International Journal of Database Theory and Application
Vol. 11, No.3 (2018), pp. 29-38
hhtp://dx.doi.org/10.14257/ijdta.2018.11.3.03

Using Cloud Computing for Managing Data in Chemistry Education Laboratories

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Abstract

Cloud computing have a significant effect on the management of data in Chemistry Education laboratories. Therefore, to promote the data management in chemistry education laboratories, there is need for adoption and integration of cloud computing system. Such system will enable chemistry education student, lectures and laboratory technologist access any form of information from anywhere, using any type of device. This paper discusses, among others, the potential benefits of using cloud computing in managing data in Chemistry Education laboratories of Nigerian Universities. It was found that cloud provides the opportunity of flexibility and adaptability to use the computing resources on-demand. Application of cloud computing in laboratory data management creates numerous advantages for universities. Notwithstanding, various challenges are associated with the use of cloud computing in managing data in chemistry education laboratories. Some of the challenges are discussed in the paper and recommendations on proper use of cloud computing are offered.

Keywords: *Cloud computing technology, managing data, chemistry education laboratories*

1. Introduction

There is significant difficulty often encountered in managing data in chemistry education laboratories because the laboratories are yet to develop efficient data management systems for data generated by a number of students (Jacqueline & Harry, 2011). However, cloud computing seems to offer solution to this problem. According to Jacqueline and Harry (2011), cloud computing offers a solution to data-management problem and allows researchers to coordinate their efforts easily whether they are operating in the same laboratory or different laboratories around the globe.

Of recent, cloud computing have become an important term in the world of Information Technology (IT) (Ercan, 2010; Bulla *et al.*, 2016) with significant impact in teaching and learning (Ercan, 2010). Cloud computing is highly scalable and it is characterized by mobility as well as independency of the platform (Ercan, 2010; Almajalid, 2017). This implies that it can be accessed from anywhere, anytime and from any device since it uses virtualized resources that can be shared by the users. Hayes (2008) pointed out that users of cloud computing do not need any background knowledge of the services. For instance, a user on the Internet can communicate with many servers at the same time and these servers exchange information among themselves.

Cloud provides the opportunity of flexibility and adaptability to use the computing resources on-demand. Contrary to having only one service provider, different providers use different interfaces to their compute resources utilizing varied architectures and implementation technologies for customers. Although this creates a management problem, a common architecture facilitates the management of compute resources from different

Received (April 15, 2018), Review Result (July 6, 2018), Accepted (July 21, 2018)

ISSN: 2005-4270 IJDTA

Cloud providers in a homogenous manner (Dodda *et al.*, 2009), University management should identify and leverage emerging technologies that are cost-effective, and strive for the broadest feasible and equitable access to technology for students and staff.

Today's "cloud" platforms such as "Microsoft" and "Google" are providing free services to students and staff at educational institutions through email, contact lists, calendars, document storage, creation and sharing documents and websites (Sclater, 2009). Cloud computing as an exciting development is a significant alternative in today's educational perspective. Students and administrative personnel have the opportunity to quickly and economically access various application platforms and resources through the web pages on-demand. This automatically reduces the cost of organizational expenses and offers more powerful functional capabilities (Ercan, 2010). The impact of cloud computing in education has gained awareness to many researchers and countries (Masud & Huang, 2012).

Thus, it is imperative that educational research laboratories get better ways to provide inexpensive quality data management using academic tools and research practices by striking a balance between cloud and on-premise services (Almajalid, 2017). Application of cloud computing in chemistry education laboratory data management and for other academic purposes creates numerous advantages for the colleges and universities. Firstly, it is cost-effective for them, considering the fact that they may be on a tight budget. Secondly, it has a positive impact on the educational experiences of the researchers who are involved in it. In addition, cloud computing increases the productivity of the IT staff. Cloud computing at its core is a technology that uses the Internet and central remote storage and processing servers to support user applications and data (Bulla *et al.*, 2016).

