Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 3 (2011) 1520–1526

Procedia Computer Science

www.elsevier.com/locate/procedia

WCIT 2010

The problems of public accessed computer laboratories and a suggestion for these problems' solution

Erzurumlu Kerem[a*], Kaya Aydin[a]

[a] *Hacettepe University Computer Engineering Department, 06532 Ankara, Turkey*

Abstract

In this paper, the cronical problems of computer laboratories which are commonly used on educational institutes will be investigated and an alternative solution to this problems will be provided.

In this concept, firstly, PC Based Computer Laboratory's problems will be investigated in details. Subsequently the Thin Client architecture –which claims that it solves all the problems of PC Based Solutions– will be investigated and the problems of this architecture will pointed out. After this point, our suggestion "Thin Client with Embedded Operating System" architecture will be given in detail and it's improvements and their disadvantages will be listed.

In the last section, cost matrix of a sample computer laboratory which is builded with 3 diffirent architecture will be listed in comperation chart.

Selection and/or peer-review under responsibility of the Guest Editor.

Keywords: Embedded Operating System, Thin Client, PC Based Solution, Computer Laboratory

1. Introduction

Republic of Turkey's, European Union entry process is still is an on going process. In this context the required laws are being enacted and improvements on social life are being realized. In this process, educational institutions like universities and high schools, are aligned with mentioned accreditations.

The most important of these conditions of accreditations are, "*Educational Contents*", "*Education Results*" and "*Academic Staff*". The other important issues are those collected under the title "*Social, Cultural and Support Services*".

The title "*IT Infrastructure and Facilities*" on these criterias, measures usage time of the computers by students and ensures the standards of educational institution's computer laboratory which is provided for students. For these days, mentioned standards must be around 20-30 student/computer. Therefore, a four-year faculty that receive 60 new students per year, must have at least one computer laboratory contains 20 to 24 computers [1].

In this paper, in light of the above information, existing laboratory systems will be analyzed and an alternative system will be proposed to form an ideal "*general purpose/education laboratory*".

Generally, educational institutions use Intel based processors, MS Windows family operating systems and MS Office solutions for laboratory implementations. Solutions are created with this method have some chronic

* Corresponding author. Tel.: +90-312-2977500; fax: +90-312-2977502
E-mail address: kerem@linux.org.tr

1877-0509
doi:10.1016/j.procs.2011.01.042

problems. The most common problems are "*crash of the operating system*", "*hard disk failure*", "*virus or malicious software infections*". Also keeping all the computer systems concurent on laboratory also important to protect students from unnecessary details. Using of Windows family operating systems and related necessary software on each computer, sooner or later will lead to the emergence of problems mentioned before.

Another solution offered as alternative is the "*thin client architecture*". This architecture eliminates personal-computer based laboratory solutions but it bring out its own problems. These problems are primarily, "*electricity based problems*", "*hidden server cost*", "*high server hardware requirement*" and "*multimedia disadvantage*".

2. Personal-Computer Based Laboratories General Problems

These laboratories, generally composed with Intel based computers and known with their performance and efficiency. Because of prevalence of use, Microsoft Windows family operating systems and separately sold office solutions are used.

In fact, these systems have some disadvantages. These can be grouped under the following headings.

2.1. Physical Space Constraints

If cost is addressed as a important factor, institutions generally prefer to buy and combine computer components individually (generally called *homemade computer*). With this method, computer components is not tested sufficiently and performance of the computer cannot be guaranteed.

Main boards and cases, used for these computer systems, are general purpose hardware and they have been created for use large amount of PCI cards and hard drives. Consequently they cover more space.

If cost is ignored, institutions are directed to branded computers. Branded computers can be created with SFF (*Small Form Factor*) solutions[2]. But these computers are more expensive than traditional computer cases. So cost and space requirements vary inversely.

Consequently, computer chassis's space is one of the biggest disadvantages of such systems. Placing computer chassis' on floor will make cleaning process of the room difficult. For this reason chassis' are being placed on tables and this solution causes other problems which will be addressed later on this paper.

2.2. Software Maintenance/Operating Problems

Microsoft Windows family operating systems are not designed as self-sufficient systems. Maintenance needed in regular intervals. These maintenance operations are can be listed like, "*cleaning unnecessary user data*", "*elimination of operating failure caused by users*", "*cleaning viruses*" and some cases "*reinstallation of operating system*".

Regarding software operability, institution's educational applications updates (new versions or patches), operating system and anti-virus software updates must be done regularly. Although providers claim that automatically updates done clearly, sometimes these operations fail so software updates must be monitored and the updates which are not completed must be handled by user. During updates/installations/upgrades, if institution uses individual licenses instead of institutional licenses, product key handling becomes a different problem itself.

