Cloud Computing: Empirical Studies in Higher Education

A Literature Review

Abusfian Elgelany
Faculty of Computer Studies & Information Technology
Garden City University
Khartoum - Sudan

Weam Gaoud Alghabban
Computer Science Department
Dhiba University College, University of Tabuk
Saudi Arabia

***Abstract*—The advent of cloud computing (CC) in recent years has attracted substantial interest from various institutions, especially higher education institutions, which wish to consider the advantages of its features. Many universities have migrated from traditional forms of teaching to electronic learning services, and they rely upon information and communication technology services. The usage of CC in educational environments provides many benefits, such as low-cost services for academics and students. The expanded use of CC comes with significant adoption challenges. Understanding the position of higher education institutions with respect to CC adoption is an essential research area. This paper investigated the current state of CC adoption in the higher education sector in order to enrich the research in this area of interest. Existing limitations and knowledge gaps in current empirical studies are identified. Moreover, suggested areas for further researches will be highlighted for the benefit of other researchers who are interesting in this topic. These researches encourage institutions of education especially in higher education to adopted cloud computing technology.**

Keywords*—Cloud computing; education system; e-learning; information and communication technology (ICT)

I. Introduction

Education plays a prime role in society's life. One of the most promising paradigms for education is electronic learning (e-learning). E-learning can be defined as "All forms of electronically supported learning and teaching, which are procedural in character and aim to affect the construction of knowledge with reference to individual experience, practice, and knowledge of the learner. Information and communication systems, whether networked or not, serve as specific media (specific in the sense elaborated previously) to implement the learning process" [1]. In recent decades, there has been substantial interest in e-learning from many people in the field of educational, especially from those in the higher education sector [2]. Higher education institutions (HEIs) play a considerable role in the development of societies. With the evolution of technology, many universities have migrated from traditional forms of teaching to online "e-learning" services, and they rely upon information and communication technology (ICT) services to do so. To support e-learning, these educational institutions must have an adequate IT infrastructure and massive investment, which is difficult to acquire in times of profound recession. In fact, some universities already face difficulties in providing different IT services for their academics and students [3].

Currently, cloud computing (CC) technology has an attractive proposition for educational environments [4], as shown in Fig. 1 [5], and it presents a promising solution to the challenges associated with reducing IT costs [6]. Currently, the use of cloud-based applications is increasing among HEIs [4]. One recent study of CC reported that in 2012, 43% of HEIs have implemented CC technology [7]. This percentage represents a 10% increase from 2011 poll data, and it is expected to continue rising over the next few years.

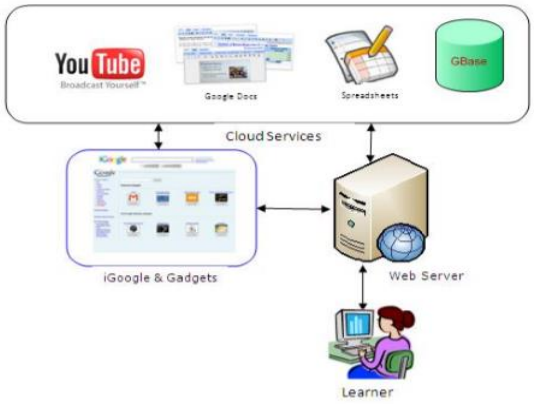

Fig. 1. Cloud-based e-learning system [5].

Today's students access the Internet constantly, and they explore the world through the Internet [6]. By accessing different programs, such as Twitter, Facebook, and Gmail, these students already are consumers of CC technologies [8]. Accordingly, [9] it has been demonstrated that CC solutions have become very attractive in supporting collaborative learning and have been incorporated in social theories of education, especially in higher education. As a result, HEIs administrators, either globally or locally, are asking IT staff to implement CC strategies, thus driving the trend of the higher education sector's increased adoption of CC [6]. Some benefits of CC for HEIs over traditional technologies are mobility, efficiency [6], economics, enhanced availability [10], increased productivity, scalability, and penetration of knowledge all over the world [11]. Moreover, common goals for CC include developing IT infrastructure in HEIs and increasing the access

of university staff and students to a wider range of learning resources [12].

