

Cloud Computing in Higher Education

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“The concept of a site as we know it will change.”
—Ben Rushlo, Keynote Systems

Background

At their January 22, 2009, meeting, members of the EDUCAUSE Board of Directors advised the staff that: (1) they believed that the time was right for EDUCAUSE to assume a more activist role in promoting higher education; and (2) the shift to above-campus computing prompted by the maturation of “cloud computing” and related emerging technologies deserved close EDUCAUSE attention and probable action. Since then, EDUCAUSE has engaged in

- a thorough review of the literature on the topic,
- a framing of the roles that EDUCAUSE might play in this emerging area of activity, and
- interviews and focus group discussions to elicit the views of members and leaders in the community.

This document is a summary of those activities and the findings from them.

What Does the Literature Conclude?

The literature on cloud computing suffers from **hype and divergent definitions and viewpoints**. One report by McKinsey & Co. uncovered 22 distinct definitions of cloud computing. For this exercise, we will use the Gartner definition of cloud computing as “a style of computing where massively scaleable IT-enabled capabilities are delivered ‘as a service’ to external customers using Internet technologies.”¹ McKinsey presents a typology of software-as-a-service that elaborates the Gartner definition and is characterized by:

- *Delivery Platforms*
 - **Managed hosting**—contracting with hosting provider to host or manage an infrastructure (IBM, OpSource)
 - **Cloud computing**—using an on-demand cloud-based infrastructure to deploy an infrastructure or applications (Amazon Elastic Compute Cloud)
- *Development Platforms*
 - **Cloud computing**—using an on-demand cloud-based development environment to provide a general-purpose programming language (Bungee Labs, Coghead)
- *Application-led Platforms*
 - **SaaS applications**—using platforms of popular SaaS applications to develop and deploy application (Salesforce.com, NetSuite, Cisco Webex)²

In addition to being ill-defined, **cloud computing is emergent**. In its 2008 and 2009 hype cycles, Gartner characterizes cloud computing as a technology that is moving up toward the peak of inflated expectations. That said, Gartner predicts that by 2011, early technology adopters “will forgo capital expenditures and instead purchase 40% of their IT infrastructures as a service.”³ Gartner analyst Daryl Plummer and his colleagues go on to conclude that **“the perception of infrastructure as something that must be bought, housed, and managed has changed. Companies are now seriously considering alternatives that treat the infrastructure as a service rather than an asset and that care less where the infrastructure is located and who manages it.”**

The analyst literature generally agrees with the Gartner assessment that **cloud computing will achieve mainstream adoption in a two- to five-year time frame**. Again, this estimate reflects the generally inclusive definitions of cloud computing. The definitions often include things like basic web services, service-oriented business applications, software as a service (SaaS), virtualization, and even managed hosting, technologies that are themselves at differing levels of maturity. Already, in 2008 among commercial firms ($n = 857$), 35% of IT software

budgets (about 10% of total IT expenditures) were spent on subscription, on-demand, transaction-based, advertisement-funded, or other nontraditional forms of software acquisition.⁴ Finally, the literature asserts that **cloud computing is different and it is important.**

What Is Different About “the Cloud”?

Information technologists—particularly those in higher education—are skeptical about hype. After all, haven’t we all seen, heard of, tried, used, or continued to use service bureaus, application hosts, grids, and other sourcing techniques? So what is different about the cloud?

The first key difference is technical: the maturity of standards throughout the stack, the availability of high-performance network capacity, and the emergence of virtualization technologies are combining to enrich the sourcing options at our disposal. Market factors are also different.

