Leveraging IT Investments: Technology-Based Partnerships and Collaborations

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Overview

To a greater extent than ever before, colleges and universities must make critical decisions regarding how and to what extent they will leverage investments in information technologies to forge synergistic collaborations to accomplish their core missions. The potential benefits to institutions that optimize IT-enabled partnerships are substantial, but these institutions face significant technological, financial, and cultural challenges in realizing those gains. Institutions that do not or cannot embrace and leverage technology-based opportunities risk both isolation and the possibility of a shrinking market share in the increasingly networked world of education and research.

The three core components supporting information technologies—digital computing, data storage, and networking—continue to evolve at an incredible rate. Exponential growth rates in quantities and types of information that can be processed, stored, and transmitted are expected to continue unabated over the next few decades. Applications and communications technologies are co-evolving with the high-performance networks and computational platforms on which they operate. These tools provide new and better means of Internet-based communication and sharing.

This technological evolution (or, perhaps more accurately, revolution) presents new opportunities for higher education institutions to build collaborations. For some types of institutions with particular research and educational targets, these technology-enabled partnerships have already developed beyond opportunities into de facto programmatic requirements. For example, many research institutions with academic programs in the natural sciences (such as meteorology, high-energy physics, and, increasingly, the broad spectrum of the life sciences) have already deployed or are rapidly deploying technologies to facilitate network-based, time- and space-independent access to rare or expensive shared equipment and computational resources. These technologies provide a rich environment for scientific collaboration and graduate-level instruction and advisement using high-bandwidth, high-resolution videoconferencing and virtual workspaces. Institutions that do not provide such enabling technologies deprive their faculty members of meaningful interaction with colleagues in their extended community; weaken joint research and education efforts; and impair recruiting efforts for graduate students, post-docs, and additional faculty. Thus, to remain competitive and avoid foundering in a scholarly backwater, these universities must continuously evaluate, acquire, deploy, and manage ever more powerful information technologies.

Mature and sustainable tools are already available to support rich interactions among colleges and universities and their academic, corporate, and governmental partners. Substantial federal and corporate investments have resulted in a number of long-standing collaborative communities of research and education, and funding agencies increasingly require collaboration as a significant component of new projects.

This research bulletin includes an overview of the technologies supporting technology-based collaboration and partnerships, cites current examples, and focuses on the opportunities and risks institutions of higher education face.
Highlights of Technology-Based Collaboration

IT-enabled collaborations are not a new phenomenon. The first examples involved researchers engaged in developing early computer networks more than 30 years ago. Scientists and engineers at institutions of higher education were among the first to take advantage of Internet-based communication technologies, such as e-mail and file transfer, to work together—synchronously and asynchronously—over a broad range of geographic distances.

In the late 1980s, the concept of a “collaboratory” (collaborate + laboratory) was being promulgated. A collaboratory is “…a center without walls, in which researchers can perform their research without regard to physical location—interacting with colleagues, accessing instrumentation, sharing data and computational resources, and accessing information in digital libraries.”

In 1993, the National Research Council (NRC) issued a report recommending the formation of testbed national collaboratories across several diverse scientific disciplines. Specifically, the NRC urged that this system of testbeds include both a research component targeting development of software and hardware tools and an educational component targeting training of individuals needed to build and use collaboratory approaches to scientific research. This effort was undertaken “… to improve the speed and output of scientific research through Internet-based access to tools, data, and colleagues—dependent of time and place.”

Investigators with the Science of Collaboratories project at the University of Michigan have identified more than 70 collaboratory projects launched since 1993. Arzberger and Finholt have suggested that these may be roughly categorized into five groups, based on their principle objective, as follows:

- Instrument sharing, to provide remote access to scarce or expensive research equipment and instruments
- Virtual research centers, to provide a space- and time-independent venue for geographically distributed researchers
- Community data systems, to provide the means for aggregation of research data derived from disparate researchers within defined subdisciplines
- Virtual learning facilities, to provide extended educational opportunities for science and research
- Product development

A small sample of current collaborative projects includes the following:

- The Network for Earthquake Engineering Simulation (NEES), funded by the National Science Foundation (NSF), is an Internet-based computational and collaboratory infrastructure for the earthquake engineering community. The
NEES links earthquake engineering research sites across the country, provides data storage facilities and repositories, and offers remote access to the latest research tools.

