Towards a generic E-Cloud Architecture for Universities

Ritu Singhal[1], Archana Singhal[2], Sonia[3]
[1,2] Department of Computer Science
IP College for Women
University of Delhi
New Delhi, India
toritu7@gmail.com
singhal_archana@yahoo.com

[3] Department of Computer Science
University of Delhi
New Delhi, India
soniacsit@yahoo.com

***ABSTRACT**: Information Technology industry is growing with very high speed and has become an integral part of the curriculum of all the universities/educational institutes. Teaching or using advanced technology in university is a costly affair with highly configurable systems. Cloud Computing has emerged as a cost effective solution to provide the latest and highly configurable resources/systems with less investment.*

Cloud Computing technology enhances traditional e-learning system by including usage of the latest hardware and software. Virtual classroom and labs are also provided simultaneously to improve e-learning systems and enhance collaboration among remote users. Focus on Cloud Computing is to serve users of different types of requirements and allocates resources to them in a cost effective manner. Users need not to worry for licensed software, hardware configuration, storage, maintenance, up-gradation of resources and big working space. If you just have a PC and internet connection, you can use the resources from the cloud, according to your requirements and pay accordingly.

This paper focuses on how cloud computing technology helps to improve education at the university/college level in a cost effective manner. It also proposes an architecture for the university system to co-ordinate among a number of affiliated colleges and collaboration among different universities. It also discusses how interaction and uniformity can be maintained in different/remote colleges under a university and enhances collaboration through the cloud. The proposed architecture is a generic and can be customized according to the need of different universities.

Keywords: Cloud computing, education, University, infrastructure, e-learning

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1. Introduction

In the present scenario, technology is growing very fast as up-gradation of hardware and the latest versions of software come on a regular basis. Internet facility brought the whole world at one place. It has led to a competitive environment where conventional education systems do not fulfill the demand of fast growing need of industry. It is very difficult for educational

institutions to provide highly configurable hardware and latest versions of software with their limited budget. For students enrolling the education using traditional e-learning system, it will be just a dream to get these resources with limited investment. These limitations enforced the use of this emerging Cloud computing technique in the education system. Cloud computing allows to access virtualized resources in a remote place with pay per usage model, without going into details of its implementation. It is basically providing an abstract version of highly configurable hardware and the latest software to end users. Resources are dynamically scalable as they can be increased or decreased according to the user's need. This technology is already being used while working using Google applications, Dropbox, skydrive, iPhones, android phones and kindle.

During traditional computing, every computer must have required software for execution of a program. If any software is not compatible with the operating system of that computer, then the program cannot be executed. In cloud computing there is no need to install software on the individual machine as these software are installed on the servers of the cloud. The Programmer can access any software from these servers using the Internet. Also, programs/data can easily be shared among a number of people working on the same project or looking for collaboration.

Data on a cloud can be accessed through desktops, laptops, tablets and even through mobiles with internet connectivity. Services are available 24x7 for everyone with a little requirement of maintenance staff and infrastructure. Now sitting at one place, one can access any required information like Journals, literature, software and so on. Resource availability at a particular time is not a bottleneck now. Basic requirements for using hardware or software from a cloud are access device, web browser and internet connectivity. Service provider controls the contents of the cloud and provides them to authentic users.

Data Center on Cloud can better manage the limited supply of resources with dynamically changing service demand.

Cloud Computing is gaining popularity by providing an abstract version of infrastructure utilization by hiding implementation, management and maintenance details. **NASA** has migrated more than 100 sites, including its main nasa.gov website and applications to the cloud, and saving millions of dollars in the process [1].

The rest of the paper is organized into five sections. Section 2 defines cloud computing, its characteristics and service models. Section 3 gives related work done in cloud computing. Section 4 elaborates the requirement of cloud computing in education by different categories of end users. Section 5 describes the proposed model of cloud for education in university. Finally, section 6 concludes the paper and discusses future aspects.

