A PROPOSAL FOR THE ADOPTION AND USE OF CLOUD COMPUTING IN SECONDARY EDUCATION IN SOUTH AFRICA

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Abstract

Cloud computing is a relatively new concept that holds significant promises for the future development and delivery of computer resources to K-12, also referred to as secondary or basic education in South Africa, especially in schools most affected by the digital divide. In view of the recent announcement by the Minister of Basic Education, Angie Motshekga, that Outcomes Based Education (OBE) will finally be scrapped, it seems advisable to investigate global benchmarks to discover how Internet resources such as cloud computing can be used to avert many of the information delivery problems that crippled OBE in the new education plan referred to as "Schooling 2025" (Mahlungu, 2010). Although details of the new education plan are still to be announced, it will suffer the same fate as OBE if the role and future of information and communication technologies (ICTs) such as cloud computing in secondary education, are not recognised and made part of the revised curriculum.

The aim of this paper is to briefly review the extent to which cloud computing applications and services currently used by secondary education systems in developed countries around the world can be used to help breach the digital divide that currently exists in the secondary (basic) education sector in South Africa.

Keywords: Cloud computing, secondary education, K12, Google docs, digital divide

Introduction

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The use of the Internet and Information and Communication Technologies (ICTs) to deliver educational resources is considered to be mainstream practice in the 21st century, yet in secondary education in developing countries it is often viewed as a luxury. This has far-reaching effects on teachers, learners and educational institutions in countries that lack basic ICT infrastructure and limited or no support for the training of teachers and learners in the use of digital online information sources. It is increasingly accepted that in the future, most information sources and desktop applications currently used will be accessed through the Internet or “cloud” applications. This means that at secondary school level, ICTs should be adopted as a matter of urgency to enable teachers and learners to access these new directions in Internet technology and application delivery. Teachers and learners will no longer have to physically carry their documents and data around with them; the “cloud” will enable them to access documents and data anywhere, from any connected device. This blending of traditional teaching and learning with online applications and tools for collaborated learning via the Internet is a fundamental concept of cloud computing.

The term “cloud computing”, which has been described as an Internet computing model that offers unparalleled access to computing resources, was introduced into the public domain around 2006 when Amazon announced a limited public beta version of its Amazon Elastic Computing Cloud (EC2) system. By this time, Google’s Gmail (first released as Google Mail in Germany in 2004) application was already more than two years old, but many did not at the time associate the application with the concept of cloud computing. It was only in 2006 when Eric Schmidt (Bogatin, 2006), Google’s CEO, described his company’s commitment to a new mode or model of computing called “cloud computing” - different from the “old client/server” computing business model invented (mainly) by Oracle - that the term “cloud computing” as a data service architecture on servers in a “cloud somewhere” began to take off. This new type of web service would allow anyone with a web browser and a connection to the Internet to access services in the cloud irrespective of the kind of digital device they used, from PCs to Mac, mobile phones or devices that have yet to be developed (Bogatin, 2006).

Because cloud computing is Internet-based, reliable Internet access over high-speed broadband connections constitutes the most significant component in its future development, marketing and delivery to secondary education. While some cloud services may not require users to have fast Internet connections or use large amounts of bandwidth to access web applications, such as text messages through Facebook or GMail, others, such as downloading a streaming video file through Youtube or uploading large quantities of data to Amazon for storage (S3) or processing (EC2), do. In the limited broadband/ bandwidth environment of the “digital divide”, this presents a significant obstacle to overcome in order for cloud computing to substantially contribute to breaching the digital divide (LeRoux and Evans, 2010).

Cloud computing, like the web, is the evolution of a variety of technologies that have come together over the last decade or more to alter an organisation's approach to building its information technology (IT) infrastructure and hosting its information systems (IS) (Reese, 2009). According to Reese (2009), there is nothing fundamentally new about any of the technologies that make up cloud computing. Just as Netscape came to harness the different web technologies into its suite of Internet tools late in 1999, Amazon in 2003 began to harness existing web technologies, web-services and protocols to deliver remote computing services collectively referred to as Amazon Web Services (AWS). The best known of these cloud computing platform services are the organization's off-site Simple Storage Service (S3) and its Elastic Cloud (EC2), launched in 2006.

While cloud computing services, especially software-as-a-service (SaaS), is rapidly becoming a reputable concept among businesses that have fast and reliable access to the Internet (which, as mentioned before, is perhaps the most crucial requirement for cloud computing), its uses and virtues in K-12 (secondary education) are poorly utilized in developing countries around the world.

