Virtualization for On-line computer labs

Juan J. Ortega, Isaac Agudo

Abstract: *Virtual or On-Line computer labs provide students with the possibility of carrying out most of the usual lab activities, but from almost anywhere, even in their own homes A virtual computer lab is a broad concept, developed to allow students to work with software or complex equipment that cannot be easily distributed. Two of the main advantages of using virtualization are that it allows student access to some complex equipment or piece of software that cannot be easily distributed and its cost saving feature.*

Key words: *On-line computer labs, Blended-learning, Virtual computer labs, and Virtualization.*

INTRODUCTION

Virtual or On-line computer labs are a means of offering a similar experience to that of physical computer labs, but allowing students to perform most of the labs activities from almost everywhere, even at home. A virtual lab is a broad concept, whose main advantage is that it allows student access to complex equipment or software that cannot be easily distributed. On-Lab [6] is a tool which offers a web environment, where interfaces can be quickly and easily developed for physical or virtual lab instruments and on-line exercises can be created based on those instruments.

Virtual computer labs are becoming a vital part of teaching computer science using blended learning [1,3,5]. Blended learning [2,4] is an emerging trend in education and can be considered the first step towards achieving a full e-learning experience. The Andalusian Virtual Campus[2] (AVC) is an example of how Andalusian universities are moving towards e-learning. In this virtual campus, ten universities share a common space where some courses are officially offered by e-learning.

As mentioned before, one of the main difficulties that has to be faced in this kind of experience is the remote use of the required software and hardware resources. Being able to offer virtual labs helps us to:

- Reduce the number of software licenses
- Save installation time and money
- Improve accessibility to the software.
- Increase the availability of the labs to 24/7.

PROPOSAL

We have created an infrastructure of virtual computers based on classic web technologies that allow students to connect to a computer inside the University at any time and from anyplace, without having to install the centralized software in their own computers.

This virtual infrastructure provides the following advantages:

- A central server stores all the virtual computers. This way fewer physical computers are needed and existing ones will be used more efficiently (for management of the global storage capacity, percentage of CPU load, reusing old software licenses, clusters, etc.). This translates into a meaningful reduction of the hardware cost, its maintenance and the space required for storing it.

2 http://www.campusandaluzvirtual.es/

- Any application installed in the virtual computers works in the usual way and devices connected to the host computer like printers, CD-ROMs or DVD-ROMs or any other will be available to the virtual computers.
- The teacher can create a virtual computer template that only includes the software required by their particular students. This avoids having to coordinate all the teachers regarding specific software versions, etc.
- Each student is assigned their own virtual computer in which they can work on their exercises and homework.
- The changes that the students make to their virtual computers will not affect the host computer.
- If a virtual computer crashes this will not have any effect on the rest of the virtual computers or even the host computer.

The other existing resources in the labs must be available to be accessed remotely when the computer labs are closed, at night or at weekends..

There are several different schemes available for virtualization depending on the purpose of the virtual systems. Below, we propose one such scheme that easily allows the implementation of a virtual computer lab.

At least a server is required that stores and runs all the virtual computers, as we can see in Figure 1. Depending on the number of virtual computers necessary, we may require more than one server to run and store them.

Apart from the server that stores and runs the virtual computers, the role of the broker that offers the interconnection of the virtual computers and the physical computers in the classical labs is vitally important.

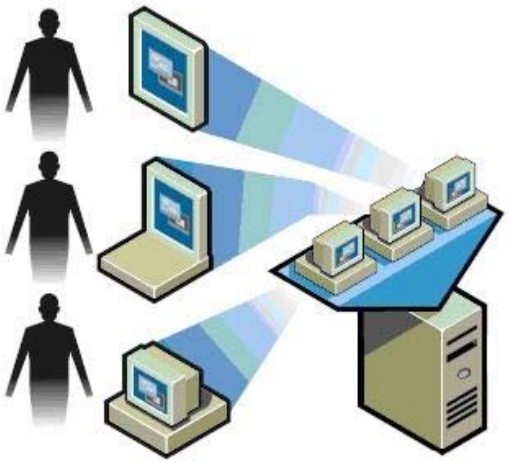

Fig.1. Scheme of VMware ESX Server and Virtual Center

The software that offers the emulation of the virtual computers is VMware ESX and VMware Virtual Center. The first is a Linux operating system adapted to emulate the virtual computers. The second helps to manage in a centralized way the different virtual computers. Both applications can be run in the same or in different servers. In Figure 2 we can see how it works.

We have chosen VMWare because it can virtualize the x86 platform instead of emulating it. This way, most of the code is run directly on the physical hardware, which provides better performance.

Technically speaking, the creation of a virtual computer per student requires a minimum of 1 or 2 GB of storage for the operating system plus additional space for the applications that have to be installed.

