

# THE ICT INFRASTRUCTURE

## A DRIVER OF CHANGE

In making the observation that “the medium is the message,” Marshall McLuhan anticipated Clayton Christensen’s characterization of communication and information systems as potentially “disruptive” technologies.<sup>1</sup> Profound and rapid changes in technologies often disrupt and even transform the environments in which they are introduced, in ways that are both intended and unintended. Thus, the information and communications technology (ICT) infrastructure is likely to influence and even shape the nature of higher education institutions and the practices of faculty and administrators. As Martin Trow has explained: “Information technology (IT) is embedded in, and used by, institutions that have a history. . . . IT will cut its own channels, leading to the creation of institutions that differ from those of today; institutions where the weight of history does not condition and constrain IT’s use.”<sup>2</sup>

By Richard N. Katz

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## The Changing ICT Infrastructure

To describe or, better still, anticipate the influence of the ICT infrastructure on the practices and the future of higher education, it is useful to summarize some of the key changes to the ICT infrastructure.

### Hardware

The ongoing driver of change in hardware is the continuing march of Moore's law, which posits the doubling of computing processing power at any given price point over an eighteen-month horizon. This law has amazing and ongoing implications both for the ICT infrastructure and for higher education. In technology terms, Moore's law signals the expectation of smaller and more powerful devices and, perhaps more important, the imbedding of machine intelligence in all sorts of unexpected devices.<sup>3</sup> Whereas intelligence in Web-enabled telephones is now an expectation, intelligence in refrigerators, smart cards, windshield wipers, keys, laboratory equipment, books, and other artifacts of daily life is not so well anticipated. Moore's law also suggests the near-term potential to create devices capable of thought. Today's leading desktop devices approximate reptile brains in processing power. Intelligence of this order is capable of processing multidimensional signals and of accomplishing rudimentary planning, for example. Networks of thousands of such devices are capable of mastering higher-order activities such as those associated with championship-caliber chess. For students and educators, Moore's law suggests the ready and widespread availability of devices capable of supporting not only basic-level word-processing, spreadsheet, database, and Web browser functions but also devices that support complex simulations, scientific visualizations, multiple media, complex modeling, animation, and so forth. Widespread availability suggests that even though there is most certainly a digital divide to overcome, most of the more pernicious and resistant-to-change constraints are likely to be about educational access and literacy and not about access to hardware.

### Networks

Two major network phenomena are likely to shape the practices and future of higher

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education. First, Metcalf's law, which posits a doubling of available bandwidth at constant prices every eighteen months (or less), suggests that network-based information and services will be available anywhere, anytime in the near future. Second, wireless networking will lower both the cost and the complexity of managing "last mile" connectivity on campuses. More important, wireless and other low-cost forms of networking will make it possible for people to stay seamlessly and continuously connected to institutional (and other) networks. Essentially, our goal should be to ensure that data communications ultimately enjoy status as a utility. Network connectivity, within such a policy objective, will come to approximate dial tone in availability, reliability, and accessibility. The role of governments will be to ensure the rights of citizens to secure network access. When network access becomes less of a concern, network services will preoccupy our investments and us.

### Leadership and Skills

John Rockart and Michael Scott Morton were correct, many years ago, when they predicted the bifurcation of the skills that would come to be associated with the ICT infrastructure.<sup>4</sup> Rockart and Morton suggested that the technologies would themselves become easier to use through a combination of breakthroughs in both hardware and software engineering. Indeed, today's information technologies are *reasonably* easy to use and reliable and, perhaps most important, are becoming self-evident to use. Technical transparency and application independence have become a design goal of hardware and software systems, aided by anticipated diffusion of standards through tools such as Web services (including XML, UDDI, SOAP, etc.). Rockart and Morton also speculated that at the technical level, the skills needed to develop systems would become more complex. This too has occurred, as each

generation of semiconductor development further erodes the frontiers of physics by fitting more and more semiconductors in small spaces and as software applications demand literally millions of lines of code in order to operate.

