TransLight / StarLight

NSF Cooperative Agreement OCI-0441094
www.startap.net/translight

ANNUAL REPORT February 1, 2006 – January 31, 2007
Submitted May 14, 2007

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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, primarily focuses on managing the link procurement process, network engineering, budgets and accounts payable, interfaces with personnel from Internet2 and DANTE/GÉANT2, coordination of project management and oversight activities with the NSF, and day-to-day project management. He participates in monthly IRNC phone calls and attends meetings as requested.

(2) Maxine Brown, co-PI, primarily focuses on managing documentation and education and outreach activities, and is responsible for TransLight/StarLight quarterly and annual reports, web pages and events planning. The co-PI 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 contributed greatly to the project, and received a salary, wage, stipend or other support from this grant:

Participant's Name(s)	Project Role(s)	>160 Hours/Yr
Alan Verlo (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 several 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 Director of Network Research, Architecture, and Technologies 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 GÉANT2 at the DANTE 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 the SURFnet chief network engineer and, while not compensated by UIC, is one of the stewards of the TransLight/StarLight link connecting StarLight in Chicago to NetherLight at the Amsterdam Internet Exchange.

(12) Kees Neggers is 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 ANL.

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 with 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 between 26 National Research & Education Networks representing 30 countries across Europe, the European Commission, and DANTE. Its principal purpose has been to develop the GÉANT2 network -- a multi-gigabit pan-European data communications network for research and education; see <www.geant2.net>. TransLight/StarLight funding makes a 10Gbps link available to connect the Internet2 network, NLR, DOE/ESnet and DANTE/GÉANT2.

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 thoUSnds 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 makes a 10Gbps link available to connect the Internet2 network, NLR, DOE/ESnet and DANTE/GÉANT2.

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 link 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 it Russia has a 10Gbps link to Moscow.

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/> (to replace Abilene <http://abilene.internet2.edu>), a hybrid optical and packet network, is being designed in collaboration with Level 3 Communications to provide next-generation production services as well as a platform for the development of new networking ideas and protocols. TransLight/StarLight funding makes a 10Gbps link available to connect the Internet2 network, NLR, DOE/ESnet and DANTE/GÉANT2.

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 and international links for schedulable production services not available with "best effort" networks.

TransLight/Pacific Wave
TransLight/Pacific Wave <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/Pacific Wave 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 usage by those scientists, engineers and educators who have persistent large-flow, real-time, and other advanced application requirements.

2.A.2. Accomplishments and Milestones

In Year 2, 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).

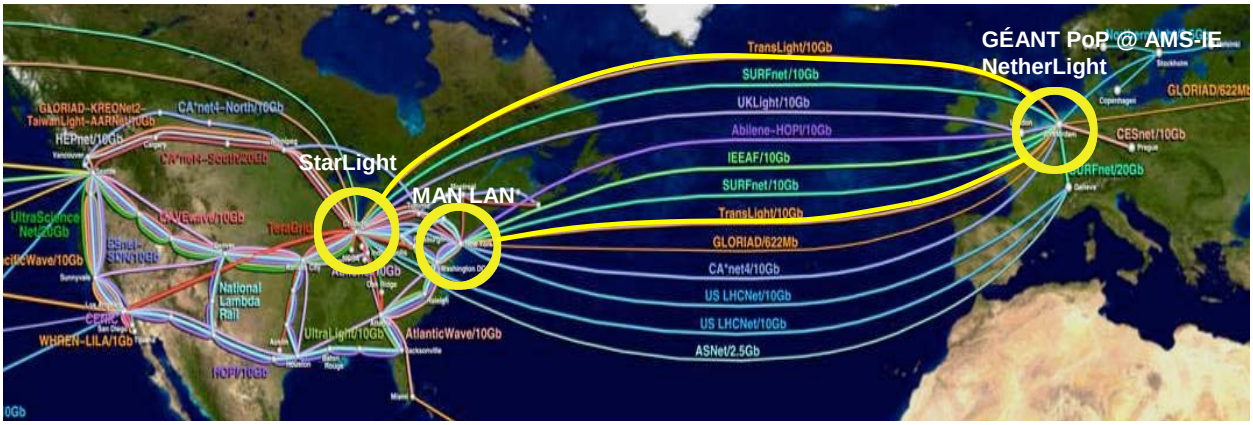
In Year 2, we also worked with our IRNC and TransLight/StarLight partners on various activities, to:

- **Identify and develop production applications on both IRNC circuits**
  - 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 SC'06 in Tampa, FL, November 13-17, 2006.
  - Planning and provisioning 1Gbps VLANs between Chicago and Amsterdam for DRAGON/eVLBI (Jerry Sobieski); GLORIAD (Greg Cole); LHC (Harvey Newman) and LHC/CMS (Don Petrovick); OptIPuter/Global Lambda Visualization Facility (Larry Smarr/Jason Leigh)
- **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 donated by Cisco Systems and deployed by NLR between TransLight/StarLight in Chicago and TransLight/Pacific Wave in Seattle.
- **Share network engineering tools and best practices**
  - Participated in the Internet2 Network Performance Workshop at the Joint Techs meeting to better understand Internet2's performance utilities: Network Diagnostic Tool (NDT), One Way Active Measurement Protocol (OWAMP), and Bandwidth Test Controller (BWCTL)
  - Participate in JET and GLIF GOLE meetings
- **Documentation and conference presentations**
  - Designed a new TransLight/StarLight website <www.startap.net/translight>
  - Presented papers at PFLDnet 2006, IEEE Infocom 2006 High-Speed Networking Workshop, and the TeraGrid '06 conference
  - Awarded a PhD to a UIC/EVL student who used the TransLight/StarLight link to develop a lightpath management, control and reservation system (PIN)
  - Guest editors of iGrid 2005 special issue of the Elsevier journal *Future Generation Computer Systems (FGCS): The International Journal of Grid Computing: Theory, Methods and Applications,* 10/2006

2.A.3. Infrastructure Topology

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

- **NYC/AMS:** OC-192 routed connection (provided by VSNL) 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
- **CHI/AMS:** OC-192 switched connection (provided by Global Crossing) between StarLight in Chicago and NetherLight in Amsterdam (also at the AMS-IE) that is part of the GLIF LambdaGrid fabric



The **NYC/AMS** TransLight/StarLight link is a L3 connection between GÉANT2 and Internet2, NLR and ESnet for production usage. The **CHI/AMS** link is a L2 connection between StarLight and NetherLight that is configured as a 10GigE circuit (carved into VLANs) for data-intensive applications requiring lightpaths. Note: SURFnet funds two complementary links from Amsterdam to New York (MAN LAN) and Chicago (StarLight), which leverages and complements the IRNC links.

The GLIF Technical Engineering Working Group is defining 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).

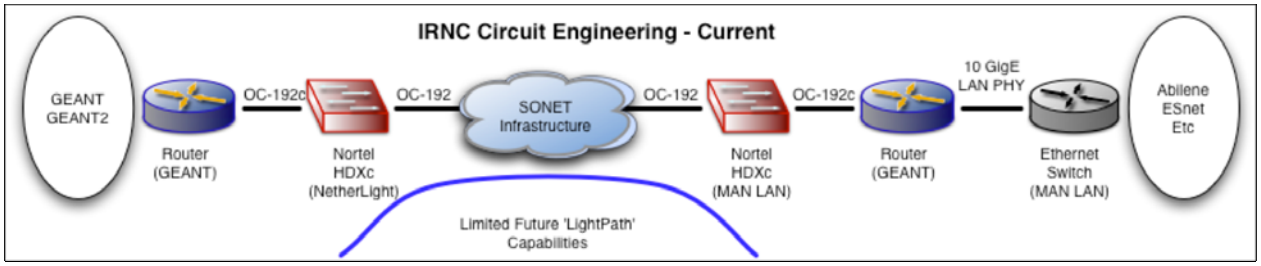
IRNC pays for links only. At MAN LAN, Internet2 pays for an HDXc and GÉANT2 pays for router. At the AMS-IE, SURFnet pays for an HDXc and GÉANT2 pays for router. At StarLight, CANARIE pays for an HDXc and StarLight has the Force10. At NetherLight, SURFnet pays for an HDXc and University of Amsterdam pays for a Force10 (previously a Nortel ERX 8600) switch.

FCC IBC taxes…VSNL, a carrier of one of our IRNC links, had to inform the FCC of international bandwidth being brought into the US on December 31, 2006, and pay an IBC tariff, equivalent to $175,000, for the NYC/AMS TransLight/StarLight link. We therefore terminated usage on December 30 and reinstated usage on January 1. There is a big debate on whether the FCC rules actually refer to voice circuits, commercial network services, or R&E networks. And, to confuse matters more, the carrier assumes it is liable but would want to pass the expense to its customer, which, in this case, is UIC, a non-profit institution and therefore exempt from paying federal telecommunications excise tax, State of Illinois excise tax, and the simplified municipal telecommunications tax.

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

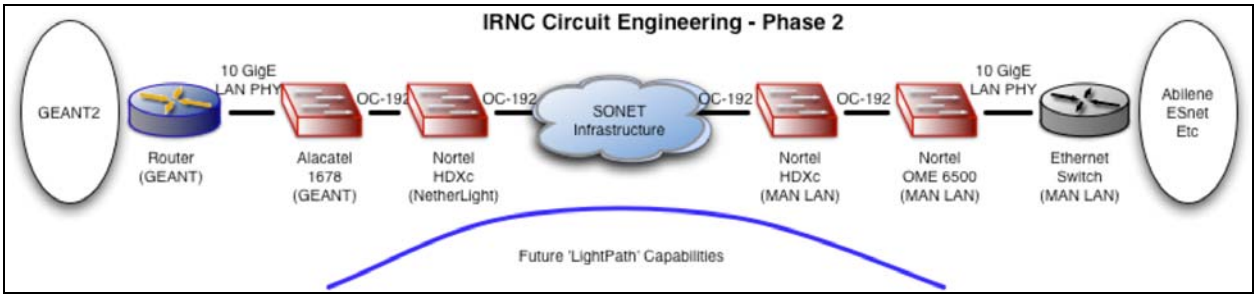
PoP Connectivity and Peering – NYC/AMS

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). In New York, the router connects to Internet2's HDXc; in Amsterdam, the router connects to SURFnet's HDXc at NetherLight.



Internet2 and DANTE want to replace DANTE's router at MAN LAN with an Alcatel MCC1678 switch to enable more flexible connections to the Internet2 network, NLR and ESnet, but experienced interoperability problems between the Alcatel and the Nortel OME6500. The Nortel OME6500 sits, along with a Nortel HDXc, in the MAN LAN facility. Interoperability testing by Internet2 and DANTE on the Nortel HDXc (at MAN LAN) and Alcatel (GÉANT2 POP in Amsterdam) equipment is underway in March and April, 2007. This testing needs to take place in order to move the IRNC circuit to the configuration illustrated in Phase 2 below.

Note: On March 15, Alcatel-Lucent and DANTE announced the successful roll out of a new converged optical-data network linking NRENs across Europe. For details, see <www.hpcwire.com/hpc/1321139.html>.



Connectivity to India…On September 11, 2006, Internet2 announced that DANTE enables Internet2 and TransLight/StarLight network users to reach India's Education and Research Network (ERNET) via a new 45Mbps link to India <www.ernet.in>. This link, connecting ERNET with GÉANT2, is operated by DANTE and funded by the European Commission. <http://members.internet2.edu/newsletter.cfm?date=2006-09-01#681>

Connectivity to Vietnam…DANTE/GÉANT2 is connected to Vietnam's VinaREN www.vinaren/vn/vietnam via the TEIN2 project <http://www.tein2.net/>. Vietnam is not part of APAN at this time.

Peering with NLR…NLR received several inquiries from US institutions that wanted to use their NLR connections to connect with European collaborators via GÉANT2 (summarized below). On October 11, 2006, Tom West, NLR CEO, sent a request to Dai Davies, DANTE General Manager, to initiate peering. This was completed February 1, 2007, when GÉANT completed peering with NLR PacketNet at MANLAN for IPv4 and IPv6. *Note: The following list is not a rigorous attempt to survey a broad spectrum of researchers, but is a list of those individuals who initially expressed interest in accessing European collaborators from their institutions via NLR PacketNet.*

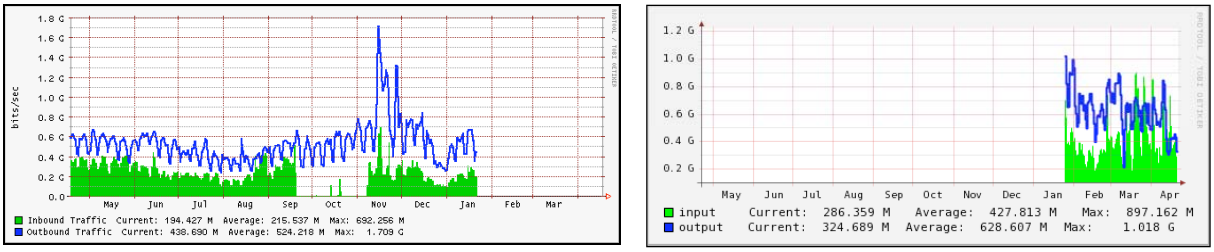
Caltech, Harvey Newman	Newman has already expressed intentions, and mentioned this explicitly in his DOE proposal on US LHCNet to use the IRNC links across the Atlantic. In return for this use, which can be limited at any reasonable level, DOE would provide a commensurate amount of backup on its US LHCNet links in case of need. Newman will soon establish a PoP in Amsterdam, in addition to existing PoPs at MAN LAN, StarLight and CERN, to make implementation easier. He is applying to the GÉANT Board, with help from Kees Neggers, for a link between Amsterdam and Geneva. The transition from DOE's present two transatlantic links NY-GVA and CHI-GVA, and NY-CHI, to three (NY-GVA; CHI-GVA; NY-AMS) plus AMS-GVA and two NY-CHI links will be done in late 2006.
Louisiana State University, Andrei Hutanu and Ed Seidel	LSU's collaborations would be greatly enhanced by high-speed network connections: • Working with Masaryk University/CESNET in Brno on high-definition video research for e-learning, videoconferencing and remote visualization • Associated through the US Enlightened project with the recently funded EU Phosphorus project, researching grid-network middleware for interoperable and coordinated allocation of cross-domain network links and compute resources • Close connections and agreements with many research groups and institutes across Europe, most

	notably the Albert Einstein Institute in Potsdam (Germany), Zuse Institute Berlin (Germany), PSNC in Poznan (Poland), Vrije Universitaet in Amsterdam (Netherlands), Cardiff University in Wales (UK), University of Innsbruck (Austria), SZTAKI, Budapest (Hungary), Sofia University (Bulgaria), Politehnica University in Timisoara (Romania)
NCAR, Rolando Garcia	NCAR is collaborating with Spanish colleagues on climate simulations using the Whole Atmosphere Community Climate Model (WACCM); in particular, they are working with Ricardo Garcia Herrera at the Universidad Complutense de Madrid (Spain). WACCM is being run at the Barcelona Supercomputer Center <http://bsc.es/>. Storage space at BSC is very limited, so ~30GB of data must be transferred daily during model runs for storage in NCAR's MSS.
Oklahoma Center for High Energy Physics, Horst Severini	Severini identified 18 researchers, postdocs and staff, from Oklahoma University, Oklahoma State University and other research organizations who need fast, high-bandwidth access to CERN. These individuals are involved in a range of research projects – ATLAS, D0 and OSG (Open Science Grid).

