The Synchronization and Sharing Mechanisms for a Three-tier Server System Architecture in an E-Learning Platform

Chih-Chun Lai,
Next Generation Technology Development Center Networks and Multimedia Institute, Institute for Information Industry
cclai@iii.org.tw

Chorng-Shiuh Koong,
Department of Arts Education, National Taichung Teachers College
csko@mail.ntctc.edu.tw

Chien-Chi Chen, Deng-Jyi Chen
Department of Computer Science and Information Engineering, National Chiao Tung University
kiki166@sinamail.com
djchen@csie.nctu.edu.tw

Abstract- *A new mode of learning that has got popular with the use of internet enables the learners to share multimedia courseware instantly and to exchange opinions interactively. The process of information sharing is not working automatically. Situations like unsatisfied transmitting speed and even disconnections often occur when the servers are linked with ADSL. This research responds to the call of teachers and the network maintainers in the government and schools for a better platform structure (three-tier Server System Architecture), in which the three servers set up in government network center, schools and teachers' laptops share and exchange resources automatically and immediately. This reinvented system is under the examination of the platforms served for Taipei Education Network Center, four elementary schools in Taipei, and the teachers' laptops. The examination result shows this architecture is available, and can automatically exchanging and backuping the courseware to the network center. Meanwhile, synchronizing courseware to the schools far away from the cities is also workable.*

1. Introduction

1.1. Motivation

With regard to the currently various types of e-learning platforms, there are some features, e.g., automatic exchanging courseware, network congestion problem, the mirror site for the e-learning platforms, automatic backup courseware mechanism, remote maintenance mechanism and courseware quality control, needed to be enhanced.

However, none of the current e-learning platform architectures which will be described in the next section can solve these problems. To work out the above mentioned, we have combined the WAN and LAN architectures into a new architecture. The design is to set a three-tier server system architecture with the synchronizing and sharing mechanisms to support e-learning activity in the elementary schools. To demonstrate this, we have taken some examinations to show that this design is workable.

1.2. Currently related e-learning platforms

In Taiwan, there are two common types of e-learning platforms, the LAN architecture and the WAN architecture, described as below:

1.2.1 WAN architecture of the e-learning platform (Figure 1): The e-learning platform connects directly to the internet and the users can directly access information supported by the server from the internet. For example, the Educanext[1], the Steve's e-learning system[2] and the e-learning station[3] supported by the education department is a WAN Architecture of the e-learning platform.

1.2.2 LAN architecture of the e-learning platform (Figure 2): The e-learning platform is located at school area, and only services the users of that very school. The users can directly access information supported by the server from the local area network. For example, the MML[4], the LIMA[5] and the e-learning site of the HHUPS[6] located at Taipei is a LAN Architecture of the e-learning platform.

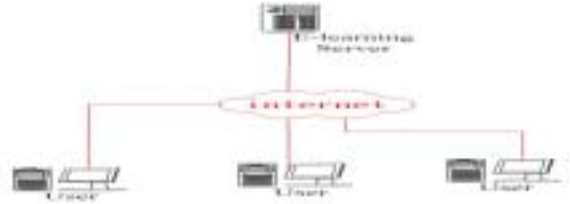

Figure 1 WAN architecture of the e-learning platform

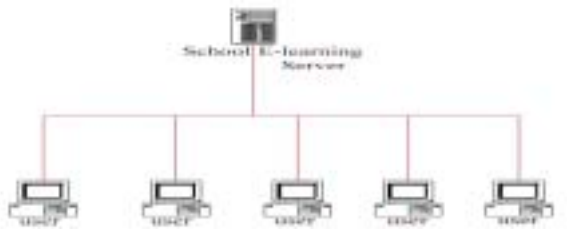

Figure 2 LAN architecture of the e-learning platform

The comparison of the two architectures is described below:

WAN architecture

1. The advantage is that every school can share its courseware. Learners can use the courseware from anywhere while teachers can share the courseware anytime. Since teaching resource is from every place, it can reach the goal of sharing teaching resource.

