Leveraging Cloud Computing in Higher Education: An Overview

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Abstract: **- Across the globe, universities and institutions of higher education are facing challenges to provide cost effective solution for necessary information technology (IT) support for educational, research and development activities. The objective of this paper is to do a comprehensive study of leveraging cloud computing in higher education in order to suggest a suitable alternative for IT support to universities and institutions of higher education to improve agility and obtain savings.**

The article begins with a brief introduction to Cloud Computing in universities and other institutions, referring to the most important results obtained so far. The research methodology consisted of rigorous analysis of the latest research on Cloud Computing as an alternative to IT support considering various issues related to provision, management and security. It also took into account the best practices for Cloud Computing usage within universities. This article encourages institutions in higher education to adopt cloud computing technology.

Keywords: **Cloud, higher education, cloud computing, IT support.**

I. INTRODUCTION

Globally, like other organisations, higher education institutions(HEIs) are dependent mostly on information technology in terms of content delivery, communication, and collaboration. Today, students and teachers, the main stakeholders of any educational institution are demanding more information technology services such as email, storage space, web based services using internet from their respective institutions. Moreover, information technology is also changing rapidly and has put an additional financial burden on the institutions. One of biggest challenge, HEIs face in providing education is the lack of infrastructure, maintenance of existing infrastructure (if available), and maintaining a wide range of hardware and software equipment. Cloud computing can provide solutions at a reasonable value.

Cloud Computing offers to HEIs the possibility of concentrating more on their core activities i.e. teaching learning and research rather than on complex IT configuration and software systems, through a fast IT implementation. [1]

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, U.S and others. [2][3][4]

In the recent past, Oracle-sponsored cloud panel at the EDUCAUSE Annual Conference in Chicago (form Oct 14-17, 2019), many higher education IT leaders talked about their experience and state their reasons for moving to the cloud.[5]

Borre Ulrichsen, CIO at Gonzaga University told that university had shifted from on premise to an on-demand licence strategy to **save investment cost** to upgrade university's administrative software platform. [5]

Peter Murray, CIO and vice president for IT at the University of Maryland, Baltimore, said that their university recognized that the newest releases of some of their tools were not compatible with their existing platform. They decided to pursue a new financial system which is **something completely transformative and state-of-the-art**. They saw an opportunity to move to the cloud. [5]

Similarly, Cheri Polenske, assistant vice president of enterprise services at the University of Nebraska. said that the cost to maintain on premise was getting very expensive and time-consuming. She also said that **student information system was the impetus for researching cloud**, as enrolment was creeping up and the cost of additional licenses was becoming a factor, in addition to hardware that was reaching end of life. That why they were looking for a way to control costs. [5]

This article will further discuss the study under the following sections. Section II provides a general description of the technology and reviews its service models as well as its basic deployment models. Section III reviews the usage of cloud computing in higher education and research which includes benefits and risks associated with cloud computing technology in higher education. Section IV discusses the issues to be decided before planning the implementation of this technology. Section V provides a summary and conclusion.

II. CLOUD COMPUTING

A. What is Cloud Computing

The term "cloud" was inspired from the "cloud" symbol that is typically used to symbolize the Internet in computer network diagrams [2]. Cloud refers to the combination of hardware and software at a data centre that support the needs of users such as storing data and remote-host application.

Cloud computing is a style of computing where dynamically scalable and virtualized resources are provided as a service over the Internet. These infrastructures enable companies to cut costs by eliminating the need for physical hardware, allowing companies to outsource data and computations on demand [6].

The National Institute of Standards and Technology (NIST) defines Cloud computing 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. This cloud model is composed of five essential characteristics, three service models, and four deployment models. [7]

B. Essential Characteristics of cloud

1) *On-demand self-service.* A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.

2) *Broad network access.* Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).

3) *Resource pooling.* The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacentre). Examples of resources include storage, processing, memory, and network bandwidth.

4) *Rapid elasticity.* Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.

5) Measured service. Cloud systems automatically control and optimize resource use by leveraging a metering capability1 at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service. [7]

C. Cloud Service Models

As per the NIST, Cloud model is composed of three service models [7]:

1) *Software as a Service (SaaS).* The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does 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.

