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## Role of Cloud Computing in Higher Education

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**Abstract-** *Cloud computing is a buzzword now days. It has changed the whole scenario. cloud computing being “on demand” following in line with other “utilities”, such as electricity and telephone .Not even the business organisation and several educational institutions have been considering and some of them even adopting cloud computing strategies in order to meet their requirements. Cloud computing services are a growing necessity for business organizations as well as for educational institutions. Although there are still several risks and challenges are associated with cloud but its potential benefits outweigh the risks. This paper begins with defining cloud computing, its key characteristics, deployment and service models, relationship between them. Then paper describes the role and challenges of cloud computing in higher education.*

**Keywords:** *Cloud computing, Characteristics of Cloud computing, Models of Cloud computing, Distance learning, Higher education.*

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### 1. Introduction

Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centers that provide those services. Gartner defines cloud computing as a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service using Internet technologies. According to Youseff et al. “cloud computing can be considered a new computing paradigm that allows users to temporary utilize computing infrastructure over the network, supplied as a service by the cloud-provider at possibly one or more levels of abstraction”. The market research company IDC for example defines cloud computing very general as “an emerging IT development, deployment and delivery model, enabling real-time delivery of products, services and solutions over the Internet”. Cruz (2011) specified cloud computing as a collection of applications and technologies which can be accessed and manipulated by a large number of users in real time. Some analysts and vendors define cloud computing narrowly as an updated version of utility computing: basically virtual servers available over the Internet. Others go very broad, arguing anything you consume outside the firewall is "in the cloud," including conventional outsourcing. Cloud computing can also be defined as an IT deployment model, based on virtualization, where resources, in terms of infrastructure, applications and data are deployed via the internet as a distributed service by one or several service providers. These services are scalable on demand and can be priced on a pay-per-use basis. Cloud Computing can be described as “the long-held dream of computing as a utility.

### 2. Key Characteristics Of Cloud Computing:

- I. **On-demand self-service**-a consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed without requiring human interaction with each service's provider.
- II. **Ubiquitous 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, laptops, and PDAs).
- III. **Location independent resource pooling** -the provider's computing resources are pooled to serve all consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. The customer generally has no control or knowledge over the exact location of the provided resources. Examples of resources include storage, processing, memory, network bandwidth, and virtual machines.
- IV. **Rapid elasticity**-capabilities can be rapidly and elastically provisioned to quickly scale up and rapidly released to quickly scale down. To the consumer, the capabilities available for rent often appear to be infinite and can be purchased in any quantity at any time.
- V. **Pay per use**-capabilities is charged using a metered, fee-for-service, or advertising based billing model to promote optimization of resource use. Examples are measuring the storage, bandwidth, and computing resources consumed and charging for the number of active user accounts per month. Clouds within an organization accrue cost between business units and may or may not use actual currency.

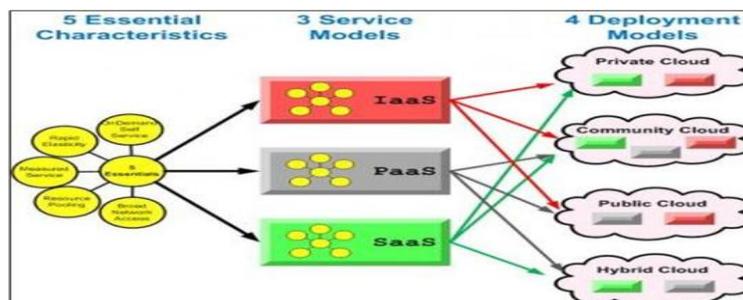
### 3. Nist Mentioned The Following Deployment Models Of Cloud Computing:

- I. **Private cloud**-the cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.
- II. **Community cloud**-the cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.
- III. **Public cloud**-the cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.
- IV. **Hybrid cloud**-the cloud infrastructure is a composition of two or more distinct cloud infrastructures (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).

