AC 2010-1447: AN EXPERIENCE WITH CLOUD COMPUTING IN THE CLASSROOM

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An Experience with Cloud Computing in the Classroom

Introduction
Cloud computing is a general term for shared applications and infrastructure provided by an external service provider and paid for on a pay-per-use basis. For enterprise computing based on a business model that relies heavily on in-house computing infrastructure, the cloud concept has major implications. Vendors such as Amazon and Google sell reliable and scalable computing resources that are generated by very large-scale virtualized, distributed computing systems. Microsoft Business Productivity Online Suite provides communication and collaboration functionality delivered through a subscription. Microsoft targets small businesses with the suite of services advertising that the organization will no longer need to "maintain a complex IT infrastructure of its own". The question for enterprises then is "Who needs in-house servers?" A somewhat parallel question for college educators might be, "Who needs to use an in-house learning management system?"

Cloud computing has implications for personal computing as well as enterprise computing. Web-based email was one of the first "hot" cloud applications to make it big. For example, Yahoo Mail, Microsoft's hotmail, and Google's Gmail all compete, offering free accounts with practically unlimited storage capacity. Many other software applications are available through the cloud now, and soon there will be many more. Rather than purchasing software and installing it on a local machine, applications like Google Docs provide free computing software together with storage resources, all available anywhere and anytime, as long as the user can connect to the World Wide Web. Coupling Google Docs with Google Groups provides the power to collaborate. Microsoft Office Live and Microsoft Office Web Apps (currently invited technical preview only) comprise Microsoft's entrant in the online personal productivity market. These cloud applications allow users to take advantage of anytime anywhere access to familiar products (built to function similarly to local installs of MS Office) in addition to online storage and sharing of documents.

This paper will first describe the history of cloud computing and then provide information about some of the technology behind cloud computing. The paper will examine results from one of the authors' classroom experiences with a cloud-based office productivity tool. Included in the discussion will be features and functionality of the product, as well as student reactions to its use in class. The purpose of the paper is to provide an overview as well as guidance for others who are considering classroom use of emerging cloud capabilities.

History of Cloud Computing

The concept of cloud computing began in the nineteen-sixties as technologies to connect computers to each other and enable them to transfer data back and forth were just beginning to emerge. Even before the first two computers were connected together to exchange data, Joseph Carl Robnett Licklider, the director of Behavioral Sciences Command and Control Research for the Advanced Research Projects Agency (ARPA), envisioned a shared computer network. His vision went far beyond what would begin as ARPANET and later evolve into the Internet, and his vision also went beyond what came to be known as the World Wide Web. The scope of

Licklider's vision, which he called the "Intergalactic Computer Network" (Licklider, 1963), included a network of computers that would share both information and live software applications. Licklider's vision and plan for the Intergalactic Computer Network more closely resemble cloud computing than does the prevalent html-based World Wide Web. Licklider's Intergalactic Computer Network plan was partially realized in time as distributed applications available by terminals connected to the ARPANET. This architecture resembles today's Software As A Service (SaaS) architecture, which is part of cloud computing.

Bolstering the idea of SaaS early on was cognitive and computer scientist, John McCarthy. At a speech commemorating MIT's 100th anniversary in 1961, McCarthy was the first to publicly propose a time sharing computer network that would sell computing resources and applications in a way similar to the way natural gas, water, and electric companies sold utilities at the time (Hongfei, 2003). This concept was sometimes referred to in its day, as "grid computing" since it mirrored the concept of the electrical grid. Today, the term "grid computing" refers to distributing processing and computing across the processors of a grid of networked computers, usually to accomplish tasks that are computationally large.

Both Licklider and McCarthy continued to rally for their different versions of software sharing networks throughout the nineteen-sixties. By the early nineteen-seventies, it became apparent that computing power and networking technologies were not sufficiently advanced to a point where SaaS would be practical (Mohamed, 2009). By the mid-nineteen-seventies, Licklider and McCarthy's vision was all but abandoned, and stand-alone software installations became the norm. Delivery and function of software would remain the same for another twenty –five years.