2) *Platform as a Service (PaaS)*. The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

3) *Infrastructure as a Service (IaaS).* The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls).

D. Cloud Deployment Models

There are the deployment models of cloud computing [7]:

1) Private Cloud: The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party, and may exist on premise or off premise.

2) Community Cloud: The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, and policy and compliance considerations). It may be managed by the organizations or a third party, and may exist on premise or off premise.

3) Public Cloud: The cloud infrastructure is made available to the general public or to a large industry group, and is owned by an organization selling cloud services.

4) Hybrid Cloud: The cloud infrastructure is a composition of two or more clouds (private, community or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).

III. CLOUD COMPUTING IN HIGHER EDUCATION

The classrooms in Higher education are changing and so are workplaces. Students are demanding more technology services on 24/7basis. Hence, for HEIs it is important to keep pace with their evolving needs and prepare them for the demands of the workplace in future.

Educational institutions are under increasing pressure to find ways to offer these services and tools in an affordable manner. Therefore, HEI are moving away from the traditional ways to provide these solutions by using Cloud computing. Moreover, by sharing IT services in the cloud, education institution can outsource noncore services and better concentrate on offering students, teachers, faculty, and staff the essential tools to help them succeed.

Cloud was mostly implemented in higher education institutions because of learning management system and student information system. [3][7][8][9] [10]

The Cloud Computing application can benefit the students and other stakeholders by enabling them with quick connections with each other and to the core of educational materials. In general, cloud computing provides the HEIs with the many benefits by providing a digital education environment and web-based services for all the stakeholders.

Some of the benefits and advantages of cloud technologies for universities and HEIs that are already visible and confirmed by many are [11]:

- Cost Reduction
- Focus on primary activities such as teaching learning and research
- Innovation, development and application
- Downsizing IT departments
- Access to advanced applications
- Energy saving and environmental impact.

For any new institution, following may be considered for transforming education using clouds

1) **IT Infrastructure.** Clouds allow the institution to get all the IT resources they need from anywhere at all time from any device. It can be managed securely and predictably. Institutions pay for only for the usage. For any budget-constrained institution, it is ideal option to select cloud w.r.t in premises IT infrastructure.
2) **Applications.** Stakeholders don't have to wait in the software procurement line, get hosted software, datasets, and services. They can focus on their objectives or jobs rather than availability of applications.
3) **Flexible services.** Cloud Supports for interactive teaching learning process (LMS) i.e. ability to share, process, store large content required for teaching learning process. It drives innovation with data services in the cloud that students, teachers, faculty, and staff can reuse.
4) **Creative IT staff.** Cloud may free IT department from a keep-the-lights-on approach to foster some creative problem solving that can help teachers better engage their students.
5) **Policies and regulations.** Institutions should proceed carefully in how cloud computing can help in meeting their institution's compliance requirements.

The use of Cloud Computing in higher education must be analysed both from the benefits point of view, as well as from that of the risks.

By implementing the solution, a gain that exceeds the capital costs and compensates the associated risks must be obtained. Many of the risks specific to cloud environment may be transferred to cloud providers. [4] [13]

The decision taking of using Cloud Computing must also take into account the risks of non-implementing, but also the implementation risk associated to the solution. [4]

As regards the implementation risks, a research conducted by the IDC Enterprise Panel in 2009 concluded that the primary concerns about adoption in higher education are: security, performance and availability, not enough ability to customize, worried on-demand will cost more, bringing back in-house may be difficult, regulatory requirements prohibit cloud, and not enough major suppliers yet. [14]

The risks associated with the cloud leading to non-adoption, include confidence, surety and trust [15] [16] [17] [18] [19].

1) **Confidence** refers to users' willingness and readiness to use and accept a cloud solution; this is a branch of cultural resistance in which users may reject the technology purely based on their unfamiliarity and the unwillingness to adapt to change [20].
2) **Surety** refers to the cloud solution delivering its intended purpose, which with new innovations can be uncertain since this is a novel technology, which many users will not be accustomed to.
3) **Trust** refers to users' acceptance of the cloud solution based on having full confidence in the technology, but given the many potential risks of novel technologies, users will more than likely not trust the innovation [2].

