Research is four things: brains with which to think, eyes with which to see, machines with which to measure, and, fourth, money.

—Albert Szent-Györgyi

Summary

For three days, January 27–29, 2014, more than a hundred thought leaders met in Tempe, Arizona, to discuss the present and future challenges and opportunities for IT’s support of research. Recommendations to improve institutions’ support of scientific and humanities research included:

- Shaping central IT’s role as an aggregator of cybercomputing demand and funding
- Ensuring that central IT plays an active and focused role in research tool development in concert with expanding staff expertise in research computing
- Applying service management frameworks such as ITIL to research computing services
- Bolstering faculty support and training in research computing
- Collaborating with faculty in service design
- Ensuring the CIO reports to institutional leadership responsible for the research mission

Backdrop: Research, an Imperiled Mission

Academic research in the United States has experienced unprecedented growth over the past half century. In 1945, there were four universities that we would today recognize as major research universities. Today there are over 100. In its initial breathtaking sprint of post–World War II and Sputnik-era expansion, federal higher education research and development expenditures increased fivefold (by 515%), and other higher education research and development expenditures grew by 369% in a decade.¹

The academic research juggernaut is responsible for a plethora of “sensational products and technologies,” such as bar code scanners, cloud computing, computer-assisted design, deep-sea drilling, forensic DNA analysis, functional magnetic resonance imaging, Google’s search engine algorithms, the Internet and web browsers, nanotechnology, discoveries leading to better understanding of global climate change, the retina chip, public key cryptography, technologies enabling deep-sea exploration, social science databases, speech recognition technology, and tumor detection.² The contributions of a single major research university to our economy are astonishing: MIT alone has spawned 4,000 companies that have employed 1.1 million people and produced annual worldwide sales of $232 billion.³ More broadly, research
investments contribute both directly and indirectly to economic growth, although estimates vary widely and depend on the methodology used.  

When considering academic research today, three noteworthy facts surface:

1. Basic research has a 25-year payoff, from basic science findings to practical applications. Our current economic climate is not conducive to funding activities that might or might not deliver benefits 25 years hence.

2. Research today is highly dependent on technology.

3. The United States’ leadership in research is waning. That is not solely due to the Great Recession. Even in 2007, a National Academy of Sciences report warned, “Having reviewed trends in the United States and abroad, the committee is deeply concerned that the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength.”

The special collaboration between government and higher education that was largely responsible for the United States’ current leadership in academic research is unraveling at a time when other countries are building research and development infrastructures. Corporations are not stepping in to take up the slack. Growth in academic R&D continues today, but its pace has slowed, from annual increases averaging 14% to 19% in the 1950s and ’60s to about 10% in the 1970s and ’80s to only 7% in the first decade of this century. Major challenges facing academic research in the United States include:

- Weakening partnerships among government, businesses, and higher education
- Declining federal and state funding
- Rising accountability demands for higher education institutions
- Declining opportunities for new faculty
- Underinvestment in campus infrastructure, particularly in cyberinfrastructure
- Increasing regulatory and reporting requirements
- Sponsored research that funds only part of research costs, leaving a gap that institutions need to cover
- Increasing international competitiveness—in research and for students

Academic research is today experiencing decreasing resources, investment, and leadership; increasing costs and regulatory and accountability requirements; and expanding requirements and needs for technology. It was against this backdrop that ECAR Annual Meeting attendees considered the opportunities and challenges facing higher education IT leaders. These proceedings distill the contributions of the meeting’s speakers as well as attendee comments. (See the appendix for a complete listing of sessions and speakers.)
Contributions of Technology to Research

Increases in computational capability can fundamentally change even the problems faculty want to attack. New technologies are changing scholarship and research for all faculty, not just those in traditional scientific computation areas or those focused on technology. Faculty have a clear notion of the new modes of research that they must pursue to be competitive. As they embrace research computing, they are starting to challenge central IT to move faster and to understand e-science more deeply.

Specialized computers and interesting technologies—like Google Glass—abound. Some of them will be critical to research computing. For example, quantum computers are in the exploratory phase now, and they are extremely effective for certain types of database queries.

