DESIGNING, IMPLEMENTING AND SUPPORTING A FOSS SOLUTION IN HELLENIC PRIMARY AND SECONDARY EDUCATION SCHOOLS

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Abstract

This paper outlines our experience and current practices in designing, implementing and supporting installation and everyday operation of Hellenic school computer labs using Free/Open Source Software (FOSS). The solution is based on the Linux Terminal Server Project (LTSP) to convert existing legacy PCs to LTSP thin clients and modern PCs to LTSP fat clients. Our application "Sch-scripts" includes automated installation, class management oriented operations and is integrated with two repositories, providing patches and educational software. The advantages of our solution, which are already acknowledged by the schools, include simplicity of installation, minimal cost, reusability of obsolete equipment, ease of administration, centralized management, patches and educational software provisioning and, above all, facilitation of the educational procedure.

Introduction

In the late 1990s the Hellenic Ministry of Education started designing and implementing school computer labs, aiming to introduce Informatics teaching and to infuse computer technology to the traditional lecture based teaching of other subjects. Since 2001 school computer labs in Greece have consisted of PCs running MS-Windows and Linux operating systems to provide pupils the opportunity to familiarize with both environments. Yet this effort did not achieve its objectives as far as Linux is concerned. Due to the technological evolution and the software and hardware prerequisites of educational software, school lab computers had to be replaced. Unfortunately, the goal of procuring and maintaining computer labs to satisfy the requirements was impractical due to limited resources.

All the above resulted in a significant percentage of school computer lab hardware becoming obsolete by 2005, therefore making computer-aided teaching hard to implement. In response to that problem, a pilot project in collaboration with the Hellenic Ministry of Education was introduced in 2006 (Kondilis et al., 2007) aiming to replicate successful references (Becta, 2004; Braaten et al., 2002; Carter

et al., 2004; Reinholdtsen, 2002) and evaluate the benefits of thin client architecture (mainly extending the lifetime of legacy workstations) as well as the acceptance of the Linux user environment by teachers and pupils. Thirteen schools of secondary education were chosen for the pilot project that was based on the Linux Terminal Server Project (LTSP) package (LTSP, 2009) and Ubuntu operating system. Each school received a pre-installed PC as LTSP server and was asked to operate lab's computers as thin clients and evaluate the usefulness of the environment in everyday teaching. The project proved to be a resounding success and some of its key findings were that 70% of the pupils and 80% of the teachers were attracted by the user interface, the application environment and the response of the thin clients (compared to their performance as normal PCs), while 40% of the teachers underlined the necessity for installation, administration and user guides; the lack of technical training in Linux environments; and the lack of certified educational software (which prerequisites MS-Windows technology) in order for the Ubuntu LTSP environment to be more productive (Kondilis et al., 2008).

Description of a Typical Hellenic School Computer Lab

In Greece the term "school computer lab" refers to both active (e.g., computers, peripherals, hubs, switches, routers) and passive (e.g., desks, structure cabling) equipment of a specially formed classroom where computer aided teaching is held. Each lab consists of ten to sixteen workstations and a server connected to a LAN. The computational model followed is that of the client–server architecture, where the server provides Domain Name System (DNS), file, print, authentication, authorization, antivirus, proxy, security, and workstation management services. A router provides automatic addressing to the workstations according to Dynamic Host Configuration Protocol (DHCP) and connects the lab to the internet using Network Address Translation (NAT) while implementing the security policy. Informatics' teachers are accountable for the school labs and perform all administrative tasks.

Description of the Solution

In response to the findings of the pilot project we designed, under the act of the Technical Support of schools' ICT infrastructure[1], the architecture of the solution

[1] The act of Technical Support of schools ICT infrastructure (http://ts.sch.gr) is funded and supervised by Hellenic Ministry of Education and supported by Educational Technology Sector of Research Academic Computer Technology Institute (http://www.cti.gr).

mainly focusing in providing technical support, training the teachers, simplifying installations and maintenance, customizing the environment according to Hellenic school computer lab needs, providing certified educational software and supplying class management features.

The Architecture

The adopted architecture is based on the latest version (5.2) of LTSP in order to convert existing legacy PCs to LTSP thin clients (requiring no additional cost unlike the usual case of an upgrade) and modern PCs to LTSP fat clients (to take advantage of their processing capabilities) (Graber, 2010). The 'heart' of the architecture is the LTSP server which is a PC with a dual core processor and 3Gbytes of RAM. School Labs need to have a switch with at least one gigabit port (where LTSP server connects to the LAN of the Lab). The server runs on Ubuntu 10.04 operating system which provides a modern user working environment with office, multimedia and internet applications.

