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Virtual computers offer to the modern educational solutions

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Abstract

During first decade of the 21st century more and more production ICT environments have already switched towards virtualized solution. This is still ongoing process which offers a lot of benefits but at the same time makes understanding relations between physical environment and virtualized systems harder. The article starts with a short survey of some problems related to effectiveness usage of IT capabilities in modern educational environments with conclusion how they can be solved using computer virtualization technique in the way which may result with better understanding invisible physical processes in virtualized e-business systems.

Keywords: virtual computers; information and communication technology (ICT); computer education

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Introduction

Dynamic development of applications of all kinds of computer technologies, including computer networks, causing difficult today indicate sphere of human activity, which is not dependent on modern information technology. From commonly used, mature technology is expected to ease of use and above all as low investments and operating costs. For reducing investment cost are responsible designers and manufacturers of equipment and software. Ease of use is primarily a development System software that allows any user to control a technically complex and increasingly architectural complicated technology with one easy teach makes contemporary systems "very easy to use". Moreover, the mature technology expected to wider security attribute, including assurance that the system does not allow the user to perform harmful to achieve his purpose.

Paradoxically, a growing level of abstraction and the security of computer systems have created a problem for the education system. Computer laboratories equipped with modern systems of all possible facilities for the training of specialists in the sphere of uses IT, but made slightly difficult and complicate the process of learning IT technologies. This concerns in particular the practice of didactics, operating systems and computer networks. Typical computer laboratory at every level of education is protected against any change by the student. It makes very difficult implementation exercises requiring control policy installation, configuration and administration distributed systems. . Certain, relatively widely used, solution for this problem is to use software for simulation, especially in the case of computer networks. Simulation software for its number of pros also has some disadvantages. Sometimes these are additional expenditures, not all schools provide, and in the case of freeware support problem arises in the case of software malfunction.

New opportunities to solve the existing problem provided recent virtualization technology. In the literature frequently see reports about the use of this technology to define virtual laboratories for use in e-learning content.

The article demonstrates concepts how to remove barriers prevented reconfiguration real laboratory equipment using virtual computer tools. Additionally it offers a student an opportunity to become acquainted with tools for virtualization. The latter competence has rapidly growing value just because in business world most modern production environments include virtualized computers for the benefits they offer.

Article has two main parts. The first is business oriented virtualization technology characteristics, while the second one is devoted to teaching concept exploration computer virtualization technology on the occasion of the fundamental objectives for training in computer networks.

VIRTUALIZATION AND ITS BUSINESS ASPECTS

The concept of virtualization is quite old as it is rooted in 1960s. "Virtualization" proposed by IBM allowed to split the machine's resources into separate entities. This enabled multiple applications/processes to be run simultaneously. The machine designed by IBM was an experimental IBM M44/44X: the IBM 7044 (M44) simulated several "virtual machines" (X44) - the latter's address space resided in the M44's memory hierarchy (virtual memory). The project's goal was to evaluate the emerging at that time the sharing system concepts¹.

¹ <http://www.kernelthread.com/publications/virtualization/>

In 1980s and 1990s virtualization was almost non-existent topic. As client-server model was established, together with the x86 as the dominant instruction set architecture, the need for virtualization became much lower. Inexpensive servers and desktops allowed for distributed computing: simple workstations were using the resources provided by fairly powerful servers. With Windows and Linux becoming major operating systems, this situation was solidified.

Nonetheless, the enormous growth of computer/information industry and the reoccurrence of the issues once solved, led to the restoration of virtualization concept. Nowadays, the computers based on x86 architecture share similar problems to the mainframes in 1960s, including infrastructure underutilization, raising infrastructure and management costs, etc. After 40 years the core ideas behind virtualization are not much different. In 1999 VMware introduced virtualization to x86 systems. Since them, the technology has matured, becoming number one technology priority in 2010 according to Gartner survey².

Virtualization Benefits

The reasons for implementing the virtualization solution may vary. However, the poll results published in February 2008 by Ziff-Davis Research point out to a handful of common virtualization drivers presented on the diagram shown on Figure 1.

