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Editorial

Special section: iGrid 2005: The Global Lambda Integrated Facility

Larry Smarr[a], Thomas A. DeFanti[a,b], Maxine D. Brown[b,*], Cees de Laat[c]

[a] *California Institute for Telecommunications and Information Technology (Calit2), University of California, San Diego, CA, USA*
[b] *Electronic Visualization Laboratory, University of Illinois at Chicago, IL, USA*
[c] *Advanced Internet Research group, Universiteit van Amsterdam, Amsterdam, Netherlands*

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iGrid 2005 was the fourth community-driven biennial International Grid event, held on 26–30 September 2005 at the California Institute for Telecommunications and Information Technology (Calit2) building on the campus of the University of California, San Diego. iGrid events are coordinated efforts to accelerate the use of multi-gigabit international and national networks, to advance scientific research, and to educate decision makers, academicians and industry researchers on the resulting benefits.

Attracting 450 participants, iGrid 2005 featured 49 real-time application demonstrations developed by multidisciplinary teams from 20 countries, as well as a symposium of 25 lectures, panels and master classes on the applications, middleware, and underlying cyberinfrastructure that was used. At its core, this cyberinfrastructure uses *supernetworks* rather than *supercomputers* as its central architectural element, which is constructed from multiple wavelengths of light (lambdas) on single optical fibers. New middleware technologies are enabling applications to dynamically manage these lambda resources just as they do any grid resource, creating a *LambdaGrid* of interconnected, distributed, high-performance computers, data storage devices, visualization displays and instrumentation.

A world-scale LambdaGrid laboratory, driven by the demands of application scientists, engineered by leading network engineers, and enabled by grid middleware developers, is being created by the international virtual organization GLIF, the Global Lambda Integrated Facility. GLIF provided the persistent high-performance infrastructure that iGrid participants used, shown in Fig. 1, and iGrid provided the forum for global teams to demonstrate advancements in scientific collaboration and discovery that this infrastructure is enabling. GLIF held its annual meeting on the last day of iGrid 2005.

Previous iGrids in 1998, 2000 and 2002, and GLIF's organization that began with a Lambda Workshop held in Amsterdam in 2001, have rapidly led to the worldwide establishment of dozens of interconnected 10-Gigabit lambdas. Since the last iGrid, there has been a global movement to support a wide range of e-science projects by adopting Service-Oriented Architectures for the middleware that rides on top of the physical infrastructure.

iGrid 2005 demonstrated global "grass-roots" application experiments combined with collegial "best-of-breed" processes to develop a new generation of shared open-source LambdaGrid Services. These Services, most of which are documented in this Journal, supported: scientific instruments, high-definition-video and digital-cinema streaming, visualization and virtual reality, high-performance computing, data analysis, and the control of the underlying lambdas themselves. These Services were in support of very-large-scale e-science applications – such as astronomy, bioinformatics, ecology, geoscience, and high-energy physics – that study very complex micro- to macro-scale problems over time and space. Participating teams represented: Australia, Brazil, Canada, China, Czech Republic, Germany, Hungary, Italy, Japan, Korea, Mexico, Netherlands, Poland, Russia, Spain, Sweden, Taiwan, the United Kingdom, the United States and the international laboratory CERN (the European Organization for Nuclear Research).

The process of building the LambdaGrid is reminiscent of the effort to build up a networked supercomputing infrastructure in the United States 20 years ago. At first there was hardly any *real* science being done. Rather, a few pioneering scientists restructured their codes to understand how to best take advantage of the high-performance hardware (e.g., vector processors), to create scientific visualizations, and to remotely control the supercomputer in real time. Gradually, as the supercomputing hardware and software matured, a second generation of *homesteaders* showed up and started using the infrastructure to do science. We are still in the pioneering phase of LambdaGrids, but by 2007, as new large-scale instruments come online, research should advance sufficiently enough to be all about homesteading science that can be done with the global

* Corresponding author. Tel.: +1 312 996 3002; fax: +1 312 413 7585.
E-mail address: maxine@uic.edu (M.D. Brown).

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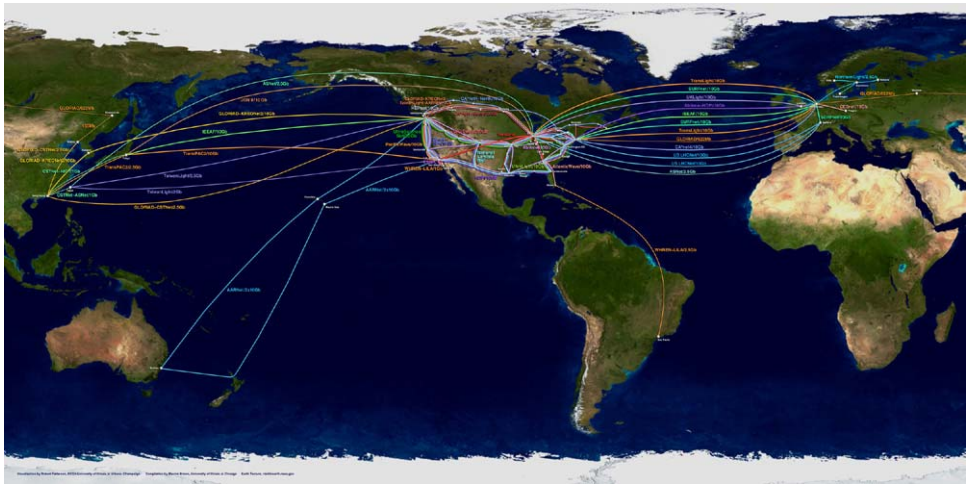

