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What is Cloud Computing Based Computer Lab: Its Challenges, Cost and Benefits?

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Abstract

This paper describes the challenges, cost and benefits of Cloud Computing Based Computer Lab that pronouncement maker's face when assessing the feasibility of the adoption of CBCL in their organisations. Cloud computing is currently being exploited by technology start-ups due to its promoted properties of scalability, reliability and cost-effectiveness. Higher educational institutes are also start to show an interest in cloud computing due to these promised benefits. This paper's original contributions are to:

1. Highlight the challenges of cloud adoption in the educational institutes and show that decisions on migrating IT services to the cloud should not simply be driven by cost considerations but should also take a range of socio-technical factors into account.

2. Introduce to cloud based computer lab and explore its features and how it will be helpful for educational institutes.

3. In this paper we present vision, challenges, and architectural elements of CBCL for utility-oriented association of Cloud computing environments. It helps address the feasibility challenges of cloud adoption in the educational institutes.

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I. Introduction

Cloud Computing is the emerging buzzword in cyberspace. It is rising day by day due to its rich and well-to-do features of services. Cloud computing refers to applications and services that run on distributed networks using virtualized resources and accessed by common internet protocols and networking standards. Cloud computing is a new flavor of computing where our trend of using Internet changes. The term "cloud" is analogical to "Internet". The term "cloud computing" is used for the computation over the Internet. It is the future of Internet.

It is also called as fifth generation of computing after Mainframe, Personal Computer, Client-Server Computing, and the Web. Currently various Internet services are available in distributed manner. There are three well-known technologies associated with Cloud Computing, specifically Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS) [1].

Hands-on practical experience through lab work has long been recognized as an essential part of the computer science / information technology education. Successful computer science hands-on activities need a full range of resources with actively maintaining. Here we introduce a novel Cloud-Based Computer Laboratory (CBCL) solution for teaching computer science / information technology especially to support teaching and research in areas such as engineering, computer science, and information assurance. Cloud-Based Computer Laboratory (CBCL) is an education platform that will provide a controlled experimental environment for hands-on experiments using cloud based lab technologies. The CBCL can be securely accessed through Secured network, and students can remotely control the Resources and perform the experimental tasks without physically being at the lab. Our goal in this paper to clarify terms, provide simple formulas to quantify comparisons between of CBCL and traditional Computing, and identify the top technical and non-technical obstacles and opportunities of CBCL. This contribution derives also some findings when cloud computing in higher education has economical advantages or disadvantages. Regarding the analysed use case it turned out that virtual labs are able to provide a more than 25 times cost advantage compared to classical dedicated approaches [1].

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II. What is Cloud Computing based Computer Labs

Based on previous research and instructional needs, we believe that it is beneficial to build Cloud Computing based Computer Lab Cloud system to take advantage of the Cloud Computing technology. Figure No.1 presents an overview of the new Cloud-based Computer Labs remote laboratory. In this Lab, we utilize the sophisticated Cloud management and scheduling Functionality to deliver a secured, scalable, and dedicated remote laboratory environment to every user. To do it, we create a remote laboratory virtual machine, set the required hardware configuration and user access privilege, and store it in the image repository of the Cloud. The Cloud manages the image and finds the available and best-suited hardware environment to launch the image when a request comes in. A user needs to register in the Cloud system first before making any requests. After registration, a user is able to make a reservation to the remote lab image at any time, and anywhere. A user can request to use the remote lab immediately or at a specified time. The cloud launches the image based on the available resources and notifies the user once it is ready. The user can then log into the dedicated environment and conduct experiments without worrying any interfering. Once the requested time slot is up, the user is asked to log off from the system and make the system resources available to the other users.

