CLOUD COMPUTING IN HIGHER EDUCATION: OPPORTUNITIES, CHALLENGES AND COUNTER MEASURES

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ABSTRACT

Cloud computing has become an adoptable technology in many organizations. It has changed the complete scenario with its vibrant scalability and usage of virtualized possessions as a service all the way through Internet. Moreover most of the educational institutions around the globe have become extremely reliant on Information Technology to tune-up their big business requirements. Cloud computing will have a significant impact on the educational surroundings in the near future. It is an exceptional substitute for educational institutions which are particularly under resources deficiency in order to function their information system efficiently without making much expense on computers and other devices. The services of cloud computing are increasingly provided using internet technologies in the universities for their staff and students.

Universities can take the benefits of cloud based applications provided by different service providers and facilitate their staff and students to perform various academic responsibilities according to their own requirements. Although there are numerous of hazards and challenges are associated with clouds and its services. In this paper I will review what the cloud computing and its infrastructure is and what will it provide in the education field, especially how it is beneficial in the higher education. In this paper I have also mentioned what the different challenges and risks involved in the implementation of cloud computing. There are number of countermeasure also to manage these risks and challenges.

Keywords: Cloud Computing, Higher Education, Remote Areas, Saas, Virtualization

I. INTRODUCTION

Cloud computing is the term which means storing and accessing data and programs over the internet instead of individual's hard drive. Cloud computing is delivering on demand computing resource from applications to data centres over the internet. So we can say that cloud is a service over the internet. A service is a kind of software function or ability that is accessible anytime and anywhere via a computer device such laptop, desktop, palmtop or mobile phone. Few examples of cloud services are Salesforce.com, Amazon EC2 and Google Apps, wikis, emails, blogs. From the user's point of view a cloud can make all these services available in such a way that user need to concerned from where these services are instigated and from where they are running. These services are somewhere in the cloud and user can access them at anytime from anywhere and from any device.

II. WHAT IS CLOUD COMPUTING?

There seems to be many definitions of cloud computing. A study by McKinsey (the global management consulting firm) found there are 22 possible separate definitions of cloud computing [1]. A more commonly definition describes that cloud computing is a type of computing that relies on sharing resources rather than having local servers, storages, networks or any other personal devices to access and handle the applications. It can also be defined as clusters of distributed computers which provide on-demand resources and services over the internet. It is a kind of shared IT infrastructure which contains large pools of systems that are linked together with each other. Number of virtualization techniques are used to maximize the power of cloud computing. Possibly cloud computing is the delivery of computing services over the internet. Cloud services allow individuals and businessmen to use software and hardware that are managed by third parties at remote locations. Online file storage, social networking sites, webmail and online business applications. The cloud computing model allows access to information and computer resources from anywhere that a network connection available. Cloud computing provides a shared pool of resources, including data storage space, networks, computer processing power, and specialized corporate and user applications. The following definition of cloud computing is developed by U.S. National Institute of Standards and Technology (NIST).

Cloud computing is a model for enabling 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 promotes availability and is composed of five essential characteristics, three service models, and four deployment models [2].

Figure 1: Cloud Computing and its Usages

III. CLOUD COMPUTING SERVICES

Cloud computing services are generally falling into three categories or levels. The lowest level is normally known as **infrastructure as a service (IaaS)**, the next level upwards is **platform as a service (PaaS)** and highest level of cloud computing service is **software as a service (SaaS).**

3.1 Infrastructure as a Service (Iaas)

IaaS is basically the virtual delivery of computing resources in the form of hardware, storage services and networking. Here consumers can rent these basic computing resources such as processor and storage and can use them to run their own operating systems and number of applications. IaaS is an on demand service rather

than purchasing servers, softwares, data centers space or network equipments, client can fully outsourced these services on demand. Amazon's Elastic Compute Cloud is a good example of IaaS, where many organisations are using this infrastructure to run their Linux servers on virtual machines and can scale up the usage as per their requirement. Generally IaaS can be acquired in two sub categories namely public or private infrastructure or a combination of both. Public cloud is measured infrastructure that consists of common computing resources which means all the computing resources will be shared; further these resources can be set up or deployed on a self-service basis. Private cloud is an infrastructure that imitates some cloud computing features like virtualization but that can be done on private network not on public network. Some cloud providers have started to offer the combination of public/private cloud networks. This combination approach is called hybrid cloud. Many companies with a hybrid environment are likely to include IaaS in some form because IaaS is a highly practical solution for companies with various IT resource challenges. Whether a company needs additional resources to support a temporary development project, an on-going dedicated development testing environment, or disaster recovery, paying for infrastructure services on a per-use basis can be highly cost-effective. An IaaS provider provides policy based services and is responsible for housing, operating and maintaining the equipment it provides for a client. Clients usually pay on a per-use or utility computing basis. Characteristics of IaaS include: Automated administrative tasks Dynamic scaling Platform virtualization Internet connectivity IaaS is also described as one of three main categories of cloud computing service.

