Institute for VLBI in Europe [JIVE] and funded by the European Commission) observed a distant galaxy called 3C273 and did the first successful real-time correlation of eVLBI data from Chinese and Australian telescopes, Chinese and European telescopes, and Australian and European telescopes.

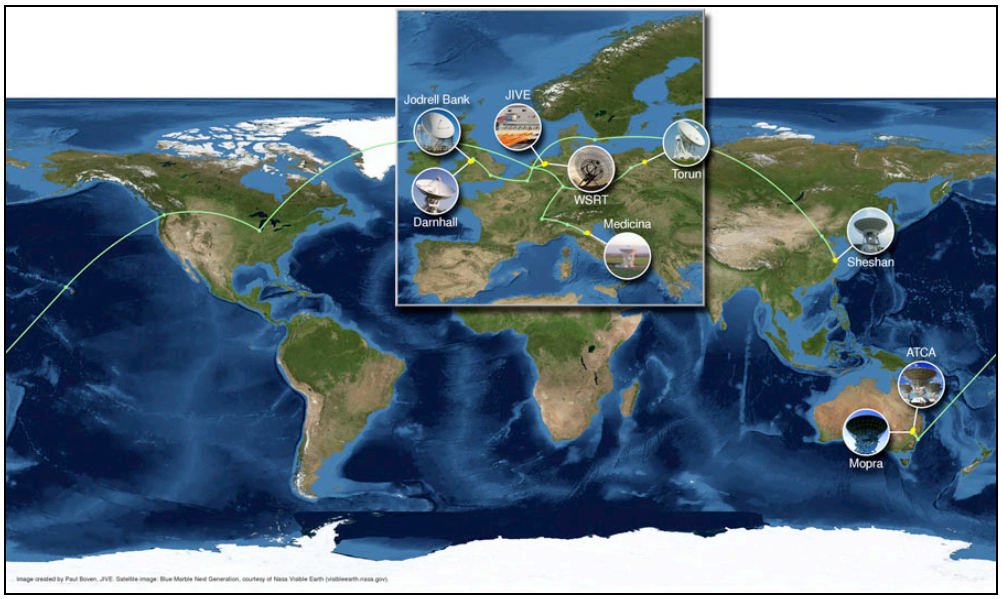
The observations were conducted by JIVE staff members, in collaboration with European VLBI Network (EVN) partners in Europe, China and Australia. Participating radio telescopes included the Mopra and Sheshan telescopes during the Chinese-Australian part of the experiment, and the Sheshan, Darnhall, Jodrell Bank, Medicina, Torun and Westerbork telescopes in the European-Chinese part.

Data was transferred to JIVE at a rate of 256Mbps per telescope. Mopra was connected directly to JIVE through a dedicated 1Gbps lightpath set up by the Australian, Canadian and Dutch national research and education networks AARNet, CANARIE and SURFnet, respectively. The Sheshan telescope was for the first time connected via the Chinese CSTNET and CERNET networks to the new high-speed route across Siberia provided by

the EC-sponsored ORIENT and TEIN2 networks, the pan-European GÉANT2 network and finally SURFnet. Most of the European telescopes have been connected for some time via dedicated lightpaths provided by the GÉANT2 partners.

Additional tests with telescopes in Puerto Rico and Chile are planned for the near future. EXPReS aims to implement up to 16 simultaneous 1Gbps network connections between the central processor at JIVE and partner telescopes across Europe, Asia, Australia, South Africa, South America and the USA by 2009.

While this experiment did not use TransLight/StarLight, it did leverage SURFnet Chicago-to-Amsterdam transatlantic bandwidth.



GLVF: OptIPuter SAGE Visualcasting @ GLIF 2007

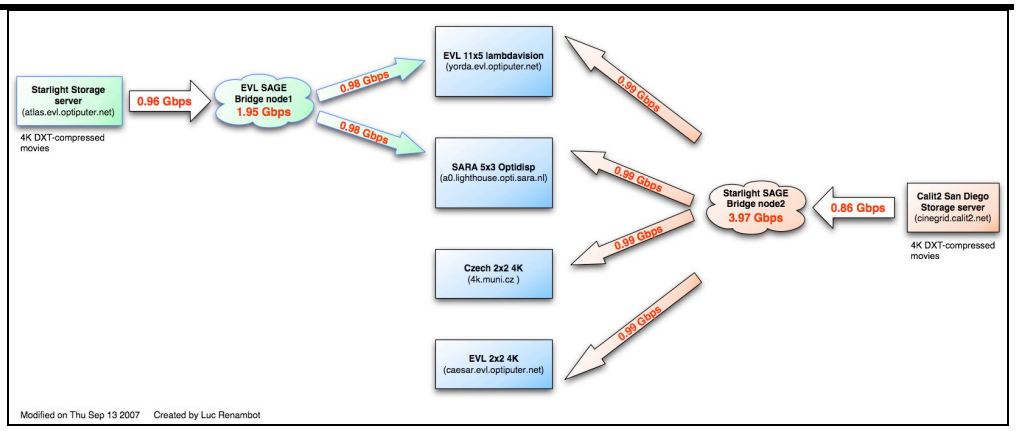
www.evl.uic.edu/cavern/sage
www.evl.uic.edu/cavern/glvf

Collaborators:
- UIC/EVL; Calit2/UCSD; US
- SARA; The Netherlands
- Masaryk University; Czech Republic
- Special thanks to StarLight; National LambdaRail; I-WIRE; CESNET; CineGrid; GLIF

For GLIF 2007, the Global Lambda Visualization Facility (GLVF), an international team of computer and application scientists, announced the results of a distributed pixel streaming experiment using the new Visualcasting feature of SAGE, the Scalable Adaptive Graphics Environment. SAGE is being developed as part of the NSF-funded OptIPuter project.

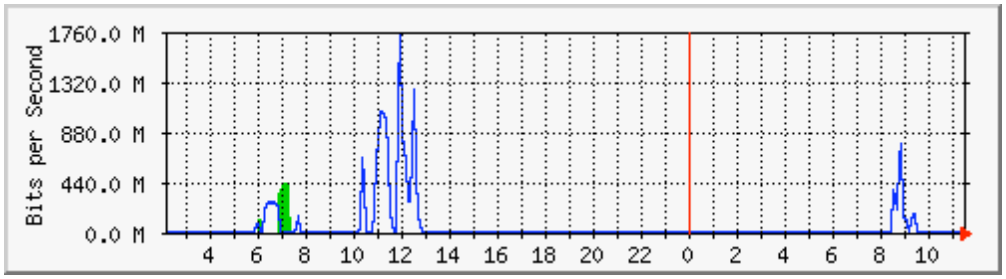
SAGE enables individual sites to generate visualizations and animations using in-house specialized and/or proprietary hardware and software, and then send streams of pixel information to a partner site so collaborators can see the results. Visualcasting extends this capability to multiple networked users by replicating the streams to multiple sites simultaneously, enabling partners to collaboratively work in a shared session.

For this experiment, multi-gigabit, high-resolution scientific visualizations were streamed from data stores at Calit2 in San Diego and at StarLight in Chicago to tiled display walls at EVL (Chicago), SARA (Amsterdam) and Masaryk University (Czech Republic). Two different animations were streamed; one was sent to four locations, and the other was sent to two locations. Each endpoint ran SAGE to send and/or receive the real-time streams.

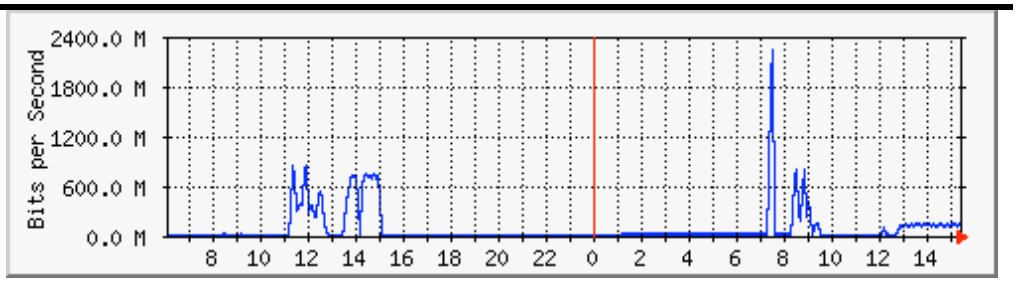


The ultra-high-resolution NCSA *Milky Way* galaxy animation, stored on disk at Calit2 in San Diego, was streamed at 1Gbps to StarLight in Chicago. There, a SAGE Bridge cluster replicated the streams, sending 1Gbps to each of the four GLVF partner sites for simultaneous viewing. A second animation, NCSA's *Tornado*, stored at the StarLight facility, was streamed to nearby EVL, where another SAGE Bridge cluster replicated the information to two of the four sites.

This SAGE visualcasting experiment was conducted prior to the GLIF 2007 meeting, on September 12-13, 2007. The following TransLight/StarLight MRTG chart ***for September 13*** shows usage between Chicago and Amsterdam.



The CESNET MRTG chart below for ***September 13*** shows usage from Chicago to Prague.



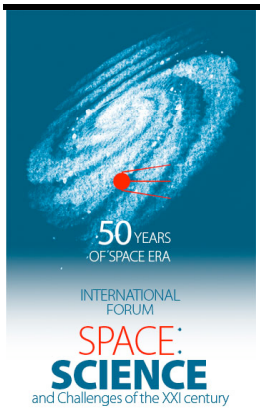
GLVF: SAGE @ European Researcher's Night 2007

http://ec.europa.eu/research/researchersineurope/events/ern07_en.htm
http://ec.europa.eu/research/researchersineurope/documents/rn07/nr07_czech_republic1_en.pdf

Collaborators:
- Masaryk University; Czech Republic
- University of Illinois at Chicago/ Electronic Visualization Laboratory; US

On September 28, 2007, more than 150 cities in Europe celebrated "Researchers' night," in which the public was invited to join the researchers and have fun (and prove that researchers don't look like the image on the left). As part of its open house, Masaryk University in Brno, Czech Republic, used SAGE to stream ultra-high-resolution movies from servers at EVL in Chicago to their 2x2 tiled display over the CESNET 10Gbps link.

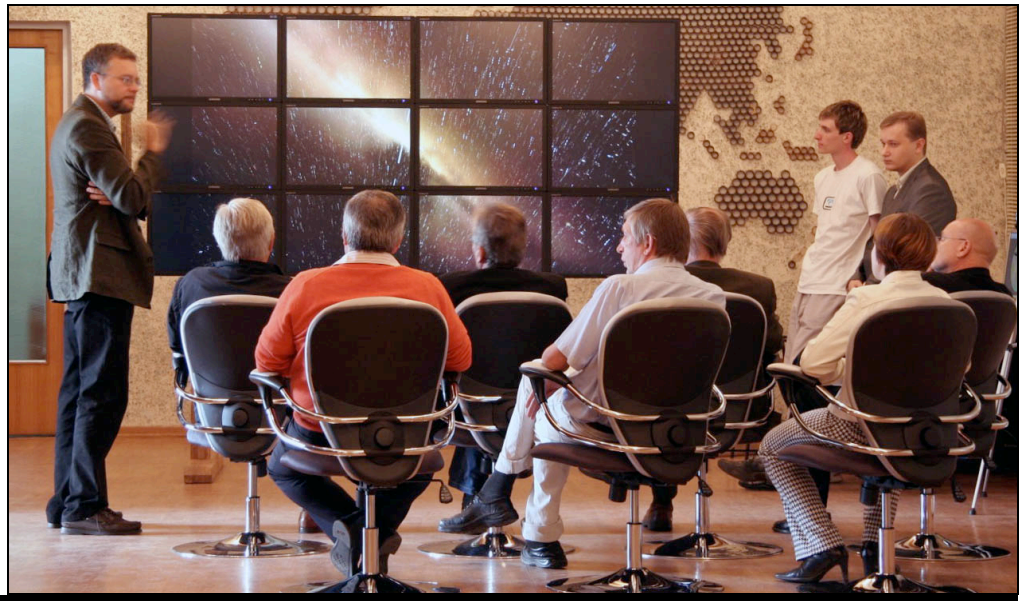
While this demonstration did not utilize TransLight/StarLight, it leveraged investments by the Czech Republic for CESNET, from Chicago to Prague.



GLVF: 50th Anniversary of Sputnik 2007

www.cosmos.ru/oct4/2007/index_e.htm

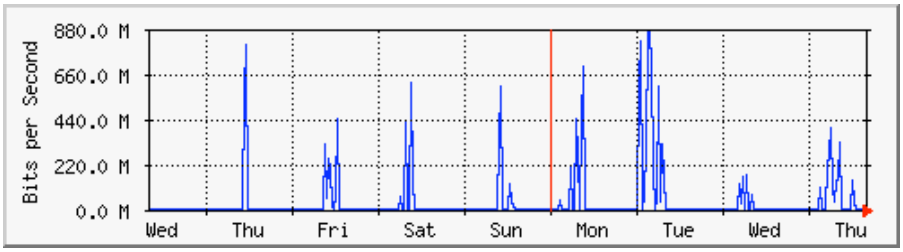
Collaborators:
- UIC/EVL; US
- Russian Academy of Sciences/ Space Research Institute (IKI)/ Grid Laboratory; Russia
- SARA; University of Amsterdam; The Netherlands
- Special thanks to GLORIAD; University of Tennessee-Oak Ridge National Laboratory/JICS; TransLight/StarLight; NetherLight; SURFnet; StarLight; Russian Research Center "Kurchatov Institute"; Russian Institute for Public Networks (RIPN)



At Russia's International Forum for the 50th anniversary of Sputnik I, October 1-5, 2007, guests attending a special demonstration at the Russian Academy of Sciences' Space Research Institute (IKI) in Moscow saw high-resolution animations streamed from the US and the Netherlands to Russia over TransLight/StarLight and GLORIAD networks using the NSF-funded Scalable Adaptive Graphics Environment (SAGE) software. On October 1, 2007, NCSA simulations of the Milky Way galaxy and a tornado as well as NASA simulations were streamed at 1Gbps from data stores at EVL (Chicago) and SARA (Amsterdam) to a tiled display wall at the IKI.

Note: IKI wanted very much to show their government how they were using the new 10Gbps network between MoscowLight and NetherLight. On Monday, Vice Presidents of the Russian Academy of Sciences as well as many academicians viewed the demonstration. On Tuesday, the Speaker of the Russian Duma (Congress) viewed the demonstration.

In addition to the SAGE demo on October 1-2 (Monday-Tuesday), Bob Grossman of UIC/National Center for Data Mining did a Teraflow Testbed demonstration between Chicago and Moscow on October 3-4 (Wednesday-Thursday). The TransLight/StarLight MRTG chart for the week of October 1 shows usage between Chicago and Amsterdam.



