An Analysis of Applicability of Cloud Computing in Higher Education

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Abstract

Modern education is changing and so is teaching in classrooms due to the advent of technology. Students are expecting and demanding more services from their institutions. Their classes do not get over with school timings. Rather, their learning continues 24x7 wherein they expect their educational institutions to keep pace with their demands. This is where the innovative role of cloud computing comes in order to meet their requirements. According to Mircea & Andreesu, cloud computing is a next generation platform that allows institutions and organizations with a dynamic pool of resources to reduce cost through improved utilization. Educational institutions these days are facing many problems with the increasing need of IT and IT related infrastructure. In such a scenario, cloud computing can be a reliable solution for fulfilling the need of software, storage services, and infrastructure of such institutions as it is based on existing IT technologies such as the internet, grid computing, virtualization etc. Cloud computing has become a buzzword these days.

The objective of this paper was to explore the role of cloud computing in Indian educational institutions i.e. how cloud computing through its various deployment & service models can help improve teaching, pedagogy, and agility of an institution? Further, this paper critically evaluated the crucial risks and challenges that institutions face in taking advantage of this emerging cost-effective technology which has the potential of bringing in a revolution in the education sector. This paper used live case studies of various Indian and international educational institutions which are using this technology to meet the ever increasing pressure to deliver more for less as the data for discussion. There are very few papers which discuss live cases of educational institutes where cloud computing is playing a crucial role and even fewer studies discuss the risks and challenges associated with this technology. Hence, this study on cloud computing brings in a real perspective through cases which are of utmost importance for better understanding of this technology in the field of education. It would provide much clearer knowledge of implications of implementation of this technology.

Keywords: Cloud computing, Characteristics of cloud computing, Educational institutes, Infrastructure, Teaching, Revolution,

I. INTRODUCTION

According to Lazowska, Lee, Elliott, and Smarr [3], "Higher education has always been acknowledged as one of the pillars of societal development. Through the partnership between universities, government and industry, researchers and students have proven their contribution to the transformation of society and the entire world economy". Commenting on the present day education scenario, Golden [4] stated that, "At the present moment, universities are confronted with a dramatic increase of costs in higher education, more than the inflation rate and a decrease of universities' budgets which leads to the pressure of finding some alternative means of reaching their purpose i.e. education of students and accomplishing research". Mircea & Andreescu [5] suggested that universities must bring in a change in their way of operation to become much more service oriented, effective, and efficient in all their internal and external processes so as to be able to withstand these pressures.

Cloud computing has become progressively more popular in modern businesses as it provides flexible on-demand and dynamically scalable computing infrastructure using the internet. Mell & Grance [6] termed cloud computing as a "silver bullet" in the educational field. According to Jain and Pandey [7], "In the academia, cloud computing is a powerful tool that offers great scalability and flexibility, making it possible for students, staff, faculties, administrators, and other campus users to access file storage, databases, and other university applications anywhere anytime.". Ercan [8] stated, "Universities especially in more developed and advanced countries have adopted this technology for many reasons ranging from reduced cost of hardware

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acquisition and maintenance to greater access of web 2.0 applications for teachers and learners and ultimately better academic outputs".

II. OVERVIEW OF CLOUD COMPUTING AND THE MODELS

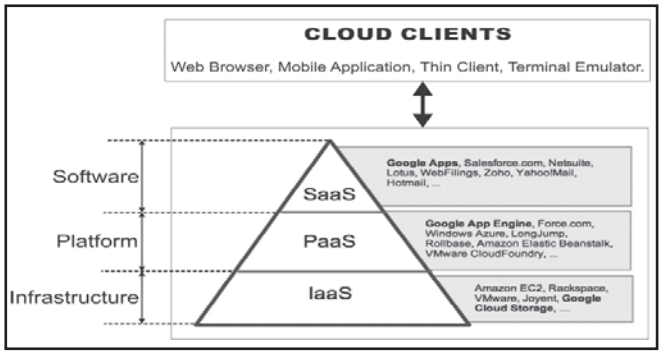
Méndez and González [9] defined cloud computing as "a computing model based on networks, especially based on the internet whose task is to ensure that users can simply use computing resources on demand and pay money according to their usage by a metering pattern". Therefore, a new business model is being created where the services it provides are becoming computing resources. According to NIST [10], "Cloud computing is 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".

