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Cloud Computing in Higher Education: Applications and Future Perspectives

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Abstract

Higher Education landscape around the world is in a constant state of flux and evolution, mainly as a result of significant challenges arising from efforts in adopting new and emerging technologies. Technology offers new opportunities in enhancing teaching and learning. The new technologies enable individuals to personalize the environment in which they work or learn a range of tools to meet their interests and needs. In this paper, we try to explore the salient features of the nature and educational potential of 'cloud computing' in order to exploit the affordance of Cloud computing in teaching and learning in a higher education context. Education today is becoming completely associated with the Information Technology on the content delivery, communication and collaboration. The need for servers, storage and software are highly demanding in the universities, colleges and schools. Although, the adoption of cloud computing promises various benefits to an organization, a successful adoption of cloud computing in an organization, particularly in educational institutes requires an understanding of different dynamics and expertise in diverse domains. This paper aims at a roadmap of Cloud Computing for Higher Education (CCHE) which provides with a number of steps for adopting cloud computing.

Keywords: - Cloud computing, Migration.

1. Introduction

Cloud computing is typically defined as a type of computing that relies on SHARING COMPUTING RESOURCES rather than having local servers or personal devices to handle applications. In cloud computing, the word cloud (also phrased as "the cloud") is used as a metaphor for "THE INTERNET," so the phrase CLOUD COMPUTING means "a type of Internet-based computing," where different services such as servers, storage and applications are delivered to an organization's computers and devices through the Internet [2]. Cloud computing is comparable to grid computing, a type of computing where unused processing cycles of all computers in a network are harnesses to solve problems too intensive for any stand-alone machine. Cloud computing is computing in which large groups of remote servers are networked to allow centralized data storage and online access to computer services or resources. Clouds can be classified as public, private or hybrid.

The criticisms about it are mainly focused on its social implications.[1] This happens when the owner of the remote servers is a person or organization other than the user, as their interests may point in different directions, for example, the user may wish that his or her information is kept private, but the owner of the remote servers may want to take advantage of it for their own business.

A model for delivering information technology services in which resources are retrieved from the internet through web-based tools and applications, rather than a direct connection to a server. [2] Data and software packages are stored in servers. However, cloud computing structure allows access to information as long as an electronic device has access to the web. This type of system allows employees to work remotely.

2. Evaluation of Cloud Computing

Figure-1 Cloud Computing

The origin of the term cloud computing is unclear. The expression cloud is commonly used in science to describe a large agglomeration of objects that visually appear from a distance as a cloud and describes any set of things whose details are not inspected further in a given context.

In analogy to above usage the word cloud was used as a metaphor for the Internet and a standardized cloud-like shape was used to denote a network on telephony schematics and later to depict the Internet in computer network diagrams. The cloud symbol was used to represent the Internet as early as 1994, in which servers were then shown connected to, but external to, the cloud. References to cloud computing in its modern sense appeared early as 1996, with the earliest known mention in a Compaq internal document.[3] The popularization of the term can be traced to 2006 when Amazon.com introduced the Elastic Compute Cloud.

The underlying concept of cloud computing dates to the 1950s, when large-scale mainframe computers were seen as the future of computing, and became available in academia and corporations, accessible via thin clients/terminal computers, often referred to as "static terminals", because they were used for communications but had no internal processing capacities.[4] In early 2008, Eucalyptus became the first open-source, AWS API-compatible platform for deploying private clouds. In early 2008, Open Nebula, enhanced in the RESERVOIR European Commission-funded project, became the first open-source software for deploying private and hybrid clouds, and for the federation of clouds [2].

In July 2010, Rack space Hosting and NASA jointly launched an open-source cloud-software initiative known as Open Stack. On March 1, 2011, IBM announced the IBM Smart Cloud framework to support Smarter Planet.

