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## I-Light: A Network for Collaboration Between Indiana University and Purdue University

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### Abstract

Indiana University and Purdue University have collaborated in the development and deployment of advanced information technology systems and services since before the development of the I-Light network. The I-Light network has enabled dramatic new possibilities for collaboration in the development of cyberinfrastructure in the State of Indiana. I-Light, and the cyberinfrastructure created by Indiana and Purdue Universities, has enabled new research discoveries by the State's leading researchers. Collaboration between IU and Purdue has brought significant federal grant money into the state in support of information technology, and the I-Light network has increased the competitiveness of IU and Purdue for major federal funding of research and development activities in the State. The I-Light network has, directly and indirectly, improved the quality of life in Indiana.

### Introduction

The I-Light Network [2] is the basis for the advanced research cyberinfrastructure of the State of Indiana and the foundation of research collaborations between the two largest and best research universities in the State: Indiana and Purdue. Cyberinfrastructure is a new term coined as an analogy with other types of infrastructure, such as the nation's electrical infrastructure. Cyberinfrastructure refers to an infrastructure for knowledge. [16] It is composed of high performance computers, massive data storage systems, data resources, advanced instruments, sensor networks, and people all linked together by advanced software and high performance networks to improve research productivity and enable new breakthroughs not in other ways possible. The purpose of this paper is to review the history of research collaborations predicated on the development, deployment, and use of the collective cyberinfrastructure resources of Indiana University (IU) and Purdue University (Purdue) – collaborations that have made possible dramatic new research results and have brought economic benefits to the State of Indiana.

### History of IU and Purdue collaboration so far this century

Indiana and Purdue Universities began collaborating in networking and research computing late in the 1990s. Together, they requested funding for a high-performance, optical-fiber network that would connect Indiana University's Bloomington campus, Purdue University's

West Lafayette campus, and the joint Indiana University-Purdue University at Indianapolis. In 1999, the Indiana General Assembly approved the creation and funding of the I-Light network with a \$5.3M state appropriation. The I-Light network was officially lit by Governor O'Bannon on Dec 11, 2001.

Collaboration in research computing between Purdue and IU began in 2000, when IU and Purdue led a joint display at the 2000 Supercomputing Conference (with the University of Notre Dame as a partner). The annual Supercomputing Conference Series [11], put on by the Association of Computing Machinery and Institute of Electrical and Electronics Engineers (IEEE), is the largest and most important conference in supercomputing, grid computing, and advanced networking in the world. The joint IU/Purdue/Notre Dame display, titled "Research@Indiana," represented the first time in the history of the conference that all of the major research universities of any state had come together to disseminate information about and promote their home state. This display made quite an impression both in the quality of the display itself and the collaborative effort to promote the State of Indiana.



**Figure 1. Photograph of joint Indiana University, Purdue University, University of Notre Dame display at SC00 in Dallas, Texas**

IU and Purdue deepened their relationship in research computing significantly during 2001. At that time, both universities had large IBM SP supercomputers. Purdue's was located in West Lafayette; IU's was geographically distributed between Indianapolis and Bloomington. IU's IBM SP supercomputer was upgraded in 2001 to become the first university-owned supercomputer in the nation capable of one trillion mathematical operations per second. Purdue's IBM SP was smaller in calculation speed, but included more memory per processor than IU's. This created an opportunity to collaborate that benefited both universities. IU and Purdue agreed to periodically link their supercomputers together via the I-Light network, using special capabilities of the IBM SP software and the I-Light network. Several significant scientific accomplishments resulted from this, including the following:

- *A realistic simulation of the 9/11 Pentagon airplane crash.* This simulation used the finite element method (FEM) to model the airliner's interaction with the steel-reinforced concrete columns of the building, and used realistic visualization techniques to produce a high quality animation of the crash. FEM modeling produces a mesh of millions of interacting elements governed by complicated equations which require many hours of computation to solve. One-

tenth of a second of this simulation took 95 hours of computation on a supercomputer. [7]

