VIRTUAL ONLINE LABORATORY SUPPORTING THE OPERATING SYSTEMS COURSE

Mr.D.Srinivasulu[1]., Mrs.V.Geetha Bhavani[2]
1,2 Assistant Professor, Department Of CSE.,
(✉seenumits @gmail.Com, ✉geethaveldandi18@gmail.Com)
1,2 Malla Reddy College Of Engineering For Women., Maisammaguda., Medchal., Ts, India

Abstract

This article is meant to supplement a course on operating systems by providing a review of cloud platforms that might work well for a virtual online laboratory. The research confirms the benefits of private cloud deployment and IaaS service models, and provides supporting evidence for their adoption. The preference for building one's own cloud environments that are optimized for educational purposes over using pre-built IaaS (Infrastructure as a Service) cloud services provided by providers. Related efforts on using cloud-based environments for OS education are reviewed. The authors' prior work on virtualization tools and environments for the Operating Systems course and the Cisco Cyber Security Operations course is also reviewed. Both the bare minimum and the ideal set of features for cloud computing software to allow a fully functional online lab for an Operating Systems course have been specified. The paper concludes with a comparison of Eucalyptus, Open Stack, Cloud Stack, and Open Nebula cloud platforms and a justification for the systems chosen as the first and second best.

1. Introduction

Practical exercises with actual operating systems are a standard feature of OS training. It is common practice to provide students administrative privileges on their virtual machine in order to do these tasks. OS classes also often include Linux OS, despite the fact that Windows still powers the vast majority of computers worldwide.
Windows is the standard operating system found on university lab computers and student laptops. This is why many virtualization methods may be employed. Operating system (OS) courses are among the many that have benefited from the rise in popularity of using virtual online labs [1]. Unfortunately, the requirements of an OS course are far more difficult to fulfil than those of the typical course, which might be taught utilizing the cloud services of the SaaS model. This article's goal is to help readers evaluate and choose the best cloud platform options for a virtual online laboratory that will house Linux online environments for an Operating Systems course.

2. Related work

The literature on cloud platforms for operating system education details the author's personal experience with a variety of tools, such as provider-

Provided cloud services and cloud environments optimized for educational purposes. Operating Systems, according to Rajeev and Aldakheel [2], are one of the classes that may gain the most from being taught in a cloud-based setting. The authors recommend using Amazon Web Services instances to teach students about the operation of virtual memory, scheduling algorithms, and other related topics. Working with processes, threads, pipelines, and sockets in the cloud is described by Gaffer and Hajjdiab [3]. (Ubuntu Linux instances on Amazon AWS). The work of Bhatia et al. [4] is cantered on the design of a cloud for a university, as well as a technique for implementing this cloud (a private cloud built on the Open Stack platform) to demonstrate its viability. Additionally, the authors develop a resource need model to predict how many physical servers would be required to support a given number of virtual machines (VMs).
In his article "Moving Harvard College's Introductory Computer Science Course (CS50) on the Amazon Elastic Compute Cloud," Malan [5] details the transition process (Amazon EC2). SaaS (Software as a Service), PaaS (Platform as a Service), and IaaS (Infrastructure as a Service) cloud services are shown and analyzed by Markova et al. [6] for use in STEM (science, technology, engineering, and mathematics) education. The authors

also list the most significant benefits of such implementations, such as the ability to use cutting-edge parallel programming tools as the backbone of cloud-based systems.

3. The survey of cloud computing software for virtual online laboratory supporting the Operating Systems course

Previous research

We have gained extensive knowledge with various virtualization technologies via our teaching of several operating systems and computer networking courses at various universities. The study [7] provides more information on the practical aspects of taking an OS course. Educators' Reflections on the Classroom The work [8] presents a Cisco Cyber Security Operations training program. According to the research [8], the CCNA Cyber Operations course at Cisco Networking Academy makes use of a virtual cloud laboratory built on Apache Cloud Stack and EVE-NG Community. This study demonstrates how a cloud computing lab was really built. The lab enables students to create an adequate number of virtual machines, alter the computing power available to them, simulate real computer systems, networks, and network topology, save the state of their virtual machines between reboots, merge their individual subnets into a single virtual network, work remotely through a virtual private network, and support and manage their own learning.