Usage

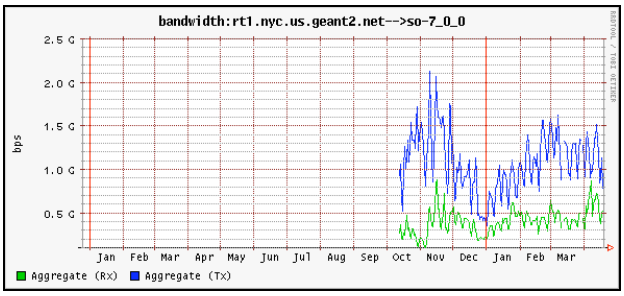
Internet2 makes MRTG traffic statistics of Internet2/GÉANT2 peering at MAN LAN available. **This is a recent link, effective January 20, 2007, when Internet2 moved its NYC router from its Qwest space to the NYSERnet space.** Statistics are at: <http://dc-snmp.grnoc.iu.edu/i2net/show-graph.cgi?title=rtr.newy32aoa.net.internet2.edu--ge-4/0/0.102&rrdname=rtr.newy32aoa.net.internet2.edu--ge-4_0_0.102.rrd>

Old stats can be found at <http://stryper.uits.iu.edu/abilene/summary.cgi?network=nycm-geant-newyork&data=bits>



Internet2's MRTG monthly bandwidth utilization chart prior to January 20, 2007 is on the left; utilization after January 20 is on the right.

GÉANT2 migrated its measurement tool to a different machine in October 2006. The GÉANT2 website is password protected, though Maxine Brown was granted access; the site is located at: <http://stats.geant.net/cgi-bin/cricket-1.0.2/grapher.cgi?target=%2Fbandwidth%2Frt1.nyc.us.geant2.net%2Fso-7_0_0;list-single-target=so-7_0_0;ranges=d%3Aw;view=Aggregate>



GÉANT2's Cricket bandwidth utilization, as of October 2006.

Routing Policies

The NYC/AMS link is a routed, L3 connection providing connectivity between GÉANT2 in Europe and the Internet2 network, DoE's 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. Internet2 peers with networks listed at <http://abilene.internet2.edu/peernetworks/>. Internet2, by default, transits traffic between all non-US peers. GÉANT2 interconnects participant networks, listed at <http://www.geant.net/server/show/nav.121>, and connects

with other research and education networks outside the European region, such as EUMEDCONNECT, TEIN2, CLARA, TENET, and others. GÉANT2 provides Internet2 not only with access to all of its participant networks, but also with transit to these other GÉANT2 peer networks. Internet2 and GÉANT2 continue to work together to address routing issues brought about by the increasing interconnectivity between all regional/continental-scale networks and the transit being provided across them.

Security

Internet2 and GÉANT2 Security Information

Internet2 and GÉANT2 work in close coordination on issues related to network operations security. The NYC/AMS link is just one of many monitored by the NOCs of the two networks. The Internet2 NOC and GÉANT2 NOC have methods for contacting one another in response to observed incidents. The Internet2 NOC and REN-ISAC monitor the Internet2 network in the US, including connector and peering connections. As part of semi-annual operational and technical direction coordination meetings, Internet2 and GÉANT2 (along with ESnet and CANARIE) are planning an operational security exercise designed to further highlight areas where communications methods, security incident tools and procedures could be improved.

GÉANT2 security information is at <http://www.geant.net/server/show/nav.599>.
Internet2 security information is at <http://abilene.internet2.edu/security/>.

The carrier, VSNL International, and the telco hotel, MAN LAN, maintain robust security procedures.

Engineering

IRNC will benefit greatly from recent 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>.

Network Description Language…SARA and the University of Amsterdam are developing a network description language based on RDF <www.science.uva.nl/research/sne/ndl> that they demonstrated at SC|06. The goal of NDL is to provide a shared common vocabulary that describes networks to facilitate the multi-domain provisioning of lightpaths. It is being used by GLIF Open Lightpath Exchanges (GOLEs), where each GOLE is represented as a virtual device with interfaces connecting to other GOLEs. From this, optimal routing and pictures of the topology can be generated. The MAN LAN GOLE NDL description can be found at: <http://dc-1.grnoc.iu.edu/ndl/manlan.rdf>.

NOC Operations

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

NOC operations for the MAN LAN facility (through which the Internet2 network and GÉANT2 peer in New York) are also handled by the Global NOC at Indiana University: <http://globalnoc.iu.edu/>

NOC operations for GÉANT2 are handled by the GÉANT NOC. Information about GÉANT2 operations can be found at <http://www.geant2.net/server/show/nav.759>

RENOG: Global NOC-NOC Communications

Following up on discussions at the CCIRN (Coordinating Committee on Intercontinental Research Networking) meeting <www.ccirn.org>, held April 26-27, 2006, Jim Williams is helping formulate RENOG to address some of the global issues that networks face today and will increasingly face in the future <www.renog.org>. While there is ongoing discussion on the usefulness of such a committee and its relationship to NANOG, it is a proactive step that TransLight/StarLight endorses. StarLight, TransLight/StarLight and Internet2 network engineers are subscribed to the RENOG mailing list.

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

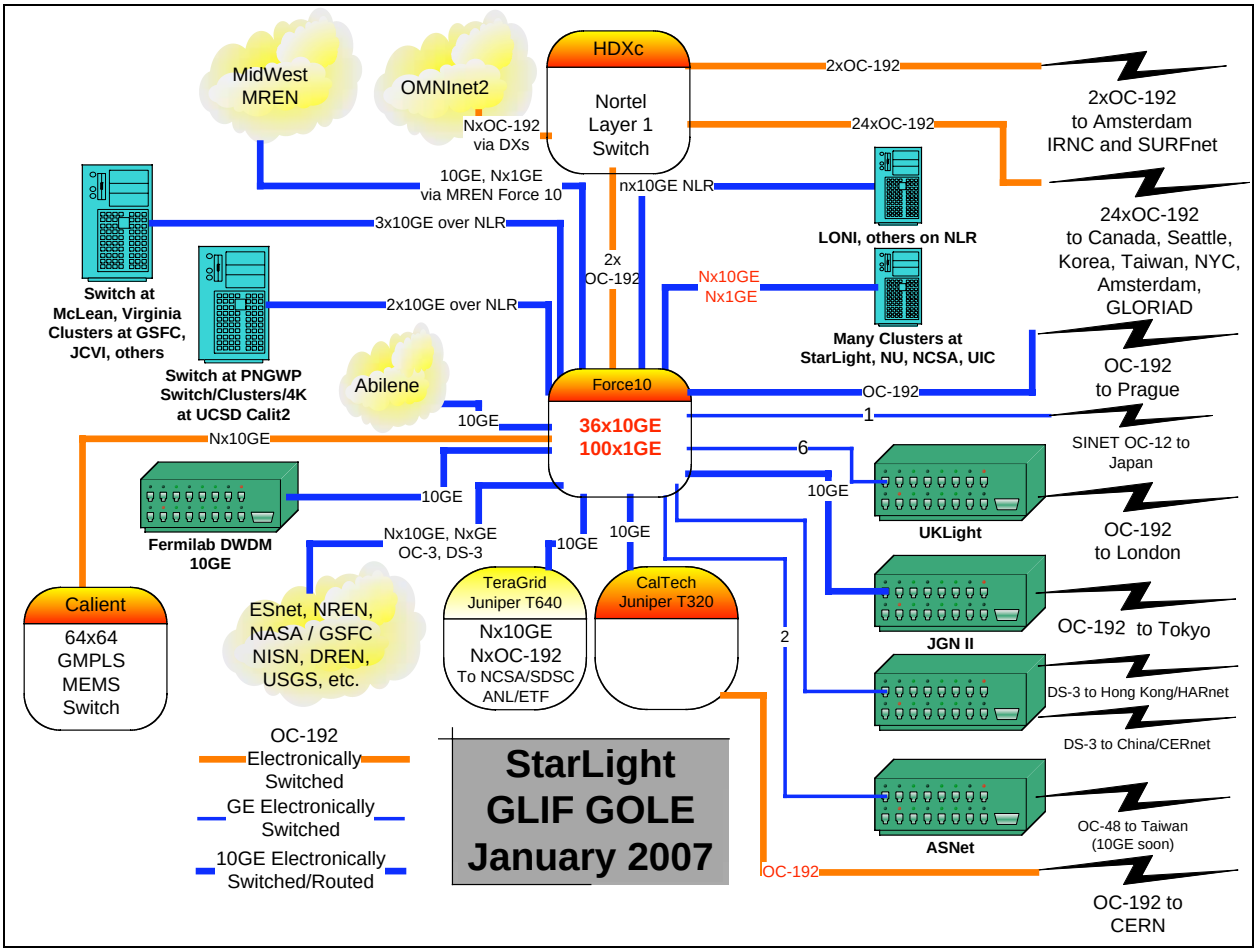
PoP Connectivity and Peering – CHI/AMS

CHI/AMS…The TransLight/StarLight OC-192 is connected to a CANARIE-owned HDXc box at StarLight and a

SURFnet-owned HDXc box at NetherLight. At StarLight, the IRNC link then plugs into a Force10 switch; in Amsterdam, the IRNC link then plugs into a Force10 (previously a Nortel ERX 8600) switch owned by University of Amsterdam (UvA). At StarLight, via the Force10, this link peers with a number of advanced international networks, as well as the Internet2 network, NLR, ESnet, and regional optical networks.

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.

In July 2006, Alan Verlo reconfigured StarLight's Calient switch for use by the DRAGON and Enlightened projects.



TransLight…As of June 30, 2006, TransLight/StarLight and TransLight/Pacific Wave were directly connected through a 10GigE lightpath connection donated by Cisco Systems and deployed by NLR. This new 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. In a demonstration of this new capability at an APAN meeting in July 2006, engineers at SURFnet in Amsterdam and T-LEX (operated by WIDE) in Tokyo established a direct path between their two routed networks using the new Pacific Wave-to-StarLight network fabric. A VLAN was created for the peering. (Note: The configuration included the IEEAF link from Tokyo to Seattle, the TransLight link from Seattle to Chicago, and the SURFnet link from Chicago to Amsterdam.)

CANARIE/HKLight…In July 2006, CANARIE, as a GLORIAD member, connected to the OC-48 HKLight circuit in Seattle, to provide end-to-end connectivity to both StarLight and NetherLight (and possibly Lyon, France).

Connectivity to Japan via Europe…On December 12, 2006, Japan's KDDI and Rostelecom publicly announced the installation of RJCN (Russia-Japan Cable Network), an IEEAF/WIDE/Pacific Wave network, <www.rt.ru/en/press/article.wbp?news-article-id=C8F0BBC4-2B57-4E5A-84FB-418025E5F7AC>. RJCN will be two 900km routes to provide 640Gbps, with a northern and southern route automatic backup mechanism (self

healing). WIDE will work to use this network from T-LEX to Moscow. This means that US researchers could, conceivably, go from the US to Japan via Russia (TransLight/StarLight/GLORIAD from Chicago to Amsterdam, Russia's RBnet from Amsterdam to Moscow) and then to Japan via RJCN.

Updated point-to-point connection to CESNET (Czech Republic)…CESNET brought a 10Gbps link from Prague to StarLight in December 2006 to peer with the GLIF fabric. CESNET also has a 10Gbps connection to NetherLight.

PERN (Pakistan) expressing interest in joining GLIF fabric…In January 2007, Professor Ashfaq Khokhar of UIC Computer Science talked to Maxine Brown about interest on the part of NSF and the Pakistan Government's Higher Education Commission to fund an extension of PERN (Pakistan Education & Research Network) from Islamabad to Amsterdam, with possible extensions to India and the Middle East. Maxine put Ashfaq in touch with Kevin Thompson on February 3, 2007. Ashfaq has a 3-year project with Arif Masud (UIUC Civil Engineering), funded by the National Academy of Sciences and Government of Pakistan, which involves development of a large-scale computing platform and computational mechanics center in Pakistan. They have established a 64-processor Beowulf Cluster at GIKI in Pakistan. There are also efforts to establish interactive e-learning projects (involving multiple HDTV quality video streams). Also, there are efforts by colleagues at Urbana, Rice, and Berkeley to establish a real-time sensor-network-based seismic monitoring facility.

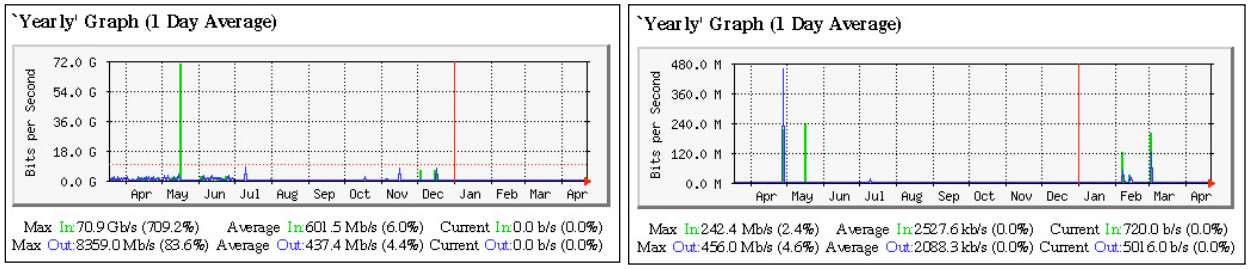
Usage

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

L1 links cannot be monitored for usage; however, the IRNC CHI/AMS link goes from the StarLight HDXc into a Force10, and from the NetherLight HDXc into a Force10 (previously a Nortel ERX 8600) Layer-2 switch owned by the University of Amsterdam (UvA).

StarLight makes MRTG traffic statistics of TransLight/StarLight available. **This is a recent link, effective January 11, 2007.** Statistics are at: <http://noc.startap.net/mrtg/206.220.240.222_tengigabitethernet_3_0.html>.

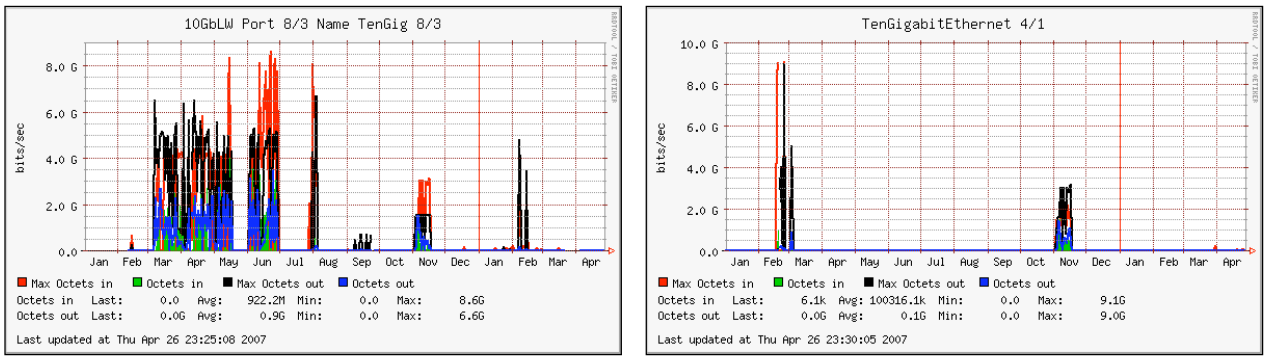
Old StarLight TransLight/StarLight statistics (prior to January 11, 2007) can be found at: <http://noc.startap.net/mrtg/206.220.240.222_tengigabitethernet_1_1.html>



StarLight's MRTG monthly bandwidth utilization chart prior to January 11, 2007 is on the left; utilization after January 11 is on the right. Utilization in November/December 2006 is ~7Gbps (approx due to MRTG showing 72Gbps Y-axis so small peak size). February/March 2007 usage is ~120-200Mbps.