HPDMnet (High-Performance Digital Media Network) Testbed 2007

www.icair.org/news/200711/20071115.html

Collaborators:

- Northwestern University/ International Center for Advanced Internet Research (iCAIR); Louisiana State University/ Center for Computation and Technology (CCT); MCNC; US
- Communications Research Centre Canada (CRC); Inocybe Technologies; Nortel; Canada
- AIST; Japan
- i2CAT; Barcelona
- Masaryk University; Czech Republic
- SARA; University of Amsterdam; The Netherlands
- Special thanks to CANARIE, CESNET, the Global Lambda Integrated Facility (GLIF), National LambdaRail and StarLight

Many types of digital media applications and services require large-scale, high-resolution multipoint-to-multipoint streaming. However, current techniques for streaming digital media are limited because networks are designed to manage many small flows of information – and not relatively few very-large-scale streams. Also, standard routing techniques do not provide sufficient support for large numbers of high-volume streams.

To address these and related challenges, a research consortium created an international testbed, the HPDMnet, to investigate new methods for streaming high-resolution digital media. In particular, HPDMnet focuses on a new capability for communication services based on optical transport (i.e., optical multicast) of high-resolution digital media streams.

The first demonstration of HPDMnet was at GLIF 2007. Component technologies used included UCLP (User Controlled Lighpaths), HARC (Highly-Available Robust Co-Allocator), and G-Lambda. Optical multicast was used to simultaneously stream several high-quality digital media streams among multiple sites on three continents. At GLIF, large screens showed diverse media content, including cultural events and historic architecture

(Barcelona), scientific visualization (Louisiana), Akihabara "Electric Town" (Tokyo), a live MusicGrid lesson and Canadian landscapes (Ottawa), nanotech virtual instrumentation (Chicago), a chess game (North Carolina), and experimental images (Amsterdam).

The second demonstration was at SC07 in Reno, NV. Component technologies utilized by this demonstration included Nortel's DRAC (Dynamic Resource Allocation Controller) and Inocybe Technologies' Argia, which is built on UCLP concepts. Participating sites were Ottawa, Chicago, Amsterdam, Barcelona, and Reno. The demonstration was awarded an SC07 Xnet designation ("eXtreme Networks"), identifying it as a cutting-edge demonstration that showcased new techniques.

Innovation Node: Western Australia

http://www.gridtoday.com/grid/2180703.html
www.epcc.ed.ac.uk/projects/grid-computing/inwa

Collaborators:

- University of Edinburgh's Management School; Edinburgh Parallel Computing Centre (EPCC); Lancaster University Management School; UK
- Curtin University of Technology; Sun Microsystems; Western Australia
- Chinese Academy of Sciences, Computer Network and Information Center; China

The INWA (Innovation Node: Western Australia) grid links nodes on three continents, forming the longest grid in the world. This grid forms part of an e-social science "collaboratory" focused on understanding regional socio-economic behavior in the context of global markets. Research councils and government and industry in the UK and Australia, in collaboration with the University of Edinburgh and Lancaster University Management Schools, funded it.

Until recently, all INWA grid connections among participating sites in Europe, Asia and Australia went via the US to access high-performance international links between national research and educational networks (NRENs). With the advent of TEIN2 (Trans-Eurasia Information Network), a 2.5Gb link is now available between Europe and Asia, thus providing the INWA grid with a more direct alternative that is less than half the distance of the US route. TEIN2 has several points of presence within the Asia-Pacific region (e.g., Beijing, Hong Kong and Singapore) providing direct connections to Europe's GÉANT2.

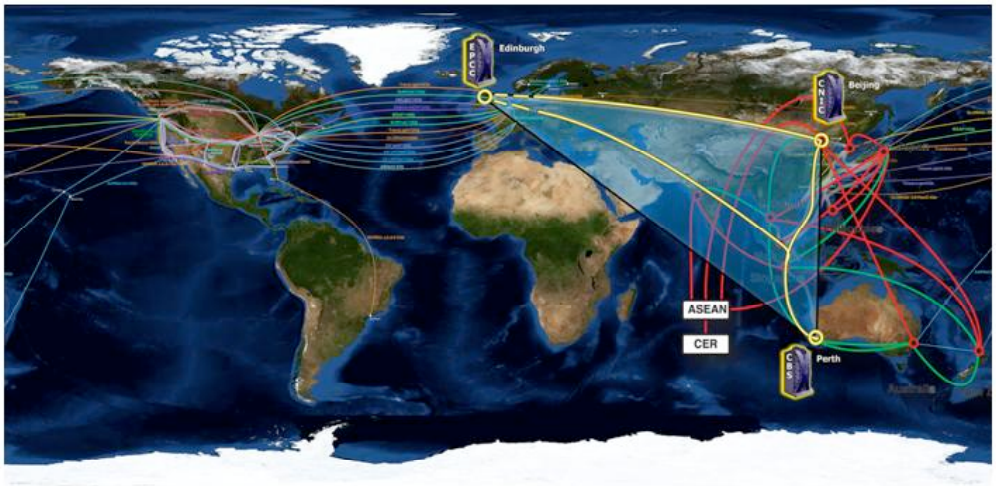


Figure 1: TEIN2 links (highlighted in yellow) connecting grid facilities in Australia, China and the United Kingdom. Each node is based on Sun servers, with servers based in Australia and Beijing provided as part of the collaboration with Sun Microsystems Australia. The TEIN2 network provides an important infrastructure for a region relatively poorly served by network connections in the research and education arena. In East Asia, the network reinforces economic ties established through free trade agreements, both in place (green) and in negotiation (red).

Terry Sloan is the INWA project manager at EPCC. "10 years ago, EPCC collaborated with

Edinburgh University's Management School and local companies to examine customer behavior in the Scottish housing market," he said. "With the advances in grid computing…we've shown that such collaborations can now work effectively at a tri-continental scale and have great potential value for commercial organizations."

"An important point is that the data, computation, visualization and voice and video communications that underpin collaborative analysis were delivered within a single grid environment," noted Professor Ashley Lloyd of Curtin University, and principal investigator at The University of Edinburgh's Management School. "This means that we can start to build on the security focus of global grids to establish trusted environments for the exchange of high-quality socioeconomic data from which we gain a better understanding of the impact of globalization on regional behavior. The link between Western Australia and China is particularly notable, as with 2 billion people in a single time zone, we expect the dynamics of consumer behavior to be more volatile in this region than any other worldwide. Coupled to volatility in the financial markets, this makes the analysis extremely challenging and is why we require a distributed high-performance computing environment."

Internet2 Dynamic Circuit Network @ SC07

http://events.internet2.edu/2007/sc07/

Collaborators:

- Internet2; Great Plains Network; Merit; NYSERNet; Northern Crossroads (NoX); Boston U; U Michigan; U Nebraska-Lincoln; ESnet; Fermilab; Brookhaven National Lab; USA
- GÉANT2; Europe
- HEAnet; Ireland
- PIONIER; Poland
- GRNET; Greece
- University of Amsterdam; SURFnet; The Netherlands
- Nortel; Northern Crossroads (NoX), a Nortel Network based in Ottawa; Canada

At SC07, Internet2 and several partners and collaborators demonstrated for the first time interoperability of its Dynamic Circuit (DC) Network with multiple regional and international networks as well as an equipment provider. The Internet2 demonstrations showcased interoperability with ESnet, GÉANT2 in Europe, the Great Plains Network, GRNET in Greece, HEAnet in Ireland, Merit Network, Northern Crossroads, a Nortel Network based in Ottawa, Canada, the PIONIER network in Poland, and the Phosphorus testbed at the University of Amsterdam (UvA) via SURFnet's NetherLight.

This interoperability was based on multiple, independent implementations of the Inter-Domain Controller (IDC) protocol. Demonstrations included:

- High-definition streaming video from HEAnet to the Internet2 SC07 booth
- File transfers from GRNET and PIONIER to the Internet2 SC07 booth
- LHC data transfers from Fermilab to U Nebraska-Lincoln
- CineGrid 4K video between U Amsterdam and the Dutch Pavilion at SC07
- High-definition streaming video between Nortel's office in Ottawa, Canada and the Internet2 SC07 booth

perfSONAR

Internet2 perfSONAR Demonstration @ SC07

http://events.internet2.edu/2007/sc07/
www.perfsonar.net

Collaborators:

- Internet2; Fermilab; Georgia Tech; Indiana University; SLAC; University of Delaware; ESnet; Open Grid Forum (OGF); US
- GÉANT2; Europe
- Rede Nacional de Ensino e Pesquisa (RNP); Brazil

perfSONAR is an infrastructure for network performance monitoring, making it easier to solve end-to-end performance problems on paths crossing several networks. It contains a set of services delivering performance measurements in a federated environment. These services act as an intermediate layer, between the performance measurement tools and the diagnostic or visualization applications. This layer is aimed at making and exchanging performance measurements between networks, using well-defined protocols.

SCinet, the high-performance network built to support SC07, used perfSONAR to expose performance monitoring information for conference participants and network engineers. The performance information monitored by perfSONAR at SC07 was visualized in several ways:

- perfOMeter – A web based network speedometer for both live and historical data
- Google Maps – A geographical view of network performance
- perfAdmin – An administrative tool for managing perfSONAR deployments
- perfSONAR-UI – A Java client capable of supplying various network visualizations

Internet2 Phoebus Demonstration @ SC07

http://events.internet2.edu/2007/sc07/
http://e2epi.internet2.edu/phoebus.html

Collaborators:
- Internet2; ESnet; University of Delaware; USA
- GÉANT2; Europe
- HEAnet; Ireland
- PIONIER; Poland
- GRNET; Greece

At SC07, Internet2, GÉANT2, and ESnet demonstrated the Phoebus performance framework, which allows applications to seamlessly set up dynamic lightpaths regardless of the user's edge network access method. In doing so, Phoebus provides a bridge to enable a broader segment of users to take advantage of the performance and reliability of optical circuit networks, such as the Internet2 Dynamic Circuit (DC) Network, ESnet Science Data Network (SDN) and the GÉANT2 pan-European research network.

Internet2, GÉANT2, and ESnet, with collaborators from GRNET, HEAnet, and PIONIER, set up a 1Gbps dynamic circuit using standard video transfer and file transfer applications. The applications were initiated from the Internet2 SC07 booth and leveraged the Phoebus framework to access, and then dynamically set up, a separate point-to-point circuit between Reno, Nevada, across the Internet2 DC network and the ESnet network, to the GÉANT2 network in Europe and then to the GRNET, HEAnet and PIONIER networks respectively. Prior to the demonstration, the applications were expected to transfer approximately 7GBs of data, the amount of data stored on a standard movie DVD, in one minute.

IU Data Capacitor @ SC07

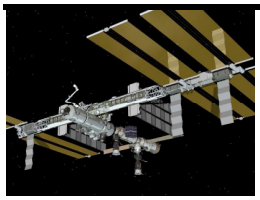
http://newsinfo.iu.edu/news/page/normal/6839.html

Collaborators:
- Indiana University/University Information Technology Services, School of Informatics, and Pervasive Technology Labs; Rochester Institute of Technology; Oak Ridge National Laboratory; Pittsburgh Supercomputer Center; US
- Technische Universitaet Dresden; Germany
- Special thanks to Data Direct Networks, Dell, Myricom and Force10

Indiana University (IU) and its collaborators were awarded first place in an SC07 Bandwidth Challenge competition for the IU Data Capacitor, a system designed to store and manipulate massive datasets. The IU team achieved a peak transfer rate of 18.21Gbps out of 20Gbps. This performance was nearly twice the peak rate of the nearest competitor. The IU team achieved an overall sustained rate of 16.2Gbps (roughly equivalent to sending 170 CDs of

data per minute) using a transatlantic network path that included the Internet2, GÉANT2, and DFN research networks.

During the competition, the IU-led team ran several applications, all of which depended upon the Data Capacitor's ability to read and write data at extreme speeds. A key aspect of the demonstration was the ability to simultaneously support a mix of several different applications from the sciences and humanities, including modeling and analysis of the amyloid peptide (cause of Alzheimer's disease); live acquisition of x-ray crystallography data; digital preservation of ancient Sanskrit manuscripts; performance analysis of a computational fluid dynamics application; and, simulations of a high-energy physics reaction between the basic particles of matter.



ISS: International Space Station 2007

www.nasa.gov/station
www.esa.int/esaHS/iss.html

Collaborators:
- NASA; US
- Russian Federal Space Agency; Russia
- Japan Aerospace Exploration Agency; Japan
- Canadian Space Agency; Canada
- European Space Agency; Europe

The International Space Station (ISS) orbits around the Earth at an altitude of 360km. The construction of this satellite was a joint effort, bringing together the resources of NASA, the Russian Federal Space Agency, the Japan Aerospace Exploration Agency, the Canadian Space Agency and the European Space Agency (ESA).

The ISS has been continuously inhabited since the first resident crew entered the station on November 2, 2000, thereby providing a permanent human presence in space. The station is serviced primarily by Russian Soyuz and Progress spacecraft and by US Space Shuttle orbiters. At present the station has a capacity for a crew of three. Early crew members all came from the Russian and US space programs. German ESA astronaut Thomas Reiter joined the Expedition 13 crew in July 2006, becoming the first crew member from another space agency. The station has, however, been visited by astronauts from 15 countries. The ISS was also the destination of the first five space tourists.

Europe, working through ESA, is exclusively responsible for two key Station elements: the European Columbus laboratory and the Automated Transfer Vehicle (ATV). Columbus is a multifunction laboratory that specializes in research into fluid physics, materials science and life sciences. ATV is a supply ship lifted into orbit by the Ariane-5 launcher, which will carry up to nine tons of cargo, including provisions, scientific payloads and rocket propellant. Once docked, the craft can use its motor to boost the Station higher in its orbit, thus counteracting the faint drag from the Earth's atmosphere. In addition, Europe's scientists and engineers also contribute other elements, equipment and design skills across much of the ISS.

At the annual conference of the American Astronautical Society in November 2007, the ISS partnership received the society's award for the advancement of international cooperation. The partnership was chosen for its outstanding cooperation in the design, development, assembly, management and operation of the ISS. The space station is the most complex scientific and technological endeavor ever undertaken, involving the US, Russia, Japan, Canada, and several European countries. The ISS effort involves more than 100,000 people in space agencies, at 500 contractor facilities and in 37 US states. The station is teaching us how to live and work in space for long duration missions. It is an important stepping stone as NASA looks to venture to the moon, Mars and beyond.

