TransLight/StarLight Enables iGrid Applications

Maxine Brown
iGrid Co-Chair
TransLight/StarLight, Co-Principal Investigator
University of Illinois at Chicago

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iGrid Workshop: September 26-29, 2005
GLIF Meeting: September 29-30, 2005
Maxine Brown and Tom DeFanti, Co-Chairs
Larry Smarr and Ramesh Rao, Hosts
iGrid 2005 is...

- 4th community-driven biennial International Grid event
  - To accelerate the use of multi-10Gb international and national networks
  - To advance scientific research
  - To educate decision makers, academicians and industry researchers on the benefits of hybrid networks
- ~450 attendees from 24 countries
- ~130 participating organizations, academic and industrial
- iGrid demonstrates how a transformed cyberinfrastructure – going from a bandwidth-constrained to a bandwidth-rich world – enables global teams to interactively obtain, analyze, and share vast amounts of distributed data.
- 49 demonstrations showcasing global experiments in e-Science and next-generation shared open-source LambdaGrid services
- 20 countries: Australia, Brazil, Canada, CERN, China, Czech Republic, Germany, Hungary, Italy, Japan, Korea, Mexico, Netherlands, Poland, Russia, Spain, Sweden, Taiwan, UK, USA
- 25 lectures, panels and master classes as part of a symposium
GLIF – Global Lambda Integrated Facility

- GLIF is the international virtual organization creating a world-scale LambdaGrid laboratory
  - Driven by the demands of application scientists
  - Engineered by leading network engineers
  - Enabled by grid middleware developers

More than 150Gb GLIF transoceanic bandwidth alone; 100Gb of bandwidth into the Calit2 building!
All groups are part of GLIF; all links used to support iGrid applications

TransLight/StarLight provides two 10Gbps connections between the USA and Europe for production science

- 10Gb routed connection between the pan-European GÉANT2 network facility in Amsterdam and the USA's Abilene and ESnet networks at the Manhattan Landing (MAN LAN) telco building in New York City
- 10Gb switched connection connecting the NetherLight optical exchange in Amsterdam to the StarLight optical exchange in Chicago, and part of the LambdaGrid fabric being created by participants of the GLIF

TransLight/StarLight principal investigator is Tom DeFanti, University of Illinois at Chicago; co-principal investigator is Maxine Brown
iGrid’s Biggest Challenge…

Transforming a construction site…
iGrid’s Biggest Challenge...

...into a leading-edge cyberworld
iGrid 2005
September 26-29, 2005, San Diego, California

• Traditional Grid middleware, based on Service-Oriented Architectures over the shared Internet, is being transformed into a LambdaGrid over the GLIF optical infrastructure, integrated with Web Services
• iGrid 2005 demonstrates how research “pioneers” are restructuring their codes for the LambdaGrid to take advantage of this new infrastructure as it matures – so that a second generation of “homesteaders” will show up and start using the infrastructure to do science
• iGrid 2005 demonstrates global experiments in e-Science and next-generation shared open-source LambdaGrid services:
  – Data
  – High-definition video and digital cinema streaming
  – High-performance computing
  – Lambda services
  – Scientific instruments
  – Visualization and virtual reality
iGrid Data Services