- *The creation of the Center for Computational Homeland Security at Purdue University.* Using a Synthetic Environment of Analysis and Simulation (SEAS) the Center performs regular simulations of cyberterrorism, bioterrorism, and infrastructure terrorism scenarios, and the governmental, commercial, and economic responses to them. In one simulation in particular, federal, state, and local officials tested and analyzed the responses to a bioterrorism scenario on campus using hand-held wireless computers linked via I-Light. [8][9]
- *The SC2003 High Performance Computing Challenge Award.* The project, "Global analysis of arthropod evolution," won the HPC Challenge Award in the category of "Most Geographically Distributed Application." The science behind the project was to determine if six-legged arthropods are a single evolutionary family, or if "six-leggedness" has arisen multiple times, independently, during the course of evolution. Analysis of evolutionary relationships based on DNA sequences requires massive amounts of computer time. For this project, the University Information Technology Services (UITS), the Indiana University Center for Genomics and Bioinformatics (CGB), and the High Performance Computing Center of the University of Stuttgart (HLRS) put together a global computing grid that had components in every continent but Antarctica to solve the problem. The I-Light linkage played an important role in this grid. [4][13]

Based on the success of the periodic aggregation of IU and Purdue supercomputers, the two universities entered into a cycle sharing agreement, meaning that researchers at IU could use Purdue supercomputers when there was unused capacity on those systems, and vice versa. One of the critical facts about supercomputers is that they do not age gracefully. The useful life of a supercomputer is somewhere between three and five years. Computing cycles that are unused are simply lost forever. By forging an agreement between IU and Purdue that ensured all supercomputers would be used to their practical maximums, the two universities ensured that the State's investment in these supercomputers would result in the maximum benefit to the state and the nation. More than one million hours of processor time were shared during the subsequent years in which this agreement was in effect.

Purdue and Indiana continued their joint leadership of a display at the annual Supercomputing conference; in 2001 and 2002 the collaborative display focused on the State of Indiana involved the Rose-Hulman Institute of Technology as well as Indiana, Purdue, and Notre Dame. This display greatly elevated the national reputation of the state as a whole in advanced information technology.

2003 saw a quantum leap in the depth of the relationship between Purdue and Indiana, as the two universities jointly wrote a proposal to the National Science Foundation to become partners in the TeraGrid. The TeraGrid is the world's largest, most comprehensive distributed cyberinfrastructure for open scientific research [14], and is the National Science Foundation's flagship effort to build a national cyberinfrastructure. The two universities were awarded a total of \$2,985,199 from 2003 to 2005 to provide computing, data, and advanced visualization resources for use by the national research community. The collaborative relationship between Indiana and Purdue Universities has deepened and become more productive as a result of the joint participation in the TeraGrid. It has provided opportunities for the staff and faculty of the two universities to work together more effectively. Together Purdue and Indiana have worked within the TeraGrid to ensure the delivery of tangible benefits to researchers of every state in the nation, including Indiana. At the same time, participation in the TeraGrid has created better administrative vehicles for certain activities. For example, the TeraGrid provides a mechanism for allocation of computing cycles to researchers, thus eliminating the need for the cycle sharing agreement between Purdue and IU. Indiana and Purdue Universities have received four subsequent federal grant awards directly related to the TeraGrid, and the TeraGrid will be a focal point of collaboration within the State and with the nation for years to come.



