A Virtual Laboratory for an Online Web-Based Course – 'Rapid e-Business Systems Development'

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Abstract. This paper is to report a previous project on showing how physically classroom training, web-based course materials and web-based communication can help in teaching an e-business development course. The various planning and implementation issues in this project will also be discussed.

The case addressed in this paper was about a virtual laboratory for an undergraduate course in City University of Hong Kong (CityU). One of the major objectives in this course is to design and develop an e-business application using existing programming tools and software packages. Students can learn the concepts of an Electronic Commerce (EC) website and follow the steps to build up a complete EC website. With the support of this virtual laboratory, the development and learning process can be carried out at any place of the world where Internet access is available.

1 Introduction

Hong Kong has an excellent telecommunications infrastructure boasting full broadband network coverage. By February 2002, broadband network covering 98% of households and all major commercial buildings through fiber-to-the-building and Digital Subscriber Loop (DSL) technologies. Broadband users in household totaled 624 thousands in February 2002 and reached 916 thousands in December 2002. Besides, the Internet traffic through broadband networks totaled 27 terabits in December 2002 [1]. The tremendous growth of Internet broadband network coverage, broadband penetration rate and broadband usage produces a new form of electronic community daily. For example, teaching and learning are no longer to be confirmed within the four walls of a classroom but can be on the Internet.

Due to the breakthrough of Internet bandwidth restriction, the materials transferred on the network are not limited to static texts or some graphical images but can also be audio and video. As the most important benefits of web-based learning are the use of hypertext and hypermedia to link plain documents or multimedia information [2, 3], it is why a fastest-moving change occurs is in the education sector. Also, a sufficient network bandwidth makes possible to implement a 'virtual classroom', which has many of the same features of a physical classroom such as access to lecture materials, to ask and answer questions, to turn-in homework, etc. As a result, web-based teaching and learning have been attracting more and more attention in Hong Kong.

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The subsequent sections of this paper are organized as follows: Section 2 describes the background of our work and the reason why to build up a web-based virtual laboratory. The discussion about the design and implementation is given in section 3. In section 4, the selection and the use of EC package will be discussed. Section 5 describes the security issue in our virtual laboratory. Section 6 concludes the paper.

2 Background

The case addressed in this paper was about a virtual laboratory for an undergraduate course. The course was developed by Department of Information Systems, which is a department in the faculty of business from CityU, in 2001 autumn. We have used 4 months to design, implement and test our virtual laboratory. Meanwhile, we also have designed a 13-week courseware material. The first student intake started in January 2002 and there were 48 students who have registered this course in that semester.

2.1 About the Course

The course, was known as IS4338 Rapid e-business Application Development, was offered to third year students using a combination of physical classroom teaching and web-based training. These students have taken a year or more of high-level programming language (eg. Visual Basic) courses during their undergraduate education. The teaching pattern of this course was a mixture of on-campus lectures and off-campus virtual laboratory sessions. They were distributed alternately along a semester with 13 weeks. We considered our virtual laboratory was a part of web-based training in this course.

This course lasted for one semester and it covered the fundamentals of EC website with emphasis on developing and programming. One of the major objectives in this course was to design and develop an e-business application using existing programming tools and software packages. Upon successful completion of the course, students were expected to comprehend the concepts of an EC website. With the support of our virtual laboratory, students could follow the steps to build up a complete EC website.

2.2 Reason to Develop a Virtual Laboratory in Our Course

There are four major reasons to propose this project. Firstly, Electronic Commerce has already become the major focus of teaching and research in our faculty of business. EC related teaching is really in demand at the levels of both undergraduate and graduate and practice of implementing an EC website is a very useful way to enhance students' knowledge and skills which are a must for their careers in the field. This remote laboratory can provide an excellent means for our students to actually implement the EC concepts learnt from their classrooms.

Secondly, although virtual teaching is not a new concept, bringing an EC building laboratory to students' homes is a new practice, at least in the faculty of business. The

price of an EC solution package, such as Microsoft® Commerce server from Microsoft Corporation [4] and INTERSHOP® from Intershop Communications [5], is far from being affordable for our students. Moreover, the installation of such a package involves a number of associated software packages and therefore is a complex task. For example, Microsoft® Commerce server requires Microsoft® SQL Server™ 2000 to host the database. Without a remote EC lab, our students have to physically come to a specific computing laboratory in order to learn the practical issues of EC systems development. Each workstation in this lab should have expensive software packages installed. Also, both hardware and software must be maintained by computing experts. The number of students who can benefit is then very small and the allocated time for an individual is limited. A remote EC lab can enable our students to implement EC applications by themselves, i.e., without any help from computing experts is required, without the constraints of time and location.