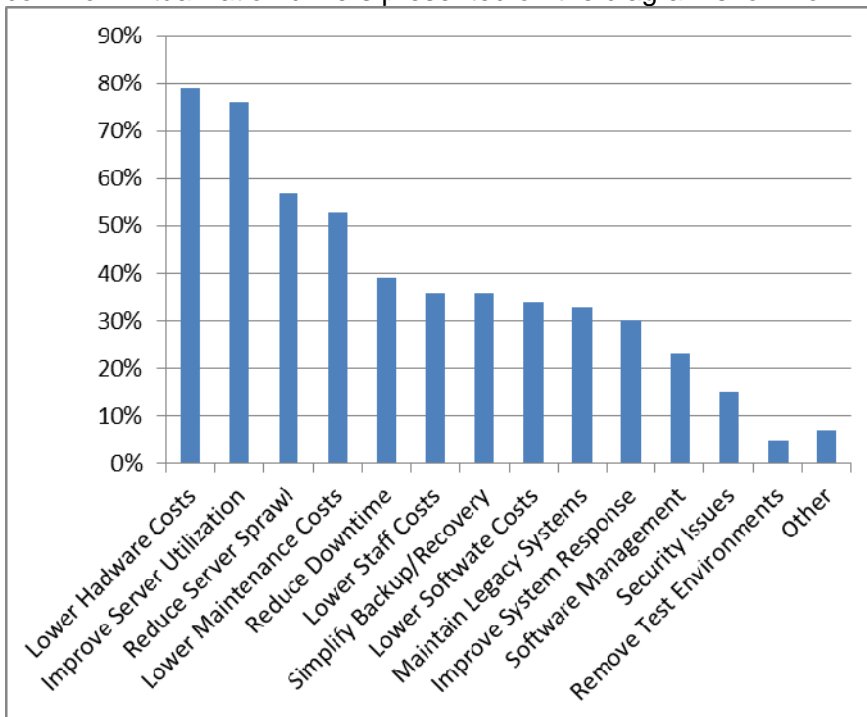


Figure 1 Benefits - common virtualization drivers

The more recent Gartner EXP worldwide CIO survey conducted from September to December 2009, representing CIO budget plans reported at that time, confirmed that virtualization is one of the key areas in terms of priorities in times of budget cuts and limited resources - virtualization ranked first among "Technology Priorities" for 2010.

The common benefits of virtualization may be enumerated as following (Menken and Blokdijk, 2008):

² <http://www.gartner.com/it/page.jsp?id=1283413>

- Facilitated management - one may easily monitor and manage numerous servers/workstations from a single computer
- No compatibility issues - different operational systems may be run on a single physical machine not raising any compatibility issues.
- Fault isolation - an error occurring on a single virtual machine does not affect others systems on the same physical machine.
- Enhanced security - information and applications can be separated between independent virtual machines (still on a single physical one).
- Better use of resources - single computer may provide environment for running several virtual machines simultaneously, enabling much higher use of its resources than in case of just on application or service.
- Portability - transferring virtual machines between physical computers is almost effortless.
- Simplified testing - virtual machines can be effectively used during application development process for test environment setup and different conditions simulation.
- Reduced costs - virtualization bring several sources of savings including spending on physical hardware, running costs and staff remunerations

Solution Providers

Currently one has numerous virtualization alternatives at his/hers disposal. The diagram shown on Figure 2³ depicts different categories of virtualization-related vendors.

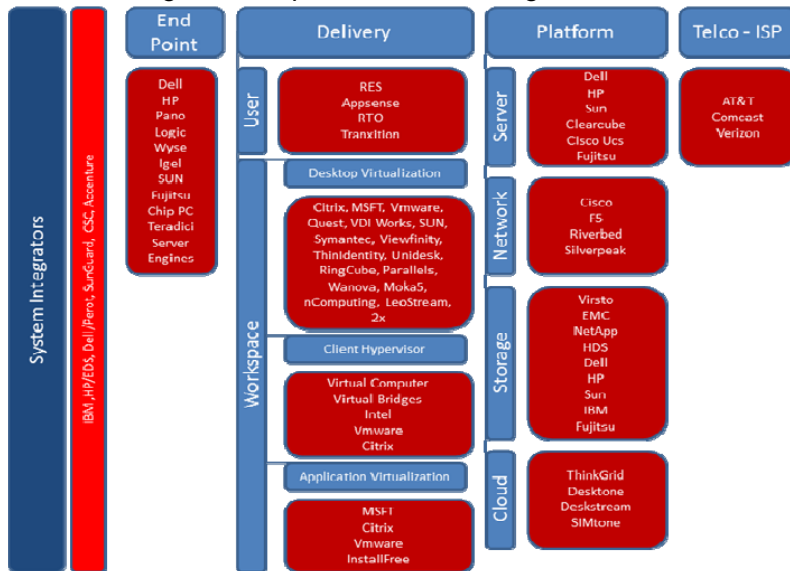


Figure 2 Virtualization technologies vendor alignment

According to the Gartner report published in May 2010⁴, the Magic Quadrant for x86 virtualization groups the major competitors into the following categories:

