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Information technology in support of research, scholarship, and creative activities

A strategic plan for Research Technologies – a division of UITS and a PTI Service and Cyberinfrastructure Center

Revision 1.1

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RESEARCH TECHNOLOGIES
INDIANA UNIVERSITY

PERVASIVE TECHNOLOGY INSTITUTE
INDIANA UNIVERSITY

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1. Executive Summary

IU is currently executing its second information technology strategic plan – *Empowering People: Indiana University's Strategic Plan for Information Technology 2009* (hereafter referred to as *Empowering People)*. In this document, we set out long-term goals for the Research Technologies (RT) division of University Information Technology Services (UITS), reaffirm specific goals set for RT for 2019, describe Actions within *Empowering People* for which RT is responsible, and describe the new internal structure of Research Technologies.

The mission of the Research Technologies division of UITS is to develop, deliver, and support advanced technology solutions that improve productivity of and enable new possibilities in research, scholarly endeavors, and creative activity at Indiana University and beyond; and to complement this with education and technology translation activities to improve the quality of life of people in Indiana, the nation, and the world.

Research Technologies is simultaneously a division of UITS and a Service and Cyberinfrastructure Center affiliated with the Indiana University Pervasive Technology Institute (PTI). UITS reports to the Office of the Vice President for Information Technology and Chief Information Officer (OVPIT). OVPIT provides leadership for the continued development of a modern information technology environment throughout the university. The primary responsibility of this office is the development and use of information technology in support of the university's vision for excellence in research, teaching, outreach, and lifelong learning.

The mission of PTI is to improve the quality of life in the state of Indiana and the world through novel research and innovation and service delivery in the broad domain of information technology and informatics. PTI is a collaboration between the School of Informatics and Computing, Maurer School of Law, College of Arts and Sciences, UITS, and OVPIT (where PTI reports within IU's administrative structure). The PTI Service and Cyberinfrastructure Centers focus on delivering leading edge services that benefit the university and the state, and that advance the scholarly community nationally.

The strategic goals for IU as regards information technology in general are set out in *Empowering People*. That strategic plan includes a number of Recommendations and Actions. The Recommendations and Actions for which RT has a lead role are as follows:

- Action 4: Cyberinfrastructure. IU should continue to advance its local cyberinfrastructure, participation in national cyberinfrastructure, and its efforts to win federal funding of cyberinfrastructure programs that enhance IU's research capabilities.
- Action 16: External funding. OVPIT should continue to lead and expand its efforts to effectively partner with academic units, campuses, administrative units, or individual investigators for external funding opportunities.
- Action 25: Research into IT. IU should support and pursue research into information technology itself. IT professionals and faculty should seek partnership opportunities for scholarly publication and invention disclosure that document meritorious research and discovery.
- Action 33: Research data utility. IU should provision a data utility service for research data that affords abundant near- and long-term storage, ease of use, and preservation capabilities.
- Action 50: K-12 outreach. IU should use its distinct capabilities in education and technology to reach out to K-12 teachers, administrators, and students in ways that further an effective primary through post-secondary (P-20) approach to improve Hoosier education.

- Action 51: Technology transfer. IU should develop its IT capabilities to support and enhance the flow of innovation from researchers and innovators to the practical use of the public and private sectors of the state of Indiana and beyond. (Research Technologies leads, PTI supporting)
- Action 70: IT-enabled research. IU should purposefully select areas of great and timely promise for strategic development of IT-enabled research, scholarship, and/or creative activity. (RT and PTI lead)
- Action 71: IT-enabled research resources. IU should identify a base of resources to provide both initial and sustained investments in selected areas for IT-enabled research, scholarship, and/or creative activity. This may include reallocating current resources and developing new ones, including endowments, grants, and/or additional fees. (RT leads)
- Action 72: IT research hiring. IU should carefully assess new skills that are necessary to advance promising opportunities as research becomes more IT-intensive. Campus, school, and departmental leaders should help to target some strategic hiring to supply or augment expertise for advanced, IT-enabled research and creative activity. (RT leads)

The Research Technologies division was reorganized during the latter half of 2011. The new structure of RT comprises four groups:

- *Collaboration and Engagement Support Group.* The mission of the Collaboration and Engagement Support Group (CESG) is to help Indiana University, PTI, and Research Technologies translate innovation into meaningful improvements in the quality of life for residents of the state of Indiana and the US (and world) as a whole.
- *Science Community Tools.* The mission of the Science Community Tools directorate is to develop, deploy, and provide innovative cyberinfrastructure tools that serve life sciences, physics, and other relevant scholarly communities at Indiana University, across the state of Indiana, nationally, and internationally. Science Community Tools includes three management units: National Center for Genome Analysis Support (NCGAS), Advanced Biomedical Information Technology Core (ABITC), and High Throughput Computing (HTC).
- *Systems.* The mission of Research Technologies Systems directorate is to provide a robust and advanced research cyberinfrastructure for IU that enables computing research, creative activities, and teaching not possible with standard IT infrastructure, and which amplify the talents and visions of local and national researchers in a wide range of scientific domains. Research Technologies Systems includes five management units: Campus Bridging and Research Infrastructure, High Performance File Systems (HPFS), High Performance Systems (HPS), Research Storage, and Scientific Applications and Performance Tuning (SciAPT).
- *Visualization and Analytics.* The mission of the Visualization and Analytics directorate is to enable researchers, artists, and students to readily harness the power of cyberinfrastructure to extract knowledge from data and to express creative ideas through interactive visualization techniques, quantitative analysis methods, and community-oriented grid workflows. Visualization and Analytics includes three management units: Advanced Visualization Lab (AVL), Research Analytics Group (formerly Stat/Math), and Science Gateways Group.

RT serves IU's researchers, scholars, artists, engineers, clinicians, and students because that is the fundamental reason it exists as an organization. RT recognizes that for each member of the IU community, their research, scholarship, or creative activity is the most important thing to them.

To further its ability to serve IU, the state of Indiana, and the US, RT pursues external funding in order to perform more top-quality scientific research, development, and deployment than would be possible with

IU general funds budgets. (Increasing IU's receipt of grant funding from federal agencies also aids the IU budget and helps expand and modernize Indiana's economy.)

To carry out its mission, RT has several principles regarding information access and use of RT services and facilities:

- Information about services provided internally within the IU community should be easily available via intuitive pathways from the UITS Online Support Environment.
- Information about services provided within the state or nation should be easily available via intuitive pathways from a coordinated, and where possible unified, RT / PTI / Digital Library Program (DLP) web presence.
- Baseline support should remain available upon request without fees whenever possible, with minimal obstacles to usage of RT services and resources in keeping with the "philosophy of abundance" defined in the *Empowering People* information technology strategic plan.

Research Technologies is unusual in its alignment as both a division of UITS and a PTI Service and Cyberinfrastructure Center. The National Center for Genome Analysis Support, because of its leadership group including representatives of the College and UITS, is also identified as a PTI Service and Cyberinfrastructure Center. Three critical facts should be understood regarding PTI and Research Technologies:

- Research Technologies cannot achieve its strategic goals without PTI being successful.
- PTI can be most successful if RT is also successful and aids PTI in pursuit of its goals.
- Research Technologies receives significant funding from Indiana University and OVPIT as part of the normal budget allocation process, in excess of the budget it would otherwise receive, to enable it to aid the efforts of PTI overall and enable PTI to be successful in its overall pursuits.

There are many commonalities between Research Technologies and PTI. The success of RT in serving IU, the state of Indiana, and our nation as a whole is tied to the success of PTI, and the success of PTI should be greatly enhanced by the contributions RT makes to it directly and to the university, state, and nation.

Research Technologies builds on and continues a strong history of more than 55 years of service to IU by the research arm of the computing organizations at IU. We have a strong history as an important element of IU's overall success and work toward and look forward to even greater success in the future.

2. Introduction

IU's long-term strengths in information technology (IT) focus particularly on the development, delivery, and support of innovative and practical IT tools and systems that serve the university's research, education, and engagement missions. The 1998 Indiana University Information Technology Strategic Plan [1] and its execution by University Information Technology Services (UITS), the IU Libraries, and IU's schools, departments, faculty, and staff have all helped strengthen IU's IT environment. The execution of that plan was particularly aided by the development of the IU School of Informatics and Computing.

In 1998, IU aspired to become an IT leader in absolute terms. More than a decade later, IU leads in many areas of applied research and advanced implementation in computer science and IT. UITS is among national leaders in delivery of excellent services related to research and scholarly endeavors. The IU School of Informatics and Computing and the Pervasive Technology Labs (PTL)[1] have helped create computer and computational science innovations used locally, nationally, and internationally. IU researchers have used IU's advanced IT infrastructure to push back the frontiers of human understanding, create new forms of artistic and literary expression, educate learners, and improve the quality of life in Indiana and elsewhere.

Since 1998, many new areas of need and opportunity have arisen for IT in support of research, scholarly, and artistic endeavors. At the same time, opportunities to capitalize on strategies outlined in 1998 still exist. Based on more than a decade of strong investment by the university, steadily increasing accomplishment locally and nationally, successfully competing for grant awards, using IU and grant funds to enable new scholarly accomplishments, research discoveries, and artistic creations, we can aspire to accomplish even more in the next decade.

Indiana University President Michael A. McRobbie has set a sweeping vision for the university and particular goals in research, teaching, and engagement. These three roles for Indiana University were emphasized in President McRobbie's inaugural speech:

> *As a great public university we have two fundamental missions: education and research. Indiana University seeks to provide the best possible education to all of our students, both undergraduate and graduate. It is an education in both breadth and depth, grounded in both the practical and the transcendent, and providing a command of the analytical and the expressive. We also seek to conduct path-breaking research and scholarship of the highest international standards from the most theoretical to the most applied. ...*
>
> *We are also a public university supported by and with a responsibility to the citizens of Indiana. They expect us to provide a great education to their sons and daughters; they expect us to do the best research and scholarship; and they expect us to be engaged in the life of the State. Therefore, engagement is a third mission, and it grows out of excellence in education and research.* [2]

The Research Technologies (RT) division of UITS and the Pervasive Technology Institute (PTI) have developed strategic and operational plans in parallel with the development of IU's second IT strategic plan – *Empowering People: Indiana University's Strategic Plan for Information Technology 2009* [3], hereafter referred to as *Empowering People*. These activities have been informed by prior reports such as the 2005 Indiana University Cyberinfrastructure Taskforce Report [4] and the Indiana University Life Sciences Strategic Plan [5].

[1] In this document, the terms Pervasive Technology Labs and PTL refer to the labs initially funded by the Lilly Endowment, Inc., from inception in 1999 to the end of 2007. PTI refers to the Pervasive Technology Institute, funded by several sources including a second award from the Lilly Endowment, Inc., with activities beginning 1 January 2009.

In this document, we concisely set out long-term goals for the Research Technologies division of UITS, reaffirm specific goals set for RT for 2019, describe Actions within *Empowering People* for which RT is responsible, and describe the new internal structure of Research Technologies.

Much of this document is based on the concept of cyberinfrastructure – a term that entered academic discourse largely as a result of use of this term by the National Science Foundation. IU was one of the leaders in creating the most commonly accepted definition of cyberinfrastructure in research, which is:

> *Cyberinfrastructure consists of computational systems, data and information management [tools], advanced instruments, visualization environments, and people, all linked together by software and advanced networks to improve scholarly productivity and enable knowledge breakthroughs and discoveries not otherwise possible.* [6]

At Indiana University – a liberal arts institution with a strong commitment to the humanities and the fine and performing arts – we explicitly expand the definition of cyberinfrastructure to encompass support of innovation and breakthroughs in all areas of research, scholarly and humanistic inquiry, and fine and performing arts.

3. Mission of the Research Technologies division of UITS

3.1.1. Mission

The context for defining the mission of the RT division of UITS, whom it serves, and how it serves them, is the mission of the Office of the Vice President for Information Technology and CIO [7]:

> *The Indiana University Office of the Vice President for Information Technology and Chief Information Officer provides leadership for the continued development of a modern information technology environment throughout the university. The primary responsibility of this office is the development and use of information technology in support of the university's vision for excellence in research, teaching, outreach, and lifelong learning. University Information Technology Services reports to the Office of the Vice President for Information Technology.*

This leads directly to the mission of the Research Technologies division of UITS:

> *The mission of the Research Technologies division of UITS is to develop, deliver, and support advanced technology solutions that improve productivity of and enable new possibilities in research, scholarly endeavors, and creative activity at Indiana University and beyond; and to complement this with education and technology translation activities to improve the quality of life of people in Indiana, the nation, and the world.*

Research Technologies is simultaneously a division of UITS and a Service and Cyberinfrastructure Center affiliated with PTI. UITS reports to the Office of the Vice President for Information Technology and Chief Information Officer (OVPIT). OVPIT provides leadership for the continued development of a modern information technology environment throughout the university. The primary responsibility of this office is the development and use of information technology in support of the university's vision for excellence in research, teaching, outreach, and lifelong learning.

