Design of a Reconfigurable Virtual Computing Laboratory

S. Baev\textsuperscript{1}, B. Peltsverger\textsuperscript{1}, and A. Shah\textsuperscript{1}
\textsuperscript{1}Department of Computer Science, Georgia Southwestern State University, Americus, GA, USA

Abstract—A growing number of online students and complexity of programming projects dictate the necessity of designing/deploying a computing infrastructure which must satisfy contradictory requirements. From one standpoint, such infrastructure is expected to grant administrative privilege to students, working on a variety of programming projects, for instance, web programming for cloud computing. From another perspective, granting administrative privilege will not only allow students to access all files on the system (including other students’ work) without legal permission but also may result in a system crash. The simplest workaround in this case would be to setup dedicated workstations to individual students but this solution doesn’t seem to be scalable, reusable, and convenient to run distance learning process.

Keywords: Infrastructure, networking, virtualization, hypervisor.

1. Proposed Solution

The authors propose a design of virtual computing laboratory which not only capable of addressing the mentioned problem but also has many other useful features: scalability, improved security measures, convenient administration, and reduced cost. The proposed design is sketched on Figure 1.

1.1 Outline of the Infrastructure

The design of the computing infrastructure is hybrid so it has a mixture of physical (hardware) and virtualized (software) components. In particular, the virtual part of the infrastructure exploits hypervisor technology in two most commonly used implementations: Citrix XenServer and VMWare vSphere ESXi server. Both implementations allow hosting multiple virtual machines on a bare-metal platform (hardware server running hypervisor software). Virtual machines are interconnected into a hybrid network supported by several physical and virtual network switches. The last crucial component of the system is a set of thin terminals which are inexpensive, diskless endpoints of the user interface provided by virtual machines. Such an interface, (a.k.a. virtual desktop) is delivered to end-users by means of either of the following approaches: Microsoft Windows Terminal Service (RDP protocol) or Linux Terminal Server Project.

From the perspective of the offered services, the infrastructure has the following components:

1) Centralized gateway/firewall/access controller implemented on the basis of pfSense appliance

2) Intrusion detection/protection system (IDS/IPS) implemented on the basis of Security Onion appliance (snort, snorby, squl, squert, and others)

3) Network Attached Storage (NAS): allows for centralized, convenient, configurable storage of user and configuration data.

4) Directory Server (OpenLDAP project): centralized storage of user credentials used for login and access control purposes.

5) Terminal servers (Windows and Linux) allowing for the delivery of virtual desktops to a set of diskless thin terminals (clients)

6) Thin terminals (clients) are robust, reliable, and cost efficient computing devices $\tilde{\text{A}}\tilde{\text{S}}$ user interface of the infrastructure

7) A variety of application servers to support teaching and research processes

a) Document management server (LetoDMS project): combines standard document manipulation functionality with a nice-looking web-interface.

b) Wiki (MediaWiki project): supports publishing supplementary materials used in a variety of classes and research projects.

c) Version control system (SVN repository): allows for centralized storage of students’ project files with proper backups, access control, and convenient web-interface.

1.2 Functionality

The introduced computing laboratory is also designed to be highly reconfigurable in terms of structure and provided
content. Having basic set components intact a new set of servers (physical or virtual), workstations and thin terminals can easily be added to extend the scope of laboratory applications. Moreover, a library of virtual machines images can be made available to allow on-demand reconfiguration of the computing environment in case of shared classroom facilities. A typical scenario can be recognized by many faculties: one same computer classroom is used throughout the day to offer a variety of classes. Say, at 8:00 AM it is a UNIX class which requires nothing more than a shell console to be available – any other software (including web browsers) is disabled to help students gaining certain skills and habits. Once the class time is over, say from 9:30 AM to 11:00 AM, the laboratory is reconfigured for assessment purposes (testing center), for instance, each workstation is locked-down to web-browsing software while enforcing limited access to the Internet. Then, say at 3:00 PM, the laboratory is used to teach a MATH class based on the Pearson’s MyMathLab web-application. All such laboratory reconfigurations could be automatically performed with respect to some schedule by means of reassigning different set of virtual machines to the same set of thin terminals located in the classroom.

1.3 Technology

The infrastructure is implemented on HP Proliant ML350 hardware platform (three servers) and two types of thin-terminals: Wyse V10L and LTSP Term 1720. From the perspective the virtualization technology, the infrastructure is based upon two hypervisor implementations: Citrix XenServer and VMWare ESXi 5. The majority of servers are Linux (Debian and Ubuntu) based ones. The OpenSource ideology is preferred throughout the design against any proprietary analog.

1.4 Licenses

The Department of Computer Science of Georgia Southwestern State University is a member of two academic alliances: MSDN (Microsoft) and VMAP (VMWare). Membership in these alliances helps reducing the cost of the infrastructure while providing convenient and hassle-free access to a variety of the software for both student and faculty members of the department.

2. Conclusions

The proposed solution has partially been implemented at the School of Computing and Mathematics in Georgia Southwestern State University. The work still in progress but several results can be outlined as accomplished:

1) A Cloud Computing course was successfully taught in Spring 2012 term. Students were individually working in the Microsoft Azure cloud computing environment while having administrative privilege on the Windows Server 2008 R2 machine and independent account-specific storages for project files.

2) A Computer Security course, in particular Network Security laboratory, was successfully conducted in Summer 2012 term. Students were divided into three groups so there were three independent virtual networks with three corresponding sets of victim, attacker, and router workstations.

3) The School Document Management Server was deployed back in Spring 2011 and successfully functions since that time. Its database along with document data storage is getting periodically backed up making last 30 days of the archive available on demand.