When a laboratory is created with this method, institution must assign personnel for laboratory responsibility. If institution has problems related to the appointment of staff, "*service quality to student*" becomes a trouble.

2.3. Hardware Maintenance Problems

Personal-computer systems are mostly consist of moving parts (processor fan, chassis fan, hard drive, etc.), as a result, the occur of hardware failures are inevitable in frequently used systems. In computer components, based on MTBF (*Mean time between failure*) value, firstly cooling fans and hard disks are tends to deteriorate.

Systems, also can has user-related breakdown issues because of the computer cases' placement. Among these issues, the most common is, user caused impact/rapture/break problems on the connectors of the computer while their attempt to connect their own hardware (like USB Dongles).

Consequently, personnel mentioned in section 2.2 must follow and handle these errors (communicate with

manufacturer, deliver and receive the component, follow the repair process, etc.). This repair process, that legally has thirty work day limit in Turkey, will cause computer system to be disabled temporarily.

The errors caused by users are not covered under warranty. This error requires replacement or repair of defected component for its cost. During institution's purchasing process (can be continue months according to institution) the computer system will not be available for usage.

Within the frame of the above-mentioned issues, the laboratory personnel must devote his/her full-time to the laboratories operation.

2.4. High Hardware Requirement Problem

Microsoft Corporation had announced that the development and sale of XP operating system has ended. The company recommends the use of Windows Vista or Windows 7 operating system on desktop computers. Equipment manufacturers also now do not develop hardware drivers for XP.

Vista and 7 consumes more system resources than XP operating system. For example, Microsoft XP Professional requires minimum 300 Mhz processor and 128 MB memory. On the other hand Microsoft Windows Vista Premium requires minimum 1Ghz processor and 1024 MB memory[4]. Personal experiences show that dual-core (each one at least 2 Ghz) processor and 4 GB memory are needed for appropriate use [5].

2.5. Conclusion for Personal Computer Based Laboratories

When all the above disadvantages are examined in detail, using the Microsoft Windows based operating system with personal computer solutions are not feasible in practice. Solutions that created with this architecture, becomes growing chain of problems day by day.

3. Thin Client Based Laboratories' General Problems

Personal-computer based laboratories' cronical problems directed the hardware manufacturers and educational institutions to different solutions. When common problems considered, solutions are created with "*thin client architecture*" and applied in many institutions. Though thin client architecture contributes to the solution of many problems of "*Personal Computer Architecture*" it also leads to new challenges and disadvantages.

The biggest disadvantages can be listed as external adapters, server operating system cost, high server hardware requirements and multimedia support.

3.1. External Adapter Problem

Thin clients are much smaller than personal-computers. The physical distress caused by the personal-computers is partially eliminated. Besides, thin clients usually use external power adapters and these adapters causes cable mess on desktops.

Also, external power adapters are overheating, as well as both entry and exit points of the adapter cable are break often according to extreme heat. These problems affect thin client's running process.

3.2. Server Operating System Cost Problem

When a laboratory wants to be established by using thin clients, thin client's server and server operating system costs are usually ignored. But in fact, as many as thin-client number, operating system must has equal number of user licence. This operating system and the user licenses are additional costs for these type of laboratories. In Table 1, Windows 2008 Server Standard, Windows 2008 Server Enterprise and RedHat Enterprise Linux 5 operating system cost comparisons for 25 and 40 clients are shown.

Table 1: Operating system cost table for thin client laboratory. (PP= per processor)

		Cost	
	Operating System	Total	PP*
25 Clients	Windows 2008 Server Standard[6]	1.798 $	72 $
	Windows 2008 Server Enterprise[6]	3.999 $	160 $
	RedHat Enterprise Linux 5[7]	799 $	32 $
40 Clients	Windows 2008 Server Standard[6]	2.395 $	60 $
	Windows 2008 Server Enterprise[6]	4.596 $	115 $
	RedHat Enterprise Linux 5[7]	799 $	20 $

3.3. High Hardware Requirement for Server

As a basic principle, thin client architecture shares the processing power of server' CPU and memory via RDP or other protocols with other clients. In this context, thin clients don't have processor and main memory that operate normally. All the needed processing power and memory are used on master server.

As the number of thin clients increases, the servers' requirements for hardware are also increases linearly. This means increasing the cost of the server needed.

When it comes to Windows 2008 Server family operating systems, the amount of memory can be considered 128 MB for each client and 512 MB for server itself [8]. Approximately, 25 thin clients need 4 GB, 40 thin clients need 6 GB main memory.

