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Study on the Application of Public Cloud Services in Education Process

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Abstract

To improve the quality of education in today's world, educational institutions must adopt modern ICT facilities in teaching and learning processes. Unfortunately most of the existing ICT infrastructures and their supporting software packages are very expensive and many learning institutions especially in the developing countries cannot afford to purchase and maintain them. Thanks to cloud computing technology which is set to revolutionize the education sector, many less privileged institutions can be able to enjoy the use of modern ICT facilities in teaching and learning processes at a little or no cost. This paper explores some possible ways of adopting cloud computing services in teaching and learning processes. For each of the cloud service model, a concrete example is provided on how it can be used in education process. Study of the cloud computing companies providing various cloud services for education was also conducted.

Keywords: Cloud Computing, Education Process, Infrastructure as a Service, Platform as a Service, Software as a Service.

1.0 Introduction

Nowadays without the use of modern ICT facilities, no any educational establishment could function effectively, prosper and achieve the desired educational objectives. The use of modern ICT facilities will perhaps make the students and staff to fall in line with the reality of the present world and the digital society. Keeping away from adopting technological innovations will likely make contact between the world of education and the society more difficult. However, the deployment of own ICT infrastructures and their maintenance at each educational institution will be very costly and the maintenance costs are expected to increase occasionally. Many educational institutions spend huge sum of money on computing and telecommunication facilities and as well as on their supporting software packages. Beside the above stated expenses a significant financial investments are required to hire or to employ professionals to operate and maintain the establishment's ICT facilities.

Unfortunately many less privileged educational institutions especially in the developing countries cannot afford to purchase and maintain the expensive modern ICT facilities for use in teaching and learning processes. Cloud computing had recently surfaced and serves as a good alternative and solution for many modern educational institutions. Many cloud service providers provide modern educational e-tools necessary for efficient and effective teaching and learning to educational institutions at a little or no cost and such cloud services are referred to as public cloud services [1, 2, 3, and 4].Cloud computing is an Internet based computing where virtual shared servers provide computing and communication resources such as software packages (such services are referred to as **SaaS** - Software as a Service), hardware (such services are referred to as **IaaS** - Infrastructure as a Service), platform for application development (such services are referred to as **PaaS** – Platform as a Service) to end-users on-demand and sometimes on pay per use basis [5, 6, 7]. The SaaS, PaaS and IaaS are known as the cloud service models. In cloud computing, files, e-mails, applications and other vital educational information of any personnel (staff or student) are stored on the remote servers of the cloud service provider. In this case educational institutions do not need to buy and maintain highly expensive computing and communication resources which are in most cases not fully utilized. For cloud deployment in an educational institution the only thing required is to guide the academic staff and students on how to use the services provided by the public cloud service provider and just Internet access. A user can access cloud services using a client, which could be mobile client (e.g. Mobile devices include Personal Digital Assistants – PDAs, laptops, smartphones, etc.), thin clients (which are computers that do not have internal hard drives, but rather let the server do all the work, but then display the

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information) and finally thick client (regular computer, using a web browser like Firefox or Internet Explorer to connect to the cloud) [8]. Currently there are numerous public cloud service providers, such as Amazon [9], Google [10], Microsoft [11], iTunes University by Apple [12] etc., that offer significant discount to educational institutions, and as such they could get cloud services almost free of charge.

This paper focuses on exploring the possibilities of adopting public cloud services in teaching and learning processes. Section 2 discusses on how cloud service requests are processed, section 3 provides a comprehensive explanation on the application of public cloud services in education process, for each cloud service model (SaaS, PaaS and IaaS), a concrete case of its use in education process will be provided, section 4 discusses on the application of Google Apps for Education and Microsoft Live@Edu Services in education process. Section 5 concludes the paper.

2.0 Process of Cloud Service Provisioning

Cloud computing is regarded as the latest trend in distributed systems and general architecture of the modern cloud service systems contain the Cloud Management System, formed by a set of servers which could be centralized or decentralized and it performs the following four (4) basic functions [13]:

i. It manages the queue that receives job requests for cloud services from different users;
ii. It manages computing resources of the cloud service system;
iii. It manages data resources of the system;
iv. It divides a request into different subtasks and assigns the subtasks to different computing resources for execution.

