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CLOUD COMPUTING IN HIGHER EDUCATION INSTITUTIONS: PROS AND CONS

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Abstract – The Breakthrough developments in Information and technology (IT) have led Higher Education Institutions (HEIs) to adopt state-of-the-art practices to change their education landscape and enhance their teaching and learning methods. Though different definitions of cloudcomputing, many of them agree that it is a system providing users with distant multi-services and tools through the internet. Cloud Computing characteristics, making it a hub as one of the ever- growing industries nowadays, include on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured Service. Besides, cloud computing models contribute to the efficient use of IT. There are three main models: public, private, and community cloud hybrid.They offer services under three delivery models: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Cloud features and services have provided convincing arguments to make cloud computing-based technology solutions a mainstream tool in HEIs running management for the benefit of students, teachers, researchers, and other educational stakeholders. Primarily through its different education cloud applications such as Microsoft Education Cloud Google, Education Cloud Earth Browser, Socratica …etc. These apps offer several significant benefits to technology enhanced learning, like cloud availability, cost- effectiveness, easiness, and safety. However, some limitations make these cloud computing opportunities unattainable and lead to non-cloud adoption as those relating to cloud privacy, security, infrastructures, and management.

Keywords – Cloud Computing, Models, Education, Pros, Cons

I. INTRODUCTION

Nowadays, the migration from historical IT systems to cloud-based hosted cloud computing technology is increasingly noticeable in various domains. It was expected that the rate of cloud computing adoption in 2017 would be faster than in years before, as a pivotal management system. Furthermore, market profits were evaluated at about $146 in 2017, whereas they were at $86 in 2015, realizing an annual growth of 22% (11). Cloud computing has taken a major chunk of attention from HEIs and it has become the main backbone in providing higher education stakeholders (students, teachers and administrations) with useful services via cloud paradigms: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) (47). Knowing that IT constituted a heavy bu5rden on some HEIs as they were unable to follow the speedy advances of IT and to meet the surplus additional expenditures of infrastructure maintenance, hardware, and software support. Unlike the cloud which provides cost-effective solutions to ease these burdens.

II. CLOUD COMPUTING

Cloud computing has become the subject of many studies to propose new solutions to different problems encountered in the domain of teaching and learning. There are no unanimous definitions of the term but there are common cloud features and modes.

A. DEFINITION OF CLOUD COMPUTING

According to McKinsey, there are more than 20 synonyms for the term "Cloud Computing" (5). The term has also been defined in many different ways: 1) as a computer service offered by large computer centers and businesses that provides on-demand access to various services such as applications, servers, networks, and storage via medium-voltage networks (33), 2) asa technology model that provides users with provisioned and on-demand resources and services such as storage, networks, services, and applications via the internet and with fewer efforts (39), 3) as a combined computer service in which various tasks are completed over the use of the internet (39) (29), 4) as a system that includes a range of services that supply users with various information via the internet (52), and 5) as a tool that allows users to benefit from remote services and tools with pay-as-you-go system as software, hardware, infrastructure and platform (4).

To sum up the above definitions, cloud computing is a system that offers users multi remote services and tools without significant effort via the internet.

B. CHARACTERISTICS OF CLOUD COMPUTING

According to NIST cloud computing is comprised of five main characteristics:

On-demand self-service: cloud computing automatically provides users, as they require, with services such as server time and network storage without any human interaction.

Broad network access*:* Cloud services can be accessed via the internet anytime and anywhere (i.e., ubiquitous) over standard devices such as laptops, tablets, mobile phones, and workstations.

Resource pooling**:** Cloud resources are pooled in the Cloud. They are locally independent and their locations are not known by users. Cloud resources includememory,processing, network bandwidth, and storage. Rapid elasticity: Cloud stakeholders can use, as they want, cloud resources rapidly and elastically without being limited by quantity or time.

Measured service: services and resource consumption are managed through a pay-as-you-gosystem. Examples of services are processing, storage, active user accounts, and bandwidth. Cloud stakeholders should pay for these services.