- The NSF-supported National Virtual Observatory involves astronomers at 17 universities who will use grid techniques to enable researchers for the first time to access and computationally analyze data from multiple sources among the leading archives of astronomical information. Networked high-end computing capabilities will allow astronomers to explore massive amounts of observational data and build their models and simulations inductively.

- The Grid Physics Network (GriPhyN) brings together seven IT research groups and scientists in four major NSF physics projects. This effort aims to establish a common “virtual data” framework and protocols that will enable physicists to use distributed high-end storage and computational resources over a grid.

- The Department of Energy (DoE) National Collaboratories Program integrates national and international facilities, distributed terascale computing resources, and several thousand investigators into a virtual laboratory infrastructure. This infrastructure enables easy access to computing resources, science facilities, and research collaborators by providing advanced collaboratory technologies, middleware, advanced network services, and scalable cybersecurity services.

- A Shared Manufacturing B2B (business-to-business) Interoperability Testbed, funded by the National Institute of Standards and Technology, is being developed to help companies boost the cost-effectiveness and efficiency of the mission-critical software products they increasingly rely on for managing production, sales, supply chains, customer relations, transaction records, and the like. Software components are run through the testbed’s Web-based, distributed evaluation process, which checks the software’s conformance to emerging B2B interoperability standards.

- The Biomedical Informatics Research Network (BIRN), recently funded by the National Center for Research Resources of the National Institutes of Health (NIH), represents a distributed approach where local databases are federated, using hardware and software, into larger-scale resources. The initial BIRN implementation is in the area of neuroimaging. In this instantiation of BIRN, more than 10 sites will join their data to tackle neuroimaging studies of greater scope and complexity and with greater geographic sampling than would be possible operating independently of one another.

The above list cites examples focused on the science and engineering communities. Similar efforts are also emerging in the social sciences, humanities, and the arts. For example, the JSTOR (http://www.jstor.org/) and ArtSTOR (http://www.artstor.org/) projects leverage IT capabilities to extend the accessibility of collections of journal literature and art, respectively. Likewise, high-bandwidth network capabilities are now sufficient to support real-time music and dance performances by performers separated by large geographic distances.
Collaborative activities like those mentioned are also driving continued innovation and development of tools for IT. Arzberger and Finholt recently listed examples of required capability for a future of distributed, IT-enabled collaborative work, including:

- assurance measures for data integrity and validity—particularly for situations in which automated data capture is used;
- meta-data definition and implementation (meta-data, or data that describe data, involve issues such as data formats, times and sources of collection, and units of measure normally associated with specific data); and
- security, including access control to specific data sets and means for proving the fidelity (unaltered state) of those data sets.

Arzberger and Finholt also emphasized the need for better tools to support interactions with data at a distance in order to meet expectations for scientific discourse. These expectations are often formed from experience in co-located settings. As they put it, “…the most elegant remote control and data transfer capabilities will be wasted if collaboratories and related technologies don’t allow convenient and normal human interaction. The importance of supporting normal interaction at a distance, such as for management and coordination of geographically distributed projects, is only likely to increase with the increased emphasis on projects that span institutions.”

**Moore’s Law Meets Higher Education**

What happens when a fast-moving technology revolution collides with bad economic times in higher education? Must technology growth in colleges and universities slow down or cease, or can the technology momentum be leveraged to boost an institution’s economic tide? The approach an institution takes to this question may influence its future viability. Understanding the rapid advances in core technologies over the past few decades and the partnerships and collaboration they have generated provides a context for opportunities for higher education today.