The generation raised on broadband connections, Google search, and their Facebook community is likely to embrace the idea of cloud-based services in their enterprise roles, just as they embrace them in their private lives. Such users—who are driving the rising sales of netbooks—are likely to fuel the drive toward lower cost and lightweight computing clients and web-delivered, open-source operating systems and applications. According to Gartner, “the consumerization of IT is an ongoing process that further defines the reality that users are making consumer-oriented decisions before [they make] IT department-oriented decisions.”⁵ The enterprise IT organization’s failure to socialize this insight might lead to the evolution of “accidental” IT architectures and to a “struggle to shut down user-introduced technologies or to accommodate them in a secure and predictable fashion.”⁶ The consumerization of IT, along with the emergence of SaaS and other web-based services options, will drive the movement of enterprise services both above and below the campus.

At the same time, the current financial crisis, along with a focus on managing IT costs and ROI, is driving commercial enterprises to move swiftly. The top-two trends identified by 56% of 857 respondents to McKinsey’s 2008 enterprise software survey were SaaS and web services/SOA. Budget cuts in higher education are likely to accelerate explorations of sourcing alternatives.

Finally, recognizing these technical, generational-consumer, and enterprise economics trends, developer communities and system integrators are shifting away from established software vendors, who in turn are shifting to “cloud-enable” their products. By 2012, Gartner predicts that more than one-third of independent software vendors will offer *some* of their applications as SaaS.

Why Is Cloud Computing Important?

McKinsey suggests that “using clouds for computing tasks promises a revolution in IT similar to the birth of the web and e-commerce.”⁷ Burton Group concludes that “IT is finally catching up with the Internet by extending the enterprise outside of the traditional data center walls.”⁸ Writers like Nicholas Carr argue that a so-called big switch is ahead, wherein a great many infrastructure, application, and support tasks now operated by enterprises will—in the future—be handled by very-large-scale, highly standardized counterpart activities delivered over the Internet.

The prospect of a maturing cloud of on-demand infrastructure, application, and support services is important as a possible means of:

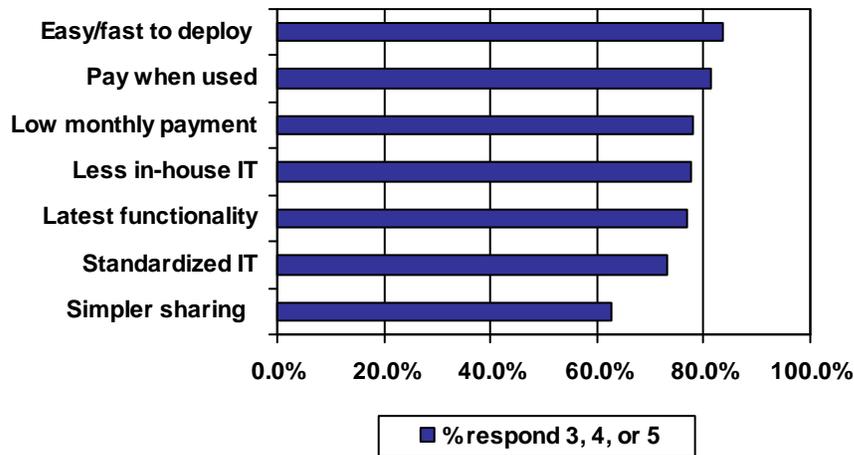
- Driving down the capital and total costs of IT in higher education
- Facilitating the transparent matching of IT demand, costs, and funding
- Scaling IT
- Fostering further IT standardization
- Accelerating time to market by reducing IT supply bottlenecks
- Countering or channeling the ad hoc consumerization of enterprise IT services
- Increasing access to scarce IT talent

- Creating a pathway to a five nines and 24 × 7 × 365 environment
- Enabling the sourcing of cycles and storage powered by renewable energy
- Increasing interoperability between disjoint technologies between and within institutions

Commercial enthusiasm for cloud computing tends to cluster around agility, economics, and the size of the in-house IT organization. One interviewee drove home the ease of deployment (agility) argument vividly: “If you are Flowers.com and your steady state business is punctuated by massive demand spikes on Valentine’s Day, Easter, and Mother’s Day, access to public cloud services represents a great opportunity to grow your IT infrastructure quickly during times of peak demand. This use of cloud services solves a very real business problem in a very cost-effective manner.”