2. The disadvantage is that the bandwidth is bounded. When teachers want to upload or download multimedia course and item sets, due to the problem of the bandwidth, they need to wait for a long time. Teachers may face problems, and the teaching quality and effect will be influenced when the net is busy or unavailable.

LAN architecture

1. The advantage is that the bandwidth is not bounded. The speed of uploading and downloading multimedia courseware and item sets is faster because servers are located on the campus. The teaching quality and efficacy wouldn't be easily affected by uploading and downloading these data while teaching.

2. The disadvantage is that courseware cannot be backuped to the government network center, nor can it be shared with other schools. Schools can only support teaching resource for themselves. The content of courseware doesn't have good sharing mechanism, nor can it share teaching resource nationally. In addition, the courseware database cannot be increased or improved. Further, every school needs its own experts to maintain the teaching platform once the system goes wrong, otherwise the network teaching cannot proceed smoothly.

1.3. Current problems and Solution

According to the analysis in the previous section, no matter the platform architecture is constructed by LAN or WAN architecture, none of which can perfectly solve these problems, which include the followings:

1. Automatic exchanging courseware: currently, the courseware exchanged between the e-learning platforms is still done manually, not automatically.
2. Network Congestion Problem: the backbone network from elementary school to the government network center is implemented by using the ADSL network. The bandwidth of the ADSL currently is not enough for the multimedia courseware.
3. The alternative e-learning platforms: the teaching activity can not be interrupted when the school e-learning platform problems occur.b
4. Reducing differences of digital learning between the city and country: through the supporting resources exchanged between platforms.
5. Courseware quality control. The low quality courseware may not only deters students from improving but also leads to confusions.
6. Remote maintenance: The lack of human resources to maintain the e-learning servers in the elementary school is a commonly recognized fact. This mechanism can reduce the sweat of the administrator of e-learning server of the elementary school.

To respond to these issues, we have combined the WAN and LAN architectures into a new architecture to solve the problems. We design a three-tier server system architecture with the synchronizing and sharing mechanisms to support the e-learning activity in the elementary schools. The system architecture is illustrated as Figure 3.

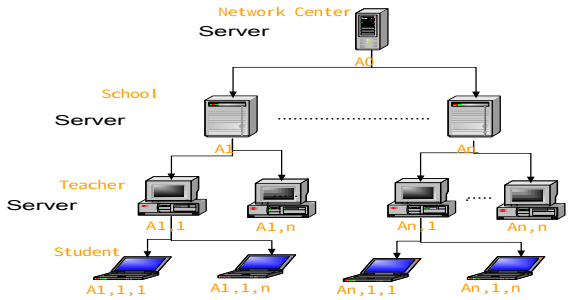

Figure 3 The three-tier server system architecture

2. A Three-tier Server System Architecture

2.1. a Three-tier Server System Architecture

We responds to the call of teachers and the network maintainers in the government and schools for a better platform structure (a three-tier server system architecture), in which the three servers set up in the government network center, schools and teachers' laptops can share and exchange resources automatically and immediately. These three servers are described as below[Figure 3] [Figure 4]:

1. The top-level servers are located at the government network center. They are responsible for the services of automatic backuping, exchanging and sharing multimedia courseware. They are also served as the alternative sites for the e-learning server while the schools' e-learning servers are unstable.
2. The middle-level server (school's server) is located on campus. It is responsible for the services of practical adaptive learning and adaptive assessment. It also uploads the new courseware or dirty data to the top-level servers while the network bandwidth is light.
3. The base-level server is the teacher's server. It is a moveable server, which serves for the mobile teaching. The teacher can design some field-trip teaching activities. When engaging field-trip teaching activities, the teacher's server can communicate with students' mobile devices to exchange information. The teacher's server can later uploads these new data to the school's server.

This reinvented system is under the examination of the platforms served for Taipei Education Network Center, four elementary schools

(ESTMTC, KFPS, CTPS, HHUPS) in Taipei, and the teachers' laptops.

- KFPS: Taipei Municipal Guang fu Elementary School.
- CTPS: Taipei Chen De Elementary School.
- HHUPS: Taipei Municipal Hsihu Elementary School
- ESTMTC: Affiliated Experimental Elementary School of Taipei Municipal Teachers College.