C.CLOUD MODELS

The emergence of cloud computing in the world of IT has made a breakthrough and resulted in a revolutionary change in the wayinformation and communication are treated. The variety of cloud models helps institutions run their businesses efficiently. That is why they were determinant keys for HEIs to accept cloud computing as a significant technological solution. The main cloud deployment models are:

According to NIST, cloud computing is composed of two types of models:

Deployment Models**:** They are divided into four types, which are:

Public Cloud: cloud computing is an open-use provider for a large number of public categories. Institutions such as economic, educational, and government organizations can benefit from cloud services. The public cloud can be accessed by Microsoft, Google, Amazon, etc. (43). It is noteworthy that the public cloud does notalways refer to free services or visible cloud operations; some institutions use security mechanisms to protect themselves and their clients against hackers (47).

Private Cloud: cloud computing can also be possessed and controlled by a single organization. The organization can avoid internet bandwidth restrictions, visible operations, and internet access (47).

Community cloud: common concern Institutions can share cloud services in their various missions as long as security requirements

and policy and compliance issues are taken into consideration.

Hybrid Cloud**:** The **c**loud-based technology has the ability to combine private and public institutions to share data and applications.

Table 1: Comparison of Cloud Computing Service Models (43)

Model	Scope	Managed by	Security Level
Public Model	General public and industries	Public and organization	Low
Private Model	Single organization	Public and organization	High
Community Mode	Single organization	Public and organization	Low
Hybrid Model	Public and private organization	Public and private organization	Medium

Delivery Models

NIST has also listed three cloud modes of delivery:

Software as a Service (SaaS): cloud computing provides applications to consumers through a thin client interface as a web browser. Noting that clients do not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings. Nowadays, SaaS is provided by computer companies such as Google, Salesforce, Microsoft, Zoho etc (17).

Platform as a Service (PaaS): This service helps users to create their own applications by deploying into the cloud infrastructure customer-created applications using programming languages and tools supported by the provider (such as Java, Python, Net, etc.). Furthermore, They do not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings. The latter is applied by providing a predefined combination of operating systems and application servers, such as LAMP (Linux, Apache, MySql, and PHP) platform, restricted J2EE, Ruby, etc. Some examples of PaaS are Google's App Engine, Force.com, etc (17).

Infrastructure as a Service (IaaS): cloud computing provides consumers witH basic computing resources such as processing, storage, networks…etc where the customer is able to deploy and run arbitrary software, which can include operating systems and applications. Thus, the customer does not manage or control the cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly select networking components (e.g., firewalls, load balancers, etc.). Some examples of IaaS are: Amazon, GoGrid, 3 Tera, etc (17).

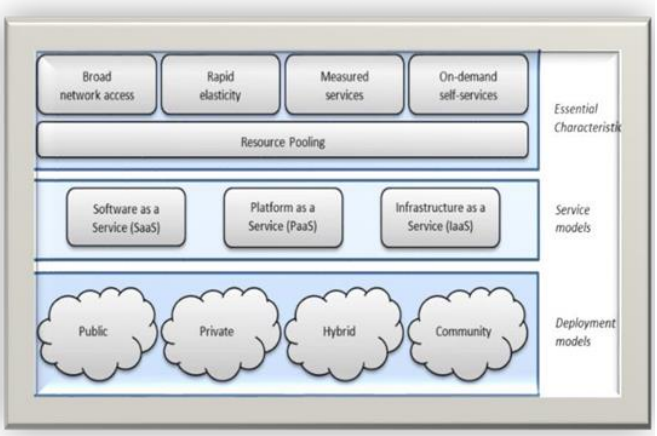

Fig.1 Cloud characteristics and models (source: NIST Definition, 2011)

III. CLOUD IN THE HIGHER EDUCATION DOMAIN

Nowadays, HEIs have decided to get rid of traditional educational management and learning system that have suffered for a long period: They were heavily burdened with hardware costs, hindered by IT sectors pressure and obsolete softwares, and damaged by costly and wasting time (4). The cloud-based solution has proved its efficiency in the past few years, that is why it is considered the most efficient educational system for its high-quality services available for teachers,

students, and researchers especially through those offered by as Saas, Iaas, and Paas.