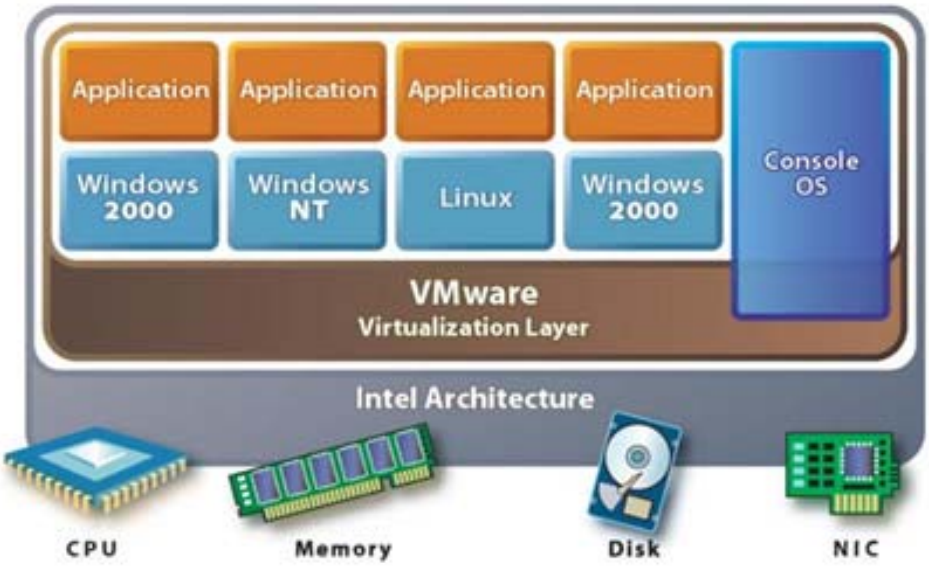

Fig.2 Virtualization in an auxiliary operating system

Students and teachers access the virtual computers using a conventional Web browser via the Internet using an RDP viewer applet. This is essential to provide an operating system independent access to the system.

COST

One the main problems that this kind of initiative has to solve prior to being put into practice is the balance of costs between the previous approach and the new one. Clearly this approach is more appropriate for the university environment where students usually require access to resources after class and where the needs for access vary from one student to another. However, the approach has also to be reasonably inexpensive, to implement, in order to convince the University of its real benefits.

In order to establish the implementation costs, we made a first draft approximation of what the cost would be of the equivalent (physical) computer labs. This is an estimation only, but it gives a rough idea of the cost.

The main parameter influencing the cost of implementation is the number of virtual computers running simultaneously. For our estimation, we set our requirements to 40-50 virtual computers, bearing in mind that the load of the system may be affected by the applications being run in each of the virtual computers.

Hardware

After some preliminary conversations with the VMWare technical service, the following requirements were established for the server for storing and running the virtual computers:

- 2 Processors Quad Core AMD Opteron
- 32 GB of RAM
- 3 Network Cards (NIC)
- Storage SCSI 1 TB

After searching the market for computers that fulfilled these requirements, validated by VMWare, we found the HP Proliant 380 DL server, which had a good Price-Quality ratio. The cost of this server is approximately 3.000€, not including

maintenance. The ideal hardware configuration will employ two servers running concurrently, ensuring greater fault tolerance and capacity.

Software

In order to implement the system we also need the following software **VMware ESX** and **VMware Virtual Center**, as explained previously.

A rough estimation of the costs for a VMware ESX license and a Virtual Center for around 40 virtual computers including Gold Support is 7.000 € VAT included[3]

Having two servers requires an additional licence for VMware Infrastructure, (VI-ENT-A y VI-ENT-G-SSS-A), although only one Virtual Center license is needed in order to manage these two servers.

As mentioned in the introduction, in order to manage the virtual computers we need an application that plays the role of a broker. The cost of the Sun&Seeds broker is approx. 50€ (VAT included) for each virtual computer when the number of total licenses is less than 60, which is our case. Thus, the estimated cost for our architecture using the Sun&seeds Broker is almost 5000€, taxes included.

Putting together the hardware and software cost makes a total of approximately **15.000€** which is roughly half the price of setting up a traditional computer lab at a price of 400€ per computer.

Performance

This system had been used in the last academic course, but only in the AVC subjects. The theoretical configuration says a good performance can achieve using approximately 8 virtual machines per CPU core. Then, for a server that has two quad core processor the theoretical limit of virtual machines running simultaneously would be 64.

We have checked that in practice, with this processor the real limit was approximately on 35 concurrent virtual machines, although it depends on what kind of applications the students are running in each of the virtual machines. For this particular estimation the students were using the software Mathematica, from Wolfram. We have had an average of 30 different virtual machines running per day, and a maximum of 10 concurrent virtual machines.

CONCLUSIONS AND FUTURE WORK

E-learning requires new resources to achieve a collaborative environment where professors and students can interact. When these resources are software applications we should be able to use them regardless of the final user operating system or the other software installed. Nevertheless, the user cannot install these applications when a commercial license is required, so a way to provide a remote access to such applications must be made available.

The best way to guarantee that users can avail of these applications is to provide remote access to a virtual machine. Each virtual machine is independent and it can be copied many times. Each one has its own operating system and software applications. An important part of the infrastructure is the broker. This is the web application that provides user authentication and virtual desktop access. It is interesting to note that the resulting architecture is not only more flexible than a traditional lab but it is also less expensive and easier to manage.

In the Andalusian Virtual Campus a VMware solution has been adopted. This approach offers an end-to-end solution called VMware View (formerly VMware Virtual

3 The VAT rate in Spain is 16%

Desktop Infrastructure (VDI)) that organizations use to provide remote users with access to virtual computers that are hosted in a central datacenter.

As future work we are developing a federated identity so that every federated user can be authenticated in a virtual machine and depending on the user attributes, they will be able to access a specific virtual machine.

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