Using Technology to Engage Students in Research

Research computing can extend powerfully into instruction. Researchers at USC created an internship program for undergraduates to contribute discipline-specific software to high-performance computers. The students use the same equipment as the faculty to meld research experience and classroom activity; they are part of the research program. Integrating research computing into courses (with sufficient funding) can elevate awareness of research computing resources and the science they support. Future steps could extend to granting certificates or minors in the use of emerging research technology in such areas as data analytics, high-performance computing (HPC), quantum computing, and visualization. Students with research computing credentials will likely be very attractive to employers, who are increasingly investing in such capabilities.

Middlebury College’s Digital Liberal Arts program gives students an opportunity to meaningfully engage in research. It creates resources for use within curriculum, fosters media literacy, and gives student participants opportunities to engage in issues such as preservation, use of technology for analysis, and representation of analysis. Michael Roy, dean of library and information services and CIO of Middlebury College, noted that a number of digital liberal arts research projects were driven by the desire to create resources in the teaching process and were then expanded and used by others. The faculty who engage students in this sort of work report that developing these capabilities through these sorts of projects is important for supporting the liberal arts mission and educating students to be lifelong learners.

Expanding the Possibilities in the Humanities

The humanities have been embracing computation as an emerging form of scholarship, particularly over the past 10 years. Examples from Middlebury College faculty include:

- A digitized, geo-coated map of the Gettysburg battlefield according to Robert E. Lee’s perspective to provide further analysis of the battle
- A WordPress site created as a platform for peer-to-peer reviews of book chapters to augment the traditional editor-mediated peer-review process
- The Mahri Poetry Archive, a structure to collect, digitize, and share audiotapes of Yemeni people reciting Mahri poetry, an exclusively oral form of poetry
Research computing services need to support both traditional quantitative research and qualitative scholarship. Michael Roy suggests that “digital humanities looks a lot like research computing in the vast majority of methods.” The tools to support those methods are fairly familiar to anyone who is working in the computing and library or curricular computing environments. Four areas distinguish digital humanities from other types of research computing support: tool building, curation and preservation, new modes of publication, and evaluation structures. Scientific research tends to be collaborative and team-based; humanities research tends to involve a singular, individual scholar, perhaps with graduate students.\textsuperscript{12}“Digital humanities looks a lot like research computing in the vast majority of methods.”

—Michael D. Roy, Middlebury College

Crowdsourcing and Collaborations

With the aid of technology, distances are no longer a barrier to collaboration. Science today is no longer a single-investigator activity, but instead involves multiple collaborators often working in different disciplines, different institutions, and different countries. IT can facilitate this kind of activity in numerous ways, whether supporting distance collaborations with videoconferencing and hosting services, providing high-speed access to external resources, delivering local services globally, or supporting collaboration applications. Tools such as the Electronic Laboratory Network (ELN) are growing in popularity. ELNs are wiki-like document or protocol repositories with better tags, date/time stamp, and digital tools for time and version control that can promote collaboration. They can be hosted on campus or in the cloud.

Collaborations come with IT-related challenges. They include the obvious bandwidth and access challenges, as well as security and even regulatory challenges. One non-U.S. participant described faculty concerns about collaboratively passing data across the Internet, especially when it crosses international borders. IT departments must understand researchers’ needs and the tools they are already using. Individual researchers can now afford some ELN solutions, but their data-protection capabilities may not meet institutional standards.

Big Data Placing Big Demands on IT

New avenues of research and scholarship have opened up as a result of technology’s ability to collect, store, process, and depict massive amounts of structured and unstructured data. Scientists and scholars in fields from astronomy to medicine to history are able to answer previously unanswerable questions. Technology has cracked the big-data nut, and that is posing challenges for IT.