Modern and legacy PCs boot from network using Preboot Execution Environment (PXE, 2011). Legacy PCs (CPUs older than Pentium 4 with RAM less than 512MB) become *LTSP thin clients* and depend primarily on the server's computing resources and use LAN to convey input and output between the user and the server, where the application is actually being executed. Pupils use thin client just like an ordinary desktop computer. Teachers responsible for lab administration only maintain the server's software. This way legacy lab PCs (practically considered as obsolete equipment that had to be recycled) can be proved useful. Modern PCs, on the other hand, become *LTSP fat clients* but in contrast to the thin clients, fat clients use their own computing resources to execute the applications (Georgopoulos, 2010b). The advantage here is that even though lab's administrators maintain only one virtual disk (operating system and applications) for all fat clients in the lab, performance even in computing intensive applications such as high definition multimedia playback is similar to that of a native installation, because fat clients do not demand computing resources from server. The virtual disk of fat clients is physically stored into server's file system. Students' accounts, user preferences and home directories are the same for thin and fat clients and reside on server. Printer drivers are only installed in the server and can automatically be used by both thin and fat clients. The internal hard drives of thin and fat clients can even be removed to provide a near zero maintenance workstation environment.

Technical Support

To back up the adopters of our solution, teachers could issue tickets to the helpdesk system and request technical support for the Ubuntu LTSP environment. We created a forum related to technical support because we found out that teachers prefer searching and posting in a forum rather than using helpdesk.

Complementary to the forum, we created an IRC channel for teachers who needed real-time support. The IRC channel was also useful in allowing us to acquire data (e.g., IPs, accounts with security permissions) before connecting remotely to school labs. Finally, we began releasing detailed guides regarding the installation and customization of Ubuntu LTSP, as well as user guides (Siahos et al., 2011).

Training Teachers

Informatics' teachers of secondary education were introduced in 2008 and 2009 to the thin client computing model and were trained to install and operate Ubuntu LTSP and convert legacy PCs to thin clients.

The Sch-scripts Application

In order to automate the installation process and the customization of LTSP package for the school's lab environment, we developed from scratch a graphical application under the name of Sch-scripts (maintained using the Launchpad tool and available from https://launchpad.net/sch-scripts). Sch-scripts aim not only to serve as an installation helper but to become a powerful tool for everyday operation and management of the school computer lab as well.

Sch-scripts: The installation and customization process. The Sch-scripts application performs the installation of LTSP package and its customization for school's lab environment in one click without user intervention. Sch-scripts build the necessary environment for LTSP thin or fat clients in one step too. This way the task of installation and customization of the environment could be performed by less experienced users, eliminating the need to open a terminal window and use command line. For example, LTSP package requires the LTSP server to act as DHCP server, a role assigned to the router in our school computer labs. Therefore we examined similar solutions and resulted in Dnsmasq package (Kelly, 2010), because its developer agreed to support Proxy DHCP protocol (Georgopoulos, 2010a). Sch-scripts replace the default DHCP server of LTSP package with Dnsmasq and perform the necessary configuration during the installation, a process completely transparent to the teacher that performs the installation.

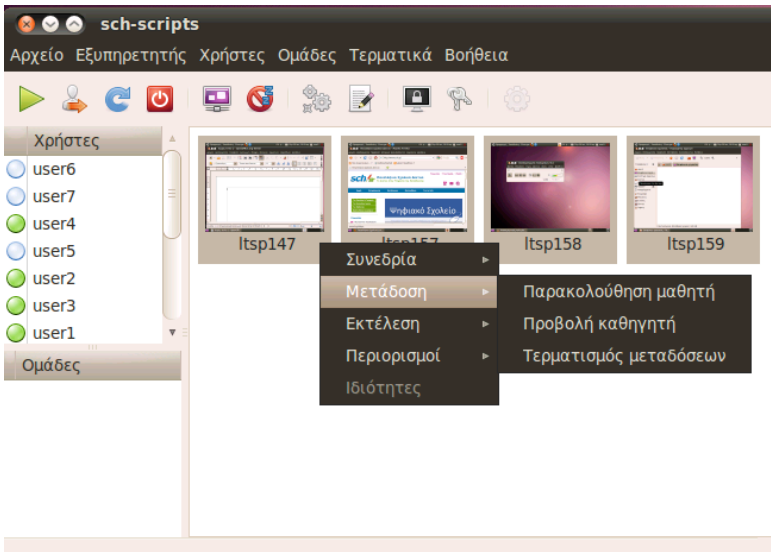
Apart from this, during installation Sch-scripts define several parameters of LTSP environment. The most important setting is that we enable the coexistence of thin and fat clients in a lab. This is critical for Hellenic school labs as they are comprised of PCs aged from one to eight years. Other settings concern faster performance and compatibility issues. For example we export home directories using Network File System (NFS) protocol and we disable the encryption in the communication between the server and the thin / fat clients. We also define time synchronization servers, default resolutions and color depth and we add repositories for the commonly used applications. Many parameters of the Gnome environment have also been defined to support Hellenic language in various applications.