3.2 Platform as a Service (Paas)

PaaS is a computing platform that allows creating the web application in a quick and easy manner without the complexity of purchasing and maintaining the softwares and infrastructure. With the help of this service the consumer will be able to install his own applications using a platform specified by the cloud service provider. PaaS service is having number of predefined or preconfigured features which can be subscribed by the consumer as per the requirement and can be discarded those features which are not required. There are many simple packages are available in the PaaS service where there is no specific expertise is required of the consumer. The user can go for more advance development with the help of simple infrastructure options supplied by PaaS. The consumer need not to bother to manage or control the underlying cloud infrastructure which includes network, operating system, servers, storages etc. but he will have full control over the deployed applications and doable configuration settings for the application hosting environment. A PaaS provider usually gives the possible support in the form of testing and deployment to the developers / consumers from the formation of their original ideas to the creation of their required application. Software developers, web developers and business analysts can get the benefit from the PaaS. Following are some features that can be included in the PaaS service:

- Network access
- Database management system
- Operating system
- Support
- Storage
- Tools for design and development of application.

3.2 Software as a Service (Saas)

SaaS is the highest level of cloud computing service. With the help of SaaS the consumer can access multiple software applications over the internet. These software applications are hosted in the cloud and can be used by any individual or any organisation as per the requirement. SaaS is often referred as software on demand and utilise its features on the basis of rent rather than purchasing it. There were many limitations with the traditional system; you need to buy the software then need to install it in your system may be need to upgrade your current system configuration to enable to run the software smoothly. Further software license may limit the number of users and so on. With the help of SaaS service the user will only subscribe to the software rather than buying it and this subscription is usually on a monthly basis. So if I say that SaaS means you do not need to have a powerful system to do powerful things, will not be wrong. The user can not only use the software application rather he can store the data in the cloud as well, just he need a web browser to access these applications. The data entered by the user will be stored in the cloud rather than storing on the individual's machine. SaaS is rapidly growing in the market which indicates that this service will soon become the commonplace within every industry and organisation.[3] Google, Twitter, Facebook and Flickr are the good examples of SaaS.

There are number of reasons why SaaS is beneficial to the organisations and individuals:

1. No additional hardware cost
2. Usage is scalable
3. Updates are automated
4. Cross device compatibility
5. Accessible from any location
6. Applications can be customized and white labelled
7. No initial setup cost
8. Pay for what you use

Office software is the best example of SaaS.

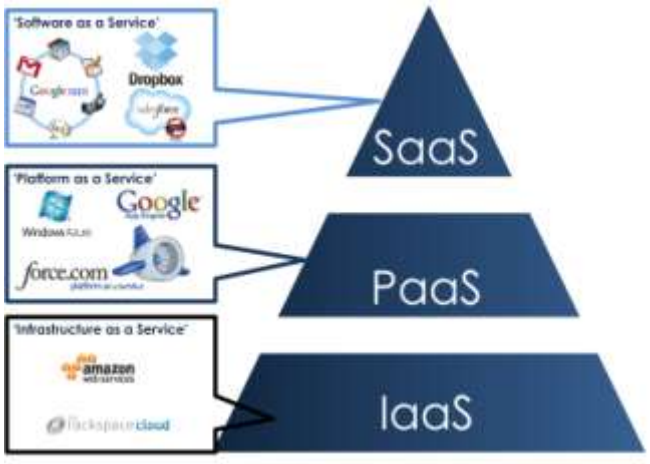

Figure 2: Cloud Services Stack

IV. OPPORTUNITIES OF CLOUD COMPUTING IN HIGHER EDUCATION

If I will talk about the education especially higher education, the cloud computing is serving so many opportunities in this field which we could never see before. Cloud computing is having many advantages and benefits over the traditional system. There are few educational institutes those are using the cloud services in

their day to day operations but still there are many others those are utilizing its benefits. Following are some advantages of cloud computing in higher education.