Therefore, the researchers are motivated to investigate the current state of the art of CC adoption in the higher education sector. The key contribution of this paper is identifying and exploring the current existing limitations and challenges identified in current empirical studies to enrich the research in this hot topic; this paper also aims to suggest areas for further investigation. This research can better inform other researchers who are interested in CC implementation in the field of higher education. Additionally, the gaps in the existing body of knowledge are highlighted. These gaps suggest essential areas of focus for future research on CC adoption in higher education.

The paper is organized as follows. Section II presents an overview about CC. Section III presents the research methodology. Section IV reports and discusses the results in depth. Section V presents conclusions from the review.

II. Cloud Computing

Over the last half century, CC has rapidly emerged as new computing technology, which evolved as a result of the advances in ICT [13], [14]. The term "cloud" was inspired from the "cloud" symbol that is typically used to symbolize the Internet in computer network diagrams [15].

Currently, it is hard to define CC, as there are many debates by researchers about the standard definition for it. While the discussions for the final definition continue to evolve, there are some characteristics of CC seem to be common to the most of its definitions in the literature. The National Institute of Standards and Technology (NIST) defines CC as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [16]. In [17], CC is referred to as a new operation rather than a new technology. Moreover, CC is defined as a convergence of utility computing, grid computing, and Software as a Service (SaaS) [18].

A. Cloud Service Models

Based on [19], CC model is composed of three main service models, as shown below in Fig. 2, which are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). The SaaS model of CC allows the user to use and access the software through the Internet for a low price, almost free. Thus, the CC allows the user to use specific applications without needing to install and run the application on the user's machine [19].

PaaS model of CC provides the consumer the development environment of a computing platform for building, testing, deploying and delivering applications or any other services through the cloud [20]. The IaaS cloud technology model provides the customers the required resources as a service from the cloud. These resources include processing, networks, storage and other computing resources that allow clients to deploy and run the software. Hence, the clients do not need to purchase the required resources; they only need to pay for the duration for which they use the provided services [21].

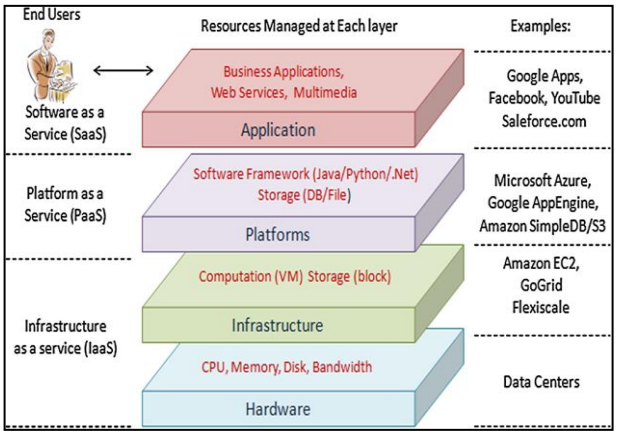

Fig. 2. Cloud computing services [20].

B. Cloud Computing Technology for Education

The advantages that CC technology can provide to academics and students make it an attractive option in higher education. One advantage to the users of CC of is the availability and ease of access using their mobile devices, university equipment, or any combination of these options at anytime and anywhere they find most beneficial. Another distinct advantage is the ability to share, process, edit, and store huge amount of data within educational environments.

One of the key characteristics of CC is an economy of scale [22]. This feature implies that cloud services can be delivered at a lower cost compared to in-house networks and computer infrastructure that is provided by educational institutions. Additionally, applying IT tools could allow access to resources globally, resulting in an increased learning quality [22]. Moreover, the use of CC could reduce the cost of resources and make education sustainability easy.

Currently, according to [23], education needs a new generation of academic staff, and students are different from their ancestors. As a result, students prefer the increased usage of new technology and applications. The CC application can benefit the students by enabling them with quick connections with each other and to the core of educational materials. CC provides the HEIs with the following benefits: 1) facilitate interactive learning; 2) the availability of huge amount of processing power; 3) no need for backup; and 4) provide a digital education environment and web-based services for academic staff and students [4]. For these valuable features, currently, all universities are transitioning to cloud-based applications.

III. Research Methodology

The search process includes reviewing various publications in some leading digital libraries such as IEEE Xplore, ScienceDirect, and SpringerLink published between 2014 and 2017. The researchers chose these years to determine the existing gaps in adopting CC in the higher education field. The researchers include empirical studies that discussed CC in

higher education. The basic focus is to identify whether HEIs have adopted CC in their education management and systems.