On June 7, 2012, Oracle announced the Oracle Cloud. While aspects of the Oracle Cloud are still in development, this cloud offering is posed to be the first to provide users with access to an integrated set of IT solutions, including the Applications (SaaS), Platform (PaaS), and Infrastructure (IaaS) layers. [4]

3. Characteristics of Cloud Computing

• Application programming interface (API) accessibility to software that enables machines to interact with cloud software in the same way that a traditional user interface (e.g., a computer desktop) facilitates interaction between humans and computers.[4] Cloud computing systems typically use Representational State Transfer (REST) based APIs.

• Cost reductions claimed by cloud providers. A public-cloud delivery model converts capital expenditure to operational expenditure. Pricing on a utility computing basis is fine-grained, with usage-based options and fewer IT skills are required for implementation (in-house).

• Device and location independence enable users to access systems using a web browser regardless of their location or what device they use (e.g., PC, mobile phone).[3] As infrastructure is off-site (typically provided by a third-party) and accessed via the Internet, users can connect from anywhere.

• Maintenance of cloud computing applications is easier, because they do not need to be installed on each user's computer and can be accessed from different places.

• Performance is monitored and consistent and loosely coupled architectures are constructed using web services as the system interface.

• Reliability improves with the use of multiple redundant sites, which makes well-designed cloud computing suitable for business continuity and disaster recovery.

• Security can improve due to centralization of data, increased security-focused resources, etc., but concerns can persist about loss of control over certain sensitive data, and the lack of security for stored kernels. Security is often as good as or better than other traditional systems, in part because providers are able to devote resources to solving security issues that many customers cannot afford to tackle

4. Functions of Cloud Computing

The goal of cloud computing is to apply traditional computing, or high-performance computing power, normally used by military and research facilities, to perform tens of trillions of computations per second, in consumer-oriented applications such as financial portfolios, to deliver personalized information, to provide data storage or to power large, immersive computer games [5].

4.1. Service Models

Cloud computing providers offer their services according to several fundamental models:

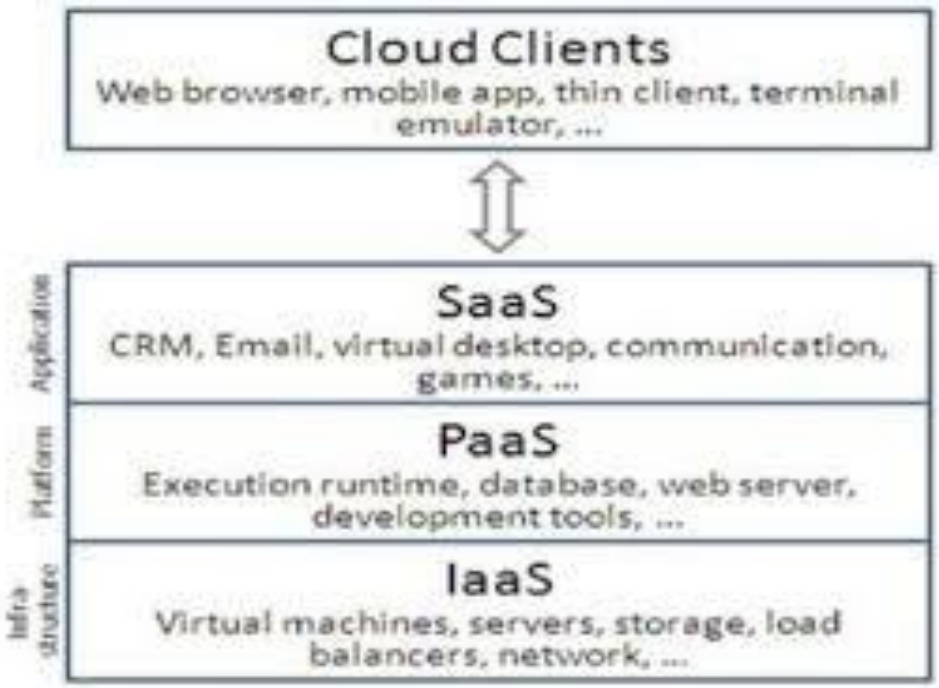

Figure-2 Cloud Model

4.1.1 Infrastructure as a Service (IaaS)

Cloud-service model & according to the IETF (Internet Engineering Task Force), providers of IaaS offer computers physical or (more often) virtual machines and other resources. (A hypervisor, such as Xen, Oracle Virtual Box, KVM, VMware ESX/ESXi, or Hyper-V runs the virtual machines as guests.[5] IaaS clouds often offer additional resources such as a virtual-machine disk image library, raw block storage, and file or object storage, firewalls, load balancers, IP addresses, virtual local area networks (VLANs), and software bundles. For wide-area connectivity, customers can use either the Internet or carrier clouds (dedicated virtual private networks).

