Towards adopting Virtual Computing Labs in Libyan Higher Education Institutions

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ABSTRACT
The majority of the IT infrastructure in Libyan universities is out-of-date and unable to support the demands of the present-day educational system. Computer laboratories constitute the corner stone of the practical sessions in IT colleges. In which students struggle to fulfil their practical lessons, and prepare course's assignments. Fortunately, Virtual Computing Labs (VCL) introduce a promising alternative supported by the big advances in cloud computing. In this research we found that the implementation of VCLs bring in flexible access, instant feedback, on the fly maintenance, top-notch equipment and lower costs which are considered as some of the great benefits wins the competition with physical computer labs. Based on Azure Lab Services as a virtual computer lab layer and Microsoft Teams as a collaboration layer, a collaborative VCL architecture that can replace the on-campus traditional labs is proposed.

Keywords: E-learning, Cloud computing, Virtual Computing Labs.

1 Introduction
Computer labs are a crucial component of the instructional environment in computer science departments and technology faculties in Libyan Higher Education Institutions (HEIs). Each lab contains up to 30 machines. Each machine has the necessary applications to conduct the practical sessions. The predominant operating system in use in college computer labs is Microsoft Windows. Equipment for computer labs that includes programs like C++ compilers, Java Virtual Machines, Eclipse, Netbeans, Visual Studio, Microsoft SQL Server, Microsoft Office, and other graphical design programs. Technical staff and IT departments' admins use the installed software to support the recognized curricula. However, missing or damaged apps, disconnections from the local server (if one existed), sluggishness, availability, a lack of internet connectivity, and out-of-date software are frequent complaints from students and faculty at Libyan HEIs. Fortunately, relying on Cloud Computing lab based VCLs is a quick and workable option to get beyond these issues. It is a service that enables numerous distant computers to connect to a single host

computer, where, users (students and teaching staff) can access files and other network resources, run programs on the host computer, and more by logging on to a terminal server. In computer labs in Libyan HEIs, the technology holds the promise of replacing the deteriorating infrastructure that is currently in existence. The term Cloud Computing refers to the on-demand, pay-as-you-go delivery of IT resources through the Internet. Through which technological services can be used from a cloud provider on an as-needed basis to access computing power, storage, and databases instead of purchasing, owning, and maintaining physical data centers and servers [1]. Great benefits of cloud computing include agility, elasticity, cost savings and fast deployment. 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) [2]. A Lab-as-a-service (LaaS) is education platform called Virtual Computing Lab (VCL) is being suggested as well, and it offers a controlled environment for hands-on experiments using cloud-based lab technologies [3]. So, using VCLs students can remotely manage the virtual machines (VMs) and carry out the experimental activities without physically being in the lab by connecting over the internet by using their access credentials. In order to remedy the existing Lab infrastructure in Libyan HEIs the following models of cloud computing may be considered [4]:

1. IaaS (Infrastructure as a Service). A university's computational infrastructure is virtualized and shared for the purpose of solving internal tasks, including special software installation. This infrastructure may be used as a base for the creation and deployment of VCL.
2. PaaS (Platform as a Service). Virtualized resources with installed required packages are shared
3. SaaS (Software as a Service). The most common model of VCL representation is as a web-service, a successful example can be found in [2] and [3].
4. DaaS (Data as a Service). It is an additional model for providing data sources as a cloud services.
5. HaaS (Hardware as a Service). This model is used for sharing unique equipment, e.g., near-field scanning optical microscopes through an appropriate interface.

The next section presents the previous studies. Following that we present important two VCLs models, Apache VCL, and Azure Virtual Service, we show their important architecture aspects and discuss how they are provisioned as a LaaS to help HEIs in the teaching and learning process. In Section 4 we discuss the appropriate VCL architecture that we should adopt in HEIs Libya. Finally, we discuss our research and draw conclusion with future work, in Section 5 and 6 respectively.

2 Related work

Over the past few years, cloud implementations in higher education institutions have steadily grown [5], [6], with many academic institutions now utilizing one or more cloud services. With its promise to supply a variety of computer services in a way that has never been seen before, cloud computing represents a new paradigm in computing in HEIs [7]. It is likely to reduce expenditure and also reduce labor-related costs, as less people (e.g., technicians, admins) than before will be required to run a cloud-based IT infrastructure [8], [9]. The Virtual Computer Laboratory (VCL) was founded in the spring of 2004 [10] with the goal of giving students and researchers dedicated remote access to a variety of computing environments from any networked location, on or off campus, the VCL code base was approved as an incubator project by the Apache Software Foundation (ASF) in November 2008, VCL became an Apache top level project in June 2012. VCL became an Apache top level project in June 2012 [10]. In another study in Georgia State University the authors presented a collaborative virtual computer lab (CVCL) environment to support collaborative learning in cloud-based virtual computer labs, a setting that allows students to reserve virtual computers labs with multiple participants and support remote real-time collaboration among the participants during a lab. In this study we proposed different model of CVCL architecture based on Azure Lab services and Microsoft teams.