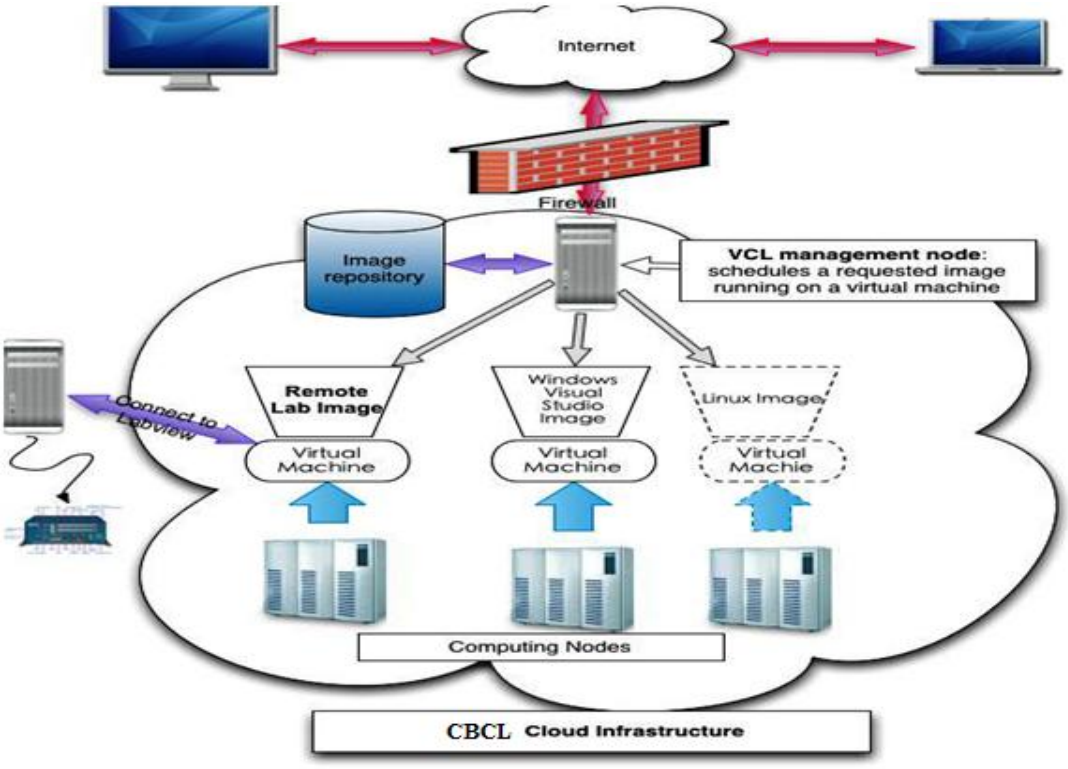

Fig.1 The new Cloud-based Computer Remote Laboratory

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It should be noted that once the Cloud launches the user requested image to a dedicated computer environment, the user will no longer contact the VCL management node. It will directly "talk" with the assigned computer using Remote Desktop and VPN. So the managing node will serve other requests and focus on resources arrangement. This scheme effectively solved the bottleneck problem in the previous remote lab framework [2].

III. Component of CBCL:

1. User: Firstly user accesses CBCL through a secure network connection using web interface to select required combination of application and Resources from given menu. If a user required image combination is not available as an image, an authorized user can have the flexibility to create their own image from the CBCL components. The Cloud-based Computer Laboratory manager software then maps that user request to available software application images and hardware resources, and schedules it for either immediate use (on demand) or for later use.

2. Apache VCL cloud software: VCL is stand for Virtual Computing Lab. The VCL can be various things; first of all it is open-source software that is providing a remote access in dedicated computing environment for an end-user. This software is powered by the Apache Software Foundation and donated to North Carolina State University. The provisioned computers are usually placed in a data centre and may be physical blade servers, or virtual machines. The main goals of VCL are to provide a dedicated computing environment to a user for a specified time slice using a secure web interface.

3. VCL Manager: VCL Manager is a centralized management console that produces fine-grained access control and functionality for the cloud based virtual labs host. VCL Manager manages all aspects of the cloud based virtual labs including all hosts and virtual machines. VCL Manager has several components that can be installed on a number of various servers in the environment. Once the VCL Manager Administration console has been installed and setup, VCL Manager will automatically deploy and install the administration client on all managed hosts [3].

4. Remote Lab Image : In Cloud based Lab, the term image is a software stack that incorporates the following utilities:

- Base-line operating system, and if virtualization is needed for scalability, this will allow on hypervisor layer.
- Required application that runs on the selected operating System.
- End-user access solution that is suitable for the selected operating system.

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Images can be loaded on an operating system/application virtual environment of choice. If the user's desired combination of images is not available, the user has the privilege to construct the images in their own choice from the VCL component library [2].

5. **Virtual Machine (VM):** A virtual machine (VM) is a Platform or operating system that not only provides the behaviour of a separate computer, but is also able of performing tasks such as managing process, work with applications and programs like a different computer. A virtual machine, generally known as a guest is created within another computing environment referred as a "host". The virtual machine usually simulate a actual computing environment, but requests for CPU, memory, hard disk, I/O devices , network and other hardware resources are managed by a virtualization layer which translates these requests to the underlying physical hardware.

6. **Computational Hardware/ Network storage:** Cloud based Lab servers provide a pool of resources that are according to the user's requirement. The allocation of resources are depends on the particular applications that are to be computed. The storage and network resource are dynamic, meeting both the workload and user demands. In a cloud based lab, computational hardware and storage can be anything from a blade centre, to a collection of diverse desktop units or workstations, to an enterprise server or to a high-performance computing engine. Each blade has at least two networking interfaces – one for the public network, and the other for a private network that is used to manage the blades and load images. Storage is attached either directly through fibre or through a network [2].

