Teaching Client-Server Application Development through Open-Source Software

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Abstract: Teaching a class that requires the use of institutional or departmental servers (e.g. web servers, database servers) usually translates to compromising position for the instructors. Often times, the instructors have to decide on the course coverage based on the software availability and the institutional policy. Thus, the notion of teaching the most up-to-date or state-of-the-market materials may be limited by the issues of convenience, availability, and economy. Moreover, by using such systems, the instructors do not have the complete control of the learning environment (e.g. to solve even the smallest problem may involve a third party such as a system administrator). Since most of these servers may be shared by hundreds or thousands of institution members, the reliability and the efficiency of such systems can have negative effects on class environment and students' learning experiences. One obvious solution is to provide each instructor with a server where he/she can have a complete control of the learning environment. This solution may not be feasible even as early as five years ago. However, the popularity open-source software may make this solution a feasible and economical one.

Keywords: open-source software, education, industry practices, Linux, PHP

1. Introduction

One major difficulty in teaching a course that involves technologies that rapidly change is the need to constantly update teaching materials and learning environment (e.g. software). Traditionally, application oriented classes such as client/server application development often rely on institutional and departmental servers for students to complete their assignments. One major benefit of this approach is less responsibility for instructors because they do not have to deal with the system administration aspect. On the other hand, instructors often have to make compromises on the teaching materials based on the software availability and departmental policies on the servers.

One solution is to provide a class with its own server. As early as five years ago, this solution would have been quite costly. A simple UNIX workstation with all the software needed can cause as much as 10 of thousands of dollars. Moreover, yearly software upgrade and hardware maintenance can also be expensive in the long run. This is one reason why the recent emergence of open-source software can have a strong impact on the quality of teaching.

The advancements of open-source software such as Linux Operating System, Apache Web Server, PHP, MySQL, and etc. provide instructors with the freedom to choose among the most suitable technologies for their classes with minimal or no expense. Because such software can perform relatively well on a more outdated hardware, it can serve as an inexpensive, but powerful learning platform for the students. At the same time, it also provides instructors with a freedom to customize and control the quality of their courses according to their needs. In a recent survey by Netcraft, the popularity of the open-source software is at a new height. Apache web server occupies nearly 60% of web servers around the world. PHP (Server side scripting language) is the most commonly integrated module for the Apache server. Additionally, MySQL is known to be one of the most popular SQL engine. Lastly, Linux OS occupies over 25% of server around the world. Undoubtedly, such software can provide state-of-the-practice computing facilities at nearly zero cost.

In the spring of 2000, we have experimented with using a Linux Server to serve our students in a graduate level class, Client/Server application development. There are forty seven students enrolled in this experimented section. The course objective is to expose our students to current practices in the industry. The hardware used to set up the server is a three years-old Pentium Pro computer. The software used on this server is Redhat Linux 6.1, MySQL Database Management System (DBMS), Apache Web Server, PHP engine, and Sun's JDK 1.2.2 for Linux. Since all of the software used is freely available, there is no licensing cost. There is also no hardware cost since the system used was a retired unit.

In this teaching environment, the instructor and the teaching assistant (T.A.) are responsible for the system administration. Students perform and submit their work on this server. At a specific time on due dates, the system would be inaccessible to the students and will remain inaccessible for a few days. During this time, the instructor and the T.A. would go in and grade the assignment. With this setup, there is no late submission, no corrupted file due to FTP. The instructor has the full control of the environment where he/she can monitor the students' activity throughout the semester. During the submission process, students are given a specific guidelines on where and how to submit their work. The instructor and the T.A. simply grade the assignments from the specified location.

Additionally, we also encourage students to share their ideas and enthusiasms. We provide an informative web-site with a discussion forum where the students can express their ideas, exchange information, and get help from the instructor and the T.A.. We find that one of the major benefits of this forum is the reduction in redundant e-mails and repeated questions. By having the forum, students can check to see if their questions have already been answered. If they have not been answered, students can either send e-mail or post the questions. Moreover, students can also share their enthusiasms about the materials, some informative web-sites, or their opinions about the class.

The remainder of this paper is organized as follows. Section 2 briefly describes open-source software. Section 3 provides detailed information about the server. Section 4 discusses the result of this experimented class. Section 5 details the future plans. Section 6 concludes this paper.