Figure 1
Question: Rate the benefits commonly ascribed to the “cloud”/on-demand model

(Source: IDC)



Adoption of Cloud Computing in Higher Education

In many technology arenas, higher education exhibits two behaviors. As regards networking and high-performance computing, higher education enjoys a reputation as an innovator. The world’s first computers were developed at Harvard, MIT, the University of Manchester, and the University of Pennsylvania, and the first four nodes of the Arpanet were located at UCLA, Stanford Research Institute, UC Santa Barbara, and the University of Utah. Research universities, often in concert with the National Science Foundation, continue to lead the way in networking (NSFnet, Vbns, Internet2, NLR) and in supercomputing, where 25 of the top 100 supercomputers are operated at universities.⁹ On the other hand, higher education is a relative late adopter in the applications and IT support arena. This relates chiefly to the unique policy environment that regulates the acquisition, storage, and dissemination of higher education information (FERPA, HIPAA, GLB, and others) and also to a unique perspective that arises from viewing one’s organization as perpetual. On a less noble note, colleges and universities rarely account for the total cost of delivering IT infrastructure, services, and support and rarely pay for key cost drivers such as space and utilities directly and hence have no easy means of comparing the costs of self-operation and sourcing alternatives. Colleges and universities also have legitimate and pressing IT security concerns and a high sensitivity to adverse publicity.

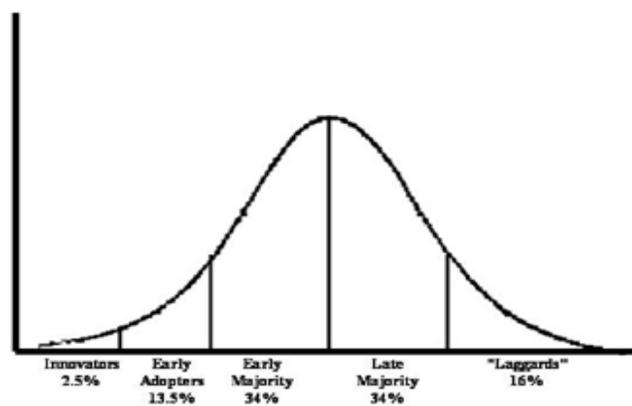
The literature review, community discussions, and interviews with higher education IT community leaders suggest that:

1. Cloud computing is an important and likely transformational new capability.
2. Many current enterprise IT responsibilities will shift over time to large-scale providers “above campus” and to consumer applications “below campus.”

3. Above-campus offerings are split into public offerings, like Google and Amazon, and private offerings.
4. Many institutions are virtualizing aspects of their IT infrastructures and services, a substantial number are experimenting with public cloud offerings (especially student e-mail), and several are considering offering private cloud services.
5. Early higher education use of public cloud services fails to recognize differences in cloud types. Commodity cloud services like Amazon's Elastic Compute Cloud are being confused with application services like e-mail, where institutional differentiation, integration (with calendar, directory, etc.) policy, and control may be important.
6. Most interviewees believe that the cloud service provider (e.g. , supply) side of this market will mature quickly (five years or less), while institutional adoption in higher education will likely be cautious.
7. Adoption dynamics will differ markedly by segment within higher education. Research university CIOs may come to embrace a "get big or get out" ethos. Some will explore becoming centers of excellence (and providers) for some elements of the IT portfolio, while sourcing other elements elsewhere. Smaller IT operations are likely to become consumers of cloud services. All agree that the future sourcing environment will be heterogeneous (with much self-operated) and that new infrastructure, services, programs, and support requirements will move to the cloud faster than those that have long been operated on premises. Many participants cited the recent McKinsey report concluding that cloud-based data center services remain cheaper when self-operated by large enterprises, while the economics favor cloud-based resources for small and medium-size enterprises.