Sch-scripts provide the automated building of thin and fat clients' environment. During this process we have also added support for network and graphics cards that usually exist in Hellenic school computer labs and we blacklisted some packages that we have certified to work improperly with the thin and fat clients. Finally Sch-scripts install the necessary certified educational software for the type of school that the teacher specified.

Sch-scripts: Everyday operation and management. Sch-scripts were developed bearing the context of a typical Hellenic school lab in mind and act as the control panel where all class management oriented operations take place. Teachers can not only take advantage of the automated installation of LTSP and customization process of the school environment, but also have a powerful tool for everyday operation and management. For example, teachers can install new applications or update the virtual hard disk image of fat clients by just selecting the appropriate task in the menu of Sch-scripts. User and group management is also performed using Sch-scripts. Teachers can create accounts automatically, either personal or group accounts, by just providing the number of group accounts and / or number of classrooms or the central authentication system to import accounts from.

Sch-scripts is a powerful didactic tool for teachers. For example, teachers can use Sch-scripts to have a visualization of all computers of the lab (as shown in Figure 1) and even take information about their hardware and their status (thin or fat, powered on or off, logged in or not), to display in real time the full screen of their desktop on all student's computers, to lock and unlock student's computers, to send messages to students, to enable or disable their audio, to remotely execute applications to every computer or to remote control student's computers, to power on and off or to reboot computers and to log off students. All these tasks are performed without the teacher having to leave his desktop.

Figure 1: Sch-scripts and Classroom Management Features



Supporting Repositories

Our solution is based in the application of Sch-scripts but is enhanced by the operation of two supporting repositories. The first one provides patches and fixes and the second provides educational software packages.

Repository for patches and fixes. To overcome the fact that teachers were not familiar with the technical steps required to apply patches and fixes to bugs discovered in the everyday use of the environment, a repository was created (https://launchpad.net/~ts.sch.gr) using Launchpad's components. This repository mainly provides updates and new releases of packages that do not exist in the official repositories (e.g., non-stable releases whose compatibility with the school's lab environment we certify, or releases that are included in the next Ubuntu version). Updates are automatically downloaded and installed simply by adding our repository in the server's trusted list of repositories.

Repository for certified educational software. The certified educational software for Hellenic educational system was only compatible to MS-Windows platform. That's why we decided to convert the existing software, so that it can be installed and run in Ubuntu. Priority was given to flash based educational packages, as it was easier to convert them. We created an installation environment in Debian software package format (.deb) and included all the dependencies (e.g., flash player, prism, wine) of each application. Presently, more than forty packages are available in our second repository (http://ts.sch.gr/repo).

What Schools Gain by Using the Suggested Solution

Our architecture combines the advantages of thin and fat clients, especially the easier administration along with the savings realized by reduction in support and maintenance costs. Only server's operating system and applications for the thin clients and virtual disk for the fat clients have to be maintained in a single point, the server. Administrators do not have to worry about workstations' local hard disk drives, they can even remove them. LTSP fat clients can be managed centrally, but still preserve the benefits of running applications locally, as normal fat clients do.

To better facilitate administration tasks, our repositories support the central distribution of patches, updates and educational software. The application of Sch-scripts hides all the setup's complexity from novice personnel and the whole environment can be installed in only two hours. Teachers only choose whether they will create an installation of thin or fat clients (or even both) and their school's type in order for the environment to be built and educational software to be installed, without them having to know anything about LTSP requirements and customization.