Networking

Advances in data storage, retrieval, and processing have enabled researchers to work with huge volumes and varieties of data. The volume of big data is increasing by orders of magnitude. As research becomes increasingly data intensive, it demands higher throughput and faster access from networks. Examples of solutions\textsuperscript{13} include:

- Software-defined networking, which can simplify network management and help address challenges involved with big data and security. NYSERNet’s work to implement OpenFlow across the NYSERNet network is an example.
The Science DMZ. Institutions used to attach the research network to the administrative or campus network. This model is reversing, with the research network as the primary Internet-facing network and the administrative network configured almost like a small local area network. The Science DMZ involves connecting supercomputer centers or large HPC clusters directly to the Internet using data transfer node (DTN) devices that sit outside the firewall and are designed to transmit data very quickly. The DMZ model allows institutions to optimize network equipment, configuration, and security policies for research computing.

Solutions like Globus, a file server with carefully crafted network interfaces for high-speed file transfer in the cloud. One potential best practice discussed at a recent conference is for each research university to have a Globus online host to move large, multiterabyte data sets across the network from campus to campus.

Regional optical networks like NYSERNet, IRON, and KyRON are a major part of the higher education networking topology. They are currently experiencing significant funding challenges, creating the potential for bottlenecks between a national Internet2 100-gigabit backbone network structure and increasingly effective Science DMZs.

Data Management

As noted by Caruso et. al, big data is also generating data-management challenges including metadata for searching, standards, preservation, archiving, reproducibility, and retrieval. Institutions need to develop practices and policies for data preservation, security, standardization, and efficient storage.

As researchers create more data, it is increasingly imperative to create intentional strategies around which data to keep or throw away—and to do this up front as part of a research project life-cycle planning phase, perhaps adopting phases familiar to researchers, like preaward, active award, and postaward. Some institutions are creating templated data-management language in grants. IT is engaging libraries in the process because they understand the data, the disciplines, and data curation, as well as sustainability. Sustainability issues include standards and long-term preservation. Libraries have experience with platforms, formats, and cataloging, all components of data archiving and management. Long-term preservation is a particular challenge because there is no clear funding model. One thought is to consider endowing data sets.

Creating an institutional one-size-fits-all plan may not be a good approach. The data challenges are different for different domains. As a result, discipline groups have begun to address these issues for their specific domain. Perhaps partly for this reason, there are no cohesive data-management requirements among federal agencies, creating another impediment to a single institution-wide solution.

The Council on Library and Information Resources (CLIR) has created an initiative called the Committee on Coherence at Scale to foster strategic thinking about how to more rigorously manage the transition from analog to digital in higher education. Among the ideas emerging in this space is applying the NSF’s cyberinfrastructure model to the humanities and social sciences, resulting in centers resembling supercomputer centers—pockets of expertise and coordinated activities.
Security Concerns
The ubiquity of data and people who wish to easily access and manipulate it lead to information-security challenges that IT needs to address. In the absence of strong security, some researchers are even opting to store data on servers that are not connected to the network, to keep them safe from intrusions.

Commercial cloud services bring their own security challenges. One solution is to buy a site license that enables faculty to encrypt data and store it in the cloud. With this arrangement, both faculty and central IT possess an encryption key to manage the university assets. NET+ is looking at services to support HIPAA compliance, such as cyberclouds that encapsulate data.

Maturing E-Science Services to Advance Research: A Service Management Approach
College and university leaders are looking to IT leaders to do more with less—or at least with the same. Research computing is no exception to that trend. Many of the solutions either in place or being explored to balance resources, expectations, and requirements in other areas of IT support may be equally appropriate for research computing. But they will need to be adapted to the unique facets of this mission.

E-Science Support Today
Computing in support of the research mission accounts for less than 1% of most institutions’ central IT budgets but reaches 4% or higher in 25% of institutions; such support exceeds 12% in 1 in 10 institutions. Even the institutions devoting the most IT support to the research mission—public doctoral institutions—spend an average of only 11% of the central IT expenses on research. In comparison, research accounts for an average of about 11% of institutional expenses in all four-year institutions (12.1% for public universities and 10.8% for privates). So the average level of institutional spending on research—11% to 12%—is a level that only 10% of institutions achieve in central IT research computing spending.

Research is arguably the most highly decentralized of the three major missions of academic institutions—teaching and learning, research, and administration. That might at least partly explain why research computing seems to be underfunded compared with overall research expenditures. In fact, about two-thirds (64%) of institutions that support research computing have departments that independently provide research computing services.