The majority of cloud services have a poor track record when it comes to building trust when migrating from existing services to a new solution that is supposed to add quality and benefit, given that it is a relatively new technology with potential uncertainty [18].

Another issue is that many HEIs are unskilled and lack the required knowledge to manage risk, as well as service performance at a third party service level, all of which requires a degree of confidence [15].

Katz, Goldstein [17] found that Institutional culture is cited as a barrier to adopting the cloud. Another issue cited by Katz is IT security and privacy is given the regulatory compliance limiting potential adoption of Cloud Computing. Potential adopters stressed that they would only be persuaded to move to the cloud if the security and privacy issues surrounding the cloud are addressed.

IV. PLANNING FORIMPLEMENTATION OF CLOUD COMPUTING IN HIGHER EDUCATION

There are various decisions to be planned before implementing or migrating to Cloud computing in any HEI. It may include:

1) Understanding the needs of major stakeholders or users
2) Selecting the right Cloud service (Saas, Paas, Iaas) for different users
3) Planning before each cloud service
4) Decision on deployment strategy

A. Understanding the needs of major stakeholders

There are four major stakeholders: Students, Faculty members, Administrators or staff members and senior management. Each stakeholder has very different and specific expectations from Cloud.

1) Students' needs a cloud solution which enables them to access course materials and emailing systems from a range of devices with anytime anywhere features. It relates to the cloud in terms of on-demand self-service and broad-network access characteristics [2] [7].
2) Faculty members needs cloud solution that is secure and has the ability to facilitate research and the teaching learning process. Cloud may help them plan, coordinate and conduct lectures in a collaborative manner. Even in research, benefits may include increase in innovation, increasing inter disciplinary collaboration, reducing inefficiencies and duplication. Therefore, lecturers were very much open to a cloud solution that would help to improve student-teacher relationships and better research environment. It relates to the cloud in terms of on-demand self-service and broad-network access characteristics [2] [7] [15]
3) Administrators or staff demand a cloud solution that is secure and private as these were perceived key risks to non-adoption identified [15] [16] [17] [18] [21]. Since they are responsible for handling sensitive data on a daily basis. Security and privacy are crucial when considering Cloud, and it has the highest priority. For adoption, it relates to the cloud in terms of resource pooling which refers to the use of cloud resources via a network, and cloud vendors use shared computing resources to provide cloud services to their users. [2] [7]
4) Senior Management mainly needs cloud solution in terms of rapid elasticity or scalability which is the process of adjusting cloud system resources to meet user demands. They are also concerned as the cloud can automatically control and enhance resource use via the introduction of a measured service, which can be altered to suit the needs of the HEI. This is a highly efficient and cost-effective aspect of the cloud as a metering service only allows users to pay for what they use, and thus no money is wasted on downtime. [2] [7]

B. Selecting the right cloud service?

There are three different types of cloud offerings. Your priorities and requirements determine the level of cloud capabilities to explore.[22]

1) **SaaS:** The cloud hosts the applications for productivity such as office360, contact management such as email, payment processing such as accounting etc. It can not only lower the expenses associated with software acquisitions. But also helps HEIs with limited IT resources to deploy and maintain needed software in a timely manner while, at the same time, reducing energy consumption and expense.

   A growing number of academic institutions are turning to SaaS for their desktop applications. Such as using e-mail solution hosted in the cloud. Students, staff and faculty members now have the free collaboration tools they want, people on campus have the tools they need to work together such as LMS, and administrators are finding it easier and more cost-effective to manage.

   Institutions may consider SaaS for the following education needs:

   - E-mail, calendar, and instant messaging
   - Desktop productivity, such as document creation and sharing
   - Collaboration and presence
   - Payment processing
   - Identity and relationship management

2) **PaaS:** PaaS is the operating environment of the cloud with the tools needed on demand to create and host online services, software, Web sites, and mobile applications. With PaaS, institutions would have their own software development team that can concentrate on delivering applications rather than on the underlying infrastructure, which a service provider maintains and updates in its data centers.