IVOA: International Virtual Observatory Alliance 2007

www.ivoa.net

Collaborators:

- Armenian Virtual Observatory (ArVO); Armenia
- AstroGrid; UK
- Australian Virtual Observatory; Australia
- Chinese Virtual Observatory; China
- Canadian Virtual Observatory; Canada
- European Virtual Observatory; Europe
- German Astrophysical Virtual Observatory; Germany
- Hungarian Virtual Observatory; Hungary
- Japanese Virtual Observatory; Japan
- Korean Virtual Observatory; Korea
- National Virtual Observatory; US
- Observatoire Virtuel; France
- Russian Virtual Observatory; Russia
- Spanish Virtual Observatory; Spain
- Italian Virtual Observatory; Italy
- Virtual Observatory India; India

IVOA was formed in June 2002 with a mission to "facilitate the international coordination and collaboration necessary for the development and deployment of the tools, systems and organizational structures necessary to enable the international utilization of astronomical archives as an integrated and interoperating virtual observatory." The IVOA comprises 16 VO projects from Armenia, Australia, Canada, China, Europe, France, Germany, Hungary, India, Italy, Japan, Korea, Russia, Spain, the UK and the US. The work of the IVOA focuses on the development of standards.

The Gemini Observatory – the Gemini South telescope is located in the Chilean Andes and the Gemini North Telescope is located on Hawaii's Mauna Kea – and the National Optical Astronomy Observatory (NOAO) produce data products for US optical astronomy science, which are also being incorporated into the IVOA.

LHC: Networking for High-Energy Physics

Below are excerpts from the report "ICFA SCIC Report: Networking for High Energy Physics" by the International Committee for Future Accelerators (ICFA), Standing Committee on Inter-Regional Connectivity (SCIC), Chair: Harvey Newman, Caltech
http://monalisa.caltech.edu:8080/Slides/Public/SCICReports2008 or
http://monalisa.cern.ch:8080/Slides/Public/SCICReports2008

The key role of networks has been brought sharply into focus as a result of the worldwide-distributed grid computing model adopted by the four LHC experiments, as a necessary response to the unprecedented data volumes and computational needs of the physics program. As we approach the era of LHC physics, the experiments are developing the tools and methods needed to distribute, process, access and cooperatively analyze datasets with volumes of tens to hundreds of Terabytes of simulated data now, rising to many Petabytes of real and simulated data during the first years of LHC operation.

The scale of the required networks has been set by the distribution of data from the Tier0 at CERN to 11 Tier1 centers, as well as the needs for distribution to more than 100 Tier2 centers located at sites throughout the world where more than 40% of the computing and storage resources will be located, and where the majority of the data analysis as well as the production of simulated data are foreseen to take place. This is complemented by hundreds of computing clusters (Tier3s) serving individual physics groups, where there will also be a demand for (1 to a few) Terabyte-scale datasets once the LHC program is underway.

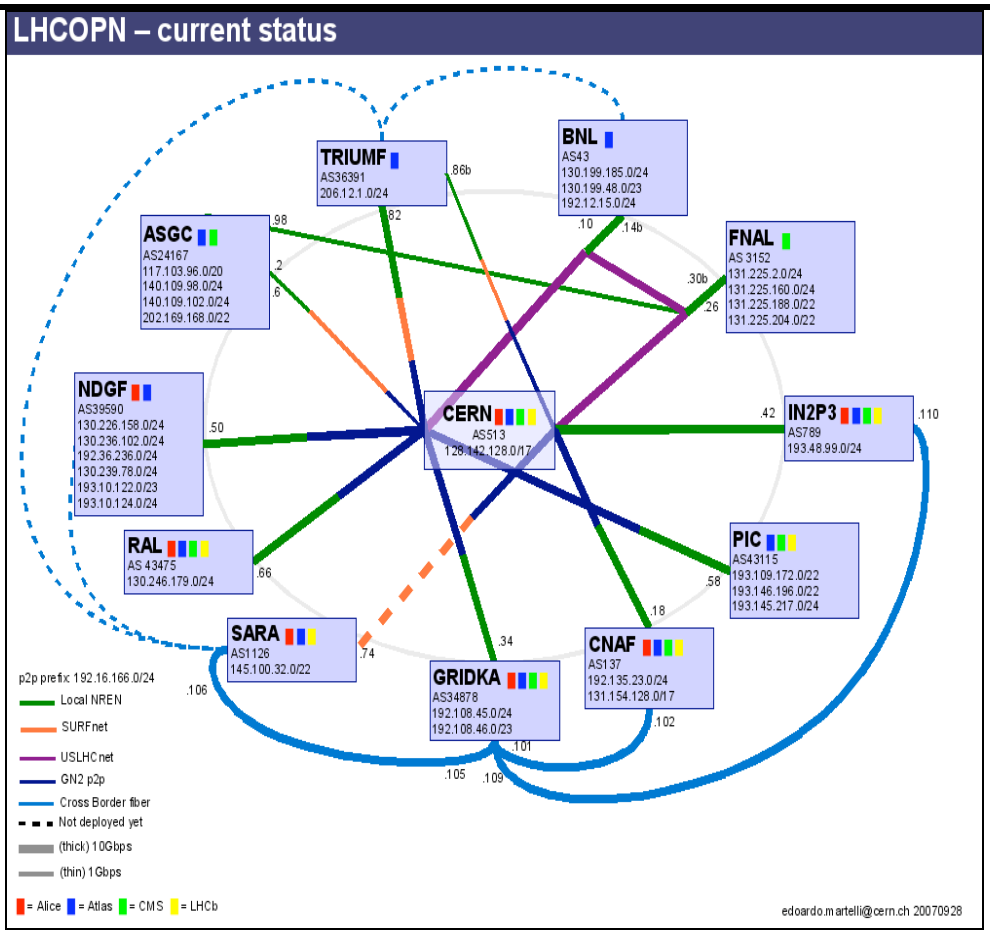


Figure 1: The LHC Optical Private Network (OPN) Status (September 2007)

In order to respond to the highest priority needs of the experiments, for data distribution from the CERN Tier0 to the Tier1s as well as data exchange among the Tier1s, the LHC Optical Private Network (OPN) has been formed. As a "private network" where only designated flows between specified source and destination addresses are allowed, the OPN will serve to guarantee adequate, secure connectivity to and among the Tier1s, as long as the links continue to evolve in future years to meet the bandwidth needs. The present status of the OPN is shown in Figure 1. Each of the Tier1s is connected to CERN at a minimum bandwidth of 10 Gbps, with some Tier1s (such as BNL and Fermilab which connect to CERN over ESnet and US LHCNet; and SARA in the Netherlands) connecting using multiple 10 Gbps links. The initial configuration of the OPN was largely a "star" network centered on CERN, and this is being supplemented by an increasing number of additional links among the Tier1s (shown at the periphery of the figure) to provide backup paths, in order to ensure that the OPN can provide round-the-clock, nonstop operation as required. As indicated (by the dashed lines) in the figure, additional links are planned to provide backup paths for the centers in Canada, Taiwan, and the Nordic countries.

In addition to the Tier0 and Tier1 connectivity shown above, the Tier2s also have very important roles to play in the overall LHC Computing Model, providing much of the resources as well as being focal points for analysis. As part of this role, each Tier2 requires connectivity to their corresponding Tier1 (in the ATLAS version of the Model) or to the ensemble of Tier1s (in the CMS version of the Model), and the ability of Tier2s to get at the datasets needed implies substantial data flow within as well as beyond the limits of the OPN, across GÉANT2, Internet2, NLR, and other national research and education networks (NRENs). The Tier2 connectivity requirements have been variously estimated in the range

from 1 to 10 Gbps, depending on the availability and affordability of bandwidth in each region. The Tier2s in the US, for example, either already have or are planning 10 Gbps connections before LHC startup.

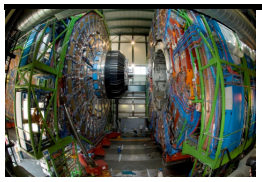
Year	Production	Experimental	Remarks
2001	0.155	0.622-2.5	SONET/SDH
2002	0.622	2.5	SONET/SDH DWDM; GigE Integ.
2003	2.5	10	DWDM; 1 + 10 GigE Integration
2005-6	10-20	2-4 X 10	λ Switch; λ Provisioning
2007-8	30-40	~100 or 2 X 40 Gbps	1st Gen. λ Grids
2009-10	60-80	~5 X 40 or ~2 X 100	40 or 100 Gbps λ Switching
2011-12	~5 X 40 or ~2 X 100	~25 X 40 or ~10 X 100	2nd Gen λ Grids Terabit Networks
2013-14	~Terabit	~MultiTbps	~Fill One Fiber

Table 1: Roadmap for major links used by HEP. Projections follow the trend of affordable bandwidth increases over the last 20 years: by a factor of ~400 to 1000 times per decade. The entries marked in yellow reflect past or present implementations.

The roadmap above is paralleled by the ESnet Science Network Roadmap, shown below, which covers several fields of data-intensive science, with a focus on 15,000 scientists supported by the US DOE. This roadmap illustrates the quantitative and qualitative needs of several fields, where bioinformatics and chemistry/combustion are also expected to present network requirements on a similar scale to high-energy physics, within the next few years.

Science Network Requirements Aggregation Summary — **W. Johnston ESnet**

Science Drivers Science Areas / Facilities	End2End Reliability	Connectivity	Today End2End Band width	5 years End2End Band width	Traffic Characteristics	
Advanced Light Source	-	• DOE sites • US Universities • Industry	1 TB/day 300 Mbps	5 TB/day 1.5 Gbps	• Bulk data • Remote control	• Guaranteed bandwidth • PKI / Grid
Bio-informatics	-	• DOE sites • US Universities	625 Mbps 12.5 Gbps in two yrs	250 Gbps	• Bulk data • Remote control • Point-to-multipoint	• Guaranteed bandwidth • High-speed multicast
Chem./ Combustion	-	• DOE sites • US Universities • Industry	-	Tens of Gigabits/ second	• Bulk data	• Guaranteed bandwidth • PKI / Grid
Climate Science	-	• DOE sites • US Universities • Int'l	-	5 PB/year 5 Gbps	• Bulk data • Remote control	Guaranteed bandwidth • PKI / Grid
		Immediate Requirements				
High Energy Physics (LHC)	99.95+% (< 4 hrs per year)	• US Tier1 (FNAL, BNL) • US Tier2 • International (Europe, Canada)	10 Gbps	60 to 80 Gbps (30-40 Gbps per US Tier1)	• Bulk data • Coupled computational processes	• Guaranteed bandwidth • Traffic isolation • PKI / Grid



Large Hadron Collider: UltraLight Data Analysis Tools 2007

http://ultralight.caltech.edu
http://mr.caltech.edu/media/Press_Releases/PR13073.html

Collaborators:

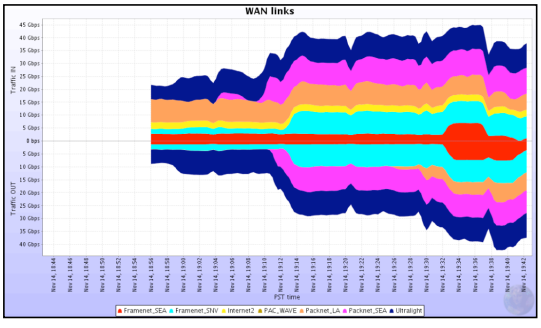
- CERN; Switzerland
- Caltech; Stanford Linear Accelerator Center (SLAC); Fermilab; Brookhaven National Laboratory; U Florida; U Michigan; Vanderbilt U; Cisco Systems; US
- Korea Institute of Science and Technology Information (KISTI); Kyungpook National U; Korea
- U Manchester; UK
- Universidade do Estado do Rio de Janeiro (UERJ); Universidade Estadual Paulista (UNESP)/Universidade de São Paulo (USP); Brazil
- National Institute of Information Technology; Pakistan
- Polytechnica U; Romania

UltraLight is a collaboration of experimental physicists and network engineers whose purpose is to provide the network advances required to enable petabyte-scale analysis of globally distributed data. Current Grid-based infrastructures provide massive computing and storage resources, but are currently limited by their treatment of the network as an external, passive, and largely unmanaged resource.

On April 24, 2007, UltraLight received the 2007 Internet2 Driving Exemplary Applications (IDEA) Awards program, which recognizes leading innovators who have created and deployed advanced network applications that have enabled transformational progress in research, teaching and learning. UltraLight provides the foundation and services for linking thousands of physicists and scientists around the world who together are investigating the origins of the universe.

At SC07, an international team of physicists, computer scientists, and network engineers led by Caltech, U Michigan, the National Institute of Information Technology in Pakistan, Polytehnica University in Romania, Fermilab, Brookhaven National Lab, and CERN, and partners from Brazil (Rio de Janeiro State University, UERJ, and two of the State Universities of São Paulo, USP and UNESP) and Korea (Kyungpook National University, KISTI) set new records for sustained data transfer among storage systems.

The team demonstrated storage-to-storage data transfer over wide-area networks from a single rack of servers on the exhibit floor. The team's demonstration of "High Speed Data Distribution for Physics Discoveries at the Large Hadron Collider" achieved a bidirectional peak throughput of 88Gbps and a sustained data flow of more than 80Gbps for two hours among clusters of servers on the show floor and at Caltech, Michigan, Fermilab, CERN, Brazil, Korea, and locations in the US LHCNet network in Chicago, New York, and Amsterdam. Shown here is a MonALISA snapshot, taken November 14, 2007, that shows Caltech reached 70Gbps of disk-to-disk throughput using a single rack of server equipment, running Caltech's Fast Data Transfer with a kernel containing the Caltech FAST TCP patch. Caltech reached a peak in one direction of 41Gbps.



Large Hadron Collider: Worldwide LHC Computing Grid 2007

http://lcg.web.cern.ch/LCG/
http://lcg.web.cern.ch/LCG/Sites/sites.html (Tier1 and Tier2 sites)
www.hpcwire.com/hpc/1572567.html

Collaborating LHC Tier1 Centers:
- TRIUMF; Canada
- CC-IN2P3; France
- FZK-GridKA; Germany
- CNAF; Italy
- NIKHEF; The Netherlands
- Nordic Data Grid Facility; Denmark, Finland, Norway, Sweden
- PIC; Spain
- ASGC; Taiwan
- Rutherford Appleton Laboratory; UK
- Brookhaven National Laboratory; Fermi National Accelerator Laboratory, USA

Collaborating LHC Tier2 Centers (Participating countries):
- Australia, Austria, Belgium, Brazil, China, Czech Republic, Finland, France, Germany, India, Israel, Italy, Japan, Norway, Pakistan, Poland, Portugal, Romania, Russia, Slovenia, Spain, Sweden, Switzerland, Taiwan, UK, Ukraine, US

The Worldwide LHC Computing Grid (WLCG) is the world's largest computing and data grid with 30,000 CPUs at 200 sites. It will process and deliver LHC data from the detectors to physicists at their home institutions. While LHC data will be transported from CERN over dedicated 10Gbps lightpaths to Tier1 sites across the globe, the traffic from the Tier1 centers to the data analysis facilities at the Tier2 centers flows over shared international Research & Education networks. The actual data analysis by physicists will take place at Tier2 Sites.

