An Overview of Cloud Solution Application in Education Process

Adamu.A

Senior Lecturer/Department of Mathematics and
Computer Science
Umaru Musa Yar'adua University, Katsina.
aminu@mail.ru

Abdu.H

Graduate Assistant/Department of Computer
Science
Federal University Lokoja, Kogi State
harunaabdumanis@gmail.com

Abstract **— To improve the quality of education in today's world, educational institutions must adopt modern IT facilities in teaching and learning activities. Unfortunately most of the existing IT infrastructures and their supporting software packages are very expensive, many learning institutions especially in the developing countries cannot afford to purchase and maintain them. Thanks to cloud computing technology which has recently surfaced and is set to revolutionize the education sector, many less privileged institutions can be able to enjoy the use of modern IT facilities in teaching and learning activities at a little or no cost.**

This paper explores some possible ways of adopting cloud computing services in teaching and learning activities. For each of the cloud service model, an example is provided on how it can be used in education process. Study of the cloud companies providing various cloud services for education was conducted.Advantages as well as the disadvantages of cloud adoption in education process is perspicuously explained, and some important recommendations are offered to educational institutions willing to adopt the cloud solution.

Index terms - Cloud Computing, Education Process, Infrastructure as a Service, Platform as a Service, Software as a Service.

I. INTRODUCTION

Nowadays without the use of modern IT facilities, no any educational establishment can function effectively, prosper and achieve the desired educational objectives. The use of modern IT 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 IT 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 IT professionals to operate and maintain the establishment's IT facilities.

Unfortunately many less privileged educational institutions especially in the developing countries cannot afford to purchase and maintain the expensive modern IT facilities for use in teaching and learning activities. 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 [1, 2, 3, and 4].Cloud computing is an Internet based computing where virtual shared servers provide computing resources such as storage space, software packages, hardware, platform for application development etc. to end-users on-demand and sometimes on pay per use basis [5, 6, 7]. In cloud computing, files, e-mails, applications and other vital educational information of any personnel (staff or student) involved in the educational processes are stored on the remote servers of the cloud service provider. And in this case educational institutions do not need to buy and to maintain highly expensive computing resources which in most cases are 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 cloud service provider and just an 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, like a Blackberry, Windows and Android Mobile Smartphones, or an iPhone), 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 information) and finally thick client (regular computer, using a web browser like Firefox or Internet Explorer to connect to the cloud) [8].

With cloud computing and continuous proliferation of the use of modern communication devices such as portable PCs, smartphones, touchscreen tablets, e-readers etc., among the students and teachers, 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). Currently there are numerous 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.

Reliability, availability, easy scalability, almost zero maintenance cost are some of the key advantages of cloud technology. Considering these advantages, some educational institutions have rushed to start using cloud services in their education process 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 IT-infrastructure 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 institution management to have a solid understanding of how cloud computing is evolving and the trends of its adoption in education process.

This paper focuses on exploring the possible ways of cloud solution adoption in teaching and learning activities. Section II of the paper provides a detail explanation on the cloud computing architecture and the cloud service models. Section III provides a comprehensive explanation of cloud solution application in education process, for each cloud service model, a concrete case of its use in education process would be provided. Section IV and V present the advantages and disadvantages of cloud solution adoption in education process respectively. Section VI offers recommendations for the choice of cloud service provider and finally, section VII gives out the conclusion on cloud solution adoption in education process.

II. CLOUD COMPUTING ARCHITECTURE AND ITS SERVICE MODELS

Cloud computing is an emerging computing paradigm that provides computation, storage and communication resources as service based on user's need in a scalable and virtualized manner. Cloud computing enables massive scale sharing, which allow users to access technology enabled services without the knowledge of, expertise with, or control over technology infrastructure that supports them [8].
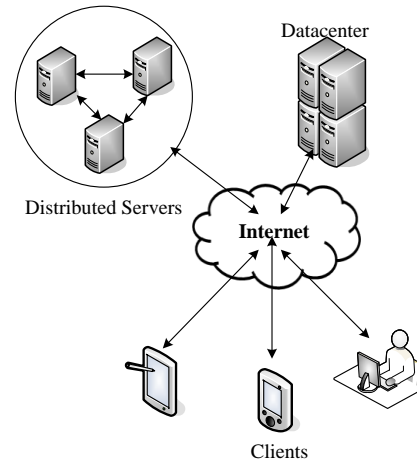

Figure 1. Cloud computing architecture

Generally cloud computing composes of three major components, namely: clients, datacenter and distributed servers (Figure 1).