Another important asset of the suggested solution is the exploitation of legacy PCs and the fact that their total cost of ownership diminishes as their life cycle extends. Several schools reported that some of their labs were not used because of obsolete PCs, but now they are at the teachers' disposal with contemporary application environment running fast over old hardware. Today's operating systems do not support local installation in eight years old equipment. Our reports showed that 13 thin clients (Pentium II and III with 64MB RAM), running xvid compressed video of 610x400 with 24fps, can be supported by a server with a Dual Core Processor, 2GBytes of RAM and a Gigabit Ethernet card.

Sch-scripts classroom management features, an essential toolkit for the teacher, is a vital characteristic. Upon installation, teachers have all the options of modern classroom management software customized for the LTSP environment of thin and fat clients.

Another important advantage is the provision of the same application environment, with similar performance in both legacy and new hardware as an equality and uniformity factor, especially in educational environments.

The small cost of converting an existing computer lab to our architecture is one of most significant benefits. Total cost is mainly hardware cost, as all the components of our solution and Sch-scripts are open source software. Buying a PC to act as a server and a Gigabit switch does not cost much, while it provides an upgrade to the whole computer lab. On the other hand, if the upgrade of the lab implied buying new workstations and a server it would cost ten times more.

Last but not least important is the advantage of introducing the culture of FOSS in educational environments, especially in Greece where software piracy is still an issue, not to mention the fact that, due to the recent financial crisis, schools' budget for buying new IT equipment is retrenched.

Are there any Drawbacks?

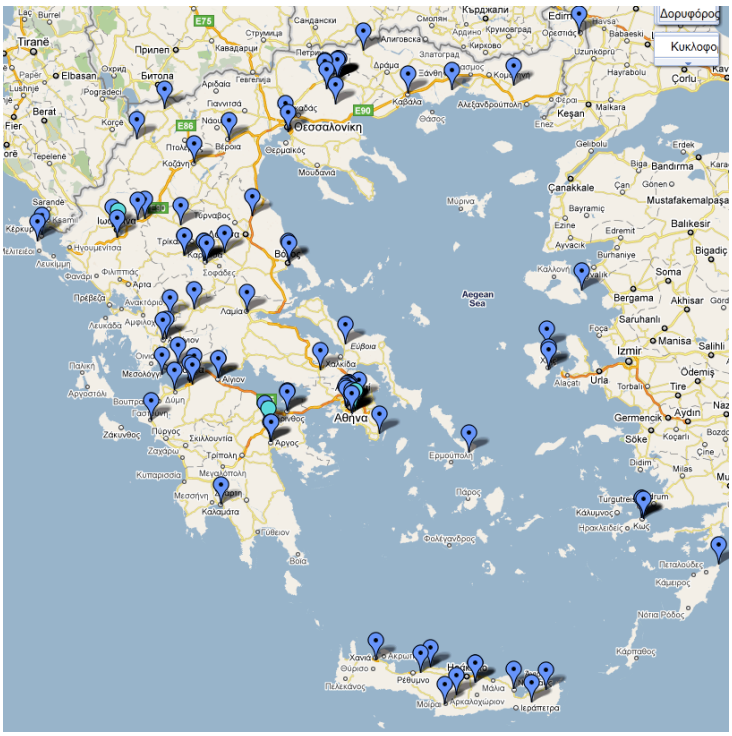
Our solution is only limited by the server's centric mode of operation. The server is the single point of failure and should this happen both LTSP thin and fat clients become useless. Of course we point out that a new server installation using Sch-scripts only takes two hours to complete.

The only components of our solution that may be considered a drawback are the known disadvantages of thin client architecture (Becta, 2004), namely the higher computing and networking requirements, as all processing is carried out on the server and resulting actions need to be transmitted over network. Applications with intensive graphics, such as high definition video playback, require high levels of processing by the server and reaches gigabit's technology limitations. Of course, this is a rather rare case in a Hellenic school environment.

Penetration of the Solution

Judging from the usage statistics of our repositories, our informational nodes, the document libraries, and the tickets issued to our helpdesk system, we can safely conclude that Hellenic educational community is aware of our solution and is trying to implement it during this academic year. We estimate that about two hundred and fifty school labs have already adopted our solution and some of them are satisfied enough to depict their labs in Google maps (as shown in Figure 2) as successful paradigms. Since last November, about one hundred of the above mentioned schools have already signed the map, yet the number is growing every week.