The rate at which information technology is evolving is difficult to grasp. This evolution is frequently represented by “Moore’s Law,” named for Intel founder Gordon Moore, who observed in 1965 that the density of transistors on a chip doubles approximately every 18 months, while the cost of those chips remains relatively stable. This estimate of the rate of increase in the performance-to-cost ratio of microprocessors continues to hold true today, more than 30 years since it was first posited.

Similar advances are evident in other core digital technologies. For example, the capacity of magnetic disks in terms of bits stored has doubled roughly every 12 months over the past few years, with resultant dramatic decreases in unit costs of storage for digital information. Digital network capacity has demonstrated similar trends. Transmission capacity of a single optical fiber increased from about one billion bits per second in 1990 to nearly one trillion bits per second by 2000.

By several estimates, the number of Internet-enabled devices (computers, wireless phones, personal digital assistants) will approach one billion by 2004, and each of these...
instruments will be available at ever-lower costs. Importantly, there is no evidence that this phenomenal rate of growth is likely to lessen. A National Academy of Sciences-sponsored panel recently concluded that it is not unreasonable to expect 100- to 1,000-fold increases of computing speed, storage capacity, and bandwidth every 10 years for the foreseeable future.8,9

An early reference point in technology evolution occurred in 1969 with the development of the ARPANET wide area network by the Advanced Research Projects Agency of the Department of Defense (DoD). Although ARPANET was designed to facilitate sharing of scarce computational resources, a great deal of its value derived from its ability to support e-mail-based communication among computational and artificial intelligence scientists on a network supporting data rates of 50 kilobits per second.10

Both the networks and the data-transfer protocols ARPANET used continued to mature throughout the 1970s and 1980s. By the mid 1980s, the NSF had established NSFNET, which linked five national supercomputer centers at 1.5 megabits per second and was quickly extended to connect major U.S. universities.

Performance increases in high-speed networking and network-based applications (such as the early precursors of today’s World Wide Web) continued during the late 1980s and early 1990s. Some designate 1995, the year in which NSFNET was decommissioned, as the starting point for the commercial Internet.11 Even before this watershed, there was recognition of the potential represented by the enhanced communication and sharing made possible by application of IT.

What It Means to Higher Education

As IT becomes more powerful, pervasive, and affordable, growing numbers of opportunities exist for colleges and universities to leverage IT investments to accomplish institutional missions of teaching, research, extension, and economic development. In a networked world, colleges and universities must develop new strategies to enrich their connections to collaborative and partnering organizations. These strategies must extend beyond the time- and space-constrained environs of the traditional campus and embrace activities occurring around the clock and the globe.

Opportunities and Challenges

Despite an ever-growing set of facilitating technologies (for example, remote access to scientific instruments, videoconferencing, shared access to databases and computer simulation, shared virtual workspaces), institutions of higher education are not yet fully leveraging the opportunities afforded by advanced information technologies.12 Some barriers to adoption are easy to identify, including costs associated with network infrastructure, bandwidth, and specialized equipment; lack of local expertise to support collaborative efforts; and absence of guarantees of return on investment in collaborative projects.

On this last note, it should be acknowledged that even with appropriate financial and staffing resources, not all collaborative efforts succeed. Collaboratories have limits, and
social and practical acceptability can be particularly challenging. IT-enabled collaboratories have sometimes fallen short because they were not able to replace the richness of face-to-face interaction. Concerns about trust, motivation, data access, ownership, and attribution can also affect collaboratory performance.¹³

It is instructive to observe that corporate institutions are facing similar challenges related to distributed collaboration. Approaches being used in these environments range from top-down strategies based on centralized decision making (administrative mandates, including selection of IT tools to be used corporation-wide) to bottom-up, laissez-faire methods built around communities of practice exerting democratic decision making at the level of individual business units.¹⁴ Neither of these extreme approaches is well suited for wholesale implementation in academic communities and their attendant cultures of self-governance. Forcing functions such as data sharing, security, and others, however, will inevitably move academies toward adoption of emerging minimal IT standards and developing sustainable IT-enabled means for collaboration and partnerships.

