Cloud Computing in Higher Education: A Guide to Evaluation and Adoption

Executive Summary
Public cloud computing—delivering infrastructure, services, and software on demand through the network—offers attractive advantages to higher education. For example, it has the potential to reduce information and communications technology (IT) costs by virtualizing capital assets such as disk storage and processing cycles into a readily available, affordable operating expense. Sometimes selecting a public cloud offering can create risk around security, privacy, interoperability, or performance. When it does, universities should consider private cloud deployment models to realize scale on demand, rapid platform deployment, and lower costs and carbon emissions while minimizing risk.

Introduction
The cloud-computing market is projected to grow from $40.7B in 2011 to $240B in 2020 ("Sizing the Cloud," by Stefan Ried and Holger Kisker, Forrester Research, April 21, 2011). Such rapid market growth is a clarion call to all chief information officers (CIOs) to explore the possibilities offered by cloud and to assess the risks. Most are familiar with the cloud concept because many already use some aspect of cloud applications—software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS); for example, Google's Gmail, iTunes University, and Amazon's infrastructure, respectively.

The cloud space is rapidly adopting a plethora of new acronyms and phrases to describe different aspects of the offering, which is the next evolution of the Internet. For purposes of this paper, the following National Institute of Standards and Technology (NIST) definitions are used for deployment models:

• **Private cloud.** The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise.

• **Community cloud.** The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.

• **Public cloud.** The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.

• **Hybrid cloud.** The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).


This list is not intended to be an exhaustive one. New deployment models will continue to emerge as circumstances demand.

The push by the IT industry, coupled with the significant benefits that cloud computing promises to deliver, leads Cisco to believe that cloud computing will be widely used in higher education. At the same time, Cisco understands that the distinctive features of higher education information management require a careful evaluation concerning whether, where, how, and when they might adopt cloud computing.
This paper seeks to help in that process. It provides a high-level overview of cloud computing models (discussed previously), outlines some of the important benefits it could deliver to higher education, examines some of the most important challenges cloud computing may pose for academia, and suggests some early steps that can be taken toward its adoption while mitigating risks.

What Is Cloud Computing?
Many IT executives contend that cloud computing is nothing more than another sourcing alternative similar to data center outsourcing. Although there are similarities, cloud is differentiated by its primary characteristics of on-demand self-service, resource pooling, rapid elasticity, and pay-as-you-go pricing. These characteristics make it attractive to some and problematic to others; for example, on-demand self-service and elasticity of compute power and storage may be attractive options for a research scientist, but a potential problem for the CIO of a university who is accountable for the integrity of the research data.

The major factor in promoting cloud computing has been the recognition that large data centers have thousands of servers that generally do not operate at full capacity, creating a surplus of compute capacity. By using these resources more efficiently through virtualization, cloud computing enables greater returns on data center investments. And it makes it possible for a university to create its own private cloud within its own infrastructure.

Benefits of Cloud Computing
Cloud computing delivers major benefits to both private and public sector organizations, as detailed in Table 1.

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<tr>
<th>Benefit</th>
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<tr>
<td>Cost savings</td>
<td>Organizations can reduce or eliminate IT capital expenditures (CapEx) and decrease ongoing operating expenses (OpEx) by paying only for the services they use and potentially by reducing or redeploying IT staff.</td>
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<td>Ease of implementation</td>
<td>Without the need to purchase hardware, software licenses, or implementation services, an organization can deploy cloud computing rapidly.</td>
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<td>Flexibility</td>
<td>Cloud computing offers more flexibility (often called elasticity) in matching IT resources to business functions than past computing methods. It can also increase staff mobility by enabling access to business information and applications from a wider range of locations and services.</td>
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<td>Scalability</td>
<td>Organizations using cloud computing need not scramble to secure additional higher-caliber hardware and software when user loads increase, but can instead add and subtract capacity as the network loads dictate.</td>
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<td>Access to top-end IT capabilities</td>
<td>Particularly for smaller organizations, cloud computing can allow access to higher-caliber hardware, software, and IT staff than they can attract or afford themselves.</td>
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<td>Redeployment of staff</td>
<td>By reducing or eliminating constant server updates and other computing problems and by cutting expenditures of time and money or application development, organizations can focus IT on higher-value tasks.</td>
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<td>Focusing on core competencies</td>
<td>Arguably, the ability to run data centers and to develop and manage software application is not necessarily a core competency of most organizations. Cloud computing can make it much easier to reduce or shed these functions, allowing organization to concentrate on critical concerns such as the policy and planning for constantly improving the learning environment.</td>
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<td>Sustainability</td>
<td>The poor energy efficiency of most data centers, due to substandard design or inefficient asset usage, is now understood to be environmentally and economically unsustainable. Cloud service providers, by using economies of scale and their capacity to manage computing assets more efficiently, can consume far less energy and other resources than traditional data center operators.</td>
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It is important to note that the scale of such benefits, the ability to capture them, and the cost/benefit ratio achieved depend on many unique factors and will vary significantly. These benefits include where an organization sits in its IT CapEx and systems-development cycle, its current hardware and software architecture (for example, some older applications may not be “cloud-ready”), and its staff and management capabilities. In higher education, legal and policy constraints may be especially important.