- **Data Reservoir** – University of Tokyo, Fujitsu Computer Technologies, Japan; Pacific Northwest GigaPoP, USA
  - 10Gb TCP flows over IPv4 and IPv6 for distributed data sharing
- **DataWave** – Northwestern University, Nortel, UIC, USA; University of Amsterdam, NL
  - Very large data transfers over lightpaths from data-file-to-data-file
- **Exploring Data Using Teraflows** – UIC, Northwestern University, USA: University of Amsterdam, NL; CERN; Kyushu Institute of Technology, Japan; Queens University, Canada
  - Data services using Layer-3 protocols over lightpaths
- **From Federal Express to Lambdas** – UIC, Johns Hopkins University, USA; Korea Astronomy and Space Science Institute, KISTI, Korea; University of Tokyo, Japan; National Astronomical Observatory, Chinese Academy of Sciences, China; University of Melbourne, Australia; Max-Planck-Institut fur Plasmaphysik, Germany
  - SDSS data transported using UDT protocol over routed and optical networks
- **LightForce** – Northwestern University, UIC, Nortel, USA; Nortel, Canada; University of Amsterdam, NL
  - Multiple gigabits of data sent to multiple nodes over lightpaths
- **Transfer of Cosmic Ray Data from Tibet** – Chinese Academy of Sciences, China; Istituto Nazionale di Fisica Nucleare, Italy
  - Tools to move 200TB/year of data from the Sino-Italian Yangbajing (YBJ) International Cosmic Ray Observatory, to be online 2007
iGrid High-Definition Video and Digital Cinema Streaming

- **Global N-Way Interactive Conferencing** — ResearchChannel, University of Washington, Pacific Northwest GigaPoP, University of Wisconsin-Madison, USA; AARNet, Australian Partnership for Advanced Computing, Australia; SURFnet, NL; WIDE, Japan
  - High-resolution, uncompressed HDTV communication among multiple sites

- **HD Multipoint Conference** — Masaryk University, CESNET, Czech Republic
  - Raw HD multicast over optical networks

- **Interactive 3D HD Video** — KISTI, Kyungpook National University, Gwangju Institute of Science and Technology, Korea Advanced Institute of Science and Technology, Korea; CANARIE, Canada
  - Uncompressed and compressed mono and stereo HD video, as well as distributed data grid tools designed as a part of the CMS/LHC project

- **International Real-Time 4K Digital Video** — Pacific Interface Inc, UIC, Calit2, USA; Keio University, NTT Network Innovations Laboratories, Digital Cinema Technology Forum and Digital Cinema Consortium of Japan, Japan
  - Live, pre-recorded and real-time 4K content (4 x HDTV) compressed and streamed in real-time via 1Gb IP networks, from Tokyo to San Diego

- **Large-Scale Multimedia Delivery** — Poznan Supercomputing and Networking Center, Poland
  - The Polish National Public Television delivery system for TV, video-on-demand and audio-on-demand with interactive access over broadband
iGrid High-Performance Computing

• Adaptive Mesh Refinement Optical Enzo Backplane Architecture Enabled Application – Northwestern University, USA; University of Amsterdam, NL
  – AMROEBA-EA achieves similar/better performance by distributing data-intensive simulations to many clusters over lightpaths, versus running on 1 supercomputer

• Interactive Control – University of Minnesota, Fond du Lac Tribal and Community College, PSC, USA
  – Real-time computational steering, visualization and data analysis of volume rendered images from supercomputer data

• Large-Scale Sim/Viz with GridLab – Poznan Supercomputing and Networking Center, PIONIER, Poland; Louisiana State University, USA; Masaryk University, Czech Republic; Konrad Zuzse Zentrum, Germany; Vrije University, NL; SZTAKI, Hungary; University of Lecce, Italy; Cardiff University, UK
  – The European GridLab’s grid tools and middleware include capabilities such as dynamic resource brokering, monitoring, data management, security, information, and adaptive services
iGrid Lambda Services

iGrid 2002 demonstrated the early phases of optical networking infrastructure; iGrid 2005 showcased many demonstrations of applications control of optical networks.

- **World’s First X GRID UCLP Switching** – CANARIE, Communications Research Centre, University of Waterloo, Canada; i2CAT/Universitat Politcnica de Catalunya, Spain; NCHC, Taiwan; KISTI, Gwangju Institute of Science and Technology, Korea
  - CANARIE and CRC in Canada, NCHC in Taiwan, KISTI in Korea and i2CAT in Spain dynamically controlled the setup and switching of lightpaths to various grid resources worldwide using CANARIE’s UCLP (User Controlled LightPath) management software
    - UCLP-Enabled Virtual Design Studio (CRC, Canada)
    - Interactive 3D HD Video Transport and Collaborative Data Analysis for e-Science over UCLP (Korea)
    - GridON – Interactive Simulation with Grid Productor/Consumer (Spain)
    - Real-Time Observational Multiple Data Streaming and Machine Learning for Environmental Research using Lightpaths (Taiwan)
iGrid Lambda Services