2. Cloud Computing

National Institute of Standards and Technology defines cloud computing as "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"[2]. There are five key role actors in cloud computing - cloud consumer, cloud provider, cloud auditor, cloud broker and cloud carrier. Every actor may be a person or organization that performs certain task. Cloud consumer uses the services and facilities provided by the cloud provider. Services can be given directly from the provider or through cloud broker. Role of a cloud broker is important when the cloud consumer wants to negotiate or require different services from different clouds. The Broker can act as mediator between consumer and provider. Cloud auditor monitors the performance , cloud services, and security plays important role in providing authenticity to cloud functioning.The NIST definition gives three service models named SaaS (Software as a service), PaaS (Platform as a service) and IaaS (Infrastructure as a service) that provides hardware and software facilities on demand. It defines four deployment models to deliver these services to the cloud consumer named as private, community, public and hybrid. User can simply use the model without learning the technical perspective of cloud implementation [3].

Characteristics of Cloud Computing are on demand computing service, virtualization, resource pooling, scalability, versatility, fault tolerance, multi-tenancy, reliability, service oriented and pay per use.

Common Cloud Management Platform defined in IBM Reference Architecture is supposed to scale and to host multiple types of cloud services [4]. The IBM's CCRA specific top-level architectural principles guide the definition of any cloud implementation and focus on delivery & management of cloud services. These principles include Efficiency, Lightweightness, Economies-of-scale, Genericity. The E-Cloud model proposed in the present work is primarily based on this architecture.

3. Related Work

The present section describes the work done by eminent researchers in the field of cloud computing technologies and its effective use in education. In [5] the author has presented an architecture for market oriented allocation of resources within the cloud. He has also presented a vision for the creation of global Cloud exchange for trading services. In [6] the author has presented a survey on cloud computing in education. According to him Cloud Computing adds features like scalability, availability and flexibility to traditional e-learning system.

In [7,8], the authors discuss about Cloud Computing in education. According to them educational institutions will be responsible only for the education related work, study material creation; management and delivery and cloud vendor would take care of system development, design, management and maintenance on educational institution's behalf. In [9], the authors proposed an e-learning system architecture which is based on cloud computing and also found that leading cloud providers are already providing customized packages of their commercial applications to the educational institutes at low cost. Microsoft's office 365 education-cloud based collaboration tool and office web apps, google's free web-based e-mail, calendar, documents for collaborative study and chromebook for education, Amazon's AWS cloud, IBM cloud Academy, salesforce.com, education cloud, HP cloud computing already providing cost effective solutions and storage resources to IT infrastructure for educational institutes[10].

In [11] the author proposed a model for designing national cloud for education in Nigeria. The author claims that this model will provide an affordable access to technology and better education outcomes in developing countries.

In [12] the author has presented the cost benefit analysis of Cloud Computing in educational institutions. According to this survey educational institution will be relieved from the burden of handling the complex IT infrastructure and lead to huge cost savings.

4. Cloud for University

Using Cloud Computing technology, resources can be made available to students, faculty and other authorized users off campus. Authorize users can be provided login and passwords by university for authentication. Submission of records from faculties to office or students to faculties can be done online without restriction of physical presence. Researchers can access research papers and study material provided by university from anywhere. Online courses by university can be made available for students at remote place too. Online interactive sessions/discussions and online admission will help students and researchers to enhance their skills and knowledge without physical restrictions. Online exams can also be conducted for students.

Cloud based education will enhance an already existing e-learning systems by providing a wide variety of software and hardware devices and storing the data in the cloud storage. Collaboration on research projects among teachers and students of different colleges under same University or among different universities with the same interest can also be done through cloud Computing. Universities can circulate information to the Colleges through Digital notice board for important circulars, instructions, notifications and information with access rights at different levels. Resources will be available 24X7 to the users.