Thirdly, due to well-provided coverage of broadband network in Hong Kong, it has made possible greatly increased access to networked multimedia information. It is easier for us to distribute high quality audio and video materials on the Internet. Students can better make use of these multimedia materials to review the lecture or to look at our demo video clips.

Lastly, although several web-based course management system such as WebCT and Blackboard [6, 7] supporting on-line lecturing and tutoring have been adopted in CityU, these tools are not able to provide students convenient online access to programming facilities available in computer labs. One of the powerful features of our virtual laboratory is the integration of the existing EC software packages together with a remote development environment.

2.3 Courseware Development

We have developed 13 lectures and 12 tutorial training exercises. All these learning materials were available on the web, including lecturing PowerPoint slides, reference documents and demonstration video clips, etc. These materials were available 'on-demand', at times and locations that most convenient to students. For each week during the semester, the students were required to come to the campus to have the lecture. Each web-based training exercise on a specific topic was followed by a lecture accordingly. The topics, which were covered in this course, were followed in this order: DHTML, JavaScript, Active Server Pages (ASP), Active Data Objects (ADO), Component Object Model (COM) technologies in Microsoft® Commerce Server and XML.

One of the optimal modes for a web-based distance lecture is to use streaming video clips for the audio/video lecturing, and dynamically loaded HTML pages to present the lecture notes [8]. We have adopted Microsoft® Windows Media™ Technologies [9, 10] to help us to develop and deploy streaming multimedia content across the Internet. The ability of this Windows Media™ platform could stream our multimedia courseware. Students could render content while that content is being received over the Internet without downloading it first. Streaming was selected instead of

downloading multimedia files because it could greatly reduce the waiting time and storage requirements of the students' computers. Otherwise, our students had to wait for the video files to fully download before they could start to view them. This was extremely helpful for those students did not have fast enough access to download large multimedia files quickly such as using 56K dial-up connection. Also, for our student there was no charge for any videotape.

The instructor recorded 13 one hour of lectures of IS4338 while having the physical classroom training. We have encoded the digital media content into Windows Media-based content by using the Microsoft® Media™ Encoder. The Advanced Streaming Format (ASF) codec was our selected file format, which is a highly flexible and compressed format, could contain streaming audio, video, slide shows, and synchronized events. With the help from Windows® Media™ ASF Indexer, we have integrated and synchronized the instructor's PowerPoint slides with the corresponding video clip. The finalized streaming materials were act like video-based presentations on the Internet. Students have taken advantages of the recorded lecture and were using them at home or elsewhere for review after lectures.

Those ASF media files and published PowerPoint slides were put on our Microsoft® Windows Media™ Service Server as on-demand contents. The streaming delivery technique was multicast that can preserve our network bandwidth. When we were going to provide streaming media, we have considered the line capacity that our student might have. As streaming video is quite sensitive to users' Internet-connection speeds, thus we have encoded the digital content at different data-delivery rates. We did not only just produce the high-bandwidth video clips but also the low-bandwidth one. We have both 100kbps (kilobit per second) and 300kbps encoding rate for streaming video. The faster the speed, the better the clip will look and sound. As we do not have to maintain a clear focus and smoothness of the lecture's movement, we use a frame rate of 12fps (frames per second) to produce the streaming video. Besides the multimedia courseware, other text-based materials will be saved in 'portable document format' (PDF) using Acrobat software and can be viewed directly on the web.

3 Design and Implementation of the Virtual Laboratory

The server operation system used in our virtual laboratory was Microsoft® Windows® 2000 Server edition. The software used to provide web services was Microsoft® Internet Information Server. The software adopted to be an EC application was Microsoft® Commerce Server 2000 and the software used to provide relational database management services was Microsoft® SQL Server™ 2000. The software used to provide streaming audio and video over the Internet was Microsoft® Windows Media™ Service Server. Besides the phpBB discussion board, most of the components of this web-based classroom environment were built in Active Server Pages (ASP). The system architecture of the remote lab is shown in the Figure 1.