### 4. Nist Mentioned The Following Service Models Of Cloud Computing:

- I. **Software as a Service (SaaS)** -the capability provided to the consumer is to use the provider's applications running on a cloud infrastructure<sup>2</sup>. 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.
- II. **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.<sup>3</sup> 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.
- III. **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).

Jerry Bishop, the Chief Information Officer at Chippewa Valley Technical College in Wisconsin, specified the inter-relationships and necessary connections of the NIST cloud computing characteristics and models (Bishop, 2011). This visual demonstrates that a cloud-based strategy can take on different configurations depending on the institution's needs.



**Figure 1**-Interrelationships with Characteristics, Service Models and Deployment Models Prevalence of Software as a Service (SaaS) Cloud Computing in Higher Education.

**Source:** - [http://www.librarystudentjournal.org/index.php/lsj/article-view/289/321#bishop2011](http://www.librarystudentjournal.org/index.php/lsj/article/view/289/321#bishop2011)

Over the past five years, cloud computing has become one of the defining secular trends within technology, and we believe the effects are just beginning to be felt across the industry [1].

According to the U.S. Federal Cloud Computing Market Forecast 2013, the Federal Government cloud computing market enters into double-digit growth phase – at about 16% CAGR over the period 2013-2018. Cloud IaaS market to grow by 47.8% through 2015 Gartner makes this prediction and it also advises outsourcers not moving in this direction that consolidation and cannibalization will occur in the 2013 – 2014 timeframe.

The cloud computing marketplace will reach \$16.7B in revenue by 2013, including the large and well-established software-as-a-service (SaaS) category, according to a research report by 451 Market Monitor, compared to a revenue of \$8.7B in 2010.

According to a recent Foresights survey nearly 50% of all enterprises in North America and Europe will set aside budgets for cloud investments in 2013. Also, 50% of software development companies are planning to deploy applications in the cloud. The security and availability concerns were mentioned as well. They indicate that the top analysts at IDC say the benefits of moving certain applications to the cloud outweigh the risks for some enterprises [2]. The cloud applications that will dominate in future and can be adopted by academic institutions are collaboration application, web servicing, cloud backup, business applications and personal productivity applications [3]. According to technology research company Gartner, more than 50 percent of Global 1000 companies are predicted to store confidential data in the public cloud by the end of 2016. The cloud is proving itself as being a techtrend that's here to stay.

## 5. Implication For Education



“Education is not the filling a bucket but the lighting of a fire.”  
- William Butler Yeats (1865–1939) Irish poet, dramatist.

Higher education is one of the pillars of society development. Through the partnerships between universities, government and industry, researchers and students have proven their contribution to the transformation of society and the entire world economy (Lazowska et al., 2008). In the field of education, cloud computing is very practical for a variety of reasons. Indeed, cloud computing will enable a certain educational institution to actually make use of the global internet resources for data analysis and data storage [4]. Walter Bailey writes on CloudTweaks.com - the entire educational system is suffering from a lack of resources: small classrooms, staffing cuts, shortage of qualified teachers and constantly changing standards. But, as Bailey points out, the cloud is a valuable tool that can be used to improve accessibility to quality education and to boost achievement. These challenges can be handled by number of ways with the help of cloud by including capitalizing on economies of scale. He proposed that the problem of outdated, too-small, overcrowded classrooms can be addressed by virtualizing the classroom environment. Students can actually log onto a space online and attend classes outside of the classroom environment. As such, the lecturers do not have to deal with overflowing classes and students packed like sardines; instead, they can focus their attention on creating content students will understand, developing their students' skills and helping students pass their exams. Cloud allows students to share their ideas, education infrastructure and tools which results drastic reduction in educational institution's overhead expenditures on quality learning materials like books and software and equal access to these scarce resources which helps the students' academic performance should increase along with the quality of education. Cloud Computing models specifically SaaS have been popular across industries including in higher education since the mid-1990s. For example, Windows Hotmail was the first Microsoft's popular email and messaging service. It now has more than 400 million users worldwide. In the past few years, Google's Gmail, Yahoo's Zimbra email and Microsoft's Windows Live Hotmail have played significant roles in higher education at universities and colleges in the U.S. The Campus Computing Survey 2010 reported that over 80 percent of U.S. colleges and universities use hosted email solutions; out of these institutions, 60 percent use Gmail, and the remaining 40 % use Zimbra and Hotmail. In 2010, the University of Texas at Austin migrated to a brand-new \$32 million data center. Roughly twice the size of the university's previous data center — and the result of two years of intensive planning and design — the new facility features a consolidated network architecture and eco-friendly power and cooling systems. It is expected to reach full capacity in just three to five years [5]. 2010 also marked the first year in which more data travelled across the Internet than during all the previous years combined. [6]