3 Virtual Computing Labs Technologies

Different cloud computing lab technologies that aim to provide LaaS are exist. For the purpose of this study in this section we present two main technologies that can help HEIs with limited budget to go for virtual labs instead of on-campus labs, Apache Virtual Computing Laboratory (VCL) and Azure Lab Services. The VCL is an open-source implementation of on-demand utility computing and services-oriented technology providing wide-area access to solutions based on virtualized resources, including compute, storage, and software resources. It is defined by University of North Carolina campuses [10]. While Microsoft's Azure Lab Services [11] is a service that makes it easier to manage the infrastructure for virtual computer labs on the Azure cloud. From setting up, starting, and terminating virtual machines to scaling infrastructure, it manages every aspect of computer lab infrastructure. Administrators can simply set up labs for classes, decide how many and what kind of VMs participants need, and add people to classes. Users of the lab only need to register in order to access the VM and complete activities in class.

3.1 Apache Virtual Computing Lab

Apache VCL platform depicted in Figure1 considered the most widely used virtual computer lab system, it is a free and open-source cloud computing platform with the primary goal of delivering dedicated, custom compute

environments to users [10], which was initiated at North Carolina State University (NCSU) for applying cloud computing to teaching and learning [12] . VCL supports provisioning several different types of compute resources including physical bare-metal machines, virtual machines hosted on several different hypervisors, and traditional computing lab computers you would normally find on a university campus [10]. When a user uses a program via VCL, the program runs on the server and VCL allows the user to control that program from his/her own computer. The VCL is equipped with user interface consists of a self-service web portal. Using the portal, students and faculty can access software and applications that were typically only available while on campus in a lab or via individual software purchase and installation [12].

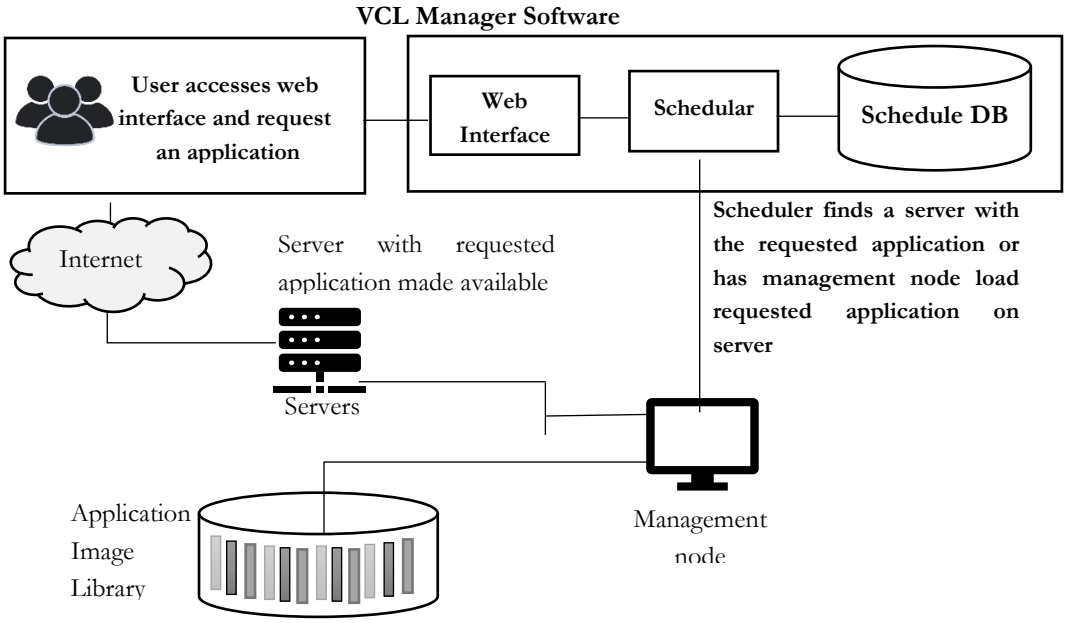

Figure 1 Apache VCL [10]

3.2 Azure Lab Services

Microsoft Azure Lab Services is a service that enables the virtual computer laboratory infrastructure administration and management in the Azure cloud. It manages all aspects of the infrastructure of a computer lab, including setting up, starting, and stopping virtual machines as well as expanding the infrastructure as needed. Administrators may easily set up laboratories for classes, decide how many and what kind of VMs participants need, and add users to classes. Users of the lab only need to register in order to access the VM and complete activities in class. Figure 2 shows an overview of Azure Lab Services [13]. The benefits of using Azure Lab Services include the following [7].

