

The Design of The Laboratory Exercise Using Virtualization Technology For A System Administration Course

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Abstract. System Administration is a field that demands understanding in computer and network system such as operating system, application, networking, hardware, security and troubleshooting technique. Real-time and hands-on practical exercise will give students the opportunity to apply and integrate system administration skills they have learned during lecture class. However it is impractical and expensive to setup a dedicated and conventional hardware based lab especially for institution with limited monetary budget. The alternative way of teaching Linux System Administration course is Virtual Based Lab where specific tools are used to represent real IT infrastructure. The Virtual Laboratory (VLAB) project was initiated at Kolej Universiti Islam Antarabangsa Selangor (KUIS). The main aim of this project is to develop a laboratory exercise using virtualization technology for System Administration Course which is currently taught at KUIS as a part of Diploma in Computer Science program. It will provide a safe platform for the student to learn basic system administration. Apart from the development of VLAB web application, the project uses Proxmox VE; an open source virtualization solution as the virtualization core engine to provide virtual machine instances to the students.

Keywords: Educational Technology, Virtualization, System Administration.

INTRODUCTION

System Administration Course is combination of principles and theories of system administration and computer science with practical information and hands-on learning using realistic projects. The subject matter of system administration includes computer systems and the ways people use them in an organization (Yang, 2007).

A typical System Administration course offered in colleges and universities are a combination of lectures and practical activities. According to Vollrath, A. (2004) teaching System Administration course requires practical activities in an environment that simulates the real world scenario. Real-time and hands-on practical exercise will give students the opportunity to apply and integrate system administration skills they have learned during lecture class. In addition to that, practical exercise is an important instrument for assessing teaching effectiveness and maintaining the quality of academic programs (Hakimzadeh, H., and Williams, L., 2006).

BACKGROUND OF STUDY

The project aims to design the virtual laboratory exercises for System Administration course based on the existing syllabus used by Faculty of Information Technology, Kolej Universiti Islam Antarabangsa Selangor (KUIS). This virtual laboratory will provide a safe platform for the student to learn basic system administration.

The Faculty of Information Technology at Kolej Universiti Islam Antarabangsa Selangor (KUIS) has offered its subject in System Administration for several years now. That class is considered equal to classes on the same topic given at other universities. The target audiences of the System Administration course are students of Computer Science in diploma level, usually in their 5th semester.

The course consists of one lecture and one lab session per week, with the lecture and the lab session being 2 hours each. The following topics are covered in the lecture and accompanying lab exercises:

- Introduction to Linux Operating System
- Linux File system Administration
- System Initialization
- Linux Process
- Linux Software and Package Management
- Systems Back-Up
- Linux Networking and Security

PROBLEM STATEMENT

A hands-on oriented, laboratory-based class that allows students to be exposed to the real-world challenges of System Administration is undoubtedly needed. In the case of Kolej Universiti Islam Antarabangsa Selangor (KUIS), having a dedicated lab for the System Administration course can be unattainable goal. Cost, space and time are major factors that prevent KUIS from building realistic computer lab and network for the students. Other than that, there exist some difficulties in teaching System Administration course in KUIS. The problems arise from three different aspects; Pedagogical and Management Issues, Laboratory Structure and Content of Exercise

RELATED WORKS

Yang (2007) describes the laboratory projects developed for system and network administration course sequence offered in an Applied Computer Science Master's program in the spring of 2006. The first course focused on system administration, while the second course focused on network part. In each course, theoretical aspects were covered in class, while projects were assigned to teach students the practical application.

Microsoft Virtual PC was chosen as a virtual machine software and students have the freedom of accessing their Virtual PC environment from any lab computer on 24/7 basis. Lists of the projects assigned to the students are as follows:

- Creating a virtual local area network (LAN)
- DNS and DHCP services

- Active Directory (AD)
- Network File System (NFS)
- Email System

University of Milan within the course of Security of Informatics Systems and Networks has designed and developed a complete training environment using Xen platform on top of Gentoo Linux (Damiani et. al., 2004). This project has successfully provided students with easy access to the virtual lab directly from normal web browser. Figure 1 shows architectural paradigm and structure of the project.