Despite the many benefits associated with cloud computing, it also has various disadvantages that emanate from the fact that all applications and data are situated within the internet (Almajalid, 2017). The cloud computing services needed to deliver the majority of IT services needed by Chemistry Education laboratories do not yet exist. There are still problems and constraints with application offerings, service-level agreements, more importantly security issues. All of the cloud providers do not have the same capability for their technological levels (Ercan, 2010). Hitherto, the potential benefits of cloud computing for data management in Nigerian Universities Chemistry Education laboratories could not be over emphasized and are vividly discussed in this paper.

2. Cloud Computing

The name cloud computing was inspired by the cloud symbol that is often used to represent the Internet in flow charts and diagrams (Voas & Jia, 2009). Cloud computing can be defined as the use of virtual resources that are highly scalable and can be shared by different and diverse users. Cloud computing can be termed as providing information technology resources when demanded through the Internet. Cloud Computing can be simply defined as a pool of computing resources that are delivered through the web. Thus, the end user is able to access all these elements using the internet. Despite the series of definitions, it is evident that the term refers to a super computing model that is internet-based. Cloud computing was driven by the increased use of electronic devices including laptops, smart phones and tablet PCs. Current studies have indicated that this is among the fastest growing areas within the digital economy (Almajalid, 2017). Cloud computing allows consumers to use applications without installation and access their personal files at any computer with Internet access. This technology is used for more efficient computing by centralizing storage, memory, processing and bandwidth. The user does not require knowledge or expertise to control the infrastructure of clouds; it provides only abstraction. It can be utilized as a service of an Internet with high scalability, higher throughput, quality of service and high computing power (Bala, 2010).

The fact that cloud computing has evolved over time has provided enormous and versatile amount of resources that are scalable in nature depending on the needs of business in addition to serving large interests for potential, as well as immediate returns on the investments. By tapping into right cloud capabilities, companies can quickly enter new markets or launch new services in existing markets. As demand grows, they can quickly scale up. Conversely, when opportunities dry up, they can scale down with minimum waste of time and capital (Were, 2013). By incorporating cloud computing in the IT strategy, institutions are able to increase their overall capacity while at the same time maintaining the required security level and limited infrastructural investment, hence ensuring that the total cost of ownership (TCO) is low (Almajalid, 2017).

Managing data in Internet based computing is a critical issue in today's IT world particularly in public clouds in which resources are made available over the internet by third party. All information resides in clouds; whenever client needs they can access data. Security must be provided in accessing database, resources and programs from cloud computing environment for customer satisfaction (Bala, 2010).

3. Development of Cloud Computing

To build efficient web based application cloud infrastructure should follow the following steps (Service Level Agreement and Master Service Agreement, 2009):

1. Selection of technology
2. Determine application infrastructure
3. Prepare network infrastructure
4. Provide visibility and automation of management tasks
5. Integration

The developer should decide which technology will be perfectly suitable for their on-demand application infrastructure. They should also resolve application infrastructure which is to be used to make efficient use of resources and ensure scalability. Other methods of load balancing/application delivery also are considered. It also provides visibility into application capacity, performance as well as resource management. Subsequently select network infrastructure to deal with an on-demand application infrastructure. In addition, it should provide visibility and automation of management tasks. Visibility is a key to an on-demand infrastructure. An associated management systems and the infrastructure must know what is running, when and where to evaluate available resources. Finally integrate all the moving parts, such that the infrastructure and realizes the benefits of automation, abstraction and resource sharing. The integration, automation of all the pieces of the infrastructure like storage, network, and application enables the infrastructure to act on-demand. The realization of cost-reduction benefits will be marginalized without automation (Service Level Agreement and Master Service Agreement, 2009). The integration process automates workflow. Automation tasks monitor the application infrastructure from the network layer to the applications executing in the environment constantly (Bala, 2010).

4. Features of Cloud Computing

Cloud computing has been so successful because of its simplicity when it comes to its usage, as well as the several other advantages that accrue from its use. It is a cost effective solution for enterprises when it comes computing operations. Cloud computing is characterized by various features including (Almajalid, 2017);

1. Optimal Server utilization: Cloud computing ensures that servers are optimally utilized.

2. On-demand cloud services: ensure that the customer is furnished with a tailor-made environment that is customized according to the needs of the client.

3. Dynamic Scalability: Cloud computing is a source of an additional processing buffer with no extra capital investment by the users.