4.1 Cost Saving

Few colleges reported that after deploying the cloud services in their campus they have achieved number of benefits. 65% cost reduction over the traditional deployment where as 55% cost saving over the useful lifetime of the solutions. Not only this they have achieved remarkable user satisfaction and significant decrease in the time amount of IT management. This is particularly very clear where the services such as email is being offered free of cost by external providers then there is no need to have any personal infrastructure or setting up the hardware at the college level. Colleges / universities have to pay per use to the cloud provider rather than having the burden of underutilized hardware of software resources.

4.2 Rapid Elasticity and Scalibility

Many distance learning institutions offer several video learning programs which are known as video learning streaming (LVS). However earlier this course was offered to very few number of students by the institutions due to lack of hardware and software resources at the institution end. To offer such type of course they need to have very expensive set up for the video lectures and so on. For example if any faculty want to share any of his idea and new innovation with the student it was next to impossible to have interaction with students online. But with the help of cloud computing these types of tasks have become very easy for the faculties and students as well. Institutions do not need to have costly infrastructure and hardware setup at their end rather they can use different cloud services for their students.

4.3 Enhanced Availability

Availability of the cloud services are definitely higher to the students are compared to the college/university's computing service department. There will be less downtime for the students to access their data and making assignments and important lecture notes. Google offers 99.9% availability to its educational applications which are used by number of students and faculties. Students can learn better and without the time boundary for their creative projects and practical assignments. The benefit is not only for students rather than it has a great help for faculties also. Lesson plans, lab practicals, student attendance, student grades, power point presentations, lecture notes, assignments and much other study material can easily be uploaded and can be accessed by students at any point of time. Student's parents can also see the performance of their ward at any point of time without to come and meet the faculty member.

4.4 Reallocation of Resources

As I have already discussed that cloud computing moves the load of technology set up and its maintenance to cloud providers, so the campus IT staff can focus on developing new and innovative instructional solutions and can provide more help to faculty/staff and students. There are many areas where faculty members required having help from IT staff. First, IT staff can help the faculty members to move more on online and mobile instructions in their course. Faculty members can use the LMS tool to increase the effectiveness and efficiency for the instruction purpose. They can online attendance system so that proxy can be stopped. Second, faculty members can use online conferencing tools (Blackboard Collaborate, Webex) to give more personal attention to students. Third, IT staff can help faculty members to learn new technical tools of Web 2.0 (blogs, wikis) so that

faculties can use these tools in their course and can improve the standard of learning and teaching. With the use of several cloud computing services we can improve our learning experiences and performance as well.

4.5 End User Satisfaction

Apart from the better availability there is a range of new applications which are provided to the user free of cost. These tools are available on user's mobile also. Companies like Google and Microsoft provide these innovative tools to users' for their day to day operations. User need to purchase or install these tools like office applications in their laptop or desktop they can simple use them. Moreover students need to bother about the storage of their data also because it is not getting stored on any individual's part rather it is stored on cloud which can be accessed anytime anywhere are per the requirement. There is no constraint to access the data as far as device is concerned. User can access his data from his mobile, laptop and from desktop as well. HTML5 technology will allow user to work offline also when the internet connection is intermittent. There lot many other things to do with the technology which may not be possible due to time and resources constraint. But with the help of cloud services we can think of to do that also. So, the end user satisfaction can be achieved by cloud services.

4.6 Concerntration on Core Education

If I will talk about the education system in past years then most of time institutions were busy in setting up their IT infrastructure, setting up the computer labs, managing IT staff and their day to day need. It was the main cause due to which faculty members were not be able to give attention or concentrate on the core studies of the students. All the time there was fight for IT resources. Because of this reason students were not able to make themselves practically sound to fit in the industry. Cloud computing has solved all these problems now faculties need to worry about the core IT resources they have to just concentrate on the studies of the students and let them to go for new innovations and research. I have seen major changes in student's work and their understanding. They can now easily and effectively use the different technologies for the research purpose which is really a good sign for the future generation.

