Cost Benefit Analysis of Cloud Computing in Education

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Abstract—**In the current financial crisis and the growing need for quality education, the educational institutions are under increasing pressure to deliver more from less. Both public as well as private institutions can use the potential benefit of cloud computing to deliver better services even with fewer resources. Application of Cloud Computing in Education not only relieve the educational Institutions from the burden of handling the complex IT Infrastructure management as well as maintenance activities but also lead to huge cost savings. Government of India is having the ambitious plan to raise the present 16 million enrolments in higher education to 42 million by 2020 as well as interconnect electronically India's 572 universities, 25,000 colleges and at least 2,000 polytechnics for enabling e-learning and content sharing across country. The lunch of low cost, affordable Aakash tablet PCs for the student community is likely to increase the number of users' for educational online resources exponentialy. In this paper we have studied about the benefit of use of cloud computing by educational institutions**.

Keywords-National Knowledge Network (NKN);Virtual Computing Lab(VCL;Meta-University; Cloud Computing & Total Cost of Ownership(TOC).

I. INTRODUCTION

Financial crisis as well as the exponential demand for quality education has put the educational institutions is under increasing pressure to deliver more from less. By sharing IT services and resources among themselves educational institutions can better concentrate on their core academic and research activities.

Cloud computing is an evolutionary step in computing that unifies the resources of many computers to function as single entity, allowing the construction of massively scalable systems that can take in and store, process and analyze all the data[2] of an organization. With cloud computing as part of IT strategy, an organization can increase their capacity without compromising security or requiring the educational institutions to make heavy infrastructure investments while helping to lower the Total Cost of Ownership (TCO). Therefore they need to find ways to offer rich and inexpensive services and tools [1] for academic and research activities with the right balance of on-premise and cloud services.

By combining the best practices of Virtualization, Grid computing, Utility computing and Web technologies the Cloud computing is a resultant computing infrastructure that inherits the agility of Virtualization, scalability of Grid computing and simplicity of Web 2.0.

Cloud Computing is a recurring expenditure model and is much like telephone or electricity expenditure and hence it is accounted as standard Operating Expense (OpEx). OpEx is beneficial as it gives the flexibility to terminate costs at will. With a capital purchase, the server or software being acquired is fully committed to regardless of whether it is being utilized or not. The ongoing costs by way of depreciation or financing costs still need to be borne contrast to OpEx, where, in case the item is no longer required, payments can cease accordingly. Due to this reason many organizations prefer leasing vehicles in place of purchasing them outright.

In this paper we have compared the costs of Total Cost of Ownership (**TCO**) versus **Cost per User per Month** model for an organization of **30 users** for a period of **3 years**. Another analysis for replacing **5 PCs** for an Office environment by shifting to cloud computing for an analysis period of **3 years** was also found very impressive in terms of cost savings as well as other benefits like relieve from the burden of maintenance of computing infrastructure etc.

The rest of this paper is organized into **9** Sections. Section-2 is about cloud computing application in education while section-3 is about the virtual computing lab. In Section-4 we have made a comparative study on Cloud versus Total Cost of Ownership. In section-5 we have mentioned about cloud initiative in Singapore Polytechnic. Section-6 is about the India cloud scenario in education. Section-7 is about the 5 steps for integrated cloud management. Section-8 is a case study on Ben-Gurion University, Israel. Finally section-9 is our observations & conclusion.

II. APPLICATION OF CLOUD COMPUTING IN EDUCATION

Cloud computing offers the educational institution the opportunity of concentrating more on teaching and research activities rather than on complex IT implementation.

Many universities have already utilized the potential and efficiency of cloud computing in higher education. Among which we mention University of California, Washington State University's School of Electrical Engineering and Computer Science, higher education institutions from UK, Africa, U.S and others. By utilizing the cloud services, North Carolina State University achieved substantially decreasing expenses of software licensing as well as reduced the campus IT staff from 15 to 3 employees with full working schedule [3].

