Exploring Cloud Computing for Distance Learning

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Abstract

The use of distance courses in learning is growing exponentially. To better support faculty and students for teaching and learning, distance learning programs need to constantly innovate and optimize their IT infrastructures. The new IT paradigm called "cloud computing" has the potential to transform the way that IT resources are utilized and consumed in education and is expected to have a large impact on educational computing during the next few years. With its focus on helping distance learning administrators and practitioners to understand cloud computing and to make plans for successful cloud adoption, this paper provides insights into the adoption of cloud computing for distance learning, based on a thorough review of the literature about cloud computing. Implications and considerations for additional research are provided as well.

Introduction

The use of distance education is growing exponentially. More and more courses and degrees at institutes of higher education are becoming available through distance-education programs (Howell, Williams & Lindsay, 2003; Johnson et al., 2010). According to a recent SLOAN-C Annual Report (Allen & Seaman, 2010), in Fall 2009, over 5.6 million students were taking at least one online course. This is an increase of nearly one million students over the number reported the previous year. In addition, blended instructional formats that include a significant portion of online activities got a boost after a recent review of online learning studies found that blended learning students outperformed both fully face-to-face and fully online learning students (U.S. Department of Education, 2009). Since blended instruction includes at least thirty percent of online activities, the actual volume of online learning goes well beyond what is typically reported.

As more faculty and students are becoming involved in distance and blended learning, there is increased pressure to build distance learning programs and modules. The 2010 Horizon Report, recently published by The New Media Consortium and EDUCAUSE, indicates that students expect to be able to study and learn whenever and wherever they want to (Johnson et al., 2010; Ally, 2009) via their network-capable devices such as iPads (Barnes, Herring, Nelson, & Notar, 2010) and iPhones (Ostashewski & Reid, 2010). Researchers are responding to this trend by proposing solutions to personalize e-learning environments (Dolog et al., 2004; Drexler, 2010).

Instructors of both blended and distance courses are expecting to include more data-intensive and computing-intensive learning resources such as interactive videos, virtual worlds, modeling and simulations, and Web 2.0 tools in their courses (Ismail, 2002; Govindasamy, 2002; Rossett & Frazee, 2006; Zgoul & Kilani, 2009; Sankey & Huijser, 2009; Downey, 2010; Chang & Guetl, 2010). To meet the growing demands of instructors and students for personalized learning, flexibility, and on-demand services, and to be able to address the IT challenges, distance learning administrators and practitioners need to explore the new IT infrastructure. The current IT infrastructure offered by most distance learning programs is not likely to be able to sufficiently meet the increasing demands and needs of instructors and students in an efficient and effective manner. Metz (2010) offers the example below to explain why the traditional IT infrastructure is sometimes not good enough:

> *When an institution develops or deploys a new application, they first must jump through a number of hoops. For example, if an institution decides they would like to install the learning management system Moodle, they might have to order a server, wait for the vendor to ship it, install the server in the data center, provision an IP address for the server, set up the DNS for the new IP address, install the operating system, etc.*

As Metz describes, this workflow process is rather cumbersome. Although, certainly, some institutions might be able to streamline and complete all of the steps in this workflow process in a timely manner, it is clear that a new method should still be explored, in order to optimize or minimize the steps in the process. The act of adding additional servers to the current IT infrastructure owned by each distance learning unit takes time, is expensive, and doesn't address the gap between demand and supply. Thus, a new IT infrastructure that can provide flexible and on-demand services to instructors and students needs to be explored. To better support instructors and students for teaching and learning, as well as to increase the competitive advantage, distance learning units need to constantly innovate and optimize their IT infrastructure, resources, and business processes.

The increasing demand for IT (and the decreasing amount of resources available to meet that demand) is making cloud computing an attractive solution for many campuses' technology needs (Blanton & Schiller, 2010). In an effort to provide better IT services to meet the expected increase in demand for distance learning, distance learning administrators should consider cloud computing as an alternative solution and should include cloud computing in their strategic planning.