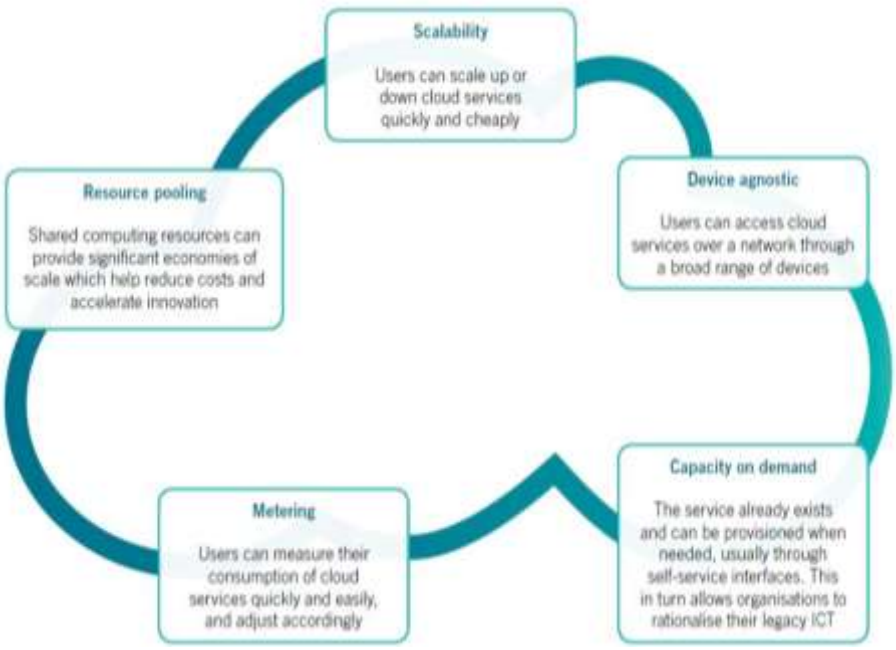

Figure 3: Qualities of Cloud Services in Education

V. CHALLENGES AND ISSUES OF CLOUD COMPUTING IN HIGHER EDUCATION

Cloud computing is a new paradigm which is intimidation to some individuals in institutions. The individual has the fear that the services provided by him to the university will be outsourced. Thus some risks may be more the perception than the reality.

5.1 Data Security

The major concern is about the security of data. Institutions may think that their data are more secure on their private network rather than the public network. Transferring the data to the third party for the hosting in a remote data centre will definitely will not be under their control. The most important concern of the institution is that there may be a breach of confidential data which involves student, faculty, staff and any other member. European Union has introduced strict data protection laws for storage of personal data to some countries with which the agreement has also signed. Some cloud providers are giving the guarantee in their contract that personal data of any institution will only be stored in some particular countries.

5.2 Unsolicited Advertising

Another risk is that cloud providers may target the users with unwanted emails and advertising. Students and faculties may receive number of offers and other unfair material on their emails. This is totally illegal. At times it has seen that cloud providers may further outsource the data for some functions to those countries that have no or little legal privacy protection which may harm the end user. Educational institutions are having very confidential data which should not be outsourced at any cost. This is one of the major cause when the colleges and universities are not approaching for the cloud computing services. Some of the cloud providers are giving their services at low cost but they don't give any kind of assurance to the consumer.

5.3 Failure of Cloud Service

While using the cloud services it will be clear to the institution that everything will be done by the cloud provider. What will happen the services are not performing well or they are failure to produce the performance? The consumer will not be able to easily recognize the problem because all the data are already hosted to third party. This way their entire work may suffer. For example there is an examination in the university and the roll number of the student is only available online; what if the cloud service is not working that particular day due to some reason? Will student not be able to sit in the examination? Will he lose his one year? Such risks are actually threatening the institutions for not to trust on cloud services.

5.4 Lock-In

There are some companies like Microsoft and Google are allowing institutions to co brand their products. There is always a risk for any institution to associate so closely with any company. The institution will become "locked-in" to the products of a particular provider. Providers may make claims about the interoperability of their products and may transfer the data from one system to another system for their personal benefit. The institutions who have started their initial educational process with cloud system may find it more difficult to migrate. The cloud provider may increase the charges at any point of time even without prior intimation to the consumer. This way the entire system of the institution may be at stack and may not work properly which will affect the student and other stakeholders.

Figure 4: Challenges in Cloud Computing

VI. COUNTERMEASURES OF CLOUD COMPUTING IN HIGHER EDUCATION

The previous section of this paper was focusing on risks and challenges in cloud computing. When there is a question to implement it definitely the major concern is security. In this section I will explain some counter measures which can be taken to avoid the risks of cloud computing. Though in context to IT security, rarely there are all countermeasures to handle all types of risks. According to an article published by the Educause ("nonprofit association whose mission is to advance higher education by promoting the intelligent use of information technology") from 2005 to 2011, the main concern of security was in the fourth issue in the field of Information Technology (IT) [4].