From the Oracle Virtual Box hypervisor and Amazon EC2 t2.micro instances to the Cloud 9 IDE and the virtual machine from the NDG Linux Essentials [9] course and the Webinar online environment, not to mention the bare-metal Linux installations on some of the students' laptops, we've used a wide variety of tools over the years in our operating systems courses. According to the technique for employing Unix-like OS virtualization technologies in educating bachelors of Informatics [10, 11], a combination of multiple virtualization solutions might be used to fulfill the demands of the course and the individual students' needs. We are sponsoring a two-semester Operating Systems course at Zhytomyr Polytechnic State University in 2021 for students majoring in Computer Engineering, Cyber security, Software Engineering, and Computer Science (Ukraine). As of right now, we mostly utilize Virtual Box and a Docker-based virtual machine from NDG Linux Essentials online course, with occasional usage of Amazon EC2 and different free online environments for backup. In the paper [7], we compared and contrasted standalone online Unix/Linux terminals for their potential usage in a college-level Operating Systems course and examined Linux pre-made online virtual environments. Accordingly, the following are some of the most notable aspects of the Linux online environment:

Basic networking operations support, the ability to upload/download files to/from virtual environments (and/or storing virtual environment state between reboots), guest OS update, and bash-scripting support. Support for most Linux commands (including administrator ones).

3.2. Elaborating the requirements for cloud computing software for virtual

Online laboratory in the Operating Systems course

Online IDEs that offer Unix/Linux terminal access (Codio, Cloud 9, Code anywhere, JS/UIX, Weblinux, Brow six, CB.VU), and standalone online Unix/Linux terminals (JSLinux, Copy.sh, Virtual x86, Webinar, Linux zoo, JS/UIX, Weblinux, Browsix, CB.VU) were among the prebuilt Linux environments that have been studied. Cloud-based Unix/Linux virtual machines (Amazon EC2, Google Cloud Platform, Microsoft Azure) (Paiza.io) and other similar services [7]. We were forced to switch virtualization environments since at least one of the previously suggested standalone online Unix/Linux terminals (Webinar) altered its conditions of availability. The necessity to use more reliable solutions while teaching an operating system course is highlighted here. Moreover, there are significant functional limitations associated with the free use of standalone internet terminals (i.e., sudo access, networking). When it comes to learning to code, online IDEs with Unix/Linux terminals are ideal, but we need this setup so that we may practice administering commands. In accordance with Infrastructure as a Service, cloud service providers provide fully-functional Unix/Linux virtual environments (IaaS). They can be implemented with little effort and overhead since they are already constructed. These services also provide virtual networking and guest OS upgrades, as well as provide guest operating systems with sudo access and persist virtual environment data across reboots. However, these programs sometimes cost money, require a student's credit card information to sign up, or have other restrictions on their use.

Another issue with using cloud services is that the provider's terms of service may change at any time, even for paid services. It's possible that changes will alter how much things cost, how many are available, and how much of a certain resource may be used. Initially, Cloud9 IDE's service was only available to providing all registered users with a free Ubuntu virtual machine, a fully functional terminal with sudo access, and an integrated development environment (IDE) for working together on software projects. Later on, however, the provider amended the conditions in light of multiple security breaches caused by these VMs. After the updates, customers may only link VMs hosted by other providers. Students taking an Operating Systems course should be provided with similar chances in their custom-built virtual Linux environments as those provided by Iasi cloud service providers; however, the solution should be less reliant on any one provider. Still, it's a plus if the studied cloud computing software and the providers' cloud service platforms are compatible.

The comparison of free and open-source cloud computing software for virtual online laboratory in the Operating Systems course

We looked at Eucalyptus, Open Stack, Cloud Stack, and Open Nebula, four widely used cloud computing software packages that are freely and openly distributed. In, the most salient features of Eucalyptus, Open Stack, Cloud Stack, and Open Nebula relevant to this investigation are outlined. In this table, we have Eucalyptus. When it comes to private and hybrid cloud infrastructure, look no farther than Eucalyptus [14], an open-source IaaS cloud computing platform. Eucalyptus Systems creates the software, releases it under the GNU GPL v3 license, and offers both free and premium support options. The fact that it works with Amazon Web Services (AWS) is a unique selling point for Eucalyptus. Like AWS, Eucalyptus employs and supports AWS APIs and makes use of comparable instance kinds, tools, virtualization technologies, and terminology. The Fast Start solution is another option for newcomers to Eucalyptus. Fast Start is designed to operate on a minimum installation of Centos 7.9 and makes little use of the available IP addresses. Downloading preconfigured Linux images (Centos, Centos Atomic Host, Fedora, Fedora Core OS, and Bunt) is a breeze with Eucalyptus, and it can be done from the command line. Eucalyptus requires an Intel or AMD processor running at least 4 cores at 2 GHz, 16 GB of RAM per virtual machine, 100 GB of storage per host with 200 GB recommended for Node Controller hosts with Linux VMs, 500 GB for Storage Controller hosts, and 500 GB for the Walrus object storage gateway (if used). Host machines (apart from the Cloud Controller and Node Controller) must have UDP multicast enabled in order to host components.