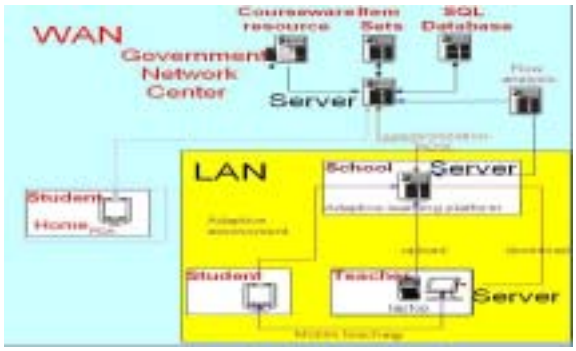

Figure 4 The diagram of the three-tier server system

2.2. The requirements of The Synchronizing and Sharing Mechanisms

According to the discussion, we have concluded some analysis for the synchronizing and sharing mechanisms of the teaching platform, and have planed some functional requirements.

1.Providing adaptive learning, assessment and diagnosis.
2. Synchronizing courseware when the net is not busy.
3. Providing automatic synchronization and sharing of the teaching courseware: the teaching platform should increase the automatic sharing and integrated mechanism for the teaching content, through which everyone can share courseware, reduce the time of producing it, and also avoid producing redundant ones.
4. Providing automatic synchronization and updating for databases: On the platform, not only the content but also the databases and the students' learning data also need to be synchronized with the net center.
5. Solving the problems and collision of the synchronization: Not only databases but also files may have some problems and collisions during synchronization. We need to know how to solve the problems and collisions.
6. Improving the quality and utility of the courseware and items: learners won't be benefited from useless courseware, and some may even be confused by faulty ones. Therefore, courseware needs to be monitored. This is where the platform should support this function, and is also the job for the courseware-measuring experts.
7. Providing the function of remote maintenance for managers:
   (1) Testing the connection between each school
   (2) Net flow analysis chart of each school
   (3) Event records of every server in each school
   (4) Event records of IIS in each school
   (5) Access event records of databases
   (6) Records of synchronization

2.3 E-learning System functional modules

The e-learning system platform is our e-learning project used to provide for adaptive learning, mobile teaching and items evaluation, etc... It originally is a two-tier architecture. In this study, we have enhance to three-tier architecture and support the synchronization and sharing Mechanisms. This platform includes the follow functional modules. [Figure 5]:

1. Bulletin discussion and private message modules will be the executive bulletin (board) or teaching bulletin (board). Here questions can be discussed, and private message can be received and mailed through the modules. The modules can increase interaction between users because by which messages can be exchanged.
2. Mobile teaching and pop quiz modules can be used on the teaching and assessment in practical situations[9].
3. Integrated courseware and composed item-sets modules are used in preparing to integrate new course and compose new item-sets or uploading new ones for teachers.
4. Adaptive learning and adaptive testing modules will provide adaptive courseware and item-sets for learners according to the degrees of difficulty[7].
5. Diagnosing learning and remedy teaching modules will provide the reference for teachers and learners. Teachers and learners can find out reasons for falling behind and do some remedies[8].
6. Homework and communicating note modules allows teachers to assign homework, and learners can upload homework from the functional modules. Through the function of communicating note, parents can communicate with teachers and be posted in learners' latest performance.
7. Basic data management modules can provide different functional management according to different priorities. Details will be discussed in the GUI section.
8. Courseware and items evaluation modules can only be accessed by evaluation expert. The modules are used for evaluating courseware and items, and it can improve the quality of courseware and items.
9. Courseware browsing and items practicing modules can provide unregistered users to practice courseware and items.