4.1.2 Platform as a Service (PaaS)

PaaS models, cloud providers deliver a computing platform, typically including operating system, programming language execution environment, database, and web server.
Platform as a service (PaaS) provides a computing platform and a key chimney. It joins with software as a service (SaaS) and infrastructure as a service (IaaS), model of cloud computing.

4.1.3 Software as a Service (SaaS)

In the business model using software as a service (SaaS), users are provided access to application software and databases. Cloud providers manage the infrastructure and platforms that run the applications.[1] SaaS is sometimes referred to as "on-demand software" and is usually priced on a pay-per-use basis. SaaS providers generally price applications using a subscription fee.
In the SaaS model, cloud providers install and operate application software in the cloud and cloud users access the software from cloud clients.[3] To accommodate a large number of cloud users, cloud applications can be multitenant, that is, any machine serves more than one cloud user organization.

4.2 Types of Cloud Computing

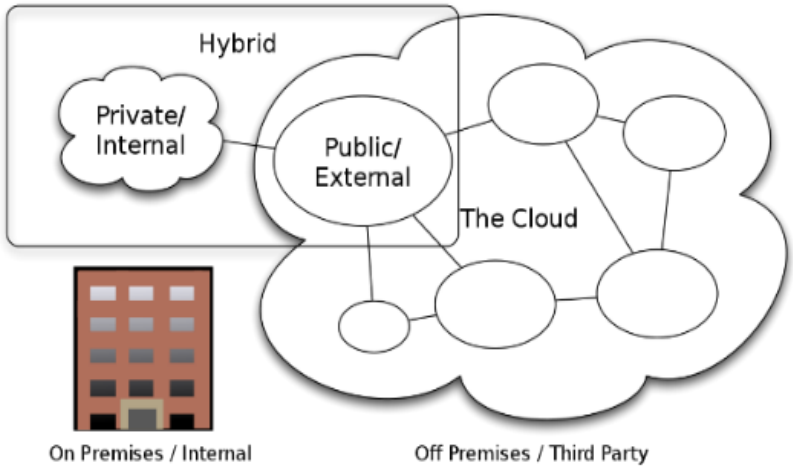

Figure-3 Cloud Computing Types.

4.2.1 Private Cloud

Private cloud is cloud infrastructure operated solely for a single organization, whether managed internally or by a third-party, and hosted either internally or externally. Undertaking a private cloud project requires a significant level and degree of engagement to virtualize the business environment, and requires the organization to reevaluate decisions about existing resources. When done right, it can improve business, but every step in the project raises security issues that must be addressed to prevent serious vulnerabilities.[5] Self-run data centers are generally capital intensive. They have a significant physical footprint, requiring allocations of space, hardware, and environmental controls.

4.2.2 Public Cloud

A cloud is called a "public cloud" when the services are rendered over a network that is open for public use. Public cloud services may be free or offered on a pay-per-usage model. Technically there may be little or no difference between public and private cloud architecture, however, security consideration may be substantially different for services that are made available by a service provider for a public audience and when communication is affected over a non-trusted network. [2] Generally, public cloud service providers like Amazon AWS, Microsoft and Google own and operate the infrastructure at their data center and access is generally via the Internet. AWS and Microsoft also offer direct connect services called "AWS Direct Connect" and "Azure Express Route" respectively, such connections require customers to purchase or lease a private connection to a peering point offered by the cloud provider [1].