The mission of PTI is to improve the quality of life in the state of Indiana and the world through novel research and innovation and service delivery in the broad domain of information technology and informatics. PTI is a collaboration between the School of Informatics and Computing, Maurer School of Law, College of Arts and Sciences, UITS, and OVPIT (where PTI reports within IU's administrative structure). The PTI Service and Cyberinfrastructure Centers focus on delivering leading edge services that benefit the university and the state, and that advance the scholarly community nationally.

We take as a foundational part of the RT mission and goals the preservation and maintenance of the university data – research data, research products, scholarly output, and digital records of fine and performing artistic activities. Data are for many members of the IU community the most critical assets of current researchers, scholars, clinicians, engineers, and artists. Access to these data and the ability to use them well are among the most important legacies we can, collectively, leave to the IU community of the future. The importance of this matter is emphasized in President McRobbie's "Principles of excellence" as quoted below:

> *The Centrality of Information*
>
> *Ensure that the Principles of Excellence are supported by outstanding information technology and information resources.*
>
> ***Pervasive Deployment of IT.*** *Ensure information technology is pervasively deployed at IU by leveraging and continuing the support of the university's long-standing and internationally recognized excellence in information technology services and infrastructure.*
>
> ***IU Libraries****. Ensure that IU's libraries provide access to information in all forms that comprises the record of human knowledge, thought, and creativity for the learning, scholarly, and research communities at IU.* [8]

Over the millennia of recorded human existence, no institution has thus far proved better at retaining critical data and information than universities. The recent economic upheaval within the US and world have shown that universities may persist and maintain their essential functions well even when seemingly robust and very large private enterprises fail. Thus, while the IU community may well use commercial storage services when economical and technically and legally appropriate, IU should control its own fate and be responsible for the storage of its critical research and artistic data. IU should maintain all data related to research and creative activities within a robust and resilient cyberinfrastructure that ensures accessibility of data even in case of localized (city scale) disasters, and develop partnerships with other universities that would preserve IU's most critical data assets even in face of a regional disaster affecting the entire Midwest.

4. Strategic goals for the Research Technologies division of UITS

One of author Stephen Covey's maxims is, "Begin with the end in mind" [9]. President McRobbie began his term by identifying a key end state for Indiana University: "Be a leader among the great universities of the 21st century" [2]. This is the overarching end goal toward which RT and PTI – and indeed the entire university – strive.

One can and should spend a considerable amount of time thinking about what it means to accomplish this goal. Two pieces of advice regarding organizational strategy and technology seem particularly relevant. Regarding organizational strategy, former Secretary of State Henry Kissinger recommended (in a different context) a path of discipline in pursuing "…a strategy of gradualism that seeks greatness in the accumulation of the attainable" [10]. This is useful advice for us to bear in mind as we ponder how IT research, development, delivery, and support can help achieve IU's goal of being a leader among the great universities of the 21st century. Regarding technology specifically, noted computer scientist Alan Kay offered sage and relevant advice in 1971 when he said, "The best way to predict the future is to invent it" [11]. Decades before Alan Kay made this observation, Herman B Wells was already at work inventing a future for IU, setting its focus, and defining what it meant to be one of the great universities of the 20th century. It falls to us, as President McRobbie said, "to keep alive and constantly renew [Wells'] vision of the undaunted pursuit of academic excellence in teaching, discovery, and creative activity" [2].

The people who plan, invent, deploy, and support IU's information technology environment, research enterprise, and public service missions must carry out these tasks in ways that will enable IU to be a leader among the great universities of the 21st century, as must those who are involved in basic and applied research in information technology and informatics. Toward that end, RT proposes the following as the desired end state for the research and scholarly information technology environment of IU:

- For IU researchers, scholars, students, and artists: To use information technology within a policy and security framework that serves as a model for academia and the US in general; to pursue their academic and creative activities without limitations created by resources for data management, computation, or visualization – all accessible with state-of-the-art ease of use; to be able to examine and present research data, simulation results, or artistic creations in intuitive ways that enhance scholarly and artistic efforts; and to have these resources available to them 24 x 365, immediately when desired.
- For Indiana residents: To have the benefits of information technology services and IT-related information made available to state residents by IU; the opportunity to obtain a first-class education at all levels; the social and economic benefits of having Indiana University produce a pool of talented graduates well educated and ready to pursue interesting and valuable careers; a vibrant economy providing satisfying, high-quality jobs with good pay that provide new career options for residents of Indiana and entice IU graduates to stay within our state; an overall high standard of living and quality of life; and an engaging and enjoyable cultural community.
- For others in the United States and the world: To have the benefits of information technology services and IT-related information made available to state residents by IU; and to reap benefits in improved quality of life as a result of economic advancement, improved health, and artistic and literary creations that are brought about by the leadership of Indiana University and the state of Indiana; and to benefit from IU's participation in and leadership of a range of national and international projects for cyberinfrastructure development and delivery.

This is a lofty suite of goals, but our ability to make computers much more functional and dramatically easier to use is apparent to anyone who ever did "word processing" (or more accurately, perhaps, "text layout") with punch cards. It bears note that, in the mid-1980s, the goal of having a personal computer (PC) in every faculty office was viewed as so aggressive as to be highly controversial; a substantial number of faculty were adamantly opposed to this idea, in favor either of proliferation of dumb terminals or advanced typewriters. Viewed in comparison to these examples, the goals outlined above seem aggressive but not impossible. They are, however, likely beyond what can be accomplished in ten years. Research Technologies has set the following goals for a desired end state in 2019 – goals that are aggressive, and if achieved highly meaningful to the state of Indiana and its residents:

IU researchers, scholars, students, and artists will . . .

- Use information technology within a policy and security framework that serves as a model for academia and the US in general.
- Be able to pursue their academic and creative activities with no limitations created by access to data, and few limitations caused by access to computational power.
- Be able to examine and present research results or artistic creations in ways that are intuitive and enhance effectiveness through
    - 2- and 3-D display and interface resources generally available in offices, labs, and meeting rooms.
    - State-of-the-art large-scale facilities located conveniently throughout IU.
- Have access to resources that

- Grow in capability and capacity predictably, steadily, and in ways that keep IU researchers at the leading edge of discovery.
- Are available resiliently by design (24 x 365 at never less than 75% aggregate capacity).
- Are available immediately when immediacy is essential.
- Are accessible through interfaces that are intuitively usable by the large majority of IU researchers.

Indiana residents will . . .

- Have the benefits of information technology services and IT-related information made available to state residents by IU.
- Benefit from new, high-quality jobs created by IU's advanced IT environment within the state (at rates exceeding the present rate of job creation and contributing strongly to the Indiana economy). Such jobs will be created in three ways:
  - By bringing federal money into the state to create new jobs.
  - By attracting existing companies to locate major business operations within Indiana.
  - By creating new companies through commercialization of innovations created by IU.
- Have available to them education and training that allows anyone growing up in Indiana to strive for and achieve the goal of having one of these high-quality jobs. The School of Informatics and Computing and other IU schools matriculate well-educated graduates, many of whom stay in Indiana.
- Have an improved quality of life stemming from these achievements:
  - Indiana will rise at least five places in at least one of the relevant rankings of state economies based on technology (such as TechAmerica's (formerly AeA) annual Cyberstates report [12, 13], or the Kauffman Foundation rankings of state high-tech economies). The basis for comparison will be rankings as of 1998 – the date of approval by the IU Trustees of the first Indiana University Information Technology Strategic Plan. In cases where there was no ranking for the year 1998, the ranking in the most recent listings prior to 1998 will be used.
  - UITS and PTI will aid the IU biomedical research and health services communities in improving the state's rankings in such major health indicators as obesity and tobacco use.

US and world residents will . . .

- Benefit through access to information technology services and IT-related information made available by IU.
- Have improved quality of life, enabled at least in part by the outcomes of IU discoveries and innovations.

Note: these goals are almost identical to the strategic goals set for Research Technologies during its extensive 2009 strategic planning exercise. During the spring of 2012, related to a mid-term review of *Empowering People*, RT solicited and received considerable feedback on these strategic goals. The basic feedback received from faculty and staff was that the goals from 2009 were basically still good guiding strategic goals, with a very few modest edits suggested. This seems just right: it would be a surprise if nothing were changed, but it is similarly reassuring that the changes were modest – strategic goals should stay largely consistent over a period of years if the strategies are sound and those setting the strategies have assessed their environment reasonably successfully.

A prerequisite for the long term goals and the shorter term goals identified above is that the IU community generally is aware of the services available to them from UITS in general and the Research Technologies division in particular. Information about services provided internally within the IU community should be easily available via intuitive pathways from the UITS Online Support Environment. Information about services provided within the state or nation should be easily available via intuitive pathways from a coordinated, and where possible unified, RT / PTI / Digital Library Program (DLP) web presence. Information about RT's accomplishments should be available via survey results and reports on cost and quality of services, managed by the Deputy CIO and the OVPIT Finance Office; via a unified RT / PTI / DLP web presence (including a balanced scorecard report); and via the UITS projects.uits.iu.edu web site.

5. History of Research Technologies and the Pervasive Technology Institute

What is now the Research Technologies division of University Information Technologies Service has a long and distinguished history of service to Indiana University, the state of Indiana, the United States, and the world. This history begins effectively in 1955 when Dr. Marshall H. Wrubel was named the first permanent director of the Indiana University Research Computing Center. Professor Wrubel was a pioneer in computing and in astronomy. Professor Wrubel established at IU the principle of "open access" to IU's research computing facilities – that these facilities exist to serve the university research and scholarship mission and should be accessible to all members of the research community including student researchers – without onerous review processes or nuisance fees. That philosophy stands yet today, uninterrupted in its implementation since 1955 and embodied in *Empowering People* [3] as the "philosophy of abundance" (Action 5, described below).

There are a number of important milestones and first in the history of the Research Technologies division, its forerunners, and collaborating organizations [14]. Some of the most critical achievements include the following:

- Establishment of the Center for Statistical and Mathematical Computing (1991)
- Library Electronic Text Resource Services (LETRS) established as a collaboration between what was then called University Computing Services and the IU Bloomington Libraries (1992)
- Digital Library Program established Victorian Women Writers Project (enabled in part by success of LETRS) (1995)
- University Information Technology Services formed as university-wide information technology organization; Research and Academic Computing Division formed as part of reorganization (the direct, and functionally similar, predecessor to Research Technologies).
- CAVE (CAVE Automatic Visualization Environment) installed at IUB; Immersadesk visualization environment deployed at IUPUI (1997)
- IU signed the first ever enterprise wide license for SPSS statistical software (2000)
- Research and Academic Computing played a key role in the Indiana Genomics Initiative grant awarded by Lilly Endowment to IU (2000)
- IU developed and became the first university ever to deploy distributed data movers for the High Performance Storage System, allowing duplicate copies of data to be stored in tape silos in Bloomington and Indianapolis (2001)
- Indiana University became the first US university to own a 1 teraflops supercomputer – the IU IBM SP, which debuted in 50th place on the Top500 list (2001)

- AVIDD (Analysis and Visualization of Instrument-Driven Data) became the first geographically distributed supercomputer cluster to achieve more than 1 teraflops achieved performance on the HP Linpack benchmark; debuted in 50th place on the Top500 list (2003)
- A team led by IU won the HPC Challenge at SC2003 for "most geographically distributed" HPC application (2003)
- Research and Academic Computing was funded by the National Science Foundation (NSF) as a Resource Partner within TeraGrid (2005)
- Data Capacitor Grant proposal was funded by the NSF (2005)
- Big Red appeared on Top500 list in 23rd place overall; fastest academic supercomputer in western hemisphere (2006)
- BARCO Virtual Reality Theatre was installed in ICTC in Indianapolis, with highest resolution 3D immersive display in existence at that time (2006)
- A team led by Research Technologies won the Bandwidth Challenge at SC07 (2007)
- IU partnered with Technische Universität Dresden to test the first commercial 100 Gbit link (2010)
- IU partnered with Penguin Computing to offer on-demand cloud computing services (2011)

There is also a tremendous history of collaboration between IU computer scientists and informaticians and the computing center staff. Key highlights in this relationship include:

