Grand Challenges Conference Application

Grand Challenges to E-Science: Realizing a National e-Science Cyber-Infrastructure

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Cyber-infrastructure encompasses the emerging computational, visualization, data storage, instrumentation and networking technologies that support our Nation's major science and engineering research facilities, enabling *e-Science*, or large-scale science that studies very complex micro to macro-scale problems over time and space. Cyber-infrastructure includes computers and networks, and the Grid middleware that enables coordinated resource sharing and problem solving among distributed facilities.

Networks are the key enabling technology for transforming cyber-infrastructure from geographically separated computational facilities and instruments into a National Information Infrastructure. NSF ANIR director Aubrey Bush describes three classes of Research & Education (R&E) networks beyond the commodity Internet:

***Production Networks*:** High-performance networks, which are always available and dependable. Examples are the *FedNets* (ESnet, DREN, NREN, etc.), UCAID/ Internet2's Abilene and WorldCom's vBNS+. These networks reach all US researchers who need them and must be 24/7 reliable.

***Experimental Networks*:** High-performance trials of cutting-edge networks that are based on advanced application needs unsupported by existing production networks' services. Experimental Networks must be robust enough to support *application-dictated* development of application software toolkits, middleware, computing and networking. Experimental Networks must provide *delivered experimental services* on a persistent basis and yet encourage experimentation with innovative and novel concepts. Experimental Networks are seen as the (missing) link between Research and Production Networks.

***Research Networks*:** Smaller-scale network prototypes, which enable basic scientific and engineering network research and the testing of component technologies, protocols, network architectures, and so on. Research Networks are not expected to be persistent, nor are they expected to support applications beyond their own testing and evaluation.

Networks for e-Science must have known and knowable characteristics. Known and knowable characteristics are not features of today's Production Networks, but could well be expected of Experimental Networks. High-performance users require networks that allow access to information about their operational characteristics. These users expect deterministic and repeatable behavior from networks before they will ever depend on them for persistent e-Science applications.

Given known and knowable characteristics, the interaction between application requirements and resources available can be addressed as computer science and engineering research; this is the networking component of the Grid. The Grid's usability will be accelerated by Experimental Networks bearing the risk of offering new services before the Production Networks are willing, and on a scale much larger and longer than Research Networks can provide.

Experimental Networks need to provide enough persistence and professional staff to support e-science applications and experiments. They must focus on end-to-end connection of aggressive leading-edge sites with supportive facilities, including software and middleware development, and fiber to the users' desks, laboratory instruments, data archives, and/or computational clusters. ***Once this level of resource availability and accountability becomes routine, domain research scientists will rapidly, even exponentially, accept and rely on cyber-infrastructure.***

The key concepts of "Grand Challenges in e-Science" can be summarized succinctly:

- Current Production Networks are not architected for high-performance e-Science
- Research Networks are not designed to be reliable or persistent
- Experimental Networks are required to solve networking issues precluding e-Science use
- Experimental Networks are needed to bridge the gap between Research and Production Networks
- International Experimental Networks are needed to reach multi-national e-Science sites
- Experimental data handling needs (network and storage) are expected to grow exponentially this decade.
- Cyber-infrastructure networking is best evaluated in terms of delivered performance to research scientists' applications rather than aggregate bandwidth utilization in the backbone.
- Specialized *on-ramp* access computers need to be designed to couple 10Gb and higher networks to resources and people; software for these systems of computers needs to be written and focused on e-Science needs.

- A full-mesh National Experimental Network is desirable, but will be a significant research and financial challenge.

- Local and regional wavelength-based Experimental Networks are achievable and practical.

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Professional Preparation

Queens College, New York, NY	Mathematics (Phi Beta Kappa)	BA, 1965-1969
University of Nancy, France	Mathematics (exchange student)	1967-1968
Ohio State University, Columbus, OH	Computer and Information Science	MS, 1969-1970
Ohio State University, Columbus, OH	Computer and Information Science	PhD, 1970-1973

Related Publications

[1] J. Leigh, O. Yu, D. Schonfeld, R. Ansari, E. He, A. Nayak, J. Ge, N. Krishnapasad, K. Park, Y. Cho, L. Hu, R. Fang, A. Verlo, L. Winkler, T. DeFanti, "Adaptive Networking for Tele-Immersion," Proceedings of the 5th Immersive Projection Technology/ 7th Eurographics Virtual Environments Conference, May 16-18, 2001, Stuttgart, Germany, (accepted for publication).

[2] Y. Zhou, T. Murata, T. DeFanti, and H. Zhang, "Fuzzy-Timing Petri Net Modeling and Simulation of a Networked Virtual Environment – NICE," Institute of Electronics, Information and Communication Engineers (IEICE) Transactions in Japan, Vol. E83-A, No. 11, 2000, pp.2166-2176.

[3] T. DeFanti, "Better than Being There: Next Millennium Networks," IEEE Computer Graphics & Applications, January/February 2000, pp. 60-61.

[4] Jason Leigh, Andy Johnson, Maxine Brown, Dan Sandin, Tom DeFanti, "Tele-Immersion: Collaborative Visualization in Immersive Environments," IEEE Computer, December 1999, pp. 66-73.

[5] C. Cruz-Neira, D.J.Sandin, T.A. DeFanti, "Surround-Screen Projection-Based Virtual Reality: The Design and Implementation of the CAVE," Computer Graphics (Proceedings of SIGGRAPH '93), ACM SIGGRAPH, August 1993, pp. 135-142.

Synergistic Activities

Award Recognitions

Fellow, International Engineering Consortium [www.iec.org], 2000
Recipient, ACM SIGGRAPH 2000 Outstanding Service Award.
Recipient (with Dan Sandin), UIC Inventor of the Year Award, (for CAVE development), May 2000
Recipient, UIC College of Engineering Faculty Research Award 1999
ACM Fellow, 1994
UIC University Scholar, 1989
Recipient, ACM Outstanding Contribution Award, 1988

International/National Professional Activities

Member, Mayor Richard M. Daley's Council Of Technology Advisors, Chicago (1999-present)
Member, External Advisory Committee, Center for Parallel Computers (Parallelldatorcentrum, PDC) at the Royal Institute of Technology (Kungl Tekniska Högskolan, KTH) (1999-present)
Member, Board of Trustees, and Chair, Applications Strategy Advisory Council, Internet2, University Corporation for Advanced Internet Development (UCAID) (1998-present)
Member, Advisory Committee, Int'l. Center for Advanced Internet Research (iCAIR), Northwestern University, Illinois (1998-present)
Member, Executive Committee, National Computational Science Alliance, NCSA/UIUC (1997-present)
Technical Advisor, White House G7 Global Interoperability of Broadband Network (GIBN) initiative (1995)
Member, Illinois Governor's Science Advisory Board (1989-94)