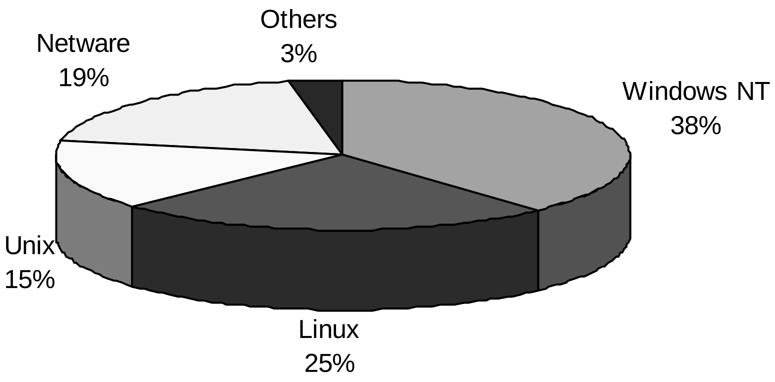
2. Open-source software

The basic idea behind open source is very simple. When programmers on the Internet can read, redistribute, and modify the source for a piece of software, it evolves. People improve it, people adapt it, people fix bugs. And this can happen at a speed that, if one is used to the slow pace of conventional software development, seems astonishing [1]. Traditionally, open-source software has been used in the academia to generate traces for trace-driven simulations and has been modified for experiments. With the recent exploding popularity of Linux for business, open-source software has its place in the mainstream and companies such as Oracle, IBM, Adobe, Corel, etc. begin to port some of their flagship software to Linux. Nonetheless, these commercial products are not used on our server due to licensing issues. However, attention paid by those companies, opens door for other similar open-source applications such as MySQL, MiniSQL, and Apache to present themselves as real alternatives for commercial software. In the following sub-sessions, we will briefly introduce some of the open-source software that are used on our class server.

2.1 Linux Operating System

Created in 1991 by Linus Torvolds, a young student at the University of Helsinki in Finland, Linux has grown to over 12 millions users to date [2]. Originally, Linux was created to surpass the standard specified by Minix operating system [3]. Overtime, the number of contributors to Linux project has exceeded ten of thousands of programmers around the world. Presently, Linux is being used on major e-commerce site such as E-Toys and other heavy traffic sites such as slashdot.org.

Figure 1. Recent Server Survey [4]

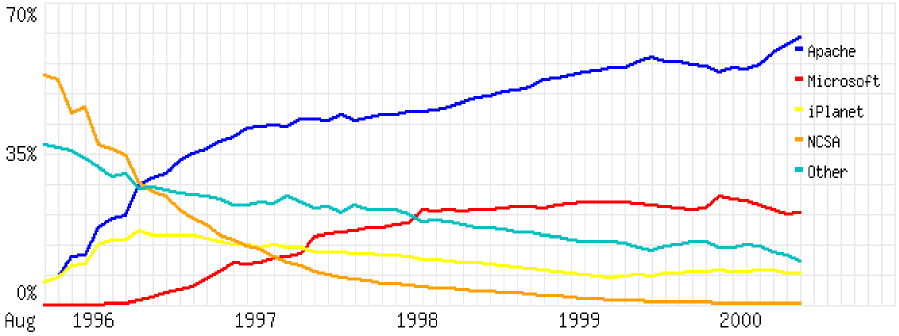


The figure above illustrates the market share of Linux operating system for server around the world. Presently, Linux is installed in 25% of servers. This is 13% behind Microsoft Windows NT [4].

2.2 Apache web-server

Apache is the most used web-server around the world. Presently, it occupies over sixty percent of web-server market. In 1998, IBM scraped its proprietary web-server in favor of Apache. Some of the sites that use Apache are javasoft, W3-Consortium, financial times, etc.

Figure 2. Web-server survey from August 1996-April 2000



The figure above indicates the gaining popularity of Apache web-server over the past three and a half year. The survey is regularly perform by Netcraft.com [5].

2.3 MySQL DBMS

One of the most used database on the internet. MySQL is a true multi-user, multi-threaded SQL database server. SQL (Structured Query Language) is the most popular and standardized database language in the world. MySQL is a client/server implementation that consists of a server daemon `mysqld` and many different client programs and libraries [6]. MySQL is also one of the fastest SQL engine around. It is capable of reliably handling large volume of data (hundreds of megabytes of mission critical information).