1. Cloud computing service models

Cloud computing is currently delivered in three main service models, namely cloud-based applications know as software-as-a-service or SaaS, development platforms known as platform-as-a-service or PaaS, and computing resources for storage and processing commonly referred to as infrastructure-as-a-service or IaaS.

SaaS applications are currently the most widely used in K-12 (secondary education). Popular applications include Google's Gmail, Google Docs, Zoho Office Suite, Microsoft Office web apps (Office Live), Quicken Mint, Adobe Buzzword, WriteRoom, Facebook, eLearning, (Microsoft) Docs for Facebook, Creatly.Com for online diagramming and collaboration, Yahoo Calendar, Sales Force Automation, and Business Intelligence (Adobe Developers Connection - ADC, n.d.).

PaaS services, on the other hand, provide the infrastructure on which SaaS applications are built and run, which can be Windows, Unix or open-source (OS) systems such as Linux or Ubuntu. Examples here include Google's App Engine, Heroku (a 'ruby on rails' platform), Joyent, which can host applications developed in various computer languages, and SmartPlatform. The latter is a Joyent, OS, JavaScript cloud platform that provides users with a single unified web application development platform with infinite capacity. According to its website, the **SmartPlatform** "abstracts away all the complexity of a modern data center" by using a "SmartDataCenter to manage specific hardware and network topology behind the scenes" and allow for "maximum productivity, efficient resource utilization and best-in-class application performance" (Joyent SmartPlatform, n.d.).

IaaS, the third group of cloud services, offers virtual computing resources as a service. This means that instead of buying servers, software, data center space or network equipment, consumers can buy these resources as a fully outsourced cloud service ('infrastructure as a service'). This type of cloud service, which is similar to buying electricity, is generally referred to as utility computing. Popular examples are: Amazon's Elastic Compute Cloud (EC2) - Amazon Web Services, GoGrid, and Windows Azure. Although one popular use of IaaS is to develop websites, IaaS resources are normally used for more challenging and extensive computing and research efforts normally not performed at K-12 or secondary school level.

To better understand the impact that cloud computing may have on the development and delivery of K-12 (secondary education) in developing countries, we need to turn our attention to the development and current use of cloud computing services in the developed world.

2. Cloud computing in K-12 (secondary education): The developed world

Perhaps one of the most informative sources on the use of cloud computing applications by K-12 - also referred to as pre-college or secondary education in the developed world - is the K-12 Edition of the New Horizon Report published annually since 2009 by The New Media Consortium in collaboration with the Consortium for School Networking (COSN) in the United States (**Horizon Report 2010 K-12 edition:1).**

The report provides a valuable insight into cloud computing resources currently being used by schools in the developed world. Each edition of the K-12 report introduces six emerging technologies or practices, their potential use and impact on teaching and learning, and their estimated adoption time over the next five years (**Horizon Report 2010 K-12 edition:1-35**). The six technologies are:

(1) Cloud computing (one year or less);
(2) Collaborative environments (one year or less);
(3) Game-based learning (two to three years);
(4) Mobiles (two to three years);
(5) Augmented reality (four to five years); and
(6) Flexible displays (four to five years).

For the purposes of this paper, the authors have decided to concentrate mainly on cloud computing because it has the best possible chance of implementation in developing countries over the next five years. Although the adoption time for collaborative environments, also referred to as Learning Management Systems (LMS), in the developed world are seen as similar to that for cloud applications, the authors believe that given the current status of Internet connectivity and infrastructure in the developing world in general and South Africa in particular, LMS' adoption time in K-12 or secondary education will be much slower than the adoption time for general cloud applications for educational purposes.

This belief is partially borne from the fact that even in the developed world, the use of cloud-based collaborative environments by schools only began to take off in the first half of 2010 compared to 2009 when, according to the 2010 K-12 edition of the Horizon Report, only a few examples of cloud computing in general could be found in schools. Many of the cloud-based applications adopted by schools in 2010 were mainly for administrative purposes and productivity, such as curriculum development, scheduling and collaboration. This development also applies to K-12 schools in other parts of the developed world. The response of different secondary educational institutions around the world to the 2010 K-12 report can be found on the COSN website (**Horizon Report 2010 K-12 edition:1-35**).

One of the most compelling reasons for adopting cloud services, especially software-as-a-service (SaaS), is the substantial cost savings in terms of IT support, software and hardware expenses. This is primarily because most of the required processing power needed for cloud computing is shouldered by large data centres; electronic devices with minimal processing power and memory can thus be used to access cloud applications, especially SaaS applications.