Clients - clients are generally devices that end-users use to interact with and to manage their data on the cloud. Clients are of three types:

- *Mobile Clients* – mobile devices consist of personal digital assistants (PDAs), windows and android smartphones or an iPhone.

- *Thin Clients* – are essentially computers that have no internal memory/hard drives, they depend on server for computational tasks, and all they do is to display the computational results.

- *Thick Client*s – are just regular desktop computers with which users connect to the cloud using a web browser like Firefox or Internet explorer.

Datacenter - Datacenter is generally a collection of servers where the applications and resources to which a user subscribed to are stored. It could be a large room at the basement of the user's building or a room full of servers on the other side of the world that a user can access via the Internet.

Distributed Servers - Often servers are geographically located at different locations, instead of hosting them at only one location. But to the cloud subscriber, these servers act as if they are residing just next to each other. This provides more reliability and better security. For instance, Amazon, a cloud service provider company have their cloud servers all over the globe, if failure occurred at one server, the services would still be accessed through another server.

A. Classifications of Cloud Service Models

Traditionally cloud services are offered in three different models [5, 6, 7, 8], which are:

– Infrastructure as a Service (IaaS)

– Platform as a Service (PaaS)

– Software as a Service (SaaS)

Let's consider in detail each of the above cloud service models, since each one of them has a its targeted audience and a purpose, about which is necessary to have a precise knowledge of, before transiting from traditional IT paradigm to cloud computing.
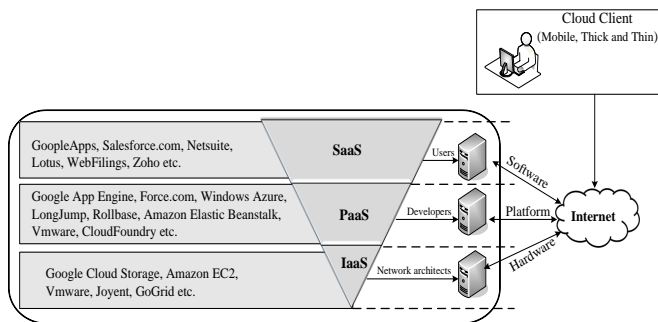

Figure 2. Cloud service models

On the Figure 2 above, a generalized scheme of the cloud service models is presented in a form of turned pyramid, which is divided into three layers, where the service models names are indicated at the centers of these layers. Upper layer of the turned pyramid contains all the features found at the layer beneath it. For instance, to provide the service "platform as a service", the service provider must be able to provide the service "infrastructure as a service".

On the left side of the turned pyramid, examples of the providers offering a service model are presented and on the right side of the pyramid the targeted end-users mostly use a service model are also shown.

Infrastructure as a service (SaaS): In this service model, a customer can independently create IT infrastructure on the cloud and control it in a virtualize form. For example, a user can create a virtual network, add virtual devices (e.g. server space, storage space, CPU cycles, memory, switches, routers and other network equipment) and install software packages as well as the operating systems necessary for the functionality of the constructed system. And this case an educational institution will use the cloud provider's machines as if it is using its real and traditionally owned IT-infrastructure.

Additionally, the infrastructure can dynamically scaled up or down based on the application resource need. The prevalent players in this service model are Amazon Elastic Compute Cloud (Amazon EC2) and GoGrid.

Platform as a service (PaaS): In this service model, cloud service provider offer all the resources required to build applications completely on the Internet without the need to purchase or download and install software packages. Examples of resources provided include, application design, tool for development, testing, deployment and hosting, operational systems, database control systems etc. Thus, a customer will have the means and tools for independent development, testing and exploiting of own software system. In this case, however, all informational infrastructures (e.g. server spaces, storage spaces and other network elements) are controlled by the PaaS service provider. Below are examples of somePaaS providers.

– Google Apps Engine (for development of software in Java and Python);

– Windows Azure (for ASP.NET and PHP);

– Cloud Foundry (Programming languages, Java, Ruby, Scala).