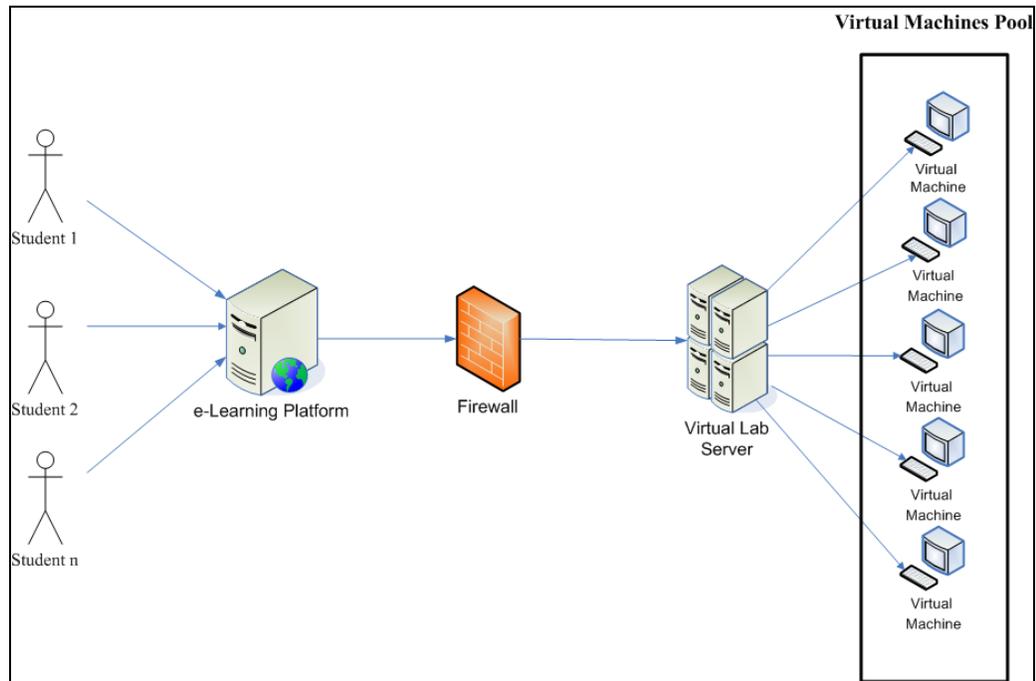


Figure 1: Virtual lab system structure
(Source : Damiani et. al., 2004)

Another similar project is The Virtual Laboratory project funded by Human Resource Development (MHRD), Government of India. Bandi, Nori, Chopella and Kode, (2011) in their papers report the development of the project that give the students a platform through which they can learn basic tasks of Linux system administration. The virtual lab consists of a suite of experiments such as File Management, Process Control and Basic Networking. Each of these is designed and presented as a web application module as depicted in Figure 2.

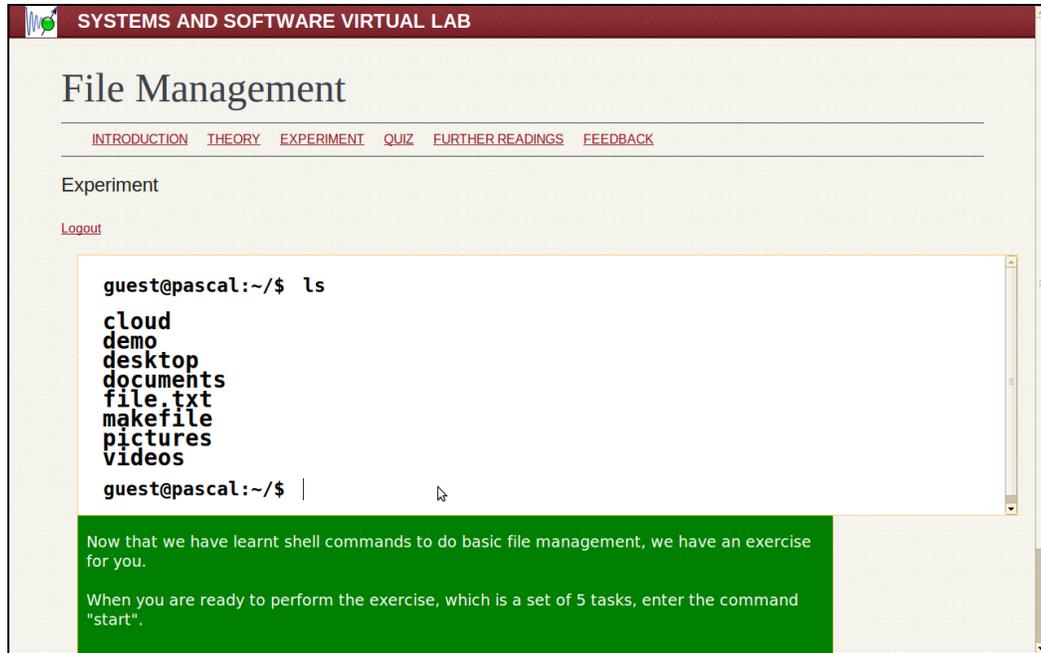


Figure 2: Virtual lab exercise module
(Source : Bandi et. al., 2011)