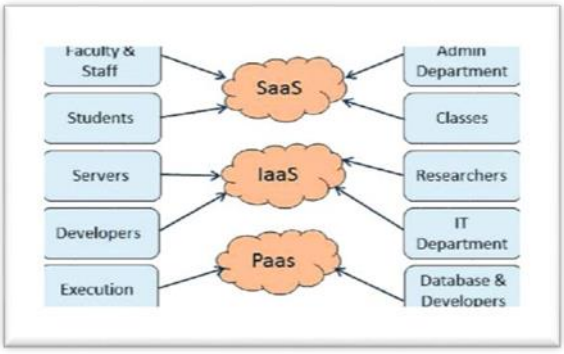

Fig. 2 : Cloud services used in the higher educational institutions:(Adapted from Attaran, 2017)

Pivital Education Cloud Applications

Due to its varied applications, cloud computing offers some advantages that make it appealing to HEIs and allowing them to improve their services to students, instructors, and other educational stakeholders. These apps are:

Microsoft Education Cloud

Microsoft Office Education Cloud supplies higher education staff with effective services. Such as Microsoft Office 365 which provides education users with free e-mails, websites with editing and storage facilities, instant messaging, web conferencing, and 25 GB of personal storage (32). Besides, any browser can be used to create Microsoft Office documents (21). However, the user has to pay to use Office Mobile, Office PC or Mac, unlimited email storage, and voicemail (32).

Google Education Cloud

Google Education Cloud is considered the best app since it is cost-effective. Furthermore, it provides users with cloud email, 30GB of storage, hosting, word processing, and collaboration tools (29). It is noteworthy that there is competition between the two companies: Microsoft and Google though some common service features such as Google Gmail, Chat, and Calendar. The downside of Google apps is that they are available to all categories unless those under 13 years of age, the category in which parent consent is required (26).

Earth Browser

The Earth Browser software was developed by Lunar Software. It is found in the online form as a flash application, and it can be installed as an application (25). It provides users with visualized geophysical information relating to weather, earthquakes, etc., three-dimensional images, non-stop updated information, and Earth presented in a satellite image form (25). Furthermore, "the representation of the earth is rendered along with a large amount of accurate data. The object can also be rotated and zoomed to a given distance'' (26).

Socratica

Socratica provides excellent educational videos for all different social categories (51). Socratica is characterized by high- definition videos, clarity, conciseness, and beauty. It selects and organizes the best free educational videos which help learners in their learning and serve age groups through its various channels on YouTube (26).

Virtual Desktops

A virtual desktop is a computer's virtual desktop. It is activated by a piece of software that is installed on computers. VMware 6 is the most popular software that provides a virtual desktop infrastructure (VDI) platform, helping users to use their virtual resources over a unified workspace (57).

IBM Cloud Academy

The IBM Cloud Academy was created to help educational institutions in their different missions. Cloud Academy leaders work together to provide academic institutions with low-cost optimized services, continuing and secure information, and credible resources to achieve student success while producing further scientific findings to help educational institutions enhance their effectiveness and resource management. As a result, they use various cloud services in their tasks, share their best cloud practices, and collaborate with associates to develop new cloud technologies (30).

Amazon Cloud Services in Education: Amazon Web

Amazon education services are web-based global programs that provide useful services to academic organizations. It offers five services: 1) Amazon Elastic Compute Cloud (Amazon EC2) offers virtual machines and extra CPU cycles, 2)

Amazon Simple Storage Service (Amazon S3) helps students, researchers, and administrations to store items with a limited size in Amazon's virtual storage, 3) Amazon Simple Queue Service (SQS) allows educators to share conversations, 4) Amazon SimpleDB provides on-demand organized data.5) Amazon Virtual Computing Laboratory (Amazon VCL) is a free web service for accessing a wide area of computational resources, storage, and software (39) (42) (53) (54).

HP Cloud Computing In Education

HP Cloud computing in education is a sort of IT that provides the education staff with available sources such as student records, knowledge management, faculty collaboration, etc., as well as professional integrated platform services (28). Furthermore, it enables private and public education staff to develop and run cloud services without the need for cloud training.HP Cloud computing in education is distinguished by the following features: a) True Integration, b) Complete management and automation, c) Security, and d) Scalability (14).