Research computing appears even less coordinated when looking at individual services. On average, central IT manages any individual research service in 25% of institutions offering that service. Even with an expanded centralized role to include system oversight (1%) or shared responsibility (32%), management of an individual research service is decentralized in an average of 29% of institutions. This is probably due largely to the sheer complexity of e-science service delivery, which ranges from technically complex services such as HPC and grid computing to knowledge-intensive consulting in visualization, grant preparation, statistics, and access to federally funded research resources (see figure 1).
The number of institutions offering research computing services is growing, particularly for institutional grid computing services (now 40%) and data management and storage services (80%). About half of institutions report having at least somewhat effective strategies for planning, funding, staffing, and managing data for research computing services, but very few report having effective strategies. As noted in a discussion session, “How must central IT adapt if 50% of research technology organizations’ strategies are ineffective or not in place at all? By adopting a service-oriented approach to research computing.”

In administrative—and to some extent in teaching and learning—areas, IT has begun employing ITIL, COBIT, LEAN, and other service management frameworks and methods to manage IT service strategy, design, delivery, and improvement. IT may have avoided this practice with research computing because it is more complex and newer. Research computing services need to support diverse communities of users, from individual scientists and scholars to international collaborations and crowdsourcing, and each faculty member has a seemingly unique set of needs. However, the movement toward e-science, or an integrated system of research-related services, is growing (see figure 2).

**Figure 1. Management Responsibility for Research Computing Services**

—Gabe Youtsey
University of California, Davis
Figure 2. How Institutions Are Organized to Support Research

An institution-wide approach to delivering research or e-science services would prevent stranding research services and funding in specific units or limiting it to the “haves.” However, research computing needs participation from many departments and offices, and so a federated approach that includes but is not limited to the IT organization is probably most sensible. Other ideas for moving to service-oriented research computing suggested by attendees included:

- Bundling research computing support with the common network services “head tax.”
- Setting institution-wide consulting rates for specific software development, especially for data modeling or custom development.
- Focusing central services on scalable, common-denominator approaches.
- Identifying and funding centers of excellence and chartering them to provide services to the entire institution, not just the department in which they may have originated. Recent National Institutes of Health (NIH) grants encourage building non-transitory centers to support researchers into the future.
- Adopting ITIL service management practices to effectively and consistently manage services.
- Designating the CIO as the chief connector to forge partnerships with IT, the Office of Research, the library, departmental service providers, and others. This role would include developing good governance mechanisms to facilitate effective collaboration and coordination.
- Hiring people who understand data, data mining, analysis, and visualization to address the challenge of finding people with a mix of domain expertise and computer science and math expertise. As one meeting participant put it, “It is much easier to take a data person and teach them science to help the science computationally than taking a domain scientist and teach them about data science.”
ECAR has developed a maturity index for research computing that enables institutions to chart their progress along relevant dimensions of culture, infrastructure, investment, and central IT involvement and service quality (see figure 3).

![Research Computing Maturity Index](image)

**Figure 3. Research Computing Maturity Index**

### Business Models: Funding Is Critical to Success

Funding may be the biggest barrier to effective and efficient research computing services. Many IT departments find themselves having a funding conversation around every instance of research service provision. One solution is to align the IT organization with institutional academic initiatives. If IT is part of a campus initiative that puts some money on the table, the dialogue with faculty is different and much friendlier.21

The current university business model for provisioning high-performance computing, in which vendors sell equipment directly to researchers and each researcher’s HPC facility is a “tub on its own bottom,” is not cost-effective. An alternative business model at Purdue University is to manage HPC as a centralized service, with service level agreements designed to address faculty needs. This new model requires that researchers can trust central IT to build a competitive research computing environment and meet their expectations. As Gerry McCartney, Purdue’s CIO, aptly put it, “The academic culture is a coalition of the willing. Once you make something a rule, you lose a lot of good will. Faculty are rational; they come for the prices and stay for the service. They will not come for the service because they won’t believe you can provide it. If you offer them a great deal and then provide them with service, they will stay.”