3.1 Web-Based Environment

In order to provide a fast, reliable and high available server system to accommodate numerous simultaneous accesses, a 3-tier web-enabled architecture will be adopted in our EC virtual laboratory. Our platform has two servers and each was equipped with one Pentium III Xeon 1GHz CPU, 1 GB of SDRAM and a three-disk 18 GB RAID5 (Random Array of Inexpensive Disks) storage. With RAID support, our systems could tolerate the loss or failure on any one hard disk. The primary purpose of these two servers was to provide web, application and database services.

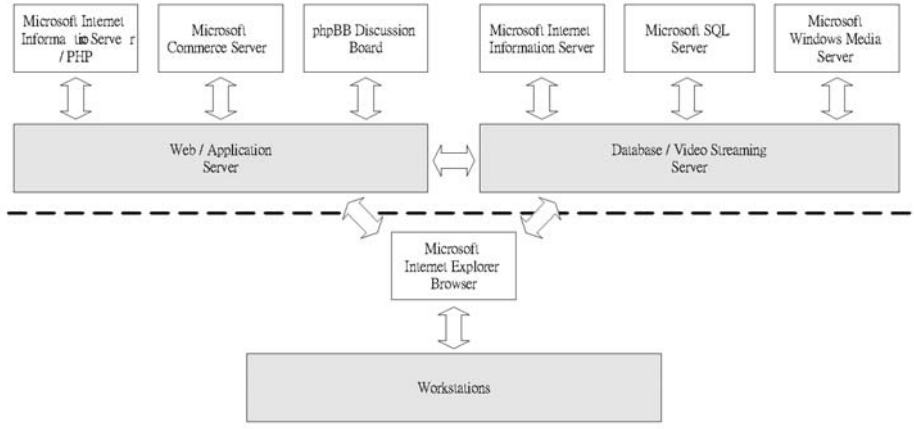

Fig. 1. System Architecture of the Virtual Laboratory

3.1.1 Web/Application Server

The Web/Application Server was the front gate of the whole system. We will not discuss the firewall and other Internet networking devices in our paper. The Web Server accepted requests from the users and sent the results back to the users. The Application Server provided all necessary facilities for the users to build an EC Web site. The users could use their own browsers to access the Web/Application Server building an EC website together with a SQL database located within our campus. Since only a browser was needed for the client side, all clients of our system were very "thin" and the users did not need to install or configure any thing before allowed to use the remote EC lab to build an EC website. The basic architecture of the remote lab is shown in Figure 2.

3.1.2 Database/Video Streaming Server

The Video Streaming Server was responsible for delivering compressed video to our students' request for a particular video stream. This was handled by Microsoft® Windows Media™ Technologies which were a commercial streaming media software packages. The Database Sever enabled the connections between the Application

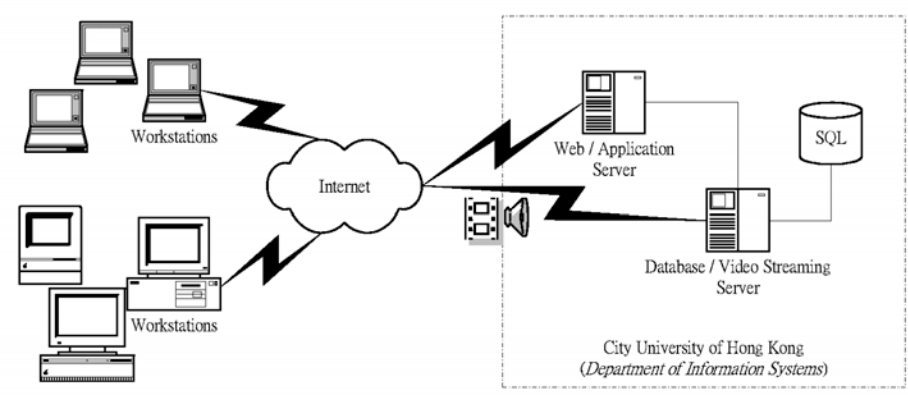

Fig. 2. Basic Architecture of the System Environment

Server and the SQL database. Data in Microsoft® Commerce Server and phpBB discussion board would be hosted in the Database Sever. As video streaming required a fairly high-performance system, that was why we separated the Application and the Video Streaming into two separate systems.