2.4 PHP (PHP Hypertext Preprocessor) server-side scripting language

Presently, PHP is running over one million web-sites around the world [7]. It is a scripting language that can be added to web server as a module to generate hypertext document on the fly. In many aspects, it is similar to Microsoft's Active Server Pages (ASP); however, PHP can be used free of charge and it can run equally well on UNIX, Windows NT, Windows 98, and Macintosh.

3. The server (ermis.cs.iit.edu)

The idea to launch the class server came about in December of 1999. Our main objective is to provide the state-of-the-practice to the students and hopefully their projects can be used as part of their portfolios. We choose Linux operating system, MySQL database management system, Apache web-server, and PHP server-side scripting language as the core components in the server because of their popularity and reliability. Moreover, these applications are commonly used by the industry which can valuable to our students. The hardware used is a retired Pentium Pro 180 MHz. with 128 MB of RAM and 6.4 GB of storage space. A small hard-drive is also used for daily backup operation. It only takes us less than 24 hours to have the server up and running. More importantly, the start-up cost for this server is zero.

One major drawback of having a dedicated server is that the instructor and the teaching assistant have to administer the system. Such tasks include setting up network, student's accounts, monitoring the system, and maintaining the system. For the spring of 2000 semester, roughly 35 hours were spent on the tasks of system administration. The system availability is one hundred percent (zero down time). On the other hand, our students receive valuable hands-on experience working with some of the most popular software available today.

There are three main projects for this class. The first project is XML based. The main goal for this project is to expose the students to XML, one of the hottest subject in today's information technology. The second project is related to socket programming which is the most important mechanism used in client/server application development. The last project is for the students to build web-database applications. In this last project, the students have to design a database to support a conference site. The front-end to this database is web based where PHP is used to connect to, issue queries to, and process result from the database. Most of the students find this project to be valuable especially from the job placement standpoint. They believe that this project represents a real world project that they expect to find in the industry.

One additional benefit is that the instructor has a complete control of the working environment. This includes the ability to monitor activity in the server, control the assignment submission processes, and monitor for academic dishonesty. By having a dedicated server, the instructor can closely monitor the progress of every student. At the same time, the instructor can easily evaluate student participation and the amount of effort each student put into his/her project. Additionally, the instructor also has a direct access to the student's accounts if students should have questions about their assignments. On several occasions, we can assist students on-line through UNIX talk command.

With a dedicated server, the instructor can easily monitor for academic dishonesty. Students are likely to log on to the class server to work on their assignment and nothing else. The instructor or the T.A. can keep an activity log for all students and pay extra attention to students who rarely log on to the system. This would provide another way to monitor against plagiarism.

The assignment submission process can be easily controlled by the instructor. On each due date, the system are set to shut off at 11:59 pm. and it remains inaccessible to the students for four days. During this time, students are not able to log on to the system. The instructor and the T.A. would grade student's assignment during these four days. Each student is instructed to leave the assignment in a designated folder. This eliminates late submission, file corruption, and other assorted tactic from students to delay submission. If a student assignment is not in the designated folder on the due date, then that student would receive a no submission.

We also provide an on-line discussion forum for our students to exchange information and ask questions. The discussion forum is one of the most valuable learning tool in this course. Large number of redundant e-mails are eliminated and many of the questions are answered by the students themselves. Moreover, students can also exchange relevant information that they find related to this course. Throughout the semester, there are over one hundred and fifty postings on the forum.

4. Results

The server was available for the entire semester without any major problems. One minor problem was encountered during the last few days before the due date of project three. The problem occurred with MySQL when large amount of students try to connect to their database through the web front-end. Majority of students used persistent connection which does not free itself after the application cease to use the connection. This causes "too many connection error" which can easily be solved by asking student to switch from persistent connection to non-persistent connection.

At the end of the semester, three students were employed as web-developers. Several projects are designed and completed at professional standard. We also find a few students who commit academic dishonesty. By and large, majority of the students are satisfied with the level of performance that the server provided and the knowledge gained from this class.

5. Future updates

In the fall 2000, we plan to include a project based Open-Software Foundation's Distributed Computing Environment. Additionally, we may also incorporate CORBA and JINI into the server.

6. Conclusions

Open-source software provides instructors with more freedom to choose teaching environments according to their needs. After experimenting for one semester, we find that it completely fulfills the objectives which are, to provide students with state-of-the-practice environment and to allow the instructor to have more control of the teaching environment. For the entire semester, the server operates without any major problem. At the end, most of our students satisfy with the working environment.

7. References

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