——Gerry McCartney, Purdue University

Recommendations resulting from the success of the Purdue model include:

- **Use faculty references to gain faculty credibility.** A senior faculty member’s endorsement of the buying program was more effective than any CIO-authored memo.
Total Cost of Ownership of Cloud Computing

CIOs are concerned about the true cost-effectiveness of cloud computing; for example, one survey showed that 79% of corporate CIOs are concerned about hidden costs in cloud applications.

There are several problems to face in calculating TCO, and most existing models are not applicable to higher education. Cloud vendors do not understand higher education’s TCO challenges: Our researchers do not pay for power, cooling, space, or graduate-student labor.

An ECAR working group is developing a methodology to calculate the TCO of cloud services for higher education. The group adopted NIST’s cloud model definitions: public hybrid, community cloud, and private cloud. The group envisions a model that will cover various implementation phases:

- Investigation of various service alternatives and some factors such as scalability, capacity, and elasticity
- Negotiation: Procurement, legal, risk assessment activities (in-cloud versus buying equipment locally), associated staff (how to quantify), service level agreement
- Implementation: Initial layout/usage fees
- Transition cost: The life cycle of products, process redesign, end-user training
- Ongoing management: capital versus operational costs

- **Ensure participant equality.** HPC nodes are priced low enough that any faculty member can buy one, and both the 60-node owner and the single-node owner can take opportunistic advantage of unused nodes.
- **Recognize that expansion propagates in pools.** Satisfied customers organically encouraged additional purchases by others in the same department who heard about favorable experiences, became intrigued, and explored the service.
- **Build a good relationship with the sponsored programs group.** The service entailed transfers of federal funds, so the sponsored program department’s active involvement was essential.
- **Create a fluid node market so that no one is stuck in the program.** If faculty members trade in nodes to move to a new machine, central IT resells the old nodes—prorated for age—to faculty members who want to try out the program.
- **Maintain a few, close solution partners.** Purdue works with Cisco, EMC, HP, and Intel. Now these partners have residential internships located on the Purdue campus, putting new technology on the campus under the supervision of full-time vendor employees.
- **Look after the early adopters.** Because they are taking a risk by partnering with central IT, they have to feel good about the program, and central IT can make that happen by adding incentives.
- **Respect your project managers.** Central IT held a “stunt computing” event in which they built the first computer in a day to demonstrate their expertise, and they invited Purdue’s president to a ribbon-cutting ceremony. (This was the first time at Purdue that a university president had visited a data center.) The group even finished half an hour early. The one-day build worked because project managers, not system managers, planned the build. This event established operational credibility in central IT from the start.
• Flex the business model. Purdue’s model won’t work exactly as described for another institution because institutions’ business models vary. The CFO has to fully understand what is going on and support it. Don’t automatically ask for money: At Purdue, there was sufficient money in the existing system to fund the new model; this may or may not be the case at other institutions.

Positioning the CIO as the Chief Connector

The CIO’s line of reporting matters to success in research computing. When CIOs report to the provost or chief administrative officer, the proportion of the IT budget spent on the research mission is, on average, 67% greater than when CIOs report to the president and five times larger than when CIOs report to the chief financial officer. Greater proportions of IT spending devoted to research computing are associated with greater offerings of research services (see figure 4). That spending seems to come at the “cost” of administrative computing, not instructional computing: As the proportion of the IT expenditures devoted to research computing increases, the proportion devoted to administrative IT decreases (see figure 5). The teaching and learning proportion stays flat.

Figure 4. Relationship of IT Expenses on Research and Offerings of Research Services
Research Computing Needs to Get Collaborative

Research and resources extend far beyond institutional boundaries and academia; research computing must follow suit. This introduces a new dimension to supporting research computing, with attendant challenges and opportunities.

Shared services offer the promise of lowering the costs of research computing, facilitating cross-institutional research, and making research infrastructure available to a broader community of scientists and scholars. Central IT can play a role as an aggregator of demand for cybercomputing to enable researchers to share pooled cycles and simultaneously lower costs and deliver more computing power to each principal investigator (PI).