Salesforce.com Cloud Computing In Education

Salesforce is a useful new IT system that supplies educational institutions with efficient services at a big discount. It is adopted by academic institutions because it is efficient. It establishes strong, successful relationships between partners and provides innovative services and programs with characteristics such as scalability, ease of use, and multi-functions. The main features of salesforce.com in education are: App. Development, Collaboration, Real-Time Analysis, Mobile Applications, Recruitment and Marketing, Advancement, Student Record Management, Student Tracking (14).

AMANDA and ZMANDA Cloud Computing For Education

Amanda Enterprise in education provides essential educational services like as quick installation, easy management, professional features, and inexpensive subscription prices. Amanda Enterprise is also the only software that employs standard formats and tools to assist students in obtaining free data [29]. Zmanda Cloud

Computing, on the other hand, is distinguished by its ease of use, efficiency, and disaster recovery solution. Education institutions can benefit from Amanda Enterprise, Zmanda Recovery Manager for MySQL, and Zmanda Internet Backup (30) (14).

IV. CONS AND PROS OF CLOUD COMPUTİNG İN HİGHER EDUCATİON İNSTİTUTİONS

Pros of Cloud Computing

Cloud computing is known as an easy-to-use computing service with cutting-edge technology. Because of its numerous benefits and capabilities, it has been widely embraced by HEIs as the most suited computing learning management and student information system. In this regard, researchers have identified the following cloud computing benefits:

Cloud computing is ubiquitous

Graduate students can access study and explore university data at their leisure, as well as receive regular and direct feedback from tutors via video conferencing or instructions and comments via e-mails(18)(13). As a result, students are encouraged to perform their best and get excellent outcomes. Furthermore, with the Pearson OnVue online proctoring system students can be examined remotely (52) (15). It is an effective technique that avoids students traveling great distances to be examined in remote exam places, which is especially important in the current Covid-19 circumstances. In addition, HEIs personnel can use the cloud whenever they want.

Cloud computing is cost-effective

Cloud based-technology allows institutions with limited financial resources to save money on hardware and software, such as on licensing and infrastructure management, and spend the money saved on more important duties. Moreover, the cloud cost-effectiveness allows universities to be more competitive by providing high-quality functionalities, scalability, and more reliable and accessible information resources and applications. Learners, on the other hand, do not need to spend more money on advanced machines because they can access platforms using simple digital devices such as smartphones, tablets, and computers, and they can store and explore data freely thanks to the cloud storage system (5) (3) (62). (40).

Cloud computing is easy to manage

Cloud providers strive to create simple cloud apps and software in order to compete with other providers and attract more customers. As a result, no user training is required to learn cloud functions (24). Furthermore, cloud computing allows institutions to eliminate complex IT and focus on more important duties such as learning and research. Besides, it offers high-quality services through easy access and quick processing, storage, and sharing a large number of data and documents in various formats (46)(19)(39) (13). In addition, cloud virtualization (software and hardware are interlinked)) allows users to effortlessly share, store, and control data.

Could computing improves knowledge collaborations

Cloud social interactions among students, professors, and researchers result in productive and efficient cooperation (29). Students, professors, and researchers from multiple universities can interact by exchanging fresh ideas and expertise (24). Data may be shared, stored, and dispersed over huge platforms with easy access. Tutors can also interact with their students by providing them with high-quality knowledge sources as well as regular feedback via video conferences and e-mail (19).

Cloud computing provides security

A considerable amount of data is regularly stored using cloud-based technologies, according to Dahdouh et al. (19). As a result, data controllers or system administrators must monitor data, assign resources, manage workloads, install programs, monitor security levels, and make precise real-time modifications utilizing one or more data with keeping users' data safe and secure (39) (19). As a result, confidential information is protected and privacy is maintained while file tracking is possible. This type of data security makes teaching and learning easier. Cloud users can do things like manage data, explore resources, install apps, and make adjustments while maintaining a high level of security(39) (19).