Indiana University, Purdue University, UCSD: Tier2 Sites
The Large Hadron Collider (LHC) Compact Muon Solenoid (CMS) is an electronic detector that is searching for subatomic particles, especially a particle known as Higgs boson, which is a missing piece in the jigsaw puzzle of the theory of particle physics (boson is the name physicists give subatomic particles with particular properties). Dubbed "the God Particle" nearly a decade ago by Nobel prize-winning physicist Leon Lederman, the Higgs boson would explain why some particles have any mass at all, while others, such as photons, do not.

Internationally there are 11 Tier1 sites and more than 100 Tier2 sites. In the US, the 7 CMS Tier2 sites are Purdue, UCSD, Caltech, U Nebraska, U Wisconsin, U Florida and MIT. They will receive CMS data from Fermilab (a Tier1 site). Data will be processed and then analyzed by university physicists. (Brookhaven is a Tier1 for the CERN ATLAS project.)

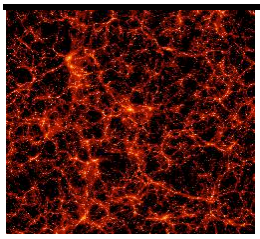
In tests so far, the CMS Tier2 sites have been able to support up to 50,000 jobs per day, and the goal is to be able to support 100,000 computing jobs per day by late spring.

Purdue and UCSD are the only two Tier2 sites connected to NSF's TeraGrid research network, and Purdue also connects to Fermilab through StarLight and Indiana's I-Light. Indiana University plays a key role in CERN's ATLAS project, which, like the CMS project, aims to discover insights into subatomic physics and the nature of matter.

Brazilian Tier2 Sites
There are two Tier2 groups in Brazil – Universidade do Estado do Rio de Janeiro (UERJ) and Universidade Estadual Paulista (UNESP)/Universidade de São Paulo (USP) – who want to connect to Tier1 and CERN at 1Gbps rates. WHREN-LILA (Julio Ibarra) is working with Harvey Newman and Tom DeFanti to connect via TransLight/StarLight.

Australian Tier2 Sites
Physicists at the Universities of Melbourne and Sydney work closely with AARNet and computing partners at APAC in Canberra, VPAC in Melbourne, AC3 in Sydney and SAPAC

in Adelaide to prepare and build the Australian nodes of the WLCG for LHC ATLAS data. Data from the Asia-Pacific regional Tier1 center in Taipei to the Tier2 federation in Australia is expected to top 300Mbps at full data rates. Delivering high network throughput from Taipei to Tier2 centers is only possible with assistance from AARNet's network engineers, in cooperation with local university networks and international network partners.



Marenostrum Numerical Cosmology Project

http://astro.ft.uam.es/marenostrum/

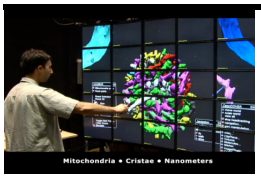
Collaborators:

- Astrophysical Institute Potsdam; Jacobs University Bremen; Germany
- Universidad Autónoma de Madrid; Barcelona Supercomputer Center; Spain
- University of Chicago; New Mexico State University; US
- Hebrew University of Jerusalem; Israel

An interdisciplinary group composed of astrophysicists from the Universidad Autonoma de Madrid, the Astrophysical Institute Potsdam in Germany and partners from Israel, the US, Russia, Greece, etc., have joined forces to try to realistically reproduce the starting conditions that originated the observable galaxies, including the one in which we live, the Milky Way.

The *Marenostrum Universe* is a 2-billion particle adiabatic SPH simulation in a 500 Mpc/h box size. The code was run on the Marenostrum Supercomputer located in the Barcelona Supercomputer Center on 512 processor during 447 hours, equivalent to more than 29 years on serial run. The total output data occupies 8.6 Tbytes distributed in 135 evenly spaced snapshots of 64 Gbytes each.

The *MareNostrum Galaxy Formation Simulation* is a 2-billion particle SPH simulation in a 50 Mpc/h size box. Radiative cooling, star formation, feedback and metallicity enrichment have been included to investigate the formation and properties of galaxies at high redshift. This simulation also runs on the Marenostrum Supercomputer at the Barcelona Supercomputer Center using 800 processors simultaneously. The total CPU time spent to evolve the simulation from z=60 until z=5.7 was more than 126 years (5 million seconds of wall clock time), which gives an idea of the complexity of this simulation as compared with the adiabatic gas dynamical runs.



Microscopy Distributed Laboratory Demonstrator 2007

www.nbirn.net

Collaborators:

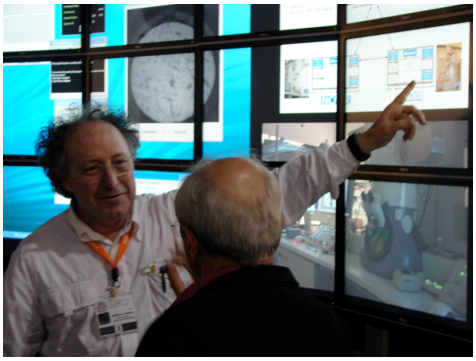
- UCSD National Center for Microscopy Imaging Research (NCMIR); UCSD Center for Research in Biological Systems; UCSD Calit2; US
- Oxford University, Materials Research Center at Begbroke; Oxford e-Research Centre (OeRC); UK

The Microscopy Distributed Laboratory Demonstrator provides a total collaboration solution for electron microscopy (EM). This project harnesses the expertise of leading researchers in tele-instrumentation, cyberinfrastructure development, optical/lambda networking, advanced visualization, and microscopy. Specifically, the project extends the OptIPuter research conducted between UCSD and UIC, to Oxford University. The benefits of internationally connected lambdas, Microsoft-enabled visualization systems, and Microsoft Windows clusters are utilized in the context of a fully integrated infrastructure for the shared use of unique imaging instruments coupled to processing workflows for the 3D characterization of connections in the brain and advanced materials.

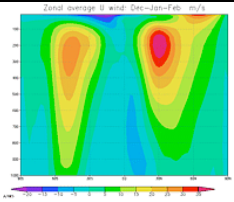
Specifically, two of the world's most advanced electron microscopes, one at UCSD and one at Oxford, are featured. These instruments represent the state of the art in intermediate voltage- and aberration-corrected geometries for Transmission Electron Microscopy (TEM). Hence, the shared use of these resources represents a unique opportunity to link biological

and materials science technical expertise across two leading resources.

For SC07, NCMIR and Oxford University demonstrated the Distributed Microscopy Laboratory system. The two groups linked resources in San Diego, Oxford and SC07/ Reno to enable data sharing and the use of Telescience tools for collaborative work. The two groups developed and deployed Microsoft-enabled software solutions to control complex functions of atomic-resolution imaging instruments, computing clusters, storage systems, and SAGE-driven tiled display walls. Demonstrated were shared views of the complexities of the nervous system and of complex nanomaterials. For this project, the OptIPuter/SAGE 2.0 software was ported to Windows XP and two Windows XP-based prototype OptIPortals were built. Other SAGE-based visualization software ported to this environment included VLC (for video streaming), MagicCarpet, Remote Desktop Viewer and LambdaCam.



This research uses CAVEwave between San Diego and Chicago, and then goes over UKLight from Chicago (StarLight) to Oxford University.



NCEP/NCAR Reanalysis Project at NOAA

www.ncep.noaa.gov
www.cpc.ncep.noaa.gov/products/wesley/reanalysis.html

Collaborators:

- National Oceanic & Atmospheric Administration (NOAA)/ National Geophysics Data Center (NGDC), Boulder, CO; National Centers for Environmental Prediction (NCEP); National Center for Atmospheric Research (NCAR); US
- Russian Academy of Sciences/ Space Research Institute/ Center of Geophysical Data Studies; Moscow; Russia

NOAA works with the NCEP/NCAR Reanalysis Project, a joint project of the National Centers for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR), to produce new atmospheric analyses using historical data (1948 onwards) and to produce analyses of current atmospheric state (Climate Data Assimilation System, CDAS). Until recently, the meteorological community had to use analyses that supported real-time weather forecasting. These analyses are very non-homogeneous in time, as there have been big improvements in data assimilation systems. This played havoc with climate monitoring, as these improvements often produced changes in the apparent "climate." Even fundamental quantities, such as the strength of the Hadley cell, have changed over the years as a result of the changes in the data assimilation systems.

A 1Gbps VLAN from NOAA to StarLight (via NLR), from StarLight to NetherLight (via TransLight/StarLight-GLORIAD), and from NetherLight to MoscowLight and Russia's Space Research Institute (via RBnet) was configured on August 1, 2007 for NCEP collaboration. The goal is to develop new data-mining algorithms to search for weather events inside Terabyte-sized databases, and then create new environmental databases.

Nearby Supernova Factory

http://snfactory.lbl.gov/

Collaborators:

- Lawrence Berkeley National Lab (LBNL); Yale University/ Department of Physics; US
- Centre de Recherche Astronomique de Lyon (CRAL); Institut de Physique Nucleaire de Lyon (IPNL); Laboratoire de Physique Nucleaire et de Hautes Energies (LPNHE); France

The Nearby Supernova Factory (SNfactory) is an experiment designed to collect data on more Type Ia supernovae than has ever been studied in a single project before, and in so doing, to answer some fundamental questions about the nature of the universe. Type Ia supernovae are extraordinarily bright, remarkably uniform objects that make excellent "standard candles" for measuring the expansion rate of the universe. However, such stellar explosions are very rare, occurring only a couple of times per millennium in a typical galaxy, and remaining bright enough to detect only for a few weeks. Previous studies of Type Ia supernovae led to the discovery of the mysterious "dark energy" that is causing the universe to expand at an accelerating rate.

To reduce the statistical uncertainties in previous experimental data, extensive spectral and photometric monitoring of more Type Ia supernovae is required. The SNfactory collaboration built an automated system consisting of specialized software and custom-built hardware that systematically searches the sky for new supernovae, screens potential candidates, then performs multiple spectral and photometric observations on each supernova. These observations will be stored in a database to be made available to supernova researchers worldwide for further study and analysis.

Specifically, SNfactory developed a collaborative visual analytics software system to provide distributed access, management, visualization, and analysis of supernova data. Sunfall (the SUperNova Factory Assembly Line) is the SNfactory software framework architecture developed by SNfactory scientists and software engineers in collaboration with the LBNL Visualization Group. Sunfall integrates SNfactory software tools, including the search pipeline, scanning software, remote observing tools, supernova candidate scheduler, and distributed, remote access to the supernova catalog database.

Phosphorus 2007

www.ist-phosphorus.eu

Collaborators:

- SURFnet; University of Amsterdam; SARA; The Netherlands
- PIONIER; Poznań Supercomputing and Networking Center (Project Coordinator); Poland
- CESNET; Czech Republic
- Athens Information Technology Institute; RACTI; University of Patras; Greece
- Fraunhofer Institute for Algorithms and Scientific Computing (SAIC) and Institute for Media Communication (IMK); Research Centre Jülich; University of Bonn; Germany
- University of Essex; University of Wales-Swansea; UK
- Interdisciplinary Institute for Broadband Technology (IBBT); Belgium
- Fundació i2CAT; Spain
- MCNC; Louisiana State University/Center for Computation and Technology; US
- Communications Research Centre; Canada

Phosphorus is an alliance of European and North American partners who are developing advanced solutions of application-level middleware and underlying management and control plane technologies. It is a 30-month project begun in October 2006 and funded by the European Union (EU) Research Networking Testbeds IST program.

The project mission is to address key technical challenges in enabling on-demand end-to-end network services across multiple domains; to treat the underlying network as a first-class Grid resource; and to demonstrate solutions and functionalities across a testbed

involving European National Research Networks, GÉANT2, Cross Border Dark Fiber and GLIF connectivity infrastructures.

At SC07, Phosphorus partners demonstrated the project's activities in the Poland research booth. They showed the usability of the Network Service Plane, developed by the members of the Phosphorus consortium, for scientists and their applications. The Network Service Plane, which allows interoperability in a seamless environment among different Network Resource Provisioning Systems (NRPS), will be verified in an environment composed of User Controlled Light Paths (UCLP), Dynamic Resource Allocation Controller (DRAC) and Allocation and Reservation in Grid-enabled Optic Networks (ARGON).

SPIDR (Space Physics Interactive Data Resource) 2007

http://spidr.ngdc.noaa.gov

Collaborators:
- National Oceanic & Atmospheric Administration (NOAA)/ National Geophysics Data Center (NGDC), Boulder, CO; US
- Russian Academy of Sciences/ Space Research Institute/ Center of Geophysical Data Studies, Moscow; Russia

SPIDR is a de facto standard data source for solar terrestrial physics, functioning within the framework of the ICSU World Data Centers. It is a distributed database and application server network, built to select, visualize and model historical space weather data distributed across the Internet. SPIDR can work as a fully functional web application (portal) or as a grid of web services, providing functions for other applications to access its data holdings. By enabling easy data mirroring and eliminating the network bottlenecks associated with transcontinental links, the distributed system architecture is a key factor for low latency in multimedia data visualization and fast data delivery.

A 1Gbps VLAN from NOAA to StarLight (via NLR), from StarLight to NetherLight (via TransLight/StarLight-GLORIAD), and from NetherLight to MoscowLight and Russia's Space Research Institute (via RBnet) was configured on August 1, 2007 for SPIDR collaboration. Current collaboration has resulted in 10 databases with total disk space of ~500 GB.

Surgery via Video @ APAN 2007

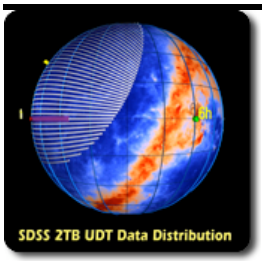
www.aarnet.edu.au/library/AARNews_0712.pdf
www.aqua.med.kyushu-u.ac.jp/index.php?Finished2007
www.apan.net/documents/2007/wg-update.ppt

Collaborators:
- Korea University Hospital in Seoul; Korea
- Tokyo Medical Dental University; Japan
- National University of Singapore; Singapore
- University of Philippines; Philippines
- Tata Memorial Hospital; India
- Concord Repatriation General Hospital; Australia
- Institute of Laparoscopic Surgery; France
- Sheraton Xi'an Hotel; China (location of APAN meeting)

At the 24th APAN Meeting, August 27-31, 2007, in Xi'an, China, a live, multi-way digital video connection of a medical procedure was broadcast among Korea University Hospital in Seoul and seven other hospitals in Australia, China, Japan, Singapore, Philippines, India and France. Remote surgeons were able to observe and comment on a laparoscopic surgical procedure in real-time via a high-quality, high-resolution videoconferencing system, bridging geographical divides and enabling medical specialists around the world to learn and

teach each other advanced procedures. The linkup occurred using the Digital Video Transport System (DVTS), which requires a minimum 30Mbps link (higher bandwidth and quality than traditional H.323 videoconferencing).