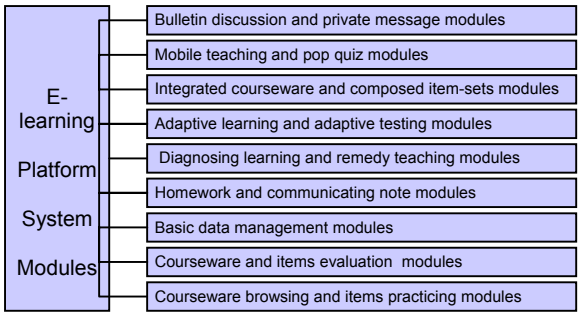

Figure 5 System functional modules

2.4. System implementation

There are some mechanisms adopted to implement the system:

2.4.1 Automatic exchanging courseware: The Wu's mechanism[10] adapts "the first registry and discovery mechanism"; the data is still stored in original location. Our mechanism is implemented by FTP protocol and can automatically exchange data. Before the transmission, it will compare the time-stamp and size of the file, and avoid synchronizing unnecessary files. This mechanism also supports setting the schedule of automatic data exchange. The flow of this operation is depicted in Figure 6. Figure 7 shows the user interface of automatic exchanging courseware.

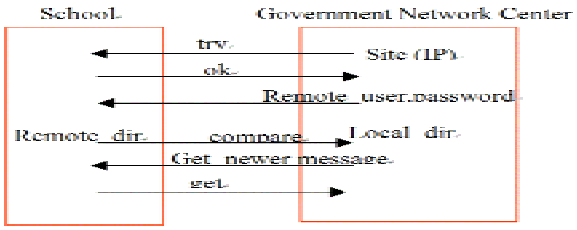

Figure 6 Automatically exchange courseware.

Figure 7 The user interface of automatic exchanging courseware

2.4.2 Design the databases synchronization and update mechanism: This system uses SQL Server 2000, and uses the replication mechanism of the databases. It synchronizes the data automatically, and allows many servers to store the same duplicate data. Users can handle the duplication when servers are off-line, and transmit the alteration of the databases after servers are on-line again. There are three roles of this mechanism [Figure 8]:

1. Publisher: It can copy data to other servers. The publisher can have more than one publishing set, and every publishing set presents a set of logically related data.
2. Distributor: It includes distribution, records or transaction storing and intermediate data servers.
3. Subscriber: It is one sever to receive duplicate data.

The three roles simulate authors, publishers and readers. You can use the SQL server as one part or many parts of them. Two types of replication are used:

(1). Transaction Replication: Because teachers or servers in every school need to synchronize the courseware to the servers or courseware databases, we use transaction replication. We only replicate the altered data to the databases. Due to the fact that subscribers only passively receive the altered data from the publishers, there is no update conflict which happens in combinational replication.

(2). Combinational Replication: Combinational replication supports schools that are far away from cities to update the courseware databases with their sister schools.

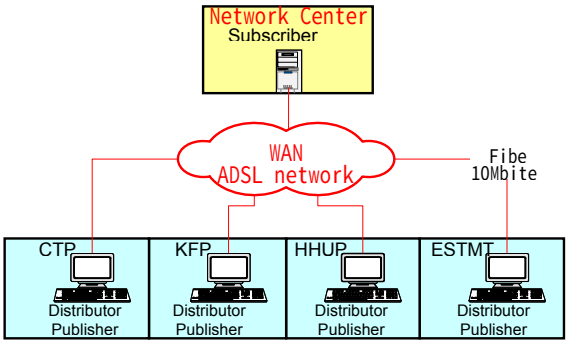

Figure 8 The three roles of the replication mechanism

3. System evaluation and result

3.1. Evaluation item

There are two factors affecting the quality of e-learning, the server respond time and the network throughput per second. They are estimated by using the ACT (Application Center Test 2000). Because the network environment between the government network center and elementary school is ADSL, network traffic jam may happen when the synchronization of the multimedia courseware is executed. Thus, we also measure the synchronization amounts (the amounts of the synchronization of the multimedia courseware per day).

3.2. Test environment

The three levels of the hardware test environment are described as below:

3.2.1. The server of the government network center:
Host1: Pentium 4 CPU 2.66G Hz、RAM 512M、Windows2000 Server、IIS 5.0.
Host2: Pentium 3 CPU 800M Hz、RAM 256M、Windows2000 Server、IIS 5.0.