- **Global Lambdas for Physics** – Caltech, Stanford Linear Accelerator Center, Fermi National Accelerator Laboratory, University of Florida, University of Michigan, Cisco, GLORIAD, USA; CERN; Korea Advanced Institute of Science and Technology, Kyungpook National University, Korea; Universidade do Estado do Rio de Janeiro, Brazil; University of Manchester, UK
  - The “Grid Analysis Environment” enables physicists to do on-demand network and resource provisioning for event analysis from desktops

- **Coordination of Grid Scheduler and Lambda Path Service Over GMPLS** – National Institute of Advanced Industrial Science and Technology, KDDI R&D Laboratories, NTT Network Innovation Laboratories, NiCT Tsukuba JGN-II Research Center, NiCT Osaka JGN-II Research Center, Japan
  - Schedule lightpaths provided by commercial network providers

- **Dynamic Provisioning** – Internet2, Hybrid Optical and Packet Infrastructure Project Design Team, Argonne National Laboratory, Mid Atlantic Crossroads GigaPoP, Information Sciences Institute, MIT Haystack, USA; NiCT, Japan; Onsala, NORDUnet, Sweden; JIVE, Westerbork Observatory/ASTRON, NL; National e-Science Centre Edinburgh, University of Manchester, University College London, UKLight, UK
  - Goal: real-time VLBI radio telescope data correlation from the USA (MIT Haystack, GGAO), Japan (Kashima) and Europe (Onsala in Sweden, Jodrell in the UK, Westerbork in The Netherlands); achieved 512Mb transfers from USA and Sweden to MIT, results streamed to iGrid.
  - Optical connections dynamically managed using the DRAGON (Dynamic Resource Allocation over GMPLS Optical Networks) control plane and Internet2 HOPI network.

- **First Optical Virtual Concatenation (OVC)/Terabit LAN** – NTT Network Innovation Laboratories, Japan; UIC, USA
  - Assigns parallel streams (e.g., streaming media) “virtual” identical paths in case of path diversity, thereby eliminating latency or jitter
iGrid Lambda Services

- **International 10Gb Security** – Nortel, Canada; UIC, Argonne National Laboratory, Calit2, Northwestern University, USA; SARA Computing and Networking Services, NL
  - Nortel’s real-time hardware encryption over Layer-1 networks
- **IPv4 Link-Local IP Addressing** – University of Amsterdam, NL
  - Automatically create end-node IPv4 link-local addresses when creating lightpaths
- **Secure Photonic Interdomain Negotiator (SPIN) with Integrated Services Optical Network (ISON)** – UIC, USA
  - SPIN supports secure interdomain access and ISON supports a multi-purpose LambdaGrid for multimedia collaborative applications with diverse network requirements
- **Token-Based Network Element** – University of Amsterdam, NL
  - A grid authentication technique in which a token is used to open a data path.
- **VM Turntable** – Nortel, Northwestern University, USA; Nortel, Canada; University of Amsterdam, NL
  - Real-time migration of a computation while supporting live applications


iGrid Scientific Instruments

- **20,000 Terabits Beneath the Sea** – University of Washington, UCSD Scripps Institution of Oceanography, Calit2, ResearchChannel, Pacific Northwest GigaPoP, USA
  
  - First real-time, uncompressed HDTV from deep-sea, high-temperature venting systems associated with active underwater volcanoes
iGrid Scientific Instruments

• **Real-Time Brain Data Acquisition** – UCSD, UIC, Northwestern University, Osaka University, KDDI R&D Laboratories, Japan; NCHC, Taiwan; University of Amsterdam, NL; KISTI, Korea
  – OptIPuter-developed technologies – lambda control, transport protocols, middleware, and SAGE – are used to run a multi-scale correlated microscopy experiment where a biologist images a sample and progressively magnifies it, zooming from an entire system