- Since Azure Lab Services manages VMs and lab access and provides supporting infrastructure like operating system images, laboratory setup can be completed more quickly and flexibly. This frees up laboratory administrators to concentrate on laboratory setup as needed.
- User-friendliness through the use of access protocols that can be used on a variety of operating systems and regular desktop and laptop computers as well as a straightforward registration process.
- Vlab consumption charges are only estimated when the VM is active to ensure accurate and efficient cost computation. The VM schedule policy can be configured by administrators to automatically turn on and off the VM when not in use.

Through VCL, users who previously had to visit to a computer lab or install hardware and software on their own machines may now access it remotely. Additionally, as it can frequently be difficult for various applications to coexist on the same machine, it reduces the workload that computer labs must bear in order to keep numerous applications on individual lab machines.

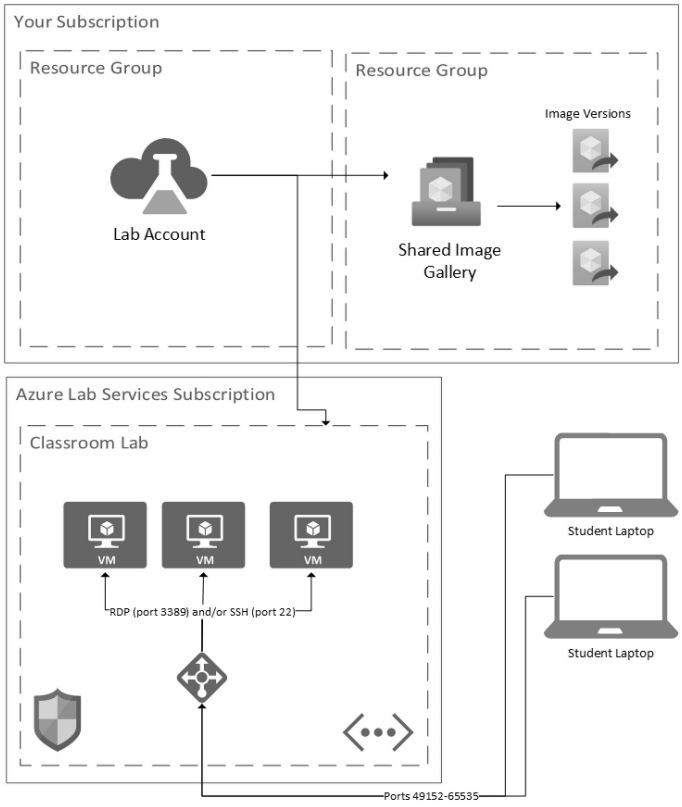

Figure 2 Overview of Azure Lab Services infrastructure [14]

For Lab administrators, a great management tool provisioned through VCL over Azure Lab Services is that it keeps operating system images with the

required apps and unique configurations and deploys them to a server as needed in response to user requests. This would significantly contribute in a better management in terms of quick installations and dynamic changes in course's requirements. Faculties, IT departments and students all share the benefits of such great technology. IT department, for example, Manage Azure Portal, create the University environment and set up access to on-premises resources if existed. Whereas, the faculty manages lab service portal, they can easily and flexibly implement virtual machine gallery for easy customization. Following that, students use Lab Service portal to access from any where using remote desktop connection that is available on every operating system or web client. Azure Lab Services offers new approach for service education institutions in general to help students learn computer programs. Just a few things are required to get it going. No matter how many students are registered or how complicated the virtual machine is, schools may easily configure and launch classes. Gratitude to Azure Labs, with a minimal management and supervision, no longer are students required to complete their coursework in a physical computer lab. The price structure Azure Labs also enables faculties to plan their budgets for the semester and maximize utilization of their budget with no loss. Finally, in this regard, Azure Labs clearly offers students a practical and cost-effective way to acquire the computer skills they will require during their educational journey.

4 Proposed VCL Architecture for Libyan HEIs

For Libyan HEIs we adopt a Collaborative Virtual Cloud Lab CVCL model presented in [12]. The CVCL environment uses a layered design to run on top of a virtual computer lab system that already exists, such as Azure. Two layers, a virtual computer lab layer and a collaboration layer make up the layered architecture, as depicted in Figure 3. The collaboration layer employs services from the virtual computer lab layer, it builds on top of Azure Lab Services, indicating a loose coupling between the two layers. Accordingly, the collaboration in the traditional lab might be accomplished utilizing our suggested design, ensuring that students do not lose out on the true benefits of cooperating in a virtual lab.