In sum, discussants agree that cloud computing is a natural technical progression to a standards- and Internet-based IT architecture that more fully exploits economies of scale. The transformational aspect of cloud computing is the potential shift in the locus of enterprise IT activity either above or below campus. This shift is strategic. Cultural, organizational, and regulatory considerations, rather than technical ones, will slow adoption. Adoption will follow a standard technology maturity model.

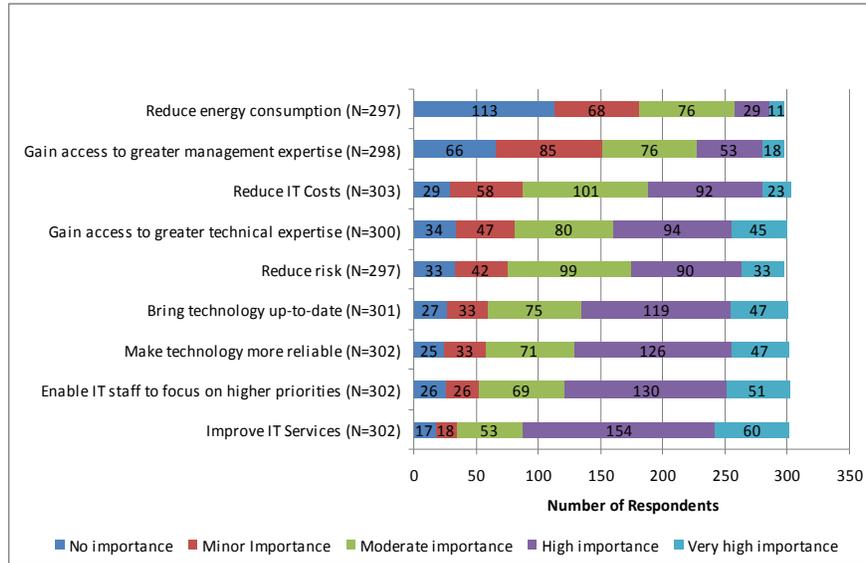
Figure 2
Everett Rogers's Model for Diffusion of Innovation



Those consulted believe that higher education is early in the "early adopters" stage of diffusion, and the analyst literature suggests that other sectors such as the commercial and government sectors are also in the early adopter stage of adopting cloud computing. The factors that will enable the move from enterprise-delivered to cloud-delivered services are somewhat different in higher education than they are in the commercial sector. More than 70% of recent higher education IT leaders surveyed (N=302) indicated that improving IT services is a highly or very

highly important factor in guiding such a sourcing decision, while only 38% (N=303) attached the same importance to reducing IT costs.

Figure 3
Factors Influencing Decision to Adopt Alternative Sourcing
(Source: ECAR)



What Is the Right Aggregation Point for Services?

One of the most complex and important issues raised by discussants is the issue of how the market for above-campus services is likely to evolve and what the right aggregation point is for the delivery or consumption of cloud services. The inherent logic of moving the locus of some aspects of IT infrastructure, services, and support management to a level that better exploits the robust internetworking capacity of higher education, the benefits of scale economies, and the differential access to highly skilled IT labor seems axiomatic and inevitable. Notwithstanding the very real policy and operational issues that will pace or constrain this movement, the question for many seems not to be *if* enterprise IT moves above (or below) the cloud, but:

1. When will it move?
2. What aspects of enterprise IT will move and when (if ever)?
3. Where is the highest (economic and noneconomic) payoff for moving?
4. What is the right aggregation point for IT, or where does enterprise IT move?

Pundits and critics argue that cloud computing might drive us to re-create a new global mainframe that will exploit massive scale, low real estate costs, nearby skilled labor, efficient access to renewable energy, low taxes, and other favorable site attributes. This recentralization of IT, of course, has limits. The sourcing questions above will be complex ones in higher education, but are likely to revolve around the questions of: (1) how commoditized an activity is, and (2) the extent to which the activity is regulated and whether regulation is comparatively local or global in character. Institutional culture, for this purpose, can be a regulator of an activity. Thinking about the IT portfolio in these terms may make it possible to develop decision guidelines that will help institutions navigate complex sourcing decisions.