A. Service Models

Cloud computing consists of three service models (Fig. 1).

1. Infrastructure as a service (IaaS)
2. Platform as a service (PaaS)
3. Software as a service (SaaS)

Fig .1. Cloud Computing Service Models.



Adapted from on the Evolution of Virtualization and Cloud Computing : A Review. Source: http://pubs.sciepub.com/jcsa/2/3/1/

1) Infrastructure as a Service (IaaS): IaaS is the lowest layer of cloud computing. At this level, consumers can use IT infrastructures services and applications such as storage, processing, networks, and other hardware resources like processor, memory, bandwidth, and HDD storage on lease for their business operations. Consumers are in a way provided virtual machines for their business operations. Amazon EC2 is an example for IaaS. The key advantages of IaaS for the consumer are: cost savings, system acquisition bypass scalability, portability, better power, and control, predictability, expert guidance, and enhanced agility.

2) Platform as a Service (PaaS): As compared to IaaS, PaaS is a higher layer of cloud computing. PaaS providers offer consumers a platform to develop, run, and manage consumer-created or acquired applications. Thus, it allows rapid creation of web applications easily and very quickly as the PaaS provider is responsible for managing the complexity of buying and maintaining hardware, software, and infrastructure underneath it. Example for Paas includes Google App Engine. The advantages of PaaS for the consumer include easy access to development platform, reduced costs as consumers do not have to maintain hardware and network infrastructure, easy marketability, lower development failure risk, and increased security.

3) Software as a Service (SaaS): SaaS providers offer consumers the software for usage as a service on a pay-per-use basis. Based on his own needs the consumer can choose the software and access it through the internet on his web browser, PDA, etc. Examples of SaaS include Google mail, Google doc, SalesForce.com etc. The consumer benefits of SaaS are easier administration as infrastructure maintenance and software updates are managed by the SaaS provider, global accessibility, easier collaboration, and compatibility.

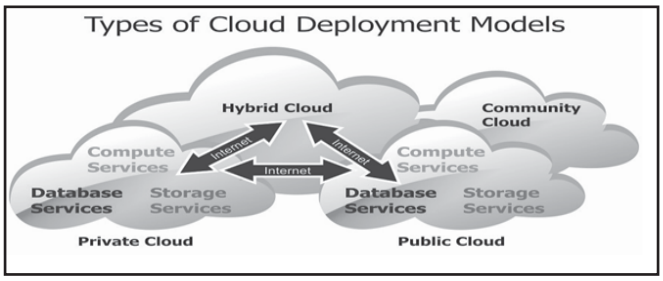
B. Deployment Models

The four kinds of deployment models (Fig. 2) are :

1. Public Cloud 2. Private Cloud 3. Hybrid Cloud 4. Community Cloud.

Public Cloud : In a public cloud deployment, the general public are offered cloud services for open use over the

Fig 2. Types of Cloud Deployment Models.



Adapted from Adapted from Choosing your Cloud Computing Deployment method (2016).

public internet. The terms & conditions as well as costing and values are defined by the service provider. Some of the most common examples of public cloud services are S3, Amazon EC2, Google App Engine etc.

Private Cloud is a cloud model which is specifically for large number of employees/users of a single organization. It is managed by the organization itself or a third party. It helps in maximizing and utilizing existing in-house resources as well as in maintaining data privacy and trust for security. Academic institutions mostly have their own private cloud which are utilized for teaching purpose and research.

Community Cloud provides for a specific group of persons or organizations who have a common interest or shared concerns such as common mission, security, and policy requirements etc. Cloud resources are shared by several organizations that have common concerns. Central banks and government departments often use community clouds. **Hybrid Cloud** is a mix or a composition of two or more clouds (public, private, and community). For example, for very sensitive data processing private cloud may be used, whereas, for less sensitive data public cloud maybe used by a consumer. Some examples of hybrid cloud are Force.com and Microsoft Azure.