Moving beyond the institution to aggregate demand—and funding—across multiple institutions can deliver even greater value, particularly to researchers in smaller institutions. One issue is the problem of enabling the faculty to build a set of tools on top of a reliable network between the United States and other countries to achieve a model of global instrumentation. Initiatives such as the NSF’s Condo of Condos,22 a professional group of research computing facilitators, enable sharing information across institutions to locate people with the right mix of domain and computing expertise. Funding agencies like the NSF now pay attention to intercampus network connection speeds to support sharing instrumentation.
The humanities encompass widely different disciplines. Any given tool may address the needs of only a small percentage of scholars. A proposed strategy is to look for commonalities across disciplines, which may exist but not be readily apparent. Cross-institutional and cross-disciplinary working groups and/or consortia might be best positioned to look for commonalities and to develop tools to serve a wider community and facilitate the development process.

Cloud and other solution providers complicate this situation. While the cloud offers the ability to aggregate services and facilitate collaboration, cloud providers are rapidly offering alternatives not just to IT departments but also to individual faculty. Peter Siegel, CIO and vice provost, University of Southern California, cited a professor who spent $33,000 at Amazon to access one of the top 500 supercomputers for 18 hours to complete and then publish some significant chemistry calculations. He did not negotiate with central IT or procure new computers. He used a reputable supercomputer as a commodity service. Institutions should spend the time to determine which circumstances are most appropriate (and least appropriate) for the cloud at the departmental, institutional, community (typically, discipline oriented), and vendor levels. The central IT data center will not disappear anytime soon; the question is which things should be on campus in order to provide added value for researchers.

**Faculty Support Is a Differentiator**

One of the top-ten IT issues for 2014 is helping faculty with instructional technology. Faculty have a similar need for help with e-science. The challenges are similar as well: how to support a broad continuum of faculty whose interest in and knowledge of technology range from having an active dislike of technology to possessing more knowledge than IT professionals. Many researchers are just now moving away from lab notebooks to resources like ELNs, and they need help moving from spreadsheets to databases. They need ways to understand the power of databases, data management, data mining, and visualization. Humanities faculty and students may particularly need bootstrapping support to help them develop a better understanding of how technology can advance scholarship.

Many faculty are using resources such as global networks; cloud services; powerful databases from the VA, NIH, and other government agencies; and other technologies. When central IT and the procurement office are unaware of these activities, as is generally the case, they miss opportunities to understand what to build into institutional programs. In addition, these sorts of resources are often less mature than they appear, creating an expectations gap between what faculty assume is easy for institutions to provide and reality.

Campuses have fewer physical spaces like the keypunch room where biologist and economist meet serendipitously and later embark on some interdisciplinary projects. As a result, scientists generally do not know scientists outside their specific fields. Interdisciplinary collaborations can yield groundbreaking results, especially between traditional and nontraditional disciplines. For example, the social sciences statistician who knows how to analyze unstructured data can be more helpful to the astronomer in this task than anyone in the astronomy field.

For years institutions have attempted to provide well-maintained databases concerning faculty research interests and accomplishments to facilitate peer discovery and other uses. New solutions such as Labroots.com, a sort of LinkedIn for scientists, are gaining in popularity. However, these community-based sites don’t give back any insights or useful information to the institutions. The curve of development for such public resources is much advanced beyond...
anything institutions can do, and so institutions stand to lose access to well-maintained information about their own faculty.

But online tools are not as effective at fostering relationships. Face-to-face forums such as institution- or vendor-hosted workshops on such topics as big data or the Internet2- and Microsoft-hosted genomic and long-tail science workshops can lead to new collaborations. The key is to find questions researchers are passionate about and that they will commit to work on.

**Recommendations**

The field of research computing is in a state of flux. The research enterprise at our institutions is still a relatively new part of the thousand-year-old industry of education, fueled by the growth of research universities since 1948. It is therefore not surprising that institutions’ research computing strategies seem less advanced than their strategies for instructional or administrative computing. Peter Siegel advocated that IT professionals need to transition “from the notion of building a network to move videos and music to one of moving science and medicine.”