The SaaS concept was used again and further developed by Bill Atkinson, Andy Hertzfeld, and Marc Porat in the nineteen-nineties when the three formed the company General Magic. General Magic's concept was to provide thin, mobile clients to customers. The client devices would contain a lightweight operating system, called Magic Cap. Magic Cap applications were based on a proprietary language created by General Magic called Telescript. The concept behind Telescript applications on the General Magic devices was that all of the computing power was handled by large servers provided by General Magic. Telescript handled the communications between the handheld devices and the General Magic servers. This group of servers would come to be known as the "Telescript Cloud" (Armbrust, et al., 2009). Unfortunate for General Magic was the fact that the Telescript Cloud was not adequately developed. The result was a lack of reliable and highly accessible infrastructure that left many customers unhappy. This lack of planning coupled with the introduction of the Mosaic browser led to the ultimate demise of General Magic, but cloud computing and SaaS had returned and interest levels rose among computing software and infrastructure builders.

Another SaaS provider emerged and this time the application was business productivity. Salesforce.com used the commonly-available Internet and World Wide Web infrastructure as their development and delivery platform. They eschewed the idea of building proprietary infrastructure, a concept that General Magic relied on that had failed them. The advantage of the non-proprietary World Wide Web was that cloud computing model could be built without the need to reinvent technology to connect the client to the server. In 1999, Salesforce.com introduced the first cloud computing service that resembles today's SaaS offerings.

Much of the concept behind Salesforce.com was not new ("Salesforce.com Exposed - Background & History," 2009). For example, Google, Yahoo, and others had been employing SaaS to provide software applications as services to users via the Internet. However, most of these offerings were geared toward personal use. The primary new thing that was done by Salesforce.com was using a similar grouping of technologies to provide a business productivity service. Salesforce.com created an online sales force and customer relationship solution that helped businesses organize and manage geographically dispersed sales teams and customers. One goal of Salesforce.com was to never require the end user to install software. Instead the software and all of the necessary computing processing power was located on Salesforce.com servers ("Editions and Pricing," 2009).

After Salesforce.com paved the way to serious business applications delivered via cloud computing, a number of other providers came on the scene. Today Amazon, Microsoft, IBM, Google, and many other companies provide cloud computing applications for business and personal users (Armbrust, et al., 2009). These companies are part of a currently unfolding trend that was foretold by Licklider and McCarthy decades ago.

Technology Overview

In the near future, the dominant model for providing computing and information infrastructure to businesses will likely involve cloud computing. Infrastructure includes both hardware and software, and the location of the infrastructure in a cloud computing architecture is the cloud, which refers to the global network of information and communication technologies and devices, the Internet. One research team likens the cloud model to multiple users sitting at dumb terminals and accessing a mainframe. But they quickly qualify the comparison with a reminder that a cloud user will not be connected to a limited-functionality mainframe, but to all the resources of the Internet, both what is there today and what will be there tomorrow (Voas & Zhang, 2009). In addition, the user is not sitting at a dumb terminal, but at a laptop, workstation, or mobile PC with a significant amount of computing power and storage capacity of its own. Tim O'Reilly (credited with coining the term Web 2.0), in an interview during Web 2.0 Expo 2008, describes cloud computing this way:

> Everything we think of as a computer today is just a device that connects to the big computer we are all collectively building. Cloud computing is really the movement of computing into the network of all connected devices, this network of networks. ("What is Cloud Computing?," 2008).

Researchers have identified a minimum set of features that are generally included in the cloud paradigm. These are scalability, a pay-per-use utility model, and virtualization (Vaquero, Rodero-Merino, Caceres, & Lindner, 2009). In other words, cloud computing refers to the provision of computing infrastructure that is highly scalable, that is offered on a pay-for-use basis, and that involves access to application and data servers over the network rather than ownership of tangible servers and software.