Florida Atlantic University (FAU) established in1964 is the first public university in southeastern Florida with intake capacity of more than 29,000 students from a main campus in Boca Raton and 6 other campuses across southern Florida. Students are offered more than 170 degree programs. The faculty researchers use more than 40 research centers and the university offers hundreds of cultural and educational events

every year [4]. By virtualizing its data center using Hyper-V (a hypervisor based server virtualization product that allows consolidating workloads onto a single physical server), the University has been able to trim IT costs by at least U.S. $600,000 and deliver new IT services without expanding its staff. The University was able to run Blackboard on Linux in the Hyper-V [22] environment, simplifying administration and delivering increased performance. By distributing computing power across campus locations and adding virtual machines on demand, the university can deliver higher availability of IT services and give students and staff a better computing experience [5].

Aga Khan University in Pakistan found that cloud computing helped strengthen security and improve protection against viruses, resulting in 66% reduction in calls to the IT department.

Cloud computing environment teaching resource library has the following characteristics:

- Stable with a powerful, convenient, fast search and query capabilities
- Standardization, classification specifications, user edit and use. Conducive to building the sustainability of the repository
- All information and data are in the clouds, local no need to retain and backup
- All types of users at all levels can be quickly and easily find the resources and the corresponding functions, and can be easily controlled cloud and treatment.

A. SaaS for Higher Education

Microsoft Live@edu is a program that provides students, staff, faculty and alumni long-term, primary e-mail addresses and other applications that they can use to collaborate and communicate online etc free of cost to educational Institutions. Students will be using Microsoft products similar to those used in many workplaces that help to prepare them for jobs after college. Microsoft's new customers include Portland Public Schools, Oregon; University at Albany, Fashion Institute of Technology, Vanderbilt University, City of Alexandria, Va [6] etc.

B. Cloud Computing in Distance Education

Modern Distance Education goal is to achieve 4A, namely Anyone, Anytime, Anyplace & Anything i.e. any person at any time, any place can be any content learning [7]. However, the services that current distance education sites to the leaner's are far away from 4A.The organizations of educational resources are basically still in the information level, far short of the level of knowledge etc.

With the development of distance education network, the experiment has played an important role in learning. Experimental teaching is conducive to individualize learning for specific individual students with different learning requirement. Experimental teaching plays unique role as it has nonverbal communication and evaluation functions in the process of teaching. The basic requirements of students' hands-on practice are possible in experimental teaching while the distance learning mode cannot meet this requirement.

Collaborative Learning creates a community in which students can get emotional support as well as build trust among students [21].

Distance education based on Cloud Computing services will change this situation. With broadband Internet access the users are able to get all kinds of materials required for personal study environment by simply signing into their account. The cloud computing enhanced network flexibility and agility to learn and reduce the cost and difficulty of Web learning resources and services .It can supply a way of agile and flexible learning and a rich learning environment, helping to improve learning productivity and ultimately improve learning outcomes.

By combining the resources of different educational Institutions in the cloud will cut the resources investment to single [8]. The personal terminal devices which may be not a high quality to access the internet, the users can enjoy the cloud service and they don't need to upgrade the software. In order to avoid reconstruction and upgrade, there exists service or many services to store the resources [9].

In Cloud Computing teachers and students and students and students can implement collaborative learning such as the online exchange, online document editing, On-line using the concept map tool like Google Collaboration Platform [10]. Students will receive some emotional support in this community and there will formulate incentives to overcome the lazy in self-study between companies.

III. THE VIRTUAL COMPUTING LAB(VCL):A CLOUD COMPUTING SOLUTION FOR EDUCATION

Universities that are deploying a cloud expect some interesting benefits not associated with traditional labs and/or student workstations [11]. Some look forward to the increased personal safety of their students and the associated reduced security costs due to the ability to close those labs at night or even permanently. Students can access VCL using their laptops or workstations from their dorms or from home. Some universities are redefining those spaces for student collaboration environments or for other purposes and activities, saving construction costs etc.