Note: It is not known if the network used for this collaboration relied on the DANTE/GÉANT2 TEIN2 Asia/Europe network or networks across the US.



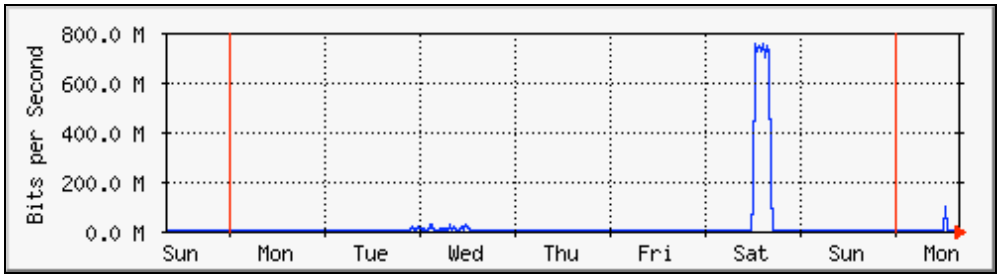
Teraflow Testbed 2007: Sloan Digital Sky Survey

www.ncdm.uic.edu
www.teraflowtestbed.net

Collaborators:

- UIC National Center for Data Mining (NCDM); Johns Hopkins U; UCSD; NASA Goddard Space Flight Center; US
- CERN; Switzerland
- University of Melbourne; Australia
- Chinese Academy of Sciences (CAS)/ Computer Network Information Center; National Astronomical Observatory; China
- Max Plank Institute for Plasma Physics/ Garching Computing Centre; Germany
- University of Tokyo/ Institute for Cosmic Ray Research; Japan
- Korea Astronomy & Space Science Institute; Korea Institute of Science and Technology Information; Korea
- SARA Computing and Networking Services; University of Amsterdam; The Netherlands
- Russian Academy of Sciences/Space Research Institute (IKI); Russia
- With support from StarLight, TransPAC2, JGN2, and KREONet2

The Teraflow Testbed was extended to Russia in 2007. GLORIAD involved its Russian partners in the Teraflow project now that there are several gigabits of bandwidth between Chicago and Moscow (3x1Gb VLANs on TransLight/StarLight from Chicago to Amsterdam, and 10Gb from Amsterdam to Moscow funded by the Russians). On May 14, 2007, the first experiment was to download and create a mirror site for Sloan Digital Sky Survey (SDSS) data on a data server at the Russian Space Research Institute (IKI). SDSS data was transferred from UIC NCDM servers to an IKI mirror site <www.skyserver.ru> over the TransLight/StarLight link. NCDM moved 1.4 TeraBytes (TB) of data in about 4.5 hours over a 1 Gbps VLAN between NCDM in Chicago and Moscow. Using NCDM's transport protocol UDT (UDP-based Data Transfer), the SDSS 2.5 TB catalog was compressed to 1.4 TB, split into 60 files, distributed, and then decompressed in Moscow to its original size. Downloads were measured on StarLight's MRTG graph (see Saturday's usage information on the weekly MRTG graph below).



In December 2007, IKI installed NCDM's UDT relay server in order to disseminate large scientific databases and visualization content. IKI has climate change and space weather databases ready for delivery to institutions that are part of the World Data Centers System under ICSU. These databases will be a major addition to the SDSS database. IKI plans to add open source port relaying services to the UDT protocol stack and will maintain the code at SourceForge <http://sourceforge.net/projects/udt/>. IKI also plans to use UDT to share satellite data with the National Geophysical Data Center at NOAA in Boulder.

Teraflow Testbed: Angle Anomaly Detection Project

http://angle.ncdm.uic.edu/
http://sc07.supercomputing.org/html/SC07AwardWinners.html

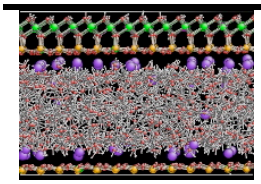
Collaborators:

- Consortium for Data Analysis Research (CDAR), consisting of the UIC National Center for Data Mining (NCDM); the University of Chicago/ Computation Institute; Northwestern University/ International Center for Advanced Internet Research (iCAIR); Argonne National Laboratory/ Mathematics and Computer Science Division; the Toyota Technological Institute at Chicago; US
- *While currently a US-based effort, it does utilize the Teraflow Testbed, which is international in scope*

UIC/EVL collaborator Robert Grossman, director of the UIC National Center for Data Mining (NCDM), won First Place at the SC07 Analytics Challenge for Angle, a new approach to cyberinfrastructure security. Angle is a new algorithm for identifying malicious attacks on cyberinfrastructure.

Since the Internet is distributed, so is the data that must be analyzed to protect it. With today's supercomputers, the data must be collected, transported to the supercomputer, and then transported back. For large data, the time required to do this can be a significant fraction of the total time required by the analysis. One of the innovations of the Angle project is the use of a data and compute cloud so that the data can be left in place and computation performed over the data. Although cloud computing has been used for the past several years by companies such as Google, Yahoo, Amazon and Microsoft to provide their services, these cloud infrastructures, by and large, are based on the standard Internet. In contrast, the Sector data cloud, used by the Angle project, is a second-generation data cloud based on wide-area high-performance networks. These high-performance networks enable the large datasets produced by the project to be handled easily.

The Angle project was sponsored in part by CDAR, a Chicago-based research consortium that is developing new technologies and methodologies for analyzing large, complex and distributed data. NCDM won two of the first three Analytic Challenges (at SC05 and SC07).



TeraGrid International Collaboration with the UK 2007

www.teragrid.org
www.exclaim.org.uk

Collaborators:

- TeraGrid (TACC, NCSA, PSC); US
- UK National Grid Service; University College London; UK
- EU DEISA (Distributed European Infrastructure for Supercomputing Applications); Europe

The *TeraGrid 2007 Science Highlights* features Peter Coveney from University College London for his efforts to create a "federated grid" with TeraGrid (TACC, NCSA, PSC) and systems at the UK National Grid Service and the EU DEISA grid. Coveney's research is to better understand how clay particles behave at the nanoscale, in particular to control how they "exfoliate" – i.e., scatter from layered arrangements, like cards stacked one on top of another, into individual nanometer-thick sheets that can be dispersed within a matrix of polymer. Previous simulations were limited to system sizes in the range of 10,000 atoms – much smaller than the realistic size of clay particles and too small to observe many physical properties of the material. Coveney and colleagues did extensive simulations of clay particles in system sizes that range up to 10 million atoms. Employing innovative UK-developed middleware called the Application Hosting Environment, researchers moved with ease among the three different grids. At large system sizes – up to three orders of magnitude larger than prior work – the simulations approached the realistic size of clay "platelets." The

results (reported this year in the *Journal of Physical Chemistry C)* revealed thermally-induced undulations in the clay sheets not before observed, findings that make it possible to calculate elastic properties (such as the bending modulus) difficult to obtain experimentally.

Supercomputers were linked by dedicated optical networks, including UKLight. So, while this project did not use TransLight/StarLight, it leveraged the UK's transatlantic circuit.

WACCM (Whole Atmosphere Community Climate Model) 2007

http://waccm.acd.ucar.edu

Collaborators

- National Center for Atmospheric Research (NCAR)/ Atmospheric Chemistry Division (ACD); NCAR Climate and Global Dynamics (CGD) Division; NCAR High Altitude Observatory (HAO); US
- Barcelona Supercomputer Center (BSC); Universidad Complutense de Madrid; Spain

WACCM, the Whole-Atmosphere Community Climate Model, is a comprehensive numerical model that spans the range of altitude from the Earth's surface to the thermosphere. WACCM development is an NCAR inter-divisional collaboration that unifies certain aspects of the upper atmospheric modeling of HAO, the middle atmosphere modeling of ACD, and the tropospheric modeling of CGD, using the NCAR Community Climate System Model (CCSM) as a common numerical framework. In an international collaboration with the researchers in Barcelona and Madrid, WACCM simulations are also run on the Barcelona Supercomputer Center's machines.

At present, using NLR/GÉANT2 L3 peering, transfer rates from Barcelona to Boulder average about 5Mbps for a single stream. NCAR principal investigator Rolando Garcia is investigating using NLR FrameNet (1-10Gbps) to Chicago, and then using TransLight/StarLight to get to NetherLight, where i2CAT has a 10Gbps link from Amsterdam to Barcelona. He also talked with UIC/EVL about using its Reliable Blast UDP protocol to transfer data at higher rates. Unfortunately, BSC requires scp/sftp encryption, which complicates matters somewhat.

2.C. Research Training

National Research Network (NRN) management and engineers from Internet2, ESnet, NLR and DANTE work closely with IRNC management and engineers at UIC and SURFnet, as well as at MAN LAN, StarLight, and NetherLight, to facilitate connectivity and greater advances in global networking than a single-investigator effort can afford. In addition, numerous researchers, middleware developers, network engineers and international NRNs are involved as users of TransLight/StarLight. This global, dedicated community has elected to work together, on a persistent basis, to further the goals of international e-science collaboration.

2.D. Education/Outreach

TransLight/StarLight's 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/IEEE Supercomputing (SC), IEEE High Performance Distributed Computing (HPDC), and Internet2 and GLIF meetings. We have participated in European conferences, 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 participated in AAAS in February 2008, and we participate in the annual SC conferences, to promote the goals of IRNC and TransLight/StarLight. We also organized the iGrid 2005 in San Diego in September 2005 to showcase international advanced applications and middleware developments.

3. Value to US Science

3.A. Assessing Leverage of the Project

3.A.1. Leveraging to Date of IRNC Award Investment

Since the beginning of the project, IRNC TransLight/StarLight funds have been leveraged approximately 20:1 internationally and an additional 8:1 non-Federal nationally.

Introduction and Assumptions

TransLight/StarLight (TL/SL) receives $1,000,000/year, over 5 years (2005-2010) to procure, engineer, maintain, develop, and document two OC-192 (10Gbps) circuits from the US to Europe. One is managed as a Layer-3 (L3) routed connection between the Internet2 Network at MAN LAN (NYC) and the GÉANT2 Network at their PoP in (Amsterdam); this link costs $240,000/yr. The second is a Layer-2 (L2) switched connection between StarLight (SL) in Chicago and NetherLight (NL) in Amsterdam; this second link costs $300,000/yr. SL and NL are the primary connection points for many national, international, and regional networks at L2. There is also approximately $40,000/yr in the TL/SL IRNC budget for switch/router maintenance costs at SL for equipment purchased with prior NSF HPIIS and related SL awards.

This document attempts to describe leveraging of NSF's total TL/SL investment of $5,000,000, which includes past, current, and future estimates. The expenditures used to show leveraging are contemporaneous with the IRNC award, to our knowledge. Some of the leveraged costs are confidential, so our estimates may be disputable, and in many cases, costs of equipment have dropped over the years, but we will use what the costs were when spent. We will also attempt to separate domestic and international leveraging, and mention, but not include in our totals, leveraging of US Federal Agency network expenses.

A circuit has several costs:

- the link itself as contracted from a carrier, per year
- the cost (or partial cost) of the Layer-1 (L1) terminating equipment at each end, plus yearly maintenance contracts and rack space rental (assumed in calculations below to be 10% of equipment cost)
- the cost (or partial cost) of the Layer-2/3 (L2/3) switching/routing equipment, plus yearly maintenance contracts and rack space rental
- the non-circuit costs (of engineering, documenting, promoting, outreach, travel, supplies, and indirect costs on these)—in TL/SL's case, this is about $420,000/yr or 42% of the $5,000,000 award. Other circuit owners and operators surely have similar costs beyond the circuit cost and equipment maintenance as well, but this is impossible to accurately estimate.

In each case below, we give our best estimate of the L1 equipment cost, and if it is a shared or single-circuit device. Some circuit owners also maintain single-user L2/3 devices for control at both ends, adding significantly to the costs (and TL/SL leveraging). For instance, UKLight has its own L1 equipment at SL, which then delivers 4 Gigabit Ethernet circuits to the SL Force10 L2/3 switch, which then connects to Fermilab and TeraGrid. As a second example, US LHCnet has both its own L1 and L2/3 equipment, but also connects to the SL Force10. At MAN LAN, GÉANT2 and Internet2 maintain L1 and L2/3 equipment for IRNC, GÉANT2, and other circuits.

Since Internet2 charges US connections $480,000/yr per 10GE, then for simplicity, we will use that figure as the leveraging value for connections to the Internet2 Network below, as if Internet2 were charging to connect to a US GigaPoP or single entity at 10GE, since we consider this a fair value for services rendered.

Category 1: Direct Contributions

UIC (the TL/SL awardee) pays the fees for two 10Gbps TL/SL circuits to SURFnet, who then handles the tenders and contracts for the services along with SURFnet's own circuits to MAN LAN and SL; we estimate the value of contract handling services to be ~10% of the circuit costs. SURFnet, MREN (at SL), GÉANT2 and Internet2 supply significant engineering and NOC services, which we estimate to be each valued at 10% of our circuit costs. Internet2 contributes a 10GE connection into the Internet2 Network at MAN LAN, which is valued at $480,000/yr <www.internet2.edu/network/fees.html>. We assume the value of the SL link into NLR and the midwest Regional Optical Networks (RONs) to be equivalent. TL/SL's share of SL engineering services are paid for by IRNC, so are not included in the leveraged costs.

Category 1 total: $810,000 international plus $5,340,000 non-Federal US (together $6,150,000) over 5 years.