A principle advantage claimed for cloud computing is a reduction in costs associated with the management of hardware and software resources (Hayes, 2008). One report refers to cloud computing as an infrastructure management methodology (*Seeding the Clouds: Key Infrastructure Elements for Cloud Computing*, 2009). Typical labor and ownership costs of installation, configuration, and updates that are associated with software installed on desktop computers are transferred to Service Providers (SPs) whose core business is providing Software as a Service (SaaS) over the network. The company pays the SPs a negotiated fee for the services, contracted through service level agreements. Typical labor and ownership costs of increasing storage capacity and increasing processing capacity to accommodate newer power-hungry software releases that are associated with in-house hardware ownership are transferred to Infrastructure Providers(IPs) (Vaquero, et al., 2009). The company pays the IPs a fee for the infrastructure services they provide, again contracting through service level agreements. The complexity of the underlying resource infrastructure is made simple by high-level web-based management interfaces and tools that enable users to request resources (applications, storage, data, training, etc.) and be granted the resources quickly and in an automated way that requires minimal hands-on support by skilled IT personnel. The resource allocation model when using cloud computing requires users to define a start and end date for their need for the resource. So, for example, in the case of software, a license for the software will be consumed by a user for only a predefined period of time. This frees up licenses to be reallocated as needed without having to purchase additional licenses. This model provides for better use of existing resources, with less waste in the form of allocated software licenses going unused. It is not difficult to see where cost advantages might be derived with this approach, which is compatible with the TPS philosophy of only paying for a resource just as it is needed as part of production. In this case, the resource is computing infrastructure (software, hardware, storage capacity, e.g.) that no longer needs to be installed on every computer where it may be used only a small amount of the workday. The software resides on the server and users access it and use it as needed through the cloud, and the client only pays fees when it is used, not when it sits idle.

There are some disadvantages identified for cloud computing. An important one has to do with security and privacy. If data is kept in-house, then companies control policies related to deleting and archiving data. It is not yet clear who controls policy regarding data deletion when the data is stored by one company as a service to another (Hayes, 2008). Data preservation and availability is generally covered with service level agreements between provider and user. For a company with sensitive data assets, it is important to negotiate security policies with the SPs and IPs. Another disadvantage may have to do with the complexity and sophistication of software that can be made available through the cloud at this time and the somewhat early stage of the development of this technology. As seen from the history of the technology, it is not new, but it is evolving. There are limitations to what software can be distributed via the cloud at this time. Certainly many office productivity tools can be made available through the cloud, but processor hungry design suites might not be available in this format for a few years. Platform as a Service providers are focusing on the delivery of software development tools that include version tracking as cloud services. These are sophisticated applications that target the one industry of software development.

Thus, in terms of the technology lifecycle, cloud computing is probably in the introduction stage, perhaps just transitioning to the growth phase. Recognized problems associated with early adoption are uncertainty, lack of standards, and no performance benchmarks. Uncertainty and lack of performance benchmarks are, perhaps, not as much of a risk since cloud computing really represents a composite of proven technologies (networking, distributed applications, virtualization). Lack of standards is also, perhaps, less of a risk since cloud computing relies on the standardization of the underlying technologies to work, and these underlying technologies do adhere to established standards. The cloud provider is as much an integrator and management provider as it is a technology provider.

One vendor working to define cloud computing for its clients is IBM. Their offering is complete service support for building the necessary infrastructure and managing it. They provide several case studies of client implementations lead by IBM with proven ROI in terms of cost savings and innovation fostered by the technology (*Seeding the Clouds: Key Infrastructure Elements for Cloud Computing*, 2009).

Implications for STEM Disciplines

Two broad areas of the cloud computing spectrum are seen in the STEM literature—the use of virtualization for remote student access to applications and the use of internet-based office productivity tools like Google Apps. The rest of this paper describes the use of another version of an internet-based productivity tool, known as Microsoft OfficeLive (MOL). The discussion involves an action research implementation for the use of MOL in a sophomore-level information systems database course. The process of action research provides a way of thinking systematically about what happens in teaching practice.

Action Planning

The problem to be solved was providing students with experience in using workplace-quality cloud computing (internet based) applications. The goal of using an internet-based application for collaboration, storage, and viewing word processing, spreadsheet, and presentation slides was to provide students with access to documents anytime and anywhere, simulating experiences that modern workplaces routinely provide and within which they expect workers to function. The documents included both individually developed and team developed deliverables for class assignments. Since the university computer labs provided students with Microsoft Office productivity tools, and because it was likely they would have access to these same productivity tools at home or at work, another goal was for students to know how to store or revise Word, Excel, and PowerPoint documents, specifically. Microsoft OfficeLive (MOL) was chosen as the platform to provide such experience. Through the experience students would learn how documents are made available to team members or the instructor through MOL, and they would learn how to communicate with the instructor and team members about individual or team assignments using MOL. The experiences would also provide opportunity to introduce vocabulary and concepts about cloud computing, which was appropriate for the sophomore-level information systems database course in which the action research was taking place.