A. Education System based on Cloud Computing

Education is fundamental to the nation's evolution and is vital to making dreams come true. The advent of CC in recent years has instigated interest from different educational institutions due to its features [24]. This technology brings a completely transformed learning experience to educational institutions [25] and it is used for cost effective and more efficient computing by centralizing storage, memory, computing capacity of personal computers and servers [2]. Moreover, CC provides a rich learning environment, a global collaboration among academics and students, and allows shared learning [25]. Additionally, CC applications provide flexibility for HEIs [2]. With the tremendous advantages of CC, this technology is expected to revolutionize the field of education, especially the higher education sector.

CC has a considerable status in the HEIs globally and locally. According to Katz et al. 2009 [26], 70% of HEIs in North America has moved to the cloud, and 50% have adopted CC collaborative system to enhance information sharing within the campus. Nearly all HEIs in the West region, according to [27], have a basic interest in adopting CC, at least at the departmental level. For example, according to Alshwaier 2012 [2], the University of California at Berkeley was focused on deploying SaaS applications in one of its courses. Moreover, the Medical College of Wisconsin Biotechnology and Bioengineering Center in the United States found that the usage of CC is very beneficial and provides them with a huge computational power by renting Google's cloud servers [28]. Moreover, some HEIs have adopted CC for economic reasons. For instance, Washington State University has suffered from budget cuts. However, the usage of CC has enabled the school to expand the educational services [15].

In Saudi Arabia, the IT market is considered as the largest market in the Gulf region [3]. The Saudi government has allocated a huge fund to improve the educational environment with the best technological facilities. However, there are new start-up universities in Saudi Arabia that lack e-learning tools compared to the older universities in SA [3]. Saudi universities still slowly seek to adopt CC in the higher education environment for distance learning and e-learning, while CC has been widely used in universities in different countries to deliver higher quality services to higher education [29]. Therefore, it is important to be aware of adopting CC in SA universities.

B. State of the Art

Related research covered the using of CC in higher education system over the last years are critically investigated. The usage of cloud services enables private and public educational institutions that work under financial constraints to update with the latest IT services and tools.

Migration to the cloud services refers to the process of moving data, applications, networks, and servers from in-premises to the cloud centers. However, the migration process still imposes a different range of challenges.

Alharthi et al. (2017) reported these issues, which are legal policies, security, and implementation. The researchers presented a framework for successful migration to the cloud environment in Saudi universities and identified a set of critical success factors concerned with the migration process. The results showed that majority of these factors were statistically significant except the physical location factor. The proposed framework can support the decision-making process about whether to migrate or not and can provide valuable data on cloud computing projects. Although the proposed framework was the first step to investigate the factors enabling the migration process, it had not been implemented in reality [3].

Another new e-learning framework based on private cloud and virtual private network was proposed by Jayasena and Song (2017). The proposed framework helps students in the university environment to access e-learning environment for resource sharing with less cost. The framework is scalable and increases availability and reliability, but it has limited access within campus networks only [30].

Ashtari and Eydgahi (2017) addressed the influence of individual users' perception towards the cloud computing applications. The researchers presented a framework focused on the association between a set of variables (IT self-efficacy, perceived cloud ease of use, computer anxiety, and users' perception of the usefulness and effectiveness of cloud computing applications) that have an influence on the cloud computing technology's perceptions for students at a university in Southeast Michigan. Additionally, the Technology Acceptance Model (TAM) model was used for analyzing adoption of cloud computing by students'. Although the usage of the TAM remains significant in technology evaluation after its adoption, there is a lack of any practical values and limited explanatory [4].

Arpaci (2017) also used the TAM for investigating the antecedents and consequences of CC adoption in higher education to achieve knowledge management. A questionnaire was distributed among undergraduate students in a Turkish university and analyzed by using structural equation modeling. The findings showed that the educational institutions promote CC adoption by increasing the awareness of knowledge management. Although the efficiency of this study, limited explanatory was one issue [31].

Rahimah and Aziati (2017) studied the factors that affect the CC implementation in HEIs focusing on SaaS. The researchers proposed a framework extracted from the Technology, Organization, and Environment (TOE) framework and integrated with the Diffusion of Innovation (DOI) theory for this study. Although the proposed framework accelerates the implementation process of computing technology, it does not consider the individual's resources or social support to adopt the new behavior [32].