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell & Grance, 2009). As a new IT paradigm for user services, cloud computing has the potential to transform the way that IT resources are utilized and consumed. Cloud computing describes a new supplement, consumption, and delivery model for IT services that is based on the Internet. It typically involves the provision of dynamically scalable and often virtualized resources over the Internet (Gruman, 2009). Cloud computing has attracted significant attention recently in the realms of academia, industry, the government, and the military. Many organizations are turning toward actual cloud adoption and deployment. Cloud computing has the potential to become the next major driver of business innovation, as it promises to enable new business models and services across almost all industries (IBM, 2009; Armbrust et al., 2010; Sriram& Khajeh-Hosseini, 2010). For instance, with cloud-based services, many of the steps listed by Metz (2010) in the work-process quoted above can be eliminated. Ideally, the distance learning IT staff will merely click a few buttons to get an application up and running in a matter of minutes, if they are using the cloud services offered by the cloud service providers (Metz, 2010).

To contribute to the understanding of the benefits and challenges of integrating cloud computing into distance learning, a thorough review of distance learning and cloud computing literature was conducted. It was discovered that although cloud computing is a popular topic at conferences and in white papers, magazines, and blogs, there are few published academic articles about how cloud computing can be exploited in distance learning. A thorough literature review also reveals that little attention has been paid to the guidelines and strategies regarding the adoption, integration, and implementation of cloud computing for distance learning. More in-depth discussions among distance learning administrators and practitioners regarding cloud computing adoption and its implications are needed. The more informed that distance learning administrators and practitioners can become about the cloud and about the options that it offers to DL, the better their position will be when they are making decisions about deploying, developing, and maintaining systems in the cloud (Metz, 2010).

To fill a significant gap in the distance learning literature and to better help distance learning administrators and practitioners understand and adopt cloud computing, this paper provides some insights for developing cloud computing strategies for distance learning, based on the literature review and on the authors' years of practical experience in distance learning. These insights are intended to assist distance learning administrators and practitioners when they are integrating cloud computing as a part of their IT strategy planning.

This paper is organized as follows: Section Two describes some of the benefits that cloud computing can bring to distance learning. Section Three describes cloud computing options, including its delivery models and deployment methods. Section Four describes the challenges of cloud computing. Section Five offers insights for DL administrators and practitioners who are interested in adopting and implementing cloud computing. Finally, Section Six presents conclusions and suggestions for future research.

Benefits of Cloud Computing For Distance Learning

Cloud computing offers a variety of benefits to overcome the challenges associated with traditional IT infrastructure, such as the setup of reliable and accessible networks, servers, storage, applications, and services. According to researchers (Jaeger, Lin, & Grimes, 2008; Rittinghouse & Ransome, 2009; Dong, Zheng, Yang, Li & Qiao, 2009; Dong, Han, Liu, & Xu, 2010; Armbrust et al., 2010), some of the main benefits of cloud computing include reduced implementation and maintenance costs, increased mobility for a global workforce, flexible and scalable infrastructure, quick time to market, and IT department transformation (because of the cloud's focus on innovation vs. a focus on maintenance and implementation). For example, The Silicon Valley Education Foundation has moved a lesson planning application named Lessonopoly into the cloud by using Amazon Web Services. In its original

configuration, Lessonopoly had been installed on a single server. This posed a risk, since a hardware failure could result in system unavailability until repairs were made. The application's migration to the cloud was highly successful, and resulted in better robustness, increased flexibility, and reduced costs (Stratos Learning, 2010). Below are explanations for some of the benefits:

Cost Saving: Perhaps the most important incentive associated with cloud computing is the cost reduction. Westmont College reports that after deploying six cloud-centric service platforms, it has achieved numerous benefits, including a 65 percent cost reduction up front (over more traditional deployments), and a 55 percent cost saving over the useful lifetime of the solutions. Beyond the cost savings, though, the college reports a significant increase in user satisfaction, as well as a significant decrease in the amount of IT management time required (Sheard, 2010).