Actions Taken

To set the stage for the introduction to the cloud computing concept, students were given an initial assignment of sending an email to the instructor from their university email account. This forced the students to access their university accounts, many of which had likely not been used recently. Because access to the MOL workspaces are granted through a user id that represents and active email account, and because the email accounts become visible through shared workspaces, the instructor chose to require that the students use their university email account. This requirement was intended to protect the privacy of students so that they would not have to expose a personal email account to undue classroom-generated email traffic. The instructor created a distribution list of the students' email addresses for each class, and sent a confirmation email to the students (from the instructor). Students were asked in class to make sure each had received the instructor's email. Those who had not received the confirmation were told to seek assistance from IT support staff to work out any email issues or problems.

The plan to enable students to use a cloud computing application for class assignments was implemented in four parts. First, an introduction to information systems that facilitate collaboration was given. A class discussion was conducted in order to reveal to students the characteristics of a collaborative environment and the requirements of an effective collaboration. Also included in the discussion was an explanation of various types of access permission levels that can be granted in MOL.

The second part of the plan included having the students view a demonstration video of the process to create a Microsoft Office Live account followed by a hands-on student walk-through of the steps for setting up their own account... Once in the Office Live site (www.officelive.com), students were instructed to use their university email address as their Microsoft Office Live account user id. The MOL system verifies the authenticity of entered email addresses by sending an invitation to the entered email address to create the actual MOL account. Most students received their account generation/activation email invitation within five minutes. Those students not receiving the email invitation typically still had an issue with their university email account. Accepting the invitation via a clickable link then took the student to their MOL account and functionality.

The interface for the MOL workspace has the look and feel of a Microsoft SharePoint workspace. In fact, Microsoft Office Live is built on the Microsoft Windows SharePoint Services platform. Microsoft Office SharePoint is an integrated suite of server functionality that provides enterprise-level content management with search. In addition, the functionality serves to promote collaboration by facilitating information-sharing throughout the enterprise. Furthermore, Microsoft has an online version of its Office productivity suite under development that it is currently calling Office 14 Web Applications. These applications are to be delivered through Microsoft Office Live. They are to be lightweight versions of Word, Excel, PowerPoint, and OneNote that allow a user to view, edit, and collaborate on these types of document using only an installed browser. The online applications will be available free. Again, the similarity of MOL to actual enterprise-level tools that a student may encounter in a workplace makes the classroom experiences more valuable and meaningful.

As an administration tool, students were given a class number corresponding to their place in the alphabetical listing found in the roster. The numbering system provided a more useful mechanism for recognition and retrieval by the instructor than a list ordered by email account (these begin with the student's first name initial according to the naming convention used by the university to generate them). This number is used in the next step of the process when students are instructed to create a workspace of their own. Each student created a workspace using the naming convention NNN Workspace, where the student's assigned class number is substituted for NNN. Within their course workspace, students created folders for Inclass, Homework, Project, and Tests. The visual representation of user-generated workspaces in MOL is a folder. Thus, students have little difficulty adapting their existing knowledge of Windows OS folders to the cloud collaboration environment provided by Microsoft.

Finally, the students went through the process of sharing their course workspace with the instructor. In the "Share your workspace" window of MOL, students gave the instructor Editor permissions to create and edit documents by typing her university email address in their Editors text box. A brief message to the instructor was also completed. In response to the share request submitted by the student, MOL generated a sharing invitation for the course workspace and sent it to the instructor. This email invitation contained a clickable authentication link to the student workspace. The instructor saved all workspace invitations for a class in one folder in her email application to make access to student accounts available in a central location.

Throughout the semester, students submitted all assignments via their course workspace. The naming convention for assignment files to be submitted started with the course number. The student uploaded the assignment to the appropriate folder in the workspace. Activity emails were sent to the instructor each time a change was made to a workspace. MOL accommodates different levels of notification for activity. For example, the instructor can choose not to receive any activity if so desired. To communicate with the student and provide feedback, the instructor sent a comment on each individual assignment to the student within the course workspace. Students could respond to the instructor's communication or send a question to the instructor through the MOL comment facility.