Public Clouds and Private Clouds

Public clouds appear to be organized around site factors like those mentioned, and, not surprisingly, massive centers like those operated by Google and Amazon are located close to sources of hydro or other renewable energy sources and exploit tax preferences, facility scale, access to networking, and the like. Public clouds are profit driven and are most effective with those services that are highly commodified. If an IT service can be offered in a standardized fashion without special regard to end-user variations or to local, state, regional, or even national regulatory differences, then that service can be offered as an undifferentiated commodity service, presumably at a great price. In such a case, the dominant legal principle is likely to be *caveat emptor* (buyer beware), backed by standard contract language shielding the provider from any significant liabilities for process failures or data corruption and loss. Public clouds do offer more highly differentiated services, like hosting applications such as e-mail. If, however, such a service either differentiates the institution, or is highly integrated with things that differentiate the institution, the benefits of scale, or the capacity to use software as a differentiator, may be blunted in a cloud context.

In cases where an IT activity adds unique value or is situated in a unique institutional or industry setting, private clouds are likely to emerge. Private clouds exploit a portion of the potential to cut IT costs by promoting asset consolidation through virtualization. Even more, private clouds make it possible in theory for enterprise IT providers to let go of more complex, risky, idiosyncratic, and value-laden IT activities. Massive organizations like the U.S. Department of Defense (DoD) are investing in private cloud technologies and deployments that have the potential to consolidate, integrate, and harmonize disparate IT operations from the Pentagon, military suppliers, military branches (and their academic academies), and so forth.

Thinking systematically about the factors of commoditization and the strength and location of regulation and control may help colleges and universities navigate the evolving public and private cloudscape.

**Figure 4
Public Cloud? Private Cloud? Self-Operate?**

Degree of Commodification High Low	Use or operate a private and local cloud service State or regional joint venture Self-operate	Use or operate a private cloud service Use a public cloud service Use or operate a national private cloud service
	Use or operate a private and local cloud service Self-operate	Use or operate a private and local cloud service Joint venture with peers Self-operate
	Local	Global
	Locus of Regulation	

The factors in the services sourcing decision are clearly more complex than represented here. That said, a discussion in higher education of these factors is important. Early sourcing decisions in higher education may be moving to public cloud offerings due to the lack of private alternatives and to the advertising-based subsidies some can provide. These factors may skew decision making in ways that will pose challenges downstream.

Finally, it is important to note that many institutions are already sourcing services above campus, if not technically in a cloud computing fashion.

Figure 5
Forms of Alternative Sourcing Currently in Use (N=309)
(Source: ECAR)

Form	Percent Adopted (N=309)
SaaS	49.8%
ERP project management	19.1%
Third party to design network	18.8%
Third party–operated call center/help desk	14.2%
Third party to manage network	9.4%
Cloud-based servers	9.1%
Cloud-based storage	7.8%
Primary data center provided by a third party	7.4%
Third party–provided desktop/computing support	7.1%
Cloud-based security applications	4.5%
Cloud-based development environments	3.6%