Rapid elasticity and scalability: Many distance-learning programs offer live video streaming (LVS) courses to online students (Abdous & He, 2009). However, the LVS courses are only offered to a limited number of students (e.g., 1000 concurrent LVS students) due to hardware constraints. The existing hardware (e.g., web servers) will not be able to maintain its performance if concurrent LVS student numbers suddenly double or triple (e.g., to 2000 or 3000 concurrent LVS students). In addition, if a faculty member develops an innovative idea and requests a computing-intensive application that needs multiple servers to support it for a temporary period, in many cases the DL IT staff will have to turn down the request because the limited budget does not allow DL units to spend a lot of money purchasing hardware for a temporary project. With cloud computing in place, DL administrators need not be concerned about overprovisioning for a service whose popularity does not meet their predicted needs (and thus wasting costly resources), or under-provisioning for one that becomes wildly popular (and thus missing potential customers and revenue) (Armbrust et al., 2010).

Cost of setup and maintenance: Complex new technologies and applications are continually being invented and they make it harder for distance learning IT staffs to install, configure, secure, and upgrade to the latest technologies. The technology setup and the maintenance workload make up a large chunk of the time spent by the Distance Learning IT staff during their workday. The adoption of cloud computing will move the burden of technology setup and maintenance to the cloud service providers.

Reallocation of resources: As cloud computing moves the technology setup and maintenance burden to cloud service providers, campus DL IT staffs can focus on developing innovative instructional solutions/resources and on providing more support to faculty and students. There are several areas in which more intensive help from the DL IT staff can be beneficial to the faculty. First, as instructors move toward more online and mobile instruction in their courses, IT staffs can help them to optimize the use of the available LMS systems to increase both the effectiveness and the efficiency of the instructional process. Second, as online instruction strives to become more personal through the extensive use of online conferencing tools (e.g. Blackboard Collaborate, Webex), instructors can benefit from more intensive initial support with the technical aspects of integrating these tools into their teaching activities. Third, IT staffs can help faculty to improve their technical skills in using various Web 2.0 tools (such as blogs or wikis) and can therefore help them to effectively integrate these collaborative tools in their courses in order to improve their students' learning experiences and performance (e.g. Cole, 2009; Trentin, 2009).

Cloud Computing Options

Cloud computing includes three delivery models (Mell & Grance, 2009):

1) Software as a Service (SaaS):The consumer uses an application, but does not control the operating system, hardware, or network infrastructure on which the application is running. Salesforce.com and Google Apps are examples of SaaS.

2) Platform as a Service (PaaS): The consumer uses a hosting environment for his/her applications. The consumer controls the applications that run in the environment (possibly with some control over the hosting environment), but does not control the operating system, the hardware, or the network infrastructure on which the applications are running. The platform is typically an application framework. Microsoft Azure is an example of PaaS.

3) Infrastructure as a Service (IaaS):The consumer uses "fundamental computing resources" such as processing power, storage, networking components, or middleware. The consumer can control the operating system, storage, deployed applications, and possibly networking components such as firewalls and load balancers, but not the cloud infrastructure beneath them. Amazon Web Services (AWS) and Rackspace Cloud Server are examples of IaaS.

According to the US Department of Commerce's National Institute of Standards and Technology (Mell and Grance, 2009), cloud services can be deployed via four methods:

1) Public Cloud. In simple terms, public cloud services are characterized as being available to the general public or to large industry groups from a third-party service provider via the Internet. Third-party companies such as Google, Amazon, Microsoft, and others run public clouds.

A public cloud does not mean that a user's data is publically visible; public cloud vendors typically provide an access control mechanism for their users.

2) Private cloud. Private cloud services offer cloud computing on private networks. Private clouds are typically designed and managed by an IT department within an organization. In a private cloud-based service, data and processes are managed within the organization without the restrictions of network bandwidth or security exposures, or without the legal requirements that using the public cloud services might entail.

3) Community Cloud. Using a 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/or compliance considerations). It may be managed by the organization or by a third party, and it may exist either on-premises or off-premises.

4) Hybrid Cloud. A hybrid cloud is a combination of a public, private, and/or community cloud that interoperates. In this model, users typically outsource non-business-critical information and processing to the public cloud, while keeping business-critical services and data in the private cloud.