Some of the benefits of VCL are summarized in the table:

TABLE I

Beneficiaries	Benefits
Students	• Raises computing resource accessibility, even in underserved districts • Increases availability and integrity of data, applications and research materials • Adds mobility • Reduces client application and system resource footprint • Amplifies application and computing performance • Improves server and data storage capacity • Offers convenient web access to the VCL
Faculty	• Grants accessibility to virtual machines • Schedules delivery of assignment instructions, study materials, syllabi or software • Enables faculty to create custom images for specific course, independent of (and not conflicting with) other faculty course images • Unites departments and campuses to eliminate information silos to deliver comprehensive

	educations
Administration	• Standardizes applications and processes • Provisions software, resources and management of data • Lightens the burden of software version control • Reduces total cost of ownership by nearly 50% to 90% • Lowers the need for in-house IT staff • Cuts resource management costs including power and cooling • Raises server utilization and software licenses, reducing purchasing requirements • Brings greater virtualization • Optimizes resource allocation

IV. CLOUD VERSUS TOTAL COST OF OWNERSHIP (TCO)

Storage is a considerable part of any desktop virtualization solution. Desktop virtualization software allows deploying and managing desktop environments and applications centrally. User access can be provided to a virtual desktop over standard network infrastructure without affecting the users' level of control over their desktop environments. The following table(survey by cloudservices@dincloud.com) gives the comparative cost for Total Cost of Ownership (TOC) for 3 years and Cost per user per month (Cloud Computing) for 30 users for virtual Desktop [12].

TABLE II

Items	3 Years TCO	Cost/User/month
Hardware	$ 761,892	$ 622.45
Cables	$ 480	$ 0.4
IP Address	$ 59,018	$ 48.21
Management	Nil	Nil
MDS(Multilayer Director Switch)	$ 17,895	$ 14.62
Server	$ 117,811	$ 96.24
Storage	$ 227,178	$ 185.6
Switch	$ 338,660	$ 276.69
Thin PC	$ 850	$ 0.69
Software	$ 210,019	$ 171.57
Hosted Virtual Desktop(HVD) Software	$ 43,414	$ 35.47
Monitoring & Alerting	$ 5,524	$ 4.51
Office Standard	$0	$0
Patch Management	$ 2,618	$ 2.14
Profile Management	$ 2,166	$ 1.77
Profile Mobility	$ 5,083	$ 4.15
Security	$ 3,507	$ 2.87
Server License	$ 116,429	$ 95.12
Virtual Desktop Infrastructure(VDI) Assessment	$ 1,666	$ 1.36
Security Manager	$ 8,000	$ 6.53
Server Security	$ 1,200	$ 0.98
Virtual Desktop	$ 14,746	$ 12.04
Security	Nil	Nil
Email Security	$ 2,611	$ 2.13
Virtual Firewall	$ 3,055	$ 2.5
Support	$ 46,930	$ 38.34
Administration	$ 28,215	$ 23.05
Deployment	$ 3,465	$ 2.83
Help Desk	$ 10,800	$ 8.82
Power & Cooling	$ 4,450	$ 3.64
Grand Total	**$ 1,018,841**	**$ 832.36**

Hence the total savings is $ 10, 18,009/-

A. Cloud vs. On-Premise Calculator

The following table shows the cost of On-premises versus Cloud computing environment [13] for an analysis period of 36 months (3 years) which is considered standard life of computing infrastructure. However, the analysis period and the number of PC to be replaced can be increased or decreased as per the requirement of the user. The calculations are for an identical office environment for 5 computers(10 users) developed by Uptime Systems, 708 South 3rd Street, Suite 110E, Minneapolis, MN 55415.

TABLE III

UP-FRONT COSTS		
Direct/Indirect Cost	**On-premises**	**Cloud**
Hardware: Server ,End points	$ 5,500	Nil
Server OS & Client Access License	$ 1,500	
Backup Hardware & Software	$ 2,000	
Auxiliary Server Equipment	$ 500	
Installation/Migration Costs	$ 4,000	$ 3000
	Total $ 13,500/-	**$ 3000**
MONTHLY COSTS		
Proactive Maintenance & Monitoring	$ 300	Included
Backup Costs (Offsite/Online)	$ 50	Included
Spam Filtering/POP3	Nil	Nil
Hosting Costs	Nil	$ 450
Total Monthly Costs	**$ 350**	**$ 450**

Source: www.uptimesystems.net/Cloud

TABLE IV

Variable costs		
Unplanned Repair Costs	$ 2000	Nil
SAVINGS ON PC'S		
No. PC's to Replace Over Analysis Period	Nil	5*
Savings per PC on Hardware	Nil	$ 200
Savings per PC on Setup Labor	Nil	$ 200
Savings per PC on Microsoft Office	Nil	$ 200
Total Savings on PC's Over Analysis Period =($200+$200+$200) x 5	Nil	$ 3,000

***No of PCs & analysis period can be increase/decrease as per requirement.**

Total cost over estimated life of 36 months for On-premise=$13,500/- + (36x $350) +$2000-0=$28,100/-

Total cost over estimated life for cloud=$3000/-+ (36 x $450) +0-$3000/-=$16,200/-

Hence the saving for moving to cloud by replacing 5 PCs was $11,900/-.