3.1.3 Workstation

In order to access our virtual laboratory, a Microsoft® Internet Explorer 5.5 web browser was a basic requirement which acted as an ActiveX container. We adopted ActiveX technology in our environment. For Internet Explorer, Windows Media™ Player was embedded as an ActiveX Control object in the web page. Windows Media™ Player needed a proprietary codec, which was called TechSmith Screen Capture Codec (TSCC), to play our streaming video.

3.2 Features and Functions

Our virtual laboratory was implemented in Windows 2000 environment. There were totally 10 functions in our virtual laboratory platform and they were done mainly in ASP. All students connected to our system through a graphic user interface as shown in Figure 3. Students needed to login to our system before they could get full access rights browsing through our website. The following features and functions were included in our EC virtual laboratory.

3.2.1 Course Materials

All the archived teaching materials were located in this section. Students could download the PowerPoint slides and exercises by simply logon to our web server. If students wanted to review the previous lectures, they could simply choose the encoding rate and click on the URL. Both the video and the presentation PowerPoint slides were played within the pop-up window with 780×550 pixels. This dimension

Fig. 3. Screen Layout for the Main Page

could suitable for those users who were still using 800×600 screen resolution. It was not recommended for our student to use 640×480 screen resolution because it was too small to display both.

A Windows Media™ Player was embedded in the top of the left frame while presentation slides were displayed on the right one. As the lecture proceeded, the slide refreshed automatically, synchronized with lecture audio. During streaming the video, student could pause the lecture at any point to take notes, or to repeat a section.

3.2.2 Design Tools

Since the development of an EC website under any EC solution packages was by default working locally, the adopted EC solution package in our virtual laboratory had to be reconfigured so as to allow remote website constructions over the Internet. A submission and deployment mechanism, which allowed the students to upload their web pages to our server and view their developed websites, were facilitated in this section.

Also, we have integrated a management tool, which was called Business Desk, from the Microsoft® Commerce Server for students remotely to manage their Commerce

Server 2000 websites. For example, students could access those pre-built modules within Business Desk to update pricing information in their product catalog or run reports base on sales transactions. Students can start to learn the components of an EC website by using these modules without doing any programming. As these beneficial features from the software package provided all basic back-end administrated tool, students would only need to focus on the front-end web pages development.

3.2.3 Demo Videos

Besides the video-based presentation, we also provided other video demo clips on our server. These videos were in streamed format showing all the necessary steps to install the commercial software packages such as Microsoft® Commerce Server and Microsoft® SQL Server™. In order to make the user guide in a more effective visual way for our virtual laboratory, we also captured the Windows desktop activities using those facilities provided. Students could simply play these pieces of streaming video from their browsers so as to understand the processes to build up an EC website.

All these multimedia screen capturing were done by Camtasia Studio [11] which was a video screen-recording studio. We have used TechSmith Screen Capture Codec (TSCC) to optimize for recording computer screens and to compress these videos. We first used Camtasia Recorder to record the Windows desktop activities into several AVI files and then used Camtasia Producer to convert them to streaming files in Microsoft Advanced Streaming Format (ASF).

The advantage on using TSCC codec was lossless whenever compressed at reasonable compression rates. We could produce the video exactly like the screen that was recorded. Although the TSCC codec was not part of the standard Microsoft distributed codecs, it was compatible with Windows. Students only needed to download and installed this freely available codec which was used by the Windows Media™ Player to play the video.

3.2.4 Sample Site

We have put together some sample sites that were built by using Microsoft® Commerce Server for our students. Students not only saw just how powerful this software package could be, but they also could get a few ideas that they might not have thought about such as the designs, the interfaces, the functions of different kinds of EC websites.

3.2.5 Discussion Board

Although there were many ways for people to communicate electronically with one another outside of class at their own convenience, our virtual laboratory was heavily relied on electronic discussion board to facilitate a communication channel. It was useful to find that we could now only need to answer a question once following by posting the answer on-line then all students could benefit from the answer. This could help us to increase our efficiency and productivity. At the end of the semester, we found that our students were more readily to interact with each other and thereby the discussion board could provide our student a new opportunity for peer-to-peer learning.