Software as a Service (SaaS): In this service model, customer is provided with readymade software package as service by SaaS providers. All data are stored on the cloud; a customer is only required to have a web-browser in order to have access to them. This type of service model is the most relevant and more attractive to educational institutions than the other service models described above, because it does not require extra cost for installation of a software systems as in the case of IaaS and PaaS. It is important to note that in the majority of cases charges are made based on the number of users using a software package in SaaS, and enterprise-licenses that allow any quantity of users to have access to particular software package without any restriction is not offered in SaaS. In SaaS costs for accessing the software can be an ongoing thing, the more a customer uses it, the more the charges. Examples of free of charge SaaS for educational institutions are Google Apps for Education and Microsoft Live@Edu services (Microsoft Office 365 for education) which are going to be discussed later in the paper. They comprise of all the functions found in Office Package (e.g. working with documents, tables and presentations), means of communication (e.g. E-mail, calendars, instant messaging etc.) as well as the effective means of information delivery (in the form of static presentations, video clips or interactive applications).

III. The Application of Cloud Computing 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. 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 for some educational institutions safety access to data is not a priority, 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 an IT infrastructure.

A. Teaching Programming Related Courses on the Cloud

A very important example of the use of cloud services in teaching and learning activities 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:

- Management and installation of IDE demand a highly qualified system administrator;

- 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 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 [13] 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 [14]. There are more examples of such service providers, e.g. Cloud9 IDE [15], CodeChef [16], etc.

B. The Use of Cloud Storage Services in Education Process

In this section let's explore the possibility of using cloud services for the storage of various types of data on the cloud as an example of the use of cloud service model (in this case IaaS) in teaching and learning processes. As an example let's consider the popular service Dropbox [17].

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

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

- *A free of charge storage capacity of two (2) and above GB*.

- *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.

- *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].

- *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.

- *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 ones 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 development of own local networked data storage system it is necessary:

- To purchase network and server equipment;

- To develop policies of storage and general access to information;

- To make initial installation and maintain the supporting software packages;

- 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;

- To employ highly qualified working personnel to manage the data storehouse.

The financial expenses to carry out the 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:

- 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);

- To purchase high efficiency RAID controller and server equipment,

- To pay the technologist and other personnel maintaining the system;

- To pay regular charges for the electric power consumed by the equipment involve in the system.

C. Registration for Cloud Storage Service

To start the use of cloud data storage service is very easy. For instance, Dropbox, for registration it is only required to specify login details, which consist of only functioning e-mail address and a new password. In order to have further access to the cloud only these details are needed.

Right after registration a Dropbox user is provided with a 2 GB free disk for data storage. However, having executed a series of simple actions, it is possible for one to increase the size of the provided free-of-charge storage space, to get an increment for instance, it is only required to recommend Dropbox services to friends or execute other actions of advertising character.

There are two (2) possible ways to access a cloud storage service: Through the web interface and through the client application. After registration a user is free to upload new file (doc files, video, pictures etc.) just by indicating the location of the file in the device where the file is stored. A user can conveniently organize the files and ease access to them as well as grant a general access to files by specifying who exactly should be given the right to read or write the stored files. And once a file is no more needed, it can be deleted from the cloud.

General instructions for educational institutions on the use of cloud storage system can be formulated as follows. First of all it is necessary to register all members involved in the educational process to the service, then to create general catalogues and provide registered users access to them. For instance, a lecture note of a particular course can be placed on the catalogue, whose access should be designed just to read and in some cases access can be granted to write. For each student it is possible to make an individual catalogue will full access for the delivery of lab works or assignments. This is an example of the use of cloud storage system for educational

purposes. It is possible to think of any other convenient scheme of data exchange using the cloud storage system by the educational institution.

D. Comparison of Some Cloud Storage Service Providers

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

Comparison of some free-of-charge cloud data storage service providers is provided in table 1.

Name	Free Disk spa-ce (GB)	Data Encryption Method	Supported Operating System	General Access	Collaborati-ve 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:

- Almost all the modern cloud storage services offer enough disk space for the storage of documents, teaching and learning materials;

- Almost all the providers use modern encryption algorithm for data transmission and storage;

- 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;

- 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);

- 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.

E. *Google Apps for Education*

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]. Google Apps for Education users 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 [19].

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, tool for collective and collaborative work, tools for effectiveness increase [10]. Let's consider each of these Google Apps tools categories in detail.

Tools for communication and planning

- E-mail Service (Gmail) with 25 GB mailbox for each student and each institution's registered employee;

- 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;

- 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

- Google Doc Service allows users to create and share text documents, tables, slides for presentation and to design a questionnaire;

- 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;

- Google Site Service provides an opportunity to develop a website for staff's and students' use;

- Google Groups for the creation of dispatch list and granting general access to documents, sites and calendars;

- Google Video Service provides an opportunity to use educational video materials in teaching and learning activities;

- 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;

- 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

- Google Service for the search of letters, messages and documents;

- 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.