3.2.2. The server of the school level. Pentium 4 CPU 2.66G Hz、RAM 512M、Windows2000 Server、IIS 5.0.

3.2.3. The Client (student's host). Pentium II 350、RAM 64M、Windows98

3.3. Network environment:

LAN：The network bandwidth of the LAN (the campus local network) is 100MB.
WAN：The WAN bandwidth of KPFS, CTPS and HHUPS is 1.5Mb/384Kb (download/upload, ADSL). The WAN bandwidth of ESTMTC is 10Mb (optical fiber).

3.4. Test case

According to the above factors, we design a number of test cases described as below:
Case1: The platform performance with different hardware level host (Pentium4 and Pentium3).
Case2: The stress test of the server respond time: The server respond time is measured when the numbers of the connected users are 50, 100, 150 and 200.
Case3: The stress test of the synchronization amounts: The times taken to synchronize the 10M, 50M and 100M data are measured during the network traffic is light.

3.3. Test result

Case1: The Figure 9 depicts the measured results of the test case1. The server respond time with simultaneous 150 users is 0.48 sec for Host1 and 0.8 sec for Host2 respectively. These results indicate that the hardware indeed affects the performance of the server.

Case2: The Figure 10, Figure 11, Figure 12, Figure 13 depict the measured results of the test case2. The server respond time with simultaneous 200 users is under 2 second. The network throughput per second is 48 KB with ADSL and 164 KB with optical fiber. These results indicate that the clients directly connect to the server of the education network center is acceptable when the server of the elementary school is unstable. In other words, the server of the government network center can be served as the secondary e-learning server.

Case3: The Figure 14 and Figure 15 depict the measured results of the test case3. The upload synchronization amounts are 1GB with ADSL connection and 24.8G with optical fiber connection during light network traffic. The download synchronization amounts are 3.1GB with ADSL connection and 20.3G with optical fiber connection during light network traffic. These results indicate that the multimedia courseware can be shared and exchanged automatically and the government network center's server can serve as the information exchange center.

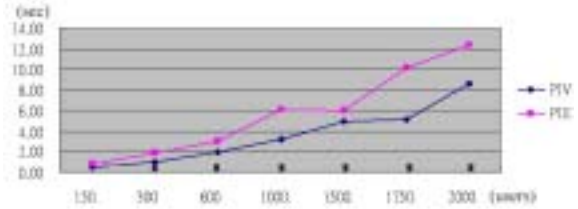

Figure 09 The average time of connections of e-learning server of the government network center

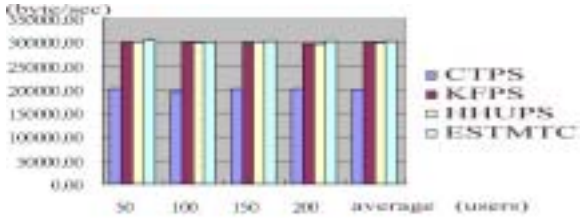

Figure 10 The average bandwidth of schools (275Kbytes)

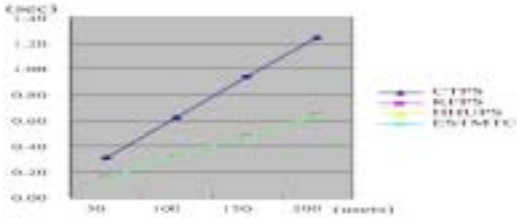

Figure 11 The average time of the connections from schools' users to school's e-learning server

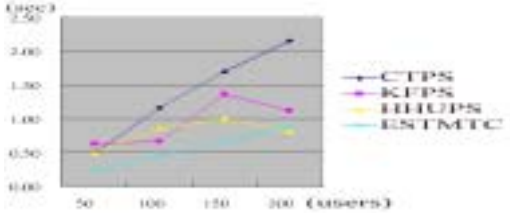

Figure 12 The average time of the connections from schools' users to government network center

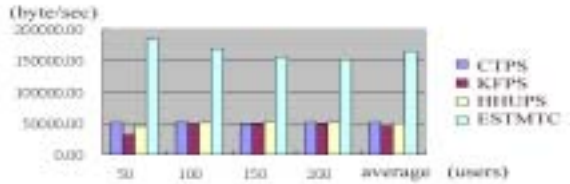

Figure 13 The average bandwidth of the connections from schools' users to government network center