According to John Omwamba- the cloud allows for “information durability,” which means information can be placed in cloud storage for as long as needed. He adds that the advent of online video has made the idea of cloud in education even more exciting, providing universal access to teaching videos and demonstrations on almost any topic.

According to a survey colleges had been moving in order to use cloud as a storage space, it increases the efficiency and mobility. Cloud allows taking initiative and to show creative ability, reduce operating costs and also allow working on other projects to IT staff.

- #1 Increased efficiency (55%)
- #2 Improved employee mobility (49%)
- #3 Increased ability to innovate (32%)
- #4 Freed current IT staff for other projects (31%)
- #5 Reduced IT operating costs (25%)
- #6 Enabled us to offer new products/services (24%)

Figure 2. Source:- <http://www.edtechmagazine.com/higher/article-/2013/02/state-cloud-computing-higher-education>

## **6. To Meet The Competing Demands In An Increasingly Complex Environment**

College and university IT organizations are expected to keep up with a long list of competing demands, such as [7]:

- i. Deploying applications and delivering web-based student services at a rapidly accelerating rate, often without a proportionate increase in budget for hardware, software, and personnel.
- ii. Drastically reducing CapEx and OpEx costs while maintaining the highest levels of security and privacy
- iii. Maintaining a traditional IT infrastructure increasingly unable to accommodate the growing number of personal devices -including tablets, smartphones, and laptops- that students bring into the campus environment.
- iv. Offering sufficient bandwidth to accommodate huge swings in network usage.
- v. Competing against other universities, many of which attempt to differentiate them in the market based on the services they offer to students.

Apart from the above said advantages Cloud computing, it can help universities, institutions by:-

- i. Accommodating the rapid increase in mobile device dependency.
- ii. Storing expansive amounts of sensitive data and information that's easily accessible
- iii. Staying current (e.g. provides students with digital campus storage for class notes, papers and projects)
- iv. Acquiring and implementing the latest software and application updates.
- v. Streamlining enrollment and admissions processes that are costly and time-consuming.
- vi. Turning subscriptions that are scalable and provide options.
- vii. Offering schools, colleges, universities and others a low cost option for using high concept computing systems. All that's needed is an internet connection which is low cost.
- viii. Sharing work without having to use paper. Using paper is costly both to the environment and in monetary terms and is therefore no longer a viable way to educate.
- ix. Removing the admin burden allows educational facilities to concentrate on their core business and be more productive .IT admin including licensing issues, software updates and IT security management will all be taken care of by Cloud provider.
- x. Storing confidential and critical data centrally in the cloud, which is less prone to exposure threats such as the loss or theft of laptops or USB flash drives.
- xi. Using cloud in underdeveloped or emerging countries creating a way of being able to teach children who would not ordinarily have access to education.
- xii. Updating stock of information.
- xiii. Allowing free access applications and other useful tools.
- xiv. Providing efficient and friendly environment.
- xv. Providing experience and feel of real world

**Katz et al.** identify 10 important **features** of cloud computing in higher education with respect to on-demand SaaS, PaaS, and IaaS:

- i. Increasing access to scarce IT expertise and talent.
- ii. Scaling IT services and resources.
- iii. Promoting further IT standardization.
- iv. Accelerating time to market through IT supply bottleneck reductions.
- v. Channelling or countering the ad hoc consumerization of enterprise IT services.
- vi. Facilitating the transparent matching of IT costs, demand and funding.
- vii. Increasing interoperability between disjoint technologies within and between institutions.
- viii. Supporting a model of a 24 x 7 x 365 environment.
- ix. Enabling the sourcing of cycles and storage powered by renewable energy.
- x. Driving down capital and total costs of IT in higher education.

