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Executive Summary

Academic research relies increasingly on information technology to collect, analyze, and distribute information across a growing range of geographic locations and disciplines. This in turn has generated the need for significant investment in the infrastructure, people, and other IT resources required to support that research. For higher education institutions seeking to grow the quantity, quality, and reputation of their research, the deployment and effectiveness of those resources have assumed greater urgency. One of the underlying premises of this study is that these concerns will only deepen as research becomes more complex, the required infrastructure and support become more costly, calls for accountability mount, and funding gets tighter.

This study sought to answer core questions about how colleges and universities manage and organize IT resources devoted to research. What IT infrastructure and services do institutions provide in support of research? How are they organized? How are roles and responsibilities distributed across central and local units? How well do IT professionals interface with the researchers they support? What are the major trends in academic research, and what impact

are they having on the demand for IT? Our research was framed by the realization that no comprehensive study across higher education had yet addressed these questions.

The Analytic Framework

One of our primary concerns was to see if and how IT support for research varied by institution type. The Carnegie classification system—at least the traditional categories that most of us have grown accustomed to—represents the most common typology, and sure enough, when we ran the statistical tests, Carnegie class served as a credible independent explanatory variable for much of our analysis. In examining differences of organization and behavior, however, a more powerful variable emerged: institutional mission. In our survey, we asked which of the following four statements best described the respondent's institution:

- ◆ *Research Essential:* Research and teaching are the primary missions, but research is what really drives faculty and institutional success.
- ◆ *Balanced:* Research and teaching are both primary missions, and they are equally important for faculty and institutional success.
- ◆ *Teaching Favored:* Teaching is the primary mission, but faculty research is rewarded.

- ◆ *Teaching Essential*: Teaching is the primary mission, and faculty research does not factor heavily in faculty and institutional success.

Because it yielded a stronger statistical relationship than Carnegie classification, we used institutional mission rather than Carnegie classification as a primary explanatory variable. We found, for example, that institutional mission had a significant impact on a variety of factors, namely,

- ◆ the degree of increase in data-intensive research,
- ◆ the level of external funding, and
- ◆ the priority accorded to interdisciplinary research, multi-institutional research, and the use of IT in research.

The behaviors of the Research Essential and Balanced institutions were nearly identical for several key indicators of research and research support, including the

- ◆ level of increase in data-intensive research;
- ◆ staffing levels of FTE assigned to research;
- ◆ proportion of institutions having a distinct unit in central IT dedicated to research;
- ◆ extent to which central IT had formal mechanisms for engaging researchers;
- ◆ use of long-term planning for research IT infrastructure and support services; and
- ◆ presence of an institutional research office.

These findings indicated to us that once an institution has made the commitment to research, the institution must engage in necessary investments and activities regardless of its attempts to balance other priorities, such as teaching.

The Rise of Data-Intensive Research

Since World War II, the use of IT in research has been part of the national agenda. Over the past 50 years, agencies such as the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), the Department of Energy, and the National Institutes of Health (NIH) have provided research-

ers with the encouragement and means to develop new forms of computation-intensive research. Just as important, these federal agencies over time have shaped some of our fundamental concepts about the conduct of research: for example, that research utilizing high-performance computing should be interdisciplinary, address questions of national import, include computer scientists as equal partners, and extend to all disciplines, and that they should be collaborations between academia, the private sector, and government. The past half century now appears as an inexorable and inevitable evolution toward today's world of computation-intensive research. It has culminated in a vision of *cyberinfrastructure* that envisions the transformation of science through technological innovation and the ability of researchers to work across spatial and disciplinary boundaries.

When we asked respondents about their current research environment, they described the recent past in bullish terms. Turning first to funding, over half of all respondents indicated that sponsored research at their institution had increased at least 10 percent over the past three years; only 3 percent of respondents reported a decrease in funding. An astounding 40 percent of respondents from Research Essential institutions, and 30 percent from Balanced institutions, claimed that grants and contracts had increased 25 percent or more over three years, an indication of a thriving research environment.

Data-intensive research, interdisciplinary research, and multi-institutional research are considered hallmarks of the emerging research environment, and our survey respondents confirmed their growing prevalence, especially among the research-oriented institutions. Of all institutions, 68.3 percent expect interdisciplinary research to increase or greatly increase over the next three years; among the Research Essential and Balanced institutions, the figures are 97.8 percent and

90.7 percent, respectively. The corresponding numbers for multi-institutional research are 56.6 percent for all institutions, but 88.8 percent and 82.9 percent for Research Essential and Balanced institutions, respectively. In contrast, the Teaching Essential respondents, and to a lesser extent those from the Teaching Favored institutions, rated these forms of research lower as institutional priorities and expected smaller increases.