UvA makes Cricket traffic statistics of TransLight/StarLight available. **This is a recent link, effective March 23, 2007.** Statistics are at: <http://trafficlight.uva.netherlight.nl/cricket/grapher.cgi?target=%2Ff10%2Ften_giga_eth_4_1;view=Octets;ranges=d%3Aw%3Am%3Ay>.

The original UvA Nortel switch port yearly graph **(prior to March 23, 2007),** can be found at: <http://trafficlight.uva.netherlight.nl/cricket/grapher.cgi?target=%2Fnortel%2Finterface%2Ften_giga_eth_8_3;view=Octets;ranges=d%3Aw%3Am%3Ay>.



UvA's Cricket monthly bandwidth utilization chart prior to March 23, 2007 is on the left (Nortel switch); utilization after March 23 is on the right (Force10 switch). Utilization in November/December 2006 is around 7Gbps (approx due to small peak size). February/March 2007 usage is ~120-200Mbps. Note that the Nortel data reports usage in November (3Gbps) and February (5 Gbps). The network engineers believe that the December traffic may be missing from the graph due to problems with the Nortel switch.

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

Current StarLight Security Information

General Security

StarLight is monitored 7x24x365. On-site staff can provide escorted access to the facility. Camera surveillance and electronic keys are used to log access to the facility. Records of each are digitally stored off-site and monitored.

Physical security: Who determines access to the StarLight facility?

Permission for physical access to the StarLight switch room is granted by the facility manager (Tim Ward) and his resident engineer (Jake Sallee), who are employees of Northwestern University. Except for occasional guided tours, access is restricted to engineers with cause to be in the facility. Access is always requested and granted in advance, except for the StarLight engineering team members who have 24x7 key access. However, once a customer's engineer is inside the switch room, they essentially have physical access to many of the racks since most of the rack cabinets are not locked. Even so, webcams monitor physical activity inside the switch room; these are viewable by 710 facility staff. The StarLight facility is hosted within the space of a larger facility that is managed by Northwestern. A document exists that describes the procedures for the entire Northwestern facility, particularly with respect to disaster recovery.

What sort of tracking is there of changes to equipment, physical wires and fibers?

StarLight engineers maintain a database of fibers and cables they install for StarLight and TransLight/StarLight connections and customers. Customers are responsible for cabling inside their racks. StarLight does offer a "remote hands" support service to assist customers with changing out failed boards, etc.; however, all customers, including StarLight, are responsible for tracking physical changes to their own equipment.

What sort of protection is there for fire, earthquakes, floods, lightning strikes, power outages, etc.?

The StarLight switch room is protected from fire by a Halon fire suppression system. There are multiple protections against power outages, including two commercial power feeds from two completely separate grids, each entering the building from separate conduit. Also, there is battery backup and a diesel generator that has an external fuel feed leading to the outside so that a fuel truck can maintain a constant fuel supply.

Electronic security: Who determines access to the switches (Force10, HDXc, Calient) and what sort of

password protection exists?

Access to switches and other equipment is primarily determined by StarLight network engineers Linda Winkler (Argonne National Laboratory) and Alan Verlo (UIC). Passwords are encrypted.

What sort of tracking is there of changes to switch settings, port assignments, etc.?

Software on an Argonne National Laboratory (ANL) NOC server periodically and automatically polls the switches and routers for configuration changes. These changes are archived for future reference and recovery in case of disaster. This is standard procedure for many NOCs.

VLAN assignment: Who determines VLAN assignments and what procedures are followed? What sort of tracking is there of changes to VLANs?

ANL NOC engineers and StarLight engineers Winkler and Verlo make VLAN assignments. VLAN assignments are agreed upon between StarLight and the connecting/peering partner. The same software that tracks configuration changes also tracks VLAN changes.

Peering: Who determines this, and what procedure is followed? What sort of tracking is there of changes to peering permissions?

Peerings are agreed upon by the two organizations that want to peer. Peering configurations are determined by both organizations' network engineers. In StarLight's case, the ANL NOC engineers currently configure most of the peerings. The software mentioned above is used to track changes to these configurations.

Peering information exchange between the switches and routers can also be protected with an encrypted password, such that the switches and routers authenticate themselves to their peer devices. These passwords are implemented on StarLight equipment at the request of peering partners.

Downtime procedures?

In the case of StarLight downtime, StarLight international partners have a process that implements redundancy links based on partners' bandwidth requirements. The StarLight facility interconnects partners to create such redundancy as needed when a new network is first connected. One example of such redundancy consists of alternative links among CERN, StarLight, NetherLight.

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)

10Gb WAN Security…At the ESCC/Internet2 Joint Techs Workshop in February 2007, Force10 announced its P-Series family of security appliances, which inspect, monitor and protect the network at line-rate 10 Gigabit speeds. StarLight principals discussed having the engineering group survey similar such appliances on the market and provide a recommendation, pending funding.

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 maintain robust procedures to secure their cables and connections.

Also, 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 IRNC CHI/AMS TransLight/StarLight link.

Pathdiag, perfSONAR…Verlo is in the process of installing the network diagnostic tool Pathdiag <http://www.psc.edu/networking/projects/pathdiag/>, which is part of the NFS-funded Network Path and Application Diagnosis (NPAD) project at PSC and NCAR. He has not yet installed Internet2's new perfSONAR tool <http://www.perfsonar.net/>.

TL1 Toolkit…TL1 Toolkit <https://noc.sara.nl/nrg/TL1-Toolkit/, released by SARA in The Netherlands, July 2006, 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). In Chicago, both the TransLight/StarLight 10Gb circuit and the SURFnet 10Gb circuit terminate on the HDXc. Alan Verlo will investigate other potential applications for the TL1 Toolkit.

Network Description Language…The StarLight GOLE NDL description can be found at: <http://www.startap.net/starlight/ENGINEERING/StarLight_GLIF_GOLE_NDL.rdf>.

Dynamic switching lightpath service on 1Gb circuits…We are investigating setting up 1Gb circuits between StarLight and NetherLight over the IRNC link. We might first use Nortel's DRAC, to be a product 1Q 2007, but will investigate other options, such as UCLP and EVL's PIN/PDC.

LightPath Services…We are talking with several projects about providing dedicated 1Gbps connections on the TransLight/StarLight CHI/AMS link in support of production science.

- **DRAGON…**The DRAGON project (Jerry Sobieski) would like an Etherent lightpath between Amsterdam and Chicago for dynamic path computation and inter-domain provisioning. DRAGON is developing multi-domain authorization capabilities with UvA researchers, and establishing a more persistent intercontinental lightpath capabilitiy for eVLBI activities. TransLight/StarLight engineer Alan Verlo is provisioning a 1GigE VLAN for DRAGON on our IRNC link; SURFnet is provisioned another GigE on their AMS/CHI route so the project has redundant paths.
- **Large Hadron Collider/CERN…**Tom DeFanti has been talking with Harvey Newman (Caltech), Don Petravick (Fermi) and Bill Johnston (ESnet) about using a portion of TransLight/StarLight links for Large Hadron Collider (LHC) data grid production. From Amsterdam, SURFnet has 20Gbps of bandwidth to CERN available for use, and Newman is in the process of putting a rack of equipment at the Amsterdam Internet Exchange, near the SURFnet and GÉANT2 PoPs. This request is still pending.
- **GLORIAD…** Per June 2006 discussions with Kevin Thompson, TransLight/StarLight has provided GLORIAD with 3x 1Gbps VLANs on its CHI/AMS link until further notice. Implementation was delayed due to installation of new GLORIAD equipment at StarLight and delays in Moscow, but was operational and in use as of April 10, 2007.
- **Teraflow Testbed…**Bob Grossman, head of the Teraflow Testbed project, has a VLAN on the TransLight/StarLight link from Chicago to Amsterdam, which then extends to Moscow for Teraflow research. This link was operational on March 28, 2007.
- **OptIPuter/GLVF… OptIPuter/Global Lambda Visualization Facility (GLVF)…** Jason Leigh, who organized the GLVF[1] at iGrid 2005, has talked with TransLight/StarLight about provisioning a VLAN for persistent collaboration with European partners. GLVF partners, some of whom are OptIPuter partners, are using OptIPuter-developed SAGE technologies and creating low-cost, high-definition video-teleconferencing with multicast for use in scientific collaborations. This request is still pending.

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

[1] GLVF <www.evl.uic.edu/cavern/glvf> was launched in September 2005, and began as a group of international researchers and students participating in the iGrid 2005 Workshop who were designing and developing complementary, distributed visualization and collaboration technologies. These researchers decided to pool expertise, build on each other's successes, and integrate their work into a coherent whole, providing a unique model for international partnerships. 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.

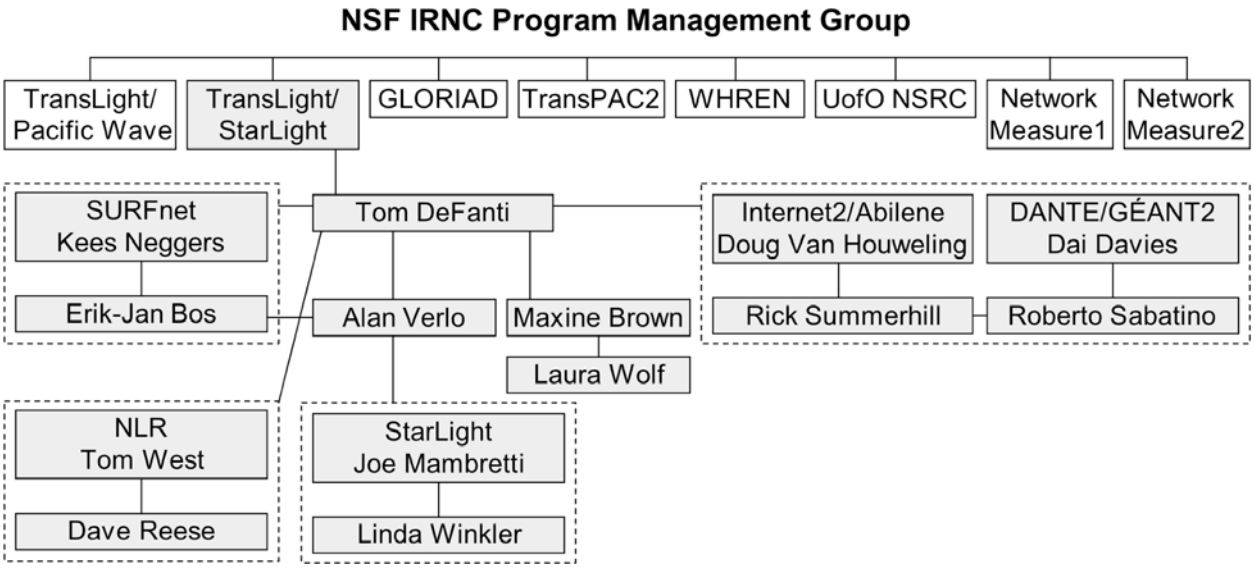
draft document describing the problem space of measurement in a hybrid network as a starting point for discussions among GLIF TECH Working Group participants. <http://www.glif.is/working-groups/tech/lightpath-measurement-0.9.pdf>.

NOC Operations

SURFnet subcontracts to the NOC Alliance, a consortium of Telindus and SARA for NetherLight NOC operations <http://noc.netherlight.net/>. Active monitoring of NetherLight and its links is done on a 24x7 basis from the highly secured International Service Center of Telindus in Belgium.

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

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/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 project annual milestones are met; coordinating all ongoing 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:

January 28-February 1, 2007. Brenda Lopez of EVL presented a paper she and Luc Renambot wrote at the IS&T/SPIE 19th Annual Electronic Imaging Science and Technology Symposium in San Jose, CA. Their paper was about the application shown at SC05 and iGrid 2005, showing networking activity and Bluetooth detection in an artistic fashion: "CytoViz: an artistic mapping of network measurements as living organisms in a VR application." <http://electronicimaging.org/program/07/schedule/index.cfm?fuseaction=confSchedule>

December 14, 2006. Alan Verlo and Linda Winkler participated in a monthly phone call of network engineers from the major GLIF Open Lightpath Exchanges (GOLEs) worldwide.

December 13-16, 2006. Tom DeFanti and Maxine Brown participated in the first CineGrid workshop (streaming super-high-definition media over advanced networks), held at Calit2 at UCSD, which included European collaborators from Sweden and The Netherlands.

December 12, 2006. Chinese American Networking Symposium (CANS 2006) attendees traveled to Washington DC and visited the NCSA ACCESS Center. There was an ACCESS/TRECC demo for 60 Chicago public school children, which the CANS folks got to see, which involved UIC/EVL staff and students.

December 10-13, 2006. Luc Renambot and Lance Long of EVL were invited to give presentations on SAGE and OptIPuter at Osaka University as part of its PRIUS (Pacific Rim International University) program. EVL already collaborates with Osaka indirectly, as Mark Ellisman of UCSD uses international networks to access Osaka's electron microscope. Osaka now has a tiled display running SAGE and is interested in a more formal relationship with EVL and other international partners.

December 7-8, 2006. Maxine Brown attended and participated in the Chinese American Networking Symposium (CANS 2006), held after the Internet2 Member Meeting in Chicago. On December 8, Maxine gave the presentation "TransLight/ StarLight, GLIF and OptIPuter." In the afternoon, CANS attendees had the opportunity to visit both EVL and StarLight, where demonstrations and tours were organized. Maxine Brown, Laura Wolf and Jason Leigh were the EVL hosts; Joe Mambretti and Alan Verlo were the StarLight hosts. Note: In addition to the Chinese delegation, a postdoc from Masaryk University (Czech Republic) attended.

December 5, 2006. Maxine Brown participated in the monthly NSF IRNC phone call.

December 5, 2006. Artur Serra of i2CAT (Barcelona), Jesus Alcober (director of Mediacat) and Francisco Iglesias (doctoral student and an expert in Ultragrid and HD videoconferencing) visited EVL to talk about Barcelona's upcoming 10Gbps link to NetherLight and potential collaborations, including CineGrid. One outcome is that Iglesias will spend several months working on media research at EVL.

December 4-6, 2006. Maxine Brown attended and participated in the Fall 2006 Internet2 Member Mtg. in Chicago.

December 4-6, 2006. Bob Grossman attended the 2nd IEEE International Conference on e-Science in Amsterdam.

November 15, 2006. Maxine Brown attended an IRNC meeting at SC 2006 organized by Kevin Thompson to discuss the outcome of the NSF IRNC Program Review.

November 15, 2006. Alan Verlo and Linda Winkler participated in the monthly JET meeting at SC 2006.

November 14, 2006. UIC/EVL hosted representatives from China, whose trip was sponsored by the World Health Organization (WHO), to demonstrate our networked visualization and collaboration technologies. The group included Degang Dong (Vice Director Liaoning Province Health Department, Shenyang), Qun Meng (Deputy

Director General, Department of Medical Science, Technology and Education, Ministry of Health, Beijing), and Jianmin Si (Vice President, Zhejiang University, Hangzhou). They purpose of their visit was to see the UIC Department of Medical Education, a WHO Collaborating Center.