- IU computer scientists Stanley Hagstrom and Franklin Prosser and IU Research Computing Center staff member Stephen Young released the FASTRAN (FAST FORTRAN II) compiler for the IBM 709. This was one of the first 10 computer programs ever protected by copyright. IBM never produced a compiler for the 709 that was as fast as IU's FASTRAN. Professors Hagstrom and Prosser credited Young's skill with the 709's I/O system as a critical to FASTRAN's speed (1963)
- IU established the Center for Innovative Computer Applications (CICA) as collaborative research & development organization (1989)
- IU received its first ever win in an IEEE/ACM HPC Challenge as IU Computer Scientist Dennis Gannon participated in the I-Way project at SC95. I-Way demonstrated the research capabilities created by a high-speed national TCP/IP network (1995)
- IU had its first display at the IEEE/ACM Supercomputing Conference Exhibition Hall with the theme "Beyond Boundaries" (1997)
- IU had its second HPC Challenge win – IU computer scientist Randy Bramley led a collaborative effort on Industrial Mold filling with other computer scientists and Research and Academic Computing staff (1998)
- Indiana University School of Informatics was founded (2000)
- Lilly Endowment funded the Indiana Pervasive Computing Research (IPCRES) Initiative, which created the Pervasive Technology Labs and funded the growth and expansion of the School of Informatics (2001)
- Geoffrey C. Fox joined the IU School of Informatics and Pervasive Technology Labs as professor and director of the Digital Science Center (2002)
- Andrew Lumsdaine joined IU School of Informatics and Pervasive Technology Labs as professor and director of the Open Systems Lab (2002)

- Beth Plale joins IU School of Informatics and Pervasive Technology Lab as Professor and director of the Center for Data and Search Informatics (2001)
- IU won a grant award to become part of the TeraGrid through the Extensible TeraGrid Facility with then Vice President Michael A. McRobbie as PI; PTL faculty and Research and Academic Computing staff all played a key role in the proposal. This was the first grant award ever received by IU to operate an element of the national cyberinfrastructure on behalf of the National Science Foundation (2003)
- Pervasive Technology Labs were reorganized to include Craig Stewart as Chief Operating Officer (and Associate Vice President, Research and Academic Computing) (2005)
- The Pervasive Technology Institute was funded by Lilly Endowment as successor to Pervasive Technology Labs with Beth Plale, Director, Data to Insight Center; Geoffrey C. Fox, Digital Science Center; Fred Cate, Center for Applied Cybersecurity Research; Craig Stewart, Executive Director (2008)
- PTI and UITS competed for and won an NSF Track II award: $10.1 M dollars for FutureGrid, with Geoffrey C. Fox as PI. Only five institutions in the US have won one of these grant awards as of 2012 (2010)
- PTI was organized into Research Centers (under leadership of Managing Director Beth Plale) and Service and Cyberinfrastructure Centers (under leadership of Executive Director Craig Stewart) (2011)
- Thomas Sterling and D. Martin Swany were recruited to IU as Professor in School of Informatics & Computing and Principal Scientist, Office of the Vice President for Information Technology. Von Welch was also recruited (2011)

In a planning session in 1996, the leadership of what was then called Research and Academic Computing identified three core strategic goals:

- Enhance quality and quantity of research done at IU by providing an excellent research environment which both responds to needs and creates new possibilities for IU's researchers.
- Achieve national prominence in research computing, enabling this to be an area of competitive advantage for IU.
- Provide leadership in deployment and use of new computing technologies.

The second item above was considered controversial in 1996. IN 2012, we can say with certainty that we have made dramatic progress in achieving these goals. The current RT goals are continuations and more detailed settings of these general goals, expanded to include greater focus on humanities and arts.

6. Core competencies, values, scope of services, and governance processes

6.1. Core competencies

The things that the Research Technologies division of UITS does distinctively and especially well (in ways that are a strong competitive advantage) are the following:

- Believe in the inherent value of the research and creative activities undertaken at Indiana University and in academia generally, and follow through on that belief with excellent delivery of services that match the needs of the university community.
- Implement novel technologies in ways that make them useful to the IU community (and academia generally) sooner than other organizations.

- Develop and deploy new cyberinfrastructure technologies locally at IU and nationally and internationally (as part of cyberinfrastructure efforts funded by the federal government, commercial entities, and not-for-profit organizations).
- Disseminate information about services and accomplishments within and beyond IU.
- Collaborate with faculty researchers and graduate student researchers.
- Pursue competitively awarded grant funds and execute well, making excellent use of university and grant funds to support the mission of IU and the missions of the funding organizations that provide RT with grant funds.
- Participate in community at the institutional, state, national, and international levels. We contribute to the development of the research and artistic communities in Indiana and the US. We help provide insightful, unbiased, clear, community-based suggestions and guidance to federal funding agencies. (Given the quality of IU faculty, the delivery of community-based and unbiased advice to funding agencies aids IU. IU faculty compete particularly effectively for grant funds when the competition is held on a level playing field and the competition is for funding to do meaningful research and development.)

6.2. Research Technologies values and scope of services

6.2.1. Values

The values of the RT division of UITS are as follows:

- We value the reputation of IU, UITS, and Research Technologies as innovative experts of the highest integrity, dedicated to serving our clients and the higher causes represented by the research, development, and deployment activities in which our clients are engaged.
- We value the intellectual, technical, and service skills of the staff of Research Technologies (and UITS) and the intellectual freedom to push back boundaries of human scholarly and artistic accomplishment through the application of these skills. We strive to provide a working environment that enables professional and personal growth, respects the skill and value of each and every staff member, is intellectually stimulating and joyful, and creates a sense of satisfaction for our employees.
- We value IU faculty as the intellectual leaders of the university and aim to support and collaborate with them in achieving the goals of Indiana University, and IU students as the researchers of today and tomorrow. We embrace researchers' technology challenges and will tenaciously work with them to resolve those challenges.
- We value the Pervasive Technology Institute as the flagship identity for IU research, development, and deployment of advanced information technology and as the organizing structure supporting collaboration in informatics and IT research, development, and deployment within and beyond IU.
- We value our local, national, and global collaborators and strive to learn from those who are our competitors in scholarly and artistic pursuits.
- We believe in our ability to do the right things, in the right ways, for the right reasons. We believe in pursuit of what is right with purpose and diligence. We believe in fact-based assessment of our accomplishments. We believe in our ability to learn and do better next time when facts show that we did not do as well as we might have.

To underscore the importance of collaboration and working in support of the IU mission, the following text is a part of the job description for every staff member in RT:

All employees of the Research Technologies division of UITS work in a highly collaborative environment which requires of all employees the willingness to cooperate and collaborate with colleagues and clients, openness with information, professional and respectful approaches to collaboration and contention, and compliance with university policies including IU's Intellectual Property policies. Code and documentation developed by staff in relation to or as part of their professional work activities are, unless otherwise designated in advance, considered to be the Intellectual Property of IU, per IU Intellectual Property guidelines. Code and documents are to be stored and maintained within identified shared code and document repositories, shared with other entities within IU, and disclosed to IURTC promptly. All employees are required to uphold and support IU's mission in deed and in spirit – and particularly its activities in research, education, and engagement in the state of Indiana and beyond.

To ensure that RT implements these values, each staff member is expected to follow federal laws, Indiana laws, and IU policies scrupulously. To ensure that the conduct of Research Technologies staff meets the highest standards of professional and research conduct, as of 7/1/2012, every RT staff member has taken and passed the Collaborative Institutional Training Initiative (CITI) training in human subjects research and responsible conduct of research [15]. At the same time, recognizing that IU policies must be constantly modified and updated to keep pace with changes in technology and best practices in education and research, RT staff are encouraged to propose changes in Research Technologies services and UITS, OVPIT, and IU policies.

6.2.2. *RT scope of services and activities*

There are several conceptual ways to define RT's scope of service:

- Do that which RT believes will lead to accomplishment of the desired end states defined above.
- Enable basic and applied research by IU faculty, faculty librarians, and research staff, and the development of creative works by scholars, fine artists, and performing artists of all sorts.
- Support applied research, development, and deployment particularly aimed at the innovative results of basic research carried out by IU faculty.
- Help IU faculty compete for federal grant and other monies.
- Aided by funding at federal levels, deliver services to the nation when RT is deemed the organization best able to deliver those services.
- Engage in economic development, education, outreach, and training activities in pursuit of the university's engagement agenda.

RT serves IU's researchers, scholars, artists, engineers, clinicians, and students because that is the fundamental reason it exists as an organization. RT recognizes that for each member of the IU community, their research, scholarship, or creative activity is the most important thing to them.

To further its ability to serve IU, the state of Indiana, and the US, RT pursues external funding in order to perform more top-quality scientific research, development, and deployment than would be possible with IU general funds budgets. (Increasing IU's receipt of grant funding from federal agencies also aids the IU budget and helps expand and modernize Indiana's economy.) There are several reasons for RT to engage collaboratively in research, development, and deployment of new IT services, funded by a variety of sources beyond the RT division's base budget. The primary reasons are:

- RT pursues grant and contract monies when so doing supports IU researchers and/or the state of Indiana, and when we sincerely believe that we can perform a set of development, delivery, support, or service tasks better than any other organization in the United States.

- RT pursues grants to help improve domain scientists' (scientists other than computer science and informatics researchers) ability to make early use of innovations developed by faculty in Informatics. This provides IU domain scientists the benefits of early access to tools not generally available to the US academic community, and also provides earlier feedback to IU Informatics researchers than might otherwise be possible.

Baseline support should remain available upon request without fees, and with applications only when essential for good stewardship of IU resources. Baseline services to the IU community may be broken down into two subcategories:

- Baseline services available to faculty, graduate students, and research staff. These are provided on request and generally without cost to the client. (Software acquisition is one exception, and in this case the cost of site licensed software is small in comparison to standard academic pricing.) This includes phone, walk-in, and email consulting about research technology problems.
- Baseline services available to undergraduate students. These services are offered on a basis similar to the above, although RT generally focuses on supporting undergraduate research and attempts to avoid doing work with students that has been assigned to them as homework.
- Extended support is provided for proof of concept work, development of prototypes, or for projects that go beyond a typical short-term consultation but are not large enough to warrant external grant support. Extended support often increases the efficiency of faculty members' research and is made available via an open, peer- review competitive process. Collaborative pursuit of grants, and of research and development activities, will be undertaken when appropriate. (Delivery of services under grant funding or as part of match effort to enhance the competitiveness of IU researchers for grant funding are defined as part of the process for developing grant proposals and in some cases may not be subject to competitive peer review processes within the university.)

As a part of IU, RT is partially funded by taxes paid by Indiana residents. Our obligation to serve these taxpayers is clear, especially upon examination of underprivileged regions of the state.

6.2.3. Governance

Like the activities of the Office of the Vice President for Information Technologies and University Information Technology Services, the Research Technologies division of UITS operates with a hierarchical decision making structure and a very open information and input gathering structure.

New ideas are welcome from anyone working within RT, and they may be brought up in meetings, on email lists, or even suggested anonymously via an online form (operated through Surveymonkey.com, which assures anonymity). We operate with a model of "input rights" and "decision rights" as described in Weill and Ross 2004 [16]. As regards services and strategies, it is generally the case that every RT staff member has input rights. Decision rights follow a standard "Churchill" model – flowing up the chain of responsibility and authority. Many decisions – particularly those that affect IU policies or involve large expenditures may go out of RT and to OVPIT leadership as a whole for final approval. Note that input rights are not always guaranteed. Sometimes strategic decisions are made at the highest levels of IU – or at least at levels above RT itself – in which case it is possible that no one in RT has input or decision rights. Also, as regards personnel matters, it will often be the case that very few people have input and decision rights. And as a matter of principle, when some sort of formal personnel matter has been taken (progressive discipline, reduction in responsibility, or termination), we will as a matter of policy not comment on the circumstances that led to such action – even if the staff member affected does not adhere to the same principles of the importance of confidentiality as regards human resources matters.

The leadership of RT all adhere to the following principles and guidelines regarding leadership (paraphrased from [17]):

- Set clear goals.
- Allow autonomy.
- Provide resources.
- Provide enough time for the work; neither too much or too little. Deadlines, and how they relate to the overall project plan, are key.
- Offer help.
- Learn from both problems and successes.
- Let ideas flow. Know when to listen.
- Display four actions that nourish staff: respect, recognition, encouragement, and affiliation

In order to ensure good organizational planning and memory, important actions (including the creation of any new service, the changing of any policy or RT standard operating procedure, or the expenditure of more than $25,000) is formally proposed using a template based on the OVPIT internal proposal template available online [18].

7. Strategic Goals

The strategic goals for IU as regards information technology in general are set out in *Empowering People* [3]. That strategic plan includes a number of Recommendations and Actions. A mid-term assessment of progress against these goals is under development as of the writing of this document.

