Cloud Computing: An Economic Solution to Higher Education

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ABSTRACT

In the information age it seems mandatory to use the services of Information Technology (IT) in all the activities of higher education. The computing resources of present are powerful, capable and aid in improving quality of work. A dilemma is faced as technology in terms of hardware and software is quickly being improved for the better. Newer technology costs and the educational institutes face financial constraints. The cloud computing provides support and as well as develops means and ways to bestow computing services at an affordable price to educational institutes. This paper, discusses the challenges of higher education environment, cloud computing followed by the cloud architecture for higher education and finally concludes by presenting cloud solution for higher education environment.

Keywords: Cloud Computing, Higher education, Infrastructure as a Service, Platform as a Service, Software as a Service, Architecture.

1. INTRODUCTION

Higher Education deals not only with classroom teaching but also includes research related activities comprising of collection of data, computation of data led by analysis, interpretation of results and eventually storing data as well as results. For the attainment of results or for verification of the results various processing are performed. Earlier the teaching was confined to the physical domain of the student, teacher and the institute. With the advent of computers bounds of the domain have disappeared. The teaching and learning process is conducted in virtual space. Ease of access to books, retrieval of earlier research performed, ability to interact with researchers around the globe, all have increased the availability of data for analysis. Keeping in view the magnitude of data, a need of automated processing device in the form of computers is required. Further, the quality of data analysis is enhanced by the use of computers. The computer easily finds deviant cases or extracts small pieces but significant information from a large set of data. Moreover, it reduces the paper requirement, makes the analytic process more pleasant and less tedious for the analyst. Further, computers in qualitative research produce real savings in terms of the amount of time saved in locating the desired data and as well as in computations performed on the data [11]. Smith et. al. in their study depicts that computers are of great help for students of university in their education [15]. Computing resources provide a roadmap for exploring research activities [12]. Computers are capable to handle vast quantities of data at a very high speed of processing. For the purpose of research, a lot of data can be generated through application software and later for analysis a high end computing processor is necessary to produce information from it. Willis et. al. state in their book [20] that computers are of great help in education: (1) computers help in searching appropriate literature (2) computers provide details of source of information (3) computers secure the data (4) basic software tools are provided (5) analyses the data using the tool.

According to Mircea et. al. Cloud Computing may be considered an extension of SOA (Service Oriented Architecture) and an alternative to the use of IT for educational environment, especially in the conditions of the present financial crisis [9].

In the book titled ‘The Tower and the Cloud’, Richard Katz focuses on many areas where the cloud may impinge on education [6]. He advocates that because companies might be storing documents which should not be made public, there are reasons for concern about what can happen to the information. Potential Cloud organizations and vendors need to be aware that it may become easier for attackers to threaten clouds by moving towards a single cloud interface. The cloud service providers could provide the educational institutions the opportunity to take the advantage of new developments in IT technologies at affordable costs. Cloud computing can be an attractive proposition for higher education establishments. The UK’s National Computing Center (NCC) estimates that small and medium enterprises can reduce the total cost of ownership of information technology using cloud solutions [8].
Students in the 21st century have different and vast learning needs which no longer can be satisfied with traditional teaching and learning methodologies [18] i.e. lecture-based, tutorial session, use of multimedia contents and etc. It is essential for universities, colleges and schools to adopt new approach and technology that will better prepare and equip students for current and future job market needs. Education Cloud will address the role of cloud computing technology to improve teaching and learning methodology.

2. CLOUD COMPUTING AN OVERVIEW

All Cloud computing is a computing model which increase the capacity or add capabilities dynamically without investing in new infrastructure or purchasing the new licensed software. Cloud computing can be thought as an extension to the existing information technology capabilities. Cloud Computing is a concept in which information is permanently stored in computer servers on the internet and cached temporarily on clients that include desktops, table computers, notebooks, wall computers, sensors, monitors, etc. [5]. Cloud computing is internet-based development and use of computer technology. The cloud symbolizes for the internet and is an abstraction for the complex infrastructure it conceals. Information Technology (IT) organizations outsource computer hardware by leasing Central Processing Unit (CPU) time through cloud computing services. A proposed modeling tool can quantitatively compare the cost of leasing CPU time from these online services to that of purchasing and using a server cluster of equivalent capability [19]. Cloud computing is a style of computing in which IT-related capabilities are provided “as a service”, allowing users to access technology-enabled services from the internet ("in the cloud") without knowledge of, expertise with, or control over the technology infrastructure that supports them [2].