We have not built up our own discussion board. We simply implemented the phpBB [12], which was an open source bulletin board system, on our Windows platform to promote asynchronous interactions between students, lecturer and teaching assistants whenever after class. Students could access the phpBB from anywhere on the Internet. This tool allowed our student to post messages containing text (in various fonts, sizes and colours), graphics, and any type of file attachment.

3.2.6 Frequently Asked Question (FAQs)

Besides our interactive bulletin board system, we have also created a Q&A mechanism which provided effective assistance to help the users to overcome possible difficulties they might encounter in building an EC Web site. Those most commonly asked questions would be posted in this section. The users read some pre-set questions and answers before sending e-mail to ask us.

3.2.7 Related Links

This section contained extensive listings of related information that can be found on the Internet.

3.2.8 Downloads

If students wanted to download the evaluation copy of those commercial software packages and installed in their own machine, they could benefit from these hyperlinks.

3.2.9 Contact Us

The e-mail address and contact number of lecturer and those teaching assistants would be listed in this section.

3.2.10 Site Map

We have added a sit map which acted like a website index for student to access the web pages at their convenience.

4 Software Justification

Microsoft® Commerce Server is the latest EC solution package of Microsoft. It reduces the complexity and the time for building tailored, effective EC solutions. By providing the application framework together with sophisticated feedback mechanisms and analytical capabilities, Commerce Server allows our students to quickly develop an EC website. This software package provides the critical EC infrastructure needed to build an effective online EC business. User profiling and management, product and service management, transaction processing, and targeted marketing and merchandising are all integrated to create a comprehensive system customizable for our students' specific needs.

The Commerce Server Solution Sites provide a significant head start for developing a website based on Commerce Server 2000. They provide a highly structured approach to building a website that will be easy to extend and maintain. Students can use the

Solution Sites to build working websites that they can customize as needed. Most of the basic features needed for creating a commercial website are present in the Solution Sites, such as a shopping basket, a checkout procedure, a product catalog, user profiles, and so on.

5 Security Issue in Our Virtual Laboratory

Besides physical restrictions were in place for the two servers, additional security controls were needed and have been implemented in our virtual laboratory. We have divided these controls into two parts: restricting access to specific files or directories and verifying the identity of users who try to view those files.

5.1 File Security

As most of the files were located in the web server including the teaching materials and students' files, the first place where security was needed was to restrict access to specific files or directories on that server. File security relied on controls built into the operating system. Windows authentication was used to verify the identity of students who tried to write files to the server. "Course Materials", "Design Tools" and "Demo Videos" were restricted categories on which viewers were not allowed to access these facilities through an anonymous account.

5.2 Identity Verification

Each student has had a login user account on the web server and they were granted with write permission on his/her own working directories. Besides the file access level control, we also have implemented application level security. In the database server, each student was separately assigned a username and password for SQL Server authentication which were different from Windows authentication.

5.3 Security Lack

Streaming media servers have relied on the security features of web server to protect their media streams. This was done by only allowing authorized students to view the "Demo Videos" category. However, whenever the users could get access to that web page, they could view the source code and discover the actual "hidden" URL for those media files. If they really did so, we had nothing to prevent them from freely accessing the file and from sharing that address with others.

Streaming video which is unlike a progressive download and suppose to be not allowed to save on the viewer's computer. However, streaming digital media files are no longer necessary to ensure stream without downloading. Several programs are currently available that allow viewers to capture an audio or video stream and save it to a file on the their computer. As those streaming materials are not that confidential, we still convert the media files into streaming media files which already good enough to provides a certain level of security on our media content.

6 Conclusions

In this paper, Microsoft® Commerce Server has been successfully integrated in our virtual laboratory which help students to understand an EC website development. Being a computer-based learning and development platform, our virtual laboratory allowed students to gain access to course materials and to use those facilitates from Microsoft® Commerce Server. According to the usage of our virtual laboratory, it can only be considered as a supplement rather than a replacement of all physically classroom training. Because of the only requirement on the client side is a Microsoft® Internet Explorer 5.5 web browser, a Windows Media™ Player and a TSCC codec plug-in, it is very convenience for students to start developing their own EC websites.

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