TL/SL Category 1: Direct Contributions

Assumptions	
5	Number of years (I2, GÉANT2, SURFnet, NLR, etc)
540,000	IRNC TL/SL link costs/yr
10%	Percent of circuit used to calculate Tender and Contract services/yr
10%	Percent of link costs for engineering and NOC services
480,000	Cost of Internet2 usage fee/10Gb connection/yr

	Annual Contribution	Total Contribution	
International Direct Contributions			
SURFnet Contract Services	54,000	270,000	
SURFnet NL engineering and NOC services	54,000	270,000	
GÉANT2 AMS engineering and NOC services	54,000	270,000	
SUBTOTAL			**810,000**
Non-Federal Direct Contributions			
MAN LAN Internet2 engineering and NOC services	54,000	270,000	
SL engineering and NOC services contributed by MREN	54,000	270,000	
MAN LAN Internet2 10GE IRNC/I2 connection	480,000	2,400,000	
SL NLR/RON IRNC connections (assume equivalent value)	480,000	2,400,000	
SUBTOTAL			**5,340,000**
TOTAL			**6,150,000**

Category 2: Contributions of Equipment, Port Fees and Engineering Services

TL/SL receives contributions (in terms of estimated dollars/yr) of equipment, equipment maintenance, and port fees/engineering services at the terminal points of its circuits, for which IRNC is ***not*** charged. In the following calculations, it is assumed that L1 devices cost $500,000 each, and that one circuit consumes a domestic and an international port at $50,000 each ($100,000 total). L2/3 devices cost about $100,000, and two 10GE ports (typically) at each site per circuit is estimated to be $10,000 each ($20,000 total). We estimate maintenance to be 10% of the cost of the equipment ports ($10,000/yr for the L1 device and $2,000/yr for the L2/3 device)[2]. Some circuit owners have their own L2/3 switches at SL or MAN LAN for control reasons, and some owners plug directly into the SL Force10, into ports that pre-existed IRNC.

- ***International:*** SURFnet owns and operates the L1 HDXc switching gear at NL into which both TL/SL circuits terminate. SURFnet hands off one circuit to a SURFnet L2 switch and the other circuit to a GÉANT2 router. GÉANT2 also maintains a router at MAN LAN. CANARIE provides the HDXc at SL into which the TL/SL Chicago circuit terminates; from there it goes into SL's Force10.
- ***Non-federal US sources:*** Internet2 provides the L1 HDXc and L2/3 switch at MAN LAN into which the TL/SL NYC link terminates. SL provides the L2/3 switch, which was bought with NSF funds prior to 2005.

Category 2 total: $720,000 over 5 years.

TL/SL Category 2: Contributions of Equipment, Port Fees and Engineering Services

Assumptions	
5	Number of years (I2, GÉANT2, SURFnet, NLR, etc)
500,000	L1 Terminating Equipment cost/device (up-front charge)
100,000	L1 Ports ($50,000 each x 2) (one-time charge)
10%	Percent of L1 Ports for estimated maintenance and rack space charges/yr
100,000	L2/L3 Terminating Equipment cost/device (up-front charge)
20,000	L2/L3 Ports ($10,000 each x 2) (one-time charge)
10%	Percent of L2/L3 Ports for estimated maintenance and rack space charges/yr

	Total Port Fee Contributions	Total Maint/ Rack Space Contributions (all yrs)	
International Equipment/Port Fee Contributions			
NL SURFnet L1 HDXc Port (IRNC CHI circuit)	100,000	50,000	
NL SURFnet L1 HDXc Port (IRNC NYC circuit)	100,000	50,000	
NL SURFnet L2 Switch Port	20,000	10,000	
NL GÉANT2 L3 Router Port	20,000	10,000	
MAN LAN GÉANT2 L3 Router Port	20,000	10,000	
SL CANARIE HDXc Port	100,000	50,000	
SUBTOTAL	**360,000**	**180,000**	**540,000**
Non-Federal Direct Contributions			
MAN LAN Internet2 HDXc Port	100,000	50,000	
MAN LAN Internet2 Switch Port	20,000	10,000	
SL switch purchased with NSF funds	0	0	
SUBTOTAL	**120,000**	**60,000**	**180,000**
TOTAL			**720,000**

[2] The majority L1/L2/L3 devices that TL/SL leverages are shared by many people (e.g., the HDXc's at SL, MAN LAN and NL) and/or were purchased prior to IRNC, so rather than use a percentage of the actual costs of the devices, we use the port counts to calculate maintenance. We could use a percentage of the actual device costs if preferred.

Category 3: International Circuits

Below are international circuit expenditures that TL/SL IRNC funds directly leverage. For the five-year IRNC period, we have estimated the total costs of the links, the up-front equipment costs, FTE engineer salaries, and equipment maintenance (10% of the equipment cost/yr). While the internationals do not charge connection fees, we assume that there is a value associated with connecting, which we estimate to be equivalent to the Internet2 Network connection fee ($480,000/yr).

- ***International transatlantic circuits relevant to TL/SL:***
  1. GÉANT2 maintains 2 OC-192 and 1 10GE links to the US, which we consider leverage to the TL/SL MAN LAN circuit and Internet2's circuit to London.
  2. SURFnet maintains 1 OC-192 link to SL and one to MAN LAN, which we consider leverage to the TL/SL MAN LAN and SL circuits, respectively.
  3. CESNET maintains an OC-192 link to SL. (CESNET just started this year, so we only calculate costs over a 3-year period). This circuit is considered leverage to the TL/SL Chicago circuit.
  4. UKLight maintains an OC-192 link to SL, which is used to connect to Fermilab and other DOE sites for high-energy physics as well as to the TeraGrid. We will count 25% for TL/SL leverage and 75% for ESnet leverage.
- ***International transpacific circuits relevant to TL/SL:***
  1. JGN2 maintains a 10GE link to SL from Tokyo via Los Angeles. JGN2 has its own L1/L2/L3 equipment in Tokyo, LA and SL. JGN2 is a four-year project, so we only calculate costs over a 4-year period. Since JGN2 does not peer with Pacific Wave in Los Angeles, we claim 100% leverage.
  2. SINET maintains a 10GE link to MAN LAN from Tokyo. Most of the use of this link is for Internet2 connectivity and connection to European circuits, the IRNC being one. Therefore, we claim 100% leverage.
  3. HARNET maintains a 1Gb connection from Hong Kong to SL (Chicago). We claim 100% leverage. Internet2 connection fees for 1Gb is valued at $250,000, so we will use this value <www.internet2.edu/network/fees.html>.
  4. CERNET maintains a 155Mb connection from China to SL (Chicago). We claim 100% leverage. Internet2 connection fees for 1Gb is valued at $250,000, so we will use this value <www.internet2.edu/network/fees.html>.
  5. TaiwanLight maintains a 2.5Gb link from Taipei to SL, and then has a 1Gb connection via CANARIE to MAN LAN. TaiwanLight has its own L1/L2/L3 equipment in Taipei. Internet2 connection fees for 2.5Gb is valued at $340,000, so we will use this value <www.internet2.edu/network/fees.html>. *TaiwanLight has a second 2.5Gb link from Taipei to Los Angeles, which TransLight/Pacific Wave should use as leverage.* Therefore, TL/SL will use 100% of the TaiwanLight circuit to SL as leverage.
  6. *Note: ASGCNet, the Taiwan Academica Sinica network in support of the LHC (Taiwan is a Tier1 site) has a 2.5Gb link from Taipei to Chicago to Amsterdam (and then Geneva). At SL, ASGCNet connects with the FermiLab Lightpath and DOE metro ring, which is operated by ANL, FermiLab, ESnet and LHCnet. Given that this link is devoted to DOE/LHC, TL/SL claims 0% leverage.*

Category 3 total (TL/SL part): $99,069,000 over 5 years.

TL/SL Category 3: International Circuits

Assumptions

5	Number of years (I2, GÉANT2 , SURFnet, IEEAF, UKLight, SINET, TaiwanLight, CERNET, HARNET)
3	Number of years (CESNET)
4	Number of years (JGN2)
10%	Equipment maintenance/yr is a percentage of up-front equipment cost
$200,000	FTE costs/yr
$480,000	Cost of Internet2 usage fee/10Gb connection/yr
$340,000	Cost of Internet2 usage fee/2.5Gb connection/yr
$250,000	Cost of Internet2 usage fee/1Gb connection/yr
100%	Percent value claimed equivalent to the Internet2 Network connection fee
$240,000	MAN LAN GÉANT2 OC-192 Estimated circuit cost/yr
$240,000	MAN LAN GÉANT2 OC-192 Estimated circuit cost/yr
$240,000	DC GÉANT2 10GE Estimated circuit cost/yr
$240,000	MAN LAN SURFnet OC-192 Estimated circuit cost/yr
$300,000	StarLight SURFnet OC-192 Estimated circuit cost/yr
$500,000	SL CESNET OC-192 Estimated circuit cost/yr
$340,000	SL UKLight OC-192 Estimated circuit cost/yr

	Total Circuit Cost	Est. Cost Equip Up-front	Total Equip Maint (1)	Total FTE (all yrs)	Connec-tion fee (2)	Subtotal	IRNC % share	Total IRNC Leverage	
International Transatlantic Circuits that land first at SL or MAN LAN or Washington DC									
MAN LAN GÉANT2 OC-192	1,200,000	360,000	180,000	1,000,000	2,400,000	**5,140,000**	100%	5,140,000	
MAN LAN GÉANT2 OC-192	1,200,000	360,000	180,000	1,000,000	2,400,000	**5,140,000**	100%	5,140,000	
DC GÉANT2 10GE	1,200,000	360,000	180,000	1,000,000	2,400,000	**5,140,000**	100%	5,140,000	
MAN LAN SURFnet OC-192	1,200,000	160,000	80,000	1,000,000	2,400,000	**4,840,000**	100%	4,840,000	
SL SURFnet OC-192	1,500,000	160,000	80,000	1,000,000	2,400,000	**5,140,000**	100%	5,140,000	
SL CESNET	1,500,000	820,000	246,000	600,000	1,440,000	**4,606,000**	100%	4,606,000	
SL UKLight (3)	1,700,000	1,200,000	600,000	1,000,000	2,400,000	**6,900,000**	25%	1,725,000	
SUBTOTAL									**31,731,000**
International Transpacific Circuits that land first at SL or MAN LAN									
SL JGN2	14,500,000	800,000	320,000	800,000	1,920,000	**18,340,000**	100%	18,340,000	
MAN LAN SINET	20,000,000	1,000,000	500,000	1,000,000	2,400,000	**24,900,000**	100%	24,900,000	
SL HARNET	3,000,000	800,000	400,000	48,000	1,000,000	**5,248,000**	100%	5,248,000	
SL CERNET	3,000,000	800,000	400,000	200,000	1,000,000	**5,400,000**	100%	5,400,000	
SL TaiwanLight	10,000,000	500,000	250,000	1,000,000	1,700,000	**13,450,000**	100%	13,450,000	
SUBTOTAL									**67,338,000**
TOTAL									**99,069,000**

(1) Equipment maintenance is a percentage of up-front equipment cost (10%/year) * IRNC award (5 years)

(2) While internationals do not charge IRNC any connection fees, nor does Internet2 or NLR charge internationals connection fees, assume there exists an equivalent value based on Internet2 fees to connect to US GigaPoPs at 10GE

(3) UKLight link – assume 75% DOE ESnet leverage and 25% IRNC TL/SL leverage

Category 4: US Non-Federal Networks

Below are US non-Federal circuit expenditures that TL/SL IRNC funds directly leverage. For the five-year IRNC period, we have estimated the total costs of the links, the up-front equipment costs, FTE engineer salaries, and equipment maintenance (10% of the equipment cost/yr).

- ***Non-Federal national circuits relevant to TL/SL:***
  1. 10% of the Internet2 Network (estimated operation cost, $20,000,000/yr), credit TL/SL with **$10,000,000** leveraging over 5 years.
  2. 10% of NLR ($60,000,000 up-front plus $500,000/yr maintenance) (including multiple waves provided by Pacific Wave, Cisco (3x10GE for CiscoWave), EVL/Calit2 (1 10GE for CAVEwave), and NLR (1 10GE for TL/SL↔TL/PW transit), credit TL/SL with **$6,250,000** leveraging over 5 years.
  3. Plus 5% of regional networks (e.g., Atlantic Wave, MREN, LONI, CENIC, PNWGP, I-WIRE, other state networks connected to StarLight and MAN LAN) costing $120,000,000 (est.) plus $12,000,000 maintenance/yr) which use the IRNC connections to Europe on a regular basis, **$9,000,000 over 5 years.**
- ***Non-Federal transatlantic circuits relevant to TL/SL:***
  1. Internet2 Network has a NYC/London transatlantic circuit that we will value at the same cost as the SURFnet NYC/AMS circuit (see Category 3, $4,840,000).
  2. IEEAF has a NYC/AMS transatlantic circuit that we will value at the same cost as the SURFnet NYC/AMS circuit (see Category 3, $4,840,000).

Category 4 total: $34,180,000 over 5 years.

TL/SL Category 4: US Non-Federal Networks

Assumptions	
5	Number of years
18,000,000	Internet2 estimated operations cost/yr
10%	Percentage of Internet2 operations cost considered IRNC TL/SL match
13,000,000	NLR estimated up-front investment (one-time cost)
10%	Percentage of NLR costs considered IRNC TL/SL leverage
120,000,000	Regional Optical Networks (RONs) estimated up-front investment (one-time cost)
12,000,000	RON estimated operations/yr
5%	Percentage of RON costs considered IRNC TL/SL leverage

	TL/SL Leverage from US Non-Fed Netwks	
Non-Federal National Circuits		
Internet2 (Operations/yr * % leverage * all years)	9,000,000	
NLR (Operations/yr * % leverage * all years)	6,500,000	
RONs at MAN LAN and SL (Up-front investment * % leverage)	6,000,000	
RONs at MAN LAN and SL (Operations/yr * % leverage * all years)	3,000,000	
Non-Federal Transatlantic Circuits		
Internet2 Network NYC/London	4,840,000	
IEEAF NYC/AMS	4,840,000	
SUBTOTAL		**34,180,000**
TOTAL		**34,180,000**

Category 5: US Federal Networks

US Federal networks that TL/SL IRNC directly leverages, because of European IRNC traffic, including testbeds:

- ***Federal national circuits relevant to TL/SL:***
  1. TeraGrid (NSF)
  2. NASA
  3. NOAA
  4. DOE ESnet (IP and SDN)
  5. DOE UltraScience Network
  6. DOE Fermi Lightpath
  7. NASA NISN
  8. NIH
  9. DOI USGS
- ***Federal international circuits relevant to TL/SL:***
  1. US LHC maintains 4 OC-192 links from StarLight and MAN LAN to Europe (Chicago/Geneva, New York/Geneva, New York/Amsterdam and, starting February 2998, New York/London). We estimate the value of each of the three circuits originating in New York at the same cost as the SURFnet NYC/AMS circuit (see Category 3, $4,840,000), though we realize that the links to Geneva are probably more money. We estimate the value of the Chicago/Geneva to equal the SURFnet CHI/AMS circuit (see Category 3, $5,140,000), for a total cost of $19,660,000. These circuits are used primarily for high-energy physics as a connection to Fermilab and other DOE sites and ESnet universities. We will count it as leveraging ESnet, not IRNC funds.

