IMPLEMENTATION AND MANAGEMENT OF FCSE LABORATORIES ENVIRONMENT

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ABSTRACT

The Computer Center at Faculty of Computer Sciences and Engineering works on continual improving the network environment at the campus, through implementation of modern technologies. These technologies enable better work environment for students as well as faculty staff.
Due to the fact that the faculty has a substantial number of laboratories with workstations and personal computers, improvement of the network security and network performance represents a key factor in the working process. In order to achieve these goals, the FCC team combines software solutions which provide efficient network management, and fast and optimized deployment of software on the computers at campus laboratories.
Due to the past experience, as well as experimentation with current Open-source software solutions, we decided to implement ClearOS as a tool for network management, and we chose FOG as a PXE image solution for the deployment of software. Used software provides scalable and user friendly solutions which enable fast and easy deployment. The initial implementation resulted in increased network manageability as well as rapid deployment of campus computers. As a result, the FCSE Computer Center can promptly respond to the dynamic changes in needed and used software for teaching and learning processes at the faculty.

keywords: faculty campus network, virtualization, network management and security, rapid and agile deployment

I. INTRODUCTION

The FINKI campus represents a “cloud campus” since it is situated in several different locations. This situation by design requires usage of advanced implementation and management technologies in order to efficiently provide a large number of services for the students and lecturers. The key component in providing such service level is the creation of a safe and user friendly network environment which will allow efficient exploitation of the services as well as good working environment for lecturers and students in the daily tasks needed to complete the curriculum. The key role in this development process falls on the FCSE Computer Center (FCC) and it's engineers.
Due to the large number of computer labs, geographically spread in few different locations, the FCC staff came up with a solution which will allow easier management without sacrificing the user experience. Working on this difficult task we decided to merge modern technologies as well as proven software which will allow the network to grow without the risk of creation of any bottlenecks.
While designing our solution, we had to take a number of elements into account. Therefore, a decision was made to base our design on following founding principles:
Using Open-Source software whenever it is applicable,
Separating hosts from different labs, which by definition are homogenous – based on the same set of hardware,
Tendency towards customizable and expandable solution,
Achieving scalability and using virtualization wherever it is possible,
Network manageability is of outmost importance, and
Providing intelligible and extensive documentation.

FCSE represents young and fast growing faculty where curriculum development runs at fast pace. Thus, the need of continually adding and removing software which must be available in the computer labs is ever present. FCSE CC staff recognized that design of an optimal solution is not a trivial task.
In general, when looking for a possible solution for a problem of this kind, there are two feasible options. The first one is the “buying a product which does most of the job done and doing the rest by hand” model, which provides for a faster initial implementation, but on the long run there is a risk of vendor lock-in or scalability problems. The second is “designing a custom solution”, based on stable and proven Open-Source projects, which will enable us to complete do all the required tasks. Also, on a long run, this solution will be more affordable and will allow the FCC team to focus on management and improvement of the FCSE campus environment.
Without any prejudice, the FCC team decided to research all possible options, both commercial and open-source, in order to find the best possible solution.

II. MOTIVATION

The FCC team started the research from simple cloning disk to disk solution like Norton Ghost [4] but since the hardware in the computer labs if different from lab to lab soon is was obvious that we need a more advanced solution. We had some experiments combining Microsoft Sysprep with Norton Ghost but the problem was not resolved. We also looked into Acronis True Image [3], which has some of the features of Windows Sysprep integrated as Acronis Universal restore technology but the result was once more not entirely satisfying. On the other hand, named solutions are more SOHO based since the image had to be placed on a remote server, or even carried on an external disks, and we had to

manually boot each computer from CD or USB in order to start the process. In addition, after the imaging operation was complete staff had to manually change the computer host-name and join the computer to the corresponding domain. The total time required to complete the installation of a whole laboratory with 25 computers was between 6-8 hours and required the FCC staff to be on site for the duration of the process.