• **Real-Time Observational Data Streaming** – NCHC, National Museum of Marine Biology & Aquarium, Academia Sinica, Taiwan; SDSC, Calit2, UCSD, USA; Nara Institute of Science and Technology, Osaka University, Japan; CANARIE, Canada; Edinburgh University, UK
  – Mono and stereo underwater HD cameras stream images from Taiwan’s EcoGrid

• **Virtual Laboratory on Demand** – Poznan Supercomputing and Networking Center, Poland
  – VLAB enables users to directly access and monitor remote grid resources, such as in chemistry (spectrometer), radio astronomy (radio telescope) and medicine (CAT scanner)
GLVF is an environment to compare network intensive visualization techniques on various display systems, and to create a persistent HDTV portal for real-time collaboration with GLIF colleagues

- **Scalable Adaptive Graphics Environment (SAGE)** – UIC, USGS, Univ. of Chicago, USA; SARA Computing and Networking Services, NL; KISTI, Korea
  - Displays multiple incoming streams of computer graphics and live HDTV on the 100Megapixel LambdaVision; CytoViz displays network statistics of streams

- **Unreliable Stream** – SARA Computing and Networking Services, NL
  - Transfers images using UDP, a lossy network protocol, which may result in temporary visual artifacts

- **NCSA Streaming Stereo** – NCSA, UIC, USA
  - A bulk movie playback package (bplay) integrated into SAGE

- **Personal Varrier** – UIC, USA
  - Auto-stereo display that integrates 3D images into the work environment

- **Solutions Server** – Simon Fraser University, University of Alberta, Canada
  - Streams visualizations to computer consoles of distantly located scientists and engineers over Canada’s WestGrid network; to be integrated with UCLP
iGrid Visualization

- **Dead Cat** – University of Amsterdam, NL
  - Viewing remote CT scan data of a panther on a local small handheld display device

- **Grid-Based Pipeline** – Information Sciences Institute, UIC, USA
  - Grid Visualization Utility enables interactive browsing of large, time-series volumetric datasets by coordinating remote resources for data storage, filtering and rendering

- **GridON** – i2CAT/Universitat Politcnica de Catalunya, Spain; Communications Research Centre, Canada
  - Raw SDI video is converted to MPEG-2; UCLP used to create lightpaths to remote resources

- **Interactive Visualization across LONI** – Louisiana State University, MCNC, NCSA, Lawrence Berkeley National Laboratory, USA; Masaryk University, CESNET Czech Republic; Zuse Institute Berlin, Germany; Vrije Universiteit, NL
  - Computational steering and visualization of complex simulations over optical networks employ Europe’s Grid Application Toolkit (GAT); also, HD multicast with Czech Republic
iGrid Visualization

- **Real-Time True-3D Viz** – Physical Optics Corporation, NASA GSFC, NASA GSFC-SWALES, University of Maryland, USA
  - NASA and Physical Optics Corporation demonstrate a holographic 3D HDTV video display

- **Scientific Collaboration with Earth Science** – Scripps Institution of Oceanography, UCSD, Calit2, USA
  - The transfer of multi-gigabyte 3D Earth Science objects among remote collaborating sites uses OptIPuter middleware

- **UCLP Virtual Design Studio (VDS)** – Carleton University Immersive Media Studio, Communications Research Centre, National Research Council, Canada
  - VDS uses UCLP to access remote visualization and data cluster arrays to create a sophisticated urban and architectural design environment
iGrid Virtual Reality and Cultural Heritage

- **Cabinet of Dreams** – Indiana University Bloomington, Indianapolis Museum of Art, EVL/UIC, San Diego State University, USA; International Media Centre (IMC), GLORIAD/Chinese Academy of Sciences, China
  - Virtual reality of the Indianapolis Museum of Art’s Chinese art collection