Keeping in mind their own requirements, consumers can choose one or more services provided by third parties. They do not require any technical knowledge of IT. They are simply leasing or accessing the needed services from the providers using the cloud. Sultan [12] stated, "Cloud computing is highly scalable and creates virtualized resources that can be made available to users. The quality of the service becomes a crucial factor of the cloud computing success."

III. CLOUD COMPUTING IN EDUCATION

Cloud computing is being increasingly used in academic institutions. According to Sasikala and Prema [36],"Within the present economical context, the use of cloud computing becomes a necessity and not an option for many universities. This aspect is due to a multitude of factors such as cost increase, pressure of income increase, students' success, institutional performance, and competition in development from an educational point of view. The cloud is a balance between control and economy of scale, offering a lower total cost of ownership model". The main advantage of cloud computing is cost effectiveness in terms of implementation of both software and hardware. Katzan [37] proclaimed, "Cloud computing can be used to develop quality, low cost education on a global basis".

According to Sultan [12], renowned universities all over the world have realized the efficiency cost effectiveness and potential of the cloud. He gave examples of universities from UK, Africa, U.S., University of California, Washington State University, Deakin State University, and London College of Business where cloud computing technology is being utilized. "Cloud computing offers to universities the possibility of concentrating more on teaching and research activities rather than on complex IT configuration and software systems through a fast IT implementation", said Wyld [13]. He further stated that higher educational institutions are nowadays either developing their own cloud resources or environment or they are leasing or purchasing cloud resources from third party service providers. Further, Flinders [14], in his research found that governments are playing a very crucial and supportive role for higher education institutions by funding their cloud computing initiatives. Colleges and universities are migrating to cloud computing environments for a variety of reasons, particularly economic. Commenting upon complexity in pedagogy these days, Tout, Sverdlik, and Lawver [15] stated that cloud computing can help in reducing the complexity in education sector. According to Thorsteinsson, Page, and Niculescu [16], "Cloud solutions can be used to support cooperative learning and socially oriented theories of learning, using computer technologies to support collaborative methods of instruction". Pocatilu, Alecu, and Vetrici [17] commenting on the benefits of cloud computing said that it offers many advantages and beneficial results to e-learning solutions. They elaborated how technologies such as virtualization, centralized data storage, facilities for data access monitoring, as well as availability of infrastructure, platform, and educational services directly through cloud providers have tremendously helped educational institutions. Wyld [13] in his research gave example of Commonwealth countries where many colleges and universities had collaborated in the formation of Virginia Virtual Computing which allowed these educational establishments to not only improve the availability of IT resources and assets to students and researchers but also reduced their IT expenditure, and further allowed them to maintain their own data centers.

Similarly, Mell and Grance [6] gave example of North Carolina State University, which by utilizing cloud services could substantially decrease their software licensing costs as well as save on employee costs as they could reduce the number of employees from 15 to 3 required to maintain IT resources on campus. Bristow, Dodds, Northam, and Plugge [18] studied the Hawaian University and their cloud based community-source project named Kuali Ready, the aim of which was to provide business continuity planning service. Cloud computing has become very important in the education sector. According to Méndez & González [9], "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. Currently, there are many practices and examples regarding the use of cloud computing".

Universities and higher educational institutions can greatly benefit from the cloud. For example, through IAAS, university administrators can use cloud as a digital place where data and servers can be stored and protected. This would provide them much better cost effective and more efficient control of their resources. With leasing of PaaS resources, universities can use it as a platform to not only develop their own unique services but are also be able to access other more advanced applications and services. Lastly, with the renting of Software as Service, universities and their students would be able to use a huge and wide range of software and applications online. SaaS allows users to access thousands of useful applications available on the internet. Goel, Kiran, and Garg et al. [19] stated, "Most of the cloud computing structures used by universities are hybrids, i.e. they are eclectically modified to serve the institution in the most efficient way possible. Provided that some minor details are resolved, cloud computing will definitely redefine the whole educational process itself". Mircea & Andreescu [1] pointed to the importance of analyzing this trend from the point of view of both benefits and potential drawbacks. As outlined in tabl I they identified the nine major benefits and limitations of using cloud computing in education.