Some universities have an intranet setup that connects all colleges under that university. Colleges can access various types of information through this connection. But it is not sufficient for all types of requirements. If somehow all the above mentioned functions are performed using a website or internet then it will be very costly. It will also slow down the server on increasing usage. This problem can be solved by increasing number of servers. But again it will lead to extra cost. With the powerful features like scalability, multi-tenancy, virtualization and load balancing, cloud computing has emerged as a powerful and improved technology with pay per usage. Data on a cloud can be accessed with any access device with internet connectivity. In this way 24x7 services are available for everyone with a little requirement of resources. Time will not be a restriction any more. Also, there will be no need for leased lines if public cloud is used.

Once the required software as per syllabus/curriculum are installed on the cloud, it would be accessible from all the colleges. There will be no need to purchase softwares by different colleges individually. It would maintain uniformity of softwares and their versions among different colleges. It will also benefit the students, as they need not to buy expensive software and can easily work over the same version at home. Even in the economically deprived category it will be a great help to access required study material with a mobile or dump terminal. It will have an impact on the research projects when faculty and students are

working in collaboration. A discussion forum can be created in the cloud for their uninterrupted communication. A number of authoring tools are available on a cloud that can enhance content creation by faculty at different locations.

Demonstration of software on smart board in the classroom will be done easily as software, running on a cloud can be shown virtually (virtual demonstration of real scenario).

With the availability of on demand provision of accessing and releasing the required configurable hardware and software through the cloud, teachers gain a lot of flexibility in designing virtual practical environment for students as per the need of curriculum using an available application, pre-configured systems and virtual machine without going in the details of their actual implementation on the servers on the cloud.

As discussed Cloud Computing can be seen as one of the biggest sources of enhancing connectivity in a university among administration, teaching, non-teaching staff and students. Although its role in enhancing interaction between faculty and students is of utmost importance and cannot be ignored. Faculty-student on-campus interaction/discussion can be actually enhanced off-campus by Cloud Computing. Online assignments can be given to the students. Students can also submit their assignments any time from their home. Student assessment can also be placed online for transparency. Important discussions can be done apart from regular teaching hours in the classroom.

4.1. How Cloud Scores

The below listed features score over other environments.

• Reduce hardware, software and maintenance cost at the user's level only basic facilities are required to access cloud through internet.

• Scalability/ elasticity.

• Pay per use or cost will be as per university norms

• Huge amount of storage space

• Online connectivity

• Collaboration on project work

• Content creation by authors using cloud tools

• Virtual classrooms

• Virtual labs

• Easy Access

• Availability of latest resources

• Fast implementation of latest resources

• 24 X 7 access

• Content management

• Online admission process

• Online examination process

• Online student information system

5. Proposed Model

In this section a model for university system has been proposed. In the model we propose the E-cloud architecture as shown in the figure 1.