To illustrate how cloud service requests are processed, consider a cloud system with five computing resources (c_1, c_2, c_3, c_4 and c_5), four datacenters (d_1, d_2, d_3 and d_4) and a service request arrived at the Cloud Management System is divided into subtasks s_1, s_2, s_3 and s_4, the Cloud Management System then identifies the interrelationships between the subtasks and their requirements in terms of computing resources and data access needs. Once these are identified, a network of computing resources and datacenters is formed based on dependencies. The Figure 1 below shows that subtask s_3, requires as input data the results obtained after subtasks s_1 and subtask s_2 are executed, and s_4 requires as input data the results obtained after s_3 is executed. To execute subtask s_1 access to datacenter d_1 is required, to execute subtask s_2 access to two datacenters d_2 and d_3 is required, execution of subtask s_3 does not need access to any datacenter and subtask s_4 requires access to datacenter d_4. The scheduler of the Cloud Management System assigns subtask s_1 to computing resource c_3, s_2 to c_1, s_3 to c_4, s_4 to c_2 and no any subtask is assigned to c_5.

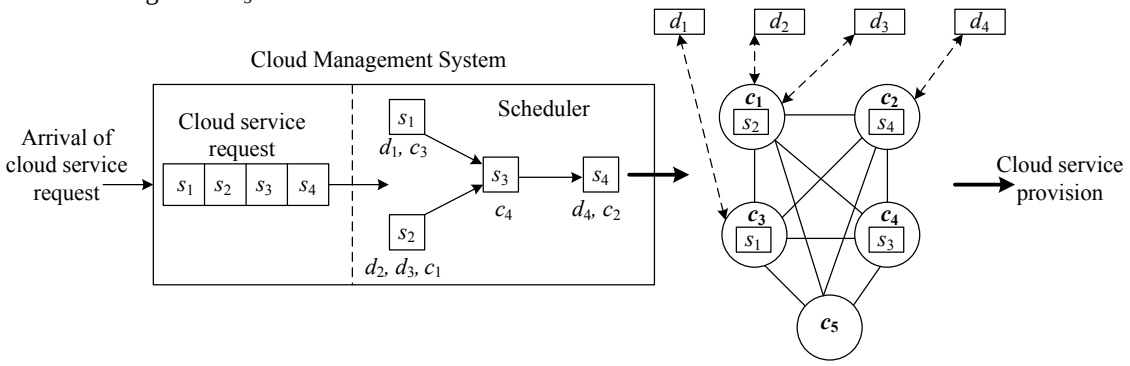

Figure 1: Scheduling and workflow in cloud service system

The cloud network illustrated above is usually very large, complex, and the link connecting various elements of the network is normally a virtual link over a long topological or geographical distance. When all subtasks that constitute the request are processed, the results are returned to the user as a service requested.

Let's obtain an expression to compute the total working time for a hardware component of cloud service system. Assume the system has N the total number of available hardware components, *M* data centers and *K* installed software systems for the execution of various subtasks. Denote by δ_n, $n=1,\cdots,N$, the processing speed on *n*-hardware component measured in million instructions per second (MIPS), by v_m, $m=1,\cdots,M$, the amount of data in megabyte (MB) downloaded/uploaded by a remote software programs of the hardware components, by w_k, $k=1,\cdots,K$, the workload on *k*-software system in NoI (number of instructions to be executed), by ε_{ij}, $i,j=1,\cdots,M$, $i\neq j$, the amount of data exchanged between *i*-subtask and *j*-subtask in MB, by B_l, $l=1,\cdots,L$, the bandwidth of *l*-communication link of the cloud system in bps (bits per second).