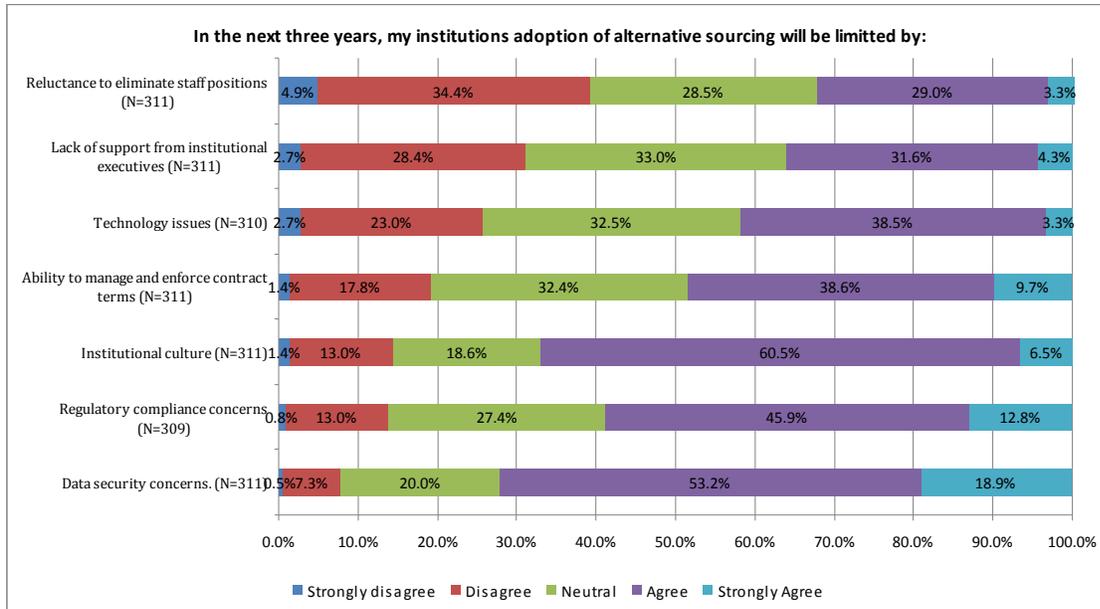
What are the Challenges and Risks?

The challenges and risks that will constrain higher education’s adoption of cloud computing relate to trust, confidence, and surety. As Burton Group analyst Drue Reeves points out, “Building an IT organization’s confidence in a solution requires a combination of consistent performance, verifiable results, service guarantees, transparency, and plans for contingencies.”¹⁰ Clearly most cloud services do not have the track record on which one can build the necessary trust to shift existing services without either great deliberation or a very compelling benefit. These service and provider attributes only come with time, reputation, and experience. Compounding these challenges, most IT organizations in higher education are not themselves highly skilled in managing risk and service performance *in third parties*. In the commercial sector, lack of confidence in the cloud stems from:

- Poor or nonexistent service level agreements
- Inadequate risk management
- ROI justification, management of change orders, and vendor lock-in
- Market immaturity
- Management issues

In higher education, the issues tend to be the same, though the magnitude of concern is amplified by the additional burdens of public trust placed on institutions that serve *in loco parentis* for students and who conduct patient care, research on human subjects, and so forth. Higher education concerns in this regard are summarized below. Two thirds of respondents to a recent ECAR survey cite their institutional culture as a real barrier to adopting alternative sourcing approaches. More than 70% (72.1) cite concerns about IT security, and more than one-half (58.7%) the respondents indicate that concerns about regulatory compliance will limit their adoption of these emerging service offerings. As one interviewee expressed it, “We need to have an honest discussion of the control and privacy issue. State and federal law make these concerns real, but these policy issues can be resolved technically and architecturally. Unless we commit to study these issues, we won’t be motivated to move services to the cloud.”

Figure 6
Barriers to Alternate Sourcing Options
(Source: ECAR)



Conclusions

1. Great Promise/Great Hype. This review of the literature and concurrent widespread discussions with IT leaders suggests that, despite the hype, cloud computing is an important development on par with the shift from mainframe to client-server based computing. As Michael King of IBM put it, “We have commoditized hardware and software. The question now is how do you drive down the cost of IT? It is a fundamental shift.”