**Figure 2. Map of the sites participating in the NSF-funded TeraGrid “Extensible Terascale Facility” project.** <http://www.teragrid.org/>

The Purdue/Indiana collaboration has aspects that go well beyond grid computing and supercomputing. Indiana and Purdue Universities provide important data resources to researchers in the State of Indiana and to the nation (via the World Wide Web and the TeraGrid). A few of the most important data resources are:

- *Purdue Terrestrial Observatory* – a real-time remote sensing ground station array, receiving a wide range of spectral data, over a wide range of spatial resolutions. The data is sent from sensors carried on American, European, Canadian, Japanese and Russian satellites. This data is then deposited real-time into GIS, distributed to research labs, and archived for future research. [10]
- *State of Indiana GIS Data* – a collection of more than 7.5 terabytes of Indiana geospatial data, including aerial photos, topographic maps, and digital elevation data, available for download to the public, and connected to Indiana University's Massive Data Storage System (MDSS). [3]
- *Life sciences data via the IU Centralized Life Science data set* – a SQL-based interface for querying a variety of public Life Sciences data, including sequence databanks and non-relational datasets that have been transformed into relational tables so that they can be searched and used more effectively. [6]

Another way in which Purdue and Indiana Universities bring distinction to the state is through management of cutting-edge 3D visualization facilities. The Purdue Envision Center is an interdisciplinary, high-performance visualization facility to support research and teaching at Purdue University. The Center allows Purdue faculty to display and visually interact with scientific data in innovative ways, and to advance the fields of visualization and perception through research and development in computer graphics hardware and software. [1]

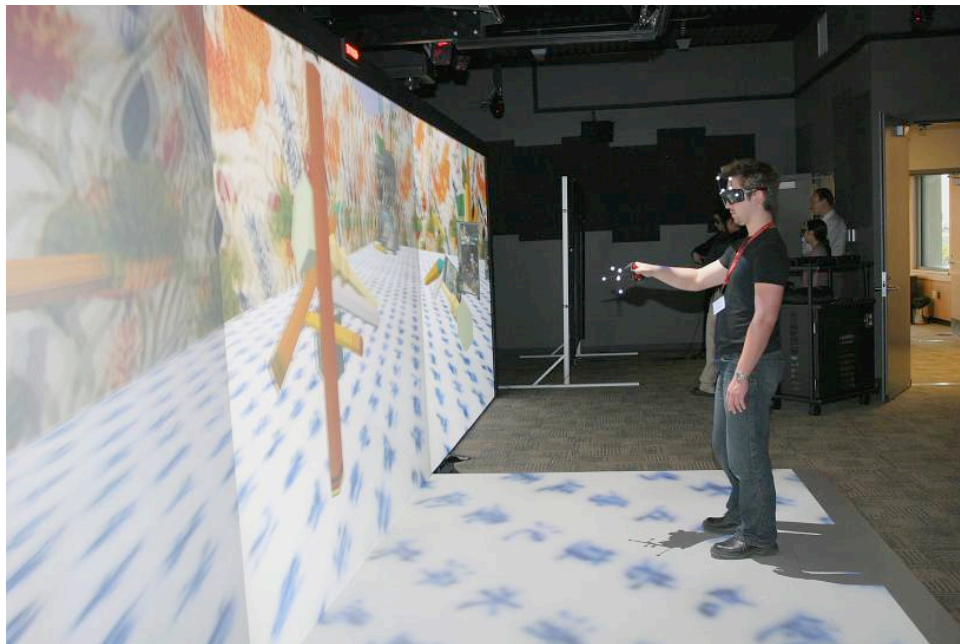




**Figure 3. Purdue researchers analyze aerial photographs in The Purdue Envision Center**

In 2005, Indiana University installed on the IUPUI campus a reconfigurable virtual reality theater in the ICTC building. The MoVE Lite system from BARCO's Virtual and Augmented Reality Division provides an immersive experience using one of the highest resolution and brightest 3D projection systems anywhere. The displays may be driven from any of several advanced computing platforms, including an SGI Onyx4, an SGI Prism, and an Opteron-based Linux cluster, and features wireless, optical tracking of multiple input devices over a 30' x 10' space. The flexible configurability and the range of computing systems and input devices allow researchers, educators, and artists to tailor the VR theater for their applications and audiences. The BARCO VR Theater can support scenarios ranging from wide screen design reviews for collaborative teams, to panoramic, semi-immersive visualization for classes, to fully immersive artistic environments for small groups. [5]

IU and Purdue are at work right now extending their collaboration through research in virtual environments, in which we will link the advanced visualization facilities located in West Lafayette and Indianapolis.