Cloud Computing Challenges

While cloud computing technologies have thrived in the mainstream, educational institutions have been reluctant to apply a cloud-based system to enterprise uses on campus (Sheard, 2010) because of security, privacy, and other barriers that prevent the widespread enterprise adoption of cloud computing (Li et al. 2009; Armbrust et al., 2010; Khajeh-Hosseini, Sommerville & Sriram, 2010). Cloud computing poses challenges and risks which require careful consideration during the planning process (Armbrust, et al., 2010; Khajeh-Hosseini, Sommerville & Sriram, 2010). Common concerns with clouds (particularly public clouds) include:

1) Security concerns (Rittinghouse & Ransome, 2009; Jensen et al, 2009). Is the data safe? Can it be backed up and restored easily?

2) Privacy concerns (Pearson, 2009). How can users be sure that their data is private when the data is in the cloud? Can the users control how their information will be used by the cloud vendor?

3) Vendor lock-in/dependency concerns (Armbrust et al., 2010). Vendor dependency or vendor changes (bankruptcies/shutdowns/acquisitions and their consequences) must be considered, including the cloud user's ability to continue business operations if the vendor shuts down unexpectedly. How viable is a potential cloud service provider? How hard would it be to move applications and data to another provider?

4) Legal/regulatory/information policy consequences concerns (Jaeger, Lin, & Grimes, 2008; Joint, Baker, & Eccles, 2009). How does the use of a cloud service impact the user's ability to comply with various legal requirements and regulations?

There is no doubt that these cloud computing challenges have a significant impact on migration decisions or that more research needs to be done to address these challenges (Khajeh-Hosseini, Sommerville, & Sriram, 2010). Many technology solutions (e.g., security, monitoring, cost-estimating technologies) and non-technology solutions (policies, regulations) are being developed to help mitigate the challenges of and the concerns about cloud computing risks. For example, Dartmouth College developed a decision tree and a set of metrics to determine the cost of hosting servers in the cloud (Goldstein, 2010a).

It is possible to effectively address many of these challenges and concerns, including training, contract negotiation, and vendor management (Trappler, 2010), through careful planning. As a matter of fact, many companies and organizations are turning toward actual cloud adoption and deployment and are "outsourcing" computing to the cloud. For example, the University of Alabama at Birmingham has moved its Blackboard system from on-site hosting to vendor hosting (Worona & Wright, 2010). It should be noted that cloud computing technologies have thrived in the mainstream (Sheard, 2010). In fact, the research firm IDC (2010) predicted that that the worldwide cloud services' market segment will be worth about $44 billion (US) by 2013. It is important to note that the challenges of cloud computing can be greatly reduced or overcome through careful planning, through collaboration, and through the sharing of best practices. In summary, these cloud computing challenges are interdisciplinary in nature and cannot be fully addressed from a purely technical perspective (Khajeh-Hosseini, Sommerville & Sriram, 2010; Sriram& Khajeh-Hosseini, 2010). To successfully adopt cloud computing in distance learning, cooperation among DL administrators and practitioners, other campus personnel, cloud users (instructors and students), and cloud service providers is needed. It is also important to note that the migration of IT applications and systems to the cloud takes time. The timeline for cloud adoption can vary from several months to several years (Thethi, 2009; Sullivan, 2009).

Insights for Developing Cloud Computing Strategies for Distance Learning

Based on the literature review and on years of practical experience in distance learning, this paper provides some insights for developing cloud computing strategies for distance learning. Since every distance learning unit has its own considerations and accompanying goals, the insights that are offered in this paper are general in nature and do not comprise a set of specific instructions about what to do or how to do it in terms of the adoption of cloud computing. It is unlikely that cloud computing can address all of the IT problems, but it could be the answer to some very specific ones (Blanton & Schiller, 2010). Every distance learning unit will need to use its own due diligence to determine whether the benefits of cloud computing outweigh the risks, based on its unique institutional environment and circumstances. Researchers at Infosys Corporation suggest that a series of steps are needed for cloud adoption. Among these are assessment, validation, preparation, and execution (Thethi, 2009).