Praveena & Betsy [20] stated, "There are iterative benefits of connecting universities through the infrastructure of the cloud. There are also efficiencies to be gained in aggregating IT services, including personnel, licensing, expertise, and business continuity". According to Sultan [12], "The pressure to reduce costs and rapid advances in technology are compelling arguments for cloud computing adoption by colleges and universities. Cloud computing improves efficiency, cuts costs, and is convenient for the educational sector. Cloud computing involves a paradigm shift for university IT departments". Supporting the idea, Laisheng & Zhengxia [21] stated that because cloud computing is proving to be a low cost e-learning solution for faculty, students, and researchers, it is being increasingly used in e-learning systems in colleges and universities.

TABLE I.
BENEFITS & LIMITATIONS OF CLOUD COMPUTING IN HIGHER EDUCATION

Benefits	Limitations
Access to applications from anywhere	Not all applications run in cloud
Support for teaching and learning	Risks related to data protection and security and accounts management
Software free or pay per use	Organizational support
24 hours access to infrastructure and content	Dissemination politics, intellectual property
Opening to business environment and advanced research	Security and protection of sensitive data
Protection of the environment by using green technologies	Maturity of solutions
Increased openness of students to new technologies	Lack of confidence
Increasing functional capabilities	Standards adherence
Offline usage with further synchronization opportunities	Speed/lack of Internet can affect work methods

Note: Adapted from using cloud computing in higher education: A strategy to improve agility in the current financial crisis. [1].
Source:http://www.ibimapublishing.com/journals/CIBIMA/2011/875547/Table%201.jpg

IV. PROMINENT CLOUD COMPUTING PROVIDERS

Some of the prominent cloud computing third party service providers especially in the field of education include the following:

A. Microsoft Live@edu for education

"Microsoft Live@edu is meant for educational needs. It provides a set of hosted collaboration services for educations institutions. The hosted services include collaboration services, communication tools, mobile, desktop, and web-based applications. It has the feature of data storage capabilities. Office Live Workspace, Windows Live SkyDrive, Windows Live Spaces, Microsoft Shared View Beta, Microsoft Outlook Live, Windows Live Messenger, and Windows Live Alerts are the part of Live@edu suite. By means of free registration process universities, colleges, and schools can enroll in the program". [22]

B. Google Apps for Education

"Google Apps is a collection of web-based programs and file storage that run in web browsers without requiring users to buy or install software.. Users can simply log in to the service to access files and tools to manipulate them. The communication tools of Google Apps are Gmail, Google Talk, and Google Calendar, and the productivity tools are Google Docs: text files, spreadsheets, and presentations, iGoogle, and Google Sites to develop web pages. Google Apps allows institutions to use their own domain name with the service and to customize the interface to reflect branding of the institution. In this way, a college or university can offer the functionality of Google Apps in a package." [23]

C. Amazon Web Services for Education (AWS)

"In software, AWS marketplace is an online store that helps customers find, buy, and immediately start using software that runs on the AWS cloud [24]. It includes software from trusted vendors like SAP, Microsoft, IBM, Canonical, and 10gen as well as many widely used open source offerings including Wordpress, Drupal, and MediaWiki. Educators, academic researchers, and students can obtain free usage credits and can utilize on-demand infrastructure. Researchers around the world have access to global computing infrastructure and storage capacity of the AWS cloud. Instead of purchasing a large amount of hardware, researchers can get started by simply opening an AWS account."

D. Oracle Cloud Platform Services for Education

"Oracle has introduced three cloud platform services - Oracle Document Cloud Service, Oracle Database Cloud Service, and Oracle Java Cloud Service for higher education institutes to support their endeavor [25]. **Oracle Document Cloud Service** enables sharing of files between staff and students or between project teams. The documents can be accessed on mobile or on desktop/laptop; online or offline. Since access to documents are rule-based, only appropriate faculties or students gain access to documents, depending on sensitivity of information included. The documents can be customized with the college logo to maintain legitimacy. Through Oracle Database students can easily perform database management and development operations in a cloud model. **Oracle Java Cloud service** provides students with an environment to build, deploy, and manage Java applications. "