The Recommendations and Actions for which RT has a lead or supporting role are as follows:

- Recommendation A1. Indiana University's national and international leadership should be sustained through continued maintenance and advancement of an IT infrastructure that is supported by sound fiscal planning.
    - Action 4: Cyberinfrastructure. IU should continue to advance its local cyberinfrastructure, participation in national cyberinfrastructure, and its efforts to win federal funding of cyberinfrastructure programs that enhance IU's research capabilities. (RT leads)
    - Action 5: Philosophy of abundance. IU should pursue strategies that approximate a philosophy of abundance, within reason, towards unmetered availability of basic IT services, support, and infrastructure for creative activity, storage, computation, communication, and other activities fundamental to the work of the university via any appropriate sourcing strategy. (Enterprise Infrastructure leads; RT supporting)
    - Action 6: Leveraging partnerships. IU should continue its highly successful program of relationships with hardware, software, and services vendors, and seek additional partnerships and creative exchanges that provide mutual benefits. (Support leads; RT supporting)
    - Action 7: Consolidated services. IU should maintain and refresh its IT infrastructure by consolidating enterprise-scale (multi-campus) services for software systems, server and data hosting, networks, backup, messaging, support services, and training, while also enabling innovative departmental-scale technology services provided at the edge. (Enterprise Infrastructure leads; RT supporting)
- Recommendation A2. Indiana University should ensure that its wired and wireless campus networks continually evolve just ahead of the needs of IU's faculty, staff, and students. The network must provide secure, reliable, effective, and appropriate access to support the missions of the university.
    - Action 9: Network partnerships. IU should continue to pursue opportunities for strategic partnerships that can provide services for advanced networks to further the missions of the university. (Networks leads; RT supporting)

- Recommendation A4. Indiana University should continue to practice responsible stewardship of all financial resources devoted to information technology across the university by providing transparency and accountability in support of wise decision-making.
    - Action 16: External funding. OVPIT should continue to lead and expand its efforts to effectively partner with academic units, campuses, administrative units, or individual investigators for external funding opportunities. (RT leads)
- Recommendation A5. Indiana University should provide a secure, resilient, policy-based information and infrastructure environment to protect the security, integrity, and privacy of data. Ongoing upgrades to the environment and policies should enhance personal confidence in the security of data and privacy of individuals in the pursuit of institutional and individual goals.
    - Action 19: Administrative data storage and retention. IU should provision data storage that provides appropriate physical and electronic protection. Sensitive, non-public, and/or important university information should be rigorously governed by policies and processes that ensure appropriate maintenance and retention. (Information Assurance leads; RT supporting)
- Recommendation A7. Indiana University should continue and strengthen its efforts to develop world-class IT professional and technical staff across the university.
    - Action 24: World-class IT staff. IU should remain competitive with regard to compensation, benefits, facilities, workplace climate, and quality of life offerings through funding choices to attract, develop, and retain the very best technical and professional staff. (Human Resources leads; RT supporting)
    - Action 25: Research into IT. IU should support and pursue research into information technology itself. IT professionals and faculty should seek partnership opportunities for scholarly publication and invention disclosure that document meritorious research and discovery. (RT leads)
- Recommendation B8. Indiana University should implement a variety of approaches to IT education, skills acquisition, support, and communication that enable any willing learner to efficiently acquire desired IT skills.
    - Action 27: Human-centered support. IU should continue to pioneer and provision effective means of user support through advanced tools for self-service and connection to IU experts to help faculty, staff, and students effectively use IT. IU should continue its work as a support infrastructure provider for national research projects and services. (Support leads; RT supporting)
- Recommendation B9. Indiana University should provision appropriate "data utilities" for administrative data/information, research data, teaching and learning resources, and multimedia scholarly life. These utilities should provide convenient, timely, and secure access to university data/information by the IU community and authorized collaborators beyond IU.
    - Action 33: Research data utility. IU should provision a data utility service for research data that affords abundant near- and long-term storage, ease of use, and preservation capabilities. (RT leads)
    - Action 39: IT accessibility. IU should ensure that information technology resources on all campuses are accessible to students, faculty, and staff with disabilities in conformance with all relevant federal regulations and guidelines. (Learning Technologies leads; RT supporting)

- Action 41: Federated identity. IU should provision a robust and secure ability to support federated identity and authentication across a range of trusted institutions and partners. (Enterprise Infrastructure leads; RT supporting)
- Action 42: Authorization systems. IU should provision a robust and secure ability to support fine-grained authorization to specific systems and data utilities across a range of internal users and trusted partners. (Enterprise Infrastructure leads; RT supporting)

- Recommendation B11. Indiana University should work within its missions as a public institution to deepen its technology-supported engagement with institutions and communities beyond IU that advance public health, education, research, economic development, and culture in the State of Indiana.
  - Action 49: Outreach database. IU should provision a comprehensive, fully searchable database of its capabilities and outreach programs that are available or could be made available to external constituencies. The database should enable processes and program owners to seamlessly keep the information current and accurate. (Vice President for Engagement leads; PTI supporting)
  - Action 50: K-12 outreach. IU should use its distinct capabilities in education and technology to reach out to K-12 teachers, administrators, and students in ways that further an effective primary through post-secondary (P-20) approach to improve Hoosier education. (Research Technologies leads)
  - Action 51: Technology transfer. IU should develop its IT capabilities to support and enhance the flow of innovation from researchers and innovators to the practical use of the public and private sectors of the state of Indiana and beyond. (Research Technologies leads, PTI supporting)
- Recommendation C12. Indiana University should pursue a position of leadership in the development (with partners) of new, sustainable models for scholarly publication, dissemination, and curation that enable scholars — and their collective communities — to re-assert control over rights to the scholarly record and its institutional preservation.
  - Action 54: Institutional Collaboration in Scholarly Communications. IU should rigorously explore collaborative approaches with other universities and organizations to create and sustain effective models for scholarly communications. (CIO leads; RT supporting)
  - Action 55: Scholarly curation. IU should provision robust systems and services that enable researchers to easily provide an institutional deposit copy of any scholarly work in any media format. (Digital Library Program leads; RT supporting)
  - Action 56: Publication and copyright. IU and individual researchers should press for an evolution of win-win publication agreements and conditions for copyright use that enable institutional preservation of the works of IU scholars. (Digital Library Program leads; RT supporting)
- Recommendation C13. Indiana University, through work with its partners, should pioneer research, development, and application of information technology to health care delivery and education to improve human health.
  - Action 59: Health care data confidentiality. IU should develop rigorous policies and procedures to ensure that confidential health information, the most sensitive of all personal information, is reliably protected during transport, while in use, and at rest in storage. (IUSM CIO leads; RT supporting)

- Action 61: Healthcare data access. IU should assertively engage with and through its partners to provide both the infrastructure and the services necessary to support the advancement of innovative activities, including access to electronic health records via health information exchange networks, telehealth consult services to underserved communities, and the education of our health sciences students. (CTSI leads; RT supporting)

- Recommendation C15. While Indiana University should advance IT-enabled research across all disciplines, it should also focus on a few highly promising opportunities for which it has a skills, knowledge, and reputational advantage to push the frontiers of IT-enabled research and scholarship.
  - Action 70: IT-enabled research. IU should purposefully select areas of great and timely promise for strategic development of IT-enabled research, scholarship, and/or creative activity. (RT and PTI lead)
  - Action 71: IT-enabled research resources. IU should identify a base of resources to provide both initial and sustained investments in selected areas for IT-enabled research, scholarship, and/or creative activity. This may include reallocating current resources and developing new ones, including endowments, grants, and/or additional fees. (RT leads)
  - Action 72: IT research hiring. IU should carefully assess new skills that are necessary to advance promising opportunities as research becomes more IT-intensive. Campus, school, and departmental leaders should help to target some strategic hiring to supply or augment expertise for advanced, IT-enabled research and creative activity. (RT leads)

All of Research Technologies' activities are pursued and executed with two critical underlying considerations:

- Implementation of the "philosophy of abundance" requires that RT activities be done in a manner that is as cost effective as possible. Even in the best of economic times, IU's ambitions and goals have always exceeded the financial resources available to the university. We are now in very trying times for the state, the US, the world, and the families of students who would come to IU to obtain an education. Thus, prudence and care in use of financial resources must be an ongoing focus. The US government is currently spending money in excess of its annual income, and some of that spending is on federally funded research. This situation calls for the staff of RT (and the university as a whole) to be especially judicious so that the long-term value of the work we do will be worth the bills that will ultimately have to be paid off by future Americans.
- IU has set sustainability as a core goal for its operational activities, and advanced computing facilities are prodigious consumers of electrical power. It is thus incumbent upon RT to develop, implement, and adopt technologies that minimize impact of IU's cyberinfrastructure upon the local and global environments.

Implementation plans and information about these activities is available online [3].

8. Joint goals of RT, UITS, and PTI

IU President Michael A. McRobbie proposed the Pervasive Technology Institute in 2008. The following are particularly relevant excerpts from that proposal:

> ***Pervasive Technology Institute***
>
> *Indiana University proposes to build upon the lessons learned from the more than seven year development of the Pervasive Technology Labs, cluster the areas of success that distinguish its strengths into three research centers, and elevate the collective capabilities of the effort as the Pervasive Technology Institute (PTI). This continues and accelerates the original IPCRES vision*

that anticipated the role of new scientific IT tools, handheld devices, faster computer networks, and immense security and privacy concerns of this new world – especially regarding the growing area of personal health information.

…

The proposed Pervasive Technology Institute will build on the success of the Pervasive Technology Labs and add organizational ties and collaborative relationships with the School of Law, the IU Libraries, University Information Technology Services, and the Office of the Vice President for Information Technology. It will marshal IU's research strengths in IT into a new, unified identity as one Institute comprising three Centers.

The institute designation will help build a strong brand name so that the Pervasive Technology Institute is widely identified with Indiana. An established brand helps provide stature for competitive federal research proposals and an umbrella organization for pulling together resources from multiple institutions. Other states have already developed well-known brands around their efforts, e.g., Renaissance Computing Institute in North Carolina or the National Center for Supercomputer Applications in Illinois.

…

Establishing a National Reputation for IT Innovation

… The scale of PTI and its concentration of researchers within IU will lead to significant achievements. As part of its mission of aiding the state of Indiana and leading the nation, PTI will invest significant effort to create a national reputation for PTI and for central Indiana in IT innovation.

The Pervasive Technology Institute will become the brand identity for IU's applied research, development, and delivery activities in applied information technology. PTI will concentrate on developing central- and south-central Indiana as a widely recognized hub of innovation and will cultivate industrial partnerships within the state as a whole. … PTI will include a formal industrial partnership program, ensuring that PTI's research, development, and delivery activities complement the needs of the state's private sector.

…

To aid in PTI's national leadership in its areas of focus, PTI will host a minimum of two national or international events per year. Our strategy will include hosting at least one major conference and one workshop each year. Hosting major conferences will bring international attention to IU and PTI as intellectual leaders. Workshops also bring such attention, and will be structured so as to produce a report that will influence federal agency funding priorities.

…

Expanded focus on workforce development

The Pervasive Technology Institute will continue the highly successful education and outreach activities of Pervasive Technology Labs, with one significant area of expansion. PTL has done extremely well at outreach and education activities for students in Kindergarten through 12th grade. Such efforts interest and inspire young Hoosiers to pursue educational opportunities and make career choices that will help develop the next generation of Indiana's workforce in advanced information technology. … The Pervasive Technology Institute will continue these efforts and add a new focus on undergraduates through an undergraduate internship program.

PTI Budget and the Path to Self-Sustainability

…

The path to self-sustainability for PTI is thus based on a simple formula: continuing to do those things that PTL has done exceptionally well; aggregating resources in a few core areas to create scale and leverage; using monies from the indirect cost component of grants to create a PTI sustainability fund; and adding new revenue streams based on models of industrial engagement already well established in other states. The Centers within PTI will progressively ramp up toward self-sufficiency during years two through five, making the transition to sustainability a gradual and natural process.

Three critical facts should be understood regarding PTI and Research Technologies:

- Research Technologies cannot achieve its strategic goals without PTI being successful.
- PTI can be most successful if RT is also successful and aids PTI in pursuit of its goals.
- Research Technologies receives significant funding from Indiana University and OVPIT as part of the normal budget allocation process, in excess of the budget it would otherwise receive, to enable it to aid the efforts of PTI overall and enable PTI to be successful in its overall pursuits.

There are also tensions between the PTI Research Centers and RT, and tension between RT and the commodity computing market outside IU for market share. The tension areas are as follows:

- Differences in reward structures:
    - Informatics and computer science researchers are rewarded for creating new innovations; once something works, it's no longer a new innovation. At that point there is generally little or no reward to the scientist who created it for continuing to refine and enhance it; the scientist is often best rewarded for moving on to the next new discovery.
    - For RT to deliver and support something for the university community as a whole, it has to work well and robustly and has to be possible to deliver and support well.
- Tensions between RT and the commodity computing market outside IU:
    - The popular technical press is filled with news of cloud computing as either the savior of us all or the next new fad in computing.
    - RT staff believe they add distinctive value to IU and its service, education, and research roles, and would just as soon continue having jobs working for IU and being part of the IU community.

