Executive summary

Being a large computer science and engineering faculty imposes many problems, both of technical and administrative nature. Insisting on having enough computer working places for every student requires the deployment of as many as 140 desktops grouped in 7 labs, available both for lab exercises and individual work for the students. But the cost of powering all these computers represents a huge item on the expenses side of the balance.
To reduce the power bill for the workstation, many techniques have been implemented, starting from powering off the monitors while not in use, entering idle modes and even automatic powering off the workstations at the end of the day. Still, the required power, both while in full operation and while not in use is high.
To mitigate this problem, we have implemented a hybrid, power efficient solution, using Raspberry PI as dumb clients and Microsoft hyper-V as virtualization platform in the datacenter. Using this solution, we expect that we will drastically lower the power consumption needed to power the required number of individual computer working places for the students.

Introduction

An average work station requires from 150 to 350 W of power to run (from idle to full load). When you multiply this number by the total number of workstation needed to satisfy the needs of the students, this tends to be a quite large number. For a faculty that maintains a total of 140+ workplaces for the students, this amount imposes a significant financial burden. Additionally, it impacts the green footprint in a very negative way.
To work around this problem, we came up with the idea to use small ARM based systems as dummy terminals and access VMs at the data center, to implement the same working environment for the students as with the classical workstations. The new approach has many advantages over the current solution.

Current solution

Currently, FCSE uses 140 desktops grouped in 7 labs.
Most of the computers run windows 7 and a very large set of software needed for the courses in the curriculum. Some of the labs have more powerful machines with powerful graphic cards which are needed for few subjects that actively use them. Still, the majority of the computers have the standard desktop subset of programs so full 3d acceleration is not a needed feature. Major software included on the computers is: Visual Studio, Codeblocks, LibbreOffice, browsers, phpstorm, webstorm, R, R-studio, Cisco packet tracer etc.
The deployment process of all these workstations is done at least twice a year, at the beginning of each new semester due to different requirements of the courses taught at that semester. Although automated, this process requires on average 7 days to be completed and verified. Additionally, due to malfunctions, this process is repeated for individual workstations on average 2-3 times per semester.
Having in mind that the average workstation requires from 150 to 350 W of power and the fact that during the working days in a semester the average usage of these systems is more

than 80% of the time, the power usage sums up to a very high estimate of 42 kW per hour to an estimated 12000 kWh per month.

New solution

Dummy terminals

The terminal are Raspberry PI model B+ which is put in a VESA mountable case and can easily be mounted on the back on the monitors. The case helps in protection of the core components of the running system, especially the SD card.
On the software side we started with a basic Linux Debian distribution image optimized for the Raspberry PI model B+ developed by the Raspberry Pi Thin Client project [http://rpitc.blogspot.mk/] which is a very stable base distribution for similar thin client projects. In order to further facilitate the process, we striped the software platform of all unneeded components and only left the Remote Desktop client. We also adapted the configuration files for the Remote Desktop client to use the required settings for the Active Directory servers we use in the classroom.

Virtualization platform

Since we mainly use Windows 7 for our workstations we decided that using the native Microsoft Hyper-V virtualization platform will ease the whole integration process. The platform itself already supports the basic functionalities like image template, master image software deployment and also has support for Hyper-V clustering which allows us to add additional nodes in the Hyper-V cluster simply by installing the new nodes and just joining them to the cluster. The cluster itself will take care of balancing the nodes with the running VM images so this additionally adds to the scalability of the system.
In order to have an easy login process we also added the Remote Desktop Services Role which has the Remote Desktop Broker service which will be used as a single entry point to which all clients can connect and then be automatically redirected to their active Virtual Machine. The same system also supports an option to have a number of VMs running and ready to accept new clients. When a larger number of new incoming connections are detected, the system will automatically spawn additional new virtual machine in order to have new resources ready for such new clients.

Advantages of the new solution

The new workstation platform, based on virtualization and low power dummy terminal consisting of Raspberry PIs offers significant advantage over the previous solutions. The most important advantage points are:

- Much cheaper solution, having a workstation for only a fraction of the price of a full blown workstation.
- Very power efficient solution, dropping the power requirements from 350W for a regular workstation to a 20W for a dummy terminal (plus the share of the costs per workstation of the datacenter virtualization platform).
- Significantly easier deployment, since there is no need to clone the master workstation image to each end every other workstation, but only to have a template image at the virtualization platform.

- Easier management since every change has to be done at the central location (on the image or the template of the VM at the datacenter)
- Simplified maintenance with higher availability. In the case of hardware malfunction, only the dumb client is replaced, while the image at the datacenter stays intact.

The main downside of this solution is the datacenter virtualization server being a single point of failure. This is usually mitigated by having redundant servers and storage, all of these already available in the datacenters.

The trial

We have conducted a small scale trial of the proposed solution, during the enrollment process for the new students. The implemented solution was based on 6 workstations built using Raspberry PI model B+, along with a monitor and peripherals. The whole process that took 4 days went without any disturbances.

Conclusion

The greening of the academic campuses should be one of the most important development principles toward a sustainable future. Using different power efficient solutions gets us even closer to this goal.

The proposed power efficient workstation solution might reduce the power consumption campus wide, while still providing enough working places and sufficient computing environment to satisfy the daily needs of the increasing number of students. The next step would be to deploy the solution on a wider scale, to tackle the network management problems and the QoS issues that will arise from a larger scale implementation and to consider various virtualization platforms, along with increased reliability and availability.

Also, considering the new development of small computer platforms similar to the Raspberry PI (and also newer versions of the Raspberry PI 2 and 3) additional analysis will be needed if more powerful thin clients, which will be even more power efficient, can use better virtualization technology to further increase the end user experience.