November 14, 2006. Maxine Brown met at SC 2006 with John Silvester, Jacqueline Brown, David Lassner and George McLaughlin (via phone) to identify TransLight/Pacific Wave and TransLight/StarLight applications.

November 13-17, 2006. Maxine Brown, Alan Verlo and Laura Wolf attended SC 2006 in Tampa; Alan Verlo was a member of SCinet, responsible for international networking connections via StarLight. Maxine gave a short invited presentation in the PRAGMA booth on "'GLORIAD, GLIF, SAGE and Visualcasting," and a presentation on "TransLight and GLIF" in the NLR booth.

November 13, 2006. KISTI president Byungtae Yang and KISTI Supercomputing Center director Jysoo Lee visited UIC/EVL to learn more about advancements in high-performance visualization and collaboration over high-speed networks. EVL Professor Andy Johnson hosted them, as others were at SC 2006.

November 9, 2006. Tom DeFanti attended a lecture by Bill St. Arnaud of CANARIE on the topic "Building the Next Generation Internet Architecture in Canada," at SDSC Auditorium on the UCSD campus.

November 2, 2006. Peter Hinrich of SURFnet developed a one-day "GigaPort seminar for astronomers." As a part of the session "Next Generation Research" (which discussed networking, SURFnet and TransLight/StarLight), high-end applications were discussed and an OptIPuter video was presented. The schedule is posted at <www.surfnet.nl/info/bijeenkomsten/bijeenkomst_content.jsp?objectnumber=168668>.

October 27, 2006. Jason Leigh of UIC gave a presentation on the OptIPuter SAGE software via high-definition videoconferencing to the JGN-II workshop on Oct. 27 in Japan.

October 25, 2006. Larry Smarr hosted Satoshi Matsuoka of the Global Scientific Information and Computing Center, Tokyo Institute of Technology. Matsuoka visited Calit2 to talk with Smarr about international OptIPuter and CAMERA activities. Matsuoka is a PRAGMA steering committee member and active in the Open Grid Forum.

October 24-25, 2006. Tom DeFanti and Maxine Brown participated in the IRNC Program Review at NSF in Arlington, Virginia.

October 23-24, 2006. Joe Mambretti represented IRNC TransLight/StarLight at the US LHC Working Group Meeting at Fermilab <https://indico.fnal.gov/conferenceDisplay.py?confId=417>. The US LHC is interested in IRNC support of selected activities. Tom DeFanti is in ongoing discussions with Harvey Newman and Bill Johnston (re LHC) and Don Petravick (re LHC/CMS). *Note: The CMS Computing model differs from the other LHC experiments is that every Tier-2 center needs good burst access to every Tier-1 center; for other LHC experiments, Tier-2 centers need good access to a local Tier-1 center.*

October 18, 2006. Alan Verlo and Linda Winkler participated in a monthly phone call of network engineers from the major GLIF Open Lightpath Exchanges (GOLEs) worldwide.

October 17, 2006. Alan Verlo and Linda Winkler participated in the monthly JET meeting at NSF.

October 11-13, 2006. Linda Winkler and Jan Eveleth (PNWGP) attended The Quilt meeting in St. Louis, Missouri. Winkler gave a presentation on "StarLight, a GLIF GOLE" and Eveleth gave a presentation on "TransLight" <http://www.thequilt.net/meetings/Oct-06-wksp/oct06mtg.html>.

October 10, 2006. Maxine Brown participated in a phone meeting with John Silvester, Jacqueline Brown and George McLaughlin to identify TransLight/Pacific Wave and TransLight/StarLight applications.

October 1-5, 2006. Xi Wang (UIC/EVL postdoc) attended Broadnets 2006 and gave the paper **"**LambdaBridge: A Scalable Architecture for Future Generation Terabit Applications**."**

October 1-2, 2006. Eric He (UIC/EVL PhD candidate) attended GridNets 2006 and gave the paper "Flexible Advance Reservation Model for Multi-domain WDM Optical Networks."

September 26, 2006. Tom DeFanti participated in the monthly NSF IRNC phone call.

September 26-28, 2006. Maxine Brown attended the 23rd annual NORDUnet meeting in Gothenburg, Sweden, and gave the paper "TransLight/StarLight and the OptIPuter."

September 25, 2006. EVL PhD student Eric He successfully defended his dissertation today: *A Flexible Advance Reservation Model for Multi-Domain WDM Optical Networks.* His Photonic InterDomain Negotiator (PIN) research received major funding from NSF, and the NSF HPIIS Euro-Link connection between Chicago and Amsterdam was used for development and testing (the precursor to TransLight/StarLight).

September 19, 2006. Larry Smarr represented IRNC TransLight/StarLight (Tom DeFanti was in The Netherlands) to host a visit by Makoto Nagao of NICT, Japan, to UCSD/Calit2. Dr. Nagao was interested in learning more about US networking, applications, etc.

September 17-18, 2006. Tom DeFanti is a member of the SURFnet Scientific Advisory Committee and attended the annual meeting in Utrecht, The Netherlands.

September 13, 2006. Tom DeFanti gave a presentation on "OptIPuter" at the Global Lambda Networking Symposium in Tokyo, Japan <http://www.e-side.co.jp/glifsymposium2006/program.html>.

September 11-12, 2006. Tom DeFanti, Maxine Brown, Alan Verlo and Linda Winkler attended the Global Lambda Integrated Facility (GLIF) meeting in Tokyo, Japan. The GLIF TECH Working Group discussed infrastructure and GLIF Open Lightpath Exchanges (GOLEs); DeFanti, Verlo and Winkler participated. The GLIF Research & Applications (RAP) Working Group, co-chaired by Larry Smarr and Maxine Brown, focused on OptIPuter-type global applications and LambdaVision/SAGE developments.

September 7-8, 2006. Tom DeFanti and Maxine Brown attended the Optical Network Testbeds 3 Workshop (ONT3) in Tokyo, Japan. DeFanti gave a keynote presentation on "Applications over Next-Generation Global Optical Networks," and presented "OptIPuter" in a panel discussion. Brown is giving a presentation on "TransLight/StarLight." <www.nren.nasa.gov/workshop9>

August 18, 2006. Maxine Brown attended a one-day planning meeting at NCSA at the University of Illinois at Urbana-Champaign on the NSF Petascale solicitation, representing visualization and networking interests. NCSA has formed the Great Lakes Consortium for Petascale Computation (UIC is a member) and was soliciting input.

August 15, 2006. Alan Verlo and Linda Winkler participated in the monthly JET meeting at NSF.

July 25, 2006. Formalizing a collaboration that puts Chicago at the hub of ultra-high-speed advanced optical network research and development exchanges with Japanese research and education institutions, a MOU between UIC and Japan's National Institute of Information and Communications Technology (NICT) was signed today at a special ceremony on UIC's campus. The NICT-funded Japanese Advanced Testbed Network for Research and Development, known as JGN2, links Japan with the US via StarLight. Among those participating in the MOU were Kunihiro Kato, Asako Toyoda, Koichi Hiragami and Yoichi Kanda (NICT); Eric Gislason, Tom DeFanti, Maxine Brown, Jason Leigh and Laura Wolf (UIC); and, Joe Mambretti (Northwestern/StarLight).

July 25, 2006. Tom DeFanti and Maxine Brown participated in the monthly IRNC phone call.

July 17, 2006. Alan Verlo and Linda Winkler participated in a monthly phone call of network engineers from the major GLIF Open Lightpath Exchanges (GOLEs) worldwide.

July 16-20, 2006. Alan Verlo and Linda Winkler attended the Summer 2007 ESCC/Internet2Joint Techs Workshop, Madison, WI. They also attended the JET meeting (July 19).

July 14, 2006. Michael Seablom, Head, Software Integration & Visualization Office at NASA Goddard, visited EVL to discuss applying LambdaRAM to prefetch data (not images) for NASA's Modeling, Analysis, and Prediction (MAP '06) project, which executes NASA's large global atmospheric model as well as NCAR's regional model for near real-time support for operations during this year's hurricane season. The goal is to reduce the substantial I/O latency in the analysis segment, which idles NASA's processors for 25-50% of the execution. Also

accompanying him were Horace Mitchell, Brice Womack, Robert Burns, Robert Link and Pat Gary. In addition to LambdaRAM discussions, Jason Leigh, Luc Renambot and Maxine Brown showed them SAGE running on the 100-Megapixel tiled display, and there was discussion of visualization applications for which these technologies would be appropriate. *Note: LambdaRAM was tested and evaluated over the IRNC link between Chicago and Amsterdam.*

June 28, 2006. Rob de Ruig, Technical Director at Global Crossing, and Marcel Boejé, Sales Manager at Global Grossing in The Netherlands, provide lightpaths, Internet Access and fiber to TransLight/StarLight and colleagues at CERN, SURFnet and DANTE (for the ALICE project between South America and Europe). De Ruig visited Joe Mambretti at StarLight to talk about new developments.

June 27, 2006. Tom DeFanti and Maxine Brown participated in the monthly IRNC phone call.

June 22-23, 2006. Tom DeFanti gave a keynote on "Global Lambda Exchanges" at the International Conference on IP + Optical Network 2006 (iPOP), Tokyo, Japan, sponsored by Japan's Photonic Internet Forum (PIF), Photonic Internet Lab (PIL), and ISOCORE <http://pilab.org/ipop2006/>. Also attending was Bernhard Fabianek of the European Commission.

June 20, 2006. Alan Verlo and Linda Winkler participated in the monthly JET meeting at NSF.

June 14, 2006. Alan Verlo participated in a monthly phone call of network engineers from the major GLIF Open Lightpath Exchanges (GOLEs) worldwide.

June 12-15, 2006. Maxine Brown gave an "OptIPuter" presentation at the TeraGrid '06 conference in Indianapolis. <http://teragrid.org/events/2006conference>. TeraGrid featured Brown's presentation in an article published in:

> "The OptIPuter: 21st Century E-Science"
> *GRIDtoday*, June 26, 2006, by Faith Singer-Villalobos, Texas Advanced Computing Center
> http://www.gridtoday.com/grid/701815.html
>
> The above article was circulated by:
>
> *CA*net-news*, Bill St. Arnaud <http://lists.canarie.ca/pipermail/news/2006/000295.html>
> *NLR News* <http://www.nlr.net>
>
> Other publications that picked up story:
>
> "Futuristic optical system tackles image processing: OptIPuter clustering system outlined at TeraGrid '06 conference"
> *NetworkWorld.com*, 06/15/06, by Carolyn Duffy Marsan, NetworkWorld.com
> http://www.networkworld.com/news/2006/061506-optiputer.html
>
> "Futuristic Optical System Tackles Image Processing"
> *CIO India*, reprinted from NetworkWorld.com, 06/15/06
> http://www.cio.in/news/viewArticle/ARTICLEID=1607
>
> "10 cutting-edge network research projects you should know about" (includes "Futuristic optical system" article that appeared in their magazine 6/15/06)
> *NetworkWorld.com*, June 27, 2006, Network World Staff,
> http://www.networkworld.com/news/2006/062706-alpha-doggs.html
>
> *SlashDot* <http://slashdot.org> pointed to the above article on June 29, 2006.
> Comments are at <http://it.slashdot.org/article.pl?sid=06/06/29/0110220>

May 31, 2006. US-India Summit on Education, Research & Technology <http://us-india.calit2.net> took place at Calit2/UCSD. India's Minister of Science & Technology and Ocean Development, the Hon. Kapil Sibal, led a delegation of top academics, government officials, corporate executives and other dignitaries from India for wide-ranging discussions with US counterparts. QUALCOMM CEO Paul E. Jacobs co-chaired the event with Jacobs School of Engineering Dean Frieder Seible, and Chancellor Marye Anne Fox welcoming attendees. A high point of the Summit was a keynote by Indian President APJ Abdul Kalam in high-definition video over optical fiber from the presidential palace in New Delhi to Calit2, organized by Tom DeFanti.

May 30, 2006. Maxine Brown participated in the monthly NSF IRNC phone call.

May 16, 2006. Alan Verlo and Linda Winkler participated in the monthly JET meeting at NSF.

May 12, 2006. Chip Cox (IRNC/WHREN) visited UIC to talk with Tom DeFanti to catch up on international networking activities.

May 10, 2006. At the April 28th IRNC briefing to NSF/OISE at NSF headquarters, Bonnie Thompson, the NSF program manager responsible for US activities with Nordic countries, asked Maxine Brown to arrange an introduction to the head of NORDUnet (René Buch) during a trip she would soon be taking to Helsinki and Stockholm. They subsequently met in Stockholm on May 10. Buch sent follow-up email saying that, as a result of the meeting, "…I am sure that the NORDUnet / NSF cooperation will be even better in the future."

May 9, 2006. Alan Verlo participated in a monthly phone call of network engineers from the major GLIF Open Lightpath Exchanges (GOLEs) worldwide. Participating in the call were: Pieter de Boer, Andree Toonk and Ronald van der Pol (SARA), Akira Kato (T-LEX), Dongkyun Kim (KRLight), Bram Peeters (SURFnet), Thomas Tam (CANARIE), Christian Todorov (MANLAN), and Verlo and Linda Winkler (StarLight).

May 5-6, 2006. Maxine Brown attended a Global Environment for Networking Innovations (GENI) Town Hall Meeting in Chicago to better understand this initiative and how it relates to advanced international and national networking and applications.

May 4, 2006. Professors Ludek Matyska and Eva Hladka from Masaryk University in the Czech Republic visited the UIC Electronic Visualization Laboratory to see our latest technologies and tools and discuss potential collaborations in networking, grids and collaboration. (Note: At the Internet2 Spring 2006 Member Meeting, April 23-26, Maxine introduced them to Jaroslav (Jarda) Flidr, a Czech who works on the DRAGON project at University of Maryland, and they had discussions about possibly extending the DRAGON testbed to Masaryk University.)

April 28, 2006. Maxine Brown represented TransLight/StarLight at an IRNC Briefing to NSF/OISE organized by Kevin Thompson of NSF/OCI. Both Jeanne Hudson and Bonnie Thompson, who are the OISE European liaisons, had many questions and we have since had subsequent discussions.

April 26-27, 2006. Maxine Brown represented TransLight/StarLight at the annual meeting of the CCIRN (Coordinating Committee on Intercontinental Research Networking) <www.ccirn.org>. CCIRN is an informal association of continental R&E networking organizations (e.g. TERENA, Internet2, CANARIE, APAN, CLARA, etc.), and a forum for discussions involving international networking.

April 23-26, 2006. Maxine Brown and Kees Neggers attended the Internet2 Spring 2006 Member Meeting in Arlington, VA. Brown attended the Internet2 International Task Force Meeting session on the afternoon of April 24 and gave a TransLight/StarLight update <http://international.internet2.edu/resources/events/2006/2006SMM-itf2.html>. She also attended an April 24th Executive Session on Supporting Connectivity for Biomedical Research, sponsored by NIH, Internet2, the US Army Medical Research & Materiel Command (USAMRMC) and the Telemedicine and Advanced Technology Research Center (TATRC). Brown also met and had several discussions with Vasilis Maglaris, a professor at the National Technical University of Athens and the chair of the European NREN Policy Council (NREN-PC) and a member of the DANTE Board (which runs GÉANT2). Vasilis was very interested in TransLight/StarLight and NLR connections.