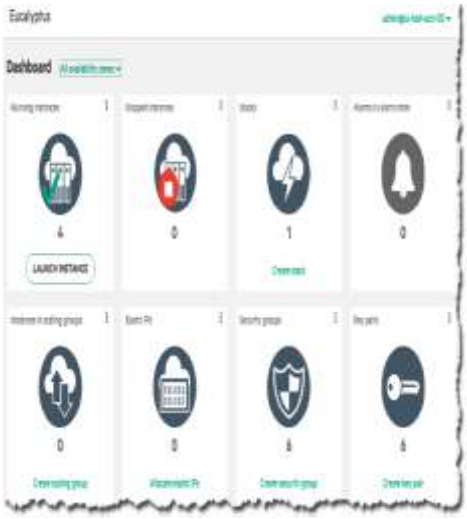

Figure 1: Eucalyptus dashboard [17].
IP address 239.193.7.3 requires all services to be set up on actual hardware rather than in the cloud [14].

Open Stack. Open Stack is an open-source cloud computing platform that prioritizes free and public access. Rack space Hosting is credited with creating and pioneering Open Stack. And NASA (the influence of the latter is especially obvious in the names of components) (the influence of the latter is particularly notable in the names of components). The Open Stack Foundation, nonprofits, is now in charge of the platform. Open Stack is what its creators refer to as a "cloud operating system" [18]. The platform is compatible with a wide range of software, Uses, and tech. It is the Apache License 2.0 that is used by Open Stack. Open Stack offers third-party technologies such as Cabernets, Cloud Foundry, and Territory, and it includes the Horizon Web UI (figure 2).

It is compatible with a broad variety of hosts, including Windows, Solaris, Linux, and the VMware ESXi hypervisor. Centos, Debian, Fedora, opens USE, RHEL, Ubuntu, and other Linux systems are all supported hosts [20]. New users may utilize the Training Labs scripts to automatically install the cluster in Virtual Box or KVM VMs on a Linux, MacOS, or Windows desktop or laptop with a minimum of 8 GB of RAM and 20 GB of free storage [21]. As a highly adaptable platform, Open Stack's system requirements are very contextual, changing based on the cloud's intended usage, the components chosen, and other variables. Deploying Bunt Open Stack, for instance, may be done in one of three primary ways: as a single-node installation, as a multi-node installation, or as a data centre cluster. One physical host with 16 GB RAM, a multi-core CPU, and 50 GB of free disk space (for a single-node deployment) or two physical hosts with 16 GB RAM, multi-core CPUs, and 50 GB of free disk space (for a multi-node deployment) are the bare minimum requirements for Open Stack.

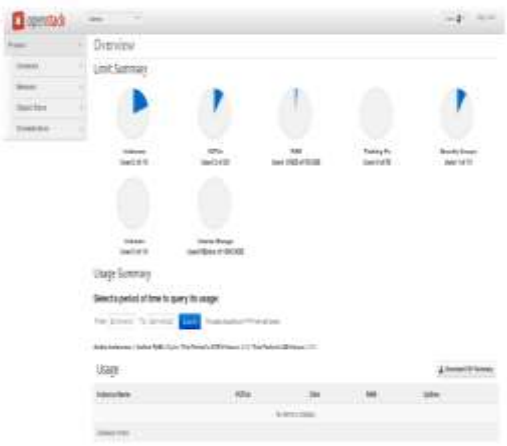

Figure 2: Open Stack dashboard [19].