VLAB SYSTEM DESIGN

The system is developed using PHP script as the middleware, running on Apache HTTPD web server and the database is residing in MYSQL 5 database. Proxmox VE; an open source virtualization is used as the virtualization core engine to provide virtual machine instances to the students.

VLAB Architecture

Architecture design is the most essential part in developing VLAB. Design is the process of defining the modules, interfaces and data for a computer system to satisfy specified requirements. Architecture design shows the basic components of web application architecture and their relationships. Communication between these components is generally based on the request-response principle. For example, a Web browser sends a request to a Web server and the response to this request is send back over the same communication channel (synchronous communication). Figure 3 shows the basic architecture of KUIS VLAB.

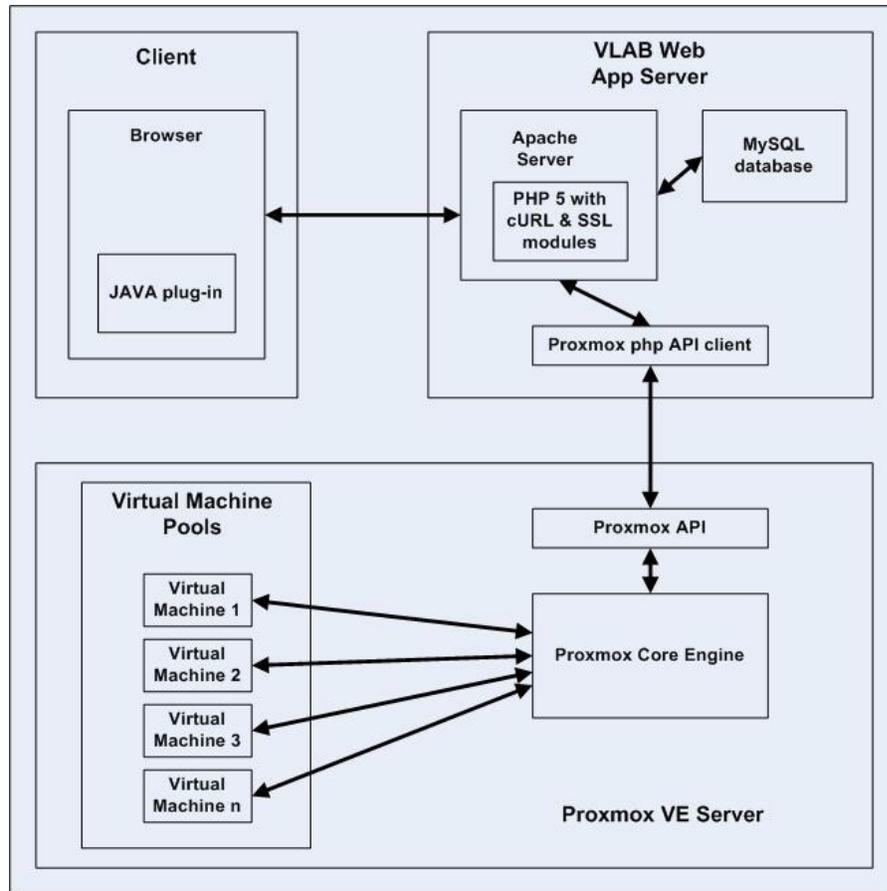


Figure 3: KUIS VLAB Web Application Architecture

- **Client**
A web browser used by a student or lab instructor to access and manage VLAB. The browser functionality can be expanded by installing plug-in or add-on. In this case, Java plug-in is required to open VLAB and Proxmox web interface.
- **Apache web server**
A Web server is a piece of software that supports various Web protocols like Hypertext Transfer Protocol (HTTP) and and Secure HTTPS (HTTPS) to process client requests. In this project, Apache2 project is used as the web server. Server side processing functionality is added to the Apache2 server by installing PHP5 complete with cURL and Secure Socket Layer (SSL) support.
- **MySQL database**
This is another component in KUIS VLAB where MySQL database server supplies data in structured form to be manipulated. Since the main focus of KUIS VLAB project is to provide accessibility to virtual machine, database server holds a supportive role where it is used to store login credential, exercise questions and quiz.