There is a very productive way to address these very real tensions. IU President Michael A. McRobbie, like former President Myles Brand (who hired McRobbie as Vice President for IT) has stated over and over that the innovative use of information technology is and should continue to be a strategic asset for IU. RT, NCGAS, and other PTI Service and Cyberinfrastructure Centers can work with the PTI Research Centers to address the tensions identified above in the following ways: 1) support innovation and discovery by the PTI Research Centers; 2) when appropriate, be prepared to accept handoffs of technology innovation that RT and NCGAS then make more robust and deliver for use by the IU community; and 3)RT should be ready to see and support the outsourcing of commodity services when the needs of the university can be well met in this fashion and the university can achieve financial economies. (There are some signs of shifts in the information technology and commercial community – with General Motors now embarking on a campaign to bring IT operations back in house due to their strategic nature [19].)

Without attempting to detail in this document the particular tactics and strategies appropriate to meeting the shared objectives of Research Technologies and the Pervasive Technology Institute, a few can be listed:

- The PTI Research Centers must be effective in informatics and computer science innovation and discovery. This requires recruiting and retaining world-class faculty to lead innovation and invention in informatics, computer science, and information technology, and then ongoing support for discovery-focused research. Leadership in academic research is one of the key sources for overall success of PTI.
- All PTI Centers face significant challenges in sustainability, including financial sustainability. RT must be cognizant of this and do what it can to support the sustainability of the Research Centers.
- For Research Technologies in particular and PTI overall to continue to benefit from widespread support from the university, RT must do the following three things:
    - Research Technologies must aid the research and discovery initiatives of the PTI Research Centers.
    - If a PTI Research Center sets a strategy of making IU a leader in a particular area of IT-related research, development, and/or delivery, Research Technologies must aid such initiatives and enable them to be successful.
    - To ensure that innovations developed by PTI Research Centers benefit the IU community broadly, RT should when appropriate aid the transfer of new innovations developed by PTI Research Centers; if not already robust, bring them to a state of robustness; and deploy them for use by the IU community before these tools or equivalent functionality are generally available at other universities.
- When security, licensing terms, and financial economies are such that some commodity computing services are best outsourced to a "____ as a service" provider, RT should add value to this process by supporting IU researchers, educators, staff, and learners in use of these services. In such a way RT can apply staff to making even these commodity service be used by IU in a way that provides intellectual and competitive benefit for IU.
- The PTI Service and Cyberinfrastructure Centers in general, and Research Technologies in particular, should use the expertise and competencies we have acquired in part through collaboration and interactions with the PTI Research Centers to benefit researchers, scholars, teachers, clinicians, artists, and engineers within IU. So that the IU community knows it is receiving this benefit in part as a side effect of the existence of PTI, such efforts should be co-branded within IU as being a service of the relevant Center(s) and PTI.
- PTI has a mission in the state to aid in economic development and quality of life.
    - PTI and RT are engaged in outreach and education. Research Technologies has base funding for this effort that should serve as a foundation for grant-funded and grant-related activities by PTI Research Centers.
    - PTI and RT are engaged in economic development. In a fashion analogous to outreach and education, RT operates a baseline of economic development activities, while PTI Research Centers are more likely to be engaged in particular deep and involved activities such as creating a startup.
    - RT has acquired responsibility for specific services within the state including disseminating GIS information to residents. These services, targeted at lay citizens, must be branded with identities of PTI, UITS, and IU in order for all of these contributing organizations to be recognized and appreciated by Indiana residents.
- Brand names matter. PTI has been identified by President McRobbie as the flagship brand identity for IU's research, development, and deployment activities in advanced information technology. RT and PTI must work actively within the university, state, nation, and internationally to fulfill the

missions of IU, UITS, and PTI. In so doing, we should also promote the value of the PTI brand as an asset for PTI particularly and IU generally.

In summary: there are many commonalities between Research Technologies and PTI. The success of RT is tied to the success of PTI, and the success of PTI should be greatly enhanced by the contributions RT makes to it directly and to the university, state, and nation.

9. Service, collaboration, credit and acknowledgment of research contributions, and policy compliance

The staff of the Research Technologies division provides a baseline set of services to all members of the IU community, and collaborates with many. As regards service delivered universally to all members of the IU community, Research Technologies expects of its staff and the rest of the community behavior in keeping with President McRobbie's statement in "The Principles of Excellence" [8] that "Indiana University strives to achieve full diversity, and to maintain friendly, collegial, and humane environments, with a strong commitment to academic freedom."

Collaboration – such as joint participation in or support for a grant proposal, grant-funded project, participation in a contract, or an extended consultation – implies more than just politeness. While collaborators and friends are different, collaboration implies mutual respect and credit where credit is due. When Research Technologies staff are involved in an extended collaboration – externally funded or not – we will execute a Memorandum of Understanding (MOU) that outlines the roles of IU researchers outside RT, RT staff, and collaborators external to IU. Such MOUs will describe communication paths and service level agreements (e.g. time for responses). Collaborators working with RT are always expected to acknowledge use of Indiana University cyberinfrastructure resources (systems and personnel), and when appropriate acknowledge grants that funded particular elements of this cyberinfrastructure. When appropriate, RT staff will be mentioned in acknowledgements or included as co-authors on technical reports, peer-reviewed publications, presentations, etc. At no point will RT staff participate in violating IU policies or generally accepted standards of professional and scientific efforts. Materials included in IU policies online, particularly http://researchadmin.iu.edu/EO/eo_citi.html, will be considered the first source of guidance on such matters. RT staff will abide, and expect the researchers with whom they are collaborating to abide, by the policies particular to topically relevant funding agencies (even if they are not funding a particular research project) such as the National Science Foundation and National Institutes of Health, or relevant statements of research practices by relevant scholarly organizations and associations. RT staff will in general not to be asked to compensate for a failure of IU researchers to adhere to policies of the Office of the Vice President for Research or units reporting to OVPR, particularly OVPR policies on timing and processing of grant proposals.

Research Technologies is pleased to offer letters of commitment of resources in support of grant proposals by members of the IU community. In some circumstances University Information Technology Services may request receipt of a share of Facilities & Administration funds associated with grant awards in recognition of matching investments made by the Research Technologies division. Sometimes these commitments are made as part of formal match and some times such commitments are implicit in facilities statements included as supplemental documents with grant proposals.

It is the goal of Research Technologies to serve the IU community as best possible in the short run and in the long run. Excellent service and mutually respectful collaborations are critical to the long-term success of the Research Technologies division of UITS and its ability to aid Indiana University as a whole.

10. Further information

For further information about the Research Technologies division of UITS, see [20]. For further information about the Pervasive Technology Institute, see [21]. For information about the Office of the

Vice President for Information Technology, including organizational charts for OVPIT and units reporting administratively to OVPIT, see [7].

11. References

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12. Appendix: Research Technologies division structure

The Research Technologies division of UITS is composed of four subunits, described below.

12.1. Collaboration and Engagement Support Group

The mission of the Collaboration and Engagement Support Group (CESG) is to help Indiana University, PTI, and Research Technologies translate innovation into meaningful improvements in the quality of life for residents of the state of Indiana and the US (and world) as a whole.

CESG in particular is responsible for:

- Preaward grant support – grant proposal preparation and submission (RT, PTI, OVPIT and their collaborators)
- Postaward grant support (RT, OVPIT and collaborators)
- Management of and reporting about economic development activities of RT and PTI
- Maintaining an ongoing program of education, outreach, and training activities on behalf of RT, PTI, and OVPIT as a whole, including management of major events.
- Facilitating collaboration between IU researchers, scholars, artists, clinicians and engineers and RT and OVPIT.
- Maintaining the core brand identity of RT and PTI, and "root level" web presence for both organizations.
- Leading major efforts in disseminating information about advanced IT research, including leadership of IU's booth at the annual IEEE/ACM SCxy conference and IU Cyberinfrastructure Days.

12.2. Science Community Tools

The mission of the Science Community Tools directorate is to develop, deploy, and provide innovative cyberinfrastructure tools that serve life sciences, physics, and other relevant scholarly communities at Indiana University, across the state of Indiana, nationally and internationally.

Science Community Tools includes three management units:

- National Center for Genome Analysis Support (NCGAS). The mission of the National Center for Genome Analysis Support is to develop, deploy, and provide innovative cyberinfrastructure tools that support and advance life sciences, particularly genomics, research across Indiana University and strategically position IU for success in life sciences research. NCGAS – in general terms – supports the basic biology and bioinformatics research done in "pre-translational, pre-clinical, pre-commercially competitive" settings.
- Advanced Biomedical Information Technology Core (ABITC). The mission of the Advanced Biomedical Information Technology Core is to help biomedical investigators integrate and manage scientific data, and collaborate with colleagues across Indiana University to advance the effective practice of clinical and preclinical research. ABITC (formerly known as the INGEN Advanced IT Core) was the first Core service certified by the IU School of Medicine outside of the organizational hierarchy of IUSM.
- High Throughput Computing (HTC). The mission of the High Throughput Computing group is to provide the highest quality operational tools and services to investigators and virtual research organizations using high throughput and grid computing environments. HTC is dedicated to developing and delivering a full suite of operational support services for high throughput

computing locally, nationally, and internationally. These services include grid operations and monitoring, support, authentication, and security as well as the engineering and delivery of tools and interfaces that enhance high throughput computing services and lower barriers to use. HTC tools and services support individual scientists, distributed teams and team science, and virtual organizations (This group was formerly known as the Open Science Grid Grid Operations Center).

12.3. Systems

The mission of Research Technologies Systems directorate is to provide a robust and advanced research cyberinfrastructure for IU that enables computing research, creative activities, and teaching not possible with standard IT infrastructure, and which amplify the talents and visions of local and national researchers in a wide range of scientific domains.

The RT Systems group designs, deploys and administers the world-class supercomputing and storage cyberinfrastructure that make up the hardware component of Indiana University's advanced cyberinfrastructure, as well as the core services which support the effective use of these systems. The goal of this research computing environment is to enable new types of research, pedagogy, creative activity and community impact. This environment combines deep human expertise, robust systems and services, and advances in computer science and informatics to address the needs of researchers and their collaborators on the local, national, and international stage.

Research Technologies Systems includes the following management groups:

- Campus Bridging and Research Infrastructure (CBRI). The mission of the Campus Bridging and Research Infrastructure group is to develop and deliver tools and services that make it feel to the individual researcher as if the local, regional, national, and international cyberinfrastructure resources to which they have access are as easy to use as any other peripheral device attached to their laptop computer. In addition, CBRI maintains service infrastructure and facilities to support campus bridging activities within and beyond IU. CBRI develops and supports use of on-demand resources accessible to the IU community. This allows for achievement of the economies of scale that are associated with on-demand computing, with license and pricing terms that are to the advantage of the IU community and consistent with IU policies on research and intellectual freedom. Campus Bridging is a relatively new concept developed through the National Science Foundation with significant leadership by IU. Further information is available online [22].
- High Performance File Systems (HPFS). The mission of High Performance File Systems is to architect, implement, and maintain high performance storage solutions to empower the local, national, and international communities that utilize Indiana University's many technological resources. To explore and test new storage hardware and software solutions to insure that we maintain a position of leadership in the high performance storage community
- High Performance Systems (HPS). The mission of High Performance Systems is to provide for the high performance computational and database needs of the IU community and their collaborators. With advanced technological support and consulting services, together we will push back the boundaries of knowledge and creativity.
- Research Storage. The mission of the Research Storage group is to deliver abundant, trusted, highly available electronic data storage systems for research data, from inception to archive, that meet the unique data management requirements of IU's researchers and their collaborators.
- Scientific Applications and Performance Tuning. The mission of the Scientific Applications and Performance Tuning group (SciAPT) of Research Technologies strives to maximize the effective utilization of cyberinfrastructure at Indiana University. The group engages in consulting projects with IU faculty and staff to enhance scientific productivity and serves as a resource for application performance analysis and tuning.

12.4. Visualization and analytics

The mission of the Visualization and Analytics directorate is to enable researchers, artists, and students to readily harness the power of cyberinfrastructure to extract knowledge from data and to express creative ideas through interactive visualization techniques, quantitative analysis methods, and community-oriented grid workflows.