Then the total time that *k*-software runs on *n*-hardware component is

$$T_k = \frac{w_k}{\delta_n}. \quad (1)$$

The transmission time of *l*-communication link is

$$T_l = \frac{\varepsilon_{ij}}{B_l}. \quad (2)$$

Then the total working time T_n of *n*-hardware component is

$$T_n = \sum_{k=1}^{K} T_k + \sum_{l=1}^{L} T_l. \quad (3)$$

3.0 The Application of Public Cloud Services in Education Process

With pubic cloud services and continuous proliferation of the use of modern communication devices such as portable PCs, smartphones, touchscreen tablets, e-readers etc., among the students and staff, things such as collaborative learning (e.g. the exchange of documents and sharing of ideas between the students and their teachers, and between the students themselves, not necessarily of the same institution but with the students or teachers from other institutions far or near, conducting group projects or team works, consultations, interactive lessons), intelligent classrooms, virtual lecture theatres, easy access to educational resources anytime and anywhere, organizational works could all become a reality especially to less privileged institutions at a little or no costs. That will provide the students with an opportunity to learn outside the school premises, on a sick bed, as well as outside the school calendar (holidays, ongoing learning after school or postgraduate training).

Reliability, availability, easy scalability, almost zero maintenance costs are some of the key advantages of cloud technology. Considering these advantages, some educational institutions have rushed to start using cloud services in their educational activities and with such a clarion call many are expected to join them, hence in the near future most of educational services would be provided on the basis of cloud computing, and this will lead to abandoning of traditionally owned ICT infrastructures and traditional teaching tools and techniques. The cloud computing technology will help in broadening the accessibility of education to the people in remote and underdeveloped communities, where there are no skilled teachers, latest text books, lab facilities, etc. It is very important for the educational institutions' management to have a solid understanding of how cloud computing is evolving and the trends of its adoption in education process. One of the first cloud service used by European educational institutions was e-mail service. E-mail service does not play a key role in teaching and learning activities, and outsourcing it is not a difficult task. Many corporations, such as Google and Microsoft provide almost free of charge e-mail service to staff and students of educational institutions.

In addition to e-mail service, these corporations provide additional applications for use on the cloud, such as standard office package which support team work with electronic documents, tables and creation of presentations. Public cloud services for educational institutions such as Google Apps for Education [10] and Microsoft office 365 for education [11] allow users to use built-in applications for the exchange of instant messages, calendars for joint planning and general directories. To work on a cloud, each user is provided with significant disk space for storage and information processing.

It may seems strange that these services are provided to educational institutions free of charge, while for other commercial organizations the prices for the use of software applications on the cloud still remain high. Such a price policy can be explained as follows: in the modern market of cloud computing, competition among the service providers is very high, that is why they provide their services to educational institutions free of charge, and the target is on future graduates, who after graduation will secure jobs in the labor market and they will likely convince their future employees to subscribe to the services of that provider, which they have already been using and knew their advantages. Additionally, the more the number of users in the academic institutions, the more the recognition, popularity and high rating the provider will acquire.

If safety access to data is not a priority to educational institution, then it may be favorable to use a low-level IaaS service as a system for storage of data such documents, video and audio materials. For some educational institutions it may be profitable to move on to the cloud an internal Learning Management Systems. This is a good opportunity for those institutions that cannot afford to buy and maintain expensive hardware and their associated software, and as such will help the institutions optimize charges on ICT infrastructure.

3.1 Teaching Programming Related Courses on the Cloud

A very important example of the use of public cloud services in teaching and learning processes is the use of the cloud in teaching programming courses. Programming is hands-on practice, to learn programming; students must practice at home and in school. Unfortunately, the prices of modern compilers are very high, must of the local learning institutions cannot afford to buy them, and many students as well cannot afford to buy them for their personal use.

Modern programming practice requires an active use of specialized Integrated Development Environment (IDE). The use of IDEs possesses the following complexities:

i. Management and installation of IDE demand a highly qualified system administrator;
ii. Modern IDEs consume much of computational resources of the computer on which they are operated.

Let's explain each of the above complexities in detail. In order to achieve the full-functionality of the IDE, an administrator is required and the qualification of the system administrator carrying out the installation, management and supporting the IDE should be high enough. This will necessitate the educational institution to employ highly skilled staff as a system administrator, whose salary may appear essential on the budget of the institution. Apart from that, expenses on the institution can also increase because modern IDE demand the use of high-efficiency computers. For example, one of the widely used IDE is Microsoft Visual Studio, which for normal functioning requires a processor of capacity not less than 1.6GHz, 1 GB RAM, and 10 GB free disk space. Majority of tasks performed with computers in many of the existing educational institutions do not require the use of computers with such high specifications, therefore the purchase of such high capacity computers which are likely to be kept unutilized, can be considered as an inadmissible waste of resources.