User skills are likely to fall into the following areas:

*Informational leadership.* In environments with plentiful communications and an easy-to-use IT infrastructure, leaders must be able to articulate an institutional/organizational vision that assumes widespread access to information and services via networks. Inherent in such leadership skills are the ability to serve as information steward, the ability to empower a workforce, and the ability to cultivate "learning" as a core behavior of staff, students, and service consumers in all aspects of their campus life. Information-based organizations also are inherently flat organizations, which have been organized in ways to promote rather than to regulate information flows. Leaders in such organizations must, by the nature of these organizations, be boundary spanners by predisposition and must foster and reward boundary-spanning behaviors within the workplace. Finally, and perhaps most important, the leaders of future information-based organizations will need to possess the skills to align institutional investments and behaviors in very loosely coupled organizational settings. This last set of higher education leadership skills is hardly new, however. Colleges and universities have been described as *ad hoc*racies, or as *organized anarchies*, and the act of leadership in higher education has been likened to herding cats. In environments that come to depend increasingly on the ICT infrastructure, alignment assumes new importance. In most colleges and universities, information technologies represent one of the three largest classes of campus expenditures. On research university campuses,



two-thirds of these expenditures occur in academic or business units outside the direct control of the central campus administration. In information-intensive environments, leaders will need to use vision, technical architectures, standards, and incentives to create alignment in this relatively new and rapidly growing area of expense.

*Acceptance of delegation and organizational risk/responsibility.* As organizational theorists such as Jay Galbreath suggest, complex organizations that organize around information require fundamentally different organizational systems and skills than do those organized around decision-making hierarchies.<sup>5</sup> Successful participants in the institutional environments that incorporate a new ICT infrastructure will need to understand how to operate in environments of broad delegations of authority—environments in which access to information and judgment are the coins of the realm.

*Innovative use of information.* Today's knowledge workers in higher education have learned to operate in environments of relative information (and/or systems) poverty. Decision-making in such environments is often political, seeking to "satisfice" rather than to optimize.<sup>6</sup> In the future technology-enriched environment, colleges and universities will increasingly expect knowledge workers to use sophisticated tools and techniques for forecasting demand, revenue, resource utilization, and pedagogical outcomes. Success in this kind of environment will depend on an intimate knowledge of higher education, the specific institution, and the information resources and tools that can be invoked to help guide increasingly complex and consequential institutional decisions.

### *Budgets*

At least two budgetary principles have emerged as part of the movement toward an advanced ICT infrastructure. First, the ICT infrastructure must be managed more holistically from a budgetary perspective. Although unpredictability and discontinuities are more inherent in IT than in other areas of institutional endeavor, a budgetary model that is rooted

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in uncertainty and opportunism is not likely to be effective. Central to any contemporary wisdom related to budgets in ICT infrastructure areas is the concept of life-cycle funding. In essence, information systems, like buildings, have both one-time costs and ongoing costs of operation and maintenance. Like buildings, only more extremely so, technologies become obsolete and need to be renewed or replaced. In environments—competitive and otherwise—that depend more than ever on the ICT infrastructure, the deferral of maintenance on key systems will become increasingly risky and ultimately unsustainable as an institutional strategy and behavior.

The second key principle of budgeting in information-rich environments is to leverage economies of scale and economies of scope. The ICT infrastructure—unlike most other areas of institutional endeavor—enjoys the economies of scale and scope. The moves toward *thin clients*, *Web-based delivery*, *enterprise information portals*, *data warehousing*, and other buzz concepts of the information age are designed to exploit economies of scale and scope. Budgets should be aligned with standards-setting activities and other strategic investments that seek to leverage scale and scope. Unnecessary heterogeneity in the ICT infrastructure is a driver of both capital costs and other expensive and scarce workforce skills. Of course, the achievement of efficiencies is only one driver of action in higher education and must be balanced against the obvious academic benefits of localized decision-making and diversity of choice.

### *Policy*

One of the most complex areas associated with the emerging ICT infrastructure is the policy arena. New technologies create new capabilities and new ways of organizing the higher education mission, information resources, and services. These new ways will likely test and perhaps even

render obsolete many important institutional policies:

*Access to information.* Access to institutional records is highly regulated by federal and state statute, by myriad regulations, and by institutional policy—and rightly so, since colleges and universities are the custodians of men and women entering adulthood, of patients requiring care in campus medical centers, of people participating in research protocols, and so forth. The new ICT infrastructure will make it relatively easy and cost-effective to acquire, store, and manage volumes of information about the institution's stakeholders. New software capabilities, service-delivery strategies, and practices will make it possible to deliver personalized and customized services for institutional constituents, based on detailed information about the roles such constituents play. One student may not, for example, have access to certain core institutional data repositories, whereas another student, this one a journalist with the daily campus newspaper, may have special-access privileges, while a third student, this one the president of the student governing body and a student regent, may have differing authorities based on this unique combination of roles. In environments that have information and services organized for self-service by empowered members of the institutional community, the rules and logistics of managing the complex role-based authorizations within the institution will form a new area of importance, complexity, and expense.