April 24, 2006. UIC/EVL PhD student Venkat Vishwanath had a paper accepted at the IEEE Infocom High-Speed Networking Workshop: The Terabit Challenge 2006, Barcelona, Spain, entitled "Wide-area Network Experiments with LambdaStream Over Dedicated High Bandwidth Networks." Unfortunately, due to visa delays, Vishwanath was unable to attend to deliver the paper.

April 20, 2006. Tom DeFanti was keynote speaker at the Mid-Atlantic Crossroads (MAX) annual meeting. His presentation was entitled "Extreme Multimedia: What's all that Bandwidth for?".

April 18, 2006. Alan Verlo participated in the JET meeting at NSF.

March 31, 2006. Maxine Brown participated in an IRNC phone call to discuss status updates.

March 30, 2006. Tom DeFanti met with the leaders of New Zealand's R&E Network, Carol Moffatt, Charles Jarvie, Warwick Clegg and Paul Bonnington, at Calit2/UCSD.

March 29, 2006. Maxine Brown met with leaders of New Zealand's R&E Network, Carol Moffatt, Charles Jarvie, Warwick Clegg and Paul Bonnington, who visited Chicago to learn about TransLight (StarLight and Pacific Wave), GLIF, OptIPuter, UIC's Electronic Visualization Laboratory, etc. The meeting was held at Argonne National Laboratory, where they also met with Ian Foster to discuss potential middleware and application collaborations.

March 21, 2006. Alan Verlo participated in the JET meeting at NSF.

March 14, 2006. In recognition of the community's effort to focus international attention to its activities and advancements, iGrid 2005 received the Corporation for Education Network Initiatives in California (CENIC) 2006 Innovation in Networking Award for Experimental/Developmental Applications, presented at its annual conference in California. CENIC awards highlight networked applications by identifying exemplary innovations that leverage the network and have the potential to improve the way instruction and research are conducted, even when the impact of those innovations may not be felt immediately. As one of the iGrid hosts along with Ramesh Rao, Larry Smarr accepted the award on behalf of the iGrid hosts and organizers Tom DeFanti and Maxine Brown.

February 24, 2006. Maxine Brown participated in an IRNC phone call to discuss status updates.

February 21-22, 2006. Alan Verlo helped configure network links for a collaboration demonstration organized by KISTI, the Korea Institute of Science and Technology Information, with UIC (Chicago) and SARA (Amsterdam), for a government committee evaluating first-year results of Korea's e-Science project and GLORIAD. This committee included Director C.W. Kim from the Ministry of Science and Technology (MOST), who will strongly influence next year's e-Science budget. (See picture of attendees.) See Section 2.B.5 for a description of the successful demonstration.

February 8-9, 2006. Alan Verlo and Linda Winkler attended interim meetings of the GLIF TECH and Control Plane Working Groups <http://www.glif.is/meetings/2006-interim/>, held in conjunction with the Winter 2006 ESCC/Internet2Joint Techs Workshop.

February 2-8, 2006. Alan Verlo and Linda Winkler attended the Winter 2006 ESCC/Internet2Joint Techs Workshop, Albuquerque, New Mexico <http://jointtechs.es.net/newmexico2006>. They also attended the JET meeting (February 7). Verlo attended the E2Epi Network Performance Workshop (February 4).

February 3, 2006. Tom DeFanti and Maxine Brown participated in an IRNC phone call to discuss status updates.

February 2-3, 2006. Jason Leigh of UIC/EVL attended PFLDnet 2006 (the 4th International Workshop on Protocols for Fast Long-Distance Networks) in Nara, Japan, to present the paper "A Case for UDP Offload Engines in LambdaGrids." <http://www.evl.uic.edu/core.php?mod=4&type=3&indi=285>

2.B. Research Findings

2.B.1. Lessons Learned

Problems and Issues

The chief problem/issue is a high-level one. How do we attract, manage and retain high-bandwidth users? When do we claim success: (1) when the application runs? (2) when the link is saturated? or, (3) when the successful users procure their own links? We continue to actively recruit high-bandwidth users and provide VLANs.

Avoidable Problems – Some Remedied in Past Year

Over the past year, NSF limited Tom DeFanti, PI, to one month of IRNC salary per year. After talking with Kevin Thompson, this has been remedied and the budget for Year 3 requests 2 months salary support. Time will be spent pro-actively developing IRNC usage, and devoting time to such activities as contacting potential users, working with Internet2-NLR if potential users have connectivity issues, attending and giving presentations at conferences, and maintaining an active relationship with GLIF peers.

The IRNC program did not previously pay for graduate students or REUs. This, too, was partially remedied, as the NSF IRNC Program Review committee recommended that IRNC support REUs. TransLight/StarLight requested funding for 2 undergraduates, which will be awarded upon receipt and approval of this annual report. We still advocate supporting graduate students, for while this is an infrastructure award, we also run a research laboratory with very talented students who can assist with the installation and implementation of network engineering and measurement tools and techniques.

Last year we suggested that NSF/OCI actively introduce IRNC opportunities to other NSF divisions. Kevin Thompson organized an IRNC Briefing to NSF/OISE. Both Jeanne Hudson and Bonnie Thompson, who are the OISE European liaisons, had many questions after the Briefing and we had a few subsequent discussions, though nothing yet has developed.

Unavoidable Problems

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" and get their own links. This has and will negatively impact our usage statistics.

L1 links from SURFnet, UKLight, GÉANT2, US LHC (DOE/CERN), Internet2, and others compete with our IRNC links.

2.B.2. NSF Interactions

Positive

NSF/OCI has been very supportive of the Layer diversity that TransLight/StarLight achieves.

Negative

Other NSF divisions do not yet actively promote IRNC links. NSF does not have a program in place to fund international computational or experimental science that would use IRNC bandwidth, so collaborations are mostly left up to us to attract and retain. We attract international science collaborations, and train technical people, as part of iGrid and SC conference activities, but these collaborations are mostly transient without substantial follow-up funding.

2.B.3. IRNC Project Interactions and Leveraging of Resources

iGrid 2005

All IRNC links were used for iGrid 2005, September 26-29, 2005 <www.igrid2005.org>. Afterwards, all iGrid participants responsible for the Workshop's 49 real-time demonstrations were invited to submit a research paper to the peer-reviewed journal *Future Generation Computer Systems (FGCS)*, describing their iGrid experiences and the performance metrics they were able to achieve. Larry Smarr, Tom DeFanti, Maxine Brown and Cees de Laat were guest editors of this iGrid 2005 FGCS special issue, Volume 22, Issue 8, Elsevier, October 2006, pp. 849-1054. Twenty-six papers were accepted. Elsevier, the publisher, makes FGCS articles available (for Science Direct subscribers) online. If you go to the following URL, you can view the table of contents. <http://www.sciencedirect.com/science?_ob=IssueURL&_tockey=%23TOC%235638%232006%23999779991%23

625366%23FLA%23&_auth=y&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=15a5756943abc5d1d31c1e7699e0e03e>

SC 2006

Together with our IRNC siblings, we supported science and engineering research and education applications at major events and activities, including SC 2006 in Tampa, FL, November 13-17, 2006.

Internet2/GÉANT2 and StarLight/NetherLight Compatibilities

TransLight/StarLight seamlessly connects the Internet2 network to GÉANT2, and the lambda-connected networks at 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 is a lead organizer 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 and Linda Winkler attended the GLIF meetings held in Tokyo, September 11-12, 2006.

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.

2.B.4. E-Science Application Identification and Support

In 2006, John Silvester formed a small group to identify and provide support for TransLight/Pacific Wave applications, and invited Maxine Brown to join the discussions, to expand coverage to the entire TransLight project, as many applications, such as eVLBI and SDSS, span Asia, North America and Europe. Other participants include Jacqueline Brown, George McLaughlin and David Lassner.

Currently, John Silvester's Application group is working with John O'Callaghan, Executive Director of the Australian Partnership for Advanced Computing (APAC) and Chris Hancock, Chief Executive Officer of AARNet, on a US-Australia Workshop at APAC '07, October 8-12, 2007 in Perth, to stimulate e-science usage of AARNet links to the US. Given that science is global, this workshop may include collaborators from Asia and Europe.

The VLBI community has an international workshop annually, and this year the CSIRO's Australia National Telescope Facility will host the meeting in Australia. One of the days is devoted to networking issues, and there is discussion about holding the meeting either at APAC '07 or at QUESTnet (Queensland Education Science & Technology Network) 2007 conference, July 10-13, 2007, in Cairns, which Jerry Sobieski will be attending.

Similarly, Charles Jarvie, Development Manager of REANNZ in New Zealand, proposed hosting a NZ/US

application and middleware workshop in New Zealand in June/July 2007.

2.B.5. E-Science Support (Quantified Science Drivers)

For many years, we have documented international applications on the StarLight website <http://www.startap.net/starlight/APPLICATIONS/> and, more specifically, US/European applications on the Euro-Link website <http://www.startap.net/euro-link/APPLICATIONS/>. However, science has no geographical boundaries; all science is global. As international collaborations become more prevalent, as collaborations expand from two to three or 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, the 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 2006-2007

ANDRILL (Antarctic geological Drilling) Program

www.andrill.org

Collaborators

- University of Nebraska-Lincoln, Department of Geosciences, ANDRILL Science Management Office; Northern Illinois University, Department of Geology and Environmental Geosciences; US
- ANDRILL Operations Management Office, Antarctica; Department of Geology, University of Otago; Institute of Geological and Nuclear Sciences; New Zealand
- Istituto Nazionale di Geofisica e Vulcanologia; Università Degli Studi di Siena, Dipartimento di Scienze della Terra; Italy
- Alfred Wegener Institute for Polar and Marine Research; Germany
- School of Earth Sciences, University of Leeds; UK

ANDRILL is an international research program that represents a partnership between the US, New Zealand, Germany and Italy, with the UK participating in an advisory role. New Zealand is a major partner in this drilling effort and is providing the drilling system and operational support for the project.

Given that New Zealand now has an R&E network to Seattle (REANNZ/KAREN), ANDRILL is interested in making drilling data available to other researchers while the core-drilling ships are still out to sea in the Antarctic. ANDRILL wants to fly small data storage drives to Otago University in New Zealand, where the data will be sent via KAREN to Seattle so schools on Internet2 and NLR can access it. Maxine Brown and John Silvester e-introduced the ANDRILL and KAREN teams, and all are willing to try this experiment once the University is connected to KAREN.

Brown inquired whether ANDRILL had similar, or more network-intensive, projects they wanted to try with their European colleagues.

AtlanTICC: An International Alliance for Innovative Research

www.iom3.org/materialsworld/mar07/news.htm#Analysis_&_Microscopy
www.atlanticcalliance.org

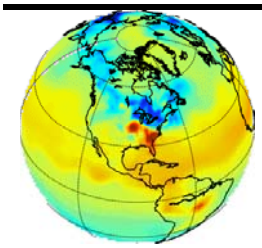
Collaborators

- Imperial College London; UK
- Georgia Institute of Technology; Oak Ridge National Laboratory; US

The Global Lab is a new computer-based facility at Imperial College London that enables researchers to remotely operate state-of-the-art equipment located in the US. The technology was established as part of the AtlanTICC Alliance (Atlantic Technology Innovation and Commercialization Center [TICC]), a joint venture between Imperial, the Georgia Institute of Technology and Oak Ridge National Laboratory, to investigate future energy solutions.

Operating through the UK provider of the US National LambdaRail (NLR), Imperial scientists can manipulate the 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.

Alongside remote microscopy, high-definition audiovisual equipment enables collaborative research via three-way teleconferencing. NLR capabilities ensure that there are no long pauses, echoing or stuttering.



Carbon Tracker

Collaborators

- National Oceanographic & Atmospheric Administration (NOAA), Earth System Research Laboratory; Columbia University, Lamont-Doherty Earth Observatory (LDEO); Oak Ridge National Laboratory, Environmental Sciences Division, Carbon Dioxide Information Analysis Center (CDIAC); University of California, Irvine; Science Systems and Applications, Inc.; NASA Goddard Space Flight Center; Duke University; US
- Meteorological Service of Canada (MSC), Greenhouse Gases Measurement Laboratory; Canada
- The Netherlands Environmental Agency (RIVM), EDGAR emissions database; Vrije Universiteit; The Royal Netherlands Meteorological Institute (KNMI); Institute for Marine and Atmospheric Research Utrecht (IMAU); Netherlands Institute for Space Research (SRON); The Netherlands

www.esrl.noaa.gov/gmd/ccgg/carbontracker/

CarbonTracker as a scientific tool will, together with long-term monitoring of atmospheric CO_2, help improve our understanding of how carbon uptake and release from land ecosystems and oceans are responding to a changing climate, increasing levels of atmospheric CO_2 (the CO_2 fertilization effect) and other environmental changes, including human management of land and oceans. Open access to CarbonTracker results means that anyone can scrutinize our work, suggest improvements, and profit from our efforts. This will accelerate the development of a tool that can monitor, diagnose, and predict the behavior of the global carbon cycle, and the climate that is so intricately connected to it.

CarbonTracker can become a policy support tool too. Its ability to accurately quantify natural and anthropogenic emissions and uptake at regional scales is currently limited by a sparse observational network. With enough observations though, it will become possible to keep track of regional emissions, including those from fossil fuel use, over long periods of time. This will provide an independent check on emissions accounting, estimates of fossil fuel use based on economic inventories, and generally, feedback to policies aimed at limiting greenhouse gas emissions. This independent measure of effectiveness of any policy, provided by the atmosphere (where CO_2 levels matter most!) itself is the bottom line in any mitigation strategy.

CarbonTracker is intended to be a tool for the community and NOAA welcomes feedback and collaboration from anyone interested. NOAA's ability to accurately track carbon with more spatial and temporal detail is dependent on our collective ability to make enough measurements and to obtain enough air samples to characterize variability present in the atmospheric. For example, estimates suggest that observations from tall communication towers (>200m) can tell us about carbon uptake and emission over a radius of only several hundred kilometers. The map of observation sites shows how sparse the current network is. One way to join this effort is by contributing measurements. Regular air samples collected from the surface, towers or aircraft are needed. It would also be very fruitful to expand use of continuous measurements like the ones now being made on very tall (>200m) communications towers. Another way to join this effort is by volunteering flux estimates from your own work, to be run through CarbonTracker and assessed against atmospheric CO_2.

CarbonTracker uses many more continuous observations than previously taken. The largest concentration of observations currently is from within North America. Data is fed into a sophisticated computer model with 135 ecosystems and 11 ocean basins worldwide. The model calculates carbon release or uptake by oceans, wildfires, fossil fuel combustion, and the biosphere and transforms the data into a color-coded map of sources and storage "sinks." One of the system's most powerful assets is its ability to detect natural variations in carbon uptake and release by oceans and vegetation, which could either aid or counteract societies' efforts to curb fossil fuel emissions on a seasonal basis.