All the aforementioned complexities can be addressed with the use of modern cloud technology. Nowadays there are plenty of online IDEs, which don't need to be installed on the end user device; to have access to them, only Internet browser is required. Browser's computer resources requirements are traditionally modest. For example, a popular web browser Mozilla Firefox 17, for installation demands a processor of not less than 1300 MHz, 512 MB RAM and 200 MB of free disk space. These figures are by far less than the requirements mentioned earlier for IDE Microsoft Visual Studio.

The use of cloud IDE for teaching programming language classes is very possible and simple. There are many paid and free-of-charge online cloud services that allow a user to develop and debug programming lessons in any programming language. For instance, Ideone [14] allows a student or lecturer to type the codes of a programme in different programming languages (more than 60 programming languages are offered), debug and run the programme in an online mode with an opportunity for the analysis of the obtained results. Obviously, more than 60 programming languages are enough for teaching programming language classes in any existing educational institution in the world; at least one will find a programming language of interest. With online IDE, a user can simply switch from one programming language IDE to another programming language IDE without the need to start several independent IDEs.

However, these online IDEs allow students to personalize a work with a programme. This opportunity of personalization is extremely important in an education process. A lecturer can order all the students to register with Ideone (students can register with login details of their Facebook accounts), this can allow the work with a given programme to be conducted in a collective manner and a team work with a given programme can be possible with the aid of modern Web 2.0 technologies [15]. There are more examples of such service providers, e.g. Cloud9 IDE [16], CodeChef [17], etc.

3.2 The Use of Cloud Storage Services in Education Process

Let's explore the possibility of using public cloud services for the storage and sharing of various types of data (study materials) on the cloud as an example of the use of cloud service model (in this case IaaS) in teaching and learning processes.

As of today, on the Internet there are more than thirty (30) [18] free of charge cloud data storage services, e.g. Dropbox [19]. Each one of them provides an opportunity to store and share data of any format, starting from office documents to multimedia information.

Almost all of the providers offer the following services free of charge

i. *A free of charge storage capacity of two (2) and above GB.*
ii. *Automatic synchronization of the stored data between all the devices that are connected to the cloud server*. There is no need to use external storage devices such as Flash-Drive, CD/DVD plates etc., to transfer data from the cloud to a given device e.g. PC, notebook, tablet, smartphone etc., the only thing needed for the transfer is to connect the device to the Internet and the actual version of the data can automatically be downloaded to the device from the cloud. This function saves ample amount of time, because it is possible to quickly continue with a classwork after a student returned back home or hostel from school.
iii. *Safety of the stored data on the cloud*. All the traffic flow between the end user device and the cloud server is encrypted (using at least Secure Sockets Layer (SSL) protocol, in some case RSA Encryption and Advanced Encryption Standard (AES) [18] are used in order to ensure data safety), this will make the transferred data very difficult to be accessed by intruders. That is why the degree of data protection provided by the cloud providers is by far greater than that provided by the e-mail service providers when sending e-mails. Some cloud storage service providers such as Spider Oak, Wuala etc. offer data encryption not only while transferring the data but also during their storage on the cloud [18].
iv. *Public access to the data on the cloud.* It is possible for someone to access files stored on the cloud with Internet connectivity. For that, it is only needed to send a link of the needed file (e.g. study materials, result of yesterday's test, last version of the lecture note etc.) to a colleague for studying.

v. *Reliability of the stored data*. Cloud storage service providers store data on their servers with the use of redundancy, data are usually replicated in data centers that are geographically distributed, which in itself guarantees reliability and availability. In addition to that on at least one device previously connected to the cloud, one more copy of a particular data can found in it, excluding the one already stored on the cloud.

For the educational institutions, the use of cloud data storage services will offer a lot of advantages. For instance, for the deployment of own locally networked data storage system it is necessary:

i. To purchase network and server equipment;
ii. To develop policies of storage and general access to information;
iii. To make initial installation and periodically maintain the supporting software packages;
iv. To regularly make reserve copies of data and to make all the necessary efforts for data restoration in the case of data lost or damage;
v. To employ highly qualified working personnel to manage the data storehouse.