- Leaders

³ adopted from: <http://www.enterprisestrategygroup.com/2010/02/2010-desktop-virtualization-trends/>

⁴ <http://virtualization.info/en/news/2010/05/gartner-publishes-a-new-magic-quadrant-for-virtualization.html>

- VMware
- Challengers
 - Microsoft
- Visionaries
 - Citrix
- Niche Players
 - Oracle VM
 - Oracle Solaris Containers
 - Parallels
 - Red Hat
 - Novell

Only VMware is classified by Gartner to the leader category, with the best capability to execute and the best completeness of vision. The other contenders are far beyond and with a little chance to catch up soon.

USING VIRTUAL DESKTOP TOOLS AS SUPPLEMENTS TO COMPUTER NETWORK CURRICULUM

Virtual machines are great tools for research and academic experiments. Since they provide isolation, they are safer to work with. They encapsulate the entire state of a running system: one can save the state, examine it, modify it, reload it, and so on. The state also provides an abstraction of the workload being run. Therefore if only computer lab LAN has software for computer virtualization installed it is possible to offer students running any kind configuration and administration computer networks experiments despite of “safe” configuration of the real computer not allowing any changes. The most vital characteristic of virtual computer networks which keep students attention and grow probability of successful course:

1. Virtualization is fun. It has something in common with computer games as getting out of virtual computer failure is as easy as copying several files. Students stop afraid of doing “wild experiments” on their own and get involved in problem solving on their own.
2. Virtual machines can be used to create operating systems, or execution environments with resource limits. It means, that students have to be aware both: the real computer installed capabilities and virtual computer requirements. It teaches them which system resources are crucial in the given exercise context. This is especially important in case of setting up a network of virtual computers working on one real host system.
3. Virtual machines can provide the illusion of hardware, or hardware configuration that you do not have (such as SCSI devices, multiple processors, etc.) It enables students to gain experience on using hardware which is not available in the computer lab.
4. Virtual machines can be used to run multiple operating systems simultaneously: different versions, or even entirely different systems, which can be on hot standby. Some such systems may be hard or impossible to run on newer real hardware.

Figure 3 presents students view of relations between physical and virtual environment on computer lab workstation. It is worth to remember that the virtual computer hardware components depend on used virtualization software and usually different type from equivalent equipment of the physical computer. It is especially important to remember it

while installing guest operating systems on virtual hardware.

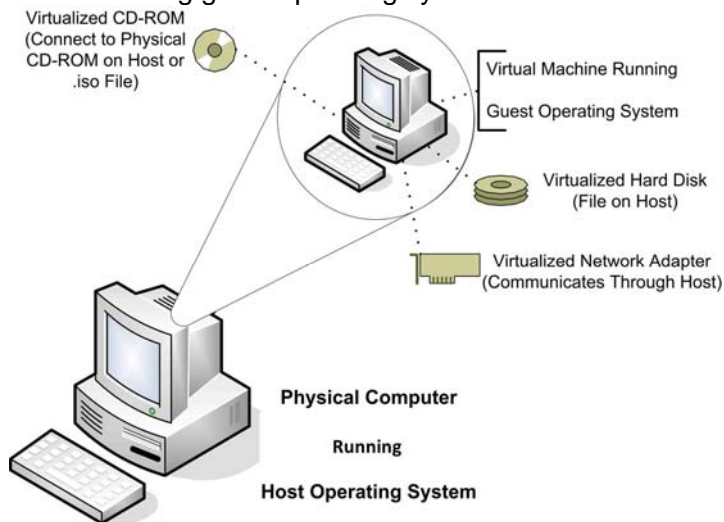


Figure 3 Virtual environment on computer lab workstation

Virtual computer software packages

The selection of software for teaching principles of computer networks and networks management restricted to freeware packages. Therefore the following packages have been tested:

1. Microsoft Virtual PC 2007⁵ (do not mix up with the Windows Virtual PC, the latest Microsoft virtual package)
2. VMware player⁶
3. Virtual Box⁷

To give to student's freedom of choice all those software packages has been made available in the computer lab environment. There was no pressure which software should a student choice. In practice most students' selection was VMware player especially when version 3.x came out⁸. Certain popularity had Virtual Box, especially among the students who declared using at home Linux operating system. To make students' decision more rational the first exercise (running live version of guest OS from ISO file) was required to be done using each of installed virtual computer software packages

The following sections briefly describe set of generic experiments students were supposed to do using virtual computer technology. The real assignments varied from described in details like used guest operating systems, required configuration parameters etc.