Due to the hardware discrepancies across computer laboratories, we tried a different approach involving use of Ubuntu Linux as the base operating system, while the additional software requiring windows environment will be implemented trough a VirtualBox virtual machine. Taking this approach, the existing problem with hardware differences will be overcome, and on the other hand, the usage of Linux will allow for use of scripting for the hostname and computer naming issues. During ths course of action, a new problem have arisen due to the usage of virtualization technology: the responsiveness of the virtualized operation system (in this case Windows XP), was not optimal and students had the problem with virtual machine lag.

Using this solution, the FCC team to some extent resolved their problem with the duration and procedure of computer deployment, but as an side-effect, the students and staff had to manage with a sometimes lagging system. The solution started to have additional problems after another requirement went into the analysis. Some of the courses in the curriculum required the usage of Windows 7, so the already slow virtual machine will have to be accompanied with an even slower Windows 7 virtual machine. Also, the problem that there was no automatic and easy way of managing the whole deployment process was not resolved.

Before the beginning of the new semester it was decided to look into a more suitable solution and since the number of required computer labs continued to grow it was evident that there is a need for a really powerful and scalable solution.

After some initial research we found an open source project called FOG, which by design complied with our requirements and concepts. Since it is an Open-source software solution, there was the additional possibility to extend the system according to our needs. Also the whole solution was based on PXE boot technology, which has the possibility for complete automation. Since the initial research and testing, it became evident that the system will be able fulfill all the needed requirements. Additionally, the FOG software has implemented a Windows client which helps in further automatization of the process of changing the host-name and joining the workstation to a domain. These features are easily managed through a PHP based interface which adds to the value and customizability of the solution. Having these facts in mind , it was almost certain that we found the imaging solution we needed.

Our second point of interest included searching for the compatible network management software, which will provide additional assistance for the purpose of control and management of the network in each laboratory.

Based on our previous experience with Monowall - an open source firewall appliance, previously implemented at Institute of Informatics, we decided to see if we can find a even more user friendly solution, which will also enable fine grained control of the traffic and network services required in each computer lab. The choice came down to the Open-source software ClearOS which was the right alternative since it was well documented and by design implements required features. Following our initial research we decided to implement a test case in order to evaluate the suggested implementation.

III. Test Implementation

Since we already had some network change that where due for implementation the FCC team decided to fast track the test implementation of ClearOS as the router device used for network services in the labs. Since ClearOS has the ability to be virtualized itself we decided to use the already installed VMware infrastructure. We decided to implement one ClearOS instance on every site and also use a dedicated VLAN for every lab. At the end of the process DHCP ip address delegation will be also done by ClearOS as well as all the content and network service filtering. This opened the possibility to also integrate the FOG project since the ClearOS was the central point in every lab network. On the FOG side on the implementation we also choose for a VMware virtualization where a central FOG instance will do all the management while storage nodes on each part of the campus will provide the images.

This way we only had to create on master image per hardware setup and FOG via the easy web interface will do most of the hard configuration part. Also we had to make a inventory of each laboratory in means of positions of the computers, their named as well as their MAC addresses since the main key on which FOG keeps track of the computer is it's MAC address. This way the FCC team created groups for each computer lab which allowed easier management. at the end of the image preparation process the FCC team installed the FOG client which is the key elemnt which connect the FOG system with the tasks required to be done after image deployment.

In the next few sections we will see the features and concept on both software pacjages in detail:

A. CLEAROS

1) ClearOS overview

ClearOS [2] represents a Linux distribution based on the CentOS stack which is mentored by the Clear Foundation with a purpose to create a all-in-one solution for easily netowkr management, All of the ClearOS features are already well good known product which are integrated together and customized with a easily web base management platform. With this concept the ClearOS system replaces a whole set of servers/services with a agile and reliable all-in-on network service solution.