IV. CBCL CHALLENGES

1. Organizational Change:

Understanding the importance and the level of the organizational deviations related with CBCL implementation is a difficult challenge. We argue that Universities/Institutes need to understand the scope of changes and the effort required to make these changes in order to understand their benefits, risks and effects. The success of CBCL "is as much dependent on the maturity of Universities/Institutes and cultural (including legislative) processes as the technology" [8].

A large number of changes will rise throughout Universities/Institutes:

- Accounting will change hardware and network resources are not procured upfront, it will be consumed as a service.
- Security will change because virtualization introduces new exposures, and there could be conflicts between customers and cloud providers who are both attempting to harden their security procedures [9].

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- Project management will change because the authority of the IT department is going to be eroded by CBCL. CBCL is gradually turning "users into choosers" [10].
- System support will change because administrators will no longer have complete control of a system's infrastructure anymore. Their work could increasingly involve contacting CBCL and waiting for them to look into system problems.
- Finally, what about the work of end user those who are not well known to CBCL?

2. Technical Challenges:

Technical challenges to CBCL One issue that can significantly affect the benefits of the cloud-based Computer science lab are the Network speed. The excellence of communication with a CBCL is dependent on two factors: (1) the internet connection speed and (2) the number of users accessing the lab simultaneously.

First, while the internet speed of the traditional computer lab is stable, it can vary on the CBCL connection and thereby unfavourably affect the user interaction. Although the CBCL now mostly have backup methods, a weak or lost connection can still result in lost work. Second, the number of users accessing the lab simultaneously can also pose a problem. Whenever there are too many connections to single application, the CBCL needs to create a new image of the application for the users. However, the larger number of images results in slower response time by the server. One solution of this problem is to configure a fixed number of the application images to ensure acceptable application response time. In this configuration, when a user needs to use the application; he or she needs to make a reservation to access to the image. However, this solution creates another problem. That is, when the number of users reserved for using the application increases, the queue overflows and the waiting time of a user to access the application increases [11, 12].

The Technology Suitability Analysis comprises a simple checklist of questions to provide a rapid assessment of the potent suitability of a particular cloud service for a specific enterprise IT system. The checklist is still under development but the current

version, shown in Table 1, analyses eight characteristics and quickly provides an indication of the cloud's suitability for a proposed IT system [14].

Table 1. Technological Suitability Analysis [14]

Desired Technology Characteristic	Questions
1. Elasticity	- Does your software architecture support scaling out? - If not, will scaling up to a bigger server suffice?
2. Communications	- Is the bandwidth within the cloud and between the cloud and other systems sufficient for your application? - Is latency of data transfer to the cloud

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	acceptable?
3. Processing	- Is the CPU power of instances appropriate for your application at the expected operating load? - Do server instances have enough memory for your application?
4. Access to hardware / bespoke hardware	- Does your CBCL provider provide the required access to hardware components or bespoke hardware?
5. Availability /dependability	- Does your cloud provider provide an appropriate SLA? - Are you able to create the appropriate availability by mixing geographical locations or service providers?
6. Security requirements	- Does your cloud service provider meet your security requirements? (e.g. do they support multi-factor authentication or encrypted data transfer)
7. Data confidentiality	- Does your cloud provider provide sufficient data confidentiality and privacy guarantees?
8. Regulatory requirements	- Does your cloud provider comply with the required regulatory requirements of your organisation?

3. Financial Challenges of Cloud Computing:

While cloud computing compromises financial benefits, it also presents some financial challenges that must be carefully inspected before Implementing the CBCL. The main issue is the licensing costs of some applications on the CBCL server such as Microsoft Office, SPSS, MTLAB, and others utilities. According to a survey of conducted by University of Montana, the top software applications in use on campus is Microsoft Office (78%) and Adobe products. Research into the cost of licensing applications on a virtual server for concurrent use by campus constituents, regardless of user computer ownership, showed that most software vendors are not agreeable to cost-effective licenses to users in a virtual environment. Furthermore, some service providers require the users to pay extravagant fees to use the software hosted on their server that has been paid for license. These costs make the idea of cloud computing lab uneconomical until the virtual lab licensing cost is more affordable [13].

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V. Cost

Cost Modelling:

The main purpose of the Cost Modelling is to support adopt CBCL decisions in two ways

1. To support organizations in obtaining accurate cost approximations of successful running IT systems on the cloud based computer science lab. This cost model helps to organizations examine the costs of migrating an existing IT system or building a new IT system on the cloud, the costs of migrating an IT system from one cloud to another, or even future costs based upon predictions of future workload[15].
2. To support organizations in evaluating the design of a planned IT system with respect to its operational costs, with the aim of decreasing the costs. Funds and operational budgets are often kept separate in most of organizations, and procurement costs have to be known in advance before approval can be gained [15].