V. USAGE OF CLOUD COMPUTING IN EDUCATIONAL INSTITUTES WORLDWIDE

A. Cornell University US

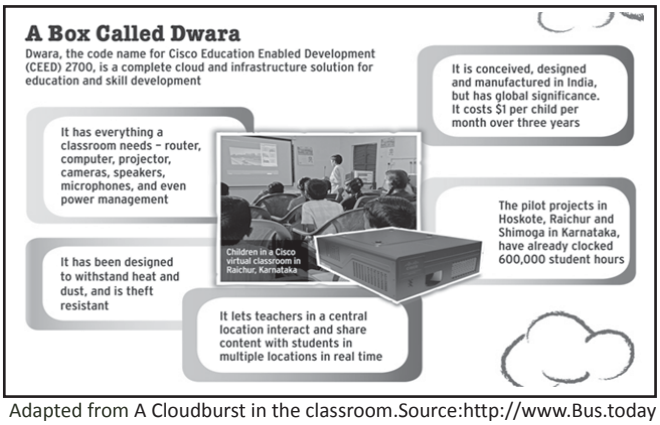
Cornell is one of the most respected and prominent institutions of the US. It has been one of the first educational institutions to move its resources to Cloud. It leased cloud services from a third party vendor offering cloud services. Therefore, it was able to highly reduce its costs of technology infrastructure. Cloud vendor also allows Cornell to scale up or scale down the resources as per the change in demand. Cornell can further buy additional services as per requirement or demand. They do not have to anticipate and plan their IT needs in advance as the cloud model allows Cornell to buy only what it needs and when it is needed. Cornell can purchase a la carte the IT services that it requires. It can now take advantage of economies of scale. Google for example, hosts millions of email accounts of Cornell students and other users less expensively than Cornell, which can host thousands. Cornell can now focus on its core business – its education, research, and outreach missions [26].

B. Dwara usage in Karnataka Education Department

Cisco has developed Cisco Education Enabled Development (CEED) 2700 which is an integrated hardware-software cloud solution for education (Fig. 3). Code-named Dwara, it is an all-in-one box that aims to decrease the cost of implementing cloud solutions to a dollar per child per month. Aravind Sitaraman, President, Inclusive Growth at Cisco, stated, "It lowers costs, provides a degree of scalability, and keeps the complexity in a central location. If you have a teacher in one location, and she is good at mathematics, this technology can be used to virtualize her to other locations."

The Karnataka government in collaboration with CISCO has been using Dwara in government schools and universities. It is being used to train teachers as well as a resource for students. Many other institutions have also adopted this technology for educational dissemination. Schools such as chain of Oakridge International Schools and Nettur Technical Training Foundation have also implemented this technology [27].

Fig. 3. Dwara:Cloud and Infrastructure Solution.

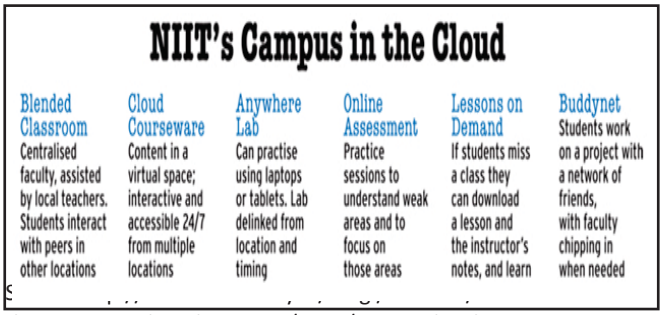


Adapted from A Cloudburst in the classroom.Source:http://www.Bus.today.in/Mag./features/cloud-could-fill-the-gaps-in-india-Edu.-sector/story/197270.html

C. NIIT Campus, India

The largest on-ground implementation is NIIT's Cloud Campus which has been implemented in more than 150 centres in India and is one of the largest on-ground implementations [27]. It provides its students 24 hour access to course content, faculty, labs, and collaborative platforms. Students of big and small cities can access these educational resources as per their convenience and time (Fig. 4). NIIT Chief Executive G. Raghavan said, "Cloud campus basically addresses the needs of flexibility and learning on demand. Flexibility will be in terms of when, what, and how to learn," he said. "This is different for each person, so we have to get an optimal mix of pedagogy to get learning effectiveness."