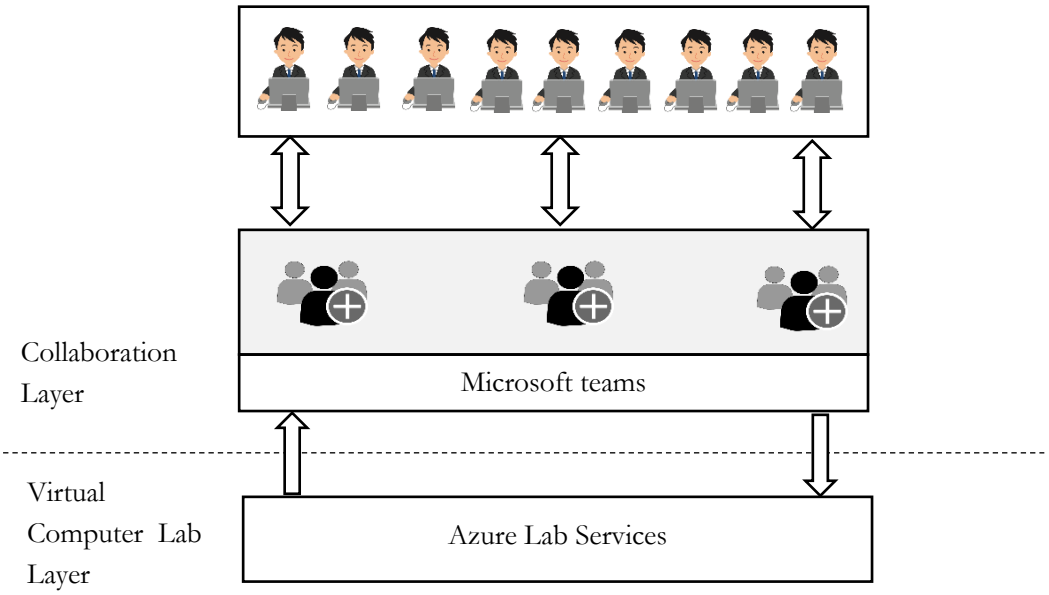

Figure 3 Collaborative Virtual Computer Lab on top of Azure Lab Services

For the purpose of bringing individuals together around tasks, interests, or other cooperation requirements, students groups established in Microsoft Teams [15] . Channels could be established within such teams to focus on a particular subject, area, or project. In Teams, meetings can be held in one of the channels where team discussions occur, files are saved, and files can be shared. Because of its flexibility, Microsoft Teams enables creating teams and channels that correspond to the needs and specific purposes.

5 Discussion

The tragedy of out-dated computer laboratories in Libyan HEIs never solved and would continue as long as there is no efficient alternative that is manageable and cost effective. As the cloud service in general follows a pay-as-you-go approach, the establishment of virtual Lab based on Azure Lab Services does not require capital expenditure investment, nor it needs extra labour requirements. So, the restrictions of high asset capital investment costs do not prevent the deployment of cloud-based such as Azure. The price of utilising cloud resources makes up the cost of developing a cloud-based Lab. Explicitly the configuration of the VMs, the applications needed, and any other features would determine the price of the laboratory. For instance, in a recent study [7], a virtual lab established on a university campus was contrasted with Azure based Lab with 50 VMs while taking the Total Cost of Ownership into account (TCO) [11], the later won the competition by 26% lower than his competitor. To this end, we stress that universities should think of the Cloud-based computer laboratories seriously. The advantages are countless, for instance:

- Increasing the accuracy and accessibility of data, software, and research materials.
- Increasing end users' mobility will make resources available wherever and whenever they are needed.
- Utilizing computational and application performance to its fullest.
- Offering a self-service portal and quick web access.
- Keep the budget to the Computer Labs' operational needs.

6 Conclusions

In this study, We discussed the difficulty with the HEIs' computer lab infrastructure in Libya. We presented two different cloud-based alternatives. On the basis of that, we proposed the cloud-based laboratories as a substitute solution, in order to transform the current scenario and provide educators and students with a better learning environment. Our proposed architecture considered the collaborations factor in practical studies as a main factor that should be included. Future study aims to implement virtual laboratory based on Azure Lab Services to teach a computer-programming course investigate its performance, usability and its real cost based on the available local resources and services.

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