USAGE OF THIN-CLIENT / SERVER ARCHITECTURE IN COMPUTER AIDED EDUCATION

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ABSTRACT
With the advances of technology, thin-client / server architecture has become popular in multi-user / single-network environments. Thin-client is a user terminal in which the user can login to a domain and run programs by connecting to a remote server. Recent developments in network and hardware technologies (cloud computing, virtualization, etc.) have made the thin-client / server architecture more efficient with respect to total cost of ownership, administration, maintenance, security and power consumption. Therefore, the usage of thin-client / server architecture in computer-aided education has scaled up exponentially since 2010. In this study, we present our architecture in a Public College with 270 user terminals and 9 servers. We describe the planning, design, testing and implementation phases of the new architecture and analyze the outcomes of this implementation in regard to students and staff.
Keywords: Computer Aided Education;Thin-Client / Server Architecture

INTRODUCTION

Thin Client / Server Architecture, which has been one of the hot topics in the information systems literature for the last decade, nowadays, becomes a powerful, secure and cost-efficient solution for Health, Finance, Education and other industrial sectors (Energy Calculator for PC Equipment). For instance, several public/private companies/institutions have tendency for cloud computing, virtualization, etc. to keep up with the speed of hardware/software technology development, and this improves the preference of thin client / server architecture. In addition to this, thin client / server architecture has different characteristics according to classical personal computer usage, which are described below in detail.

Thin clients improve information system efficiency at several institutions. In thin client / server architecture, software and data are stored in the remote servers on the network. However, it is possible to communicate and exchange data with other clients on the network. As there is no local disk or portable media drive on the thin client, user data is stored on the remote file servers on the network. Software upgrade is done remotely on the network. Thin clients have more lifetimes according to personal computers as they have less vulnerable hardware parts. Moreover, it is easier to use thin clients as they have standard software and user interface all over the related institution. In addition to this, ease of thin client installation makes recovery in case of system crash faster and lessens the need for technical assistance.

The information and data security can be improved with the usage of thin clients. As they do not have local disks or portable media drives, they are less vulnerable to anti-viruses and spy wares. Users can only store data on remote file servers and cannot copy or move critical data to a portable media. The usage of thin clients in a domain on the network makes system administration easier and safer with respect to the remote user control and system policy checking in the domain that lessens the system internal threats.

Thin client / server architecture is a cost-efficient information system infrastructure. Thin clients are cheaper, have less hardware parts and more lifetimes. At the same time, system management and maintenance is easier as software upgrade and data storage/backup are done on remote servers. Finally, thin clients have less power consumption than personal computers. According to above-mentioned characteristics, a detailed comparison of thin clients and personal computers with respect to several criteria is summarized in Table 1.

Table 1: Comparison of PC and Thin Client with respect to several criteria.

Criteria	P C	THIN CLIENT
Operating System	Manual installation on local disk	Installed on flash memory (DOM). No need for manual installation.
Anti-Virus Protection	Needs anti-virus protection software	No need for anti-virus protection for portable media
Software Upgrade	Needs for manual software upgrade periodically.	No need for manual software upgrade. Only remote software upgrade.
System	Risk for system crash according to user	Remote system recovery in case of system

Recovery	faults.	crash.
Local Drive Crash	Risk for local drive crash (bad sector, etc.)	No local drive and no data loss.
Hardware Upgrade	Needs for hardware upgrade periodically.	No need for hardware upgrade.
Data Backup / Recovery	Needs for data backup periodically in case of recovery after system crash.	Usage of remote file server. No local backup.
Power Consumption	300 - 350 watt. (avg)	8 - 20 watt. (avg)
Technical Assistance	Needs allocated technical staff for frequent hardware/software problems with respect to more portable hardware parts and software on local drive.	Less hardware/software problems and less allocated technical staff with respect to lower risk for system crash.
Emulation	Needs emulation software for connection to servers such as AS/400.	Pre-installed emulation software for connection to several server types.
Cost of Purchase	600 – 1000 $ (avg)	250 – 400 $ (avg)
Noise and Physical Appearance	Works more noisy according to several hardware parts. Needs more space.	Works quieter and needs less space.