Fig. 4. NIIT's Cloud advantages. Adapted from a Cloudburst in the classroom



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D. Deakin University's custom cloud systems

Deakin University, Australia's web-based system called DeakinSync is an example of major cloud implementation of this type in the education field of Australia [28]. DeakinSync makes learning environment and experience more efficient for students. It provides easier access to shared open resources of the university. DeakinSync assimilates multiple Microsoft cloud tools which allow students to manage their assignments, connect their apps, and ensure their availability round the clock. This tool showed excellent performance in the first trimester of 2015. The idea behind the tool was to increase presence on high traffic.

Mr. Roberts, CIO, said, "Besides the custom platforms, Deakin University also uses Microsoft's cloud systems to connect its research and academic community in order to create a functional learning and collaboration environment. The key benefits include research collaboration improvement, mostly achieved through Lync and SharePoint that represent secure sharing and collaboration spaces. A consistent set of tools for all students and researchers regardless of their actual physical location, enhanced student experience that enables everyone to work efficiently from anywhere and innovative use of technologies among both students and academics."

E. The University of São Paulo

USP is a global research powerhouse. It is Brazil's largest and most prestigious public university. Relentless dedication to advancing research in all areas of knowledge and accelerating the time to discovery have helped USP become one of the world's leading research institutions [29]. In 2012, USP embarked upon one of the most ambitious cloud projects in all of Latin America. The project, now known as "Cloud USP," was aimed at consolidating the university's 150 data centers into 6 and bringing all its corporate, educational, and research environments together in a massive private cloud built on FlexPod. Today, Cloud USP provides access to online education opportunities to more than 150,000 students on campus and across the globe. Students are accelerating learning and enriching their education with unprecedented access to real-time lectures, fast access to e-mail, and digitized access to the school's library and museum collections. The first and largest educational private cloud deployment in Latin America, Cloud USP is attracting the attention of other educational and research organizations in the region, which now look to USP as a model for cloud in education. USP also has plans to open its private cloud to offer Cloud USP as a service to other research institutions in Brazil. It is

confident that when it does, it will be able to deliver the same high levels of service, performance, and security to all of its users.

F. Universitas Terbuka (UT), Jakarta

With 406,000 students, Jakarta-based Universitas Terbuka (UT) is a mega university and ranked the third-biggest in the world by the UK's Open University. What makes UT exceptional is its commitment to provide degree courses to students from all levels of society at an affordable cost, irrespective of what they do or where they live. UT, therefore, has an eclectic mix of students – rural and urban, employed, and stay-at-home young and old. To improve the performance of its core Moodle-based learning management system (LMS), UT transitioned it to Microsoft Azure in 2015 [30]. Today, costs are down 20% and the LMS enjoys world-class security and automated backup. Lecturers are leveraging Azure's openness to create top-grade learning experiences. UT's 406,000 distance learning students now enjoy fast, problem-free access to their online course materials. The university has reduced IT costs and IT staff have reduced the time spent on issue and incident management. Today, UT has the infrastructure it needs to pursue its goal of being a world-class distance learning university. Students, teachers and administrators are all happier because Azure PTTJJ works flawlessly. The result is that UT is providing a superior service to its students. It can now provide high quality e-learning resources that can easily be accessed by students wherever they live with minimal delays. Azure's openness and ability to interoperate with a wide range of solutions – open source or proprietary – ensures that UT will be using the latest technology for our long-distance teaching and learning (Azure in Education, n.d.).

G. Edreams, India

eDreams Edusoft, an education technology company was set up in 2010 in Bengaluru. They found that personalized learning was a critical problem with the Indian education system [31]. To overcome this problem, they developed and implemented Funtoot. Mr. R. K. Sharma, M.D., EDreams stated, "Funtoot is an intelligent and adaptive online tutor helps every child by enabling personalized learning. It observes, assesses, identifies, interacts, encourages, and tutors each student based on his/her individual characteristics". This leads the company to be an award winner at NASSCOM Social Innovation Honors 2013 [32].

Edreams utilizes both private and public cloud computing using Microsoft software and cloud services. The biggest benefit of Microsoft Azure Cloud technologies for eDreams Edusoft was that it was able to implement Funtoot at a rapid pace with minimal development time. With Windows Azure, scaling is simple, immediate and at low cost.