2) ClearOS features

ClearOS was chosen as a network management and security solution, in large due to the fact that it provides following features:

- Open Source Software
- Integrated LDAP for User and Group Management
- User Security Certificate Manager
- Multi-WAN
- VPN - PPTP, IPsec, OpenVPN
- DMZ and 1-to-1 NAT
- Stateful Firewall
- Local DHCP and DNS Servers
- Antimalware - Antivirus, Antiphishing, Antispyware
- Bandwidth Management
- Intrusion Protection, Intrusion Prevention, Intrusion Detection
- Protocol Filtering including Peer-to-Peer Detection
- Content Filter
- Web Proxy
- Access Control
- Virtualization compatible
- Simple web based configuration on the above services shown in *Figure 1* and *Figure 2*.

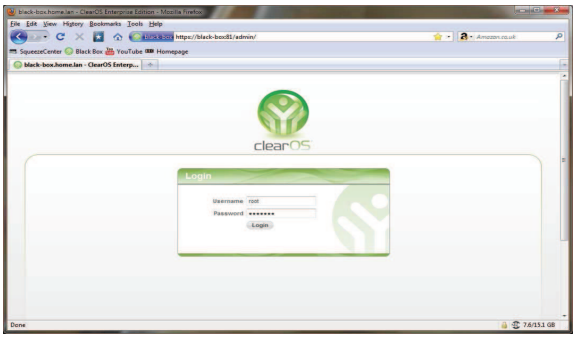

Figure 1: The ClearOS login screen

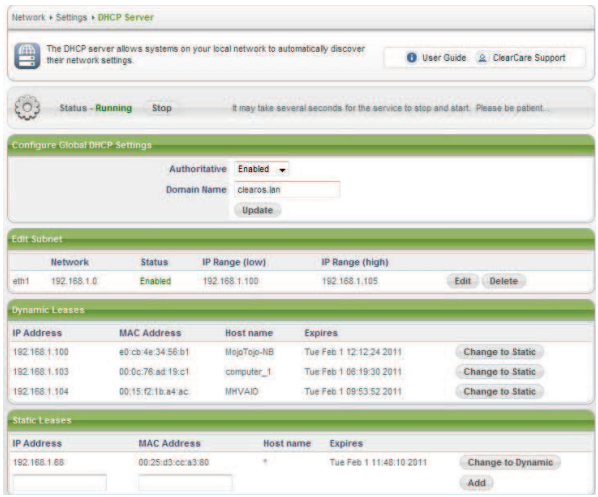

Figure 2: The ClearOS web GUI

From the feature list shown above it was clear that the ClearOS implementation has some very strong points to be chosen for the required tasks. Expecialy since it integrates a lot of services and appliances into one which can be seen on *Figure 3* After further development and configuration it will also be possible to integrate ClearOS DHCP servers to integrate with the FOG software.

Figure 3: The ClearOS integration concept

Also since ClearOS is based on RedHat and Centos it is clear that its development cycle will provide the required stability and support for hardware platforms which graphically is shown on *Figure 4*

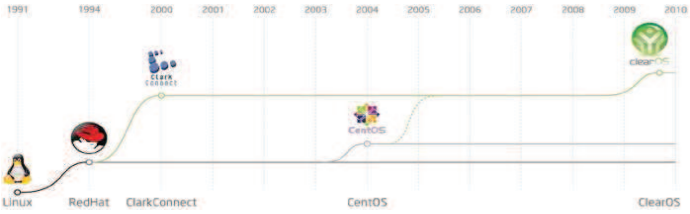

Figure 4: ClearOS development cycle

B. FOG

1) FOG Overview

FOG [1] is a Linux-based, open source computer imaging solution that ties together a few open-source tools with a php-based web interface. FOG doesn't use any boot disks everything is done via TFTP and PXE. The PC boots via PXE and automatically downloads a small Linux client. From there the FCC team can select many activities on the PC, including imaging the hard drive. With FOG many network drivers are built into the Linux client's kernel, so we don't really need to worry about network card drivers (unless there isn't kernel support for it yet). FOG also supports putting an image that came from a computer with 80GB partition onto a machine with a 40GB hard drive as long as the data is less than 40GB. One of the best features of large scale deployment of FOG is its support for multicasting, meaning that we can image many PCs from the same stream. This way the imaging process last the same time, regardless of the number of cloned machines.