An example total cost of ownership analysis is presented in Table 2 with respect to purchase costs, software license costs, network support costs, desktop support costs, upgrade costs, security costs, power consumption, heat generation and office real estate.

Table 2: Comparison of PC and Thin Client in terms of Total Cost of Ownership.

Criteria	PC	Thin Client	Saving ($)
Purchase Cost	650	350	300
Hardware Upgrade (CPU, Memory, Disk etc.)	320	-	320
Software Upgrade (OS, User Programs, etc.)	250	-	250
Virus Protection	30	-	30
Upgrade Labour Cost	250	-	250
Technical Staff Cost. (Per 100 users)	3 staff = 180.000 (annual) 1800 (per user)	1 staff = 60.000 (annual) 600 (per user)	1200
Data Backup and Storage Maintenance	200	-	200
Power Consumption (watt/h)	350	20	450
Total savings per client after 5 years: 3000 $			

In the light of above analysis, we conclude that:

* Using thin client instead of PC saves 3000$ after 5 years (50$ monthly). In other words, thin client redeems itself after 7 months.

* In a middle-sized unit, using 100 thin client instead of 100 PC saves 300000$ in total. Besides, the fact that hardware is an imported product and has foreign currency, the cost analysis shows the contribution of usage of thin client to country's economy.

Thin client / server architecture has a prominent advantage in terms of power consumption (Energy Calculator for PC Equipment). Forrester Research Inc. in 2008 shows that thin clients reduce power usage by 24% and carbon dioxide emission by 23% and increases the life span by five to ten years. By replacing desktops by thin clients, nearly two-thirds of the power consumption can be reduced (Davis, 2008).

Thin client / server architecture is used by educational institutions as they allow students to analyze real data in their research without modifying or removing data either deliberately or unconsciously (Hatakeyama, Kataoka, Nakajima, Watabe, Okuhara, Sagara, 2011, p.494-497). Also, this architecture disallows unauthorized access to critical data from outside the institution. Moreover, computer-aided education has overlapping characteristics with thin client / server architecture in terms of multiple usage of digital resources and cost-effectiveness (Reynolds, 2006, p.73-78).

There are a lot of benefits of cloud computing in education, (e.g. providing educational resource storage and databases, e-mails, educational applications and tools for students and teachers and clients located all over the world involving in an educational program) and advantages in cost for improving the quality of system in terms of Total Cost of Ownership (Anwar Hossain Masud, Xiaodi Huang, 2012). This encourages the use of thin clients in several implementation areas and has renewed people's interest in the thin client concept (Deboosere, 2012, p.60-67).

IMPLEMENTATION

To make use of thin client / server architecture in our public college having approximately 1000 students and 500 staff, we install 270 thin clients in total (222 for students and 48 for staff) at the moment. We also install 7 terminal servers and 2 file servers. The network diagram of this architecture is represented in Figure 1.