4.2.3 Hybrid Cloud

Hybrid cloud is a composition of two or more clouds (private, community or public) that remain distinct entities but are bound together, offering the benefits of multiple deployment models. Hybrid cloud can also mean the ability to connect collocation, managed and/or dedicated services with cloud resources. Gartner, Inc. defines a hybrid cloud service as a cloud computing service that is composed of some combination of private, public and community cloud services, from different service providers [10]. It allows one to extend either the capacity or the capability of a cloud service, by aggregation, integration or customization with another cloud service. Another example of hybrid cloud is one where IT organizations use public cloud computing resources to meet temporary capacity needs that cannot be met by the private cloud.

4.2.4 Community Cloud

Community cloud shares infrastructure between several organizations from a specific community with common concerns (security, compliance, jurisdiction, etc.),[7] whether managed internally or by a third-party, and either hosted internally or externally

5) Distributed cloud

Cloud computing can also be provided by a distributed set of machines that are running at different locations, while still connected to a single network or hub service.[8] Examples of this include distributed computing platforms such as BOINC and Folding Home.

4.3 Cloud Computing Architecture

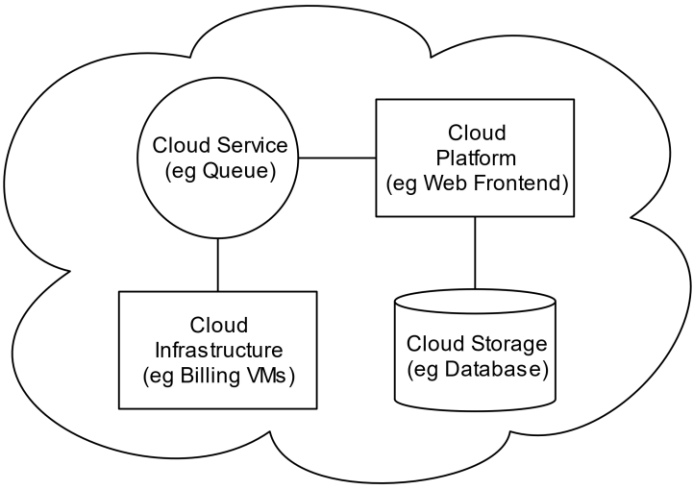

Figure-4 Architecture of Cloud Computing.

Cloud architecture the systems architecture of the software systems involved in the delivery of cloud computing, typically involves multiple cloud components communicating with each other over a loose coupling mechanism such as a messaging queue. Elastic provision implies intelligence in the use of tight or loose coupling as applied to mechanisms such as these and others.

4.4 Cloud Computing: Issues

Cloud computing poses privacy concerns because the service provider can access the data that is on the cloud at any time. It could accidentally or deliberately alter or even delete information. Many cloud providers can share information with third parties if necessary for purposes of law and order even without a warrant.
That is permitted in their privacy policies which users have to agree to before they start using cloud services. There is the problem of legal ownership of the data.[2] Many Terms of Service agreements are silent on the question of ownership.
Physical control of the computer equipment (private cloud) is more secure than having the equipment off site and under someone else's control (public cloud)

4.5 Cloud Computing in Higher Education

The potential and efficiency of using Cloud Computing in higher education has been recognized by many universities among which we mention University of California, Washington State University's School of Electrical Engineering and Computer Science, higher education institutions from UK, Africa 2010, U.S and others. Cloud Computing offers to universities the possibility of concentrating more on teaching and research activities rather than on complex IT configuration and software systems (McCREA, 2009), through a fast IT implementation. According to Tout et al., 2009 complexity can be reduced with Cloud Computing.
Cloud computing offers many benefits to e-learning solutions by providing the infrastructure, platform and educational services directly through cloud providers and by using virtualization, centralized data storage and facilities for data access monitoring (Pocatilu et al., 2009) [10]. In order to ensure success in e-learning, universities use metrics systems adapted to measure the effectiveness of e-learning solutions based on the cloud.