Notwithstanding the near-unanimous belief that cloud computing is an important enabler of a fundamental shift in the organization and economics in enterprise IT, the (nonhyperbolic) literature and the discussion with community leaders also make clear that at present the topic is mired in hype and near-utopian optimism. While a shift to above-campus computing may be inevitable and while planning and experimentation should begin now, it is clear that the higher education IT community needs guidance and that many pitfalls will be encountered in the road ahead. As Scott Siddall of Kenyon College argued, “We need to take a magnifying lens to the cloud. This whole topic needs to be stripped clean of hype.” In addition to needing to see through the hype, members of higher education’s IT community will need to take care to acknowledge that not all clouds are the same. As Internet2’s Doug Van Houweling put it, “Different clouds have different implications for the weather. We have not yet learned enough about these different clouds.”

2. Policy and control issues will slow cloud adoption in higher education. Among a great many issues related to adopting a cloud computing approach to delivering services, policy and control issues seem paramount. These issues run the gamut from audit to process management, to IT governance, to regulatory compliance, to IT security, to the management of and accountability for access management, privacy, e-discovery, and protection of research results. Both the literature and discussions make clear that, while the issues are substantial, improved understanding of these risks will shift the preference of many IT owners and regulators over time away from the costs and inconsistency of on-premises IT and toward the auditable and highly professional practices of cloud service providers as this market matures.

3. Above-campus services will have real costs, and an honest accounting needs to be done. The people who participated in this discussion believe that public and private cloud services will come to market quickly and that the

uptake of these services will occur more slowly and unevenly within higher education, depending on the severity and length of the current economic slowdown. Participants also overwhelmingly agreed that the shift to above-campus computing is presently being influenced by subsidies from providers who exploit advertising or other revenue sources. The shift to above-campus services in the long term will need to be based on both a realistic assessment of the limits of alternative funding and a full and honest accounting of the costs of in-house enterprise IT activities. Services provisioned above campus will have a real financial cost, and they will be consumed (or not) in part based on a real comparison of these costs with the full accounting and opportunity costs of self-operation.

4. Different classes of computing activity will move to the cloud at different rates of speed. Discussants distinguished between three classes of computing capabilities: (1) services for campuses that overlap services provided commercially (like e-mail and VOIP telephone); (2) applications that campuses need to run for their institutions (ERP), and (3) research work that exhibits scale economies at the application level. The first area will very likely grow, perhaps quickly. The second area has particularly strong policy, process, and control needs and will therefore likely shift slowly, if at all. The third area is already highly virtualized (grids, remote instrumentation, supercomputing, etc.) and will likely become increasingly virtualized.

5. There is a good deal of consensus regarding which services might be candidates for sourcing above campus. Participants in the discussion of higher education cloud services identified candidate services for delivery above campus. Entries to this list were not evaluated in terms of their degree of difficulty to source off premises. This topic deserves further treatment.

- Business availability/disaster recovery
- Computer labs for students
- Computing cycles
- Cooperative (library) collection development
- Desktop support
- Data storage
- E-mail
- ERP
- Identity services
- IT help desk (Tier 1)
- Telephony

6. Many organizations and firms are exploring becoming providers of cloud services. A number of higher education organizations are engaged in discussions, plans, and actions that might position them as cloud service providers. These include large universities and university systems like Carnegie Mellon University, Indiana University, the University of California, North Carolina State University, and others, as well as national organizations like EDUCAUSE, Internet2, the Quali Foundation, the Quilt, the CampusEAI Consortium, and regional organizations like the regional optical networks (RONs).

7. New services will move above campuses before older self-operated services. The literature and higher education experts agree that the migration to cloud-based services is likely to occur more rapidly when a service is new or where demand for an existing service is new. Migrating mature services to meet existing demand will lag.

8. If the institution does not create a cloud strategy, it may inherit an “accidental strategy” formed around consumer choice. Consumer adoption of cloud services is creating a situation where the “cloudification” of institutional services will take place with or without institutional leadership. Like Gandhi, CIOs may need to run to catch up to their users if they are to remain IT’s leader in the enterprise!¹¹

What Can Be Done?