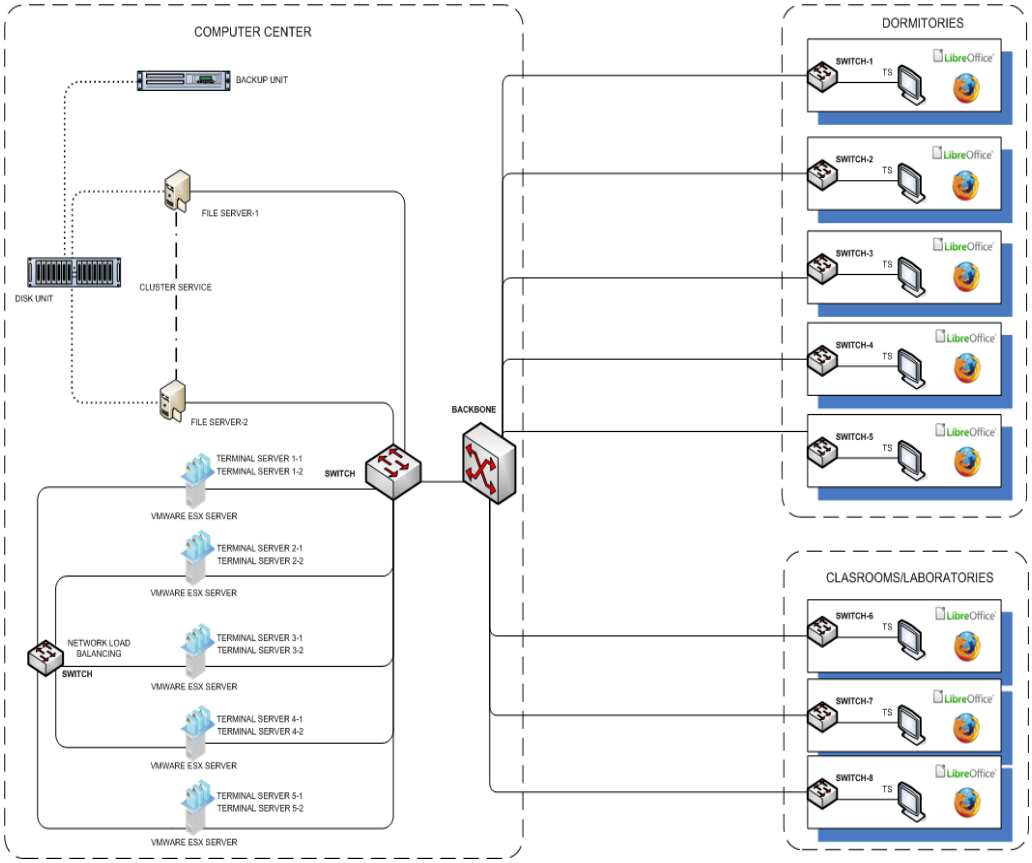

Figure 1: Thin client / server architecture in our college

We use thin clients having model as ASTC TA-1381 and terminal/file servers having model as IBM X3650-M3. We utilize VMware ESXi 4.5 software on terminal servers for the purpose of virtualization. We install Windows 2008 R2 Enterprise operating system on the servers. Also, we install Libre Office, Foxit Reader, 7zip, IrfanView, Mozilla Firefox, Thunderbird, Notepad++, VLC player, Eclipse and Dev C++ software programs on the terminal servers for users through thin clients.

We reserve one-gigabyte data storage on the file server for each student and the owner student can only access his/her corresponding data storage. In addition to this, we define roaming profiles for each student so that each

student can define and use personal settings (shortcuts, program settings, etc.) on different thin clients without any loss of information.