Cons of Cloud Computing

Though there are several cloud opportunities for higher education institutions, Cloud migration, on the other hand, may come with its own risks and obstacles. Because studies show that few higher education institutions have adopted the cloud paradigm due to a range of challenges that act as significant roadblocks to cloud adoption: According to Gartner, 4% of cloud usage in education, 12% of cloud users in education are unable to work on the cloud, while 88% of users believe that cloud adoption in educational institutions is necessary (36). The challenges to cloud adoption are:

Ccloud Security

Three main issues should be taken into consideration in cloud adoption: security, performance, and availability (11) :stored and shared information may be explored by unauthorized users due to the cloud redundancy, multi-tenancy, resiliency, and signs of unachieved or unlocked removal of data or unauthenticated users(14). Especially with cybercrime rates predicted to treble in the next three years, costing $2 trillion in 2019 (66). Due to the ever-increasing number of cloud compliance, it would be a burden for educational institutions confronted with escalating regulations for more transparency. They should be dependent on a specific cloud provider

to ensure data portability (14). Then, legal considerations such as the location of stored data, service providers, and international users living in different countries should be taken into account by institutions (4). Such points, thus, should be negotiated, agreed upon, and documented in the Service Level Agreement (SLA) by institutions to know how to manage in case of a data breach(4).

Cloud Privacy

Privacy is serious problem institutions face due to low data and information security requiring cloud developers to keep careful monitoring. In this context higher education institutions should establish research and development control units to seriously handle data and information by reinforcing intellectual property and patent protection among other users (38). Education institutions should endeavor to protect data from cloud unauthorized and unauthenticated users: student records, researcher's intellectual property, and patents should be protected. Nowadays, Data and information privacy are taken seriously by the EU which imposes a regulation to prevent any type of information to be unveiled. Computer companies such as Amazon, hence propose their storage services in the EU. however, some cloud security regulations hinder some institutions to adopt the cloud paradigm (1)(55)(43).

Cloud Reliability

Studies confirmed that the availability of cloud services is not assured 100%. It is noticed even in famous companies such as Salesforce and Amazon. In February 2008, Salesforce.com services were not available for six hours, and Amazon services were suspended three times during one year: 3 hours, a few days, and 8 hours. Cloud unavailability impacts the quality of higher education services hampered due to students' learning interruptions and class scheduling disturbances (44)(58). Cloud service unreliability is also caused by cloud installation which cannot fit all kinds of educational programs and degrees, especially in educational systems (47).

Cloud Bandwidth

Certain higher education institutions have limited financial resources. They may experience internet outages in their cloud hosting system, and university staff, such as students and researchers cannot access cloud computing. Furthermore, a slow internet connection necessitates additional network expenditures (36) (44) (28). Moreover, slow connection speeds and limited internet access may cause cloud functionalities to fail (2). As a result, educators may stop using cloud e-learning platforms.

Cloud Mismanagement

Cloud computing mismanagement have different aspects in HEIs: high costed cloud management to satisfy education needs, high- priced cloud software and tools (47) (Selecting in- house cloud applications could be not an easy matter and is sometimes unrealizable (42)), unstandardized prices (different ways of pricing) (42), cloud market immaturity, computing staff jobless as e-learning is digitized, and the acute competition among cloud providers. These management risks may create a disturbance, lack of performance, and loss of investments in education institutions business causing bad effects on students, researchers, and even the public (52).

V. CONCLUSION

We live in a world where technology is causing a sea change in IT and society. No one can expect today's rapid technological development to simplify teaching and learning processes, according to Christensen (67). Cloud technology has emerged and permeated several of fields: from theoretical computer science to economy, from marketing hype to educational domain, and from the R&D lab to enterprise IT infrastructure (53). Cloud computing is regarded as an emerging mainstream technology with incredible benefits that entice higher education institutions to adopt it. Among the benefits of cloud computing for HEIs are the following: it can be accessed at any time and from any location, it is less expensive, it allows for simple processing management, it does not require extensive research, and it provides security. Despite the numerous cloud

opportunities available to HEIs, cloud computing can pose risks and problems, particularly for institutions with limited resources. Cloud limitations can include a lack of security, privacy, confidentiality, reliability, inadequate bandwidth, and cloud economic side effects. To address these issues, researchers proposed a cloud road map to investigate cloud computing issues and offer guiding solutions (31).

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