The changing research environment was also clearly demonstrated when we asked about the demand for IT services from disciplines that are traditionally not viewed as users of data-intensive research methods, such as the social sciences and humanities. In contrast to the 42.3 percent of respondents who had seen an increase over the past three years, 58.5 percent expected an increase over the next three years. Again, the trend was more pronounced among the research-focused institutions. Significantly, however, predicted increases among the “noncomputing” disciplines were overshadowed by expectations of even greater demands from the biological, life, and physical sciences, signaling a continuing juggernaut of researcher demands for IT support and services.

Infrastructure

Survey respondents reported increased infrastructure demands over the past three years, and they projected that growth would be greater over the next three years. Expected growth rates were markedly higher in the Research Essential and Balanced institutions.

Among the three primary infrastructure elements—network, computation, and storage—storage has been experiencing and will continue to experience the fastest-growing demand. Over the past three years, 81 percent of institutions claimed to see an “increase” or “great increase” in the level of demand for data storage.

Network capacity was strongly associated with institutional mission. Bandwidth speeds greater than 5 gigabits per second (Gbps) were more likely among Research Essential (39.1 percent) and Balanced (26.1 percent) than among Teaching Favored (12.0 percent) and Teaching Essential (2.8 percent) institutions. Research-focused institutions were more likely to participate in national research networks. From a researcher perspective, important network features include flexibility, identity management, and the ability to manage remote instrumentation and sensors at the input end.

Key researcher needs in the area of computation include capacity, stability, flexibility in system design, and training and support. The expansion of capacity is being addressed through such mechanisms as condominium clusters hosted by the computer center and the harvesting of unused cycles across campus.

Driven by research that can, in extreme cases, generate as much as a petabyte (1,000 terabytes) of data, data storage is becoming the bottleneck to research. Researchers’ concerns involve not just storage but also data capture and the use of metadata.

Central IT Capacity

Given the expected growth in the amount and variety of data-intensive research, we were interested in exploring how well positioned and resourced central IT organizations were to provide the needed support to researchers. We looked at four dimensions: FTE, the presence of a unit dedicated to research, funding, and perceptions of satisfaction.

Central IT organizations reported limited numbers of personnel dedicated to the support of research. Of all institutions, 55.9 percent had fewer than one FTE assigned to research, and an additional 23.2 percent had between one and three FTE dedicated to research support. As expected, staffing patterns were associated with institutional mis-

sion, but even a quarter (24.4 percent) of the Research Essential institutions had less than one FTE assigned to research. Slightly more than three-quarters of the Research Essential (77.8 percent) and Balanced (77.3 percent) schools had fewer than seven people assigned to research in their central IT organizations.

Another indicator of central IT capacity to support research is the presence of a specialized unit dedicated to IT support. Twenty-eight percent of all institutions had such a unit, with Research Essential (42.6 percent) and Balanced (46.6 percent) again leading the way. The slightly larger percentage of Balanced institutions with a central research IT unit is one example of how a mission of research elicits similar structures and behaviors among institutions, whatever their other commitments. Institutions with a research unit were more likely to report higher levels of formal engagement with researchers and slightly higher levels of researcher satisfaction, although it is hard to determine cause and effect among these variables.

The level of funding for research-specific technology was harder to determine because much of the infrastructure, such as the network, is multipurpose. Still, when we asked how much money the central IT organization spent annually on infrastructure and research-related services, 81 percent of respondents reported that they spend \$500,000 or less. The level of spending was associated with institutional mission, with just over one-third of Research Essential institutions reporting that they spend \$1 million or more. One-half of institutions claimed not to have a sustainable budget model for either IT infrastructure or services related to research.

Finally, in terms of perceived researcher satisfaction with the research IT infrastructure, the responses across the world-class/excellent/good/fair/poor spectrum followed an almost perfect bell curve. When responses were broken out by institutional mission, the

one anomaly was that respondents from the Research Essential institutions were more likely to rate their infrastructure lower. We interpreted this as research-focused institutions having higher standards against which they evaluate themselves.

The overall picture that emerged was of central IT organizations that have small research-related staffs, have small research-related budgets, and will be hard-pressed to meet the current and burgeoning demand from researchers. Given this situation, how—and how well—does the central IT organization work with academic researchers?

Central IT Engagement with Researchers

To understand the extent to which central IT is actively involved with researchers, we asked about five forms of engagement: formal mechanisms, advisory groups, long-term planning, involvement in pre-award planning, and participation in the faculty recruitment process to understand researcher needs.