A significant finding of the K-12 report was that while schools were increasingly beginning to adopt cloud-based applications in 2010 to manage calendars, rosters, grade books, and to facilitate communication between school and home, the actual use of cloud applications by students was still slow, suggesting that either teachers were slow to adopt cloud applications for use in classrooms or that the infrastructure, namely fast high-speed broad connectivity, was not available, or a combination of both factors.

While some schools, like the Columbia Secondary School (CSS) in New York and the Minnesota Online High School, have adopted cloud solutions to facilitate student work in engineering, English and debate, others have not yet utilised the available cloud applications for teaching and learning. In the case of the Minnesota Online High School, the use of cloud applications has actively freed the school from having to press, ship, and inventory software CDs. It also made it simpler for their IT support staff to assist students, who use a wide range of computer platforms.

K-12 teachers of some Science Technology Engineering and Maths (STEM) courses in the US have started to partner with some US universities to access higher-end computing resources to enable students to work on complex projects involving scientific research data that K-12 desktop computers are unable to process. North Carolina State University, for example, is working with IBM to provide cloud applications, computing power, and storage space to every public school in the state.

In November 2009, IBM in the United States announced the release of its Cloud Academy (IBM, 2009), a global forum for educators, researchers and information technology (IT) personnel at K-12 and higher educational institutions, to pursue cloud computing initiatives, develop skills and share best practices for reducing operating costs while improving quality and access to education. According to IBM: "Cloud computing makes it easier for those in the education industry, including students, faculty and administrators, to gain immediate access to a wide range of new educational resources and research applications and tools."

Cloud computing therefore represents good value for money by providing access to services and tools that would otherwise require substantial infrastructural investment. Add to this the fact that cloud applications can be accessed from a variety of devices, ranging from desktop to laptop computers, notebooks as well as many mobile devices, and the reason for shifting to cloud computing for secondary education starts to make a great deal of sense (**Horizon Report 2010 K-12 edition:10**).

As a result of the rapid growth and emphasis on cloud computing applications since 2008, some schools have started to integrate cloud computing into their design from the ground up. Coleman Tech Charter High in San Diego, California, is an example of one such institution. With new uses for cloud applications and services being discovered almost daily, designing and moving applications and services for K-12 institutions to the cloud makes increasing sense.

In October 2009, it was reported online that Australian primary and secondary schools had begun publishing educational content on iTunes U, which is a Section 25 of the Apple Store, allowing educators to share material. Although iTunes U was originally designed for universities and other tertiary institutions, it now actively caters for K-12 schools (Withers, 2009). The Western Australia Department of Education (DET), the Catholic Education Network (CEnet), the Presbyterian Ladies' College WA (PLC), and the Scotch College WA are the main drivers of this program. While the DET's content is designed mainly for the professional development of teachers, the CEnet's contributions are mainly classroom-oriented.

3. Cloud computing in K-12 (secondary education): The developing world

Although cloud computing is a relatively new concept and many of the current SaaS applications, especially the cloud-based office suites offered by Google, Zoho and Microsoft, have some way to go before they will be as functional, future-rich and compatible as existing Office applications, there can be little doubt that the future of Office suites is cloud rather than desktop based.

As pointed out at the beginning of this paper, cloud computing is primarily dependent on high speed broadband connectivity. According to the latest statistics released by the International Telecommunications Union (ITU stats, 2010), the developing world had only 12.3% fixed line connections compared to 42.7% for the developed world in 2009.

Cellular subscription for the same period stood at fifty seven point nine percent (57.9%) for the developing world compared to 115.3% for the developed world. However, when it comes to mobile broadband subscription, the figures are as low as three point one percent (3.1%) for the developing world compared to thirty nine point nine percent (39.9%) for the developed world. The figure for fixed-line broadband subscription is slightly higher at 3.6% for the developing world compared to 22.6% for the developed world. Estimated Internet usage for the developing world is given as 18% compared to 66.6% for the developed world (see Table 1 below, page 7).

As far as Africa is concerned, 37.5% of the continent's population has access to cellular devices, but only 2.2% has mobile broadband subscription compared to 0.1% for fixed-line broadband subscription. Although mobile broadband subscription is still low, it is expected to grow in the future as more and more people make use of mobile devices to access the Internet. Total Internet usage was estimated at 8.8% for the entire continent by the end of 2009 (ITU stats, 2010; see Figure 2, page 8).