Visualization and Analytics includes the following management groups:

- Advanced Visualization Lab (AVL). The mission of the Advanced Visualization Lab is to promote the innovative application of visual technologies to advance Indiana University's missions in research, education, creative activity, and community outreach. AVL provides open access to a variety of advanced hardware and software resources, offers a range of consulting and development services, engages in extended research collaborations, and leverages the unique communicative capabilities of visualization to educate stakeholders and the public about the applications and benefits of information technologies and research cyberinfrastructure. AVL delivers services through three functional groups: the Visualization Displays and Systems team, the Scalable Visualization and Virtual Reality team, and the Advanced Digital Arts and Media team. The activities of these teams are as follows:
    - The Visualization Displays and Systems (VDS) team designs, deploys, and maintains a variety of advanced visualization displays, compute systems, interface devices, and data acquisition systems. Systems include large-scale virtual reality displays, ultra-resolution tiled walls, low-cost semi-immersive systems, and stereoscopic displays, as well as haptics (force feedback) devices, spatial tracking systems, and 3D scanners. This team implements Research Technology's vision of a tiered visual cyberinfrastructure at IU with a combination of a few centralized, high-end systems per campus and a larger number of mid-range systems distributed across departments and buildings to complement ubiquitous desktop workstations and grid-based visualization workflows.
    - The Scalable Visualization and Virtual Reality team provides expertise in a range of software-based visual techniques, including scientific visualization, information visualization, interactive virtual reality environments, visual simulation, and 3D modeling and rendering techniques. The team develops scalable, sustainable, and repeatable workflows using a combination of visualization hardware (provided by VDS), open standards, open source and commercial software, and custom software extensions. The team partners with local and national groups to expand services, leverage cyberinfrastructure, and to advance open community projects. A key initiative and expertise within the team is immersive visualization that applies virtual reality technologies and methods to scientific visualization challenges.
    - The Advanced Digital Arts and Media team embodies IU's long and successful history of supporting the innovative use of advanced IT in creative endeavors. For the arts, including visual, musical, and performance arts, the team uses a range of hardware and software to develop custom displays, sensor systems, and interactive interfaces to help realize the artists' creative visions. For advanced media forms – including stereoscopic video and photography, gigapixel photography, and ultra-high resolution video – the team proactively explores new technologies, prototypes workflows, provides hardware resources, and educates users. The team partners with key university departments and initiatives, including the Institute for Digital Arts and Humanities, the School of Fine Arts and the Telecommunications Department at IUB, the Media Arts and Sciences program at IUPUI, and the IU Cinema.
- Research Analytics. The mission of the Research Analytics Group (formerly the Stat/Math Center) is to promote the innovative, scalable, and sustainable use of analytics tools and methods to advance the research, education, and external engagement missions of Indiana University. The

group delivers a range of research and education support services through three functional teams: Research Software Support, Quantitative Analytics Support, and Geospatial Analytics Support. These teams support analytical reasoning methods, data representations and transformations, visual representations, interaction techniques, and the production and presentation of information in order to identify trends and patterns, explain the causes of these patterns, and share these analyses with others in order to turn data into understanding.

  - The Research Software Support team provides the IU community with low-cost licensing, installation support, and centralized access to a variety of research-related software applications, including statistical software, mathematical packages, CAD and engineering tools, and 3D modeling and animation software. In conjunction with other UITS units, the group supports the centralized delivery of these applications on systems ranging from IU's virtual desktop environment to high-performance computing systems to student teaching labs, while also supporting individuals and departments who still desire direct laptop or workstation installation and configuration.
  - The Quantitative Analytics Support team provides a range of consultation services and training opportunities on the effective use of analytics software packages, especially statistical packages (SPSS, SAS, Stata, etc.), mathematical packages (Maple, Mathematica, etc.) and data analysis tools (MATLAB, R, etc.) Support ranges from free short-term consults (up to four hours), long-term consults (up to one month, possibly requiring cost recovery), and grant-funded extended collaborations. The group partners with local and national collaborators to provide seamless and scalable support for analytics workflows. Key partners include the Indiana Statistical Consulting Center, the UITS High-Performance Applications group, the UITS IT Training program, and NSF-sponsored cyberinfrastructure resource providers.
  - The Geospatial Analytics Support team (formerly GIS Support) provides stewardship for geospatial technology research, instruction, and data administration at IU. The group provides access to GIS and remote sensing software (including ArcGIS and ERDAS IMAGINE), archives and provides access to Indiana's massive geospatial data sets, and documents software and archived data. The group provides data and map publishing services and online interfaces to promote the needs of both IU and the residents of Indiana.

- Science Gateways Group. A *science gateway* provides web-based access to community-developed computing tools, scientific applications, scientific instruments, and data collections to support online science and to simplify and expand the use of cyberinfrastructure. *Scientific workflows* power science gateways by providing the tools to manage complex applications and collections of applications on distributed computing resources. These technologies allow researchers to focus on their scientific research goals and facilitate interdisciplinary collaborations. The mission of the Science Gateways Group is to support the advancement of web-based scientific research capabilities by developing open source, open community software; providing support for the integration of that software into operational science gateways; providing consulting support to scientific and scholarly communities for the development of new science gateways; supporting core research and development for web and distributed computing; and developing, delivering, and supporting scholarly gateways to IU cyberinfrastructure resources as well as custom gateways for IU users to nationally-accessible cyberinfrastructure resources. As a side effect of carrying out its mission, the group has acquired significant expertise in developing sustainable software through open source, open community, and software engineering processes, and actively seeks to share that knowledge and methodology with others.

13. Appendix: Pervasive Technology Institute Overview

The mission of the Indiana University Pervasive Technology Institute (PTI) is to improve the quality of life in the State of Indiana and the world through novel research and innovation and service delivery in the broad domain of information technology and informatics. As a world- class organization, PTI pairs fundamental academic computational research with the widely known strengths of Indiana University through innovations and service delivery in networking and high performance computing. By means of organization into research and service centers, PTI encourages collaboration that crosses center boundaries, where practice informs the science, and science advances the practice, the results of which advance the university, state, and nation as a whole. PTI is a collaboration between the School of Informatics and Computing, Maurer School of Law, College of Arts and Sciences, University Information Technology Services (UITS), and Office of the Vice President for Information Technology (OVPIT, where PTI reports within IU's administrative structure).

PTI is a sustainable embodiment of a vision set by IU President Michael A. McRobbie, who in 2008 wrote:

> *"Creating the Pervasive Technology Institute is the logical next step to securing our position of leadership in the information technology field and will serve as a catalyst to our efforts to expand all of our research enterprises within the university and state. It will build on nearly a decade of outstanding applied research work in information technology and on IU's highly advanced IT."*

PTI has two types of affiliated centers: Research Centers, and Service and Cyberinfrastructure Centers. The PTI Research Centers focus on excellence in computationally related research and education. The PTI Service & Cyberinfrastructure Centers focus on delivering core mission of the service and cyberinfrastructure centers is leading edge services that benefit the university, State of Indiana, and advance the scholarly community nationally. Both types of centers are involved in education, outreach, and economic development. Current PTI Centers are:

PTI-affiliated Research Centers:

- Center for Applied Cybersecurity Research (CACR) leads the creation of IT security policy, security tools, and secure applications in critical areas of cyberinfrastructure, including health. CACR is affiliated with PTI, the Maurer School of Law, OVPIT, and UITS.
- Center for Research in Extreme Scale Technologies (CREST) develops new technologies for high-capability computing systems and applications and exascale computing environments. CREST is affiliated with PTI, the School of Informatics and Computing, the OVPIT, and UITS.
- Data to Insight Center focuses on the life cycle of digital data while furthering tools for discovering and gaining insight from the vast quantities of data now produced in digital form. D2I is affiliated with PTI, the School of Informatics and Computing, OVPIT and UITS, and works closely with the IU Libraries.
- Digital Science Center (DSC) advances cloud computing and network science and is home to the well-known FutureGrid. DSC is affiliated with PTI, the School of Informatics and Computing, and OVPIT.

Current PTI-affiliated Service and Cyberinfrastructure Centers:

- Research Technologies develops, deploys, delivers, and supports cyberinfrastructure for IU and scholars, educators, clinicians, engineers, and artists throughout the United States. Research Technologies is affiliated with PTI, OVPIT, and is a Division of UITS.
- The National Center for Genome Analysis Support (NCGAS) deploys and supports software for analysis and understanding of genomes. NCGAS is affiliated with PTI, OVPIT, UITS, and the IU Bloomington College of Arts and Sciences

Indiana University

Pervasive Technology Institute – High Level

March 2012

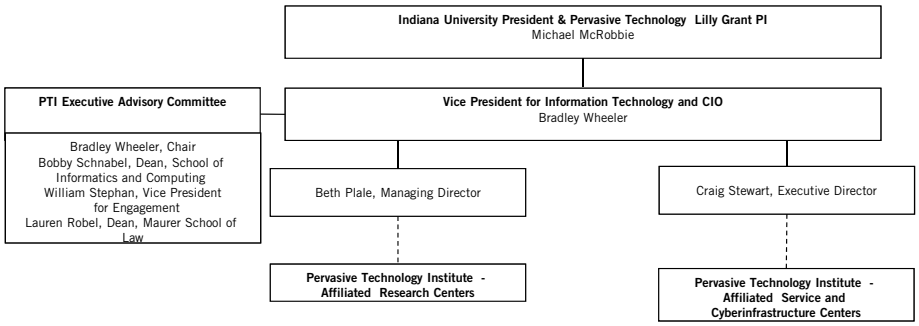
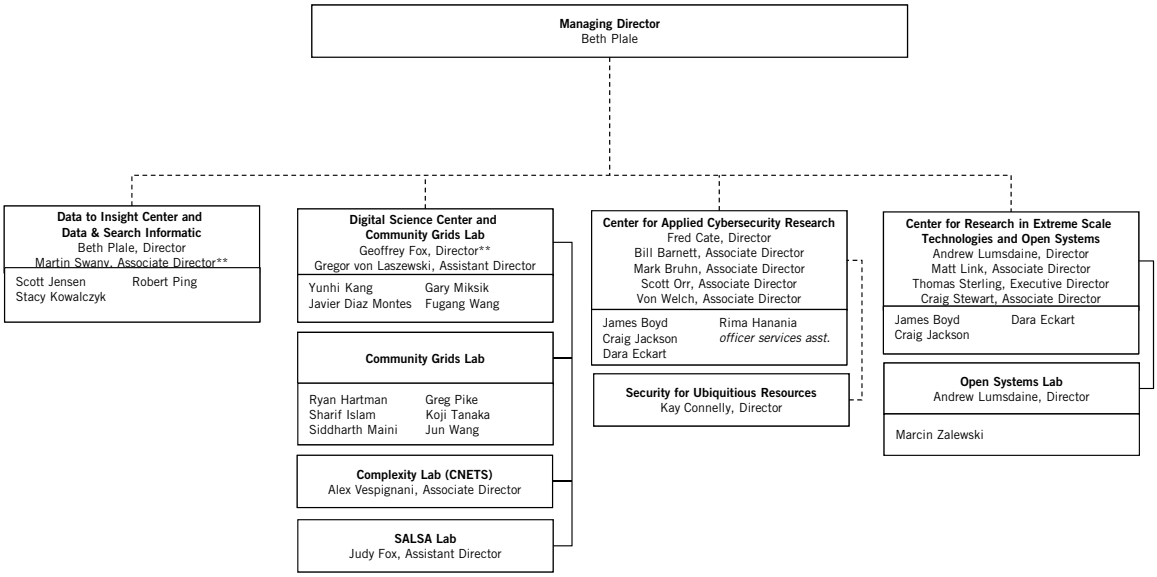


Chart includes appointed staff only. See http://uits.iu.edu/scripts/ose.cgi?ltxt.help.

Indiana University

Pervasive Technology Institute – Research Centers

March 2012



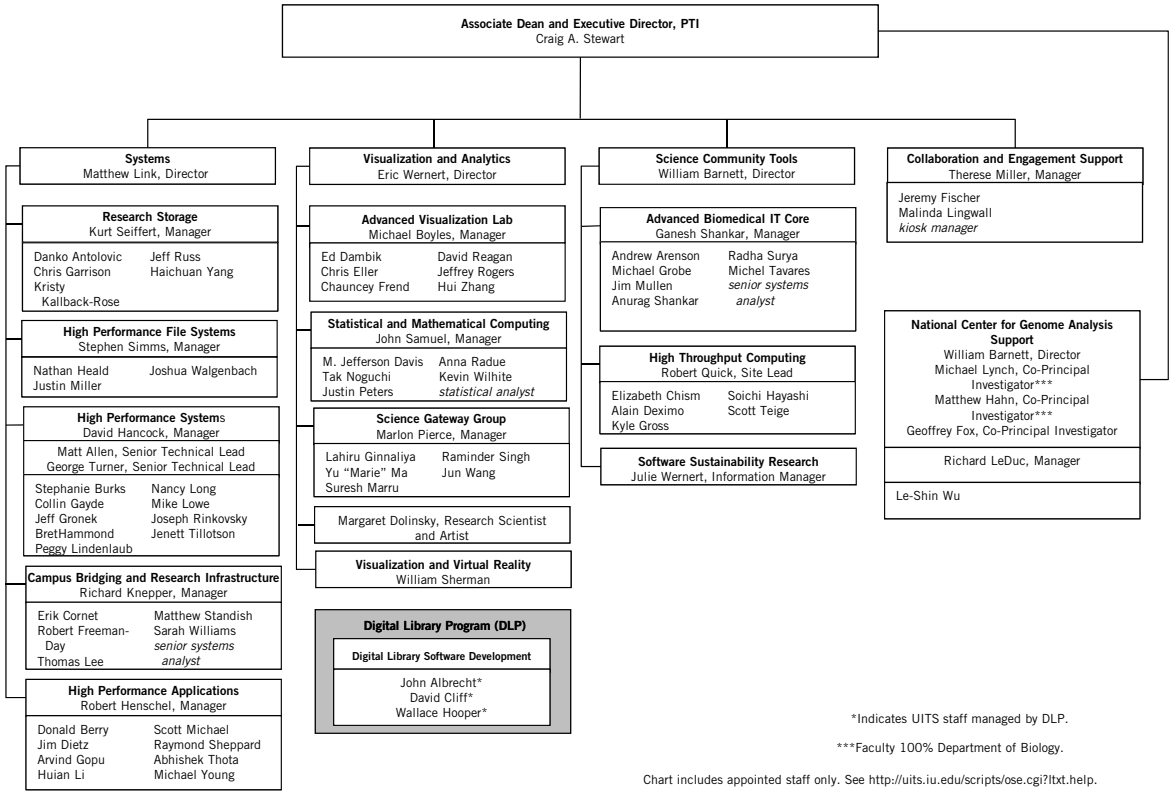
** Designates direct reports to Bradley Wheeler

Chart includes appointed staff only. See http://uits.iu.edu/scripts/ose.cgi?ltxt.help.

