

A Virtual Laboratory for Teaching Linux on the Web

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Abstract—The shortage of experimental platforms needed for learning IT systems in a hands-on way is one reason for the lack of quality education in the area of IT. For most students who have access to a PC, their ability to experiment on that machine is limited by the risk of possible irrecoverable damage their experimentation may cause to the equipment. We report the development of a 'Virtual Laboratory for Systems and Software' that teaches the basics of Linux. The goal of this laboratory is to give the students a platform through which they can learn the essentials of linux. The student interacts with a virtual instance of a linux machine through the browser on his machine to learn basic tasks of linux system administration. The student's machine could be running any operating system (not necessarily linux). This obviates the need to have a linux machine on the part of the student. The lab consists of a suite of experiments designed as web applications which are based on IT Workshop courses at undergraduate level in universities.

Keywords-Virtual Labs, learning; web technology, software development

I. INTRODUCTION AND MOTIVATION

Learning the fundamentals of Linux to do basic system administration tasks is essential for every IT engineer which requires a good amount of hands-on experience to avoid irrecoverable damages. But due to absence of adequate training facilities such as lab infrastructure, lab programmes and workshops, the motivation and ability to experiment on linux machines is hindered. Providing such infrastructure requires maintenance of machines which may lead to irrecoverable damage due to experimentation by beginners. The maintenance requires the administrators to be patient enough to recover the machines everytime a damage occurs. Hence, some administrators impose constraints on what the students can experiment leading to restrained experience on the side of the students.

To mitigate this problem, we present 'A Virtual Laboratory for Systems and Software'.

The goal of this laboratory is to increase the students knowledge and practice of basic but essential tasks of systems administration. The lab consists of a suite of experiments designed as web applications. The students interact with a remote virtual instance of a linux machine via a web browser. This exempts the students from having a linux machine and prevents the fear of risking their system in learning linux. Thus the virtual laboratory provides a safe platform for the student to learn basic system administration. This Virtual Laboratory is a part of the larger Virtual Labs project [1] funded by the Ministry of Human Resource Development (MHRD), Government of India. As a part of this project a consortium of technical institutions in India is building virtual labs in various branches of engineering.

This paper deals with the approach that has been used to implement the Virtual Lab and goes on to explain the current state of the lab and the work that is planned for the future. As this lab is a part a larger collection of labs, scaling is an issue that will be addressed centrally for all the labs. Thus, this paper does not discuss the scalability aspect of the lab. However, a mention has been made in the Future Work section.

II. APPROACH

The Virtual Lab for Systems and Software [2] will consist of a suite of experiments each designed as a web application. Each web application will manage a learning platform for a set of software resources or systems (applications, OS's). We have initially focused on building a virtual lab for teaching the elementary Linux and system administration tasks such as File Management, Process Control, Basic Networking and Version Control using Subversion. Each of these concepts is presented to the user as an experiment. Each experiment contains a theory

section explaining the concept along with examples and a simulation section which is a set of tasks that are to be performed by the user. The user is given access to a remote linux machine to be able to experiment and perform the tasks of the experiment via a command line interface presented via the browser. After successfully finishing the experiment, the student is expected to have reached a good understanding of the concept involved.

III. ARCHITECTURE

The student communicates with a server through the browser on his system. This communication between the server and the student machine happens via HTTP requests and responses. The server runs virtual instances of operating system (Linux) depending on the server's hardware capabilities. When the user executes a command on the command line interface of the web application, an AJAX request is sent to the server.

This request received onto the server is processed and sent to the virtual instance of linux machine. The communication between the server and the virtual instance happens through SSH. The output of the response is sent from the virtual instance to the server. The server then sends back the received response to the browser on the host system in the form of a HTTP response as shown in Figure 1.

IV. STRUCTURE OF EXPERIMENTS

Each lab experiment contains five sections: Introduction, Theory, Simulation, References and Exercises.