Cloud computing is categorized into three levels of services as shown in Figure 1. The levels namely, Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) form the backbone of the cloud computing.

**Figure 1 Levels of Cloud Computing**

**IaaS:** It is the access of hardware (server, storage, network). It is an evolution of traditional hosting that does not require any long term commitment and allows users to provision resources on demand. The IaaS provider will generally provide the hardware and administrative services needed to store applications and a platform for running applications. Scaling of bandwidth, memory and storage are generally included, and vendors compete on the performance and pricing offered on their dynamic services. The service provider owns the equipment and is responsible for housing, running and maintaining it. IaaS can be purchased with either a contract or on a pay-as-you-go basis. However, most buyers consider the key benefit of IaaS to be the flexibility of the pricing, since one should only need to pay for the resources that the application delivery requires. Features and components of IaaS include: utility computing service and billing model, automation of administrative tasks, dynamic scaling, desktop virtualization, policy-based services and internet connectivity [4]. Examples of IaaS providers are Amazon Web Services Elastic Compute Cloud (EC2), Terremark (NASDAQ: TMRK) and Secure Storage Service (S3).

Server resources are essential elements of IaaS. A cloud computing installation should never be overwhelmed by peak demand, because the infrastructure service should be able to quickly add the resources needed to accommodate peak demand. The consumer does not manage or control the underlying cloud infrastructure.

IaaS is sold as a metered service; the user pays only for the bandwidth and other services that the user is using. Generally, fees are based on throughput but some vendors charge for server time, as well [23] [7].

**PaaS:** In the traditional computing model each application managed locally acquired hardware, an operating system, a database, middleware, web servers and other software. One also needs to remember the team of network, database, and system management experts that are needed to keep everything up and running. With cloud computing, these services
are now provided remotely by cloud providers under this layer [16]. PaaS provides the cloud consumer with the capability to deploy applications onto the cloud platform using programming languages and tools supported by the cloud provider. The cloud provider manages the cloud-network, servers and operating systems. The cloud consumer controls the deployed applications and the application hosting environment configurations. The PaaS makes available a stage to the consumer to execute the much needed applications of the consumer. Examples of PaaS providers are Google App Engine, Mosso Rockspace, Force.com and exocloud IDE.

SaaS: SaaS is highly flexible, scalable, great performance with better availability, vast services and less maintenance. Yahoo mail, Google docs, Enterprise Resource Planning (ERP), Business Process Management (BPM) and Customer Relationship Management (CRM) are some applications of SaaS. Under the umbrella of SaaS customer needs to register on a subscription basis, login to the central system and select the features that are wanted, and any additional databases and applications if required and import any existing customer data. End user is free to use the service from anywhere with availability of application and data host by service providers. SaaS is very effective in lowering the costs of business as it provides the business an access to applications at a cost normally far cheaper than a licensed application fee which is possible due to its monthly fees based revenue model. Hence no need to purchase and support the infrastructure that the application runs upon. SaaS provides enhanced productivity and faster deployment anywhere, anytime. There is no need to license and support the software in the traditional fashion. SaaS has rapid, flawless platform extension, geographic expansion and worry-free bandwidth [3]. SaaS is always up to date. It runs the most recent version of the application. The pain of installation and upgrading is replaced by a simple request to run a specific version of the software. It eliminates the need to install hardware or software on the client premises [17]. SaaS offers the software on demand. Some popular service providers are Salesforce.com, NetSuite, exoprise systems, antenna software CVM solutions and Aplicor.

3. IT CHALLENGES IN HIGHER EDUCATION

Though use of computers is of immense help in higher education but a number of challenges exist, which may be categorized into institute level and student level.