At present, the cost estimation process is based on predicting the high quantity of resources (i.e. processing power, memory, storage etc.) that a system might essential and provisioning at that level. It may be that maximum of the acquired resources remain idle during regular operation because the estimates were based on peak load. In fact current figures show server utilization in traditional data centres ranging from 5% to 20% [17]. The purposed cost model has a certain degree of uncertainty that goes against current policies. The uncertainty may : i) the resources consumption in CBCL, which is determined by its work load; ii) deployment of CBCL , which can affect its costs as resources for example networks speed and bandwidth are more expensive between clouds compared to bandwidth within clouds; iii) the cloud service provider‘s pricing model, which can change at any time [15].

The utility billing model is also a shift away from capital to operational budgeting, and many enterprises are less savvy about operational budgeting for IT than they are for capital budgeting. Cost Modelling extends the capabilities of UML deployment diagrams [18], which enable a system‘s deployment to be modelled. The purposed modelling allows users to model a system‘s software applications and how they could be deployed on CBCL. The model is then processed to elasticity users an exact estimate of the operating costs of CBCL. Table 2 shows all costs per group. In total the Lübeck University of Applied Sciences had to spend 847.01$ in providing (a virtual) unlimited amount of server instances to 49 students organized in 9 groups for a timeframe of 13 calendar weeks [1].

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Table 2.[1] Group Overview

Group	Students	Project	Cost in $
A1	5	WRSC Website	88.39$
A2	6	WRSC Website	265.37$
A3	4	WRSC Website	88.14$
A4	6	WRSC Website	162.88$
B1	6	Sailbot Tracking	41.17$
B2	6	Sailbot Tracking	57.58$
B3	6	Sailbot Tracking	57.46$
B4	5	Sailbot Tracking	37.42$
B5	5	Sailbot Tracking	48.58$

Almost 2/3 of the costs were generated by server uptime – that means running servers and being billed for per hour (server hours). Almost 1/3 of the costs were generated by data storage – that means all costs which have to do with the provision of server hard drives, backups or other data storage services. Other costs like network (requesting IP addresses, DNS names, etc.) or even data transfer had no relevant impact to the total costs. So the main cost driver was server uptime, the second relevant one was data storage [1].

Advices for setting up CBCL: After a long study about the virtual labs, some of our made experiences are delivered as advices for everyone planning similar approaches (see table 3).

Table 3. Advices

1	CBCL will be new for students. So an initial training may require for students into touch with the cloud services. The effective way for this is detailed step by step manuals.
2	If CBCL is used more than one practical course you should think about a virtual lab training program in first semesters of a study program. This might avoid double and triple trainings.
3	It provides flexibility. Use it! Let your students play within their virtual lab in presence phases, at home, at university, where and whenever they want.
4	Estimate your costs

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VI. Benefits

A traditional computing lab may be required to support computing exercises and tasks for different courses and trainers; moreover, the same lab may also be used as a teaching lab. Thus, the lab may require a different set of hardware and software to provide effective computing support to students and faculty. Therefore, developing and maintaining such a lab can be an expensive undertaking

CBCL provides followings benefits:

1) The utilization of online services with high infinite scalability, 2) Higher throughput and availability, 3) Reduced software, hardware, and launching time, 4) High quality of service and computing power, 5) Every user get enough resources in a well-organized manner, 6) Simultaneously accessed by any variety of users, 7) More efficient computing by consolidate data storage, processing and bandwidth, 8) On demand technology since it offers dynamic and versatile resource allocation for reliable and warranted services in pay as-you-use manner to public, 8) Tremendous fault tolerance capability and accessibility, 9) It supports the work in groups on collaborative projects where project team members are geographically distributed, by providing development infrastructure that include tools and programming languages, 10) Allows to move the processing effort from the local devices to the data centre facilities. 11) Possesses lower cost services, re-provisioning of resources and remote accessibility. 12) No more worries about hardware failures and no hardware upgrades needed (everything will be managed virtually, for example, we can increase the hard disk size instantly as you go) [4, 5, 6, 7]

VI. Conclusion

The CBCL offer students flexibility in accessing the lab resources from outside the university at any time. With the advantage of cloud technologies, not only software labs and applications but also hardware based labs such as network laboratories can now be transitioned to cloud environments. This paper presents CBCL as a new trend for e-teaching and learning in universities and students can take advantage of the cloud. We introduce the CBCL, the challenges to CBCL including problems, risks, cost and benefits have been also discussed. It will help universities/ Educational institutes to allow their faculty, staff and students to accomplish their work better and faster than ever.

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