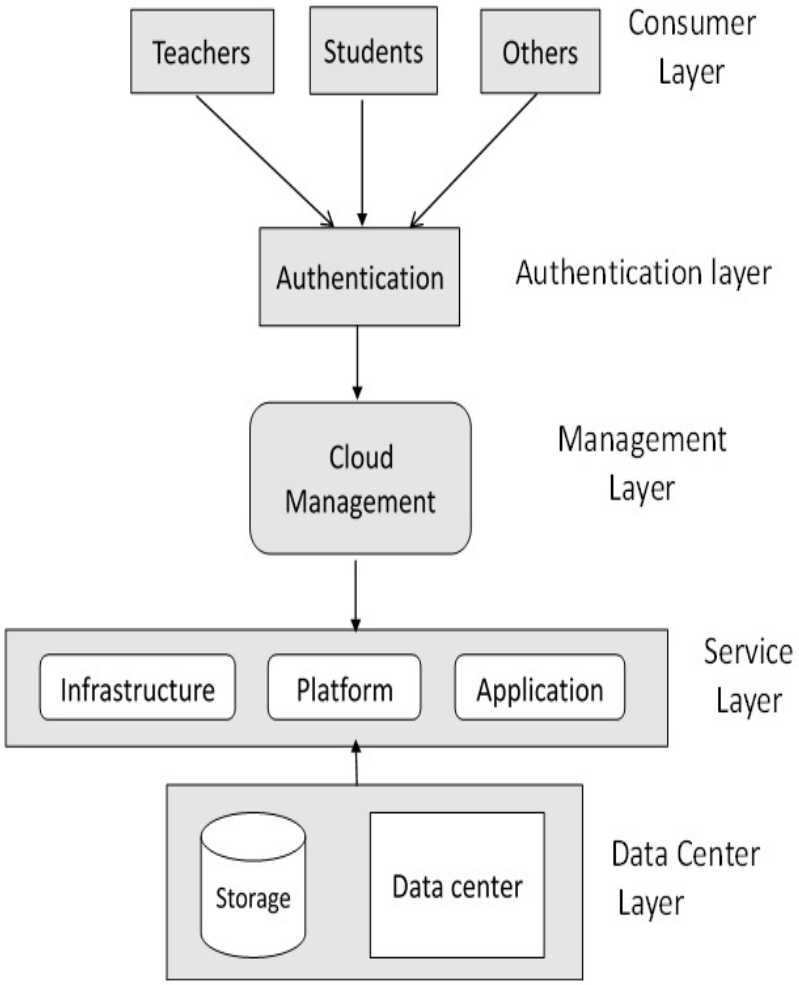

Figure 1. Proposed E-cloud architecture

The proposed architecture consists of five layers as described below:

1) Data Center
2) Service layer
3) Management layer
4) Authentication layer
5) Consumer layer.

The first layer is the Data Center. It consists of servers, storage, highly configurable hardware, licensed and open source software, library infrastructure, course structure, network devices, Course contents, virtual networking, virtual classrooms, virtual labs, databases, backup, security and protection provisions. It is the pool of dynamic and scalable resources.

Second layer consists of services that are required by the user. Service layer include infrastructure service, platform service and application software service. Infrastructure service includes storage, CPU access time, memory and networking. A platform service includes operating systems, virtual classroom, virtual labs, application development and testing tools, integration,

Application software services include all the applications created for direct usage. Some of the common applications used are admission package, accounting package, online journals and research papers, video conferencing, e-mails, student information system for managing their attendance, assessment, grading and achievements and so on. They are loosely coupled software.

Third layer is the backbone of this architecture. It consists of management of the cloud. It deals with accounting, billing, auditing, reporting, pricing, SLA management, and rapid provisioning. Load balancing and virtualization is also done at this layer to optimize the resources. It deals with the user's request. If it is authorized user, then it provides the services required by user in required combination and generate billing as per university norms.

Fourth layer checks the authenticity of the user. Unauthorized use is not allowed. Different level of access rights may be given to different types of users. The teacher can read, write and update information related to student, course content, lectures and lab work. Students can read, write and update their assignments and class work, but can only read course content, circulars, instructions, lectures and lab work provided by the faculty. Authorized student can give feedback or suggestions separately. Subscribed Research papers, Journals and project can be made accessible to faculty as well as researchers. University Administration can have all access rights for information updates, online evaluation, admissions, examinations etc.

The last layer is the users. Users can be university, college students, faculty, researchers and administrative staff with different roles. Students, teachers, non-teaching staff and researchers of a college can access information only through college for security and protection reasons.

The proposed architecture defines three key roles: Cloud Provider, Cloud Consumer, and Cloud Developer as shown in fig. 2.

Cloud Provider in this model is a University. It contains the infrastructure, manages resources and provides service to the consumer. Billing formulation is the decision of cloud providers. Role of Cloud Provider is to provide services like online admission, examination, course schedule, student/faculty information system, hardware, software and library resources to cloud consumer.