The process describe above for workspace creation also was used for teamwork assignments. One member of the team created a team workspace and became its owner. The other members of the team, as well as the instructor, were then invited as editors (create and edit permissions) by the workspace owner. The team members had to accept the owner's invitation. The students collaborated on in-class and homework assignments, as well as project work. Any student could upload a document to the workspace. All students were instructed on possible scenarios for completing collaboration assignments and how to use the version control feature of MOL.
As a means of distributing course documents to students, such as syllabus, class schedule, weekly checklists, presentation slides, and class handouts, the instructor established her own workspace for each class and shared it with all the students in the class. Students were invited to the workspace as viewers (read only). The students had to accept the invitation to the workspace. They could choose to receive activity emails when changes were made to the repository.

Observation and Reflection

The creation and use of the student workspaces was successful for the most part. Students were most satisfied with having a place to save documents for all their classes that was accessible anytime from anywhere with internet access. They also liked being able to use productivity tools that they already had experience with and that had greater functionality than internet-based products (e.g., Microsoft Excel versus Google Docs – Spreadsheet). Students had difficulty understanding the concept of sharing a workspace versus sharing a document. In spite of sharing their workspace, they would also share a document within the workspace. This step prevented the instructor from having access to the entire workspace rather than just a document, which served to target specific documents as those being "turned in" as opposed to others that may have been drafts or support artifacts for the final deliverable artifact. Also some students could not gain access to their university email accounts for two to three weeks, so they got behind in completing and uploading their assignments. Although the instructor provided grades for each assignment and periodic summaries of their grades, some students wanted an overall view of their grades in one place online. From the instructor perspective, grading online can become quite time consuming. This fact would be true whether using a cloud platform or a typical learning management system.

The collaboration process did not go as smoothly as students turning in individual assignments. The problem was not so much with the platform but more with the lack of responsibility on the part of some students. As with any group project, some members were not responsible in getting back to others in a timely manner nor did they follow through on their commitments. Oftentimes, this behavior would lead to last minute synchronization of documents just prior to submission time. Some students did indicate that they would continue to use OfficeLive at least for its storage capability in future classes.

Other observations serve to compare this experience with that of using a learning management system (LMS) environment. The University of Houston supports and supplies Blackboard Vista (was WebCT Vista) for courses taught in a traditional face-to-face format, online, or some combination of the two formats. Like other LMS, the tool provides extensive functionality in support of instruction. Faculty can upload course artifacts to the system or link to course artifacts stored elsewhere on a web server. In addition, faculty can create assignments, online quizzes, and point-based discussion questions, all of which can then be graded online with the grades being first stored in a course grades database that is part of the LMS, and then grades being presented securely to each individual student through the LMS. The MOL experience would be able to replace only some of the composite functionality provided by the LMS, namely, that of the assignment tool and, possibly, the discussion board.

With respect to the assignment tool provided in Blackboard Vista, the students are able to upload documents or submit text directly in a text box. The instructor must then open each student assignment "dropbox" and grade, with the system allowing the instructor to type commentary in a text box or upload a document with commentary. The upload process can be quite time consuming. With MOL, the instructor is able to open the submitted document, add commentary, and then save it back to the workspace in a more seamless way that mimics saving to local storage as opposed to uploading to the "cloud". Also the simplicity of having all of one student's assignment submissions located in a single workspace (the MOL model) is attractive and could be used to easily review all of the student's work for the semester as an entire body of work.

A fairly significant drawback to MOL as opposed to Blackboard Vista is the lack of integrated grading that allows the students to view all the grades they have accumulated for the semester in one view. A fairly significant advantage to MOL as opposed to Blackboard Vista is the fact that

MOL is a tool that integrates with Microsoft business productivity tools and that MOL itself resembles the Microsoft business collaboration tool, SharePoint Services. Significant value is derived any time a student is provided with workplace experience and software. Such experience may provide the student with an employment advantage. Few students will benefit from having “experience with Blackboard Vista” as a line of their résumé.

Overall, the instructor was satisfied with the results of using a cloud computing platform. Future implementations will be handled similarly, with hope that the problems experienced with email accounts will be minimized. On the horizon is a completely web-based version of the Microsoft Office tools which should make the implementation even more appealing. Direct development with SharePoint services API might be used to produce a grading application that could deliver student grades individually to each student workspace. Additional exploration with respect to classroom applications of cloud applications may provide further insight.

Conclusions

This paper reviewed the historical underpinnings of cloud computing along with an overview of the technology background of cloud computing. The final sections of the paper described the results of an action research project that was implemented to address the implementation of a cloud computing application in an undergraduate information systems class.

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