4. Disaster Recovery: This is one of the core feature associated with cloud computing. It mitigates the need of comprehensive disaster recovery plans for the information technology infrastructure. It ensures faster recovery and information is available in multiple sites hence making it more efficient and effective.

5. Virtualization technology: Virtualization is considered to be the most essential cloud computing feature. This means that the computing elements are not real; rather, they are of a virtual nature. It is possible for the virtualization technology to expand the hardware capacity thus simplifying the reconfiguration process of the software. The virtualization technology ensures that the platform can run several operating systems, with each application running independently as a result of the single CPU simulation of multi parallel CPUs.

5. Benefits of Cloud Computing

In essence, according to (Bulla *et al.*, 2016), the top five benefits of cloud are as follows:

1. Achieve Economies of Scale: Increase volume output or productivity with fewer resources (computing and human).

2. Reduce CapEx by moving to OpEx: The pay as you go model (weekly, quarterly or yearly), based on demand / utility computing, will help reduce capital expenditure on hardware and software licenses.

3. Improve Access: Information access can be anytime, anywhere and anyhow through omni channel access.

4. Implement agile development at low cost: Design, development and rollout of new solutions and services using agile methodologies on cloud based shared development operations.

5. Leverage global workforce. Follow-the-sun model for defining, developing and rolling out new solutions and applications.

6. Benefits of Cloud Computing in Education System

Cloud computing is a significant alternative for today's education environment. The benefits to educational system include (Bulla *et al.*, 2016);

1. Universities can open their technology infrastructures to business and industries for research advancements.

2. The efficiencies of cloud computing can help universities keep pace with ever-growing resources requirements and energy cost.

3. The extended reach of cloud computing enables institutions to teach students in new, different ways and help them manage projects and massive workloads.

4. When students enter the global workforce they will better understand the value of new technologies.

5. The cloud computing release the institutions from data management, ensures that the users always have the newest documents and reduces the requirements and costs associated with data security.

6. It offers a range of online tools and services that provide secure communication and collaboration capabilities.

7. Cloud computing allows both the teachers and the students to access, share and publish documents, class calendars or web pages.

8. The problems like low graduation rates, insufficient infrastructure, tiny classrooms, lack of teachers can be solved using Cloud computing solutions.

9. Geographical distances will not be any hindrances in the education system.

10. Institutions not having ample infrastructure will also be able to provide quality education as there is no need to purchase hardware, software licenses, or implementation services.

11. Education can be easily democratized as organization can deploy cloud computing rapidly.

12. Maintenance and upgrades will be lot more easier. The cloud model provides the ability to rapidly acquire, provision, and deploy new IT platforms, services, applications, and test environments. With cloud capabilities, months-long IT hardware procurement processes can be eliminated, reducing time spent on such tasks to a matter of hours or even minutes.

13. Cost is reduced as institutions reduce or eliminate IT capital expenditures and decrease ongoing operating expenses by paying only for the services they use (pay-as-you go plan or a subscription) and potentially by reducing or redeploying IT staff.

14. Availability of the services is 24/7 as desired by the user using an education cloud.

15. Accessibility is good as data and services are publicly available.

16. Education cloud will surely decrease the carbon footprint and we can move towards Going Green project.

17. Education cloud is user friendly and can effectively manage large amounts of data.

7. Data Management in Chemistry Education Laboratories through Cloud Computing

These days, most of the communications take place through the Internet. Particularly, in today's society, Internet has become a very important learning tool. It is used for day-today activities, such as a place to look up research, a method of getting in touch with friends and family, and somewhere to go to find information about almost anything imaginable (Bala, 2010). The internet has played a very vital role in the betterment. The internet is a very valuable resource when it comes to Chemistry Education laboratory research, but it is not limited to that area. The evolving demands of the global economy make laboratory data management vital to sustainable social and economic success. Cloud computing appears to be a correct choice for providing flexibility for all data management in Chemistry Education laboratory. Thus, the use of cloud computing can support Chemistry Education laboratories to resolve some of the common challenges like reduction of cost and provide flexibility and accessibility.