Indiana University

Research Technologies & PTI Service & Cyberinfrastructure Centers

June 2012



*Indicates UITS staff managed by DLP.

***Faculty 100% Department of Biology.

Chart includes appointed staff only. See http://uits.iu.edu/scripts/ose.cgi?ltxt.help.

14. Appendix: IU planning documents relevant to Research Technologies strategic planning

- *Empowering People: Indiana University's Strategic Plan for Information Technology*. 2009. http://ep.iu.edu/
- McRobbie, M.A. Principles of Excellence. http://www.iu.edu/~pres/vision/principles-of-excellence/index.shtml
- Indiana University Information Technology Strategic Plan – Architecture for the 21st Century. 1998. http://www.indiana.edu/~ovpit/strategic/

14.1. Notes from "Empowering People: Indiana University's Strategic Plan for Information Technology. 2009."

The Recommendations and Actions relevant to Research Technologies have also been quoted at the beginning of this document. The early portion of the text of the document is important in helping set the stage for the plan and the broader goals it sets out to achieve. The early segments of this document are thus quoted at length here:

Looking to IU's Future

Strategic Positioning

Since information technology is a critical resource that lies at the very essence of the university's functions of knowledge creation, preservation, and instruction, it follows that investments must continue in IT if Indiana University is to remain competitive. Major research universities will continue to face formidable competition in " ...virtually all aspects of the education and research enterprise... The competition will be for faculty, for students, for funding, for intellectual property rights and for recognition and visibility, and each aspect of this competition will be global.

A question arises about the role that IT could play in providing a competitive *advantage* for IU. The visionary 1998 plan *Architecture for the 21st Century* (ITSP1 hereafter) positioned IU among the leaders in the provision of information technology infrastructure and services. In the ensuing years many other universities have also recognized the critical role that IT plays and have made substantial investments in IT. Sharply reduced cost/performance ratios and the commoditization of many aspects of IT that were cutting edge only a few years ago continue to encourage widespread adoption.

The net result is that while a strong IT infrastructure and the provision of services are necessary to compete with major research universities, it is unlikely that general investment in IT alone could provide competitive or strategic distinction. However, the innovative use and application of information technology can be a strategic advantage for IU if IT investments are made in concert with the strategic objectives of the university, its human skills, organizational structure, and operational capabilities. After years of substantial investment, IU appears to have a considerable head start on IT infrastructure. The challenge is to identify the optimal strategy to advance these interdependent areas going forward.

John Seely Brown and John Hagel provided some useful perspectives in a 2003 letter published in the *Harvard Business Review* that offers relevant ideas regarding the strategic role of IT for universities today.

- Extracting value from continuing investment in IT requires changes and innovations in institutional practices and processes. The differentiation is not in IT itself, but in the possibilities for new activities that are not performed optimally or were not previously feasible.

- Opportunities for extracting value from IT may be greater across institutions rather than within institutions. IT enables new possibilities for multi-institutional collaboration across universities that would have been prohibitively expensive or impossible just a few years ago. IU's leading investments in Sakai, Kuali, EVIA, HathiTrust, and grids are early indicators of the potential for such collaborations.
- The most successful IT initiatives showing tangible results have developed from incremental waves of innovation of six to twelve months, rather than from complicated, expensive, and very risky "big bang" efforts. Smaller projects afford opportunities for refinement and learning, and reduce financial risk.
- Real strategic advantage will come from the cumulative effects of focused investments in IT rather than from dispersing efforts across too many programs. There are more technology options than any single university can or should pursue. IU can achieve strategic differentiation by adopting a long-term view of opportunities and focusing efforts on achieving advantage in the basic functions of the university through IT.

The implication is that while IU must continue on the evolutionary path of IT development begun in 1998, this alone will not result in distinctive excellence for the university. Instead, a three-part strategy is recommended for the next five years that aims to achieve leadership and distinction by:

1. *Continuing to invest in IU's IT infrastructure and services, ensuring its position of leadership and providing its faculty, students, and staff with needed IT resources. Sustained investment in IT to maintain IU's leadership is necessary and can be further strengthened by:*
    - Continuing to provide a reliable and stable computing infrastructure.
    - Continuing to develop the foundation of standard teaching/learning hardware, software, and devices, as established in ITSP1.
    - Sustaining IU's successful practices in maintaining a solid financial basis for information technology and for supporting and protecting all physical and intangible assets associated with IT.
    - Continuing efforts to attend to a constellation of issues that include social behaviors, supportive policies, balance between continuity and innovation, engaging communities, forming partnerships and networks, and creating environments that offer incentives for innovation and building trust.
2. *Adopting a human-centered approach to developing and implementing IT systems and applications in order to achieve more pervasive and creative use of these systems and applications. Creating a user-centered approach to information technology involves:*
    - Continuing to seek input from the IU community and other stakeholders and continuing IU's tradition of transparency in IT expenditures, not only at the university level, but also by campuses and schools.
    - Focusing on IT investments that enhance IU's effectiveness and/or efficiency in achieving its core mission in the long or short run and that carefully balance gain versus risk, agility versus stability, and long- and short-term perspectives.
    - Striving to hide complexity while maximizing functionality. Applications need to be accessible and perceived as easy to use. Technological sophistication can be made to enhance — not encumber — research, teaching, creative activity, and university operations. With proper support and training, the IU community will be able to employ state-of-the-art technologies without unduly diverting time and effort from fundamental activities. Creative

and innovative ideas for IT applications can also be stimulated by keeping IU faculty, staff, and students up to date regarding new and forthcoming technological developments.

- Recognizing that one size does not fit all. Substantial heterogeneity of IT needs, capabilities, and resources exists among the various constituencies at IU and explicit recognition and consideration of such differences will aid the diffusion and adoption of IT applications.
- Collaborating with other institutions and organizations. Much more can be achieved through collaboration and partnership than by working alone. A continuing strong commitment to working with partners will further strengthen IU's ability to provision new and powerful tools that promote innovation in teaching, learning, research, and administrative services.

3. *Focusing on a few key areas and grand challenges where IU can achieve true distinction rather than attempting to lead in all areas of IT. Areas for leadership investments are those that:*
   - Align with university priorities for the future.
   - Contribute to IU's distinction by strengthening areas in which IU has established leadership and expertise.
   - Are important in an absolute sense. Application areas that have major impacts on the achievement of the university's missions related to research, creative activity, teaching, outreach, and engagement with the community and beyond are much more likely to create paths to true leadership.
   - Leverage IU faculty research and innovation leadership. IU can be most effective at the research, development, and delivery pipeline if IU starts with areas of faculty thought leadership, supports faculty innovation with investment of staff time and facilities, and speeds development of new tools into enhancements for the university community, state, nation, and world.
   - Present challenges amenable to improvement with technologies that are newly becoming available or are likely to emerge in the next five to ten years.
   - Leverage the information technology infrastructure to more broadly support IU faculty, staff, students, academic disciplines and key university partners.
   - Are visionary, inspiring, and creative.

With continued investment in the infrastructure, attention to human-centered use and application, and focused efforts to attain distinction in specific areas, IU can achieve leadership in the creative use and application of IT in key areas with broad progress across the entire university. This strategic positioning will enable IU to lead from a position of strength as a contributor and partner in the best academic opportunities.

Aspirational Visions for IT at IU

Envisioning aspirational scenarios for the future provides a useful tool to establish goals and direct progress. Imagine the state of IT at Indiana University a few years into the future. The following scenarios, written in the present tense, provide a look into the future of IT at work at IU.

Since the adoption of ITSP2 in 2009, sustained investment in information technology on all IU campuses has created a digital technology environment in which teaching, learning, research, creative activity, and virtually all university activities have become more effective and more efficient. IU continues to be regarded as a leader among universities in providing pervasive information technology resources. Importantly, IU is recognized as a clear leader in creating and deploying innovative applications of IT in several key areas of research and instruction.

Vision for Faculty and Scholarly Excellence

All IU faculty members have access to state-of-the-art personal computing devices, many of which are transportable so that work can be conducted in the office, at home, or while traveling. These devices enable creative work and revision, either individually or in collaboration with others and allow access to a vast array of functional data and systems that support instruction, research, decision-making, and creative and administrative activities. These devices are updated or replaced as needed via a sound fiscal process of lifecycle funding.

Collaboration with groups of colleagues for meetings across IU campuses is enabled through advanced communications systems that provide high-resolution video and high-fidelity audio - creating a virtual sense of presence. Advanced collaboration technologies, integrated with personal devices, afford high-quality audio and video, visual displays, and low latency for convenient communications. Immersive technologies enable visualizing results in ways that afford paths to new insights. Faculty work routines move seamlessly between research and teaching activities. For example, scholarly work by faculty that generates primary data is placed in IU's public data utility, and it is available to be incorporated in teaching and research in other parts of the world. IU faculty draw on similar utilities and educational resources to incorporate material in their classes.

The university has implemented a program that provides IT devices that are tailored to meet individual faculty requirements. For example, one cultural anthropologist's device includes video- and audio-editing software and multiple displays. Another faculty member, a visual artist, designs on a high-resolution work surface, scaled for dimensional accuracy, and calibrated for color fidelity. This artist also requires enhanced network connectivity and bandwidth so that she can easily move and process with reduced latency the large datasets that she transmits to colleagues and external displays.

IU research scientists are able to store massive amounts of computational data in a secure data storage area that allows setting permissions for specific subgroups of colleagues at IU and beyond. Scientists using the data are able to track and retrieve multiple versions of the data, including the raw data, the cleaned version, and subsets, in formats readable by the various statistical packages used by colleagues. Integration with data analysis tools makes it easy to extract data subsets and test various scenarios.

Another IU professor is a member of an interdisciplinary team comprising a group of researchers in the humanities, informatics, and senior IT support professionals. The team is developing a special cross-disciplinary collection of resources, IT tools, and methods for studying and analyzing the collections of digitally captured and born-digital documents, videos, and images. The idea for this project came about as a result of a special forum IU routinely provides to keep faculty, staff, and researchers informed about emerging IT developments and their possible merits and applications in teaching and research. This forum is one part of a multi-faceted approach to IT support, training, and personal assistance that can be tailored to individual levels of expertise, and delivered in modes that suit individual preferences. Faculty and staff can get help in the office, in the classroom, in the lab, or on research trips abroad. A variety of digital tools that are easy to use create efficiencies of time and are flexible enough to fit a variety of preferences and needs.

Vision for Student Success

Students at IU bring their own computing and communication devices (in a variety of form factors) and are quickly able to connect to IU's vast array of services and software. In fact, many students begin interacting with and using IU's technology resources long before coming to campus through outreach initiatives with elementary and high schools throughout the state of Indiana. Facilities throughout IU complement these student devices to provide space to work in informal environments where students can connect their personal devices to larger displays and keyboards, recharge batteries, or secure computing devices between uses. Modern technology centers and labs are also available on IU's campuses for students to access community devices.

…

Technologies that support multiple communication modes and one-to-one and one-to-many interactions bolster opportunities for meaningful faculty-student communication, including discussion and feedback. Other systems support assessment tools and processes, enabling measurement of learning and promoting accountability. IU students interact with a world of IT services and demonstrate good habits in protecting their own privacy and the intellectual property of others.

As participants in a global, connected community of learning, IU students benefit from the backgrounds and perspectives of a spectrum of international faculty and students with whom they interact on campus and remotely. Class sessions often include dialogue with experts at IU and beyond, via rich, reliable communication technologies. In many cases topical experts and IU alumni from Asia, Europe, Africa, and elsewhere join with IU instructors to provide truly global perspectives. For appropriate projects, students use these communication tools to collaborate with mentors in private industry, research agencies, and State and local governments.