Research conducted by Al-Hamami and Hashem (2016) looked into developing an efficient framework for Higher Education Ministry that serving all the universities in Iraq. The proposed framework provides some characteristics such as low cost, flexibility, mobility, and business continuity. However, there are some issues that need further investigations: security, reliability, and loss of sensitive data. Furthermore, there is a

lack of standards to enable multiple clouds to work as a single entity [33].

Madhav and Joseph (2016) discussed how cloud computing could help higher education institutions in South Africa by providing a framework for the cloud-based virtual computing labs. Findings depicted by Madhav and Joseph (2016) revealed the cost saving on hardware and software and the flexibility of the cloud-based virtual computing labs. However, the usage of the proposed framework was limited to the campus [34].

Khan (2015) proposed a hybrid-computing model that facilitates the higher educational institutions in Saudi Arabia to share knowledge and different research activities. The proposed model improves the effectiveness and quality of teaching by providing support regarding course material, assessments, and projects. Additionally, it saves the budgets of institutions to update with the latest IT and provides a treasure of knowledge at one place. On the security aspect, however, Khan did not consider security issues in his proposed model [35].

A survey conducted by Alajmi and Sadiq (2016) demonstrate that cloud computing continues to play an increasingly significant role in higher education in the modern world. Higher education is embracing cloud-computing services due to economic advantages, increase productivity, and improve learning strategies and knowledge penetration. However, there is a debate on different issues such as privacy, integrity, and ownership of data. Moreover, there is a lack of new security techniques to adopt cloud computing in the universities [11].

Militaru et al. (2016) explored the factors that lead to cloud computing adoption in higher education based on the TAM framework by surveying 96 students at a university in Romania. Findings revealed that the factors are significant to enhance the understanding of cloud computing adoption for faculty members and students. However, there is a lack of any practical value and limited explanatory [36].

Another exploratory study based on Technology Organization Environment (TOE) framework conducted by Tashkandi and Al-Jabri (2015) aimed to identify the factors that affect cloud computing adoption by higher education institutions in Saudi Arabia. The factors were tested through statistical analysis, and the results revealed the significance of the following factors: complexity, relative advantage, and data concerns. Although the researchers provided a better understanding of factors affecting cloud computing adoption, they did not include bandwidth and reliability factors in their study [37].

Different studies in higher education demonstrate the usage of computational environments improve the learning process [8], and this encouraged Segrelles and Molto (2016) to introduce virtualized computing environments based on cloud computing using the On-demand Deployment of Infrastructures to Support Educational Activities (ODISEA) platform. The benefits have been evaluated at a university in Spain. Findings demonstrated that ODISEA provides students with highly ubiquitous access and strong economic benefits for higher education institutions. Although the platform has a lot of flexibility, it does have challenges due to the complexity of communication among its levels [38].

A case study conducted by Musungwini et al. (2016) explored the benefits of using Google Docs in academics and analyzed the factors affecting cloud computing adoption at a university in Zimbabwe. Interviews and questionnaires were conducted in order to get in-depth insight into the issues affecting the adoption of cloud computing. Findings revealed there are many benefits of Google Docs to academics, but there is also a lack of knowledge about how to use cloud computing among lecturers. There was a need to conduct different workshops for all lecturers to explain cloud computing. Although the researchers used different research design approaches, there was a lack of consideration for security issues [39].

Ibrahim et al. (2015) conducted a survey to analyze the evidence of cloud computing adoption in the educational sector. A total of 27 papers were included in the literature review. The results of the study revealed a clear lack of research focusing on using cloud computing in educational institutions [40].

Higher education institutions are facing challenges in providing IT support for educational activities. Hence, higher education institutions must consider opportunities afforded by cloud computing. For that, Pardeshi (2014) proposed cloud-computing architecture for higher education institutes that contains cloud computing deployment models, services models, and user domains. Additionally, a strategy for migration from the traditional system to cloud computing was presented. Although the proposed architecture improves agility and increases efficiency, it has not yet been evaluated [6].

The most common cloud computing service model that has an impact on the learning sector is Software as a Service (SaaS). Hence, Akande and Belle (2014) explored whether SaaS is a viable option for higher education institutions in South Africa. Interviews were conducted with undergraduate students regarding using Office 365 as SaaS. Findings revealed many advantages of using Office 365, such as installation, upgrading, and maintenance of applications. Additionally, Office 365 assists higher education institutions via cost reduction and improved access to resources. However, there are other solutions available rather than Office 365 that provide all the same features but with lower costs [12].