1) Institute level: The management of the institute faces difficulty in providing computer resources to the students and faculty members due to various factors:
   a) Purchase of costly hardware: The computer system, followed by network services for the purpose of connectivity and servers to manage the IT services are needed. The lack of affordability of computer hardware has impact on use of IT and further any purchase of cheaper computing resources result into incorrect assumptions leading to discourage of the use of computers [14].
   b) Updation of hardware: The technology is shifting for the better at a very fast pace. The processing capabilities of the computer system are increasing every now and then. In the past decade the Intel Corporation has launched more than 25 processors into the market. Year 2000 witnessed Intel Pentium III processor, on its way to the latest processor of today, Intel brought in Solo (single-core), Duo (dual-core), Quad (quad-core), and Intel Core 2 processors with vPro technology (designed for businesses) include the dual-core and quad-core branches [24] [22]. Similarly the memory capacities of the secondary storage devices have increased in manifolds. A few years ago a meager Giga byte of storage device capability has risen to availability of tera bytes of storage capacities. The teaching institutes may not be ready to face the brunt of the continuous up gradation of processors at the pace set by the innovations of the technology.
   c) Maintenance of hardware: The electronic devices require repair at some or the other stage for which an Annual Maintenance Contract (AMC) is signed with the hardware vendor for a price. All this leads to financial burden and requires management of such activities.
   d) Decreasing life span of hardware: The average life span of computer hardware has decreased over the years to about 3-4 years [21]. It means that the heavy expenditure made on purchase of hardware is depreciated to almost negligible value in a period of 3-4 years. Computer hardware has a very low resale value and software has none. Building renovations to accommodate information and communication technology tend to create teaching spaces with few alternative uses [13]. Old hardware has problems of compatibility with latest software and with new hardware. Storage of hardware gives birth to creation of junk yards. This has further led to the creation of another problem of e-waste [1]. The disposal of obsolete hardware is cumbersome in the light of environmental hazards [10].
   e) Installation of hardware and / or software: New hardware needs to be installed and has to be made compatible with the existing hardware as well with software. System software and application software both have to be installed on the purchase of the hardware and as well as when the software is procured. Personnel have to be hired and trained with the advent of new technology for this task. Finances and management requirements are necessary for it.
   f) Purchase of costly licensed software: Software in the form of licensed copies of system software and application software are to be purchased which incur heavy expenses.
The work of the students generally become easier with the use of computers, however certain difficulties are also faced by the students.

a) Working hours: The students are restricted to make use of computer resources within the working hours of the institute.

b) Non availability of resources: The students are not able to access the computer resources as the same are preoccupied by others.

c) Portability: Purchase of new hardware by the institute requires old data to be copied onto the new system. But portability, compatibility and no time given for copying data may be some of the problems faced by the students. At times newer application software makes old data useless.

d) Limited resources: Student is dependant on only those computer resources which are made available by the institute. It may be frustrating to the student, as his study may suffer due to lack of resources.

e) Demands not met: The requirements as laid down by the student for the hardware and / or the software may not be satisfied by the institute on time. This would increase the level of stress and as well delay the process.

f) Compatible: New software may not be compatible with the old hardware or vice versa.

g) Working area: The student is restricted to work only in the institute on the task assigned. The student has to be physically present in the institute premises to work upon.

h) Delay: The process of procurement of hardware / software may require a lengthy process of quotations and tenders leading eventually to purchase of obsolete item(s) or getting access to an older version of software.

i) Computing power: In today’s world one has access to huge amount of data due to the fact that the data can be downloaded using internet, thus denying the limitation of boundary walls, rather having access to data from any corner of the world. Any calculation / processing of such immense data require high end calculating processors and / or high storage capacity devices. Such devices are costly and only a limited access to such devices is available.

4. CLOUD ARCHITECTURE FOR HIGHER EDUCATION INSTITUTION

In this section the researcher proposes a three tier cloud computing architecture to meet the IT challenges that are faced by the higher education institutions. The architecture is based upon

• The IT needs of the researchers can be the specialized software and hardware that will be needed for carrying out the research which involve a great deal of processing (high end processors) and computation.

• The IT needs of the software developers can be the web development tools and software that are required for writing and hosting the web applications.

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The higher study institute comprises of student, teaching faculty, management, administrative staff, researcher and software developer. The various IT needs of a higher education institution can be met by migrating from traditional IT environment to the cloud environment. For example the IT needs of the students, teaching faculty, management, administrative staff can be met by using the services of the providers of the SaaS and IaaS cloud.