The introduction section gives a brief notion of what the experiment is about. The theory section provides relevant theory which explains the concepts involved in the experiment. It includes a general tutorial on the commands that the user is expected to learn in the experiment.

The Simulation section provides a UI for the user which enables him to perform the tasks in the experiment. The UI here contains two components: a command line interface and an instructor section. The command line interface mimics the terminal of a linux machine. This command line interface supports a few basic commands that enable the user to experiment

with those commands. The instructor section guides the user to perform the tasks included with the experiments.

The References section contains pointers to some resources which the user is expected to go through to get a comprehensive understanding of the concept involved.

The Exercises/Quiz section contains a set of questions that the user can solve to test his understanding of the lab. These questions are both theory oriented as well as practical to allow the user to test them out on the command line interface provided.

V. EXPERIMENTS

Till date, five experiments have been developed as a part of the Virtual Laboratory. These are File Management, Process Control, Basic Networking Concepts, Version control using Subversion and User Management. A brief explanation of each of the experiments is given below.

A. File Management

This experiment underscores the importance of learning how files and folders are managed on a linux system and gives the user an understanding of how files and folders are created on a linux system. The user will be able to list, create & delete files and folders on the remote system. A screenshot of the experiment is shown in Figure 2.

B. Process Control

Process control refers to managing the processes running on a linux system. This experiment will give the user an understanding of basic process management. Through this lab, the user will be able to find out which processes are running in the system along with other information such as the process ID and the user running it. He will be able to kill the processes, change the priority of a process, delegate them to the background and again bring them back to active state.

C. Basic Networking Concepts

The knowledge of Basic Networking Concepts is a must for anyone who wishes to administer his own linux machine. This experiment will enable the user to get an understanding of basic

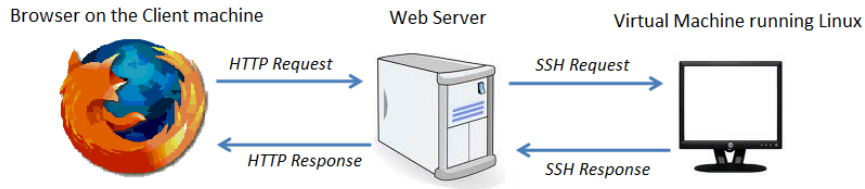


Figure 1. Architecture Diagram of the Virtual Lab for Linux on the Web

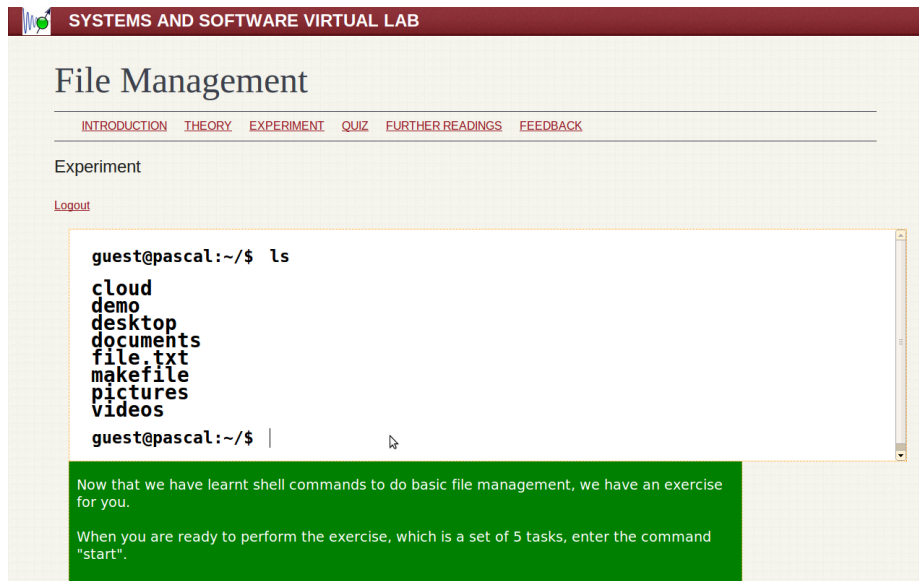


Figure 2. Screenshot of the File Management Experiment

networking commands in Linux. Through this lab, the user will be able to find out about the different network interfaces on the machine, identify the hardware (MAC) & IP addresses of the respective interfaces. He will be able to manually assign IP addresses to the interfaces, as well as obtain the IP address through services such as DHCP.