In using cloud computing for data management in chemistry education laboratory, the developer should provide the following services for effectiveness and enrichment of education (Bala, 2010).

i. Infrastructure as a Service: Chemistry Education laboratories can utilize on-demand computing and storage to host, scale, and manage data for entire institution or individual departments within it, globally or locally.

ii. Platform as a Service: It consists of an operating system, a fully relational database, claims-based access controller which provides security-enhanced connectivity and federated access for on-premise applications. It provides on-demand scalability, and reduced time to market for Chemistry Education laboratory data.

iii. Software as a Service: It provides collaboration and online communication between students and staff without any cost of the education institution. It should deliver security-enhanced data, hosted communication and collaboration tools. It must help the laboratories to protect itself from spam and malware, encrypt data to preserve confidentiality, and maintain access to e-mail during and after emergency situations. Furthermore, it should help automate workflows and centralize information.

In addition, the following are the benefits of cloud computing in Chemistry education laboratories:

1. Low-Cost and Free Technology: cloud computing is cost effective thus efficient where the resources are minimal. Hence, there will be a huge growth in low-cost and free technology for data management, content creation, computing, editing, social interaction, publishing, collaborating, *etc*. Also, Cloud computing allows Customers (Chemistry Education laboratories) to pay for only few things including what they use like the processing time, memory and the bandwidth, hence making it cheaper (Almajalid, 2017). Additionally, Cloud computing implementation has been found to be cost-effective as it helps organizations to eliminate the cost of buying, installing, maintaining, and upgrading hardware and software (Akande, 2004).

2. Content Growth: The amount of content such as analyzed data, results and findings, will grow at an exponential rate, available to a broad audience, and anyone will be able to contribute.

3. Collaboration: Technology is rapidly improving the ability to communicate and collaborate with others. Thus, it will improve the ability to communicate and share data and resources among Chemistry Education laboratories (Bala, 2010).

4. Elimination of Disaster Recovery Risk: Adopting cloud network redundancy eliminates disaster recovery risks and its high costs in Chemistry Education laboratories. There can always be new tools and applications to improve IT features (Ercan, 2010).

5. Accessibility and Availability: Not only does cloud computing provide teachers and students with free access to different services and applications within the cloud for both informal and formal use in the education sector, but it also provides greater mobility and flexibility when it comes to the utilization of resources and creates a learning environment that is personalized or rather virtual teaching and learning (Almajalid, 2017). Thus, Students increasingly dependent on online services for learning and assessment are given the best possible availability through the use of cloud computing in Chemistry Education laboratories (Isaila, 2014).

6. Increased productivity of personnel: the chemistry education laboratory staffs and students will derive a positive experience from its use. Additionally, the laboratory IT staffs productivity will increase through the use of cloud computing (Almajalid, 2017).

7. Scalability and Elasticity: The infrastructure of cloud computing is very scalable. Cloud providers can add new nodes and servers to cloud with minor modifications to cloud infrastructure and software. This will enable Chemistry Education laboratories to quickly scale their operations - scaling up and down hardware, network capacity, and cost based on demand. Provisioning of new resources, data and software applications can be delivered at a pace that does not hold back the rest of the activities (El-Alfi *et al.*, 2016).

8. Centralization of Data Storage: The cloud provides much storage recourses than that available in local, corporate computing systems. Moreover, there is flexibility in increasing or decreasing these cloud storage resources according to operating cost adjustments. This form of centralization of storage infrastructure results in cost efficiencies in utilities, trained personnel. In addition, it will be much easier to implement and monitor data protection schemes in a centralized system than on large numbers of computing platforms (Dahshan, 2014).

Beyond the benefits of cloud computing in managing data in Chemistry Education laboratory, mentioned above, it can be added that, cloud computing provides value that is dissimilar to the traditional IT environment. It offers economies of scale through aggregating computing resources and virtualization. Cloud computing ensures a global reach of information and services using a computing environment which allows on-demand scalability and minimal initial investment. It can also provide pre-built services and solutions together with the required skills for running and maintaining them, hence reducing the risk and need for the institution to maintain a group of staff that is highly skilled and scarce to find. As for the end-users, they do not have to purchase new equipment or maintain hardware, upgrade or update existing software, obtain licenses for the software or data synchronization since the clouds service includes all of them (Almajalid, 2017).