The researchers can use the IaaS cloud for their IT needs. Moreover, the IT needs of the employees responsible for computerization can be solved by hiring the services of the PaaS cloud. The three tier architecture for higher education institution is depicted in the Fig. 2. As shown in the Figure 2, the 3 tier of the architecture are represented by SaaS, IaaS and PaaS. The services of SaaS can be well utilized by students, faculty the IT needs of the students, teaching faculty, management, administrative staff, researchers and software developer. The IT needs in any of the higher education environment can be classified as follows:

• The IT needs of the students, teaching faculty, management, and administrative staff can be the software (e.g. operating systems, application software, antivirus, email accounts, programming environment, databases and hardware
In the cloud environment SaaS provides the feature of application software, email management software, programming environment databases, middleware, antivirus, firewalls and many other related software at the doorstep of user against a price of “as-you-use” or duration specified. Similarly, IaaS provides the facility to researchers, personnel responsible for computerization, students working on IT related projects on the same analogy of “pay-as-you-use” or duration specific or hardware specific.

Figure 2. Three Tier Cloud Architecture for Higher Education Institution

Finally, personnel accountable for automation and researchers may use web development, hosting software and specialized tools under the layer of PaaS.

5. CLOUD SOLUTIONS FOR HIGHER EDUCATION ENVIRONMENT

For effective cloud service usage an assortment of cloud service providers exist. Table 1 portrays a list of cloud service providers in accordance with the level of service and the users of cloud. The symbol (√) used in the table denotes that the particular IT need of either student, teaching faculty, administrative staff, researcher and developer is fulfilled by the specified cloud solution in the form of a product. Microsoft office 365 is a SaaS solution which can be operated by students, faculty members, administrative staff, researchers and developers as it provides features such as email, office documentation, communication and management tools. Salesforce.com is another SaaS solution and is useful because of its various features namely student, alumni, faculty management, real time analytics, application development, team collaboration, student recruitment and mobile communication. Google big query is a web service to perform analysis on huge data bases. It lets developers and researchers do powerful data analysis. New Relic solution delivered in a SaaS model, monitors applications running in cloud, on premise or hybrid environments. It is of use to researchers, developers and faculty members.

Blue lock is an IaaS specializing in disaster recovery of data. Google app engine enables developers to build web applications using PaaS model. Windows azure provides PaaS and IaaS with classification as public cloud for storing data, building, developing and mapping applications. Rackspace email provides numerous facilities which are applicable to student, faculty, administrative staff, researcher and developer in the form of web mail, calendar, contacts, notes and email related activities are of use to all.

Iland is an IaaS cloud based disaster recovery service along with management of network, storage, security, build and manage data centre. Soft layer deals with IaaS. It provides high performance computing servers, scalable storage capabilities, private clouds, network facilities and remote access to management tools.

Amazon Relational Database Service makes it easy to install, operate and scale relational database in the cloud. It allows to ease applications, database administration tasks, provides access to capabilities of most efficient RDBMS for students, teachers, administration and researchers to explore and also to developers to build databases.

Table 1: Cloud Computing Solutions

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<tr>
<th>Cloud Service</th>
<th>IT Need</th>
<th>Student</th>
<th>Teaching Faculty</th>
<th>Administrative Staff</th>
<th>Researcher</th>
<th>Developer</th>
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6. CONCLUSIONS

The computing resources are playing a very important role in higher education. In today’s computing environment the hardware, software are changing at a very rapid speed and the institutes of higher education suffer the burden of high cost of purchase of computing resources and later the hassle of maintaining the same in terms of repair, AMC and up-gradation. The cloud provides a solution for all such challenges which the higher education institute faces. Cloud computing is an information processing model in which centrally administered computing capabilities are delivered as services, on an as-needed basis, across the network to a variety of user facing devices. Thus, cloud computing provides an economical, viable, scalable, flexible solution, to the problems of ever growing technology of computing resources. The paper elaborates the correlation between the problems faced by the educational institute’s management relating to IT infrastructure with the facilities given by the cloud computing. Thus it has been established that with the use of cloud computing higher education could be highly benefited.

REFERENCES


[23] http://www.iaasdefinition.com/ accessed on 30-10.11 at 17:00