Institutions need to develop a nuanced and integrated strategy for e-science:

- **Central IT needs to define its role in supporting research.** Is central IT the compliance police? To what extent are IT organizations too distracted by administrative IT to develop an e-science strategy and program and to focus on framing and forming the needed relationships with the faculty? How does IT form relationships with the faculty yet manage research computing as a service and as part of the research enterprise? Central IT needs to determine its optimal role in service delivery and balance that with contributions from other institutional and external partners and stakeholders. As Peter Siegel advised, “Build globally, support locally.” Researchers are building globally, so IT organizations have to help them access a global infrastructure, even if that access is built locally. Data or systems need not be local. It is incumbent on the IT organization to understand what data needs to be local.

- **Central IT can play a role as an aggregator of demand for cybercomputing.** This will enable researchers to pool resources to both reduce costs and deliver more computing power to each PI. Moving beyond the institution to aggregate demand—and funding—across multiple institutions can deliver even greater value, particularly to up-and-coming faculty or researchers who have fewer needs or are at smaller institutions.

- **IT organizations should focus on building blocks and tools.** The infrastructure is developing rather well, but this is not true for tools. Very few tools are developed or harnessed by the IT organization. Key technologies are maturing and going mainstream with—or without—central IT. To avoid misdirecting its energies and funds, the IT organization needs to understand which technologies are critical to enabling truly exciting research.

- Institutions need to recognize research computing’s impact on the humanities and other disciplines not traditionally associated with research.

- **Institutions need to develop a data-management strategy for the life cycle of data.** To ensure valuable data remains secure, accessible, and interoperable long after the investigation has ended.
• IT organizations should **help faculty collaborate and learn research computing skills**.

• **Consider the relationship between instructional IT and research IT.** There is a bright line between the two in our organizations, and yet most of the faculty we support in research also teach, and vice versa. Institutions need to support real access for undergraduates, and that will entail allowing research and instructional IT to intersect in meaningful ways.

How do institutions get started? Purdue’s Gerry McCartney suggests you can start with one faculty member. Every institution can do that. It’s time for all to get started and, having started, to excel.
Appendix: Sessions and Speakers

Over two and a half days, the 2014 ECAR Annual Meeting featured four invited speakers and facilitated discussion sessions led by the ECAR Working Groups. Resources from the meeting, including slide presentations, can be found at http://www.educause.edu/events/ecar-annual-meeting-2014.

- **Lawrence Krauss**, Foundation Professor, Cosmology, Arizona State University, “Life, the Universe, and Nothing” (Keynote speaker)
- **William Gerry McCartney**, Vice President for Information Technology and CIO, Purdue University, “Better Than Removing Your Appendix with a Spork: Developing Faculty Research Partnerships at Purdue University” (Invited speaker)
- **Michael D. Roy**, Dean of Library and Information Services and CIO, Middlebury College, “The Digital Liberal Arts: Problems and Possibilities in the Digital Humanities” (Invited speaker)
- **Peter M. Siegel**, CIO and Vice Provost, University of Southern California, “Researchers and the Petabyte Go Global: Preparing the Next Generation of Innovators” (Invited speaker)
- **Susan Grajek**, Vice President for Data, Research, and Analytics, EDUCAUSE, “The Current State of Research Computing in Higher Education”
- **ECAR Strategies Committee**, “The Research Computing Organization: Roles and Staffing, Structure, and Organization” (Facilitated discussion)
- **ECAR Campus Cyberinfrastructure (CCI) Working Group**, “Research Computing Services” (Facilitated discussion and working group report)
- **ECAR Mobile Strategy and Application Development (MSAD) Working Group**, “Research Meets Mobile: Implications and Opportunities” (Facilitated discussion and working group report)
- **ECAR Communications Infrastructure and Applications (CIA) Working Group**, “Research Networking: Infrastructure and People (Trends in Research Network Infrastructures and Collaboration Applications)” (Facilitated discussion and working group report)
- **ECAR Data Management (DM) Working Group**, “Research Data Management: Is It Realistic to Think That We Can Do It All?” (Facilitated discussion and working group report)
- **ECAR Total Cost of Ownership for Cloud Services (TCO) Working Group**, “Management of Research Computing: Funding, Outsourcing, Promoting Services, Establishing Partnerships” (Facilitated discussion and working group report)

Citation for This Work

Notes

6. Ibid.