TABLE V

OTHER FACTORS	On-premises	Cloud
Accessible from Anywhere	Maybe	Yes
Subject to Facility Problems	*Yes	No
Built-In Business Continuity	No	Yes
Scalable	No	Yes
Built-In Branch Office Support	No	Yes
Consistent Desktop Environment	No	Yes
Microsoft Office Built-In	No	Yes
Secure & Private	Maybe	Yes
Likelihood of Outage	Low-Medium	Very low
Financing Necessary	Maybe	No

*An on premise server is subject to problems with the building, power, Internet, etc.

*With the business in the Cloud, the user has a built-in Business Continuity/Disaster Recovery plan.

*Owning a server is rigid and expensive to scale.

*Cloud allows flexibility and scalability.

*Virtual WORKPLACE provides a consistent desktop environment no matter where you are.

*Office licensing can be built into users plan and they are automatically entitled to new versions.

*Virtual WORKPLACE is protected by state-of-the art security and privacy systems.

*Virtual WORKPLACE guarantees 99.99% uptime. The significant up-front costs of a server may force user to obtain financing.

From the above analysis in both the cases the savings for moving to Cloud is impressive. The savings per user per month for the analysis of TCO versus cloud was $942.60 whereas the savings in case of replacing office PCs by moving to cloud was $33.05. In terms of cost savings the option of moving to cloud in comparison to TCO was more economic than replacing the PCs.

(i) On-premises versus Cloud:

The following table gives the details of the resources the user have to manage in On-premises, Hosted and Cloud environment:

TABLE VI

On-premises	Hosted	Cloud
Application **Runtimes** **SOA/Integration** **Databases** **Server Software** **Virtualization** **Server Hardware** **Storage** **Networking**	**Application** **Runtimes** **SOA/Integration** **Databases**	**Application**

Hence in case of On-premises the entire responsibility of the computing environment is bestowed on the user.

V. SINGAPORE POLYTECHNIC CLOUD COMPUTING CENTER

Singapore Polytechnic Electrical and Electronic Engineering Cloud Computing Center (SPE3C3) at Singapore Polytechnic (SP) is the pioneer institute in Asia Pacific to equip its students with the latest skills in cloud computing through an operational data center environment.

Conceptualized by School of Electrical and Electronic Engineering of the polytechnic, the SPE3C3 will also provide teaching staff and students with on-demand, scalable, virtual computing and storage in labs to enable more sophisticated projects and research work. Singapore Polytechnic is utilizing the benefits of cloud computing to realize cost savings, energy efficiency and dynamic scalability.

The SPE3C3 was developed in collaboration with technology industry leaders Cisco, Citrix Systems and NetApp. While the resources will initially be available to the School of Electrical and Electronic Engineering students anywhere on campus, it will be accessible by all students on and outside of campus, as long as they have internet access, in the near future.

In the new academic year starting in April 2012, students in the 3rd year of the Diploma in Computer Engineering course at Singapore Polytechnic's School of Electrical and Electronic Engineering can look forward to two brand new elective modules- Data Center Management and System Virtualization -that will harness the power of the SPE3C3. These new courses are designed to train students to setup, manage and support data centers, virtualization techniques including server, storage and network virtualization and data recovery.

II. INDIAN EDUCATION SYSTEM SCENARIO

Education sector is the 2nd largest sector globally and Indian school system is the world's largest school system with over 1.12 million schools. As on 26th August, 2011 in India there are 42 Central Universities, 280 State Universities 130 Deemed Universities and 94 Private Universities [14].

The development of the education sector is solution for economic growth and improvement in the standard of living. The challenges posed by the growing demand for education requirements are gigantic. India will have about 45 million people in the age group of 18 years to 20 years by 2020. To train them, we need more than 20 million teachers and the present vacant post of teachers in India is 1.2 million as on 05.09.2011. As per present trends, we will create only 20,000 teachers by 2020[10].