Getting familiar with virtual computer software interface

Students were supposed to use every software package for computer virtualization installed in the lab. As it was already mentioned there were three different packages.

⁵ <http://www.microsoft.com/downloads/details.aspx?FamilyId=04D26402-3199-48A3-AFA2-2DC0B40A73B6&displaylang=en>

⁶ <http://www.vmware.com/products/player/>

⁷ <http://www.virtualbox.org/>

⁸ Earlier versions of VMware Player did not allow definition of virtual computer.

Using each of them student was asked to define virtual computer and run on it live version of the suggested by instructor operating system. For the reason of small resource requirement the instructor choice was Linux mini distribution namely DSL (Damn Small Linux) the latest version available on Internet. At home students were supposed to prepare MS Word (or any other editor) document with their own detailed interface description of one selected for further usage package using appropriate help files or other documents available on the vendors Web pages. The obligatory part had to include description of the virtual machine settings parameters interface (example of an interface is shown on Figure 4).

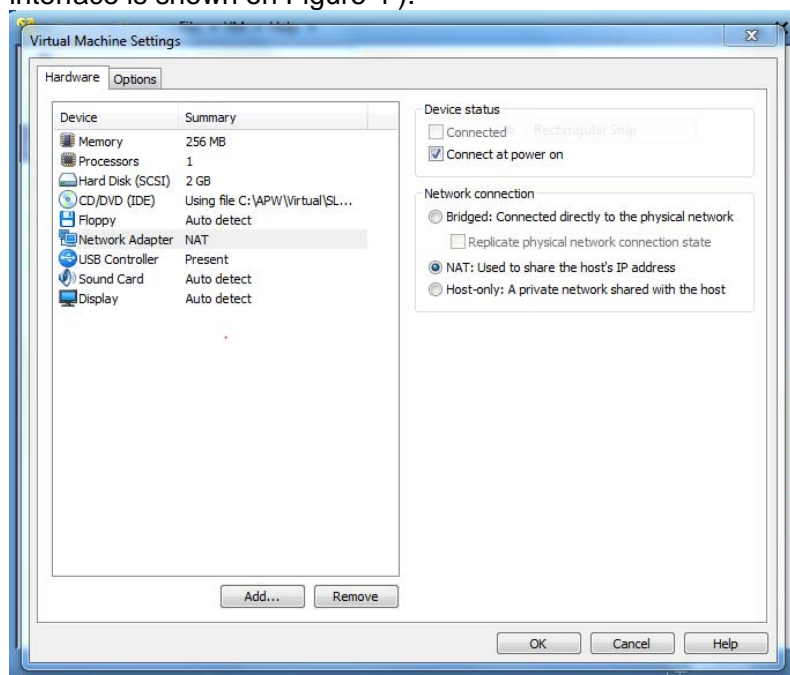


Figure 4 VMware Player interface to virtual machine hardware settings

In case of any difficulties with proper understanding certain interface options student was supposed to prepare questions to instructor in writing.

Guest operating system hard disk setup

The main objective of this exercise was restoring or developing basic skills on installing operating system on hard disk. To make task easier students were asked to install as guest operating system this particular one they used in live version during the first lab exercise. For the same reason the assignment required NAT configuration of the obligatory one network interface as to make Internet resources available after successful OS installation on hard disk of the virtual computer.

Virtual Network Interface configuration survey

Different packages use slightly different terminology to describe much the same base network connection preconfigured for the virtual network adapters (virtual computer like the physical one may have more than one network interface card). VMware Player provides bridged, NAT, and host-only network connections. Each of them is briefly explained below:

1. Bridged networking

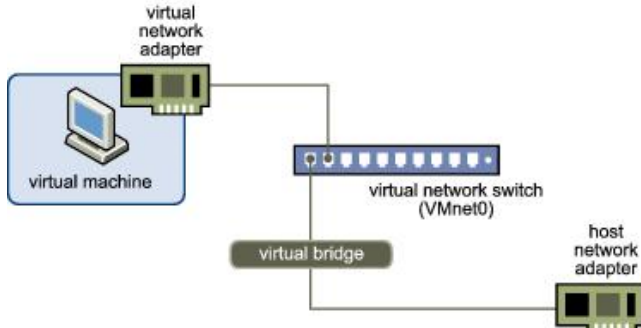


Figure 5 Bridged networking setup

If the host computer is on a network and virtual computer can have a separate IP address in this network (i.e. can obtain one from a DHCP server), selecting “Bridged” option enables other computers on the network communicate directly with the virtual machine.