Cloud solutions can be used to support cooperative learning and socially oriented theories of learning, using computer technologies to support collaborative methods of instruction (Thorsteinsson et al., 2010).

Ed Tech Magazine and Cult of Mac surveyed colleges and found:

- i. 6 percent maintain cloud-based technologies
- ii. 28 percent are implementing cloud computing
- iii. 29 percent are planning to adopt the cloud
- iv. 32 percent are discovering cloud computing

A Pew Internet/Elon University survey reports that of 1,021 participants, including Internet research experts and users, by 2020 higher education will strongly focus on tech-centric solutions and methodologies such as:

- i. Teleconferencing
- ii. Distance learning
- iii. Hybrid classes (i.e. online and off-campus learning)

According to TechJournal's info graphic on schools and the cloud, cloud computing spending is expected to increase by more than 30 percent as of May 2011. Boston College, New York University and Maryland Institute College of Art are higher educational institutions leading the industry into cloud-based applications. The institutions rely on FolderWave, Google Apps and Fischer International Identity for admissions, financial aid, collaboration tools and system management. While using internet first word comes in mind is security. There should be reliable and secure network infrastructure. These requirements are also desirable to users related to educational institutions as many faculty members pursuing research, and with student privacy safeguarded by strict regulations, colleges and universities must be careful to minimize exposure to legal risk and compliance risk. And cloud computing is able to meet all these competing demands — it provides greater agility, less risk, and lower. Cloud computing is also helpful in distance learning. Distance education sector is growing rapidly. Universities are offering more and more courses and degrees through distance-education programs. According to a recent SLOAN-C Annual Report (Allen & Seaman, 2010), in 2009, over 5.6 million students were taking at least one online course. This is an increase of nearly one million students over the number reported the previous year. In addition, blended instructional formats that include a significant portion of online activities got a boost after a recent review of online learning studies found that blended learning students outperformed both fully face-to-face and fully online learning students (U.S. Department of Education, 2009).

Due the growth in distance learning sector, more students and faculties are attracted towards it. To meet the growing demands of instructors and students for personalized learning, flexibility, and on-demand services, and to be able to address the IT challenges, distance learning administrators and practitioners need to explore the new IT infrastructure. The current IT infrastructure offered by most distance learning programs is not likely to be able to sufficiently meet the increasing demands and needs of instructors and students in an efficient and effective manner.