Government of India is having the ambitious plan to establish the meta-university with "new pedagogy" in tune with the requirements of the knowledge society of the 21st century.

Further on Government is seeking to open up establishment of foreign educational institutions in India through enactment of a Foreign Education Providers Act, which will allow for 100% foreign direct investment (FDI) in higher education.

Thus, the aim is to raise the present 16 million enrolments in higher education to 42 million by 2020. A 2nd wave of creating institution of excellence has been initiated by starting 8 Indian Institute of Technologies, 5 Indian Institutes of Science Education and Research, 16 central universities, 2 schools of Planning and Architecture, 3 Indian Institutes of Management, and 10 National Institutes of Technologies. The 14 innovation universities are also on anvil for setting up benchmarks in education and research. Government of India is also aiming to establish at least 50 research parks for quality research programs [15].

National Knowledge Network (NKN) [16] is a state-of-the-art multi-gigabit pan-India network for providing a unified high speed network backbone for all knowledge related institutions in the country. The NKN will enable scientists, researchers and students from different backgrounds and diverse geographies to work closely for advancing human development in critical and emerging areas. NKN has already connected 640 institutions and aims to connect electronically India's 572 universities, 25,000 colleges and at least 2,000 polytechnics for enabling e-Learning and content sharing across country soon [17].

The Indian clients such as mid-market vendors, universities, telecommunication companies and government bodies will be able to access the access the center for the resource they need to pilot cloud infrastructure and application to their customer. Indian Institute of Technology, Kanpur is the first to use IBM lab. Indian IT Industries like Infosys, IBM India, Accenture etc. have shown keen interest in promoting research in cloud computing.

India's Telecom Commission proposal to create a US $4.5

billion National Optical Fibre Network (NOFN) approved by the Department of Telecom (DoT) which will broaden the country's existing fibre optic network from the district level to the village level giving the country of 1.2 billion people services like e-Education, e-Health, e-Banking etc [20].

VI. 5 STEPS TO SUCCESSFUL INTEGRATED CLOUD MANAGEMENT

A recent global IDC survey, sponsored by HP, examined the experience of this proactive group of integrated cloud managers. These organizations are actively integrating and automating application development, provisioning, security, and management across public and private cloud resources as well as Non-cloud application development and datacenter operations teams.

They are seeing many benefits, including faster application provisioning, lower application development and maintenance costs, improved business agility, higher service levels and improved business and IT relationships. Their experiences also highlight that success depends on cultural transformation as well as integrated and automated management processes and tools. An analysis of the experiences of these early adopters identifies five important steps for successful integrated cloud management. Specifically [18]:

- Define a plan that coordinates the organization's application modernization strategy with its cloud infrastructure and SaaS agenda
- Assess current costs and develop benchmarks for application support, provisioning and ongoing resource consumption
- Identify opportunities to reduce costs and speed up service delivery via use of automation for integrated application and infrastructure provisioning
- Implement systems to monitor and integrate application performance and real-time capacity planning analytics with automated provisioning solutions
- Integrate security strategies and priorities across the application development, release, and operations life cycle IDC recommends that organizations begin the journey toward integrated cloud management by targeting early pilot projects at developer teams and application environments that can deliver quick payback to validate the business agility benefits and operational efficiency improvements.

A. Security

Education institutions are entrusted with confidential information and private data. Security plays an important role in distance education [12]. The data either about hardware or software access Internet will be attacked by virus or Trojan when the users are dealing with the distance education. In worst case this will result in paralysis of the entire network system. The cloud storage mechanism can protect and monitor the data greatly enhanced the security of resources. As for the managers of Internet, they can unify data management, resources allocated, load balance, software deployment and the control of the security result in the reduction of investment in human resources. NIST likens the adoption of cloud computing to wireless technology. Institutions learned how to protect their wireless data as they moved forward and they will do the same with cloud computing.