   With PaaS, HEI can develop new applications or services in the cloud that do not depend on a specific platform to run, and can make them widely available to users through the Internet. PaaS delivers cloud-based application development tools in addition to services for testing,

deploying, collaborating on, hosting, and maintaining applications.

The accessibility of PaaS offerings enables any programmer to create enterprise-scale systems that integrate with other Web services and databases—an aspect of cloud computing that fosters additional opportunities for education IT and allows bigger thinking.

The open architecture of PaaS can support integration with legacy applications and interoperability with on-site systems—important considerations because education operates in a mixed IT world. Interoperability gives you the flexibility to take advantage of cloud benefits while retaining data and applications on-site as needed.

Institutions may consider PaaS for the following education needs:

- Coordinating collaborative software development projects that involve multiple departments
- Developing applications that can be shared by many users simultaneously
- Creating social networks or communities according to grade, school, or area of study
- Porting on premise, line-of-business applications to the cloud
- Deploying Web services quickly
- Creating mashups of data to meet accountability and assessment needs

3) **IaaS:** It provide compute power, memory, and storage, typically priced per hour according to resource consumption. Some call IaaS bare metal on demand. Institution pay for only what they use, and the service provides all the capacity needed. Here HEI would be responsible for monitoring, managing, and patching on-demand infrastructure.

   One big advantage of IaaS is that it offers a cloud-based data center without requiring to install new equipment or to wait for the hardware procurement process. This means HEI can get any IT resources at their place that otherwise might not be available.

   With IaaS, savings come from hardware and infrastructure costs but not necessarily from staffing because institution are still responsible for system management, patch management, failover and backup, redundancy, and other system management tasks. Depending on the service, an IaaS provider typically handles load balancing, monitoring, and scaling automatically, and you manage your cloud deployments.

   Institution may consider IaaS for the following education needs:

   - Hosting community and other public-facing Web sites.
   - Storing—especially public data. The public cloud might even be a safer place to store data than institutional data center, according to a team of engineers and computer scientists at the University of California. However, data classification is a key requirement for evaluating risk and making informed decisions about the use of cloud computing.
   - Testing large-scale applications in a discrete environment before deploying publicly.

C. Planning before each cloud service

Following points may be considered while planning to switch or migrate to any of the selected cloud service. [22]

1) **SaaS:** The following points may be considered for SaaS
   a) **Ability to customize or configure**: Select applications that a user can customize or configure as per the environment. Not all SaaS providers allow configuration.
   b) **Availability of all the needed features**: While selecting ensure that a SaaS solution has all the features for users. Some hosted versions of applications are not identical to their equivalent desktop versions.
   c) **Costs vs benefits**: Rather than focusing solely on costs—look for ways to improve efficiencies. For example, can on-demand resources free your time to offer more critical services to students or staff, reduce time spent on more mundane IT chores, or get features into use more quickly?
   d) Variety of **approaches** exists for running applications in the cloud. Look for service-oriented architectures (SOA), Web services standards, and Web application frameworks—they're easier to integrate.
   e) **Owning Data**: Service level agreement (SLA) with a provider should explicitly specify that the client owns the data—without a time limit. User don't want to get locked in if they need to switch providers.
2) **PaaS:** The following points may be considered for PaaS
   a) Programmers or developers in the institution should implement a secure, ***development-life cycle methodology*** for their applications that are hosted in the cloud, and evaluate the cloud provider's compliance against a similar process.
   b) ***Plan to scale your service***. The multi-tenant architecture of PaaS offerings often comes with concurrency management, scalability, failover, and security so that institution can think big when testing and developing software.
   c) Select a cloud provider that help institution to ***develop more custom Web apps faster***. For example,

some PaaS environments help geographically dispersed teams collaborate and share code or include services for creating data models and policies visually.

d) Compare ***how well vendor tools enable portability across clouds***. Do they support application interactions and provide resources and policies for service interoperability? Some providers may not allow you to take your application and put it on another platform.