CineGrid

www.cinegrid.org

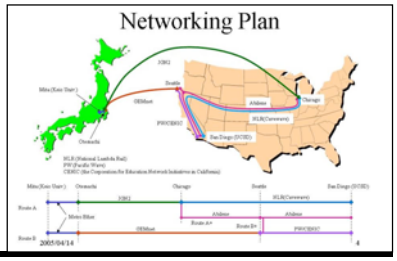
Collaborators

- Pacific Interface; University of California San Diego, Calit2; University of Southern California, School of Cinematic Arts (USC/SCA); University of Illinois at Chicago, Electronic Visualization Laboratory (UIC/EVL); US
- Keio University, Research Institute for Digital Media and Content (Keio/DMC); Japan

- University of Amsterdam; deWaag Society; The Netherlands
- i2CAT/Universitat Politecnica de Catalunya (UPC); Barcelona, Spain
- Royal Institute of Technology (KTH); Sweden

Note: De Waag, with assistance from University of Amsterdam and SURFnet, will be hosting a CineGrid event in June 2007.

CineGrid is a virtual network for extreme media collaboration running on advanced research IP networks. In October 2006, a CineGrid demonstration at the Audio Engineering Society (AES) annual meeting at the Letterman Digital Arts Center in San Francisco streamed, for the first time, 2K and 4K resolution digital motion pictures and 24-channel digital audio from three different locations in real time, then mixed live for an audience of audio and video professionals. This CineGrid@AES special event was structured in four parts: (1) a sequence of 4K "digital shorts" at 24 frames per second (fps), together with fully mixed synchronized audio, were pulled from network-connected servers in Los Angeles and San Diego; (2) 4K telepresence was used for interactive video-conferencing and ultra-realistic reproduction of a classical music performance from Tokyo (illustrated to the left); (3) 4K motion pictures were sent compressed from Tokyo, and 24-channel non-compressed digital audio was streamed from San Diego; and, (4) the performance system was re-configured to use uncompressed 2K motion pictures coming from local servers, synchronized to 24-channel, non-compressed digital audio streaming from San Diego.



Note: Images from Tokyo went via JGN2 to StarLight, and then over CAVEwave to San Francisco. This network map was drawn for the first CineGrid demonstration at iGrid 2005, where various routes from Tokyo to San Diego (over JGN2 to Chicago and then CAVEwave to San Diego, or over IEEAF to Seattle, and then down Pacific Wave to San Diego) are illustrated.

Data Reservoir

http://data-reservoir.adm.s.u-tokyo.ac.jp
http://data-reservoir.adm.s.u-tokyo.ac.jp/lsr-200612-01
http://data-reservoir.adm.s.u-tokyo.ac.jp/lsr-200612-02

Collaborators – 2006-2007 Land Speed Record participants

- University of Tokyo; WIDE Project; JGN2 network; 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

The Data Reservoir Project is designing an online 2-PFLOPS system, part of Japan's GRAPE-DR project, to be operational in 2008. Its goal is to create a global grid infrastructure to enable distributed data sharing and high-speed computing for data analysis and numerical simulations.

In preparation for the Internet2 Land Speed Record competition in Spring 2007, 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.

At SC 2006, Data Reservoir had a Bandwidth Challenge entry [Tokyo (JGN2) > Chicago (NLR FrameNet) > Tampa > Chicago (NLR FrameNet) > Seattle (over TransLight) > Tokyo (IEEAF)].

In April 2006, the Project set two consecutive new Internet2 Land Speed Records (I2-LSR) in the IPv6 single and multi-stream categories. For the IPv6 records, the Project created a network path over 30,000 kilometers in distance crossing eight international networks and exchange points. The team successfully transferred data at a rate of 8.80Gbps, which is equal to 264,147 terabit-meters per second (Tb-m/s). For the IPv6 record, the team created a path over 30,000 kilometers in distance crossing five international networks, transferring data at a rate of 6.96Gbps, achieving a mark of 208,800 terabit-meters per second (Tb-m/s).

"Data Reservoir on very-long-distance IPv6/IPv4 network" received the SC\|05 Bandwidth Challenge award for "Fastest IPv6." They achieved 6.84Gbps peak traffic on IPv6.

On November 14, 2005, this group won the Internet2 Land Speed Records (I2-LSR) in both the IPv6 single-stream and IPv6 multi-stream categories for successfully transferring data at a rate of 5.58Gbps over a distance of over 30,000 kilometers traversing the WIDE, IEEAF, JGN2 networks, achieving 167,400 terabit-meters per second (Tb-m/s).

DRAGON

http://dragon.maxgigapop.net

Collaborators

- Mid-Atlantic Crossroads (MAX); University of Southern California (USC), Information Sciences Institute (ISI) East; George Mason University (GMU); StarLight; Internet2 Hybrid Optical Packet Infrastructure (HOPI); US
- SARA Computing and Networking Services; NetherLight; SURFnet; University of Amsterdam; The Netherlands

DRAGON (Dynamic Resource Allocation via GMPLS Optical Networks) is conducting research and developing technologies to enable dynamic provisioning of network resources on an inter-domain basis across heterogeneous network technologies.

DRAGON inter-domain lightpath provisioning was demonstrated at the Internet2 Spring 2006 Member Meeting in Arlington, Virginia, on April 25, 2006. DRAGON installed a 10GigE switch and its VLSR code in Amsterdam to extend lightpaths to Onsala, Sweden, necessary for its eVLBI application. DRAGON demonstrated real-time setup and tear down of lighpaths, one from Los Angeles to Amsterdam to Washington DC, and one from Los Angeles to Chicago to Washington DC. <http://winmedia.internet2.edu/smm2006-vod/20060425-hopiupdate.wmv>. The Dutch decided that the most appropriate topology would be a direct GbE over the SURFnet circuit; however, there were problems with the link and the network engineers at NetherLight and StarLight immediately provisioned VLANs over the IRNC TransLight/StarLight10Gbps link.

University of Amsterdam's Network Description Language (NDL) is similar to DRAGON XML for application specific topologies, so the two groups are working together to integrate these into a single XML language that describes physical and logical networks, and instantiates and configures them.

Jerry Sobieski contacted Tom DeFanti in May 2006 to inquire whether DRAGON GMPLS software could be run over CAVEwave; lessons learned would be useful as DRAGON begins using the IRNC links for eVLBI development; his request was granted.

Alan Verlo made arrangements at StarLight for rack space for the DRAGON PC and a 10Gbs port on the StarLight Force10. Verlo also configured StarLight's Calient switch for use by the DRAGON and EnLIGHTened projects.

Note: One by-product of the Internet2 Spring 2006 demonstration was that Maxine Brown met the DRAGON team, and introduced a MAX/DRAGON researcher, Jaroslav (Jarda) Flidr, originally from the Czech Republic, to two professors from Masaryk University, Czech Republic, Ludek Matyska and Eva Hladka, who were attending Internet2. They discussed extending the DRAGON testbed.

eVLBI, an application of DRAGON, was one of the recipients of the first Internet2 Driving Exemplary Applications (IDEA) Awards, presented on April 26 at the Spring 2006 Internet2 Member Meeting. Winners represented applied advanced networking at its best, and hold the promise to increase the impact of next-generation networks around the world.

EnLIGHTened Computing

www.enlightenedcomputing.org

Collaborators

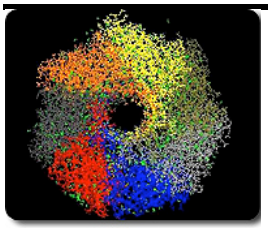
- North Carolina State University; Renaissance Computing Institute at UNC Chapel Hill; MCNC; Louisiana State University; Southeastern Universities Research Association; Naval Research Lab, National LambdaRail; US
- National Institute of Advanced Industrial Science and Technology (AIST); KDDI R&D Laboratories; NTT Network Innovation Laboratories; National Institute of Information and Communications Technologies (NICT); Japan
- Corporate sponsors: Cisco, IBM, AT&T Research and Calient Networks
- Other collaborators: Computing resources were donated by the N.C. State University Virtual Computing Lab and MCNC in North Carolina, the Center for Computation & Technology at Louisiana State University, the California Institute of Technology (Caltech), and the StarLight facility in Chicago. (Alan Verlo configured the StarLight Calient for use in this project.)

Note: While initial demonstrations did not involve Europeans, the EnLIGHTened Project does have European collaborators.

At the GLIF 2006 meeting in Tokyo, Japan (September 11, 2006), researchers in the US and Japan demonstrated "automated" interoperability between network and computing resources on two national grid computing research testbeds: the G-lambda project in Japan and the Enlightened Computing project in the US. More specifically, a software application in a research testbed in one country was able to reserve, manage and monitor computing and network resources across both countries − a key milestone toward developing a Global Grid of networked, interoperable resources.

Researchers working with the G-lambda group in Japan and the Enlightened Computing group in the US demonstrated how software applications can establish network connections "on demand" to computing resources, databases of information and scientific instruments. The duration of these connections is based on the particular application's requirement for precisely the amount of time that is needed, and no more. Whether seconds or days, the network and resources are connected and managed to perform a task. Then, the connection is released in order to share resources for other purposes.

This demonstration was also done at SC 2006.



ESLEA

www.eslea.uklight.ac.uk

Collaborators

- Council for the Central Laboratory of the Research Councils (CCLRC), UK Office of Science and Technology; Lancaster University; National e-Science Centre, Edinburgh; University College London; University of Edinburgh; University of Manchester; University of Oxford; UK
- Other collaborators: Tufts University; TeraGrid; NCSA/TeraGrid, Pittsburgh Supercomputing Center; Argonne National Laboratory; StarLight; US

The UK e-Science ESLEA (Exploitation of Switched Lightpaths for eScience Applications) project, a two-year EPSRC-funded project, is a collaboration among 6 leading UK research centres and two industrial partners (Cisco Systems and Boston Ltd). The project has a remit to demonstrate the potential of circuit-switched optical networking to the UK e-Science community by running "proof of benefit" pilot applications in several data-intensive fields of academic endeavor, including particle physics, high-performance computing, radio astronomy and e-health.

The pilot applications demonstrated the feasibility and benefits of transferring data across the UKLight circuit-switched network. UKLight is an optical R&D network, managed through UKERNA as a complement to the SuperJanet production network. It comprises a 10Gbps backbone to selected points in the UK and connects to global optical networks via 10Gbps links to Chicago (via StarLight) and Amsterdam (NetherLight).

Network protocol research and development of control mechanisms and interfaces by ESLEA have helped the pilot applications to exploit the UKLight network effectively.

A closing conference for ESLEA was held in Edinburgh, March 26-28, 2007 <www.nesc.ac.uk/esi/events/748>.

SC|05 HPC Analytics Challenge Award was awarded to the ESLEA "SPICE: Simulated Pore Interactive Computing Experiment" demonstration (University College London, University of Manchester, University of Edinburgh, Tufts University, TeraGrid, Nottingham University, NCSA/TeraGrid, Pittsburgh Supercomputing Center, Argonne National Lab, CCLRC Daresbury. This prize tied with one of Bob Grossman's applications, "Real Time Change Detection and Alerts from Highway Traffic Data."

Grid Interoperation Now (GIN) Testbed

http://goc.pragma-grid.net/gin/default.html

Collaborators

- PRAGMA; US and Pacific Rim
- TeraGrid; DOE Open Science Grid; US
- Enabling Grids for E-Science (EGEE); European Commission
- NorduGrid; Nordic Countries

GIN is a grass-root, multi-application international testbed to enable real science applications to run on a routine basis. Applications to be tested include Time-dependent density functional theory (TDDFT), Savannah, QM-MD, iGAP, Gamess-APBS, Siesta, Amber, FMO, HPM, GEON, Sensor, Ninf-G, Nimrod/G, Mpich-Gx, Gfarm, SCMSWeb, MOGAS.

GLEON

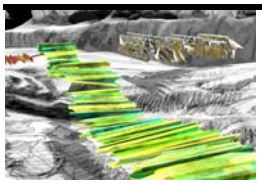
http://gleon.org

Collaborators

- University of Wisconsin-Madison, Trout Lake Research Station/Center for Limnology and Department of Civil and Environmental Engineering; University of California, San Diego, Calit2 and Center for Research on Biological Systems and San Diego Supercomputing Center; Archbold Biological Station; State University of New York-Binghamton, Thomas J. Watson School of Engineering; Indiana University-Bloomington, Pervasive Technology Labs; US
- Academia Sinica, Research Center for Biodiversity; National Center for High Performance Computing (NCHC); Taiwan
- University of Waikato, Centre for Biodiversity and Ecology Research; New Zealand
- Kangwon University, Center for Lake Management Research; Korea
- Centre for Ecology & Hydrology; UK
- University of Western Australia, Centre for Water Research; Australia
- Ontario Ministry of Environment, Dorset Environmental Science Centre, Inland Lakes; Canada
- University of Helsinki, Lammi Biological Station; Finland
- Israel Oceanographic & Limnological Reseasrch Ltd., Kinneret Limnological Laboratory; Israel
- Nanjing Institute of Geography & Limnology; China

GLEON is a grass roots association of limnologists, information technology experts and engineers 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 episodic events such as typhoons in resetting lake dynamics, and carbon cycling within lakes. The observatories will consist of instrumented platforms on lakes around the world capable of sensing key limnological variables and moving the data in near-real time to web-accessible databases.

Sensors used in lake observatories are capable of generating large amounts of data, though one does not typically think about gigabits of information when one thinks of sensors. At NCHC in Taiwan, ecological observations use HDTV cameras to stream information over optical networks controlled using Canada's UCLP. The following underwater images from Taiwan are provided courtesy of Fang-Pang Lin, NCHC.



GridJam: A Networked 3D Immersive Performance

http://jackox.net/pages/gridjampages/Gridjam1.html

Collaborators

- University of New Mexico, Fine Arts Department, ARTSLab and Center for High Performance Computing; Mills College; University of California, San Diego, Calit2; US
- University of Alberta; Canada
- De Waag; V2, Institute for the Unstable Media; The Netherlands

GridJam is an art and research project to study real-time, interactive, low-latency, partly improvised, 3D visualized musical performances. The Virtual Color Organ (VCO) is a 3D immersive environment in which music is visually realized in colored and image-textured shapes as it is being played.

The VCO visually illustrates information in a musical score, the composer's instructions to the musicians and the musicians' contributions to the score as they improvise in response to one another and to the immersive visual experiences. The VCO displays the emergent properties within the

meaning of music, both as information and as art.

Large Hadron Collider: UltraLight Data Analysis Tools

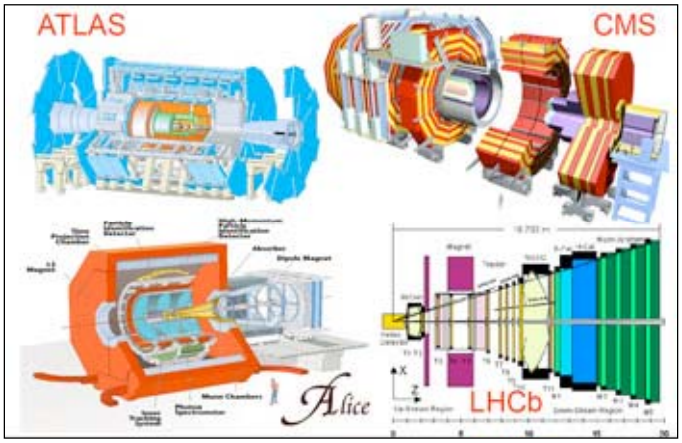
http://ultralight.caltech.edu/web-site/igrid

Collaborators

- CERN, Switzerland
- Department of Physics and Netlab, Caltech; Stanford Linear Accelerator Center (SLAC); Fermi National Accelerator Laboratory (Fermi); University of Florida; University of Michigan; Vanderbilt University; Cisco Systems; US
- Korea Advanced Institute of Science and Technology; Kyungpook National University; Korea
- University of Manchester; UK
- Universidade do Estado do Rio de Janeiro; Universidade Estadual Paulista; Universidade de São Paulo; Brazil

The Large Hadron Collider (LHC) is a particle accelerator and collider under construction at CERN, and is expected to become the world's largest and highest energy particle accelerator in 2008, when commissioning at 7 TeV is completed. The LHC is being funded and built in collaboration with over 2,000 physicists from 34 countries, universities and laboratories. When in operation, about 7,000 physicists from 80 countries will have access to the LHC, the largest national contingent being from the US. When it begins colliding particles, it will provide proton collisions for four large physics experiments that seek to expand our understanding of the universe <www.isgtw.org/?pid=1000416>.