Students can track their progress toward majors and degrees by consulting the personal dashboard. As they take classes, engage in IU's rich learning environment, and participate in campus clubs, they can also log their experiences in an electronic portfolio that is accessible from their dashboard. The portfolios are also used in some cases to demonstrate competency levels in areas such as written communication, critical thinking, quantitative analysis, and the like. Students are able to include course-related work and other experiences (e.g., internships, study abroad) in their portfolios to provide evidence of their skills. The portfolios are also useful in demonstrating accomplishments in job interviews and graduate school applications.

Vision for Supporting the IU Community

Information and communication technologies have become more pervasive in community activities. Systems focus on making easy and reliable some common forms of communication across distance - whether to the next building or another campus - with interfaces to common services that simplify coordinating work, team, and personal activities. For example, a flexible, customizable calendaring tool allows individuals to learn of the many events on IU campuses and see how these relate to personal calendars. IT systems make access to essential administrative services and tools easier and more user-oriented. Purchasing tickets for events, paying parking fines, requesting advising appointments, switching course sections and conducting many other day-to-day student, faculty, and staff activities are handled via well-designed IT systems.

For example, when an IU scientist is preparing a grant application for government funding for her research, she can easily complete preparatory data gathering, electronically submit her research protocols for appropriate institutional review, develop budget scenarios for the grant, and collaborate with co-investigators - all without having to re-enter data or wonder about the status of any necessary approvals.

…

IU constituencies have access to rich, multimedia collections of many of the activities and events that comprise the scholarly life at IU. A student can search for video clips of presidential speeches that refer to initiatives in the humanities. A graduate student can find a podcast of a lecture by a visiting distinguished scholar from years ago to assess how his theorizing work began and has evolved over time. IU alumni around the world have access to a substantial portion of the performing arts and cultural events at IU.

Alumni also experience greater support in their transactions with the university. For example, a group of IU alumni and friends who live across the country are able to get tickets to a Jacobs School of Music opera performance via a gateway that shows calendars and schedules. The system allows ticketing and seat selection, lets them book rooms at the Indiana Memorial Union, and completes the transaction with a secure payment utility.

Vision for Engaging the Community Beyond IU

As one of the great universities of the 21st century, IU is highly connected via communities, alliances, and engagements that extend far beyond its campus borders. Through its advanced networks, IU combines the advantages of its location, such as high quality of life, modest cost of living, and strong Midwest work ethic, with the ability to project the skills and interests of its faculty, staff, students, and alumni almost anywhere. IU has contributed to an economic revitalization of the state of Indiana that has moved the state from the lower third of the nation to well above the median. IU has partnered with the State government and other institutions of higher education to take major indicators of public health from the bottom 10% of the nation into the middle third. The benefits of IU scholarship extend far beyond the borders of Indiana, through the US generally, and to the world as a whole.

IU's engagement with the state and beyond takes many forms. For example, a professor in the School of Education at IUPUI collaborates with teachers in high schools across the state, sharing statistical information and co-authoring instructional materials for high school students. IU scientists and research technologists provide students in primary and secondary school the opportunity to participate in authentic science learning opportunities. This engagement helps inspire students to pursue higher education and careers in science, technology, engineering, and math (STEM) in ever- greater numbers. Staff members working in university financial aid offices provide scholarship, grant, and loan information to Federal and State regulatory bodies in the secure format they require. Common formats for data exchange or system integration further ease the transfer and articulation agreements for students taking courses at Ivy Tech Community College of Indiana and IU East. As an example, student interns working in Informatics in Indianapolis are able to receive funding for their research project from a private corporation in South Bend, and managers from the corporation can regularly interact with the interns to provide input on their work.

IT systems have been integrated with the extensive health and medical care institutions in the state. A physician at the IU School of Medicine in Indianapolis can log on to her personal device and use it to set up a syllabus and assignments for a class she teaches, submit travel expenses to the finance department of her clinic at Clarian Health, review a former patient's x-ray results stored at the Regenstrief Institute, and then check on the status of a grant submission that is being led by a co-investigator at Purdue University. IU expertise in advanced networks also helps with remote diagnostics for a new academic digital education network in Liberia. While learning about another part of the world, IU School of Dentistry students can share newly developed techniques with colleagues in Kazakhstan who are building a rural clinic.

Similarly, many Indiana and national companies are now able to effectively and appropriately tap into IU's expertise and form mutually valuable alliances that advance the Indiana economy. IU research and expertise in data informatics, advanced visualization, and networks has become more integrated with key health partners, such as Clarian Health, to improve the lives of Hoosiers.

Realizing the Aspirations via Sustained Effort

The scenarios presented above provide a vision for the future of IU that is ambitious, yet achievable over time. It is achievable because of the rapid developments in IT that will continue in the coming years and, importantly, because Indiana University has much of its IT house in good order in 2008 as an outcome of the 1998 IT Strategic Plan and the sustained efforts to implement its recommendations over the past 10 years. It is essential that the university not fail to sustain the momentum that has enabled progress thus far as it moves to even greater levels of creative use and application of information technology among its faculty, staff, and students.

14.2. Notes from"Principles of Excellence"

N.B.: This document is so concise and so thoughtful and so well written that one really ought to read the whole thing and commit the basic principles to memory. Somewhat more than half of it is directly relevant to Research Technologies, and is quoted at length below:

Vision

To be one of the great research universities of the 21st century and to be the pre-eminent institution of higher education in Indiana, specifically by:

Providing an excellent world-class, relevant, and responsive education across a wide range of disciplines in baccalaureate, graduate, and professional education to students from all backgrounds from Indiana and around the globe;

Pursuing excellent world-class research, scholarship, and creative activity; and

Engaging in the economic and social development of Indiana, the nation, and the world by building on this base of excellence in research and education.

Indiana University will be both entrepreneurial and collaborative in pursuing this vision and generating the resources to accomplish it.

Mission Statement

Indiana University is a major multi-campus public research institution, grounded in the liberal arts and sciences, and a world leader in professional, medical and technological education. Indiana University's mission is to provide broad access to undergraduate, graduate, and continuing education for students throughout Indiana, the United States, and the world, as well as outstanding academic and cultural programs and student services. Indiana University seeks to create dynamic partnerships with the state and local communities in economic, social, and cultural development and to offer leadership in creative solutions for 21st century problems. Indiana University strives to achieve full diversity, and to maintain friendly, collegial, and humane environments, with a strong commitment to academic freedom.

The Principles

1. An Excellent Education

   Ensure that IU's schools and programs provide an education of the highest quality appropriate to their campus and school missions and are recognized for their excellence through national and international peer comparisons.

   The best academic programs. Provide an excellent, rigorous, contemporary education through an extensive range of undergraduate, graduate academic, and professional programs and degrees that meet the needs of Indiana, the nation, and the world.

   Educating outstanding students. Attract academically outstanding, promising students from diverse and under-represented backgrounds throughout Indiana, the nation, and the world.

   …

2. An Excellent Faculty

   Recruit and retain an outstanding, diverse, and inclusive faculty from researchers, scholars, teachers, and creative artists worldwide who are recognized as among the very best in their fields.

3. Excellence in Research

   Maximize IU's full capacity for research, scholarship, and creative activity that is recognized as excellent through national and international peer comparisons.

Increase research and scholarship. Increase external funding and other support for research and scholarship in all areas of inquiry, and ensure that these activities are strongly supported both academically and administratively.

Stimulate the Arts and Humanities. Expand and enhance IU's renowned traditions in the creative arts that enrich the lives of Hoosiers and reach around the globe.

A commitment to outstanding professional education and research. Build on IU's superb professional education programs to continue to meet the present and emerging needs of Indiana, the nation, and the world.

Expand intercampus collaboration. Leverage the combined intellectual resources of the IU campuses through broad-based, interdisciplinary research and other collaborations internally and externally.

4. The International Dimension of Excellence

Increase IU's engagement internationally through globally aware education, enlarged study abroad activity, alumni activity, and expanded strategic partnerships with leading institutions of higher learning throughout the world, and continue IU's historical commitment to institution-building around the globe.

5. Excellence in the Health Sciences and Health Care

Support the highest quality research, clinical care, education, and workforce development in the health sciences by deepening and expanding Indiana University's relationship with IU Health (Clarian) and with the university's other clinical partners, thus contributing to better Hoosier, national, and global health.

6. Excellence in Engagement and Economic Development

Actively engage the university's strengths to support the health, economic, and social development of Indiana, the nation, and the world.

Translating innovation. Accelerate the transformation of the innovations and intellectual property developed by IU faculty, staff, and students into new products, services, and companies to improve the Indiana economy and national competitiveness.

Strong communities. Partner with the communities and regions of which IU is part to provide education, expertise, innovation, and leadership for their advancement.

…

9. The Centrality of Information

Ensure that the Principles of Excellence are supported by outstanding information technology and information resources.

Pervasive Deployment of IT. Ensure information technology is pervasively deployed at IU by leveraging and continuing the support of the university's long-standing and internationally recognized excellence in information technology services and infrastructure.

IU Libraries. Ensure that IU's libraries provide access to information in all forms that comprises the record of human knowledge, thought, and creativity for the learning, scholarly, and research communities at IU.

10. Responsible Stewardship of Indiana University's Resources

Ensure that all of the public and private resources entrusted to IU are used as effectively and efficiently as possible in pursuit of the Principles of Excellence.

Accountability. Undertake continuing analysis, including appropriate metrics, to measure and evaluate the effectiveness and efficiency of all aspects of IU's operations.

Excellence in Administration. Provide outstanding administrative services in support of the Principles of Excellence and IU's broader missions.

Communicating Excellence. Ensure the accomplishments of IU are widely known throughout Indiana, the nation, and the world.

14.3. Notes from Indiana University Information Technology Strategic Plan – Architecture for the 21st Century.

The Goal for Information Technology at IU

President Myles Brand in his 1997 speech, "State of the University: The Next Step," set a challenge for Indiana University to "take the next step in institutional academic excellence and move into the very top tier of the nation's public universities."

As is argued in this Plan, the creation of new knowledge and sharing of information are defining features of a university, and so the goal of excellence in the use of information technology is an essential ingredient in achieving academic excellence.

The vision put forward in this Plan is one in which our advances in information technology help to achieve this overall vision of academic excellence for Indiana University. Information technology will be one strategy among others that must be pursued by IU, but is one that must be pursued with commitment if we are to "move into the very top tier."

The goal of this Plan is for Indiana University to rise to a position of absolute leadership among institutions of public higher education in the creative use and application of information technology.

E.5 Research: Computation, Communication, Collaboration

Revolutionary changes in information technology have set the stage for social and economic transformations. These changes, brought about by the convergence of computational and communication technologies, have created entire new industries. Information technology now allows problems to be solved in new ways and human communities to be thought about in a new light. All researchers work in intellectual communities and increasingly one of the most important uses of information technology in research will be to support their collaboration. It is essential that all researchers have access to at least a common base of collaborative technology such as Web access and email and, in addition, that more advanced collaboration technologies are introduced and systematically deployed at Indiana University.

High performance computing has been an area of distinction for IU, and one that can only be maintained through continued attention and support. The University's participation in many national and international research partnerships will depend upon its capabilities in high performance computation and communications. Advances in computing and communication have created increased demands for data storage and management. And underpinning all of this is the need to provide researchers with good software tools and good support services.

RECOMMENDATION 5: In support of research, UITS should provide broad support for basic collaboration technologies and begin implementing more advanced technologies. UITS should provide advanced data storage and management services to researchers. The University should continue its commitment to high performance computing and computation, so as to contribute to and benefit from initiatives to develop a national computational grid.

E.9 Digital Libraries and the Scholarly Record

The transformation of teaching and learning through the use of information technology also entails the transformation of scholarly literature and learning resources through the widespread implementation of

electronic journals, online databases, digital libraries, and other networked information services. Academic research is integrally involved with access to information and the creation of the scholarly record. While it is tempting to view the Web as the new paradigm for knowledge acquisition and distribution, this volatile collection of community culture was never designed to be the next evolution in research resources.

There is a science to the management and mining of information, and the library is the heart of this enterprise. The nexus of the next revolution will not be based on Web technology alone, it will be based on tools that integrate intelligent knowledge acquisition systems with the ingenuity of the individual scholar, teacher, or learner who has access to a well catalogued, distributed, national digital library. In this process there will develop a new role for the academic librarian as information agent and information broker, working across many traditional boundaries of organizations and scholarly disciplines, providing a service to faculty and students by connecting them with the information resources they need for research, teaching and learning. The professional expertise of librarians in the IU Libraries and of faculty in the School of Library and Information Science will be invaluable in this transformation.

RECOMMENDATION 9: The University should build upon and expand its digital library program, and develop the digital library infrastructure needed to support research, teaching and learning.