Based on the preceding extensive analysis, which focused on a critical review of the literature, the findings from previous studies are summarized below in Table 1.

TABLE I. SUMMARY OF RELATED STUDIES

Author(s)	Technology	Pros	Cons
Alharthi et al. (2017).	Framework	• Investigate the factors enabling the migration process to cloud in South Africa. • Supports decision-making processes whether to migrate or not. • Provides valuable empirical data for hiring cloud-computing projects.	• Not implemented.
Jayasena and Song (2017).	Framework	• Scalability. • Increases availability and reliability.	• Limited access within the campus.
Ashtari and Eydgahi (2017).	Framework	• Effective usage of the model.	• Lack of any practical values. • Limited explanatory.
Arpaci (2017).	Model	• Efficacy.	• Limited explanatory.
Rahimah and Aziati (2017)	Framework	• Accelerated technology implementation in HE.	• Does not consider the individual's resources or social support.
Al-Hamami and Hashem (2016).	Framework	• Lower cost. • Flexibility. • Mobility. • Business continuity.	• Security issues not considered. • Reliability issues. • Loss of sensitive data. • Lack of standards to enable multiple clouds to work as a single entity.
Madhav and Joseph (2016).	Framework	• Cost saving in HW and SW. • Flexibility.	• Only uses the framework within the campus.
Khan (2015).	Model	• Treasure of knowledge at one place. • Improves effectiveness and quality of teaching. • Budget saving.	• Security issues not considered.
Alajmi and Sadiq (2016).	Survey	• Increases productivity. • Penetration of knowledge. • Improves educational strategies.	• Integrity, privacy, security, and ownership of the data. • Lack of new security techniques.
Militaru et al. (2016).	Framework	• Effective framework.	• Lack of any practical values. • Limited explanatory.
Tashkandi and Al-Jabri (2015).	Framework	• Provides valuable insights about critical factors that affect adoption of cloud computing.	• Lack of including bandwidth and reliability.
Segrelles and Molto (2016).	Platform	• Flexible platform.	• The complexity of communication among the levels.
Musungwini et al. (2016).	Case study	• Using different research design approaches. • Better collaboration.	• Lack of considering security issue.
Ibrahim et al. (2015).	Survey	• High quality selected research.	------
Pardeshi (2014).	Architecture	• Improves agility. • Increases efficiency.	• Lack in the evaluation stage.
Akande and Belle (2014).	Model	• Allow focusing on teaching and learning. • Reduces cost. • Improves access to resources.	• Using costly application.

IV. RESULTS AND DISCUSSION

Although CC is gaining momentum in HEIs, many issues still need to be addressed. Based on the critical, in-depth analysis of collected previous empirical studies, many knowledge gaps are evident. Theses gaps present new limitations and challenges that need further investigation. The following list presents the issues that are the most pressing and are opportunities for further study:

- Most of the existing systems fail to consider reliability, security, privacy and integrity issues. Additionally, some systems have limited access only within the campus and fail to support access from anywhere, which prevents academics and students the opportunity to access educational materials at their convenience.
- Some existing models allow focusing on teaching and learning; however, these models use costly applications.
- Most research just investigates the migration process to CC without implementation and evaluation process to assess their results.
- Some existing frameworks are based on other models; however, these frameworks have limited explanatory results.
- Some existing platforms are flexible, but the complexity of communication among the levels is still an open issue.
- Some systems fail to consider social support that allows knowledge exchange among educators.

V. CONCLUSION AND FUTURE WORKS

CC is an emerging technology that provides ICT services for various industries, especially higher education sector. The migration from traditional systems towards CC provides academics and student's access to educational materials anytime and anywhere, and CC enables HEIs to cope with the needs of software and hardware changes rapidly at lower costs. Therefore, the adoption of CC into higher education promotes students' academic level and efficiency. However, the expanded use of CC comes with different significant adoption challenges. Understanding the position of higher education

institutions with respect to CC adoption is an essential research area. The existing limitations and challenges in current empirical studies related to this topic are highlighted, and the areas for further investigation are suggested to inform other researchers who might be interested in CC implementation in the higher education field. These suggest essential areas of focus for future CC adoption in higher education research.

The research concluded that there is an urgent need to develop a new web application based on cloud computing, and cover some of gaps in current web applications.

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