- The ATLAS and CMS collaborations designed multi-purpose detectors; these will hunt for the Higgs boson, traces of supersymmetry and evidence of extra dimensions, among other things.
- ALICE aims to study the quark-gluon plasma, a new phase of matter expected at extreme energy densities.
- LHCb will examine beauty quark physics.



Analysis tools for use on advanced networks will enable physicists to control global grid resources when analyzing major high-energy physics events. Components of this "Grid Analysis Environment" are being developed by such projects as UltraLight, FAST, PPDG, GriPhyN and iVDGL.

Today, we believe US Tier-2 to/from European Tier1 sites go via the Internet2/GÉANT2 link by default, as one of hundreds of sets of "production" R&E traffic flows between the US and Europe. TransLight/StarLight is talking with Harvey Newman about utilizing more bandwidth on both the NYC/AMS and CHI/AMS links, effective June 2007. Newman will determine where the traffic from the various Tier-2s goes across the Atlantic, and will work with US Tier-1s (FermiLab and Brookhaven) regarding the location of Tier-1s in Europe. Note: Not all US Tier-2s connect to Internet2 as their preferred path. Some have separate 10Gbps links to StarLight, and are (so far) only able to use this path to get to the US Tier-1 at Fermilab. Others are working on getting a dedicated 10Gbps path to StarLight.

For the SC'06 Bandwidth Challenge, this team set new records for sustained data transfer between storage systems. Their demonstration of "High Speed Data Gathering, Distribution and Analysis for Physics Discoveries at the Large Hadron Collider" achieved a peak throughput of 17.77 Gbps between clusters of servers at the show floor and at Caltech. Following the rules set for the SC06 Bandwidth Challenge, the team used a single 10-Gbps link provided by National LambdaRail that carried data in both directions. Sustained throughput throughout the night prior to the bandwidth challenge exceeded 16 Gbps (or two Gigabytes per second) using just 10 pairs of small servers sending data at 9 Gbps to Caltech from Tampa, and eight pairs of servers sending 7 Gbps of data in the reverse direction.

First prize for the SC|05 Bandwidth Challenge went to the team from Caltech, Fermi and SLAC for

their entry "Distributed TeraByte Particle Physics Data Sample Analysis," which was measured at a peak of 131.57 Gbps of IP traffic. This entry demonstrated high-speed transfers of particle physics data between host labs and collaborating institutes in the US and worldwide. Using state-of-the-art WAN infrastructure and Grid Web Services based on the LHC Tiered Architecture, they showed real-time particle event analysis requiring transfers of Terabyte-scale datasets.

Large Hadron Collider: Worldwide LHC Computing Grid (LCG)

www.cern.ch/lcg/
www.eu-egee.org/
www.opensciencegrid.org/
www.gridtoday.com/grid/1181211.html

Collaborators

- CERN; Switzerland
- Open Science Grid (OSG); US
- Enabling Grids for E-SciencE (EGEE); Europe

In February 2006, a global collaboration of physicists and computer scientists developing the first truly worldwide grid computing infrastructure participated in a test, which saw data transferred around the world at a rate of up to one gigabyte per second. This test was a crucial step on the way to making LHC data available to scientists worldwide when it begins operating in 2008 at CERN. Data was transferred from CERN to 12 major computing centers around the globe, including Brookhaven National Laboratory and Fermi National Accelerator Laboratory (Fermilab), and to more than 20 other computing facilities, ten of which are located at US universities.

The global grid infrastructure, organized by the Worldwide LHC Computing Grid collaboration (WLCG), is built from international, regional and national grids such as OSG in the United States and EGEE in Europe. In the US, the OSG, together with Brookhaven, Fermilab and other collaborating institutions, provides computational, storage and network resources to fully exploit the scientific potential of two of the major LHC experiments: ATLAS (A Toroidal Large Hadron Collider Apparatus) and CMS (Compact Muon Solenoid).

Brookhaven serves as the Tier-1 center for the US ATLAS collaboration. For this experiment, Brookhaven received data at a rate higher than 150 megabytes per second from CERN. The data was then distributed to Tier-2 computing centers at Boston University, Indiana University, the University of Chicago and the University of Texas at Arlington at an aggregate rate of 20 megabytes per second.

Fermilab, the Tier-1 center for the US CMS collaboration, has already set records in data transfer from its computing center to CERN. In this challenge, Fermilab tested its brand new connections to six Tier-2 centers: Caltech; Purdue University; UCSD; the University of Florida; the University of Nebraska-Lincoln and the University of Wisconsin-Madison. Fermilab received data from CERN, archived it and replicated 50 terabytes to the Tier-2 centers where it was stored and retrieved for analysis – all using grid tools and infrastructure.

Note: January 2007, University of Chicago and Indiana University announced the MidWest Tier 2 Center, one of five Tier-2 (regional) centers in the US that will receive data from one of four massive LHC detectors. Physicists at Chicago and Indiana built components for the ATLAS particle detector, and also collaborate on scientific grid computing projects. Data from the ATLAS experiment will first flow to Tier-0, the main computational center at CERN. Tier-0 will then transmit the data to 11 Tier-1 centers worldwide, including Brookhaven. Brookhaven will, in turn, distribute portions of the CERN data to the various Tier-2 centers. The initial set of computer servers, data storage and networking equipment has been deployed in the basement of the Research Institutes building at the University of Chicago and at the Indianapolis campus of Indiana University, both of which will serve ATLAS data over the Open Science Grid. The sites are connected to the national infrastructure via 10Gbps wide-area connections. The Chicago-Indiana Tier-2 center is funded by annual $600,000 grants from NSF. The project also was made possible by investments from the states of Illinois and Indiana in I-WIRE (Illinois Wired/Wireless Infrastructure for Research and Education), and I-Light (Indiana's high-speed fiber optic network for higher education and research).

Microscopy Distributed Laboratory Demonstrator

www.nbirn.net

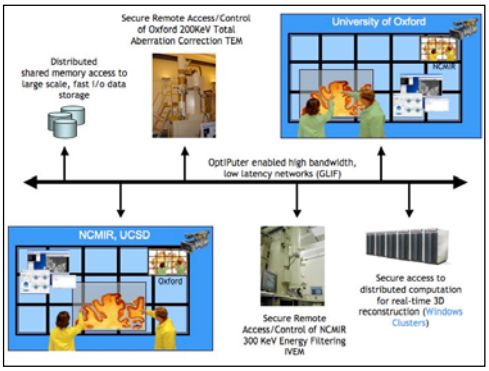
Collaborators

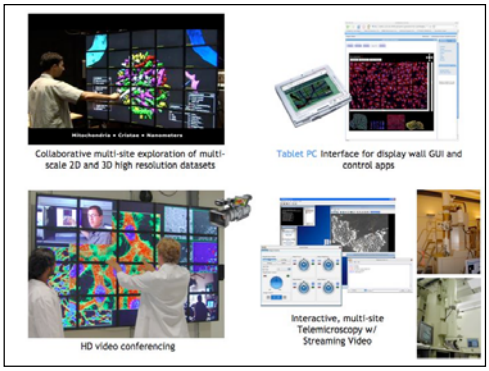
- UCSD, National Center for Microscopy Imaging Research (NCMIR); UCSD Center for Research in Biological Systems; UCSD Calit2; US
- Oxford University, Materials Research Center at Begbroke; Oxford e-Research Centre (OeRC); UK

With Microsoft funding, UCSD and Oxford University created a Microscopy Distributed Laboratory Demonstrator to provide a total collaboration solution for electron microscopy. The project's goal is to demonstrate how a Microsoft-enabled infrastructure can provide a solution for collaborative tele-instrumentation that scales beyond the singular capabilities being leveraged for this effort.

Biological and materials science electron microscopy are both challenged by a need to increase the collaborative use of rare and specialized instruments; effective solutions need to connect researchers to these unique resources, to one another, and to the data. For electron microscopy, this goal is complicated by a number of constraints. The imaging techniques are extremely data intensive, and the ability to process the 3D and 4D data at the time scales suitable for interactive collaboration typically requires more computational horsepower than is available at most advanced microscopy facilities. The further need for high-definition video to "steer" the instruments in real time requires next-generation networking performance that spans oceans, and more importantly, navigates last-mile hurdles. The exploration and analysis of massive data, especially to assist real-time control, requires visualization technologies that can integrate and interactively display ultra-high-resolution data from multiple sources and of multiple modalities (3D, 4D, streaming, etc.).

The Microscopy Distributed Laboratory Demonstrator will extend the switched LambdaGrid optical network project "OptIPuter," now active at UCSD, to Oxford University. Specifically, two of the world's most advanced electron microscopes in the US and UK will be featured. The instruments at UCSD and Oxford both represent the state of the art in intermediate voltage and aberration corrected geometries for TEM, with the instrument at Oxford being the world's only double corrected instrument (for both spherical and chromatic aberrations). The shared use of these resources represents a unique opportunity to link biological and materials science technical expertise across two leading resources, and provides a forum by which materials scientists and biologists can share expertise and experience.





OptIPuter and Global Lambda Visualization Facility (GLVF)

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

Collaborators

- Gwangju Institute of Science & Technology (GIST); Korea Institute of Science & Technology Information (KISTI); KRLight; South Korea
- SARA Computing and Networking Services; NetherLight; SURFnet; The Netherlands
- UIC Electronic Visualization Laboratory (EVL); StarLight; UCSD Calit2; UCSD National Center for Microscopy Imaging Research; UCSD Scripps Institution of Oceanography; NCSA; NCSA-TRECC; NCSA-ACCESS; Purdue University, Envision Center; University of Michigan, Collaboratory for Research on Electronic Work, (CREW); US Geological Survey (USGS), Earth Resources Observation Systems (EROS); US
- Kyoto University, Academic Center for Computing and Media Studies; National Institute of Advanced Industrial Science and Technology, Grid Technology Research Center; Japan

- Simon Fraser University; University of Alberta; CANARIE; Canada

The Global Lambda Visualization Facility (GLVF), established in September 2005, addresses the need to integrate visualization and collaboration technologies with global cyberinfrastructure. GLVF leverages networking infrastructure amassed as part of the Global Lambda Integrated Facility (GLIF). EVL is a founding member of GLIF. TransLight/StarLight is a GLIF resource and StarLight is a model for GLIF Open Lightpath Exchanges (GOLEs).

Having worked with OptIPuter/GLVF participants to prototype a global collaborative visualization environment for iGrid 2005, the KISTI Supercomputing Center wanted to demonstrate the benefits to Korea's Ministry of Science and Technology and to KISTI scientists in February 2006. KISTI, an OptIPuter partner, used its 100-Megapixel SAGE-enabled tiled display to show 5-6 high-definition streams sent simultaneously from partner sites in the US, Canada and The Netherlands. KISTI received an average of 3Gbps of information for several hours.

OptIPuter and NASA

www.evl.uic.edu/cavern/optiputer
www.evl.uic.edu/cavern/lambdaram

Collaborators
- University of Illinois at Chicago, Electronic Visualization Laboratory (UIC/EVL)
- NASA Goddard Space Flight Center, Software Integration & Visualization Office

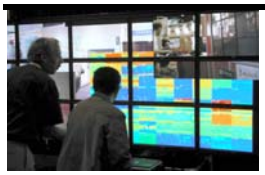
OptIPuter-developed network tools being developed by UIC/EVL (and tested over IRNC links with OptIPuter partners in The Netherlands) are getting interest from other communities.

Image Caption: Hurricane Katrina sea surface temperature, from August 23-30, 2005, is visualized. Ocean colors represent sea surface temperatures, and satellite images of the hurricane clouds are laid over the temperatures to clearly show the hurricane positions. Image courtesy of NASA Goddard Space Flight Center Scientific Visualization Studio.

As NASA's large scientific applications scale to greater numbers of processors, this creates Input/Output (I/O) bottlenecks. Applications like numerical weather prediction models, scientific data-analysis applications, and scientific visualizations can take advantage of EVL's LambdaRAM's approach to memory management. The global forecast models used in the Modeling, Analysis, and Prediction (MAP) project have substantial disk I/O latency in the analysis segment, which idles NASA's computer processors for 25-50% of the execution time. If this I/O latency is reduced, model results can be obtained faster!

The ability to quickly prefetch data from disk storage and temporarily store (or cache) it in a computer's memory, and then move the data from this "staging" computer to the computer running the weather simulation, assumes that the machines are all connected at high speed. Based on earlier experience and information gained as an OptIPuter partner, NASA Goddard was able to more easily install several high-speed networks within its facility, which connect to the nation-wide NASA Research & Education Network (NREN) 10Gbps backbone. Ultimately, the machines used to store, access and analyze data can be located at any NASA facility connected to Goddard at high speeds.

EVL recently made modifications to make LambdaRAM work seamlessly with a legacy application to locally access large data files. LambdaRAM allowed NASA to transparently access data files across multiple servers over high-speed networks, instead of from local disks. The next step is to analyze the performance of LambdaRAM and extend the work to other NASA applications, such as MAP.



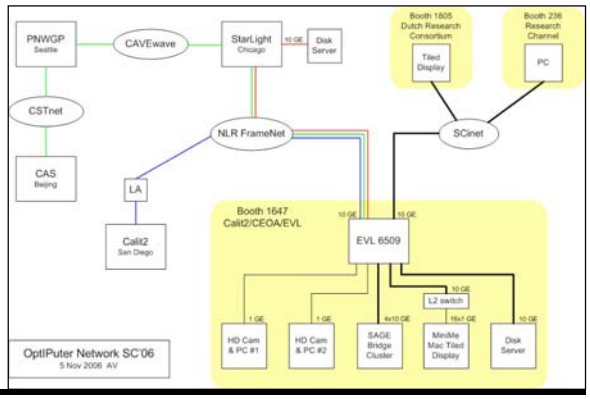
OptIPuter and SAGE Visualcasting

www.evl.uic.edu/cavern/sage

Collaborators
- University of Illinois at Chicago, Electronic Visualization Laboratory (UIC/EVL); University of Michigan; StarLight; US
- SARA Computing and Networking Services; NetherLight; SURFnet; The Netherlands

SAGE, the Scalable Adaptive Graphics Environment, is a window manager that enables the real-time streaming of extremely high-resolution content − such as ultra-high-resolution 2D and 3D computer graphics from remote rendering and compute clusters and storage devices, as well as high-definition video camera output − to scalable tiled display walls over high-speed networks. SAGE is funded by the NSF OptIPuter project.