VII. CASE STUDY: BEN-GURION UNIVERSITY

Ben-Gurion University in Israel is a major center for teaching and research, with more than 19,000 students enrolled. The IT department at Ben-Gurion University is responsible for all computer related projects and issues for the entire university, including registration, academic research, computing classes and supported programs [19]. By utilizing a "Storage On-demand" model that enables researchers, labs, and whole departments to acquire managed disk space on an as-needed basis, Ben-Gurion allows groups to grow over time while ensuring all data is fully backed up to the university's backup filer and then archived to tape. Ben-Gurion was experiencing exponential data storage growth with an expanding number of research groups, university administration, and academic departments demanding ever-larger amounts of storage capacity. The department currently has a VMware server farm that runs over 50 virtual servers with 1.5 TB of disk space each from a centralized NetApp file server. With data storage demands continuing to grow rapidly, the IT department was looking for a new technology that would improve its storage efficiency. It needed a solution that would enable it to utilize existing disk capacity more efficiently without affecting performance or creating an additional layer of management complexity.

The university reduced storage management requirements and driving efficient utilization of its storage-on-demand services by 65% to 83%. The lifetime of its existing disk capacity extended and the frequency of new disk purchases reduced lowering the total cost of ownership of storage. This resulted in a better storage ROI for individual departments and research groups in less than one year. The IT department is able to offer its end users more storage capacity at the same cost and extend the life span of its current infrastructure despite growing storage requirements.

The seamless integration and transparency of the IBM Real-time Compression solution made the entire process transparent to the end users. In addition, the reduced storage footprint simplified storage management and made it easier to run mirroring and backup processes for ensuring data availability.

VIII. CONCLUSION

Application of Cloud Computing in Education not only relieve the educational Institutions from the burden of handling the complex IT infrastructure management as well as maintenance but also lead to huge cost savings. As the educational institutions facing lots of difficulties to handle the shortage of resources, the cloud is one of the viable options. Moving to Cloud the Educational Institutes can concentrate on their core activities of teaching and research.

Educational Institutes can start courses on cloud computing which will open up lots of job opportunities for the pass out. The existing computer centers of the Universities/

Engineering colleges can be upgraded to cloud computing center which will lead optimal utilization of computing resources as well as the technical expertise of the faculty/ scholars of the institutions. Based on availability the computing services can be offered to nearby institutions which by beneficial for both the parties.

In case of On-premises computing infrastructure entire responsibility like Application, Runtimes, SOA/Integration, Databases, Server Software, Virtualization, Server Hardware Storage & Networking etc lies on the shoulder of the user. While in cloud the users have to manage only the Application stored on the Cloud.

The savings as a result of moving to Cloud is impressive. The total cost saving for 10 users for office PCs was found to be $11,900/- for an analysis period of 3 years whereas the savings for same no of users' for the same an analysis period was $33, 9613/- for cost per user per month model vs. TCO (including hardware, software, networking equipment etc).

The following table shows the cloud computing market predicted by various surveys by **2020**:

TABLE VII

Cloud Type	**Year 2011**	**Year 2020**
Public Cloud	**25.5**	**159.3**
Virtual Private Cloud	**7.5**	**66.4**
Private Cloud	**7.8**	**15.9**
Total	**40.8**	**241.6**

All figures in US $ in Billions

The transfer of the research results and the knowledge between cloud and networks and moving the knowledge to external providers may become a striking target to attackers.

For data protection issues special attention must be paid to the sensitive data from the institution such as research results, students' scholastic records, employees' accounts etc. The main options that may be taken regarding data are to preserve the sensitive data within the on-campus data centers and externalize the others with the risk of achieving a high latency for many applications and users. Externalize all the data with less potential for security risks.

The lunch of Aakash tablet PCs for the student community is likely to increase the number of users' for educational online resources exponentially. Considering the mammoth Indian education sector, cloud computing can play a great role to bring a paradigm shift in teaching learning process in the future. The cloud computing has significant relevance in India considering the divergence of resources at multiple locations to converge it in an economical way.

Research and development of cloud computing in India has yet to take active role. In spite of having huge potential in human resources and marketing final product it is still in nascent state.

An integrated approach is need of the hour to handle the situation. If the educational data is moved to the cloud, it can be very smoothly accessed by the NKN. The NOFN will be solving the connectivity problem to a great extant. As on date there is no Database of the passed out students of the Universities/Educational Institutions which is a handicap for cross verification/verification of the records in case of malpractices/forgery in India.

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