The financial expenses to carry out the set forth above actions depend on the number of users. The population of many educational institutions can be very high. For instance to organize a data storage system for 1000 students with the allocation of 5GB disk space for everyone, it is required:

i. To buy four (4) hard disks of two and a half (2.5) TB (There is also a need to have additional 10 TB to store a duplicate copy of all the data using the RAID 1 technology);
ii. To purchase high efficiency RAID controller and server equipment,
iii. To pay the technologist and other personnel maintaining the system;
iv. To pay regular charges for the electric power consumed by the equipment involve in the system.

Nowadays, there are many existing cloud data storage service providers. For wise choice, characteristics of most popular ones are presented in the table below.

Table 1: Comparison of some free-of-charge cloud data storage service providers

Name	Free Disk space (GB)	Data Encryption Method	Supported Operating System	General Access	Collaborative Work
Drop box	2	SSL, AES 256	Windows, Mac OS, Linux, Android, iOS	Yes	No
Spider Oak	2	RSA 2048, AES 256	Windows, Mac OS, Linux, Android, iOS	Yes	No
MS Sky Drive	7	SSL, AES 128	Android, iOS, Windows, Mac OS	Yes	Yes
Box.com	5	SSL, AES 256	Android, Windows, Mobile, Ipad, Iphone	Yes	Yes
Wuala	5	AES 256, RSA 2048, SHA-256	Windows, Mac OS, Linux, Android, iOS	Yes	No
Adrive	50	SSL	Android, iOS	Yes	Yes

Looking at the above brief comparison of the cloud service providers for data storage, it is possible to draw the following conclusions:

i. Almost all the modern cloud storage services offer enough disk space for the storage of documents, teaching and learning materials;
ii. Almost all the providers use modern encryption algorithm for data transmission and storage;
iii. For the storage of backup copies of educational materials, it is recommended to use the service of Adrive, owing to its storage capacity of 50GB;
iv. If the confidentiality of data is given a priority, then high level of protection during data transfer and storage on the cloud is provided by SpiderOak (encryption of data occurs on the client device);
v. For a consultations, team and collaborative work, Box.com service will be a perfect choice.

Online data storage services possess greater advantages in comparison with the local networked storage system. The use of one or more cloud storage systems by the educational institutions may raise the standard and effectiveness of the education process and that will make the educational institution to be in line with the current IT world no matter how small the institution might be.

4.0 Google Apps for Education and Microsoft Live@Edu Services

Google Apps for Education (GAFE) is a set of free of charge cloud applications which are provided by the Google Company to educational institutions within the limits of the domain chosen by the educational institutions [10]. Users of Google Apps for Education has grown from eight (8) million users in 2010 to over forty (40) million users as of February 2015, maintaining this rapid growth, Google Apps for Education would result in hundred and ten (110) million users by 2020 [20].

Google Apps originated in February 2006, when for the first time provided e-mail services to organizations using the e-mail domain name chosen by the organization. In October 2006, Google Apps for Education became accessible to educational institutions, the services provided include, e-mail services, Google talk for chatting, Google calendar and Google page creator for web-page development. As of November 2015 Google Apps for Education include tools for communication and planning (e.g. E-mail Service, Google Calendar and Google Talk), tool for collective and collaborative work (e.g. Google Class Room, Google Doc, Google Groups, Google Disk, Google videos, Google Forms and Google Site), tools for effectiveness increase (e.g. service for the search of documents, messages and letters) [10, 21].

Tools for communication and planning

i. E-mail Service (Gmail) with 25 GB mailbox for each student and each institution's registered employee;
ii. Google Talk Service which provides an opportunity for the exchange of text documents, audio and video messages. Google talk service can conveniently be used for distance learning;
iii. Google Calendar Service which can be used to set lecture time tables, to schedule meetings, and to schedule any other event in a general access form.

Tools for collective and collaborative work

i. Google Doc Service allows users to create and share text documents, tables, presentations and to design a questionnaire;
ii. Google Disk Service provides a free of charge storage space of 5GB per user for safe storage of any file on the cloud with an opportunity of granting general access;
iii. Google Site Service provides an opportunity to develop a website for staff's and students' use;
iv. Google Groups for the creation of dispatch list and granting general access to documents, sites and calendars;
v. Google Videos Service provides an opportunity to use educational video materials in teaching and learning processes;
vi. Google Class Room provides an opportunity to create and share lecture notes, create and organize assignments quickly, provide feedback efficiently, and communicate with classes. Google Class Room is an effective tool for collective and collaborative learning;
vii. Google Forms can be used to gather and analyze information. They are great for quizzes, tests and surveys. Export results for easy grading. Send surveys to get feedback from families.