While most of the dialogue on cloud computing focused on its aspects, opportunities, risks, maturity, and prospects for the enterprise, discussants also reflected on activities that could be taken or considered on an above-campus level. There was surprising agreement on a number of near-term actions:

1. Lay out the issues and opportunity in a white paper. Universally, participants agreed that what is needed is clear thinking. One participant said, “What we need to do is a white paper that lays out all of these issues in a clear and unmistakable way. A clear exposition of the issues then needs to go to the CFOs and provosts. If CIOs perceive that their bosses are open to these things, there will be a clear pathway to see the institution through it.”

2. Develop a common service agreement. Many participants believe that collaboration in higher education would be promoted by developing a common service agreement for any institution (or higher education entity) that proposes to become a service provider to other institutions. In the extreme this could take the form of a standard set of terms and conditions that reflect and recognize the unique policy and control needs of higher education. Brad Wheeler suggested that such a clarification effort could also address standardized language and a model agreement for commercially sourced services, and could identify the risks and opportunities associated with delivery variants in which higher education collectively owns and operates a cloud service (either via operation by a commercial host or by self-operation by the higher education entity).

3. Develop a roadmap. In addition, participants agreed that all college and university IT leaders would benefit from a roadmap that describes what a multi-enterprise scholarly infrastructure might look like and how it might evolve over the next six months, year, eighteen months, etc. A broad roadmap might define the future campus IT organization and what services might be hosted on premise or above the campus, and what services might move into the consumer IT sector. Of course, such an analysis would need to articulate the policy and control implications of such a “service architecture.”

4. The transformational aspect of this shift suggests the need for a new set of IT leadership skills. There was universal agreement that a shift to managing an IT infrastructure, service portfolio, and support environment that are sourced above and below campus will require a set of skills that is not abundant in the higher education IT community. If a new “age” of provisioning IT services is dawning, a new set of skills is needed in our community. Contract management, SLA management, and the management of policy and regulatory compliance in third parties are just a few of these skills. Organizations like EDUCAUSE (information technologists), NACUBO (business officers), NACUA (attorneys), ACUA (auditors), and others will need to develop and deploy a curriculum to meet this important challenge.

Beyond an aggressive research and education campaign, participants in discussions were less well aligned. They had differing opinions on how big the cloud opportunity is and how soon it might play out. Also, many who engaged in the conversation are themselves—through their organizations—likely to become providers of cloud services. The question of whether higher education can or should seek to aggregate private cloud services to provide a common user interface, common identity infrastructure, and common service attributes (like the agreement discussed above) is a question for another day.

Acknowledgments

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Recommended Reading

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Endnotes

- ¹ Gartner, Inc., *Cloud Computing: Defining and Describing an Emerging Phenomenon*, June 17, 2008, p. 3. IDC defines cloud computing as “consumer and business products, services and solutions delivered and consumed in real-time over the Internet.” That is, “shared services, under virtualized management, accessible over the Internet (by people *and* other services) via Internet standards.” See Frank Gens, IDC, *Clouds and Beyond: Positioning for the Next 20 Years in Enterprise IT*, presentation delivered, San Jose, Calif., March 2009.
- ² McKinsey & Co., *Enterprise Software Customer Survey, 2008* (Sand Hill Group), 2008, p. 6.
- ³ Daryl Plummer et al., *Gartner’s Top Predictions for IT Organizations and Users, 2008 and Beyond*, January 8, 2008.
- ⁴ McKinsey & Co., *Enterprise Software Customer Survey*, p. 4.
- ⁵ Plummer et al., *Gartner’s Top Predictions*, p. 12.
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- ⁸ Plummer et al., *Gartner’s Top Predictions*.
- ⁹ *Ibid.*, p. 13.
- ¹⁰ Reeves et al., *Cloud Computing: Transforming IT*, p. 33.
- ¹¹ B G Verghese describes a famous cartoon by Shankar that shows Gandhi running to catch up with a ragged crowd. The caption says, “There go my people. And I must hurry to follow them. For I am their leader.” See <http://www.bgverghese.com/YouthCadres.htm>.