- 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;

- Reliable data encryption and safe authentication are offered. All data transferred between Google servers and user device are encrypted using SSL protocol;

- High availability of services is provided. Google Company guarantees 99.9% of service availability;

- Google Company promised to secure the copyrights 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;

- 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:

- To register the educational institution;

- To tender an application for the connection to the Google Apps for Education services;

- To customize the GAFE as needed by the educational institution.

To register it is necessary to visit the link [20] 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. On an average license fee for the use of domain name is eight (8) 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.

F. Microsoft Live@Edu Services

Let's consider Microsoft Live@Edu (MLE) services provided to Educational institution by Microsoft, which is practically identical to GAFE services. Because of MLE and GAFE similarities in both approaches and principles, hence many details of MLE were already discussed in GAFE explanation above [11].

For 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 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 the help of 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) controllable outlook services in an online mode, e-mail services using the institution's preferred domain.

IV. ADVANTAGES OF CLOUD SOLUTION ADOPTION IN EDUCATION PROCESS

For cloud computing adoption we can extract the following key advantages.

On-demand self-service: A customer can independently choose the set of computing capabilities and resources for use (e.g., storage space, server space, network equipment, memory, CPU cycles etc.). However, a customer can scale up or down the resources as needed in an automatic mode without any human interaction or collaboration with the service provider. Cloud services are sometimes based on *pay per use mode*, i.e. customers pay only for actually consumed resources (e.g. the amount of transferred data, used bandwidth etc.)

Scalability of resources: Thanks to scalability, computing resources can easily be reduced or increased, based on the educational institution's need. In the case of high load on a service, the quantity of computing resources will promptly rise without significant preliminary investments, and if the load decreased, the resources will be reduced. The workloads dictate computing resources. If the educational institution will urgently need more computing resources, especially when the workload is at its peak (example, during academic session), the management does not need to spend time and monetary resources to purchase and install additional equipment and its related software package, which are afterwards rarely used or utilized by students or institution's staff. With local IT infrastructure, institution may unknowingly purchase under- or over-sized resources. Typically 50-90% of server capacity is unused.

Upgrades guarantee: The cloud service providers provide automatic update to IT equipment and the associated software in a centralized passion commensurate to the change in technology, this helps to ensure that all IT equipment and software packages are appropriate, relevant and up-to-date.

Cost savings: The use of cloud computing does not require capital expenses for creation and maintenance of own data processing centers, purchase of servers and network devices for the creation of own local IT infrastructure. Additionally, cloud computing eliminates operational expenses, since there is no need for the purchase and installation of expensive software packages, system updates, regular platforms, management skills, physical security for the premises where servers and other equipment are housed and payment of electricity charges for power consumed by equipment of the local IT infrastructure. All these expenses are shouldered by the cloud service provider.

Human resources savings: The main objective of any educational institution is to concentrate maximum effort on teaching, learning and researches. The use of cloud technology in an institution expunges the deployment of local IT infrastructure as explained above, subsequently the workload on technical personnel decreases or in other words, human resources are liberated, and as such they can be fully utilized in other important academic activities, rather than concentrating efforts on the local IT infrastructure.

Fault tolerance and high level of availability: Data-centers of cloud service providers are reliably networked together, where the participating nodes are strategically placed at various corners of the world. Fault-tolerance of such network is obviously above that of any local network, since it is designed with reiterative redundancy and the data-centers are under the control or serviced by highly qualified technical personnel. As a result, such distributed networks provide services with high level of availability. Many educational institutions cannot afford to establish such a distributed network system. Availability of most cloud services is around 99.5% (of all time), and some cloud service providers guarantee availability up to 99.9%. This make the cloud services more comfortable for teachers and students, because with high availability, the dream of learning anything, anywhere and anytime can become reality, without depending on the local educational resources of the institution. Besides that, constant availability removes the obstacles for distance learning, for instance in remote regions, where a time difference could affect the learning process or for people in remote communities, that cannot afford for transportation to the Institution. High availability of educational resources will favorably influence the rating of educational institution.

User satisfaction: Cloud technology offers more advantages to end users. It is very convenient when data are accessible from anyplace anytime using devices such as personal computers, smartphones or tablets; the only thing required is an access to Internet. Users do not need to bother themselves about data backup copies; data are safely stored on the cloud, since the cloud infrastructure guarantee the safety of data. Teachers and students do not need to purchase, install expensive educational software packages and update them regularly on their devices, everything is provided by the cloud service provider, the only thing required is, users to regularly update their web-browsers.