Fig. 1. September 2005. This map illustrates the Global Lambda Integrated Facility (GLIF) infrastructure partly used for the iGrid 2005 Workshop. To create this infrastructure, National Research & Education Networks (NRENs), countries, consortia, institutions and individual research initiatives are providing the physical layer. The world's premier research and education networking engineers are defining GLIF Open Lambda Exchanges (GOLEs) to assure the interconnectivity and interoperability of links by specifying equipment, connection requirements and necessary engineering functions and services. Computer scientists are exploring the development of intelligent optical control planes and new transport protocols, building on the wealth of middleware that currently exists. And e-science teams are the primary drivers for these new application-empowered networks. GLIF is building more than a network—it is building an integrated facility in which broad multidisciplinary teams can work together. *GLIF map visualization by Robert Patterson, the National Center for Supercomputing Applications at the University of Illinois at Urbana-Champaign; data compilation by Maxine Brown, University of Illinois at Chicago; Earth texture provided by NASA,* http://visibleearth.nasa.gov.

LambdaGrid Services developed by and demonstrated at iGrid 2005.

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 14 March 2006 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.

The primary iGrid 2005 organizers were GLIF participants; an extensive list can be found on the iGrid website; see www.igrid2005.org. Overall planning responsibilities were handled by the Electronic Visualization Laboratory at the University of Illinois at Chicago and Calit2 at the University of California, San Diego, in cooperation with the Mathematics and Computer Science Division of Argonne National Laboratory, SURFnet, University of Amsterdam, and CANARIE. Major sponsors included the National Science Foundation of the United States, CENIC, Ciena, Cisco Systems, Force10, GlimmerGlass, Globus Alliance, GRIDtoday, HP, Looking Glass Networks, National LambdaRail, Nortel, Qwest, Silicon Graphics Inc/James River Technical Inc, Sony, TeraGrid, and the University of California (UC) Industry–University Cooperative Research Program (IUCRP).

GLIF's mission is to create and sustain a Global Facility that supports leading-edge capabilities based on new and emerging technologies and paradigms related to advanced optical networking. These capabilities will enable high-performance applications and services, including the timely transfer of massive amounts of data, distributed computing, data analysis, collaboration and visualization, and control of remote instruments. GLIF provides leadership in advanced technologies and pre-production services on behalf of NRENs, NREN consortia, or pan-continental Research and Education Networks, creating new models that they can implement. Once such services are available from NREN consortia, GLIF will refocus on new emerging paradigms to support its communities. For more information, see www.glif.is.

Larry Smarr is the founding Director of Calit2, a partnership of the Universities of California at San Diego (UCSD) and Irvine (UCI), and is the Harry E. Gruber Professor of Computer Science and Information Technologies in the UCSD Department of Computer Science and Engineering. He was founding Director of the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign in 1985, and founding Director of the National Computational Science Alliance in 1997. Smarr is principal investigator of the National Science Foundation (NSF)-supported OptIPuter initiative, co-chair of the GLIF Research & Applications (RAP) working group, and was the co-host of iGrid 2005 with Ramesh Rao, the Director of the UCSD Division of Calit2.

Thomas A. DeFanti is a Research Scientist at Calit2 at the University of California, San Diego. He is also co-director of the Electronic Visualization Laboratory, a distinguished professor and a distinguished professor emeritus in the department of Computer Science, and the director of the Software Technologies Research Center at the University of Illinois at Chicago. Currently, he is principal investigator of the NSF international networking TransLight/StarLight award,

a co-principal investigator of the NSF-funded OptIPuter initiative, a founding member of GLIF, and was co-chair of iGrid 2005.

Maxine D. Brown is an Associate Director of the Electronic Visualization Laboratory at the University of Illinois at Chicago. Currently, she is co-principal investigator of the NSF international networking TransLight/StarLight award, project manager of the NSF-funded OptIPuter initiative, a member of the Pacific Rim Applications and Grid Middleware Assembly (PRAGMA) steering committee, a founding member of GLIF, co-chair of the GLIF Research & Applications (RAP) working group, and was co-chair of iGrid 2005.

Cees de Laat is an Associate Professor in the Informatics Institute at the University of Amsterdam. Current research efforts include optical/switched networking to optimize Internet transport of massive amounts of data for the Grid, distributed cross-organization Authorization architectures, and Grid Workflow systems. With SURFnet, he implements projects in the area of GigaPort Research on Networks. He serves as the Infrastructure Area Director and IETF Liaison of the Global Grid Forum Steering Group (GFSG). He is a co-founder of GLIF and the primary organizer of several of its past meetings. For more information, see: http://www.science.uva.nl/˜delaat.