Similarly, in normal conditions, there must be one core for each five of RDP clients on server processor. Memory and processor calculations made for works that not force systems too much (e.g. Internet surfing, basic office applications). In addition to these processes, server memory and processor must be upgraded, if thin clients require high memory and processor operations (e.g. playing multimedia files, doing high calculations).

3.4. Multimedia Support Problem

Thin clients do all the necessary multi-media operations (e.g. decoding) on server's main memory and processor; and send decoded audio/visual information on network to show users via output units.

If a student wants to play a audio file on his/her USB disc, first this file is sent to server and it returns to client after analysis/decoding is done. This processes causes network interference and over-tires the server system. Especially, excessive network traffic prevents normal jobs in cases where multiple users use multimedia applications.

3.5. Conclusion for Thin Client Based Laboratories

Considering all the disadvantages mentioned above, the thin client systems cause less trouble than personal-computer systems and they are also less capable on user needs. On the other hand, thin client systems provide a very small advantage on laboratory cost.

4. A laboratory solution: Thin client with embedded operating system

Thin client with embedded operating system is a side product of doctoral studies in Hacettepe University, Computer Engineering Department. The product which is coded as P"Z"İ, brings thin client architecture's and personal-computer system's advantages together to obtain optimal performance.

As is known, in recent years thin clients become popular parallel to developments on three-tier architectures. Operating cost, ease of maintenance, ease of operating, high security are advantages of thin clients. There are also

disadvantages such as network traffic and initial acquisition cost according to client-master server intercourse.

In this context, developed P"Z"İ systems work independently in terms of basic operations. Pardus Linux based operating system embedded to device using special methods without using components like hard disc and system cooling fans. Embedded operating system can be changed according to institution's special needs (Special applications, opening/closing screens, predefined applications etc.).

For embedding the operating system to DOM chips, "Block Based Compression" (*BBC* for short) is applied. As well known, compressed file systems are inferior to normal file systems by performance because of the constantly done compess/uncompress process. With BBC, before creating of operating system, the applications which will be installed, analyzed. According to this analysis' report, the files which will create the operating system are sperated to groups. For an example, if the application "firefox" will be installed, then the firefox binary and all the required shared object files are placed in a "*block*". In creating of compressed file system, these blocks are the milestones. In decompression (using) the block is uncompressed in whole to the RAM. When an application is requested to be runned, the process' block is gathered from DOM, uncompressed, and placed into RAM. So in run time, all the required shared objects are also uncompressed at the first place. This mechanism is faster than all the compressed file systems but slightly slower to uncompressed file systems. The difference between BBC and uncompressed file system which is located in a 7200RPM, 8Mb Cache, 250Gb capacity hard drive is described in table 2.

Table 2: BBC and Uncompressed File System Comparison (Units are in Seconds)

	Time Required	
Architecture	BBC	UFS
Boot Time	43.12	58.57
Firefox First Run	14.09	12.44
Firefox Cache Run	6.53	7.14
OO Writer First Run	25.42	22.34

P"Z"İ devices contains all software that handles the laboratory users needs and OpenOffice, Firefox and Thunderbird applications. If it is requested, this list can be enhanced with applications which work on Linux or Wine Emulator [9].

P"Z"İ devices have natural immune to viruses because of Linux infrastructure. And each boot process is exactly same as the previous one. Changes and damages done by end-users on operating system have no effect. They will be all gone on next reboot.

Since P"Z"İ device does not contains hard disc, if central NFS or CIFS server are not to be used, user can be use the P"Z"İ device as a temporary disc space. But this mechanism doesn't restrain users to use their own USB devices. User may copy files on desktop to USB storages.

If desired, P"Z"İ devices can authenticate from any RADIUS, LDAP, NIS and SAMBA compatible server. Similarly printer configurations can be done by operator for all P"Z"İ devices. This kind of fine adjustment information is secured by system and cannot be changed or deleted.

These systems regularly updates their operating systems on internet and don't need operator intervention. So P"Z"İ based laboratories don't need an operator, except from opening and closing of laboratory's door.

P"Z"İ series devices occupy less than %28 of SFF systems and can be mount under tables with special apparatus. This provides users to easier movement on desktop space[2].

5. Cost Analysis and Comparison Table

In Table 3, previously described issues in detail are summarized. Similarly in Table 4, cost analysis of different systems on laboratories have 25 and 40 clients is shown.