V. DISADVANTAGES OF CLOUD SOLUTION ADOPTION IN EDUCATION PROCESS

Data safety: Cloud computing had surfaced relatively recently, that is why some users have mistrust feelings towards it. Not every head of an IT-section will agree to outsource some of the organization's services or to handover some key data necessary for the functionality of the organization as well as confidential information of the organization to a third party. Many companies and organizations consider their data to be in greater safety if they are stored in a locally deployed and owned IT-infrastructure, where it is physically possible to see the storage device or other equipment which in one way or the other directly participates in data processing. It is quite difficult to some administrators to imagine a situation, whereby the confidential data of their organization are physically placed in data-centers located in other countries, which are perhaps parts of other continents.

Actually there is no special cause to worry about data safety on the cloud. Data are usually encrypted while they are being transported in an open communication medium. Additionally, before signing a contract with the cloud service provider, there must be an agreement on nondisclosure of confidential data. The user (a student or staff of an educational institution) has the right to take a legal action against the cloud service provider in case of confidentiality violation or when a loss of data occurred, which can lead to a huge legal cost and strong damage to the provider's reputation. That is why in the current condition of modern market competition, each cloud service provider tries to use best efforts to guarantee integrity and safety of data.

Dependency: Again another one more serious risk is sticking to a particular cloud service provider. Costs of migration from locally deployed IT-infrastructure to the cloud are quite significant, if for the instance the cloud service provider ceased to satisfy the needs of an educational institution for one reason or the other, or if the charges for the services provided are increased, or if new service providers with high quality and cheap services emerged etc., to switch to another service provider will cost a lot and the process will last for a long time. That is why it is very necessary to carefully and responsibly choose cloud service provider from the very beginning.

Excessive security measures: Cloud service providers reserve the right to block the delivery of any type message if it is necessary for the protection of services or its clients. Cloud service providers treats the right of blocking e-mails essentially more widely, for example, any letter which the provider counts as a threat could be blocked for the protection of its clients. Unfortunately such strict spam detection method can lead to the blockage of practically many non-spam user e-mails. Although in practice, blockage of e-mails is connected in a greater extent to spam-message filtration, as such the educational institutions should note that using cloud mail server, any e-mail could potentially be blocked, which couldn't have been the case if the traditional e-mail server is used in the educational institution.

Undesirable advertisements: According to the agreement for the provision of cloud services by some providers to educational institutions, the service providers reserve the exclusive right to sale and accommodate advertisements in the services offered, and the institution itself has no right to do so. The advertisement could be graphical (advertisement banners), textual (a running line) or in video and audio form. Though as stated in the agreement, the advertisements are for different type of provider's products as well as for the services the provider offers.

Collection of service data: At times cloud service providers can automatically compile, use and disclose some data from the user's device in order to analyze the performance of their services (if such disclosure will not lead to the identification of the user identity). Usually these sorts of information are not confidential; therefore such disclosure will not pose any risk to the user.

Confidentiality of Information: While transferring personal data outside the limit of the country where the educational institution is located i.e. to a third country, cloud service providers must observe the Safe Harbour Privacy Principles [21], with respect to collection, use and storage of data received from other countries. Additionally, all personal data of any user from the educational institution are protected in accordance with the 95/46/EC directives of European Parliament and the Council of the European Union [22]. If such policy of data processing mismatches the institution's data security and privacy requirements, then it is necessary to consider such policy as one of the essential risks for cloud adoption.

Apart from the use of the stated above directives, without any written agreement, cloud service providers are not legally allowed in any way to use educational institution's confidential information within the period of five years after its reception, except for the realization of mutual business relations. Also cloud service providers are not legally allowed to disclose any confidential information of an educational institution except for the cases, where there is a need for the providers to receive advices from legal or financial advisers or such information is demanded by law enforcement agency.

Cloud service providers must notify the educational institution on the detection of any unauthorized access or disclosure of institution's confidential information, and must take all the necessary measures to secure back the institution's confidential information from the other party and to prevent the further occurrence of such unauthorized access.

The disclosure of end user's personal information (including the contents of received or sent messages) can occur in the following cases:

– For granting answers to judicial inquiries or fulfilling the requirements of judicial bodies.

– For the protection of the rights or the property of the company and its clients.

– For the protection of the company's employees, its clients or other persons.