*Information privacy.* Colleges and universities will need to incorporate safeguards in the ICT infrastructure to ensure the privacy of members of the community. New efforts to organize systems and information to customize and personalize services will raise concerns about the institution's rights to "re-purpose" personal

information that has been collected for other reasons. New policies will need to balance individual privacy with complex institutional objectives so as to simplify, customize, and personalize service offerings. Most students would love expert systems that create model curricula based on their profiled preferences and/or academic histories, and such systems would enhance the academic counseling process. But such systems also depend on the tracking of students' choices and grade performance in new and unexpected ways. For some students, these new ways may challenge the trust that they place in the higher education institution.

*Information security.* Information security is a closely related area that will demand the creation of new policies to protect the institution and its constituents. The rise of the Internet and other key elements of the ICT infrastructure has meant that, in a virtual sense, all sorts of new people will visit an institution. University Web sites such as those at the Universities of Washington, Wisconsin, and Minnesota are among the most frequently visited sites on the Internet. Although such popularity can create new and politically potent supporters for the institution, it can also attract those who continually probe the campus network looking for openings to launch denial-of-service attacks, engage in theft of personal information, damage institutional computing and information resources, and conduct other criminal activities. Security policies must recognize these threats and protect the institution against them while also protecting basic rights of speech and expression—rights consistent with the purpose of higher education.

*Ownership of faculty course materials.* The evolving ICT infrastructure makes it possible to deliver instruction across time zones and geographies. It is not clear in such an environment whether information content becomes “king,” as some have argued,<sup>7</sup> or whether content starts to behave more like a commodity. Either scenario has profound implications for the course materials that faculty have developed to support their instruction. When courses are modified for use across

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networks, their cost of production and their revenue potential are altered. Under such conditions, institutions are expressing new levels of interest in a share of ownership of such materials, and individual faculty are often displaying a greater “proprietary” concern about such materials. Institutions must develop equitable policies and practices to reflect the new realities of courses produced for delivery over networks.

### Putting Humpty-Dumpty Back Together Again

In mid-1999, EDUCAUSE President Brian Hawkins asserted three axioms about the impact of information technology on higher education:

1. The new technology affords exciting opportunities for more effective teaching.
2. The new technology offers a scalability that is greatly needed.
3. The new technology will transform higher education as we know it today.<sup>8</sup>

Based on these axioms and on his assessment of the higher education landscape, Hawkins later peered through a “very foggy crystal ball” to make several credible forecasts, including the following:

1. New markets will be smaller than predicted.
2. Residential campuses will continue to be significant.
3. An erosion of traditional markets will occur.
4. Individual campuses won't effectively participate as standalone entities.
5. The new marketplace will be associated with new models of faculty motivation.
6. Technology will transform college and university operations.<sup>9</sup>

This forecast creates a powerful impression about the future operational

context for colleges and universities. This context—at the macroeconomic level—is characterized by increased competition. Gordon Winston, for instance, has compared the current environment of tuition discounting to a “positional arms race” for the world's finest students.<sup>10</sup> Private residential institutions, as Hawkins suggests, depend increasingly on segmented markets for their prosperity and even survival. Technology has also created new opportunities for a variety of competitors to simultaneously incorporate new tools and pedagogy and eschew the plant and infrastructure investments that are required by comprehensive, site-based institutions. Yale University's David Collis suggests that some of these new providers will quietly establish beachheads in relatively “peripheral” niches (continuing education, general education, remedial education) but will also, over the long term, develop the skill and market acceptance to move up the education food chain.<sup>11</sup> Finally, major new initiatives such as eArmyU and Universitas 21 bear witness to Hawkins's forecast that the future higher education landscape will be influenced by the emergence of powerful educational consortia.