Category 5 total: $0 (Federal leveraging doesn't count for IRNC)

Category 6: Non-US Networks

Category 6: Non-US networks that TL/SL IRNC indirectly leverages, because NSF's funding of IRNC and connection to Internet2 and NLR inspires other nations' funding of their networks:

1. CANARIE (~20 10Gb links to SL, Seattle, MAN LAN, and 10Gb to Europe)
2. GÉANT2 and its national partners (3 direct 10Gbs link to MAN LAN)
3. SURFnet (2 direct 10Gb links to SL and MAN LAN, and several 10Gb links from NL to CERN)
4. CESNET (direct 10Gb link to SL)
5. NORDUnet (direct 10Gb link to NL)
6. i2CAT (Barcelona) (direct 10Gb link to NL)

Category 6 total: $0 (this huge international contribution to R&E networking isn't counted below here for IRNC TL/SL leveraging)

Conclusions

Total Categories 1-4: $93,085,000 over 5 years ($62,315,000 international, $30,770,000 national)

Since the beginning of the project, IRNC TransLight/StarLight funds have been leveraged approximately 20:1 internationally and an additional 8:1 non-Federal nationally.

3.A.2. Future Leveraging Opportunities

In the future, as transatlantic connections get more economical and as scientific demands increase, there is likely to be an upswing in additional connectivity between North America and Europe from Internet2, DANTE/GÉANT2 and other European, Asian and South American countries. NSF's costs, as shown above, are well leveraged, and continued IRNC investment assures that US researchers can benefit from ongoing and increasingly global scientific efforts. There is a growing list of NSF instruments and research foci that depend on reliable, available, high-bandwidth connectivity between the US and Europe.

3.A.2.1. Communities Benefiting from the Network Services

A number of US science initiatives depend critically upon equipment, facilities and/or expertise located in Europe. All of these US-led initiatives now depend or will depend on high-speed connectivity between the US and Europe, and, in most cases, sites in Canada, Asia and South America as well.

Major NSF-supported large-scale facilities mentioned in this report are the Atacama Large Millimeter Array (ALMA), the International Space Station (ISS), the Large Hadron Collider (LHC) and the TeraGrid. Other NSF OCI initiatives mentioned include Sloan Digital Sky Survey (SDSS) terabyte data-transfer efforts, DRAGON, EnLIGHTened, OptIPuter and PRAGMA. Previous reports have described other major NSF investments, such as ANDRILL (ANtarctic geological DRILLing). These applications are documented in detail in NSF IRNC reports and on the TransLight/StarLight website.

3.A.2.2. Assessing Use

Current usage can be obtained from MRTG and Cricket graphs available via the TransLight/StarLight website. These links are clearly utilized, though they are not saturated.

The cost of transatlantic (and domestic) OC-192s is within reach of single-domain large-scale projects, so we expect high-bandwidth users to "graduate" from the IRNC-provided links and get their own. Layer1 transatlantic links from SURFnet, UKLight, CESNET, GÉANT2, US LHC (DOE/CERN), Internet2, and others compete with IRNC links, and this has and will negatively impact usage statistics. However, IRNC also leverages greatly from the links and equipment provided by these other organizations, and through the Global Lambda Integrated Facility (GLIF), network engineers are collaborating to support and assist one another to create a worldwide LambdaGrid fabric.

However, how does one assess usage? This is a high-level issue. TransLight/StarLight principal investigators are working hard to attract, manage and retain high-bandwidth users. When do we claim success: (1) when an application runs? (2) when a link is saturated? or, (3) when the successful users procure their own links? We continue to actively recruit high-bandwidth users and provide VLANs.

3.B. Contributions to Science

NSF funds basic research and related activities to sustain the Nation's leadership in science and engineering; funds the acquisition, construction, commissioning, and upgrading of major research equipment and facility resources to enable transformational research; and, funds cyberinfrastructure – the information technologies and collaboratories (networking, computing, visualization, data, middleware) – to provide ubiquitous access and enhanced usability.

The adoption of cyberinfrastructure is forever changing the nature of science. Science has no geographical boundaries, so science is increasingly global. And, science relies on high-performance computing and communications, so science is increasingly *e-science.* With NSF IRNC-funded persistent links in place, researchers are becoming more dependent on networked collaborations to support data-intensive science. IRNC provides a science and engineering research and education production network environment to support global e-science.

This section describes some of the activities that contribute to scientific knowledge as a result of the availability of TransLight/StarLight links. Significant contributions are being made in the areas of astronomy, biodiversity and ecological research, computer science, geoscience, medicine and bioinformatics, physics, and space exploration, involving collaborations between the US and Europe and, in many cases, with other continents as well.

Astronomy

ALMA, the Atacama Large Millimeter Array, is an international astronomy facility that receives major support from North America (US National Science Foundation and the National Research Council of Canada), Europe (European Southern Observatory and the European Regional Support Center) and Japan, in cooperation with the Republic of Chile. Taiwan also contributes to ALMA as a partner of Japan. Currently under construction on an Andean plateau in Chile, ALMA will be the forefront instrument for studying the cool universe – the relic radiation of the Big Bang, and the molecular gas and dust that constitute the building blocks of stars, planetary systems, galaxies, and life itself. Several IRNC initiatives, including WHREN-LILA and TransLight/StarLight, will enable data transfers from South America to the US and to European partners.

The YBJ International Cosmic Ray Observatory, located in the Yangbajing (YBJ) valley of the Tibetan highland, is a Chinese-Italian partnership, with international connectivity supported by the Chinese Academy of Sciences, a

founding GLORIAD partner. The ARGO-YBJ (Astrophysical Radiation with Ground-based Observatory) experiment studies cosmic rays, mainly cosmic gamma-radiation. TransLight/StarLight and GLORIAD are partnered to enable data transfers from China to the US and to European partners.

The International Virtual Observatory Alliance (IVOA) mission is to "facilitate the international coordination and collaboration necessary for the development and deployment of the tools, systems and organizational structures necessary to enable the international utilization of astronomical archives as an integrated and interoperating virtual observatory." The IVOA comprises 16 virtual observatory projects from Armenia, Australia, Canada, China, Europe (European Virtual Observatory), France, Germany, Hungary, India, Italy, Japan, Korea, Russia, Spain, the UK and the US (National Virtual Observatory). The Gemini Observatory – the Gemini South telescope is located in the Chilean Andes and the Gemini North Telescope is located on Hawaii's Mauna Kea – and the National Optical Astronomy Observatory (NOAO) produce data products for US optical astronomy science, which are also being incorporated into the IVOA. All the IRNC initiatives will surely facilitate collaboration among IVOA partners.

The eVLBI (Electronic Very Long Baseline Interferometry) community, since 2005, has been developing the necessary infrastructure for real-time correlation of radio-astronomy telescope data. At iGrid 2005, radio astronomers in the USA (MIT Haystack), Japan (Kashima) and Europe (Onsala in Sweden, Jodrell in the UK, Westerbork in The Netherlands) achieved real-time correlations with 512Mbps transfers. On August 28, 2007, collaborators did the first successful real-time correlation of eVLBI data from Chinese and Australian telescopes, Chinese and European telescopes, and Australian and European telescopes. Additional tests with telescopes in Puerto Rico and Chile are planned for the near future. The eVLBI community's goal is to do 16 simultaneous 1Gbps network connections between the central processor at JIVE in The Netherlands and partner telescopes across Europe, Asia, Australia, South Africa, South America and the US by 2009. Again, all IRNC initiatives will surely facilitate collaboration among eVLBI partners.

Biodiversity and Ecology

CAMERA, the Community Cyberinfrastructure for Advanced Marine Microbial Ecology Research and Analysis, is a Gordon and Betty Moore Foundation-funded project under the leadership of the UCSD division of the California Institute for Telecommunications and Information Technology (Calit2). The field of *environmental metagenomics* is a component of biocomplexity, which is an NSF priority. The term *biocomplexity* refers to the interrelationships that arise when living things at all levels – from their molecular structures to genes to organisms to ecosystems to urban centers – interact with their environment. CAMERA is accelerating the field of environmental metagenomics by creating a globally accessible community resource of microbial metagenomic data. CAMERA has 1300 registered users from 48 countries, with major users in the UK, Germany, Canada, France, as well as South America and Asia. Again, all IRNC initiatives will surely facilitate collaboration among CAMERA partners.

GLEON (Global Lake Ecological Observatory Network) is a grass roots association of limnologists, information technology experts and engineers from the US, Asia, Europe, and Canada who are building a scalable, persistent network of lake ecology observatories. Data from these observatories will help researchers better understand key processes, such as the effects of climate and land use change on lake function, the role that episodic events such as typhoons play in resetting lake dynamics, and carbon cycling within lakes. Many IRNC initiatives will surely facilitate collaboration among GLEON partners.

Computer Science

CineGrid: Digital streaming…CineGrid is an organization whose mission is to enable the production, use and exchange of very-high-quality digital media over photonic networks. In the past year, CineGrid members conducted the first successful transatlantic demonstration of streaming 4K digital motion pictures and 5.1 surround sound; the first prototype workflow for remote color grading of digital rushes from a 4K digital camera shoot in Prague to a specialized rendering processor in San Diego and a 4K color correction system in Prague operated by a colorist in Toronto; and, the first 4K uncompressed transmission over both the Atlantic and Pacific oceans. These technologies are apropos to scientific visualization collaboration and streaming, and CineGrid has the support and participation of many computer scientists, computational scientists, network engineers, and the entire Global Lambda Integrated Facility (GLIF) community. TransLight/StarLight facilitates collaboration among CineGrid partners.

Data Reservoir is a Japanese research project to create a global grid infrastructure for distributed data sharing and high-speed computing for the 2-PFLOPS system being developed as part of the GRAPE-DR project, to be operational in 2008. At the Internet2 Spring 2007 meeting, April 2007, the Data Reservoir project won two

consecutive Land Speed Records (LSRs) in the IPv6 single and multi-stream categories for trials to see how fast and far data could be transferred. The network path went over 30,000 kilometers in distance, from Tokyo to Amsterdam and back. Since the project wanted dedicated links for these trials, the SURFnet link from Chicago to Amsterdam was used instead of the TransLight/StarLight link. While this is an example of IRNC leveraging its capabilities with those of its European partners, actual data transfers once the GRAPE-DR is online may indeed use IRNC links.

DICE (DANTE-Internet2-CANARIE-ESnet) partners hold regular technical meetings to discuss issues of common interest. University of Amsterdam is working with DICE to integrate its Token Based AAA mechanism inside OSCARS (ESnet domain controller development) and DRAGON (NSF-funded GMPLS based control plane/ routing/resource brokering functions). This work will also be embedded into the EU-funded Phosphorus project. This project primarily performs trials on the Internet2 Dynamic Circuit between New York and London; however, it is an example of IRNC TransLight/StarLight leveraging its capabilities with partner institutions.

EnLIGHTened, an NSF-funded project being developed by MCNC, focuses on the development of dynamic, adaptive, coordinated and optimized use of networks connecting geographically distributed high-end computing resources and scientific instrumentation. EnLIGHTened collaborates with the AIST G-Lambda project in Japan and the Phosphorus project in Europe. MCNC has a Cisco Research Wave (EnLIGHTened) deployed on National LambdaRail from Raleigh to StarLight in Chicago, where it uses IRNC TransLight/StarLight to connect to collaborators in Europe, and JGN2 to connect to collaborators in Japan.

High-Performance Digital Media Network (HPDMnet), under the leadership of Northwestern University, has collaborators in the US, Canada, Japan, Barcelona, Czech Republic, and The Netherlands who are developing new communication services based on optical transport (i.e., optical multicast) of high-resolution digital media streams. HPDMnet relies on the SURFnet, CESNET and IRNC TransLight/StarLight links at StarLight to reach European partners, and the JGN2 link to reach Japanese partners.

Indiana University (IU) Data Capacitor, a system designed to store and manipulate massive datasets, was developed by IU and collaborators in Germany, and was awarded first place in an SC07 Bandwidth Challenge competition. This project could take advantage of either the IRNC TransLight/StarLight or Internet2 transatlantic networks.

The Inter-Domain Controller protocol is being developed by Internet2 partners and collaborators to interoperate the Internet2 Dynamic Circuit Network with ESnet, GÉANT2 in Europe, as well as regional and other international networks and testbeds (e.g., GRNET in Greece, HEAnet in Ireland, PIONIER in Poland, and the Phosphorus testbed at the University of Amsterdam via SURFnet's NetherLight). This project primarily performs trials on the Internet2 Dynamic Circuit between New York and London; however, it is an example of IRNC TransLight/StarLight leveraging its capabilities with partner institutions.

OptIPuter, an NSF-funded ITR to UCSD, has as one of its major outcomes the Scalable Adaptive Graphics Environment (SAGE), specialized middleware developed by OptIPuter partner UIC that simultaneously enables human-to-human communication and data-sharing communication on variable-sized tiled displays connected via optical networks. SAGE serves as a window manager, allowing users to move, resize, and overlap windows as easily as on standard desktop computers. SAGE Visualcasting supports global collaboration by enabling two or more users to share application content, sending multi-gigabit streams as required. International trials with partners of the OptIPuter project and participants in the Global Lambda Visualization Facility (GLVF) are taking place, particularly among sites in US, The Netherlands, Czech Republic and now Russia. TransLight/StarLight-GLORIAD facilitates collaboration among OptIPuter and GLVF partners.

OptIPuter's LambdaRAM, developed by OptIPuter partner UIC, is middleware that prefetches data to eliminate I/O bottlenecks from data storage devices. OptIPuter partner NASA Goddard is now working with UIC to incorporate LambdaRAM into its simulation system process. LambdaRAM is being used to mitigate I/O bottlenecks inherent in current applications and to enable data coupling among multiple supercomputers and data storage devices, with the goal of creating more timely weather predictions and employing more powerful forecasting models. Initial results using LambdaRAM with an I/O intensive application demonstrated a 20-fold performance improvement over traditional storage systems. LambdaRAM was originally developed to prefetch data from remote (and international) data storage devices, requiring the IRNC TransLight/StarLight link. While NASA's application is national in scope, the technology has implications for international "federated grid" architectures in the future.

Phoebus is an Internet2/University of Delaware project to enable applications to seamlessly set up dynamic lightpaths regardless of the user's edge network access method. This has been tested on regional, national and

international networks. This project primarily performs trials on the Internet2 Dynamic Circuit between New York and London; however, it is an example of IRNC TransLight/StarLight leveraging its capabilities with partner institutions.