Table 3: Laboratory system alternative comparision table

	Personal Computer	Thin Client	P"Z"İ
Physical Space	- Troublesome because of case size.	- Can't use space effectively on standard tables.	- P"Z"İ's are use less space.
Installation Time	- Averagely two hours.	- Three hours for server. - Ten minutes for each client.	- Ten minutes for each system.
Operating System	- Installed on hard disc. - Licence needed for each system.	- Installed on server. - User licence needed for each client.	- No license needed.
Virus Software	- Must be installed on each system.	- Must be installed on server.	- Operating system is immune to viruses.
Software Updates	- Each system must be controlled regularly.	- Server must be updated regularly.	- Updates are done automatically.
User Damage	- Can be damaged according to user privilages.	- Not possible according to server configuration.	- Not possible.
Mechanical Breakdown	- Hard discs are often breaks.	- Does not fail under right conditions.	- Does not fail.
Hardware Updates	- Hardware updates needed for extending economic life.	-Server hardware updates needed according to usage requirements.	- Hardware updates not needed during economic life.
Backup	- Backup needed before operating system installation.	- Server backup needed regularly.	- Not needed.
Technical Support	- An operator for installations and controls.	- System admin. For server.	- No technical support needed.
Noise	- Includes high-noise sources	- Server noise is more than a normal PC's.	- A fan works according to location temperature.
Multimedia	- Effective and successful.	- Limited.	- Effective and successful.
License	- Requires one licence per PC	- A license for server and a licence for each thin client.	- No licence needed.
Application Software	- Softwares installed on operating system.	- Softwares on server.	- Softwares can be embedded on system.
Network Usage	- Use as needed.	- Intensive use.	- Effective and successful use.
Cost	See cost analysis table.		
Economic Life	2-3 Years	5 Years	At least 5 Years

As can be seen on table, P"Z"İ systems have personal-computers power/performance and are issueless as thin clients. This makes P"Z"İ systems, an ideal solution for general purpose computer laboratories.

Table 4: Laboratory system alternative's cost comparisons table

	Homemade PC		Branded PC		Thin Client		P”Z”İ	
Client Number	25	40	25	40	25	40	25	40
Client Cost	300$	300$	849$	849$	369$	369$	450$	450$
Monitor Cost	133$	133$	199$	199$	133$	133$	149$	149$
Server Cost	0$	0$	0$	0$	8.000$	10.000$	0$	0$
Operating System Cost	140$	140$	0$	0$	1.799$	2.395$	0$	0$
Office Application	193$	193$	193$	193$	193$	193$	0$	0$
Anti-virus Application	20$	20$	20$	20$	20$	20$	0$	0$
Cabling Cost	800$	1050$	800$	1050$	800$	1050$	800$	1050$
Desk Cost	95$	95$	95$	95$	95$	95$	95$	95$
Cabinet Cost	70$	70$	70$	70$	70$	70$	70$	70$
Switch Cost	250$	400$	631$	1152$	631$	1152$	631$	1152$
Total Cost	**23.145$**	**36.760$**	**35.401$**	**56.512$**	**26.438$**	**38.760$**	**18.851$**	**30.032$**

6. Conclusion

When all data analyzed, P”Z”İ based laboratories is superior to other alternatives on both cost and capability, both in terms of operability.

References

1. Capital Aylık İş ve Ekonomi Dergisi, http://www.capital.com.tr/haber.aspx?HBR_KOD=2407

2. Wikipedia, Small form factor - Wikipedia, http://en.wikipedia.org/wiki/Small_form_factor

3. Microsoft Corporation, Windows XP Professional System Requirements, http://www.microsoft.com/windowsxp/sysreqs/pro.mspx

4. Microsoft Corporation, Get Windows Vista: System Requirements, http://www.microsoft.com/windows/windows-vista/get/system-requirements.aspx

5. Wikipedia, WindowsVista - Wikipedia, http://en.wikipedia.org/wiki/Windows_Vista#Hardware_requirements_2

6. Microsoft Corporation, Pricing and Licensing, http://www.microsoft.com/windowsserver2008/en/us/pricing.aspx

7. RedHat, Red Hat Enterprise Linux Server Operating Systems, https://www.redhat.com/apps/store/server/

8. ThinSoft Pte Ltd, Thin Client Software, http://www.thinsoftinc.com/support_winconxp.aspx

9. Wine HQ, Wine Application Database, http://appdb.winehq.org/

10. Sözüer S. and Kutucu H., Bilgisayar Laboratuvarında İnce İstemci Mimarisi ile Paralel Küme Oluşturulması, Akademik Bilişim, 2007

11. Erzurumlu K. and Kaya A., Ortak Kullanım Amacı ile Oluşturulan Bilgisayar Laboratuvarları İçin Alternatif Bir Öneri, BTIE’2009