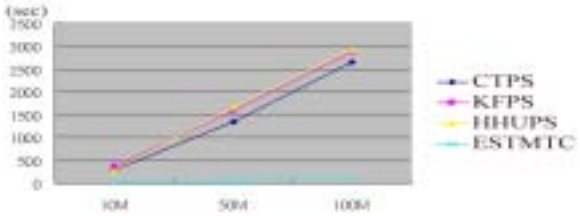

Figure 14 The upload synchronization amounts during light network traffic (ADSL and optical fiber)

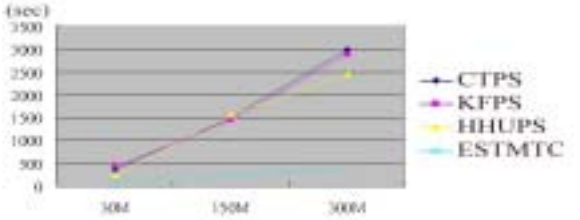

Figure 15 The download synchronization amounts during light network traffic (ADSL and optical fiber)

4. Conclusion and Future Work

4.1. Conclusion

Interactive multimedia courseware needs more bandwidth for learning and teaching. This paper combines the advantages of WAN and LAN to design a Three-tier Server System Architecture. This architecture supports multimedia interactive learning and teaching. After testing, the result shows this architecture is available, and automatic exchanging and backuping the courseware to the network center and synchronizing courseware to the schools far way from cities are also workable. Under this architecture, the network teaching won't be bounded by the bandwidth of WAN. In addition, through the courseware sharing and synchronizing mechanisms we made, the teaching platforms can exchange courseware. Therefore, the resource of the whole multimedia network teaching platforms will be improved. Through the courseware exchange, teaching resource can be shared, and the difference between the cities and the countries can be decreased.

4.2. Future Work

1. We will develop file synchronization proxy that can automatically detect the time when the net is not busy and then synchronizes the files.
2. Design the automatic compression/decompression mechanism. This will reduce the time of file transmission.
3. Reduce the time of comparing files between servers during the synchronization by using database technique.

5. References

[1] Juan Quemada, Gabriel Huecas, "Sharing educational resources: Educanext: a framework for sharing live educational resources with isabel", *ACM, Alternate track papers & posters of the 13th international conference on World Wide Web*, May 2004

[2] Steve Neely, Helen Lowe, "An architecture for supporting vicarious learning in a distributed environment", *Symposium on Applied Computing archive, Proceedings of the 2004 ACM symposium on Applied computing*, pp. 963 – 970, 2004.

[3] The e-learning station , http://content.edu.tw

[4] W. Nagler, L. Fickert, "E-learning for electrical power sysbtems at the Technical University of Graz Nagler", *EUROCON 2003, Computer as a Tool. The IEEE Region 8*, vol.2 , pp. 351 – 355, Sept, 2003.

[5] T. Ostermann, C. Lackner, "LIMA: The new e-Learning platform in microelectronic applications", *Microelectronic Systems Education, Proceedings. 2003 IEEE International Conference on*, pp.115 – 116, June, 2003.

[6] The e-learning site of the Taipei Municipal Hsihu Elementary School, http://www.hhups.tp.edu.tw.Taipei.

[7] Hsu-Chih Liu, *The Design and Implementation of an Adaptive Learning Website with Competence Indicators -based Unit Courseware*, a Master Thesis, The Department of Computer Science and Information Engineering, National Chiao-Tung University, Taiwan, 2003.

[8] I-Chang Liu, *The Design and Implementation of a Web-based Multimedia Cognitively Diagnostic Test and Learning System*, a Master Thesis, The Department of Computer Science and Information Engineering, National Chiao-Tung University, Taiwan, 2003.

[9] Chen-Zong Yan, *The Design and Implementation of an Interactive Multimedia Teaching and Learning System for Mobile Environment*, a Master Thesis, The Department of Computer Science and Information Engineering, National Chiao-Tung University, Taiwan, 2003.

[10] Wu Di, Yang Zongkai, "Learning resource registry and discovery system", *Advanced Information Networking and Applications, AINA 2004. IEEE 18th International Conference on*, vol.1, pp.433-438, March, 2004.