Table 1: World telecommunication stats for 2009

World telecommunication stats as a percentage of total population, 2009		
Fixed telephone lines	**Year**	**Per 100 of the total population**
Developed	2009	42.7
• Developing	2009	12.3
Mobile cellular subscription	**Year**	
Developed	2009	115.3
• Developing	2009	57.9
Mobile broadband subscriptions	**Year**	
Developed	2009	39.9
• Developing	2009	3.1
Fixed broadband subscriptions	**Year**	
Developed	2009	22.6
• Developing	2009	3.6
Estimated Internet users	**Year**	
Developed	2009	66.6
• Developing	2009	18.0

Table 2: Telecommunication stats for Africa 2009

Telecommunication stats as a percentage of total population for Africa, 2009				
Fixed telephone lines	**Mobile cellular subscriptions**	**Mobile broadband subscriptions**	**Fixed broadband subscriptions**	**Estimated Internet users**
1.5	**37.5**	**2.2**	**0.1**	**8.8**

While the above figures are not very encouraging for the use of modern, Internet based technologies in K-12 or secondary education in teaching and learning in the developing world, especially Africa, progress is being made despite questions being asked about the cost and sustainability of the process and whether such investments are justified when the road networks remain poor, the energy supply is unreliable, and there is still no fixed line infrastructure in Africa (African ministers pass ICT directive, 2010).

According to a report on the 5th International Conference on ICT Development for Education and Training held in Lusaka, Zambia, in May 2010, "More and more African nations are embracing full-scale regulatory reforms and market liberalisation in a bid to attract more investment in the Information and Communication Technology (ICT) sector and exploit the potential of low-cost technologies [and] their efforts to improve access to the Internet are slowly paying off" (Ng'andwe, 2010).

The conference acknowledged that while approximately 17 African countries already have an Information and Communication Technology (ICT) policy for education, only 10 have developed an implementation plan or actually started implementation. While a number of best e-learning practices were proposed at the conference, no mention was made of applying cloud computing as a solution to the digital divide in African K-12 or secondary education (African ministers pass ICT directive, 2010).

4. Cloud computing in K-12 (secondary education): The South African picture

In January 2010, it was reported by World Wide Wrox that the number of South African Internet users had passed the 5 million mark, which represents about 10% of the total population. The data released by WW Wrox shows that the Internet user base grew by some 15% in 2009, from 4.6 million to 5.3 million, and was expected to grow at a similar rate in 2010 (Broadband Speeding Ahead, 2010). Most of this growth was in urban areas.

The same study found that most of the growth in fixed-line broadband came from small and medium enterprises (SMEs) upgrading to ADSL, thereby providing Internet access to more than half-a-million South Africans working in small offices who did not previously have access to the Internet. Although wireless broadband was found to have grown by some 88% during 2009, this was mainly the result of large companies supplying 3G cards to employees who needed to be connected whilst out of the office (Broadband Speeding Ahead, 2010).

According to the World Wide Wrox's "Mobile Internet in South Africa 2010" study, almost all urban cellular users have WAP-capable phones, and a high proportion have used that WAP capability to access a variety of Internet based content on a regular basis. Mobile web browsing, which is measured directly in the new study, accounted for almost three and a half a million users by the end of 2009. The Mobile Application Internet, which is measured across several applications - instant messaging, downloadable applications, Gmail, etc. - is estimated at about 9 million (The Mobile Internet pinned down,2010).

As far as South Africa's public schools are concerned, most have no library facilities or any form of formal access to the Internet or make use of Internet applications for teaching and learning. In July 2010, the South African Minister of Basic Education, Angie Motshekga, announced that a new education curriculum will replace the widely criticised Outcomes-Based Education (OBE) system. Entitled "Schooling 2025", the new education plan comes after years of criticism by teachers and education experts that OBE was a disaster and that it has failed a generation of learners since its introduction by the former Minister, Kader Asmal, in 1998 (Mahlangu, 2010). According to Kader Asmal, OBE was the brain child of Dr. Blade Nzimande who was the chairman of the parliamentary education portfolio committee in 1998. Dr. Nzimande apparently had the support of the then Minister of Education, Sibusiso Bhengu, Cosatu and the SA Democratic Teachers' Union, who wanted the "…immediate implementation of OBE as a progressive response to apartheid education" (Asmal, 2010).

OBE largely failed for three reasons: the lack of supporting resources such as libraries and Internet access, lack of training, and inadequately qualified teachers to implement its principles. Dr. Graeme Bloch, considered by many to be OBE's main architect, had to admit that they were overoptimistic and that the system was too complex. The system, he pointed out, could not work in an education environment where only 8% of the more than 27 000 government schools have libraries and only ten percent (10%) have some form of Internet connection. According to Dr. Bloch, without the necessary resources, OBE was doomed from the start (Bloch and Ndebele, 2010).