3) IaaS: The following points may be considered for IaaS

a) **Weigh the impact** to institution IT team/department before adopting IaaS because they are still responsible for software patches, maintenance, and upgrades. Monitoring and managing applications in a provider's data center, in addition to those host in premise, can become a burden to staff.

b) **Security and compliance**: Create a strong internal IT team to manage security and compliance requirements together with a chosen cloud provider.

c) **Understanding requirements**: Make sure that IT team have a thorough understanding of how institution current system works before outsource any of it to the cloud. It is necessary for the institution to know what they are getting.

d) **Security and identity management**: Negotiate service-level agreements (SLAs) to get the level of security and identity management required by the institution.

e) **Understanding pay-per-use**: Institute must understand the demand and take advantage of pay-per-use pricing for some of the applications that they run in a data center. Use existing, dedicated capacity for baseline resources while IT team assess the impact on IT staff.

f) **Access methods**: Look at the access methods for an IaaS offering, and see if existing standards are used. Common protocols include XML (Extensible Markup Language), REST (Representative State Transfer), SOAP (Simple Object Access Protocol), and FTP (File Transfer Protocol).

g) **Plan an exit strategy**: In future, If institute choose to change providers, make sure that IT team know how to get applications from the cloud.

D. Decision on deployment model

In the cloud, institution share computing resources with others. The right deployment model is the one that meets institution data classification (based on stakeholders needs), security, privacy, and other IT requirements. Between the flexibility of the cloud and the power of on premise software, education institution must map a cloud deployment strategy that works. Following points may be considered for selecting a model: [22]

1) **Public cloud:** This is the cost-effective options for all the major application requirements of the institution on a pay-per-use bases**.** Resources are easily made available on demand within a short span of time**.**

2) **Private cloud:** Institutions with sensitive information and workloads would probably never want all of their data in a public cloud. Private clouds offer the scalability and shared resources of cloud computing on institution terms. To achieve true cloud scalability in a private cloud, IT team must forecast demand to support the requisite degree of excess capacity and invest accordingly.

3) **Community cloud:** A cloud infrastructure shared exclusively by certain groups (here it can a group of institutions)for better collaboration and managed by the group or a third party. It can be hosted on or off premise. It may be more expensive than public clouds to provision but other service requirements may be tailored to the requirements of the community.

4) **Hybrid cloud:** An approach that uses a public cloud for some services, such as managing mails, announcements etc, but uses a private data center for others, such as storage of sensitive data that need compliance.

In the following cases, cloud may be avoided: [22]

- A regulatory or security issue prevents the institution from hosting even encrypted data in a public cloud.
- An application requires greater reliability or speed than the Internet.
- Institution want control over their assets, including physical possession of the hardware where data resides on. A private cloud offers is the solution if institution still want to take advantage of cloud benefits.

V. CONCLUSION

Cloud computing is an emerging technology paradigm that promises HEIs to cope with rapidly changing software and hardware needs at lower cost. Other benefits include increase in organizational efficiency, improved agility and stimulate innovation. Before taking a decision to dip into the world of Cloud Computing, it must be analysed both ways- from the benefits as well as from that of the risks point of view.

Therefore, to support a smooth shift/transition, HEIs must first plan a comprehensive cloud computing strategy that addresses the challenges unique to each institution. In this article, apart from discussing the issues related to potential benefits and risks, we have presented four steps for planning for smooth implementation or migration of cloud computing in higher education.

REFERENCES

[1] McCREA, B. (2009). "IT on Demand: The Pros and Cons of Cloud Computing in Higher Education," Campus Technology. [Online], [Retrieved Feb 23, 2020], https://campustechnology.com/Articles/2009/08/20/IT-on-Demand-The-Pros-and-Cons-of-Cloud-Computing-in-Higher-Education.aspx?p=1

[2] Sultan, N. (2010). "Cloud Computing for Education: A New Dawn?," International Journal of Information Management, 30, 109–116

[3] Mathew, Saju (2012), "Implementation of Cloud Computing in Education - A Revolution," International Journal of Computer Theory and Engineering, Vol. 4, No. 3, June 2012