A number of leading higher education institutions herald the emergence of the information- or knowledge-based organization.<sup>12</sup> The *information-based organization* is a metaphor for an ICT infrastructure that has been optimized for ergonomic integration, ubiquitous and secure access, personalization, and self-service use by an educated and empowered institutional community. It is a powerful metaphor. Conceptually, the technological framework that supports this vision proposes a Web-based system (portal) that recognizes individual users and tailors accessible information and services to the needs, interests, and authorities of these individual users. Although this compelling conceptual framework may sound simple, and

indeed its goal is simplification, the integration of such a new infrastructure with existing college and university practices is extremely difficult.

### Changing Expectations

College and university practices, in the context of a changing ICT infrastructure, are being driven by changing expectations. In today's environment, early technology adopters carry cell phones and palmtop computers and expect nothing less than a constant stream of information that has been tailored to meet the demands of their busy lives. In the academic context, students want to conduct all institutional "administrivia" over the Internet, phone, or any other convenient device twenty-four hours a day, seven days a week. Most higher education institutions are variously a mile or a millennium from actually delivering such an environment. Increasingly, students will come to expect (and demand) all course materials on the Web. They will also become adept at identifying useful online course supplements that can help them learn (through simulation, virtual reality, or other tech-

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nologies) in ways that best reflect their learning style and pace. Before too long, such students will come to expect instructional personalization to a degree that cannot likely be contained within the current academic calendar concept.

In addition, faculty, parents, staff, and alumni are likely to become similarly voracious in their expectations of the ICT infrastructure. Grade reporting, student loan payment and tracking, class registration, and contract administration processes will be expected to operate automatically, to be completely integrated and personalized to users, and to be available 24 hours a day, 7 days a week, 365 days a year. These expectations should not be surprising. Today, one can use a digital cell phone to find out about flight delays and cancellations, dining

options, and much other information. Daily newspapers can be downloaded to wireless handheld computers, so why can't class schedules, grant balances, and campus events calendars be downloaded as well?

### Changing Practices

The changing ICT infrastructure will affect college and university practices both internally, in terms of political structure, and externally, in terms of cooperation/competition with other institutions.

#### *Leadership, Organization, and Governance*

The college and university political system, variously described as an *adhocracy* or a *cottage industry* or an *organized anarchy*, will need to explore the development of

new institutional compacts that will guide the development of an integrated ICT infrastructure. Fiefdoms that evolve around the ownership of information, processes, or Web sites will be unlikely to realize the vision of the information-based organization described above. Institutional leaders will need to explore how to confederate campus leaders in ways that will allow local campus units to continue to operate services and processes, but within agreed-upon frameworks and standards that will create the sense of institutional integrity that campus constituents will demand. Robert Kvavik, of the University of Minnesota, has even suggested the need for institutional constitutions that will regulate the rights and responsibilities of campus community members in the context of information-based, self-service organizations.<sup>13</sup>

Leadership and followership change in organizations designed around empowerment and access to information. Most colleges and universities continue to rely on specialists who understand the complex rules and regulations that guide

access to student records, care of laboratory animals, employee benefit entitlements, and the like. As a result of tremendous regulation and the fear of errors and omissions, these campus experts have generally been charged with providing services while protecting the institution against any number of risks. In such environments, the mastery of rules and the reduction of risk take precedence over service, and service suffers. In an information-based organization, complex rules either are rendered transparently into the information systems of the institution or are explained in a clear and concise manner so that the consumer can invoke a service without invoking an expert. At the University of California, San Diego, for example, teams of “journalists” are tasked with working with the owners of the institution’s key business processes in an effort to render the policy infrastructure transparent and user-friendly.

The information-based organization that emerges from the new infrastructure assumes an alignment around this vision of integration, personalization, and self-

service. Such an alignment suggests the need for an organizational culture that is team-based and multidisciplinary. Such an alignment also suggests the increasing need for skilled generalists and the concomitant, decreasing reliance on specialists. This is another gap that needs to be managed. Finally, the leadership of the information-based organization will demand extraordinary skill in creating the incentives, training opportunities, technology investments, and trust to create a vision, to engage key leaders of the institution in the vision, to remove barriers, and above all else, to give people the authority to make the vision happen. Increasingly, by their examples, leaders will work to reshape the policy environment in ways that reinforce not only the vision but also the behaviors of those on whom the vision depends.