8. Challenges

The following reason will impede the successful application of Cloud computting technology in Chemistry Education laboratory:

1. Data Security and Privacy: The fact that cloud computing introduces a third party due to outsource essential services will make it difficult to maintain data integrity and privacy in the laboratory. This is the top most concern of most users as they will not know exactly where their data are going to be stored and who would have the privilege to access it inside the cloud infrastructure, and how the safety and integrity of their data can be guaranteed (Alwi *et al.*, 2010ab; Gustafsson & Orrgren, 2012).

2. Real Benefits: The potential benefits of this technology in the chemistry education laboratory are yet to be appreciated by the management of these laboratories. The main concern is how to realize the full potential and make cloud part of the mainstream IT portfolio of chemistry education laboratories. Chemistry education laboratories need to be aware of the real benefits of cloud computing rather than the seeing the potential of cloud computing to add value. There should be indicators to compare availability, performance versus costs benefits and utilization (Bulla *et al.*, 2016).

3. Service Quality and Availability: Service quality is one of the crucial factors that the educational customers of cloud computing technology cite as a core value for not moving their applications to cloud. Outages of a service become a major worry when customers have deposited all their information in the cloud and might need it at any time. Given that the customer management interfaces of public clouds are accessible via Internet, there is an increased risk of failure when compared to traditional services since there are more weak points in the chain of elements needed to access the information or application (Delgado, 2010; Bulla *et al.*, 2016).

4. Performance/Insufficient responsiveness over network: Delivery of complex services through the network is undoubtedly impossible if the network bandwidth is not suitable. Most of the Chemistry Education laboratories do not have enough bandwidth and are

waiting for improved bandwidth and lower costs before they consider moving into the cloud since many cloud applications are still too bandwidth intensive (Bulla et al., 2016).
5. Integration: Many applications have complex integration needs to connect to other cloud applications as well as other on-premise applications. These include integrating existing cloud applications with existing university systems and data structures. There is a need to connect the cloud application with the rest of the university systems in a simple, quick and cost effective way (Bulla *et al.*, 2016).

6. Data Location: The geographic location of the data matters in some cases. Knowing data's location is fundamental to securing it, as there might be important differences between regulatory policies in different countries. Customer could be involved in illegal practices without even noticing, as some governments prosecute companies that allow certain types of data to cross geographical boundaries (Delgado, 2010).

7. Data Lock-in: Lock-in means that the data is locked to a certain Cloud Service Provider (CSP) because there are no standards followed in data formats or in services interfaces that could guarantee data portability. This make the customer migration from one provider to another or migration of data and services back to an in-house IT environment a difficult task (Dahshan, 2014).

9. Recommendation

Elasticity, pay as you go model of payment, and use of commodity hardware in a large scale to exploit the economies of scale are the primary reasons for the success of the cloud computing in Educational institutions. Therefore, for sustainable success of cloud computing technology in Chemistry Education Laboratories in Nigerian Universities, the design of a scalable and elastic system that can provide data management as a service is imperative. This system should efficiently and effectively run on commodity hardware, while using the elasticity of the cloud to deal with the erratic workloads of modern applications in the cloud, and provide varying degrees of consistency and availability guarantees as per the application requirements. The spectrum of data management systems has the scalable key value stores on one end, and flexible, transactional, but not so scalable database systems on the other end. Hence, efficient data management should be provided to the wide variety of applications in the cloud by bridging this gap with systems that can provide varying degrees of consistency and scalability.

10. Conclusion

The adoption of cloud computing will enrich the efficiency of effective data management in Chemistry Education laboratories in Nigerian Universities and other Universities around the globe, and importantly, reduce the budget impact in academic institutions. Cloud computing students and lectures can access any form of information from anywhere, using any type of device. Thus, all Chemistry Education laboratories in Nigerian Universities and other institutions can adopt this type of technology for data management as a way of providing improved services using the few resources at their disposal. The efficiencies of cloud computing can help chemistry education laboratories keep pace with the ever-growing resources, so new cloud-based solutions had to be thought of, to allow maximum efficiency and utilization of resources and the same time to be economically viable. Likewise, substitute methods must be developed to enhance laboratory data management systems' architecture with cloud computing technologies.

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