- **Proxmox API client**

Proxmox API client is a small piece of code written in PHP programming to allow communication with Proxmox API. Code snippet depicted in Figure 4 shows an example of Proxmox API client.

```
<?php
require("../pve2-api-php-client/pve2_api.class.php");

$pve2 = new PVE2_API("hostname", "user", "realm", "pass");
# realm above can be pve, pam or any other realm available.

if ($pve2->constructor_success()) {
    $pve2->set_debug(true);

    if ($pve2->login()) {
        foreach ($pve2->get_node_list() as $node_name) {
            print_r($pve2->get("/nodes/".$node_name."/status"));
        }
    } else {
        print("Login to Proxmox Host failed.\n");
        exit;
    }
} else {
    print("Could not create PVE2_API object.\n");
    exit;
}
?>
```

Figure 4: Example of Proxmox PHP API client

- **Proxmox API**

Proxmox Application Programming Interface (API) is a specification intended to be used as an interface by VLAB web application modules to communicate directly with Proxmox core engine. The details of the Proxmox API will be discussed in the next section.

- **Proxmox core engine**

This is the main component of the Proxmox VE server; virtualization technology solution used by KUIS VLAB project and its task is to allow creation, management and configuration of virtual machines.

- **Virtual machine pools**

Pools of virtual computers that are assigned to the students as a platform to practice basic Linux system administration skills.

Use Case Diagram

A use case is a set of scenarios that describe an interaction between a user and a system. A use case diagram displays the relationship among actors and use cases. The two main components of a use case diagram are use cases and actors. A use case represents the main functionalities, some actions and the processes that the user might perform in order to complete a task in KUIS VLAB application. Figure 5 shows the KUIS VLAB Use Case.