### **7. Benefits Of Cloud Computing For Distance Learning [11]:-**

- I. **Cost Saving:** Perhaps the most important incentive associated with cloud computing is the cost reduction. Westmont College reports that after deploying six cloud-centric service platforms, it has achieved numerous benefits, including a 65 percent cost reduction up front (over more traditional deployments), and a 55 percent cost saving over the useful lifetime of the solutions. Beyond the cost savings, though, the college reports a significant increase in user satisfaction, as well as a significant decrease in the amount of IT management time required (Sheard, 2010).
- II. **Rapid elasticity and scalability:** Many distance-learning programs offer live video streaming (LVS) courses to online students (Abdous & He, 2009). However, the LVS courses are only offered to a limited number of students (e.g., 1000 concurrent LVS students) due to hardware constraints. The existing hardware (e.g., web servers) will not be able to maintain its performance if concurrent LVS student numbers suddenly double or triple (e.g., to 2000 or 3000 concurrent LVS students). In addition, if a faculty member develops an innovative idea and requests a computing-intensive application that needs multiple servers to support it for a temporary period, in many cases the DL IT staff will have to turn down the request because the limited budget does not allow DL units to spend a lot of money purchasing hardware for a temporary project. With cloud computing in place, DL administrators need not be concerned about over provisioning for a service whose popularity does not meet their predicted needs (and thus wasting costly resources), or under-provisioning for one that becomes wildly popular (and thus missing potential customers and revenue) (Armbrust et al., 2010).
- III. **Cost of setup and maintenance:** Complex new technologies and applications are continually being invented and they make it harder for distance learning IT staffs to install, configure, secure, and upgrade to the latest technologies. The technology setup and the maintenance workload make up a large chunk of the time spent by the Distance Learning IT staff during their workday. The adoption of cloud computing will move the burden of technology setup and maintenance to the cloud service providers.
- IV. **Reallocation of resources:** As cloud computing moves the technology setup and maintenance burden to cloud service providers, campus DL IT staffs can focus on developing innovative instructional solutions/resources and on providing more support to faculty and students. There are several areas in which more intensive help from the DL IT staff can be beneficial to the faculty. First, as instructors move toward more online and mobile instruction in their courses, IT staffs can help them to optimize the use of the available LMS systems to increase both the effectiveness and the efficiency of the instructional process. Second, as online instruction strives to become more personal through the extensive use of online conferencing tools (e.g. Blackboard Collaborate, Webex), instructors can benefit from more intensive initial support with the technical aspects of integrating these tools into their teaching activities. Third, IT staffs can help faculty to improve their technical skills in using various Web 2.0 tools (such as blogs or wikis) and can therefore help them to effectively integrate these collaborative tools in their courses in order to improve their students' learning experiences and performance (e.g. Cole, 2009; Trentin, 2009).

Cloud computing reduces operating and capital expenses while increasing IT efficiency through server consolidation, improves service delivery, and offer online access to systems and applications over a variety of devices. Several educational institutions recognize that adopting the latest technologies and solutions has become essential to stay competitive and retaining students. Institutions can take the advantage of cloud computing in reducing high expenditures on hardware, software and IT maintenance as it provides a centralized and virtual data center that is accessible to faculty and admissions personnel irrespective of time and location. According to a 2011 study by CDW, only 5 percent of U.S.

college and university respondents were not considering a cloud migration. 29 percent had developed a written strategic plan for the adoption of cloud computing, with 28 percent in the midst of implementation. [8] Todd mentioned that Lakehead University in Canada, one of the first major Canadian university to outsource their email services to Google, saved \$250,000 a year and students were given storage space in the cloud equivalent to 250 fold what they were getting at the university. According to Weintraub-by using Gmail for its student email needs, Arizona State University saves \$500,000 per year and Vanderbilt University saves \$750,000 annually .

### **8. Challenges of Cloud Computing In Higher Education**

Many challenges of cloud computing for academic institutions relate to its relative newness and the underdevelopment of the marketplace for cloud services. For higher education, decisions to adopt cloud computing will be influenced by more than technical and cost considerations. Information flow is like a lifeline in the academic system and decisions, on how to manage that information, can have far reaching political, social and economic effects on the students, faculty and the society. Adoption of cloud computing presents many risks and other challenges like security, interoperability, control, performance, integrity and reliability instead of using a traditional outsourcing arrangement. The academic institutions need to weigh the costs and benefits but a major factor of these decisions will be their level of trust in both the cloud deployment model under consideration and the entity providing it [9]. Metz (2010) offers the example below to explain why the traditional IT infrastructure is sometimes not good enough:

When an institution develops or deploys a new application, they first must jump through a number of hoops. For example, if an institution decides they would like to install the learning management system Moodle, they might have to order a server, wait for the vendor to ship it, install the server in the data center, provision an IP address for the server, set up the DNS for the new IP address, install the operating system, etc.