4.5.1 Cloud and Its Demand in Higher Education

• 55% of institutions want increased efficiency, and believe that cloud computing is the answer
• By the end of 2014, 4 out of 5 higher education students are expected to take coursework online
• 68% of institutions use (or will use) the cloud for conferencing and collaboration
• 65% of institutions use (or will use) the cloud for storage
• 65% of institutions use (or will use) the cloud for office/productivity suites
• 62% of institutions use (or will use) the cloud for messaging
• 59% of institutions use (or will use) the cloud for computing power
• Many popular services and applications are cloud based, like Ever note, Amazon Web Services, and Prezi [9]

4.5.2 Cloud Can Help Colleges and Universities In:

• Accommodate the rapid increase in mobile device dependency
• Store expansive amounts of sensitive data and information that's easily accessible
• Stay current (e.g. provides students with digital campus storage for class notes, papers and projects)
• Acquire and implement the latest software and application updates

• Streamline enrolment and admissions processes that are costly and time-consuming
• Turn to subscriptions that are scalable and provide options
Higher education institutions are rapidly embracing the potential of cloud technology to improve the way it serves both internal and external constituents [6].

4.5.3 Higher Education Used the Cloud

4.5.3.1 Current Adoption Levels

Already, nearly 70% of higher education institutions in North America have moved (or are in the process of moving) their email systems to the cloud. [7] About 50% have adopted a cloud-based collaboration system to improve information sharing across campus.
Higher education institutions can now find point solutions for student recruiting, talent management, research, administration, and fundraising in the cloud. Cloud-based enterprise-level solutions are also available, with several vendors offering financial management solutions.

4.5.3.2 Higher Education's Unique Needs

Higher education institutions have a unique culture and mission that affects how decisions about cloud computing are made.
• COMMITMENT TO STUDENTS. Above all, higher education serves students. And those students come to campus with their own devices and expectations about how and when they want to use them. IT departments must now provide greater interoperability between campus and student platforms; 24/7 access to secure, reliable networks; and the ability to create, deliver, and share content campus-wide on any number of devices.[5] Cloud computing is now as much about meeting student needs as it is about running an efficient campus.
• COMPLEX FINANCE MODELS. Higher education finance models are complex and precarious, comprised of various combinations of tuition, philanthropy, investments, public funding, and research dollars [4].
• PARTICIPATORY DECISION-MAKING MODEL. Another piece of the puzzle is higher education governance, modelled on a participatory culture often precluding--or at least complicating -- top-down decision-making. Seeking consensus takes time, especially when stakeholders are dealing with decisions about where to allocate limited resources. In this environment, stakeholders need to fully understand the benefits of cloud-based services models [2].
When developing a cloud strategy, higher education can draw on certain general principles from the business community. But an effective and durable cloud strategy for your institution will require: creating a framework built around the needs of your unique stakeholders – from students to faculty, board members to alumni; engaging all stakeholders early in the process; [11] and developing an institution-wide cloud strategy that addresses IT challenges specific to higher

4.5.4 Embracing the Cloud

The question of whether or not to embrace the cloud has largely been answered -- by students, faculty, and staff, who are already relying on cloud services each day. Higher education professionals in IT and well beyond are not asking if but when and how they can begin the transition [7].
That's a sea change in how we perceive and practice technology. Managing that change requires a partner who understands higher education and the benefits the cloud can deliver to your constituents and to your mission [6].

4.5.5 Why Store in The Cloud?

A recent conversation about cloud computing with several colleagues in the education field, including a college and school teacher, revealed significant advantages [5]:
• No more carrying around devices, such as thumb drives or CDs. You don't need to worry about losing the device, breaking the CD, or not having your information load properly.
• Easy access! Lesson plans, labs, grades, notes, PowerPoint slides – just about anything digital that you use in teaching is easily uploaded and accessed anytime.
• Stability: cloud computing is now to the point of being a very stable technology that you can rely on.
• Security: Your data, content, information, images – anything you store in the cloud usually requires authentication (ID and password, for example) – so it is not easily accessible by anyone. In addition, should something happen to the technology at school, your content will still be available to you and your students if it is stored elsewhere.
• Shareability: Working on an instructional assignment with other teachers? You can share some or all of your files that you have stored in the cloud. No more obtaining an extra thumb drive or burning another CD or DVD. You just need to send a link to the file(s) destination.
• Good-bye copier! That's right! With cloud computing, the amount of photocopying is reduced significantly – even more so if each student has their own smart device (computer, laptop, tablet, etc.). Quizzes, tests, assignments all can be taken, scored, shared with student and parents, and stored.
• Good-bye file cabinets! With cloud computing redundancy, there is no longer the need to both save files digitally as well as in paper format. Cloud computing systems are regularly backed-up, so the chances of losing content are quite small. And, no more file cabinets mean more classroom space for you and your students!