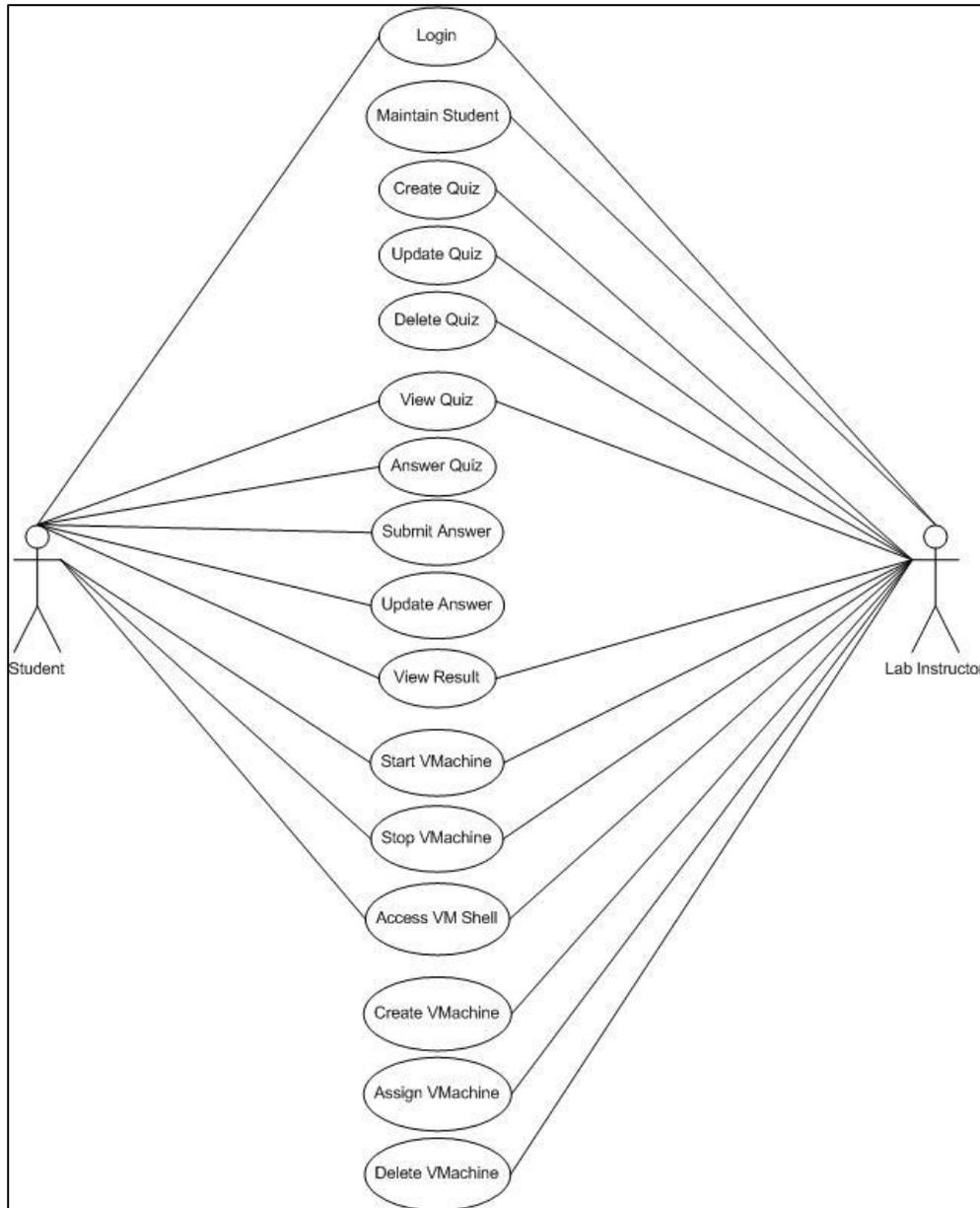


Figure 5: Use case diagram

User Roles

Users in VLAB have two different roles which described in Table 1:

Table 1 – User roles in KUIS VLAB

Roles	Roles Description
Lab Instructor	<ul style="list-style-type: none">• First time setup during system implementation• Proxmox VE host management• Manage virtual machine• Assign virtual machine to student• Perform maintenance for the following information:<ul style="list-style-type: none">○ List of exercise & quiz○ List of Linux experiment• Perform maintenance on student profile• Search student• Monitor student progress• Assess student answer for quiz
Student	<ul style="list-style-type: none">• Start and stop virtual machine• Access to virtual machine shell (console)• Answer quiz and exercise• Check correct answer for exercise

Interface Design of VLAB Main Features

- KUIS VLAB: Login Page



Figure 6: Login page

Figure 6 shows the login page of KUIS VLAB. The login process requires user to enter their username and password which initially created by Lab instructor.

- KUIS VLAB: Main Page

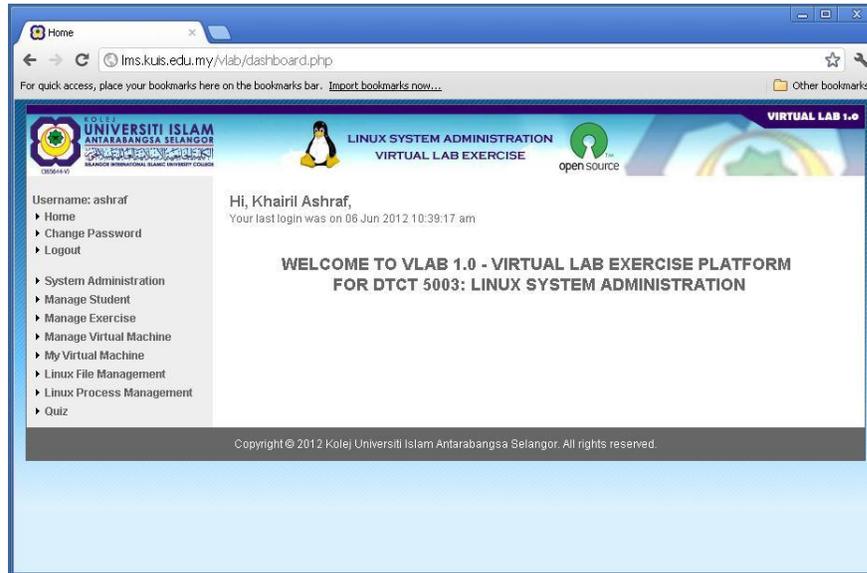


Figure 7: Main page (Lab instructor)

Figure 7 shows main page for lab Instructor upon successful login. Lab instructor is granted all access to the VLAB system.