2) FOG features

FOG is more than just a simple imaging solution, since it implements both imaging/cloning and network management solution. FOG can perform a number of different tasks, such as installing and managing printers, tracking user access to computers, installing applications remotely via snap-ins, and automatic user log offs. If a computer is badly infected with a virus or malware, we can boot FOG in AV mode and have it remove the viruses. Also we can wipe securely disks, destroying all information present, we can restore deleted files, or scan the disk for bad blocks. All these features extend to the usage of such a system on the campus.

3) Image deployment Concepts

Since FOG uses PXE as the boot method it supports many of the modern network technologies the linux kernel provides. One of those features is the possibility to choose between imaging with Unicast or Multicast technologies. Both options have their strenght and weaknesses and combining them is the ideal application in the average computer environment:
- Unicasting in FOG means sending a single image to a single host. This can mean an upload or deploy, and is independent of the image type.
- Multicasting in FOG uses UDPcast to send a single image to multiple computers using only slightly more bandwidth than sending the image to a single computer or unicast. Multicasting in FOG may require special switch configuration. A multicast will not begin until all members are ready to begin by default. Since there is a risk that some machines will not be available in the given time the whole multicast group waits for a so called multicast timeout in which all members of the group should enter the group and after this timeout period the imaging process is forced although maybe we still wait for some members of the group.

4) Queuing

FOG uses a simple queuing system to prevent its storage servers from being overworked. If you have a single FOG storage node in FOG with a queue size of 10, then this means that if you unicast an image to 30 computers, only the first 10 computers will be imaged. The other 20 computers will be waiting "in queue" for an open slot.

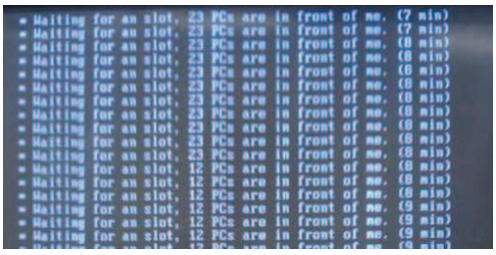

Figure 5: The FOG client queue

This queue system shown on *Figure 5* allows for the IT staff to start tasks for hundreds or thousands of computers and let FOG manage the clients so the servers don't get overwhelmed with client requests.
We can safely assume that it is now clear that we will use the multicast deployment options for initial imaging of whole labs, but in case we need to image a few computers without disturbing the usage of the already functional ones we should use the unicast option.

Figure 6: The FOG login screen

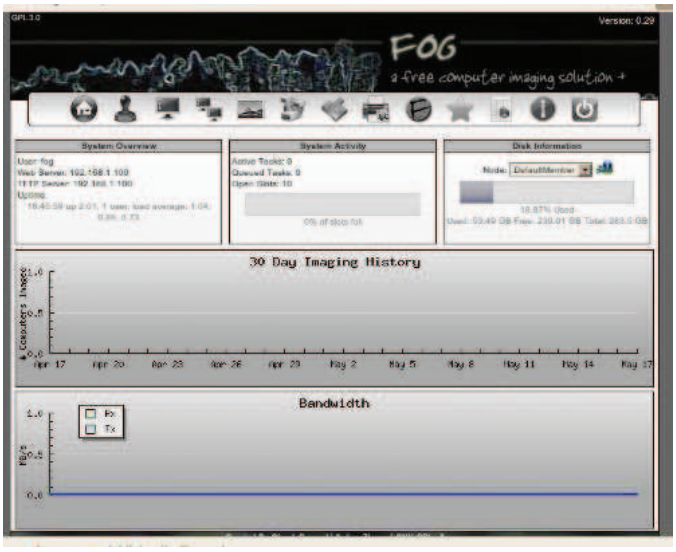

Figure 7: The FOG management panel

After the initial imaging process is complete, the FOG client utility, which is already installed on the image, will take care of all other tasks, such as changing the computer name or joining the computer to an Active Directory domain. Since we saw the true potential of both solutions, the FCC team decided to do a test run combining both ClearOS and FOG in a deployment scenario.