Benefit realization will also depend on the chosen cloud-computing deployment model. The “public cloud” as infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services, such as Rackspace or Amazon. In the “private cloud” approach, organizations develop or procure their own dedicated cloud-computing environments (either alone or in group “community clouds”) rather than simply using the existing multitenant offerings of third-party providers. Cisco has built an internal cloud for efficiency and agility. There is also a hybrid option where an organization might use a public cloud for some functions (for example, basic business applications such as email) and their private cloud for others (for example, storage for personnel data that is very sensitive). It should be clear that the choice of a cloud model is not an all-or-nothing proposition. In the short to medium term, we believe that selection of a cloud deployment model is one of the most important decisions higher education IT managers will face. Universities may choose to build their own private cloud for their own consumption, and even offer hosting services to other universities for the purpose of revenue generation.

Cloud Computing for Small Colleges and Universities

Public cloud computing will deliver benefits beyond the major universities. Its advantages may be even more pronounced in small colleges that have not yet achieved high levels of computerization, or do not have and have trouble recruiting people with adequate IT skills, or those worried about their ability to secure and protect data. By contracting with a cloud service provider (perhaps another, larger university), that small college can adopt state-of-the-art applications and services, enabling the college to skip a whole generation of academic computing, thereby bypassing many of the costly and debilitating challenges discussed previously.

Challenges of Cloud Computing

Many challenges of cloud computing for higher education relate to its relative newness and the underdevelopment of the marketplace for cloud services. For higher education, decisions to adopt cloud computing will be influenced by more than technical and cost considerations.

Information is the lifeblood of higher education, and decisions on how to manage that information can have far-reaching political, social, and economic considerations. Adoption of cloud computing presents many of the same risks and challenges as deciding to use a more traditional outsourcing arrangement. The increased possibility that the service provider or its resources may reside outside of a government’s legal or territorial jurisdiction, however, can make some of these concerns more acute.

Carnegie Mellon University has developed a useful overview of some of the challenges higher education will face in adopting cloud computing (refer to Table 2).
This list is surprisingly similar to the concerns that topped the list of a survey of businesses done by IDC Enterprise Panel in 2010—among their top concerns were security, performance, availability, and integration.¹

The good news about these barriers is this: You can mitigate many of them by building a private cloud with levels of confidence you have already established and tested in your own data center, or parsing out the pieces of the environment according to your level of confidence in any other deployment model of cloud.

### What Should Higher Education Managers Do About Cloud Computing?

It is important for higher education managers to gain a solid understanding of how cloud computing is evolving, and the trends in its adoption. In the near term, Cisco expects rapid growth in third-party “public” clouds offering many different application, computing, and storage services. Although academic organizations may choose to use these services—especially, we suspect, for standard business applications such as email or document creation—we think it is more likely they will elect to create their own private clouds for core applications, either alone or in partnership with other institutions of higher learning. Although higher education organizations will weigh the costs and benefits of each approach, we anticipate that a major factor of these decisions will be their level of trust in both the cloud deployment model under consideration and the entity providing it.

### Next Steps

You can take several important steps now in preparation for cloud-computing adoption, whether public or private:

- Identify all potential opportunities and benefits for switching from existing computing arrangements to cloud services.

- Ensure that in-house infrastructure complements cloud-based services. The shift to cloud services is not all-or-nothing, and some cloud services (for instance, infrastructure services) will support the ability of in-house IT to extend into some clouds for additional compute and storage capacity. Virtualization will be a critical piece of a compatible infrastructure.

- Develop a cost/benefit and risk-evaluation framework to support decisions about where, when, and how you can adopt cloud services. Develop a roadmap for optimizing the current IT environment for adoption of public and private cloud services. Identify which, if any, data cannot be held in public cloud-computing environments for legal or security reasons.
• Identify and secure in-house competencies that will be required to manage effective adoption of cloud services.

• Evaluate technical challenges that must be addressed when moving any current information or applications into a cloud environment, even a private cloud. Experiment with and pilot various services—both internal and external—to identify where problems may arise.

• Ensure that the networking environment is ready for cloud computing.

This last point is particularly important. We see cloud computing as a natural evolution of the Internet. Rather than regarding networks as mere plumbing, it is vital for higher education managers to understand them as the fabric “within” the cloud, and as the connection between the cloud and the user. In the future, networks will also be the fabric that connects and mediates between different types of clouds. The network must be a critical part of providing security and quality of service at scale. It is not a matter of simply choosing either the endpoints or the network for a particular function.

In our view, university CIOs’ interest in cloud computing is or will be the foundation for future IT efforts, and you should, therefore, address and incorporate this factor into existing IT strategy as soon as possible. You should consider cloud computing at its simplest for its ability to enable academic organizations to respond to calls for transformation with agility, efficiency, and confidence.

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