Increasingly, the risks associated with not investing capital and human resources in IT-enabled collaboration outweigh the dangers of participation. In many ways, the current economic downturn is enhancing these risks, as institutions are unable to garner resources to acquire local faculty expertise or specialized equipment for research and discovery. Institutions not engaged in advanced IT-enabled collaborative approaches face technological balkanization and isolation and will likely increase overall operational costs through unnecessary investment in redundant, expensive equipment and staff and faculty skills.

The opportunities provided by IT-enabled partnerships exemplify the extent to which technology has become integral to the full spectrum of higher education’s missions. No longer can IT be viewed as simply as a support service to local (campus-based) administrative, educational, and research activities. It is, instead, fundamentally changing the definition of those activities and extending their scope to a global scale.

To address the current and future challenge, the academy must

- Continue existing initiatives and develop new ones to provide cross-disciplinary training between computer and information sciences and other areas of scholarship
- Foster a culture of sharing that transcends institutional boundaries
- Provide an environment supportive of participation (including experimentation) in the application of IT to form new alliances with other academic institutions, as well as with corporate and governmental organizations
- Acknowledge the pervasive role that IT has in all institutional missions, and fully integrate IT-related issues into the strategic planning processes at the very top of the campus administrative structure
Internet2 As a Catalyst for Partnerships

The ability of higher education to participate in, and leverage value from, the ongoing IT revolution was greatly enhanced by the Internet2 initiative. Begun in 1996 as a consortium supported by academia, government, and industry, Internet2 specifically targets enabling the development and use of technologies focused on research and education. Internet2, under the oversight of the nonprofit corporation University Corporation for Advanced Internet Development, operates the Abilene network, an advanced backbone network that connects regional network aggregation points, to support the work of the more than 200 Internet2 member universities as they develop advanced Internet applications. Abilene has become the most advanced native Internet protocol backbone network available to universities participating in Internet2.

Internet2 is participating in many of the national initiatives mentioned earlier. Through the regional Internet2 gigabit per second points-of-presence (gigaPoPs), universities can connect to federally supported next-generation Internet networks and other advanced federal networks, including the Very High-Performance Backbone Network Service, the National Aeronautics and Space Administration (NASA) Research and Education Network, the DoD Research and Education Network, and the DoE Energy Sciences network. Working with appropriate federal agencies, Internet2 helps ensure that advanced networking services are available on interoperable backbone, regional, and local networks that are competitively provided by multiple vendors.

Internet2 member organizations have enhanced opportunities to develop collaborative partnerships with academic peer institutions and industry partners to advance their institutional missions. Specific areas of endeavor currently targeted by Internet2 include

- Middleware—software providing services such as identification, authentication, authorization, directories, and security
- End-to-end performance—technologies focusing resources and efforts on improving performance of Internet-based applications, including problem detection and resolution
- Engineering—including deployment and use of Internet Protocol version 6 (IPv6) and multicast capabilities

Key Questions to Ask

- How important are IT-enabled applications to institutional strategic objectives for teaching, research, and outreach?
- Does the institution have the local infrastructure necessary to take advantage of contemporary high-bandwidth networked applications?
- Is this institution a Regular or Affiliate Internet2 member? A Sponsored member?
What institutional strengths represent unleveraged opportunities for IT-enabled collaborations?

Where to Learn More

- Internet2, <http://www.internet2.edu/>
- National Coordination Office for Information Technology Research and Development, <http://www.itrd.gov/>

Endnotes


4. Ibid.


6. Arzberger and Finholt, op. cit.

7. Ibid.


12. Duderstadt et al., op. cit.

15. Van Houweling, op. cit.

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