There must be a network switch and an Internet gateway (for data centre cluster deployment), as well as six physical servers, each having 8 GB of RAM, IPMI BMCs, dual NICs, support for HA designs, and a terabit uplink [22]. Minimal Wallaby series deployment is also worth mentioning (released in June 2021) comprises Keystone id management, Glance images, Placement, Nova computing, Neutron networking, and perhaps Horizon had and Cinder block storage as well [23]. Cloud Stack. Cloud.com (now acquired by Citrix) is credited for creating Cloud Stack [24]. The Apache Foundation is actively implementing new features to further the project. As open-source Iasi cloud software, Cloud Stack was developed with huge networks in mind, although it may be used with any size of network. It's released under the terms of the Apache License 2.0.CloudStack is compatible with the Open Cloud Computing Interface and the Amazon Web Services APIs [25]. The user interface (UI) for Cloud Stack may be accessed using a web browser (figure 3). Every physical host has to have a 64-bit x86 CPU, 4 GB RAM, 250 GB of free storage (500 GB is preferable), 1 NIC, a static IP address, and a fully qualified domain name for the Cloud Stack management server, database, and storage. There is the option of using a virtual machine for the administration server. Hosts, where hypervisors and VMs would be housed, need to be Intel-VT or AMD-V hardware virtualization compatible, have a 64-bit x86 CPU, 4 GB RAM, 36 GB of free storage, and 1 NIC [26]. Open Nebula. When it comes to creating and maintaining corporate clouds, Open Nebula [27] is the open-source IaaS platform of choice. Provided under the Apache License 2.0, and created by Open Nebula Systems and the Open Nebula community.

While Open Nebula is free for most users, commercial users may sign up for a subscription (Open Nebula EE).

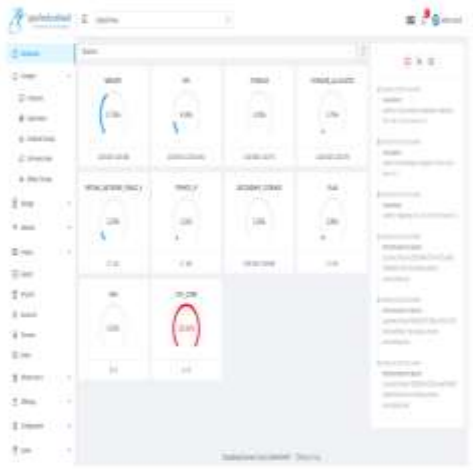

Figure 3: Apache Cloud Stack dashboard [25].

Open Nebula is compatible with both AWS and Azure. The solution is compatible with third-party technologies like as Territory, Cabernets, Ansible, and Docker [28], and it also comes with its own user interfaces (Sunstone GUI and Fire Edge GUI). It displays the Sunstone graphical user interface. Figure 4 the minion tool is available for first-time users. This utility not only facilitates the deployment of an Open Nebula cloud using KVM virtual machines, but it also installs and configures the prerequisite software for doing so. Open Nebula minion

necessitates a host machine (virtual or otherwise) with 4 GB of RAM, 20 GB of available disk space, and ports 22 (SSH), 80 (Sunstone), and 2616 (Fire EDGE) open [29].

All the systems we looked at provide extensive, easily accessible online documentation, including user guides and tutorials. After comparing Eucalyptus, Open Stack, Cloud Stack, and Open- Nebula, Bedi et al. [30] concluded that while all of the listed systems could be used for cloud deployment, Open Stack and Eucalyptus are better suited for infrastructure provisioning, and Cloud Stack and Open Nebula would show better results on data enter virtualization. In light of the above, we have settled on the Open- Stack cloud platform as our top pick, mostly due to its openness and adaptability. Training Labs scripts are available in Open Stack, and they would be especially helpful in the early stages of implementing a virtual laboratory, but they may also be used for students' extracurricular and scientific projects. Also meeting most of the criteria are the other three platforms (Eucalyptus, Cloud Stack, and Open Nebula). These systems are the runners-up for our platform selection.

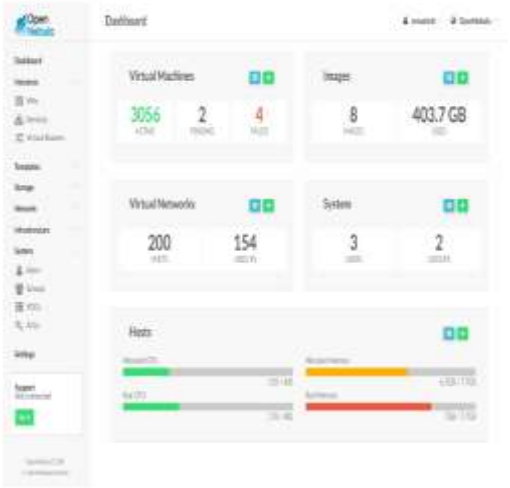

Figure 4: Open Nebula dashboard [27].

