
Labs@Home

Patrick Seeling

University of Wisconsin-Stevens Point
2100 Main Street
Stevens Point, Wisconsin 54481 USA
pseeling@uwsp.edu

Abstract: In this publication, we introduce the Labs@Home framework, which enables students to conduct laboratory elements of courses on their personal computing equipment. A major benefit of this approach is that students are able to progress through assignments at a time and pace of their choice, before submitting the results to the instructor for review. The introduced framework is based on capturing differences between versions of the virtual machines and exchanging these between instructor and students. We are currently implementing several parts of the framework and expect to evaluate its implementation in the near future.

Categories and Subject Descriptors: K.3.4 [Computer Uses in Education]: Distance learning

General Terms: Design, Experimentation

Keywords: Virtual machines, lab, Distance education

1. INTRODUCTION

In the past, several laboratory elements were taught on-campus as part of the regular undergraduate curriculum in the Computing and New Media Technologies Department at the University of Wisconsin-Stevens Point. These laboratory elements in courses are aimed at fostering student learning, understanding of complex systems, and retention of the content taught. As found in the past, practical laboratory exercises are beneficial for student learning outcomes [5]. One of the challenges for instructors during the lab elements of courses taught are that students have a broad spectrum of previously gained knowledge and practical understanding of the subject matter. Laboratory elements in turn are difficult to plan and schedule, as the time needed to perform individual tasks varies greatly among individual students and student groups.

Virtual and remote laboratories have been implemented and used in the regular curriculum in the recent past, mostly targeting off-campus or distance education students, see, e.g., [1, 2, 6]. This allows the asynchronously connected distance education learner to use a self-paced active learning approach during the online laboratory elements, whereas traditional on-campus learners are typically bound by timeframes of lab sections and variation among previous knowledge in the domain. The on-campus learner, however, in this scenario has the benefit to receive immediate feedback from the instructor. To alleviate this problem for traditional on-campus learners, labs can be supported by faculty through email support or discussion boards/chats [7], which is out of the scope of this paper. We propose the following described

Labs@Home approach for courses that are traditionally based on practical student experiences using laboratory elements in courses.

2. OUTLINE FOR LABS@HOME

The Labs@Home project is based on virtual machines to implement activities that students can perform on their own computer at a time and pace of their choosing. Students will be given a virtual machine environment in which they need to perform different tasks. As typically multiple paths can lead to the same solution, changes between virtual machines will be exchanged between the individual student (or student group) and the instructor to evaluate the appropriate fulfillment of assignments by the instructor. The exchange of differences between subsequent versions has the benefit of reducing the amount of data that will be transmitted between students and instructor. This approach in turn makes the overall framework suitable for internet-based distance education courses. We illustrate the general process in Figure 1 for the completion of assignments and application of modifications.

The initial base file is shared between instructor and students. Based on the initial virtual machine, the instructor can apply changes to reflect fulfillment of individual steps or completed assignments to allow all students to continue to subsequent assignments. The differences between the original base file (or its modification) are captured in a file, e.g., a patch file, and distributed to students. On the student computer, the patch is applied on a copy of the original base file or the previous instructor modification. Students, on the other hand, can perform assignments on a local copy of the base file and

modify 'their' virtual machine as needed to fulfill the assignments. After completion, the differences are captured in a similar manner and sent to the instructor for evaluation. The instructor in turn applies the difference files received from the students to the initial base file or a modification thereof to obtain a local copy of the students' submitted virtual machine.

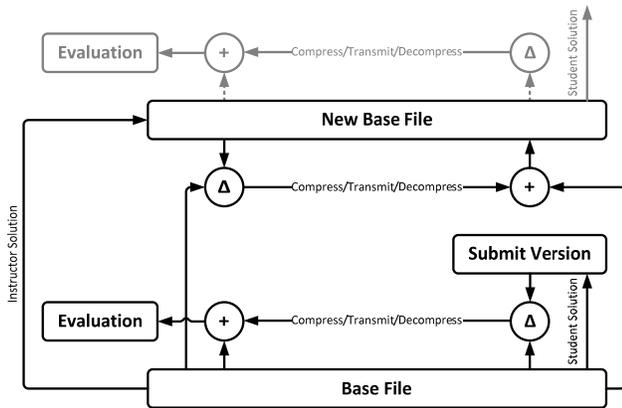


Figure 1: Overview of the patching process of the virtual machine for instructor (left) and student (right).

One potential drawback of this approach is the hard drive space required on the computers of instructor and students. With the abundance of hard drive space in recent computer desktops and laptops, however, this drawback may not have significant impact. Similarly, selecting operating systems and applications that run in the virtual machine will have an impact on the final size. A different approach to use virtual machines to conduct laboratory elements of courses is to enable students to log into the virtual machines remotely. This approach, however, requires significant hardware on the laboratory side, which might not be affordable for smaller schools or colleges.