Tools for effectiveness increase

i. Google Service for the search of letters, messages and documents;
ii. Centralized administration for all the Google Apps for Education services.

All the set forth above tools are offered to educational institutions free of charge. Thus the Google Apps for Education possess the following prominent features.

i. Full back-up copies of all the stored data is granted. For instance, if teacher's or student's computer crashed, the teacher or student can continue with the work after few seconds using another device connected to the Internet;
ii. Reliable data encryption and safe authentication are offered. All data transferred between Google servers and user device are encrypted using SSL protocol;
iii. High availability of services is provided. Google Company guarantees 99.9% of service availability;
iv. Google Company promised to secure the copy rights and to protect the confidentiality of the educational institution's data. The policy of confidentiality guarantees that Google Company cannot in anyway publish or misuse the personal information placed on the Google Cloud Applications. The educational institution is the only and unique owner of its data and it completely controls them;
v. Possibility of using the educational institution's domain name while working with all the Google Apps. Each staff of the institution can register an e-mail account in the form of *name@youruniversity.com*.

To start the use of Google Apps for education it is necessary to undertake the following steps:

i. To register the educational institution;
ii. To tender an application for the connection to the Google Apps for Education services;
iii. To customize the GAFE as needed by the educational institution.

For registration it is necessary to visit the link [21] and to follow all instructions provided by the registration window, which will suggest the filling of a number of standard forms.

During registration, Google Apps for Education will require to confirm the property right of the institution's domain or to register a new domain name. In connection to this, it is recommended to use the services of an IT expert which will be responsible for the registering the institution's domain name.

If the educational institution has no domain name it can obtain one from any Internet Service Provider. License fee for the use of domain name cost few dollars per annum. However, it should be noted that it may take up to 24 hours for a new domain to be registered after an application is rendered; it takes that long because of the need to update the information on the root DNS servers.

After registration with the GAFE services, a super administrator account will be created with login details provided during the first registration process. To connect the institution to the Google Apps Services the super administrator has to login to the Google Apps for Education and apply for the connection of the institution to the free of charge GAFE services. It is important to note that the process of considering the application may last for one to two weeks. After the permission is granted the customization of GAFE tools for the institution need can follow immediately.

Microsoft Live@Edu (MLE) services are also cloud service provided to Educational institution by Microsoft, which is practically identical to GAFE services. MLE and GAFE share similar approaches and principles [11]. Before the use of Microsoft Live@edu services by educational institution it is necessary to make an agreement between the institution and Microsoft cooperation in which the conditions for the use of the services are stipulated [11].

For the use of Microsoft Live@Edu services, the educational institution should be a lawfully existing educational institution whose main activities is granting educational services to end users (graduates, students, teachers, regular and former employees, volunteers or other persons attached to the given learning institution). Each end user must register for an account with which user can have access to Live@Edu services.

After making an agreement, Microsoft will provide the end users in the institution (staff and students) with controllable outlook services in an online mode, e-mail services using the institution's preferred domain.

5.0 Conclusion

Education in many developing countries is in bad shape and crying for salvation. The dream of every parent is for their children to acquire good quality education, unfortunately for some countries with large population, inadequate learning institutions, inadequate qualified academic staff, limited budgets and resources that dream may not likely become a reality. Many companies are providing modern educational tools applicable in teaching and learning processes to educational institutions almost free of charge, when such services are properly adopted and utilized by educational institutions that will break down the existing barriers between well-being institutions and less privileged institutions, and the underdeveloped institutions will definitely prosper, be in line with today's technological word, achieve educational objectives and subsequently increase the institution's rating all at a little or no cost. This paper carefully explored some of the situations where public cloud services could be applied in teaching and learning processes. Concrete examples on how to incorporate different cloud service models such as SaaS, PaaS and IaaS in teaching and learning processes were discussed.

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