- **Collaborative Analysis** – Sandia National Laboratories, USA; High Performance Computing Center Stuttgart (HLRS), Germany
  - Mixed reality sessions in which humans interact with architectural virtual environments containing vehicles and dynamic cognitive human avatars

- **Great Wall Cultural Heritage** – International Media Centre, Great Wall Society, GLORIAD/Chinese Academy of Sciences, Chinese Institute of Surveying and Mapping, China; San Diego State University, SDSC, GLORIAD/University of Tennessee-Oak Ridge National Laboratory Joint Institute for Computational Sciences, University of Texas-Dallas, University of Idaho, Stanford University, USA
  - Visualizations of the Jinshanlin Section of the Great Wall, located in the Hebei Province of China, constructed during the Ming Dynasty

- **Rutopia2** – UIC, Indiana University Bloomington, University at Buffalo, GLORIAD, USA; Russian Academy of Sciences, Russia
  - A Russian folktale of utopian environments

- **Virtual Unism** – UIC, Gosia Koscielak Studio & Gallery, Indiana University at Bloomington, University of Buffalo, GLORIAD, USA; Russian Academy of Sciences, Russia
  - An exploration of Unistic art theories from the 20th century
iGrid e-Science

• Exploitation of Switched Lightpaths for eScience Applications (ESLEA) – National e-Science Centre Edinburgh, University of Manchester, University College London, UKLight, UK; Internet2, Hybrid Optical and Packet Infrastructure Project Design Team, Argonne National Laboratory, Mid Atlantic Crossroads GigaPoP, Information Sciences Institute, MIT Haystack, USA; NiCT, Japan; Onsala, NORDUnet, Sweden; JIVE, Westerbork Observatory/ASTRON, NL
  – ESLEA applies switched lightpaths to scientific applications using UKLight: high-energy physics (protocols for moving data disk-to-disk), computational science (remote computational steering and visualization), and radio astronomy

• Human Arterial Tree – Argonne National Laboratory, University of Chicago, Northern Illinois University, Brown University, USA
  – First human arterial tree simulation contain the body’s largest 55 arteries with 27 artery bifurcations at a fine-enough resolution to capture the flow dynamics as well

• Opening Fiber Highway Mexico/USA – CUDI, CICESE, CONACyT, Telmex, Mexico; SDSU, Stanford University, UCSD; USA
  – San Diego/Tijuana connectivity, ultimately to CICESE in Ensenada, enables joint research in Earth, oceanographic and atmospheric sciences

• PRIME – UCSD, USA; Osaka, Japan; CNIC, China; Monash (APAC), Australia; NCHC, Taiwan
  – UCSD undergraduates discuss experiences working at PRAGMA destinations in Australia, China, Japan, and Taiwan this past summer
CERN’s Large Hadron Collider will come online

- Global Lambdas for Particle Physics Analysis – *USA, CERN, Brazil, Korea, UK*
- Interactive 3D HD Video Transport and Collaborative Data Analysis for e-Science over UCLP – *Korea*

The Sino-Italian ARGO-Yangbajing (YBJ) International Cosmic Ray Observatory in the YBJ valley of the Tibetan highland will be fully operational

- Transfer, Process and Distribution of Mass Cosmic Ray Data from Tibet – *China, Italy*

Japan’s 2-PFLOPS system being developed as part of the GRAPE-DR project will be operational

- Data Reservoir on IPv6: 10Gb Disk Service in a Box – *Japan*
Where is the Next Technology Leap?

• **GLIF Mission:** To create and sustain a Global Facility supporting leading-edge capabilities, especially those based on new and emerging technologies and paradigms related to advanced optical networking, that enable high-performance applications and services.

• **iGrid Mission:** To provide a forum and testbed for the world’s premiere e-science research community – including network engineers, middleware developers, application scientists – to work together to tackle the demands created by new and emerging technologies and paradigms in high-performance computing and networking.
iGrid 2005 Acknowledgments

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Thank You!

- www.igrid2005.org
- www.startap.net/translight
- www.glif.is