The above explained policies on processing and transfer of confidential data indicate the level of security for institution's confidential information is very low, which can essentially affect the decision on the use of cloud services.

VI. RECOMMENDATIONS FOR THE CHOICE OF CLOUD SERVICE PROVIDER

Certain aspects are very essential to consider before adopting the cloud solution, in this section, some very important criteria are recommended for consideration before the total migration to cloud.

Functionality: Before choosing a cloud service provider it is important to consider the user requirements and the possibilities of using other programmes while working on the cloud. For instance, for office packages the need will be to list all the supported formats and their compatibility with other cloud and non-cloud applications, possibility of their export to other formats. It is also important to assess the maximum storage capacity offered to each user. Additionally, it is necessary to analyze additional functionalities of the applications offered by the service providers, which will add "zest" to their usage in teaching and learning activities (such as ability to send a notification message on the time shift for forthcoming examination or lecture to all the students instantly etc.)

Platform: Nowadays web-browsers developers are doing their best to make sure that web-page contents are displayed correctly regardless of the kind of operating system used by a concrete user. But nevertheless the educational institution should give a special attention on the choice of basic platform, it is especially important for all the users to adopt the platform recommended by cloud service provider in order to enjoy high level functionality e.g. to recommend users to install and use a specific operating system recommended by a service provider in order to ensure better compatibility and high response speed.

Testing technical features and simplicity of the system: Before totally transferring working processes on to the cloud, it is required to test the technical features of the system by conducting some routine actions on an automation mode. It is important however, before choosing a cloud service provider to consider how friendly the system is to users. User friendly interface will allow users to carry out a task before them more effectively. Many cloud service providers give free of charge test period, hence it is recommended to organize a control group consisting teachers and students, which would test the comfort and simplicity of the use of the system. People with disabilities may perhaps be among the users of the chosen system, therefore they must be taken into consideration while testing simplicity.

Contract agreement: It is necessary to analyze the terms and conditions given by the provider in the contract agreement. Special attention should be given to the following items: validity of the contract; penalties for early termination of the contract; possibility of migrating data to external sources or systems; initial and subsequent charges for the services. In accordance with the service level agreement, there must be a specified compensation in the case of failures while using the system. It is however important to assess the scope of the guarantee, especially for the cases where the services are provided free of charge. Before adopting such services it is recommended to know the opinion of other users, who have already been using the services of the provider on the effectiveness and reliability of the services. Even though cloud services are very easy to use, it is very important to consider the possibility of rendering technical support in certain situations, in such cases it may appear more favorable to order for a paid technical support from the cloud service provider, than to outsource technical supports locally.

Charges: While planning budget for migration to cloud it is necessary to estimate and consider not only the charges of the cloud services, but also to estimate and consider all the accompanying expenses, which could be expenses related to management of the project, coordination and technical realization of the project, various legal consultation associated to the contract conclusion, works on initial training of users on how to work with the system etc.

VII. 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 sound and 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. Cloud computing as a new trend in communication and collaboration technologies is set to revolutionize the education sector all over the globe by providing modern educational tools which promote exchanges of knowledge and ideas, group works, interschool projects etc., at a little or no cost. Many companies are providing such modern educational tools applicable in teaching and learning activities 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 world, achieve educational objectives and subsequently increase the institution's rating all at a little or no cost.

This paper carefully explored some situations where cloud services are applicable in teaching and learning activities. Examples on how to incorporate different cloud service models such as SaaS, PaaS and IaaS in teaching and learning activities were provided. To ensure proper and effective cloud solution adoption, recommendations were provided to institutions planning to adopt the cloud solution.

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Authors Profile
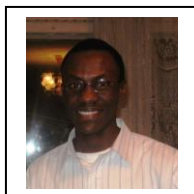
AdamuAminu received a **B.Sc.** Degree in Mathematics and Computer Science in 2007 and **M.Sc.** Degree in Applied Mathematics and Informatics from Peoples' Friendship University of Russiain 2009. He receivedhis**Ph.D.**in Theoretical Computer Science from Peoples' Friendship University of Russiain 2012. His research interest includes P2P networks, cloud computing, video streaming systems, and performance analysis of computer and communication systems.

Abdu Haruna received a**B.Sc.** Degree in Computer Science from Umaru Musa Yar'adua University, Katsina, Nigeria, in 2011.Currently undertaking his**M.Sc.** programmein Computer Scienceat Umaru Musa Yar'adua University, Katsina, Nigeria. His research interest includes cloud computing, analysis of computer and network systems.