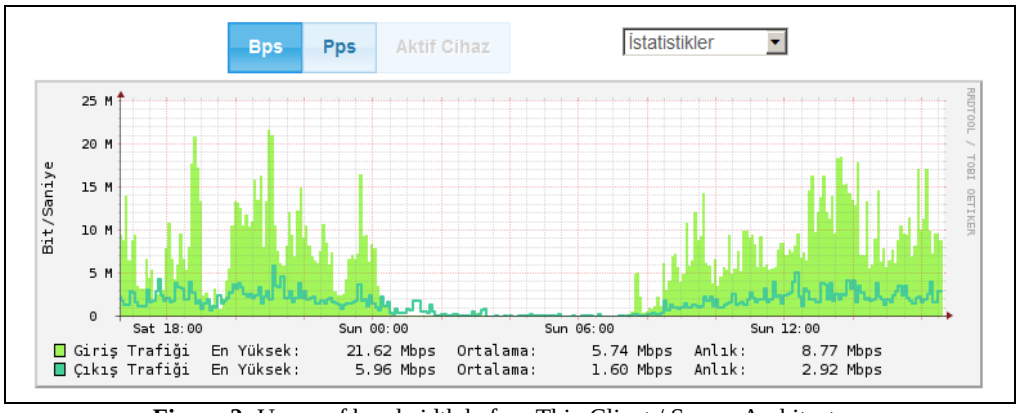

Figure 2: Usage of bandwidth before Thin Client / Server Architecture

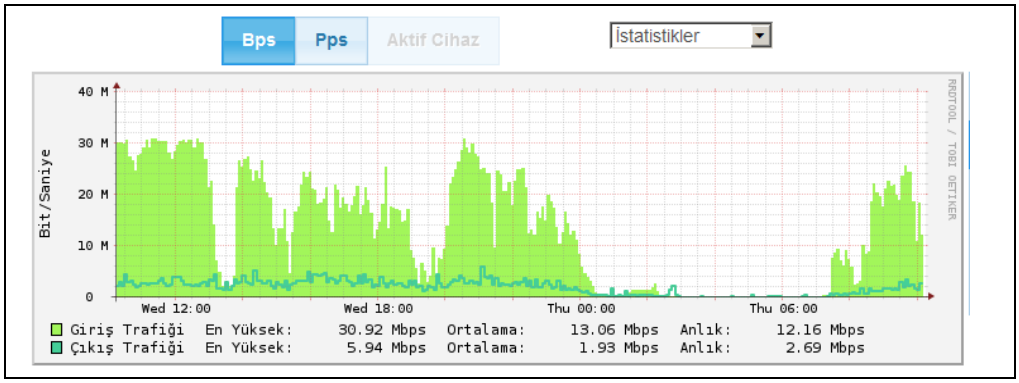

Figure 3: Usage of bandwidth on Thin Client / Server Architecture

We define two different server profiles on each terminal server with the usage of VMvare ESXi virtualization software. The first one is defined for students and the other one is defined for staff use. There are different settings and software programs on two virtual terminal server types. We define different hardware (SPU, RAM, etc.) usage settings on two servers at different times during the day. For instance, we reserve most of the hardware capacity for staff during working hours as the students are taking classes. And, we reserve most of the hardware capacity for students after working hours as students mostly use thin clients on those times.

After the implementation, 10 hours labour force per daily is needed for maintenance problems. A survey about the new architecture is applied on the users and 91% of them express their satisfaction about the usage of thin clients. In addition to this, we analyze that the usage of bandwidth has increased after the implementation of the new architecture. At the moment, we have 30 Mbit/s Internet connection bandwidth in our college. The usage of bandwidth before this implementation is plotted in Figure 2, whereas, Figure 3 represents the usage of bandwidth on the new architecture.

Consequently, we make cost-effectiveness analysis of the new architecture by using several tools implemented in the literature and web. The overall analysis is described in Table 3. Although the results vary because of the different parameters of tools, we conclude that we get a significant amount of saving by using this new architecture in our college.

Table 3: Cost saving analysis of our architecture according to several tools

Tool	Total saving	Period	Parameter
www.xiteb.net	107154 £	Annual	270 PC
www.netvoyager.co.uk	9,614,000 $	Five year period	1000 Users
www.2x.com	312660 $	Annual	270 PC

www.eu-energystar.org	79595 €	For six year	270 Thin Client instead of 270 PC

CONCLUSION

The usage of thin client / server architecture for the purpose of computer-aided education scales up with respect to developments in the information systems technology. In this study, we present our architecture in a public college in which we install 270 thin clients for students and staff. The increase of bandwidth usage represents the effectiveness of this new architecture on the education in our college.

Students and staff can access to their data from several units (dormitory, lab, library, etc.) by using the same settings and interface (which is more user-friendly) as a result of roaming profile definitions. The need for new software in education can be met easily by installing them on a small number of terminal servers. In addition to this, we adjust the usage of resources by students and staff by using virtualization technologies so that, all users can use thin clients more effectively.

We also apply a survey on the users about the performance of new system and most of the users show their satisfaction through the survey. We also need less maintenance labour for hardware/software problems on the client side.

We analyze the cost of new architecture according to several tools exist on the web. One of the important results is the less power consumption of thin clients, which is approximately 10% of personal computers. This has a big contribution not only to the total cost of ownership but also to reduce environmental impact. This can be seen as a social responsibility. After getting a primary saving and social responsibility contributions by implementing new computer architecture in education, we conclude that, the usage of thin client / server architecture will become widespread on educational institutions.

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