4. Conclusions

After all this effort, a virtual online laboratory may be built to accommodate a course on operating systems, complete with Linux online environments. The authors of these papers on cloud platforms for OS education explain the process of employing resources built on a variety of technologies, such as Amazon Web Services (AWS) and Open Stack and Cloud Stack cloud environments designed with education in mind. The report provides a concise summary of prior work on virtualization technologies and settings. The fundamental necessities for cloud computing software for the virtual online laboratory supporting the Operating Systems course have been elaborated, and they include support for the private cloud deployment model, Linux as a guest operating system, free and open-source software licenses for distribution, virtual networking, and a web interface for students to create, administer, delete, and set up and configure network connections between virtual instances (LDAP). Additionally, compatibility for Windows guests and an easy-to-follow installation process for novices are necessitated.

This study compares four widely-used cloud computing programs that are freely and publicly accessible (Eucalyptus, Open Stack, Cloud Stack and Open Nebula). Based on its adaptability, its support for open standards, and its provision of Training Labs scripts suitable for use in classroom experiments and extracurricular projects, Open Stack cloud platform was chosen as the platform of first choice in this research. The second-best cloud systems are Eucalyptus, Cloud Stack, and Open Nebula since they also satisfy most of the criteria. Pilot empirical investigation of chosen cloud platforms, as well as the development of the concept of a virtual online laboratory to support the Operating Systems course, are two areas that need to be investigated further.

References

[1] A. Streak, O. Rybalchenko, S. Bilashenko, Development and using of a virtual laboratory to study the graph algorithms for bachelors of software engineering, CEUR Workshop Proceedings 2732 (2020) 974–983.

[2] H. Rajaei, E. A. Aldakheel, Cloud computing in computer science and engineering education, in: Proceedings of 119th ASEE Annual Conference & Exposition, ASEE Conferences, San Antonio, Texas, 2012, pp. 422–431. Doi: 10.18260/1-2--21076.
[3] M. A. Gaffer, H. Hajjdiab, Teaching operating systems concepts using the cloud, World Transactions on Engineering and Technology Education 16 (2018) 156–
161. URL: http://www.wiete.com.au/journals/WTE&TE/Pages/Vol.16,%20No.2%20(2018) /10-Hajjdiab-H.pdf.
[4] G. Bhatia, I. A. Noutaki, S. A. Ruzeiqi, J. A. Maskari, Design and implementation of private cloud for higher education using openstack, in: 2018 Majan International Conference (MIC), 2018, pp. 1–6. doi:10.1109/MINTC.2018.8363161.
[5] D. J. Malan, Moving CS50 into the Cloud, in: 15th Annual Conference of the Northeast Region of the Consortium for Computing Sciences in Colleges, Hartford, Connecticut, 2010. URL: https://cs.harvard.edu/malan/publications/ccscne10-malan.pdf.
[6] O. M. Markova, S. O. Semerikov, A. M. Striuk, H. M. Shalatska, P. P. Nechypurenko, V. V. Tron, Implementation of cloud service models in training of future information technology specialists, CEUR Workshop Proceedings 2433 (2018) 499–515. URL: http: //ceur-ws.org/Vol-2433/paper34.pdf.
[7] O. Holovnia, Linux online virtual environments in teaching operating systems, CEUR Workshop Proceedings 2732 (2020) 964–973. URL: http://ceur-ws.org/Vol-2732/20200964. pdf.
[8] N. Balyk, Y. Vasylenko, V. Oleksiuk, G. Shmyger, Designing of Virtual Cloud Labs for the Learning Cisco Cyber Security Operations Course, CEUR Workshop Proceedings 2393 (2019) 960–967. URL: http://ceur-ws.org/Vol-2393/paper_338.pdf.
[9] NDG, Linux Essentials – Online Courses & Labs Training, 2022. URL: https://www. netdevgroup.com/online/courses/open-source/Linux-essentials.
[10] O. M. Spirin, O. S. Colonia, Using Unix-like operating systems virtualization technologies in training the bachelors of Computer Science, Information Technologies and Learning Tools 65 (2018) 201–222. doi:https://doi:10.33407/itlt.v65i3.2055.