4.5.6 Applications of Cloud Computing in Education

Advantages that would be especially useful for both students and educators:
• Back Up: An important function of the Cloud is that it automatically saves content, making it impossible to lose or delete any valuable material. This means that even if a computer crashes, all documents and content will remain safe, saved, and accessible in the cloud [9].
• Storage: The Cloud allows its users to store almost all types of content and data including music, documents, eBooks, applications, photos, and much more [2].
• Accessibility: Any data stored in the Cloud can easily be accessed from almost any device including mobile devices such as phones or tablets.
• Collaboration: Because the Cloud allows multiple users to work on and edit documents at the same time, it enables effortless sharing and transmission of ideas.[3] With this feature, group projects and or collaborative lesson plans can be optimized for both teachers and students.
• Resource and Time Conscious: With the availability of content online, it is no longer necessary for teachers to spend time and resources printing or copying lengthy documents or lesson plans.[2] Now, students are able to access homework assignments, lesson notes, and other materials online.
• Assignments: I love that the Cloud allows teachers to post assignments online. Students are able to access these assignments, complete them, and save them in a folder to be reviewed later.[4] This means no wasting time turning in papers at the beginning of class as well as no passing germs around the pesky flu seasons!

4.5.7 Privacy and Security Concerns

However, the very features that make cloud computing ideal for education (the ability to collaborate, ease of accessing homework files) rely on hosting companies being able to control communication between the company and the student. Continuous access to student data raises privacy concerns.[5] SafeGov.org found that 74% of teachers saw threats to privacy as the top risk, followed by security breaches (70%).[9]

4.5.8 Future Perspectives

Cloud computing is poised to redefine the landscape of higher education in profound ways, offering a multitude of benefits and opportunities for institutions, faculty, and students alike. By leveraging cloud-based solutions, universities and colleges can transcend the limitations of traditional on-premises infrastructure, unlocking unprecedented scalability, flexibility, and cost-efficiency. Through cloud platforms, educational resources and services become accessible anytime, anywhere, fostering a seamless and inclusive learning environment that accommodates diverse student needs and preferences. This accessibility extends beyond academic content to encompass administrative functions, enabling streamlined processes and enhanced collaboration among faculty and staff.
Moreover, cloud computing empowers institutions to harness the power of big data analytics and machine learning algorithms to gain valuable insights into student performance, engagement patterns, and learning outcomes. By leveraging these insights, educators can tailor instructional strategies and interventions to optimize student success and retention rates.
Additionally, cloud-based technologies facilitate the development and deployment of innovative educational tools and applications, from immersive virtual reality experiences to adaptive learning systems, thereby driving continuous improvement and innovation in teaching and learning practices. As higher education continues to evolve in the digital age, cloud computing stands as a cornerstone of transformation, enabling institutions to adapt and thrive amidst unprecedented challenges and opportunities. Through strategic investment in cloud infrastructure and services, universities and colleges can position themselves at the forefront of educational innovation, driving positive outcomes for students, faculty, and society as a whole.

6. Conclusion

Cloud computing technology is still relatively young in terms of maturity and adoption. The expectation is that it will undergo several changes in the future, in terms of resources, issues, risks, and ultimately best practices and standards. However, there are some sought of greet advantages it can potentially provide value for institutions of higher education. On-demand services can reverberate positively with the current university tight budgets across the nation and other parts of the world.

Conflict of Interest

The Authors declares that there is no conflict of interest in this manuscript.

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