6.1 Security of Saas

Cloud providers are providing many services to their consumers. SaaS is one of the most important service in the cloud computing. It is suggested to the educational institution that before accepting any service model by the cloud provider, they should be aware of security of data and their selling policies. Before using the services provided by CSP (Cloud Service Provider) they can simply block the unwanted access of data. Institutions can make sure that cloud provider should only have access to that data which is the part of the agreement, not any other data of their domain. Many institutions are using software as a service in their campus without having much knowledge of accessing of data. So it is always a good practice that before implementing or using any service they should have depth knowledge of the services provided by the cloud providers.

6.2 Trusted Computing Platform and Environment

Platform attestation is a mechanism by which a computing platform gives the proof to third party that it is trusted. In this process a system's capability will be judged or checked by those system/s with which it is going to interact. After this process it will be sure by the institution that this particular cloud provider is trustworthy or not. This should also be checked by the institution that there should not be multiple providers; data should not travel from one provider to another provider. The computing environment used by the cloud provider should be trustworthy and it should properly be checked by the institution on its own.

6.3 Surveillance Team With in the Institution

Another countermeasure which we can have in the institution to defeat the risk in cloud computing is to form a supervision committee A surveillance team can be formed to provide guidance and care about the security

strategies of the institution. This committee shall define all the roles and responsibilities of the security functions to the other member of the institution. They should teach the security awareness programmes to faculties, students and other staff members. They can help them to understand the vulnerabilities to threats. The team can discuss about the social engineering attacks which can slow down the respond to possible security events and can cause the lot of financial loss to the institution. This team should be responsible to implement the different firewalls in the system and tell the importance of these firewalls to other members also. There should be a security alert so that if any point of time any data tampering takes place the institution or the surveillance team be alarmed.

6.4 Legal Contract with Cloud Service Provider

An educational institution must ensure that there should be a legal contract between them and cloud provider. That contract should have sufficient provisions to ensure that data is well protected. Even when the data is outsourced to the external party the backup should be with the institution, because the primary responsibility of that data is of the institution. If anything happen dot that data it just not only harm the reputation of cloud provider rather it will spoil the reputation of that institution also. So while outsourcing the data it should be ensured by the educational institution that their data is secure and provider is taking adequate care of the data.

6.5 Biometric Mechanism

While implementing the cloud computing in the college or university it is assumed that all the lecture notes, power point presentations, pdf and other study material is uploaded on the internet by the faculty members so that students can take benefit of it anytime anywhere. But institutions are always have one major concern that the study material or any research made by one faculty member can be seen by number of other persons who are not the part of their organisation. The solution of this problem is to implement the biometric mechanism which is very useful nowadays. During the registration phase user's physical or personal individuality such fingerprint, voice recognition, iris recognition will be stored in the database. So while accessing the data from the database these characteristics will compared and if matched then only the contents will be provided to the user.

6.6 Reputation of Cloud Service Provider

Prior to engaging education with the cloud provider, an educational institution must do some diligence on the provider and check what is the reputation of cloud service provider in the market? They have to make sure that provider should have good record and reputation of providing the services in the other institutions as well. CSP should provide good security policies and practices. The institutions should ask few questions to the provider like how their data will be stored, how the data will be protected, where the data will be stored, as data can be stored in that country where it can be accessed by the government without sufficient limitations.

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VII. CONCLUSION

Cloud computing is an emerging computing paradigm which is growing very rapidly. It can help societies and nations to transform the education. A whole world is now available to students and teachers through cloud services which were never experienced before. It was discussed in this paper how educational institutions can take the benefit of cloud computing and its services to fulfill their complex operations which will automatically reduce the cost and provide more powerful functional capabilities. Basically cloud computing will enable learners to come out from the walled classrooms and explore the whole world. There is a great benefit for the institution's IT staff of the cloud, which will take away the extra burden of maintenance of hardware and software set up. There are number of factors like scalability, portability, payment per use model, managing the risks and maintaining the security, efficiency, anytime access, and 24x7 alive and many other features represents the positive face of cloud computing. We should conduct a survey in the different private and government universities, colleges and other educational institutions to collect the required data for the use of cloud computing. This may help use to review the current status and possible considerations to adopt the cloud computing technology. Definitely there are some challenges and risks are involved in the implementation of cloud and its services. But they can be very well handled and managed with the experience. So the educational institutions may and should take the decision to move on to cloud computing for the new innovation and the betterment for their student's future.

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