Over half (55.2 percent) of respondents indicated that their central IT organization has no formal mechanism for engaging researchers. When given a list of various engagement mechanisms and the opportunity for multiple responses, the majority of responses showed a leaning toward informal mechanisms. For all institutions, 64 percent engaged in ad hoc consultations, and 34.8 percent claimed regular and active informal networking. The most common formal forms of engagement—consultations supported by specific grants and regular meetings with academic leaders—are maintained by fewer than one-fifth of the institutions. As expected, there was a strong association between the presence of formal engagement with researchers and institutional mission, with approximately two-thirds of the Research Essential and Balanced institutions (62.5 percent and 66.7 percent, respectively) claiming to have a formal mechanism. Fewer

than half (42.7 percent) of all respondent institutions have an advisory group that addresses research IT issues.

Thirty-two percent of institutions, including 54.2 percent of Research Essential and 52.2 percent of Balanced institutions, do not engage in long-term planning for IT support of research. Where long-term planning does take place, it is more likely to occur in institutions with a configuration of other elements that indicate a research focus, including a distinct unit within central IT dedicated to research-related IT, larger numbers of central IT staff concentrated on the support of research, and the presence of a vice president or vice chancellor for research.

Central IT consultation in the pre-award process is important to ensure that the institution can deliver on its commitments to funding agencies. Twenty-two and a half percent of respondents reported that they are “often” or “always” consulted in the pre-award stage, to identify infrastructure or support needs. An additional 35.3 percent maintained that they are “sometimes” consulted.

The hiring of faculty is the prerogative of the academic departments, but where the faculty member is also a data-intensive researcher, it would be helpful if central IT were consulted in the recruitment process, to identify their IT needs. Nine percent of respondents said that they are “often” or “always” consulted, while two-thirds (67.6 percent) said that they were “never” or “rarely” consulted.

Local IT Units

IT units abound in the schools, centers, and departments, and the EDUCAUSE core data survey for 2004 (Hawkins, Rudy, & Nicolich, 2005, p. 9) indicates that along three dimensions—IT staff, IT personnel expenditures, and total IT funding—the more research-focused doctoral institutions had significant activity in the local units. We were

interested, therefore, in the distribution of services and levels of collaboration between central and local IT organizations.

When we asked about research-related infrastructure, we found that responsibility for the network was held all or mostly centrally at 95.8 percent of institutions, a condition that held across institutional mission. However, there was a greater tendency for responsibility to be held completely or mostly locally for high-performance computation (32.5 percent of all institutions) and data storage (28.2 percent). In the Research Essential institutions, responsibility for both of these infrastructure elements was more likely to be held locally.

We found a similar decentralizing story when we asked about the locale of responsibility for 12 research-related IT services. The association was not perfect, but the more discipline-specific services such as Web site development and maintenance, research tools, and application development were more likely to be performed locally. The most centralized services—collaboration tools, vendor contracts, and training classes—were fairly generic services. The tendency for discipline-specific services to be situated locally was closely tied to institutional mission, with the Research Essential and Balanced institutions having a far greater propensity to localize all research services.

Decentralization makes sense in that it allows researchers to have the needed IT resources close at hand. But it also has potential costs, including duplication of effort and gaps in service. We sought to understand, therefore, the degree of coordination between the central and local IT organizations and the extent to which those risks were mitigated. Using the same set of research-related IT services, respondents told us that of the six services most often performed locally, five were the services with the least active coordination: Web site development, research tools, application development, server hosting, and

data archive migration. The greatest amount of coordination occurred among services that were most likely to be centrally based.

Research IT at an Inflection Point

As technology has evolved, IT management has swung between centralized and distributed models of support. The current model as practiced within higher education is for the central IT organization to exercise institutional stewardship for core areas of infrastructure, administrative computing, security, and other areas. Local (collegiate, departmental, or lab) units more or less strongly linked to central IT provide an array of support services. Within the research sphere, our survey data highlight the importance of these local units along several dimensions:

- ◆ Local IT units at about one-third of institutions are responsible for providing high-performance computing and data storage to researchers.
- ◆ IT services related to the discipline were more likely to be managed locally.
- ◆ These previous two tendencies are more pronounced in the institutions that have made research a primary element of the institutional mission.

This localizing tendency is running up against new forces and drivers within both higher education and research itself. Research is becoming more complex and interdisciplinary, breaking down the walls between isolated labs and researchers. The vision of cyberinfrastructure promises an exciting—but very expensive—new world of research. The flattening of external funding signals a need to seek more cost-effective ways of managing the technology that supports research. There is a growing appreciation for the need for security from human and natural calamities, as well as for the benefits of professional management of technologies.

These forces are changing both the philosophy and dynamics of IT management within research. The trend is not so much toward centralization as toward ways to foster collaboration and community across disciplinary and institutional lines. From cluster condominiums to the sharing of technical expertise, researchers are seeking ways to leverage people, equipment, and other resources. This, in turn, is creating opportunities for central IT organizations to expand their role within the research community and to forge the kinds of partnerships that enhance both the capacity for and quality of research.