VI. RISKS AND CHALLENGES OF CLOUD COMPUTING AND REASONS OF LOW ADOPTION IN UNIVERSITIES & EDUCATIONAL INSTITUTIONS

Katz, Goldstein, and Yanosky [33] stated that as compared to commercial and governmental sectors, cloud computing is still in a nascent stage in the education sector. Universities are still in "early adopters" phase. Low, Chen, and Wu (2011) [34] and Mircea and Andreescu [5] found that inspite of the enormous advantages and benefits of cloud computing, the adoption is on a low scale in higher education. The barriers to adoption as identified by them include "concerns regarding security and confidentiality of data stored in the cloud, privacy, and regulatory compliance, vendor lock-in, location of data, legal jurisdiction, and reliability of the cloud service provider" (Network Online, 2011). Their study additionally discovered that "the relative newness and underdevelopment of cloud services" also further acted as barriers to cloud adoption by higher educational institutions. Some of the associated risks or issues of cloud computing tools include concerns about:

A. Data and Privacy Protection

Universities tend to lose strict control over their sensitive data and information as their data is stored on third party's hardware. The cloud service providers are responsible for the protection and security of data from hackers, both internal and external. Due to the very nature of cloud computing, it is very difficult to find out where data of educational institutions is stored, if it has been breached, who has accessed, if it has been moved, and what particular security protocols are in place. There is also a risk of incomplete or unsecured deletion of confidential data of universities due to multi-tenancy, and reuse of hardware and software resources in cloud computing.

B. Isolation and Segregation

Various cloud resources such as network, storage, and computing capacity are shared between multiple users. Because of this very basic nature of cloud computing that is built on features multi tenancy and shared resources, there is always a risk of failure of mechanisms separating routing, memory and storage between different customers of shared infrastructure. SQL injection and side channel attacks become a real threat in cloud computing environment.

C. Malicious Insider

Sometimes employees of cloud service providers, such as system administrators and others may get private access to the sensitive data which is stored in their cloud. Any abuse of such system privileges can harm and risk the confidentiality, integrity, and availability of universities, data and information which is maintained by cloud service providers.

D. Dependency on Service Provider

There is lack of standardized tools, data formats, procedures, or services interfaces. This makes data, application, and service portability unfeasible. This acts like a constraint as it makes switching from one service provider to another by educational institutions almost impossible. Thus, they become dependent on a particular cloud service provider.

E. Loss of IT Governance

Academic institutions have to give away control over their resources to CSP. Universities and cloud service providers sign a service level agreement in the beginning. These SLA mostly do not offer very comprehensive measures and commitment to desired level of security by cloud service providers. This leaves a huge gap in security of data of universities and applications stored on the cloud platform or software.

F. Cloud Service Termination or Failure

Cloud computing is a very new and upcoming technology; therefore, cloud service providers face lot of struggles of a new business. Often, many go out of business or they change or restructure some of their originally offered services. This often leads to poor quality & deterioration of service delivery performance, as well as a loss of investment. Hence, such a situation becomes risky for the educational institutions attached with such cloud services providers.

VII. CONCLUSION

Overall, cloud computing has an important place in higher education. Day by day costs of various resources are increasing for educational institutions. They are under intense pressure of institutional performance and competition. In such an environment, cloud computing has become a vital prerequisite for many educational institutions. Cloud computing resources and e-learning tools can augment engagement and interaction of faculty, students, and researchers in a very cost efficient way. Various educational institutions can collaborate with each other. They can develop a common virtual platform using centralized data storage facilities, virtualization, and other facilities, overall reducing the expenditure and manpower requirement.

Cloud computing is slowly bringing in a paradigm shift in the education sector and the way teaching is done. It involves some of the associated risks and challenges but the cases of these various universities and educational institutes show the capabilities and prospective advantages of cloud solutions that can not only greatly enhance pedagogy and experience of teaching but also advance their IT infrastructure leading to quicker and more effective and efficient learning and research. These advantages do outweigh the challenges and risks associated with it. The cloud is at present being utilized by numerous educational institutions on a global scale. They all are experiencing the benefits of providing and delivering relevant info via innovative technologies. Not only has it lessened IT staff requirement but has immensely fulfilled expectations of students and their ever growing demand for the newest technology on the campus.

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