### **9. Dan Morrill Mentioned A Number Of Challenges In Cloud Computing [10]:-**

- I. Cloud computing did not originate in the college environment, there are few colleges that are taking cloud computing seriously enough to be developing or teaching courses in this subject like MIT.
- II. Cloud computing is truly multi-disciplined, in that the average system admin needs to understand a bit about networking, virtualization, routing, data movement, data use, process management, and security to be helpful to an organization using cloud computing.
- III. Educators are not prepared to teach cloud computing – in general with a broad paint brush, many computer science educators at all but the most prestigious colleges are simply not able to teach this not so new but still cutting edge technology.
- IV. Cuts in funding – everyone everywhere has had their budgets slashed while we wait for consumers to come back and start spending again. This includes colleges because many colleges' budgets are tied to the states budgets that are tied directly or indirectly to sales tax, use tax, B&O tax, or the many other ways that government taxes both businesses and consumers to accomplish tasks.
- V. Cloud Computing is generally ill understood by the general public, including governments, workers, and corporations. It is not enough to teach virtualization, you have to teach automation, design, architecture, monitoring, and with a dearth of tools out there, in many cases, you have to teach enough scripting or programming to get the tasks accomplished.

In cloud computing data centers exist in multiple nations, this may trigger cross border issues or outright barriers for the education institutions. Institutions having the sensitive information for instance government contracts, in such cases government doesn't allow to reveal or access such information by foreign countries. Universities, of course, are typically subject to numerous state and federal law covering data on academic grades, health records and financial aid, among other things. Certain countries have very strict rules about cross-border transfers of personal information, and complying with those rules can be challenging in the virtual world of the cloud.

Vulnerability to security breaches are the biggest obstacles to cloud computing adoption in higher education, according to recent surveys of IT leaders in higher education (Jitterbit, 2010; Schaffhauser, 2011b). The most important of these security risks includes the loss of governance, lock-in issues, isolation failure, compliance risks, management interface compromise, data protection, incomplete or insecure data deletion and malicious insiders (Catteddu & Massonet, 2010). In addition, concerns regarding privacy, data integrity, intellectual property management, regulation issues and audit trails are significant barriers to adoption of cloud-based solutions (EDUCAUSE, 2009a). However to help mitigate these risks for higher education institutions, several organizations have emerged in the last few years. The Cloud Security Alliance was launched in 2009 as a non-profit organization tasked with conducting research in cloud security and offering information and resources about best practices in security protection in cloud computing (EDUCAUSE, 2010a). Apart from the security concerns, there are certain other issues like maintaining the integrity of data, ensuring access is limited to authorized users and maintaining the availability of data and services. Controlling and protecting these assets becomes a much more complex and challenging proposition as the data and services are external to the campus with the cloud. Cloud vendors provide service level agreement is not specific and detailed enough to meet college and university requirements. Fortunately, through the Higher Education Information Security Council, a toolkit called the Data Protection Contractual Language is available to provide guidance and languages to assist institutions in crafting appropriate SLAs and contracts to meet their specific needs. This is an evolving area, and although much

progress has been made, much more is needed before colleges and universities can place their complete trust in these third party cloud vendors.

## 10. Conclusion

Cloud computing has been growing rapidly; it evolves models offering significant advantages, yet potential fallacies as well. Cloud computing seems to be worth exploring from small businesses and major enterprises to elite universities and online colleges. The cloud is poised to revolutionize the educational sector, and schools and learning institutions. Basically, cloud computing will enable learners to formally undergo education even without going to the four-walled classrooms. In fact cloud can also help those families who travel a lot, cloud computing will allow their children to travel while continually learning lessons, submitting assignment, and getting grades. As a coin has two facets so as cloud computing therefore the decision taking of using Cloud Computing must also take into account the risks associated with it. But by using cloud the gain that exceeds the capital costs may compensates the associated risks. Some of the risks specific to cloud environment may be transferred to cloud providers.

Cloud Computing having both strong and weak aspects , we may say that the scalable, portable, payment per use model and the management policies of risks and security , efficiency ,anytime accessibility and several other aspects represent positive factors in taking the decision of using Cloud Computing. In the end,universities may and should value the opportunities offered by Cloud Computing lead to innovation.

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