Figure 2: Schools that Adopted our FOSS Solution



(source: http://goo.gl/maps/nOoQ)

What about Teachers' and Students' Perspectives?

In order to explore the pedagogic impact of our solution we conducted a survey among the one hundred schools that have adopted our solution. A total of 58 questionnaires (one from each school) were collected and processed.

High schools represent a large percentage (43%) of our adopters while senior high schools follow with 31% and technical schools with 14% and finally elementary

schools with 12%. The relatively low percentage demonstrated by elementary schools, despite the fact that there is plenty of educational software available, is attributed to the lack of Informatics' teachers for this school level.

The overall opinion is favorable to our solution since most of the answers consider it very good (72%) or good (28%). Considering the time it took them to become familiar with the environment, most of the informants answered that they were not troubled at all (31% very little time and 55% little time) while 10% claimed that they had to spend some time to get accustomed. Only 3% claimed that they needed enough time to get used with the environment. These results are in accordance with those concerning whether the new environment facilitated teaching: 86% considered that our solution facilitates teaching while only 14% claimed that teaching was not affected by the new environment. Respectively, most of the teachers (76%) did not encounter serious technical issues during teaching, while 21% noted that they had minor issues and 3% noticed significant technical issues that emerged during teaching.

Most teachers (86%) believe that using our solution increases the time they dedicate to teaching and observed that their productivity has increased as well, while the rest 14% did not notice a remarkable increase. The classroom management application drastically changed their teaching techniques, according to the 48% of the informants, although 28% claimed that they did not change at all their techniques and 24% declared that they slightly changed their tactics because they were already using a proprietary classroom management application.

The majority of the teachers (90%) did use the available certified educational software during teaching. Teachers not related to informatics (52%) were also interested in teaching in the school lab using our solution.

Teachers responded that their students are intrigued by our solution: 76% of the students believe that the FOSS environment supplied is superior to the proprietary one previously installed while 24% prefer the previous environment. 52% answered satisfied and 34% very satisfied by the user environment provided. There were no negative opinions at all, as 14% declared that they are neither satisfied nor dissatisfied. Teachers also reported that their students also appreciated the response speed of the new environment: 28% are very satisfied, 62% are satisfied and 10% are neutral — as well, 79% of the students appreciate the fact that their teacher can take control of their workstation and help them while 21% are negative to the remote control functionality. A final comment made by most of the teachers is that students are more focused and more efficient during teaching mostly because they have an improved user experience in the new environment.

We also asked teachers to report the three most positive and the three most negative points of our solution. We were very happy to find out that most of the informants found one or two negatives, mostly that they are not very familiar with

the Linux environment and the fact that the server is the single point of failure. Some of them (30%) also reported the lack of MS-Windows environment and its applications which they anticipated by installing a virtual machine in the same hardware of Ubuntu server. The positive points on the other hand (which are already analyzed in the previous section) are related to the performance, less administration, utilization of obsolete equipment, low implementation cost, the culture of FOSS as opposed to piracy, the quick installation and the classroom management application.

Conclusions and Future Plans

The feedback we received from the schools verifies the integrity, liability and effectiveness of our solution. Installation is now a very easy automated process that can be performed even by novice Linux users. The financial cost for upgrading an existent lab to our solution is minimal. Schools can reuse the obsolete equipment that was previously stored or recycled and provide a contemporary application environment to the pupils, increasing the computer to student ratio. Management costs are also minimal, because there is only one point of administration. Relatively new hardware can be used as LTSP fat clients, keeping the advantages of local processing along with those of central administration. Teachers' feedback on the effectiveness of our solution used during teaching is highly positive as actual teaching time is increased and also students focus more on the lesson rather than trying to resolve technical issues. The faculty demonstrates a positive approach to the introduction of FOSS because of its potential to improve the quality of education.

For the above reasons Hellenic Ministry of Education is leaning towards applying the solution to at least one thousand school computer labs in order to obtain a more statistically significant impact.

Our future plans include the extension of Sch-scripts with characteristics such as a tool for the teacher to send and receive assignments and enable video streaming in class management. We are also planning to provide virtual school appliances for any school type with the necessary applications pre-installed. This can be very useful for the schools of primary education where most of the teachers are not familiar with information and communication technologies. Finally, we are planning to design online collaborative learning activities related to the Ubuntu LTSP thin/fat clients operation and administration as a self-training tool for the faculty.

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