2. NAT (Network Address Translation)

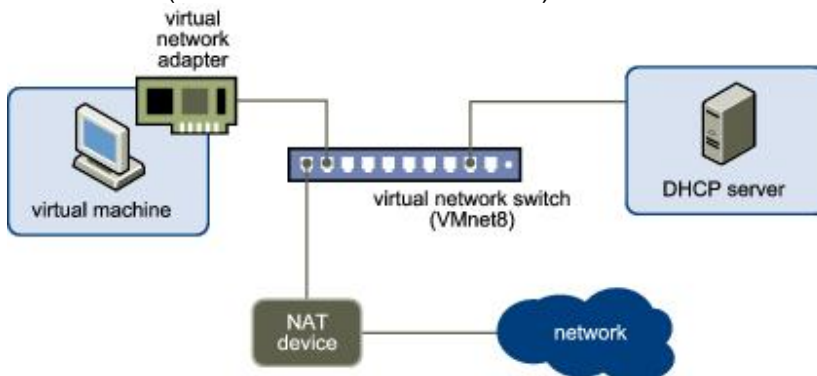


Figure 6 NAT setup

The easiest to configure connection to the outside network via physical computer network interface. It is recommended especially if the virtual computer does not have a separate IP address for the network physical computer is attached to. The virtual machine and the host share a single network identity that is not visible outside the network.

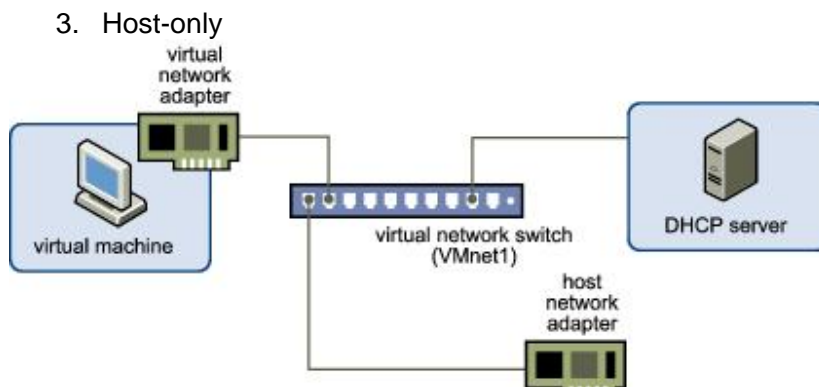


Figure 7 Host only networking

Host-only networking provides a network connection between the virtual machine and the host computer, using a virtual network adapter that is visible to the host operating system. With host-only networking, the virtual machine can communicate only with the host and other virtual machines in the host-only network. Selecting “Host-only” will set up an isolated virtual network.

Examples of typical assignment which enabled students exploring capabilities different type of virtual network interfaces connection include:

1. Make a copy of virtual computer with operating system installed on hard disk. Put both copies into work. Put network interfaces on both computers into Nat mode and check network connections: between both virtual computers; between one virtual computer and the host operating systems and between one of the guest operating systems and the Internet.
2. Host only mode and check the network communication as above. Explain differences.

Computer network administration

This set of exercises assumed that students understand virtual computer technology well enough to be able work with more complicated architectures delivered to them by instructor. The experimental computer network was setup with minimum two virtual computers and the physical one. The testing “enterprise network” should be small enough as to be able run on one physical computer⁹ and at the same time “big” enough as to be able carry on Network Directory Services. The proved solution included one Novell Network 5 guest operating server with Novell Directory Services and one MS NT 4.0 workstation with Novell Netware client installed. The host operating system was part of the working environment.

Using given environment with typical for small businesses architecture client server students practiced full bunch different kind administration tasks like:

- Users management
- Resources management
- Network services management
- Security system management

⁹ Most computers had still only 1 GB RAM configuration

CONCLUSION

Provided experiments fully proved that virtual computer technology can be very valuable enhancement for the traditional curriculum of learning computer networks principles. Student's feedback during course evaluation pointed out that they found the idea very interesting and fruitful (many of them have declared that they will continue using virtual tools for their own purposes). At the same time they made some suggestions how to improve the whole concept. All students' suggestions will be taken into account with the new edition of the courses using virtual desktop tools as supplements to computer network curriculum.

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