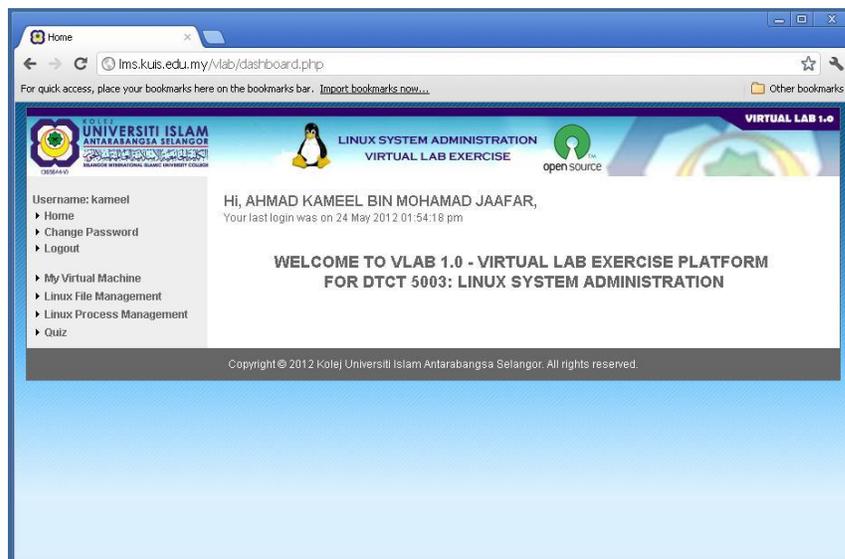


Figure 8: Main page (student)

Upon successful login student will get the main page with restricted access as shown in Figure 8.

- KUIS VLAB: View Student List

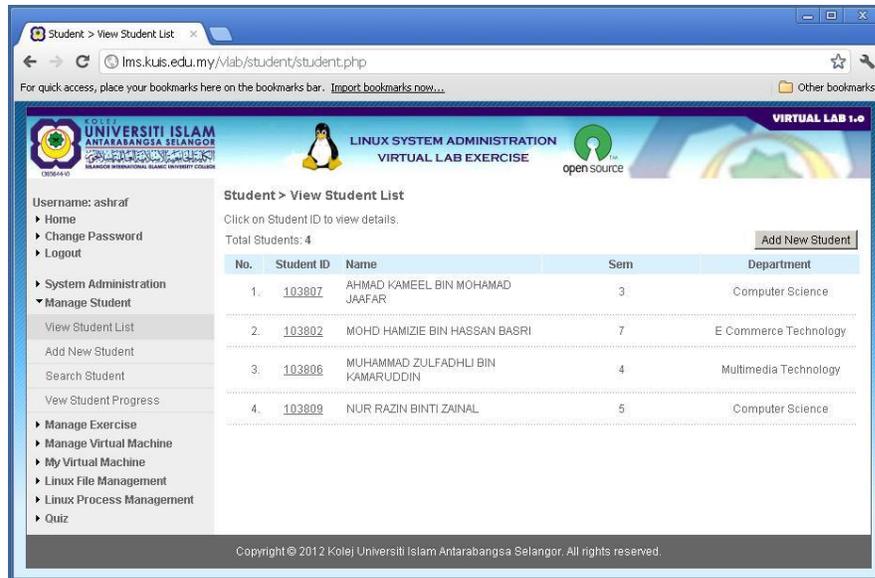


Figure 9: Student list

Figure 9 shows list of student currently registered to the VLAB system. Lab instructor also can add new student, update, search and view student progress using menu available.

- KUIS VLAB: Virtual Machine



Figure 10: Virtual machine status (Lab Instructor)

Figure 10 shows manage virtual machine page for Lab Instructor. Full access is granted where the Lab Instructor can view and manage the status of all virtual machine and the Proxmox server itself.



Figure 11: Virtual machine status (student)

Figure 11 shows how students are granted access to monitor and manage their virtual machine only. Also from this page, student can launch virtual machine console by clicking at “Launch VM Shell” link.