#### *Cooperation and Competition*

As previously noted, the shift in the ICT infrastructure is heightening the level of competition in higher education. A smaller number of U.S. institutions are garnering a growing share of the world’s

college-bound high school graduates. Similarly, a smaller number of institutions are controlling most of the endowment resources in higher education, with their faculty receiving most of the private and public research funding. New for-profit entities are entering and exiting the marketplace with increasing regularity. Microsoft, SUN Microsystems, and Cisco set international curricular standards through their software-certification programs. Hawkins is likely correct that new markets will be smaller than those expected in the heyday of dot-com enthusiasm, and he is also correct that the new ICT infrastructure will allow new modes of teaching and learning and may change the economies of scale in higher education. These possibilities suggest that competitive rivalries will intensify over time and that some institutions will fail to adapt and will, possibly, perish.

Cooperation is one promising strategy to strengthen institutions operating in this promising but complex environment. If indeed the changing ICT infrastructure is likely to transform policies

and operations and the practices that support them, and if, further, this infrastructure will be costly in financial and political terms, will it not be wise to consider new cooperative arrangements? Such arrangements can spread the risks and the shortening life-cycles of the infrastructure over a larger financial base. Similarly, such arrangements can spread the risk of procedural innovation (new processes, new pedagogies, etc.) over this larger base. New forms of collaboration make it possible for institutional partners to focus on what creates institutional distinction and comparative advantage. For too long, colleges and universities have trumpeted one another's idiosyncrasies in order to justify the need for distinctive payroll systems, accounts receivable operations, grant-accounting systems, and so forth. Much like contemporary automotive engineering, the new ICT infrastructure is likely to be built as software components that are integrated by common standards to a portal-like Web framework. If so, institutions will be able to source complex technical solutions

from the commercial marketplace and from other institutions, again reinforcing the potential presented by new forms of collaboration. Finally, new consortia and other forms of collaboration make it possible to break the bonds of complex rules and practices. This can be of value to leaders who are attempting to manage change in environments steeped in risk-averse cultures of rules and experts. It is perhaps axiomatic to note that the barriers to realizing the promise presented by the changing ICT infrastructure are far more likely to be found in the organizational, leadership, and policy arenas than in the technology and resources domains. New forms of collaboration, bound often in contracts and performance agreements, can provide powerful counterincentives to the campus-based rewards that often drive behaviors antithetical to constructive change.

### **Conclusion**

The changing ICT infrastructure will affect the practices and the future of higher education in significant ways. Transform-



mational rhetoric is not hyperbolic. Although certain changes in the ICT infrastructure will be discontinuous, such as the wrenching changes in architecture associated with the move to client/server-based ERP systems, the path to transformation is likely to be paved with continuous changes in both technology and practice.<sup>14</sup> Traditional residential institutions are likely to continue to serve the needs of a growing population in need of postsecondary education, though competition will likely intensify. Competitive success will depend in part on a strategy of organizing around an increasingly segmented marketplace. New information technologies will make it possible to deliver the core college and university mission in new and exciting ways. One vision suggests the creation of an information-based college or university. The information-based institution radically simplifies the policy environment, making it possible to imbed complex rules in the information systems themselves. The systems can then be organized and integrated in ways that allow those who use institutional services to consume these services directly via the Web. In this vision, institutional processes and services are organized around a common vision for security, access, navigation, and Web functionality. Through the incorporation of standards, such a vision allows a college or university to develop and deploy services in a confederated fashion, much as automobile manufacturers assemble cars using component parts created to conform to a set of industry standards.

The information-based organization and the infrastructure supporting it enable an institution to liberate the members of the institutional community from the tyranny and oppression of institutional rules, processes, and administrivia. Such new freedom can, in turn, create a renaissance in the higher education institution's primary roles of teaching, discovery, patient care, and service. Rising expectations, combined with new technological capabilities and new competition, will likely foster new forms of cooperation among traditional colleges and universities. These collaborations carry with them both the potential to transform and, more important, the potential to enhance the

role and performance of higher education in an era that will demand greater educational attainment and outcomes. *e*

#### Notes

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