We prepared the master image from a computer that is used in 3 labs at the FCSE campus and did a few unicast test imaging sessions. The results were very promising so we invested into a test run involving multicast imaging session on 45 computers. During the test run we encountered a number of problems, which required additional interventions on our part. Namely, we found out that we should modify the settings on Dlink switches we use in those computer labs, since the default implemented access lists and multicast settings were preventing successful completion of our deployment scenario. Following these modifications, and after a number of test runs, we proceeded with computer cloning process. We can report that during the imaging and cloning processes, the FCC team was impressed with the speed and efficiency of performed operations.

Since the initial deployment scenario was successful, the FCC team decided to follow through the solution for the purposes of deploying operating systems and software for labs, according to curriculum and study programs for summer semester 2012.

Additional work was done in deploying the test virtual images to real hardware. For the FOG system we decided to increase the performance by additionally putting the stored images on the FCC storage system which allows the system to grow and provides redundancy to the data.

IV. CONCLUSION

The FCC team was very satisfied with the benefits both software solutions provide. After the initial analysis it was clear that the right choice was made, and that in the future, administration of the computer labs will become more trivial process, and will allow growing of the number of computers and active labs, without the need to take substantial additional time for management on behalf of the FCC team. One advantage over the other solutions the FCC already used, such as Norton ghost, Acronis True Image, Clonezilla [5], is the fact that the FOG / ClearOS combination represents centrally operated and fully integrated solution. This solution will allow for further future development, while the FCC team will continue to contribute to both projects, with the purpose of further improving both software packages.

This new solution gives the FCC team a clear view on the status of each lab as well as the possibility to promptly deploy new software to all labs, or in case of individual failures, redeploy the software on a number ofs selected computers.

Although the implementation of the new services took a substantial amount of time, the end results were impressive. Prior to described implementation, the time required for deployment of the required software for a computer laboratory with 25 computers took between six and eight hours. Following the implementation, the deployment process takes about two hours. Following the imaging process while using the other solutions, required substantial additional configuration on the engineer's part (join the, PC to the AD, set a hostname etc.), while with the new imaging system, at the end of the automated cloning and setting up process, we have a fully operational computer.

V. FUTURE DEVELOPMENT

The FCC team decided to focus future development and deployment on both systems, in the accordance with the global development plan. The FCC team plans for further increasing of the number of services available in the network, as well as developing the emerging trends based on the following principles:

- We would like to reduce power usage, especially for the periods of time when the computer labs will not be used, through implementation of the so called "Green FOG" concept, which will allow computer to be shut down after a period of inactivity.
- The FCC team will increase cooperation with talented students and teaching staff, for the purpose of development of Snap-ins and tools, for easier software deployment using the FOG system, without the need of full image deployment.
- Special attention will be invested in further development of the ClearOS system, with the possibility to give teaching staff greater control of each separate computer lab via an easy web interface, which will allow fine grained control of network access and services available in given time interval.
- The FCC team will work on further increasing the scalability of the FOG system, through implementation of multiple clustered storage nodes, which will allow even faster deployment of images on every location. This way, all locations will be managed from a single web interface, while image storage and deployment will be organized through local storage nodes, which will be distributed on each location.
- We would work on improving the complete integration of both systems to the level of implementing "Software as a service" scenario, compatible with the development of future cloud technologies.
- Additional analysis will be made for the upcoming new release of ClearOS 6. One of the new features on whichthe FCC team will work on, is the so called ClearOs application market integration which will enable all the customizations to be deployed as applications.

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