Furthermore, those distance learning units that have determined to adopt cloud computing need to take the time and effort to design a cloud computing strategy along with a plan that will work best for their own needs. Distance learning administrators and practitioners must be diligent about protecting institutional data and must sharpen their contract writing skills (Blanton & Schiller, 2010; Trappler, 2010) with cloud service providers. In fact, the following insights provide good strategic guidance for distance learning administrators as they integrate cloud computing as part of their IT strategy:

- Select the type of cloud solution that fits the structure of the instructional activities for your institution. For small colleges serving a small number of DL students, the straightforward adoption the public cloud might be the best method to use. For example, some small colleges may lack the dedicated in-house servers and/or staff to support their distance learning courses. Thus, it might be better for them to consider the adoption of a public cloud for their distance learning courses, considering the benefits such as cost savings and reduced setup and maintenance burdens that cloud computing can offer. Large DL units which already have invested in their own IT infrastructures over the years should consider maximizing existing assets by building a hybrid cloud. As an initial step, administrators of such large DL units should focus on transforming the existing IT applications and systems (e.g., learning management systems, customer relation management systems, instructional support systems) into an internal private cloud (Li et al., 2009). They can build a small-scale exploratory cloud and conduct pilot testing first. For example, they can experiment on ways to enable authenticated access to IT applications and systems on the cloud using internal user account databases and they can examine possible integration issues (such as data sharing and access control). Once the DL staff members have developed the skills and experience for the cloud implementation and integration, they can move further to build internal private clouds for the whole distance learning unit, and eventually build a hybrid cloud. Mission-critical applications (including students' personal and financial information) can reside in the private cloud, which will generally provide better control, security, and privacy protection. On the other hand, non-core IT applications (e.g., learning management systems, customer relation systems, instructional support systems) should be outsourced to the public cloud as much as possible (Motahari-Nezhad, Stephenson, & Singhal, 2009). The hybrid approach brings together the best of both the public and private cloud worlds. A phased implementation strategy is recommended to realize the evolution of the cloud (Bakshi, 2009). A distance learning unit can focus initially on Software as a Service (e.g., moving applications such as Blackboard and syllabus creation system to clouds), and then move on to Platform as a Service and to Infrastructure as a Service. By evolving the cloud services gradually, these larger distance learning units will have time to see the benefits and to get buy-in throughout the organization.
- Evaluate and select cloud service providers using multiple criteria. Thethi (2009) proposes four criteria: cloud platform maturity, technology alignment, operational alignment, and geographic alignment. Leong (2009) suggests that while cost, operational stability, and the ability to scale are important when choosing a cloud service provider, each organization also needs to consider how well the cloud solution suits its organization's application architecture, how well it provides the level of customer support needed by the organization, and how well it meets the organization's service level, security, privacy, and compliance needs. Particularly, organizations should look for a cloud service provider who can provide cost-effective architecture and a high-quality customer experience (Leong & Chamberlin, 2010). Leong and Chamberlin (2010) also propose weightings for specific evaluation criteria, including ability to execute and completeness of vision. Additional selection criteria should be created that will specifically address distance learning needs. For example, does the cloud service provider have expertise in supporting specific software and learning management systems such as Moodle or Sakai? What are their pricing models and licensing schemes?

There are a variety of cloud service providers in the marketplace. Careful evaluation is needed to compare these cloud service providers' capabilities. The purpose of the evaluation is to choose a cloud service provider which can provide a cloud designed to meet each specific distance learning unit's needs and requirements. Many cloud service providers have teams of developers who can provide customized services to meet the specific needs of their clients. Trappler (2010) offers a number of suggestions to help users deal with contract issues with cloud service providers, including: codifying the specific parameters and the minimum levels required for each element of the service and the remedies for failure to meet those requirements; affirming the institution's ownership of its data stored on the service provider's system and specifying the institution's rights to get it back; detailing the system infrastructure and security standards to be maintained by the service provider along with the institution's rights to audit compliance; and specifying the institution's rights and costs to continue or discontinue using the service. Conversations among DL administrators and practitioners are needed, in order to set up a set of specific criteria for the selection and evaluation of cloud service providers. It might be best if existing DL professional associations take the initiative in this regard.

