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Introduction

Research has long been one of the pillars of higher education. The creation and dissemination of new knowledge has been prized for both its intrinsic value and its contribution to the betterment of society. Until recently, the Carnegie classification system categorized institutions largely on the basis of their research capacity, and the implicit assumption was that the major research universities—the "R-1s"—were at the top of the heap.

Over the past decade, research has assumed an even greater importance in the academic mindset, and universities are increasingly looking to research as their avenue to expansion, revenue, and prestige. At the same time, the cost, complexity, and competitiveness of playing in the big leagues have increased. Many universities have made public bets that they will break into the top echelons of research institutions, and this has set off an arms race to find new sources of funding, construct new research centers, and attract star researchers with proven grant-magnet abilities.

What makes this relevant to the IT world, of course, is that research is increasingly computational and data intensive. Ever-larger data sets are being collected and shared across larger and more geographically dispersed teams of researchers from diverse disciplines. Simulation and visualization are becoming routine tools. The coevolution of science and computing increasingly requires scientists to have solid grounding in information management and complex software. Project teams include computer scientists as key project members. When the March 2006 issue of *Nature* envisioned the state of computing in 2020, it foresaw the collection of large-scale, real-time data from the natural world being enabled by smart dust, a "vision of sensors smaller than the eye could see joined into networks larger than the mind could comprehend." The annual doubling of data volumes, *Nature* predicted, will generate a need to manage data sets at the petabyte level. And these changes are not confined to "hard" scientific inquiry, as many disciplines in the social sciences, arts, and humanities are being transformed by computational and data-intensive methods. Today, as *New York Times* science writer George Johnson (2001) expressed it, "All science is computer science."

In late 2004, when an ECAR team envisioned this report on IT engagement in research, the first order of business was to create reasonable boundaries around the topic. We knew that the ECAR community wanted a study that would focus on the intersection of IT and research, but where to draw the

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line? We knew that it had to be more than an inventory of the IT infrastructures, hardware, tools, and applications used in the conduct of research. We also knew that it needed to portray the state of the art as practiced in today's research-oriented universities and colleges. One line of inquiry would have led to an analysis of grant management systems, but that felt too much like administrative systems, and it missed entirely the focus on research itself. Other topics, such as the use of collaboration tools or a study of researcher needs, created enthusiasm, and the consensus was that these topics deserved separate studies in their own right.

In this study, we focus on the practices and perspectives of IT organizations that support the academic research enterprise. Some of the more dramatically successful stories—such as those at Purdue, Princeton, and Virginia—have already been the focus of separate ECAR case studies. But in this report, we wanted to portray the broader context of IT's engagement in research.

We begin with an overview of the evolution of data-intensive research since World War II. While there has been a certain inevitability about the infusion of computation into the research enterprise, its specific forms and foci have been the result of deliberations and decisions made, especially within federal agencies, over the past half century. *Cyberinfrastructure*, the most current articulation of the intersection of technology and research, is both the product of this evolution and a blueprint for the establishment of future infrastructures and technologies. Chapter 4 presents the significant milestones in this history and identifies the salient features of the current research environment.

We were also curious about how the research landscape looks from the perspective of IT professionals. Are they experiencing significant changes in the level and type of research? Are the highly publicized trends in interdisciplinary, multi-institutional, and undergraduate research, for example, having an impact on their world? Are they seeing an increase in demands for support from traditionally non-IT-intensive disciplines such as the humanities and arts? These questions constitute the foundation for Chapter 5.

Chapter 6 presents an empirical description of what universities and colleges have as key components of their IT research infrastructure, including networks, computing, data storage, and support. We also wanted to see how differences in institutional type affect decisions about organization, infrastructure, and support. To this latter end, on the basis of survey results, we formulated a typology of institutions categorized by their stated mission. This allowed us to peel back the traditional Carnegie labels and understand how colleges and universities deploy their IT resources in light of their strategic intent. Chapter 6 provides this baseline information.

The next three chapters, 7 through 9, focus on the organization of IT support for research. Universities are complex beasts, and the more research oriented they are, the larger and more complex they become. We knew at the outset that roles and responsibilities would be distributed across the institutions' central and local IT organizations, but we wanted to understand more about how these units are structured, resourced, and deployed. Are there distinguishing features, such as the presence of a research unit within central IT, that have an impact on effectiveness? Are there patterns to how specific types of support services are distributed across central and local IT units? Do these units coordinate with each other in the assignment and delivery of services? These questions constitute the core of Chapters 7 through 9.

The overarching story presented in this report is that IT and research are at a critical point in their intertwined history. The past 50 years have seen a dramatic growth in a research agenda that has been increasingly enabled by ever more sophisticated and powerful technologies. Much of the IT support for science has been positioned at the local level. But several trends signal essential changes in the academic research enterprise. The interdisciplinary nature of research itself is diminishing researchers' capacity to operate as independent islands of inquiry. Concerns about costs and security are prompting researchers to seek more cost-effective and professional management of their computing resources. We are at a juncture at which both IT professionals and the researchers they support are asking fundamental questions about how they can best conduct research with more-limited resources. This has created an opportunity for central IT organizations to rethink how they organize and deploy IT in the support of research.