[4] MarinelaMircea and AncaIoanaAndreescu, "Using Cloud Computing in Higher Education: A Strategy to Improve Agility in the Current Financial Crisis", Communications of the IBIMA, http://www.ibimapublishing.com/journals/CIBIMA/cibima.html Vol. 2011 (2011), Article ID 875547, 15 pages DOI: 10.5171/2011.875547, IBIMA Publishing

[5] Konard, K. (2019) "Educause 2019: Tips for cloud implementation in Higher education", *EdTech: Focus on Higher Education*. [Online]. https://edtechmagazine.com/higher/article/2019/10/educause-2019-tips-cloud-implementation-higher-education

[6] Samah A. Massadeh and Muhammad A. Mesleh, "Cloud Computing in Higher Education in Jordan," World of Computer Science and Information Technology Journal (WCSIT) ISSN: 2221-0741 Vol. 3, No. 2, 38-43, 2013

[7] P. Mell and T. Grance, "The NIST definition of cloud computing," National Institute of Standards and Technology, Gaithersburg, Report on Computer Systems Technology, Sep. 2011.

[8] Boja, C., Pocatilu, P. and Toma, C. (2013). The Economics of Cloud Computing on Educational Services. 3rd World Conference on Learning, Teaching and Educational Leadership, 93 (21) October, 1050-1054.

[9] Gonzalez, N., Miers, C., Redígolo, F., Carvalho, T., Simplicio, M., Näslundy, M., and Pourzandiy, M., (2012). An quantitative analysis of current security concerns and solutions for cloud computing. Escola Politécnica at the University of São Paulo (EPUSP), São Paulo, Brazil.

[10] Angela Lin,Nan-Chou Chen, (2012). Cloud Computing as an Innovation: Perception, Attitude, and Adoption, International Journal of Information Management. Retrieved from: http://dx.doi.org/10.1016/j.ijinfomgt.2012.04.001.

[11] Tumbas, Pere &Matkovic, Predrag&Sakal, Marton&Tumbas, Sanja. (2014). Exploring the Potentials of Cloud Computing in Higher Education.

[12] Ali, M. (2019), "Cloud Computing at a Cross Road: Quality and Risks in Higher Education." Advances in Internet of Things, 9, 33-49.https://doi.org/10.4236/ait.2019.93003

[13] Patterson, D. (2010). "Cloud Computing and the RAD Lab," UC Berkeley, Reliable Adaptive Distributed Systems Lab," [Online], http://www.mvdirona.com/jrh/TalksAndPapers/PattersonMSCloudComputingRADLab.pdf

[14] NIST, (2009). "Presentation on Effectively and Securely Using the Cloud Computing Paradigm v25," http://csrc.nist.gov/groups/SNS/cloudcomputing/cloud-computing-v25.ppt

[15] Shayan, J., et al . (2014) Identifying Benefits and Risks Associated with Utilizing Cloud Computing. International Journal of Soft Computing and Software Engineering, 3, 416-421.

[16] Djemame, K., et al . (2016) A Risk Assessment Framework for Cloud Computing. IEEE Transactions on Cloud Computing, 4, 265-268. https://doi.org/10.1109/TCC.2014.2344653

[17] Katz, R., Goldstein, P. and Yanosky, R. (2009) Demystifying Cloud Computing for Higher Education. EDUCAUSE Center for Applied Research Bulletin, 19, 1-13.

[18] Katz, R., et al . (2010) Cloud Computing in Higher Education. https://net.educause.edu/section_params/conf/CCW

[19] Ali, M. (2019) The Barriers and Enablers of the Educational Cloud: A Doctoral Student Perspective. Open Journal of Business and Management, 7, 1-24. https://doi.org/10.4236/ojbm.2019.71001

[20] Shakeabubakor, A.A., Sundararajan, E. and Hamdan, A.R. (2015) Cloud Computing Services and Applications to Improve Productivity of University Researchers. International Journal of Information and Electronics Engineering, 5, 153-157. https://doi.org/10.7763/IJIEE.2015.V5.521

[21] Reeves, D., et al . (2009) Cloud Computing: Transforming IT. Burton Group Publication, Utah, 33.

[22] Cloud computing in education Savings, flexibility, and choice for IT A Microsoft U.S. Education white paper April 2010 www.microsoft.com/educloud