At SC06, EVL demonstrated a new SAGE network service called *visualcasting* that supports global collaboration by enabling two or more users to share application content, sending multi-gigabit streams as required. Connected, participating endpoint sites form a virtual laboratory, as visualcasting enables everyone to see the same content at the same time. Endpoints can be of any size and configuration, varying from a single high-resolution monitor to room-sized tiled display walls. Each site maintains control of the layout (position, size, overlapping) of its displays. Visualcasting lets users select what information they want to send, and to whom. Unlike multicast, which requires network engineering, visualcasting is application-centric. Visualcasting was successfully demonstrated between the Calit2 and SARA booths at the SC06 conference.



Note: Per the networking diagram shown, StarLight and Pacific Northwest GigaPoP engineers connected CAVEwave to China's CSTNET 2.5Gbps network to Seattle, to attempt demonstrations with the Chinese Academy of Sciences, though delays in the SC06 convention center infrastructure (power, networking) gave us no time to test, so this collaboration will take place at another time.

Optical Multicast and High-Performance Digital Media

www.cct.lsu.edu/news/news/191

Collaborators

- Masaryk University; CESNET; Czech Republic
- Louisiana State University, Center for Computation and Technology; Northwestern University/iCAIR; StarLight; US

Louisiana State University (LSU) Center for Computation and Technology (CCT) professor Thomas Sterling, a renowned researcher in the field of high-performance computing (HPC), is teaching a Spring 2007 semester class "High-Performance Computing: Concepts, Methods and Means". It is the first course in the US being taught using high-definition (HD) video broadcast for distributed classroom instruction. The course is offered to students at LSU, Louisiana Tech University, University of Arkansas, MCNC in North Carolina, and Masaryk University in the Czech Republic.

The NSF IRNC TransLight/StarLight link between the US and Europe (as well as the SURFnet link) is being used to transmit uncompressed HD video streams to the Czech Republic; ultimately, the Czech Republic wants to use their 10Gbps CESNET link from Prague to Chicago, but technical problems delayed this. Statewide research and education optical networks Louisiana Optical Network Initiative (LONI) and the Arkansas Research and Education Optical Network (ARE-ON), and the nationwide optical network National LambdaRail, help support the course to locations in the US. Virtual presence requires high-quality HD video and two-way audio transmission with minimum latency. A single raw HD stream consumes about 1.5Gbps of bandwidth, and multi-site virtual meetings like this course can easily saturate a 10Gbps link. This far exceeds the on-demand bandwidth available on the Internet, though course organizers are distributing the course via the Internet to Access Grids at select sites that do not yet have their optical connections and/or HD technologies in place.

In collaboration with Nortel, Northwestern University is working on a dynamic optical multicast technique for disseminating streams in lieu of the stream replication method currently used. The optical multicast equipment and the computers used for multicast replication are homed at StarLight. L1 dynamic optical multicast and L2 multicast were demonstrated at SC 2006.

Phosphorus

http://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 global partners to develop 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 service 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 (NRNs), GÉANT, Cross Border Dark Fibre and GLIF connectivity infrastructures.

PRAGMA Grid Testbed

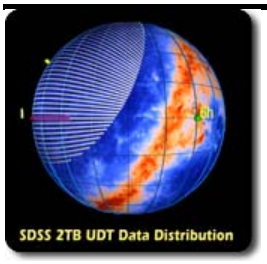
http://pragma-goc.rocksclusters.org/pragma-doc/org.html#INTRO

Collaborators

- Academia Sinica Grid Computing Center; National Center for High-performance Computing (NCHC); Taiwan
- Binghamton University; National Center for Supercomputing Applications (NCSA); San Diego Supercomputer Center (SDSC); University of Utah *[in preparation];* US
- Bioinformatics Institute (BII); Institute of High Performance Computing (IHPC); National Grid Office (NGO); Singapore
- Center of Investigation Science and Education at Superior Ensenada (CICESE); National University of Mexico; Mexico
- Computer Network Information Center, Chinese Academy of Sciences (CNIC); Graduate University of Chinese Academy of Sciences (GUCAS); Jilin University; Chinese University of Hong Kong *[in preparation];* China
- HCMC Institute of Information Technology (IOIT-HCM); Vietnam
- Korea Institute of Science and Technology Information (KISTI); Korea
- MIMOS Berhad; University Sains Malaysia; Malaysia
- Monash University (MU); Australia Partnership for Advanced Computing *[in preparation];* Queensland University of Technology *[in preparation];* Australia
- National Electronics and Computer Technology Center; ThaiGrid; Thailand
- National Institute of Advanced Industrial Science and Technology (AIST); Osaka University; Tokyo Institute of Technology; University of Tsukuba *[in preparation];* Japan
- University of Chile; Chile
- University of Hyderabad; India
- **University of Zurich (UZurich); Switzerland**

With Kim Baldridge of University of Zurich, the PRAGMA Grid is being used for Siesta/Nimrod: molecular simulation.

The PRAGMA (Pacific Rim Applications and Grid Middleware Assembly) Grid Testbed is composed of cluster systems and technical expertise from PRAGMA members and friends institutions. It provides the infrastructure and a collaborative environment for grid middleware and grid applications to interoperate and improve. It's also where PRAGMA researchers can innovate and experiment with new approaches and new solutions to make the grid easy to use.



Teraflow Testbed: High Performance Flows for Large Distributed Data Archives

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

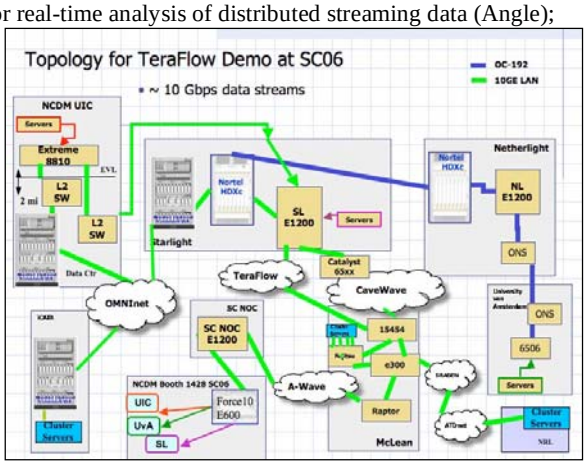
Collaborators

- University of Illinois at Chicago, National Center for Data Mining (NCDM); Johns Hopkins University; University of California, San Diego; NASA Goddard Space Flight Center; US
- 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
- With support from StarLight (US); TransPAC2 (US); JGN2 (Japan); KREONet2 (Korea)

Supported by NSF OCI-0430781 for the period October 1, 2004 – September 30, 2007, principal investigators: Robert Grossman and Alex Szalay (Johns Hopkins University).

The TeraFlow Project is developing data mining middleware to transport, explore and mine high-volume data flows. The Teraflow Project supports the development of several tools and applications, including UDT for high volume data transport, SOAP* for high-performance web services, and applications in several domains including astronomy, bioinformatics, and sensor networks, built over UDT, SOAP*, and related tools. Part of the project includes the operation of the Teraflow Testbed, an international application testbed for exploring, analyzing, integrating and detecting changes in massive and distributed data over wide-area high-performance networks. The Teraflow Testbed has nodes in Chicago, Kingston, Amsterdam, Geneva, Daejeon, and Tokyo connected by 1Gbps and 10Gbps wide-area networks. The Teraflow Testbed is currently used to distribute the Sloan Digital Sky Survey data to researchers worldwide. It is also used in experiments to detect changes in high volume data flows.

The Teraflow Testbed 2, introduced at SC 2006, will soon be extended from Chicago to UCSD/Calit2 over CAVEwave. Teraflow Testbed 2 will support persistent data services for moving large scientific data sets (Sector); persistent data services for real-time analysis of distributed streaming data (Angle); and, next-generation distributed storage, data, and integration services. It will have several dedicated paths using fiber from NLR, as well as several shared optical paths to other sites.



Using a subset of this Testbed (illustrated here), NCDM won the SC06 Bandwidth Challenge. Its entry, "Transporting Sloan Digital Sky Survey Data using SECTOR," sustained a disk-to-disk data-transfer rate of 8Gbps over a shared 10Gbps routed link between SC'06 (Tampa), UIC and StarLight, with a peak rate of 9.18Gbps. StarLight network engineers greatly assisted.

Whole Atmosphere Community Climate Model

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

The Whole-Atmosphere Community Climate Model (WACCM) is a comprehensive numerical model, spanning the range of altitude from the Earth's surface to the thermosphere. The development of WACCM is an 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.

NCAR collaborates with Spanish colleagues on WACCM climate simulations; in particular, Ricardo Garcia Herrera at the Universidad Complutense de Madrid and the Barcelona Supercomputer Center (BSC), where the simulation is run. Storage space at BSC is very limited, so NCAR wants to transfer ~30GB of data daily during model runs to store on NCAR's MSS.

2.B.6. Other NSF-Funded Infrastructure Leveraging of Resources

Application-Level Performance Measurement

We maintain that meaningful lambda usage measurements are those taken by the applications themselves. EVL has developed, as part of the OptIPuter project, several UDP-based streaming transport protocols, notably LambdaStream and Reliable Blast UDP (RBUDP). These are used among OptIPuter partners, over CAVEwave and TransLight/StarLight, as development and testing requires. Several papers have been written on these protocols, which have been presented at major conferences.

Lambda Control and Management

UIC/EVL graduate student Eric He recently received his PhD for implementing the *Photonic Inter-domain Negotiator (PIN)*, an inter-domain optical signaling gateway that enables applications to make lightpath reservations spanning multiple optical domains. PIN research was supported by NSF OCI-0229642 (STI StarLight), OCI-0123399 (Optical Networking: Intelligent Signaling and Control) and OCI-0225642 (OptIPuter). PIN development was done over the NSF HPIIS Euro-Link link (the precursor to TransLight/StarLight), and over TransLight/StarLight.

PIN supports inter-domain routing, signaling and global resource discovery. It translates application-initiated signaling requests into native signaling protocols for each sub-domain, allowing applications to be coded once, yet operate over heterogeneous optical domains.

PIN invokes a control layer interface called *PDC (Photonic Domain Controller)*, which has been developed over the basic switching classes to manage lightpaths. PDC sends TL1 commands to EVL's Calient and/or Glimmerglass switches to set up and tear down optical inter-connections and query the list of connections from a switch.

Data-intensive applications can significantly benefit from new methods of dynamic digital communication provisioning, based on advanced optical technologies; i.e., new methods that allow for instantaneous on-demand lightpath provisioning and optimized L2 switched paths. In addition to dynamic provisioning, wavelength-based services can be optimized through various methods for advanced scheduling.

2.C. Research Training

National Research Network (NRN) management and engineers from Internet2, ESnet, DANTE and NLR 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 would 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 organized the iGrid 2005 in San Diego in September 2005, and we participate in the annual SC conferences to promote the goals of IRNC and TransLight/StarLight.

3. Publications and Products

3.A. Journals/Papers

E. He, X. Wang, V. Vishwanath, J. Leigh, "AR-PIN/PDC: Flexible Advance Reservation of Intradomain and Interdomain Lightpaths," IEEE GLOBECOM 2006, November 27-December 1, 2006.

X. Wang, V. Vishwanath, B. Jeong, R. Jagodic, E. He, L. Renambot, A. Johnson, J. Leigh, "LambdaBridge: A Scalable Architecture for Future Generation Terabit Applications," Broadnets 2006 --Third International Conference on Broadband Communications, Networks, and Systems, sponsored by IEEE Communications Society/Create-Net, October 1-5, 2006, San Jose, CA. Papers available via IEEE Xplore.
<http://www.evl.uic.edu/core.php?mod=4&type=3&indi=307>

Eric He, Xi Wang, Jason Leigh, "Flexible Advance Reservation Model for Multi-domain WDM Optical Networks," GridNets 2006: 3rd International Workshop on Networks for Grid Applications, (co-located with BroadNets) <http://gridnets.org/2006>, October 1-2, 2006, San Jose, California.
<http://www.evl.uic.edu/core.php?mod=4&type=3&indi=305>

Maxine Brown, Larry Smarr, Tom DeFanti, Jason Leigh, Mark Ellisman, Phil Papadopoulos, "The OptIPuter: A National and Global-Scale Cyberinfrastructure for Enabling LambdaGrid Computing," TeraGrid '06 Proceedings, Indianapolis, IN, June 12-15, 2006.

V. Vishwanath, J. Leigh, E. He, M.D. Brown, L. Long, L. Renambot, A. Verlo, X. Wang, T.A. DeFanti, "Wide-Area experiments with LambdaStream over dedicated high-bandwidth networks," IEEE INFOCOM High-Speed Networking Workshop: The Terabit Challenge 2006, Barcelona, SPAIN, April 24-26, 2006, CD-ROM

V. Vishwanath, P. Balaji, W. Feng, J. Leigh, D.K. Panda, "A Case for UDP Offload Engines in LambdaGrids," Proceedings of The Fourth International Workshop on Protocols for Fast Long-Distance Networks (PFLDnet 2006), Nara, Japan, February 2-3, 2006, <www.hpcc.jp/pfldnet2006/technical.html>.

3.B. Books/Publications

Eric He, A Flexible Advance Reservation Model for Multi-Domain WDM Optical Networks, PhD dissertation, Electronic Visualization Laboratory, Computer Science Department, University of Illinois at Chicago, 2006.

Larry Smarr, Maxine Brown, Tom DeFanti and Cees de Laat (guest editors), Special issue on the International Grid (iGrid) 2005 Workshop, Future Generation Computer Systems/The International Journal of Grid Computing: Theory, Methods and Applications, Elsevier B.V., Volume 22, Issue 8, Elsevier, October 2006, pp. 849-1054.

3.C. Internet Dissemination

www.startap.net/translight

3.D. Other Specific Products

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

4. Contributions

4.A. Contributions within Discipline

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), national networking groups (Internet2, ESnet and NLR) and foreign NRN (DANTE and SURFnet) technical and administrative contacts.

4.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'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 a unique infrastructure to study the effects of long-distance, high-bandwidth networks on advanced applications.

4.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) 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.

4.D. Contributions to Resources for Research and Education

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

4.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.

5. Special Requirements

5.A. Objectives and Scope

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

5.B. Special Reporting Requirements

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

5.C. Animals, Biohazards, Human Subjects

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

6. Program Plan

6.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.

6.B. Proposed Activities

6.B.1. Capacity Planning and Circuit Upgrades

Working with SURFnet, we have co-procured and implemented two 10Gbps transatlantic CHI/AMS networks, one paid for by IRNC, one by SURFnet, between StarLight and NetherLight. We are in the process of load balancing to handle the specific demands of GLORIAD (3Gbps), the Teraflow Testbed, CESnet, CAVEwave/CineGrid, 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.

Working with SURFnet, we have also co-procured two 10Gbps transatlantic NYC/AMS networks, one paid for by IRNC, one by SURFnet, between MAN LAN and NetherLight. We are in the process of considering circuit sharing techniques for Internet2-NLR, and ESnet traffic to GÉANT2 when and if the need to isolate the connections emerges, and how this interacts with the new GÉANT2 Washington DC link. 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 (see Section 2.A.3, PoP Connectivity and Peering – NYC/AMS, IRNC Circuit Diagram 2).

6.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 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)

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, in which Alan Verlo is an active member <http://www.glif.is/working-groups/tech/lightpath-measurement-0.9.pdf>.

6.B.3. Community Support and Satisfaction

We will work with Internet2-NLR, SURFnet/NetherLight, ESnet, 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, and GLIF meetings, as appropriate.