- KUIS VLAB: Linux experiment

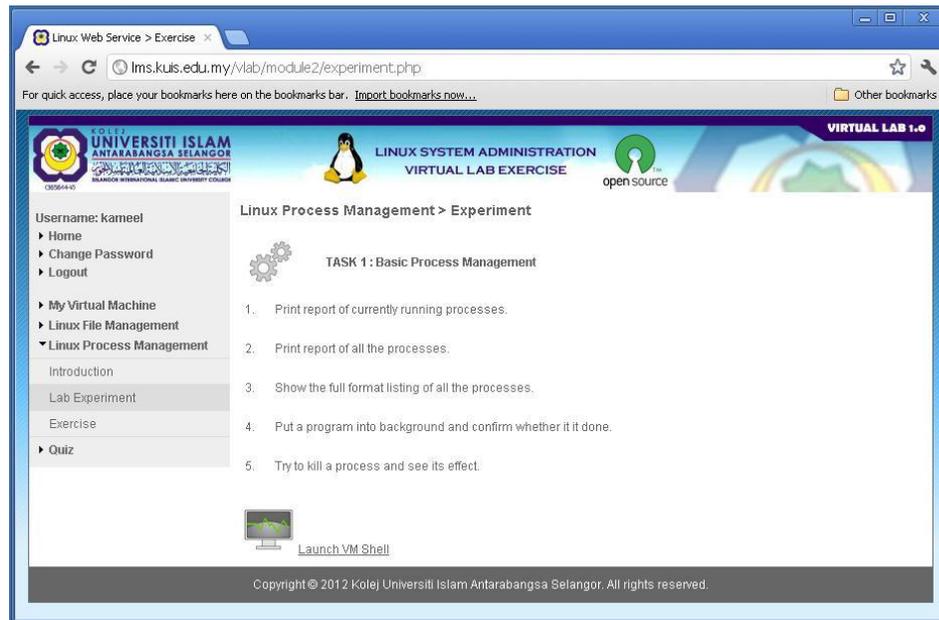


Figure 12: Linux experiment

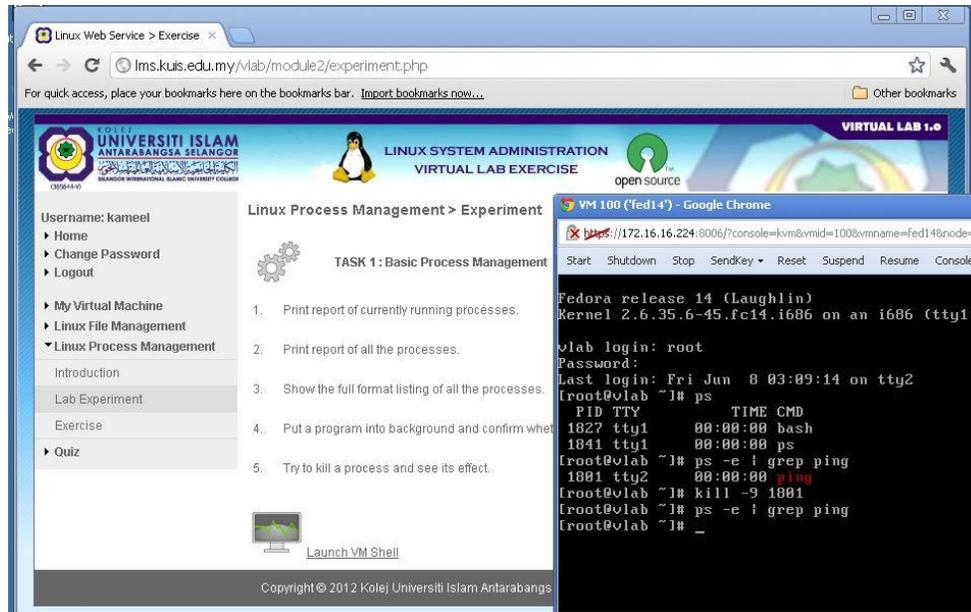


Figure 13: Linux experiment and virtual machine console

Figure 12 and 13 shows example of Linux experiment to be completed by the students. They can click at “Launch VM Shell” link and begin their Linux experiment.

DISCUSSION

This paper has presented experience on designing and implementing a laboratory exercise using virtualization technology (VLAB) for a System Administration course in Kolej Universiti Islam Antarabangsa Selangor (KUIS). The result is positive, with some lessons learned from various early implementations in both academic and industrial world. Virtualization is an exciting technological field, which can be efficiently utilized to help resolve pedagogical issues surrounding System Administration teaching and learning process. Using KUIS VLAB, both instructors and students can now experience with various computer and system administration tools using virtualization without spending more money on IT infrastructure.

Full virtualization features in Proxmox Ve used in this project has successfully allow the students to interact with their virtual machine. However it still consume large amount of computer resources (especially RAM). It is recommended to look into another type of virtualization type supported in Proxmox VE which is OpenVZ to enable better server resource utilization.

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