3. IMPLEMENTATION

One of the challenges in selecting a virtual machine environment is the availability of the virtual machine architecture for different operating systems. As observed in the past, students have mostly three different operating systems installed on their personal computers, namely Microsoft Windows, Mac OS X, or one of several Linux distributions. Several different virtualization environments that use processor emulation exist to date. Freely available environments that can be used are, for example, VMWare products such as the VMWare Player [10], Microsoft's Virtual PC [8], SUN's VirtualBox [9] or others, such as QEMU [3]. In our implementation, we selected the QEMU virtualization environment, as it is an open-source processor emulator that has been made available for

different underlying operating systems. In addition, the QEMU environment does not require any installations in the hosting operating system, which allows for simplified distribution.

Processing speed in a QEMU-based virtual machine is typically slower than in some of the commercial packages, but can be increased by installing additional drivers, such as KQEMU [4]. Using typical desktop systems, the virtual machines can run Linux distributions with adequate speed. Using Linux distributions and freely available (open-source) software for the virtual machines is a simple approach to avoid potential copyright restrictions and other limitations.

To determine the changes that occurred during either the modifications on the instructor or student side, a byte-wise comparison between the QEMU image files is performed. The changes are written to a patch file and the patch file is subsequently compressed. The compressed file size varies depending on the amount of changes, the manner in which changes are captured, and the compression algorithm used.

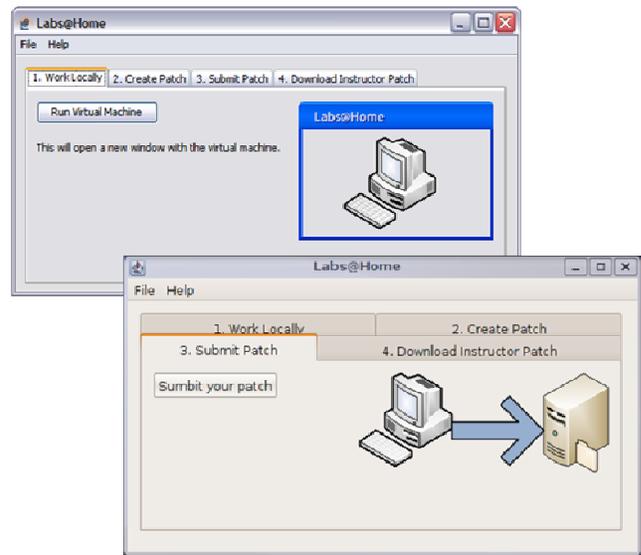


Figure 2: Example screenshots for the Labs@Home environment in JAVA (top Windows XP, bottom Ubuntu Linux 8.04).

We developed initial tools for the comparison of the individual files, patch generation and compression, and the application of the patches to files in JAVA, see Figure 2. Additionally, management tools for the instructor and students are currently under development and expected to be ready for initial deployment and use in courses in the near future.

4. CONCLUSION AND OUTLOOK

The framework introduced in this paper allows students to conduct laboratory elements of courses using virtual

machines on their own computing equipment. The main benefits resulting from this approach are that students can progress at a time and pace of their choice and the reduced costs in infrastructure for schools. We will use the outlined implementation in several courses in the domain of computer networking in the near future. We expect that

student motivation, learning gains, and finally retention will improve as students are able to spend the time they need on the individual assignments. We intend to evaluate the outcome of our approach on these important factors and make them publicly available.

REFERENCES

- [1] Anisetti, M., Bellandi, V., Colombo, A., Cremonini, M., Damiani, E., Frati, F., Hounsou, J.T. and Rebecani, D. Learning computer Networking On Open Paravirtual Laboratories. *IEEE Transactions on Education*, 50 (4). 302-311.
- [2] Barros, B., Read, T. and Verdejo, M.F. Virtual Collaborative Experimentation: An Approach Combining Remote and Local Labs. *IEEE Transactions on Education*, 52 (2). 242-250.
- [3] Bellard, F. QEMU - Open Source Processor Emulator, 2008.
- [4] Bellard, F. QEMU Accelerator (KQEMU), 2008.
- [5] Colwell, C., Scanlon, E. and Cooper, M. Teaching Computer Networking Fundamentals using Practical Laboratory Exercises. *IEEE Transactions on Education*, 49 (2). 285-291.
- [6] Colwell, C., Scanlon, E. and Cooper, M. Using Remote Laboratories to Extend Access to Science and Engineering. *Computers & Education*, 38 (1-2). 65-76.
- [7] Ekman, J. A Web-based Information Centre to Provide Help, Guidance and Support for Students. *ACM SIGCSE Bulletin*, 38 (3). 363-364.
- [8] Microsoft, I. Microsoft Virtual PC 2007, Microsoft, Inc., 2008.
- [9] Sun Microsystems, Inc. VirtualBox, Sun Microsystems, Inc., 2008.
- [10] VMware, Inc. VMware Player, VMware, Inc., 2008.

Get Connected with

Computing History

Visit the

IEEE History Center and Virtual Museum at

www.ieee.org/museum