- Use a holistic approach. The adoption of cloud computing will have a profound effect on both the organization and the individuals (particularly the IT staff) at work. For example, Westmont College estimates that at least 80 percent of the time spent by its IT staff focuses on uptime-related work (Sheard, 2010). Now, keeping the applications and systems up and running (including monitoring, maintenance, upgrades, and troubleshooting) is now the responsibility of their cloud service partners. Moving uptime support to partners gave time back to Westmont's IT staff members, who can now provide more time directed at instructional support to help instructors and students with their teaching and learning needs. However, this example also shows that the adoption of cloud computing changes the various roles of the IT staff (e.g., database administrator, operators, technicians, etc.) within an organization and changes their importance, relative to one another (Golden, 2011). In addition, the adoption of cloud computing has implications for institutional IT funding practices, economic models, and budgets (Goldstein, 2010b). Therefore, DL administrators should use a holistic approach when considering cloud adoption instead of just focusing on moving the application x, y, or z (Gunson & Blasis, 2002) to the cloud.Top management support, careful planning, and a thorough education of all stakeholders are needed in order to identify the best cloud strategy.
- Partner with other DL institutions. The authors of this paper feel that this should be an overarching goal, in order to build a distance learning community cloud that will offer the most benefits to both students and faculty. Such a shared distance learning community cloud, once established, would allow online learning resources and applications to be shared across the whole distance learning community. That also means that students and faculty (either at small community colleges or at large prestigious research universities) would have equal access to online learning and teaching resources. To that end, existing professional associations in distance learning should take a leadership role in working with their member institutions to set up cloud adoption, implementation, and evaluation standards and criteria, and should develop agreements and information policies for distance learning to address various shared issues such as educational resources, copyright, security, and the privacy protection of personal and financial information. Resources (such as forums and wikis) can be used to support and facilitate discussions among DL administrators and practitioners (Blanton & Schiller, 2010). A community cloud in distance learning will also make it easier to secure federal and state financing and grants, to reduce the overall cost of development and operation, and to avoid the wasting of costly resources.

Conclusions and Future Research

Cloud computing is changing the way that IT resources are utilized and consumed (Armbrust et al., 2010). Cloud computing provides a good solution which should address some of the IT challenges and bring new opportunities to distance learning. While many still have concerns about the use of cloud computing, there is no doubt that cloud computing is becoming widespread and is likely to change the way in which IT services are provided and used. The more informed that distance learning administrators and practitioners can become about the cloud, the better their position when they are making decisions about deploying applications and systems in the cloud. Thanks to the many benefits of cloud computing, forward-thinking distance learning programs need to explore and include cloud computing as a part of their IT strategy planning, although the benefits also come with challenges.To better meet the growing technology needs of both instructors and students, DL administrators and practitioners need to begin to discuss and share their ideas and strategies about cloud computing, in order to take the IT infrastructure and services employed by distance learning to a new level.

A thorough literature review reveals little prior research about how distance learning can adopt and implement cloud computing. Further research is needed to develop, identify, and disseminate the best practices, in order to address a variety of issues concerning the adoption and implementation of cloud computing. Future research should also include an exploration of the impact of cloud computing implementation on delivering distance learning to students. Some research directions that would provide more insights in the potential impact of cloud computing include: a) the perceived impact on students' learning experiences in fully online and blended formats using cloud computing resources; b) the perceived impact on teaching effectiveness and efficiency for online and blended learning instructors using cloud computing resources; and c) the potential increase in the volume and quality of the IT support for faculty development when cloud computing solutions are implemented.

The authors hope that this paper will serve as a good starting point for DL administrators and practitioners interested in cloud computing, since it provides relevant insights to guide DL administrators and practitioners in this area even as it identifies a potentially significant area for DL research and development. It is our belief that this paper will help DL administrators to reduce their confusion about cloud computing, to think proactively about cloud computing, and thus to engage in more productive discussions about the best practices of cloud adoption and its potential implementation in distance learning.

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