Phosphorus is an EU-funded alliance with European and North American partners (MCNC and Louisiana State University) who are developing advanced application-level middleware and underlying management and control plane technologies. This project relies on SURFnet, CESNET and IRNC TransLight/StarLight links at StarLight to enable US/European collaboration.

The PRAGMA (Pacific Rim Applications and Grid Middleware Assembly) Grid Testbed is composed of cluster systems and technical expertise from PRAGMA member institutions. It provides the infrastructure and a collaborative environment for grid middleware and grid applications to interoperate and improve. In addition to members from the US, the Asia-Pacific and South America, University of Zurich in Switzerland is also a member. All IRNC initiatives surely facilitate collaboration among PRAGMA partners.

TeraGrid is working with the UK National Grid Service and the EU DEISA (Distributed European Infrastructure for Supercomputing Applications) to create a federated grid of computing resources. TeraGrid is also working with PRAGMA sites, the European Commission-funded Enabling Grids for E-Science (EGEE) project, and NorduGrid in the Nordic countries, as well as sites in Canada and South America, on the Grid Interoperation Now (GIN) testbed, a grass-root, multi-application international testbed to enable real science applications to run on a routine basis. All IRNC initiatives surely facilitate collaboration between TeraGrid and its partners.

The Teraflow Testbed is an international collaboration, under the leadership of the UIC National Center for Data Mining, with funding from National Science Foundation, the US Army, and the Department of Energy. This Testbed is used to explore, integrate, analyze, and detect changes in massive and distributed data over optical networks, with sites in the US, Asia, and Europe (Russia, Germany, The Netherlands and CERN). It consists of computer clusters distributed over three continents that can transmit, process, and mine very-high-volume data flows, or teraflows. Notably, teraflow data services are used to process and distribute Sloan Digital Sky Survey (SDSS) data. TransLight/StarLight facilitates connectivity between the US and European partners.

Geoscience

ANDRILL (ANtarctic geological DRILLing) is a multinational collaboration comprised of more than 200 scientists, students, and educators from five nations (Germany, Italy, New Zealand, the UK and the US) to recover stratigraphic records from the Antarctic margin. The chief objective is to drill back in time to recover a history of paleo-environmental changes that will guide our understanding of how fast, how large, and how frequent were glacial and interglacial changes in the Antarctica region. Several IRNC initiatives surely facilitate collaboration among ANDRILL partners.

National Oceanic & Atmospheric Administration (NOAA) has several collaborations with European and Russian sites: CarbonTracker, a scientific tool that, together with long-term monitoring of atmospheric CO_2, will help improve our understanding of how carbon uptake and release from land ecosystems and oceans are responding to a changing climate and other environmental changes, including human management of land and oceans; CLASS (Comprehensive Large-Array Stewardship System), NOAA's premier on-line facility to distribute NOAA and US Department of Defense (DoD) Polar-orbiting Operational Environmental Satellite (POES) data, NOAA Geostationary Operational Environmental Satellite (GOES) data, and derived data; ESSE (Environmental Scenario Search Engine), an easy-to-use "natural language" search engine for mining environmental data archives; NCEP/NCAR (National Centers for Environmental Prediction/National Center for Atmospheric Research) Reanalysis Project, a new atmospheric analyses that uses both historical and current atmospheric data; and, SPIDR (Space Physics Interactive Data Resource), a de facto data source for solar terrestrial physics. TransLight/StarLight and GLORIAD facilitate connections between US and European collaborators.

Medical and BioInformatics

Amyotrophic Lateral Sclerosis (ALS) genome-wide analysis research is being facilitated between the University Medical Center Utrecht and the David Geffen School of Medicine and Neuroscience and Genetics Research Center at UCLA. SURFnet, The Netherlands Research & Education network, working with National LambdaRail and Cisco, is establishing a lightpath between Utrecht and Los Angeles. This lightpath is the result of the "Enlighten Your Research" lightpath competition organized by SURFnet and NWO. Dutch scientists received a lightpath to their research lab and the sum of 20,000 Euros for integrating the use of a lightpath in their research. This project

relies on the SURFnet link between Amsterdam and Chicago; however, it is an example of IRNC TransLight/StarLight leveraging its capabilities with partner institutions.

The AtlanTICC Alliance (Atlantic Technology Innovation and Commercialization Center) is a joint venture between Imperial College London, Georgia Institute of Technology and Oak Ridge National Laboratory. One project on which they collaborate is remote operation of state-of-the-art equipment. Currently, Imperial scientists can manipulate an aberration corrected electron microscope (ACEM) at Oak Ridge in real time, while the Oak Ridge and Georgia teams can use the nuclear magnetic resonance (NMR) facility at Imperial. This project relies on the UKLight link between London and Chicago; however, it is an example of IRNC TransLight/StarLight leveraging its capabilities with partner institutions.

The **Microscopy Distributed Laboratory Demonstrator** is being developed by the UCSD National Center for Microscopy Imaging Research (NCMIR) in cooperation with Oxford University's Materials Research Center at Begbroke and Oxford e-Research Centre in the UK. NCMIR, an OptIPuter partner, has extended SAGE software to run on Microsoft-enabled visualization systems in order to remotely collaborate and control two of the world's most advanced electron microscopes at NCMIR and Oxford University. At SC07, they demonstrated shared views of the complexities of the nervous system and of complex nanomaterials. This project relies on the UKLight link between London and Chicago; however, it is an example of IRNC TransLight/StarLight leveraging its capabilities with partner institutions.

Surgery via Video 2007 was demonstrated at the 24th APAN Meeting, August 27-31, 2007, in Xi'an, China, by collaborators at hospitals in Korea, Australia, China, Japan, Singapore, Philippines, India and France who are developing live, multi-way digital video connections, enabling medical specialists around the world to learn and teach each other advanced surgical procedures. Several IRNC initiatives surely assisted collaboration among these medical institutions.

Physics

The DØ Experiment is a worldwide collaboration headquartered at Fermilab's Tevatron Collider. It is focused on precise studies of interactions of protons and antiprotons at the highest available energies in a search for subatomic clues that reveal the character of the building blocks of the universe. Collaborators are located in Argentina, Brazil, Canada, China, Colombia, Czech Republic, Ecuador, France, Germany, India, Ireland, Korea, Mexico, Netherlands, Russia, Sweden, Switzerland, UK, US and Vietnam. Several IRNC initiatives surely assist collaboration among these DØ collaborators.

The Large Hadron Collider (LHC), an international collaboration headquartered at CERN, is highly anticipated among teams of physicists, computer scientists and networking engineers who have been collaborating for several years now on the development of the Worldwide LHC Computing Grid (WLCG). The WLCG consists of over 200 sites, including LHC Tier1 and Tier2 sites, where LHC data from the detectors will be processed and delivered to physicists at their home research institutions. DOE funds several LHCnet transatlantic links, though TransLight/StarLight has had discussions with Harvey Newman (Caltech), Don Petravick (Fermi) and Bill Johnston (ESnet) about using a portion of the TransLight/StarLight links for LHC data grid production.

UltraLight, an NSF-funded project headquartered at Caltech, is focused on providing network advances required to enable petabyte-scale analysis of globally distributed LHC data. UltraLight has numerous collaborators, including CERN and other sites in the US, Korea, Brazil, UK, Pakistan and Romania, to name a few. This year UltraLight was the recipient of the 2007 Internet2 Driving Exemplary Applications (IDEA) Awards program, and also set new records at SC07 for sustained storage-to-storage data transfer over wide-area networks from a single rack of servers on the exhibition floor. While UltraLight uses DOE-funded LHCnet transatlantic links, a portion of TransLight/StarLight will be made available for LHC data grid production.

Space Exploration

The International Space Station (ISS) is a joint effort of the US (NASA), the Russian Federal Space Agency, the Japan Aerospace Exploration Agency, the Canadian Space Agency and the European Space Agency. Researchers on Earth are using several experiments aboard the international space station to study various issues, so data from these experiments must be accessible to scientific investigators worldwide. All IRNC initiatives surely facilitate collaboration among the ISS research community.

4. Publications and Products

4.A. Journals/Papers

None.

4.B. Books/Publications

Maxine Brown and Thomas A. DeFanti, "United States' Transatlantic R&E Connections to Europe: The History of TransLight/StarLight and Euro-Link," The History of European Research Networking, Howard Davies (editor), TERENA, 2007 (to appear)

4.C. Internet Dissemination

www.startap.net/translight

4.D. Other Specific Products

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

5. Contributions

5.A. Contributions within Discipline

TransLight/StarLight, by its very nature, is interdisciplinary. There is clearly a fine team of computer scientists, computational scientists and networking engineers involved with TransLight/StarLight, facilitating greater advances in global networking than single-investigator efforts can afford. TransLight/StarLight developed its management team in the Chicago area (UIC/EVL), and leverages the efforts of its IRNC partners (particularly TransLight/Pacific Wave and GLORIAD), national networking groups (Internet2, ESnet and NLR) and foreign NRN (DANTE and SURFnet) technical and administrative contacts.

5.B. Contributions to Other Disciplines

Within the Computational Science and the Computer Science communities, TransLight/StarLight efforts help lead 21st century discipline science and computer science innovation. TransLight/StarLight's OC-192 L3 circuit among the Internet2 network, NLR, ESnet and GÉANT2 provides greater transatlantic connectivity, and the OC-192 L2 circuit between StarLight and NetherLight provides long-distance, high-bandwidth capability for demanding data-instensive applications.

5.C. Contributions to Human Resource Development

We promote TransLight/StarLight through web documentation, journal articles, demonstrations and presentations at major networking conferences (e.g., Supercomputing, HPDC, Internet2) and workshops (GLIF), PowerPoint presentations and other instructional material. We teach the infrastructure, the grid advancements, the technological innovations and the application advancements that global connectivity enables. In fact, thanks to previous NSF funding of STAR TAP, StarLight and Euro-Link, we have a mailing list of ~1,000 <stars@startap.net> individuals, from academia, government and industry, interested in information about international advanced networking developments.

5.D. Contributions to Resources for Research and Education

TransLight/StarLight is a necessary and integral part of application advances and technological innovations for the US Computational Science and Computer Science research and education communities, as well as of major interest to network engineers. In particular, the TransLight/StarLight L2 circuit between StarLight and NetherLight is part of the GLIF LambdaGrid fabric and represents a major resource for science and technology.

5.E. Contributions Beyond Science and Engineering

Because of TransLight/StarLight's interest in advanced applications and lightpath provisioning, we often get inquiries from network equipment manufacturers and telecommunication 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. Our users expect us to grow in capacity and sophistication, and we look forward to the engineering challenges ahead.

6. Special Requirements

6.A. Objectives and Scope

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

6.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.

6.C. 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.

7. Program Plan

7.A. Plans and Milestones

In cooperation with US and European national research and education networks, Translight/Starlight will continue to implement a strategy to best serve established production science, including usage by those scientists, engineers and educators who have persistent large-flow, real-time, and other advanced application requirements.

7.B. Proposed Activities

7.B.1. Capacity Planning and Circuit Upgrades

Working with SURFnet, we co-procured and implemented two 10Gbps transatlantic CHI/AMS networks, one paid for by IRNC, one by SURFnet, between StarLight and NetherLight. We continue to load balance to handle the specific demands of GLORIAD (3Gbps), the Teraflow Testbed, NOAA, OptIPuter/Global Lambda Visualization Facility, CineGrid, and TransLight (Pacific Wave to StarLight), SURFnet, NORDUnet and i2CAT (Barcelona) via NetherLight, GÉANT2 L2 (future), and increasing LHC/CERN traffic, and leave headroom for new short-term and long-term projects as approved by the IRNC Cognizant Program Officer. In addition, we are setting up permanent servers at Calit2, University of Amsterdam and Keio University (Tokyo) for the CineGrid Exchange, a digital archive of high-resolution imagery for computer science research, connected by IRNC and partner circuits.

Working with SURFnet, we also co-procured two 10Gbps transatlantic NYC/AMS networks, one paid for by IRNC, one by SURFnet, between MAN LAN and NetherLight. The IRNC circuit is shared by Internet2, NLR and ESnet traffic to GÉANT2, with full understanding that usage needs to be monitored so that when and if the need to isolate these connections emerges, we can do this in the best way possible. Thus, working with Internet2, NLR, ESnet, SURFnet, and DANTE/GÉANT2, we have been and will continue to implement new circuit engineering at MAN LAN and the GÉANT2 PoP in Amsterdam.

7.B.2. Network Operations and Engineering

We will continue to work with our IRNC and TransLight/StarLight partners to investigate and provide our users with advanced networking technologies and services. We will also actively work with IRNC members and the IRNC Measurement Committee <irnc-measurement@psc.edu> on measurement and performance tools.

Security…In the coming years, TransLight/StarLight will, pending budget, manpower and equipment, adopt security best practices under NSF's guidance. In addition, Alan Verlo attended the Cybersecurity Summit 2007 for NSF Large Research Facilities, February 22-23, 2007, in Arlington, VA, and distributed the URL for online proceedings and other relevant information (listed below) to StarLight principals. We trust there will be follow-up activities in 2008 through NSF or other agencies.

- <www.educause.edu/Proceedings/12196> (Cybersecurity Summit proceedings)
- <www.educause.edu/ir/library/pdf/CYB07001d.pdf> (NSF security requirements for Cooperative Agreements for Large Facilities and FFRDCs)
- <www.educause.edu/security> (Educause/Internet2 Computer and Network Security Task Force website)

Identifying Lightpaths and Measuring Lightpath Services…Much remains to be learned about how to identify, measure and report traffic on hybrid networks that deliver lightpath services as well as routed IP services. On February 6, 2007, SURFnet distributed a draft document describing the problem space of measurement in a hybrid network as a starting point for discussions among GLIF TECH Working Group participants, in which Alan Verlo is an active member <www.glif.is/working-groups/tech/lightpath-measurement-0.9.pdf>. On December 6, 2007, GLIF TECH started discussing global identifiers for lightpaths. We will continue to be active participants in these efforts.

7.B.3. Community Support and Satisfaction

We will continue to work with Internet2, NLR, ESnet, SURFnet/NetherLight, DANTE/GÉANT2, the JET, GLIF members, and relevant regional entities to identify and encourage lambda usage among US/European computer scientists and discipline scientists who have ongoing large-flow, real-time, and other advanced application requirements at Layer 1/2 and Layer 3. We will work with our partners to connect these scientists with GigE circuits end-to-end, provided that NSF agrees that such effort is within scope and that usage can be adequately measured; thereby meeting NSF's expectations. We will continue to document our activities on the TransLight/StarLight website. Also, we will continue our active involvement in national and international network meetings, including IRNC, JET, ONT, Internet2, NLR, GLIF and CineGrid meetings, as appropriate.