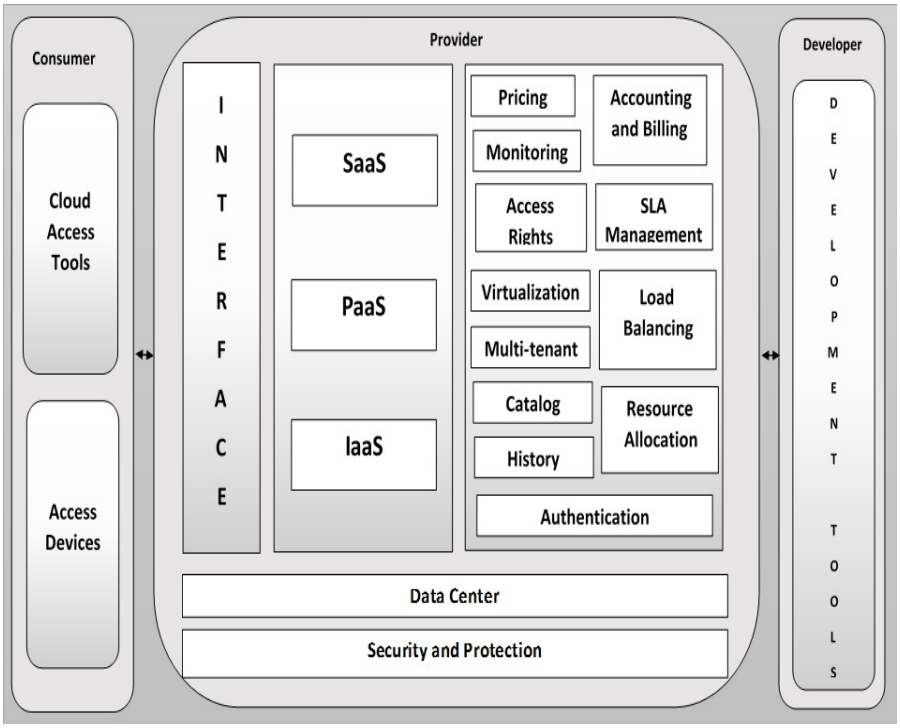

Figure 2. Key Roles in E-Cloud

content creation tools and database management. It contains the tightly coupled application developing on a specific platform. Cloud consumers are the Colleges under the universities, students, faculty and researchers from different departments of the colleges and other universities in collaboration of the university if required.

Role of Cloud developer is the development and deployment of various customized services like online admission, examination, course schedule, student/faculty information system, virtual classrooms, database and lab environment using infrastructure of data centers.

Steps for accessing this cloud model for education:

• The user browses the service catalog.

• The user submits the request for the service/resource

• User's authentication is checked in authentication layer for security reasons. A List of access rights is also created in the authentication layer according to the designation of user for further security and resource availability.

• Management layer receives the request and checks the access list for the user. If it is in the list, service will be granted by allocating resources through allocated virtual machine to the user. If requested services do not lie in the access list then a decision will be taken on the basis of availability of resources and workload at that particular time.

• Requested services are provided to the user by the allocated virtual machine.

• Bills will be generated on the basis of pricing and accounting of resource utilization.

• History is maintained by the management layer for further planning the improved strategies of resource allocation decisions.

• List of allocated resources and virtual machines is maintained separately for evaluating the status of resource overloading.

Cloud Computing model in education can be a great contribution to the people with physical disabilities who wanted to learn the latest technology at their doorsteps without physical barriers.

Cloud Computing is the emerging technology in the field of education with the benefits of resource availability, scalability and huge space with little infrastructure requirements. It leads to revolution in education as it breaks the barrier of location specific teaching. The blended learning would improve the educational standards.

6. Conclusion And Future Work

This paper proposes a cloud model for educational institutions. It describes the requirement of Cloud Computing in the basic education system by including advanced technology with cost effective solutions. With the implementation of cloud, educational institutes need not invest huge amount for infrastructure as it is now provisioned by the cloud provider. Yet the establishment of a legal framework, security, privacy and reliability require more attention. Flow of information with secure data and analysis is required to evaluate the success of the proposed model. A suggested model is generic in nature that can be customized further as per the requirement of various universities. Future research will be on the study of services in details with security. Future research needs to incorporate collaboration on projects and courses sharing with different universities having a different architecture in the national and international level. Sharing of cloud architecture among different universities with same interest requires the protocol for compatibility with their structure and format. To identify the tools for content creation in multilingual form by the authors of different subject and delivery of the contents requires further research.

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