D. Version Control using SVN

Version Control is an integral part of any project management paradigm. As every project involves multiple members working simultaneously, having a proper version control system in place becomes more and more important. In this context, this experiment teaches the user the basics of version control using Subversion,

which is one of the most popular version control systems. Through this experiment, the user will be able to create a subversion repository, add files to the repository and delete files from the repository. He will be in a position to commit his work, update to the latest revision, revert to an earlier version and resolve conflicts.

E. User Management

User Management is another essential task that needs to be learnt by a linux system administrator. The User Management experiment provides a hands on experience with various tasks involving managing user accounts on a linux machine. Through this experiment, the student will be able to create and delete user accounts on the linux system, manage groups,

set various parameters of users and groups such as their passwords and default shells.

VI. RELATED WORK

Applications that provide services similar to our virtual laboratory have been developed. In this section, we present a few of them.

WebShell[3] The WebShell is a web based ssh shell for the iPhone. It provides a linux shell environment over the web browser. It is based on Ajaxterm. Unlike the proposed Virtual Laboratory, the WebShell is not platform agnostic. It can only be installed on Unix based systems like Linux, BSD and Mac that run Python 2.3. Another major difference is that the WebShell is not a learning environment.

Online Programming Environments There are various online programming environments present on the web. These applications provide a live environment for the user to learn a specific language. Some of the popular languages which these programming environments support are Python, Ruby[4] and JavaScript.

WebGoat[5] WebGoat is a deliberately insecure J2EE web application maintained by OWASP designed to teach web application security lessons. In each lesson, users must demonstrate their understanding of a security issue by exploiting a real vulnerability in the WebGoat application.

VII. FEEDBACK, CHALLENGES AND FUTURE WORK

Feedback As a part of the larger Virtual Labs project evaluation, the lab presented in this paper was evaluated by an expert committee consisting of eminent researchers and faculty members. The expert committee noted that the lab was well implemented.

Integration with University Courses

This Virtual Laboratory is designed to be used as a supplement for Unix related courses for undergraduate students in Computer Science and Engineering (CSE) and Information Technology (IT) branches. Work is underway to identify relevant courses belonging to the Jawahar Lal Nehru Technological University, Hyderabad for which this lab can be used as a supplement.

Advanced Experiments

We are also building more advanced experiments that deal with complex parts of linux

system administration such as OS and Package installation, Disk Partitioning, Examining log and Configuration files. These tasks require sudo access to the machine and require a change in the current architecture.

Scalability and Private Cloud setup

To ensure scalability and seamless connectivity, the maintenance of a private cloud infrastructure is necessary. Work is underway to put this infrastructure in place. The next step would be to host a private cloud in every college that uses the virtual labs. This will result in huge bandwidth savings for the participating colleges.

VIII. CONCLUSION

Open Source software is increasingly being used in many leading IT companies for software development. However, for reasons mentioned earlier in this document, the same is not being followed in many engineering colleges. The goal of this Virtual Laboratory is to mitigate those problems by providing a linux environment that is safe, easy to learn and understand.

Through this project, we aim to build awareness among students about the linux operating system and its administration. We attempt to teach the students, the basics of linux system administration. We hope that these labs will encourage the students to explore open source software and enthuse them into using it for their software building activities. This will not only add to the skillset of the students, but also encourage them to spread the philosophy of open software.

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