**Figure 4. Visitors to the ICTC explore and interactive virtual reality piece of art by IU Assistant Professor Margaret Dolinsky**

## It's about the science

Collaboration between two great universities and bringing grant money into the State is important, but new science and new innovations are what matter most. Here are a few of the scientific collaborations now going on that are facilitated by the I-Light network, and the collaborations that have developed between Indiana and Purdue Universities as a result:

- *Collaborative Initiative on Fetal Alcohol Spectrum Disorder.* Fetal Alcohol Spectrum Disorder is a suite of maladies that affect children whose mothers drank alcohol while pregnant. Researchers in the IU School of Medicine, Purdue School of Science, and IU's University Information Technology Services are collaborating to design new and better ways to diagnose FASD with optical 3-D scanners; data for the consortium as a whole is being stored at IU – an effort made possible by I-Light. [12]
- *The Indiana Center for Insect Genomics.* The Indiana Center for Insect Genomics aims to develop new ways to control insect pests by better understanding their genomics and genetic vulnerabilities. This institute is supported by an Indiana 21<sup>st</sup> Century Center of Excellence Award, and will make use of the grid cyberinfrastructure available within the State of Indiana. The Center itself is a collaboration of the Purdue University Department of Entomology, the University of Notre Dame Center for Tropical Disease Research and Training, and the IU Bloomington Center for Genomics and Bioinformatics. [15]
- *The Purdue Center for Computational Homeland Security.* The Center for Computational Homeland Security focuses on the creation, validation, and implementation of new technology, knowledge, and tools to be used in aiding homeland security. The center brings together people, technology, and infrastructure capitalizing on Indiana's advanced computational TeraGrid and 21st Century funded Synthetic Environment for Analysis and Simulations (SEAS) technology. The CCHS has already made extensive use of simulations running simultaneously on Purdue and IU supercomputers in West Lafayette, Indianapolis, and Bloomington. [8][9]
- *Telecollaborative Class Instruction.* Drs. Eric Wernert (UITs, Indiana University) and Dr. Laura Arns (IT@P, Purdue University) used the telecollaborative capabilities of the I-Light network to team teach a course called "Introduction to Virtual Environments." This course was taught simultaneously to Purdue and IU students by Drs. Arns and Wernert – and this capability was made possible by the I-Light network.

## Impact on the State of Indiana

The collaboration between Purdue and Indiana Universities in research computing, built on the capabilities of the I-Light network, has had tremendous benefits for the State of Indiana. I-Light has benefited the research and educational missions of Indiana and Purdue Universities. In many areas where IU and Purdue do not compete, because of different areas of focus and concentration, the I-Light network has strengthened the grant competitiveness of each of the universities. In some areas where IU and Purdue might compete – such as IT infrastructure – they have most often chosen to collaborate. As a result, the State of Indiana is one of just six states in the nation that are home to resource providers who are responsible for the TeraGrid (the others are California, Illinois, Tennessee, Pennsylvania, and Texas.) Hundreds of millions of dollars of federal grant money are brought into the State of Indiana each year by Indiana and Purdue Universities. The I-Light network and the State's advanced cyberinfrastructure have been critical assets as IU and Purdue have successfully competed for federal grant funding.

Purdue and Indiana Universities compete in many contexts. But by carefully collaborating on infrastructure, and on select grant opportunities, the State of Indiana's two leading research universities are enabling new research and the development of new technologies, making possible discoveries and therapies that improve human health, and creating high paying jobs thanks to federal grant dollars – thus improving the overall quality of life for Hoosiers.

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This paper is dedicated in honor of two colleagues who helped forge the relationships between Indiana and Purdue Universities – Mary Moyars-Johnson and the late David Moffett, both former Associate Vice Presidents of Purdue University.

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