Whether the new curriculum will accommodate any of these concerns remains to be seen. The 2003 Draft White Paper on e-Education was never implemented as a policy. A new policy on e-education that accommodates the new directions in technology, especially cloud based technology, is therefore urgently needed.

In a paper entitled “Realities versus ideals with regard to e-learning in South Africa”, Conradie and Roodt argue that there is a stark contrast between the ideals of e-learning that have been put forward by education policy makers in South Africa and the realities and challenges facing its implementation, particularly in the rural and disadvantaged areas of the country (Conradie and Roodt, 2004). The authors argued that while there have been optimistic statements from official quarters on the one hand, such as the hope that was expressed in the 2003 Draft White Paper on E-learning that South Africa could ‘leapfrog into the future’, there are also many serious challenges to overcome, such as the marked urban-rural digital divide in the country (Conradie and Roodt, 2004).

The reality is that seven years after the release of the Draft White Paper on e-Education, only a small percentage of government schools have libraries and access to the Internet (Bloch and Ndebele, 2010). Equal Education (EE), a non-governmental group based in the Western Cape, has estimated that R2.2 billion was needed to equip every public school with a functional library and qualified school librarian. KwaZulu-Natal and the Eastern Cape are the worst affected (OBE was wrong from the start).

In August 2010, Zwelinzima Vavi, Cosatu’s secretary-general, launched a scathing attack on the country's 'corrupt political elite', saying that instead of focusing on and dealing with the country’s many problems, such as the dysfunctional school system, they are fighting political battles and using the state’s resources to enrich themselves. South Africa, Mr. Vavi pointed out, was moving towards a 'full-blown predator state' that cares little about service delivery (Steenkamp, 2010).

Yet in stark contrast to the digital divide in its basic educational system, South Africa in 2010 delivered the most hi-tech World Cup event yet. The semi-state telecommunications giant, Telkom, played a pivotal role in exclusively controlling and operating the two main digital hubs (carrier rooms). All stadiums were supplied with 20Gbps bandwidth networks that had capacity for High Definition TV broadcasting. A total of 1900 km of fibre optic cables were laid out for the World Cup venues (The Most hi-tech World Cup yet, Sunday Times, 22 May 2010**)**. It has been estimated that the World Cup could cost the South African taxpayer as much as R30 billion (2010 World Cup: A showdown of Costs).

In 2010, an amount of R165.1 billion was allocated for education in South Africa. Of this, R5.5 billion was allocated to infrastructural development. This figure was expected to rise to R9.4 billion by the 2012/2013 financial year. In March 2010, the Minister of Basic Education told parliament that South Africa needed R140 billion – slightly less than the total 2010 education budget - to build new schools, fix up old ones and provide libraries and other facilities, and that government was seeking outside assistance to foot the bill(R140bn is needed to fix school facilities. The Mercury, Durban, 24 March 2010)

Four months later, in July, the Department of Basic Education announced the official rollout of “The Teacher Laptop Initiative”. While this development represents a step in the right direction, the need to provide teachers and learners with Internet access so that they may use existing and future cloud-based applications such as Google Docs, Zoho and Microsoft Office online, should be the cornerstone of the new curriculum. Without this, the Teacher laptop Initiative, the TuThong National Educational Web Portal it will be of little use to the majority of the country’s teachers and learners.

Conclusion

In the introduction to this paper, we asked to what extent cloud computing applications and services, currently used by secondary education systems around the world, can be used to help breach the digital divide in secondary (basic) education in South Africa. The answer is that while a growing number of K-12 schools in the developed world are starting to make use of cloud applications, particularly suitable SaaS applications for teaching and learning, education systems in the developing world have not even began to access these new developments in technology. The absence of fast and reliable high-speed Internet access is one (if not the) main stumbling block to progress. Providing teachers with laptops is a step in the right direction, but without Internet access they will be used as little more than glorified typewriters. Rolling out broadband Internet access and using cloud-based applications would allow for cheaper and more baseline laptops to be issued to teachers as less processing power is needed to access cloud-based applications than standard desktop applications. The savings incurred by installing broadband connectivity and moving from desktop to cloud-based applications for teaching and learning can be substantial.

Setting up libraries with Internet access should go hand in hand with the “Teacher Laptop Initiative”. Internet access and its supporting technology should no longer be seen as a luxury, but rather as an essential part of the education process, especially in the developing world.

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