

Virtualization technology and possibilities of its use in education

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Abstract—In this research, we review the possibilities and benefits of using virtualization technologies in a secondary education environment. All tests were made on-site at the "Orce Nikolov" High School in Skopje, using real equipment and in real classroom scenarios. Our main goal with this research was to provide creative and better ways for the school to: manage their IT equipment, cut costs, provide better learning environments for students, but also for teachers.

Index Terms—Education, Human-Computer Interaction, Virtualization

I. INTRODUCTION

Over the past years and especially lately with the current COVID-19 world situation, most educational institutions have experienced many problems related to moving to the cloud, but also with the system administration of IT equipment and laboratories. Many of these problems have found elegant solutions in the deployment of virtualization suites. Providing schools with solutions for the problems mentioned above was the main idea behind this research.

Hardware virtualization refers to the creation of a virtual machine that acts like a real computer with an operating system. Software executed on these virtual machines is separated from the underlying hardware resources. For example, a computer that is running Microsoft Windows may host a virtual machine that looks like a computer with the Ubuntu Linux operating system.

Desktop virtualization means that each desktop lives in a virtual machine, which is partitioned off from other virtual machines in the server. The operating system and applications are not shared resources, but they still physically live on a remote server. These virtualized resources can be accessed from any device that is able to connect to the server.

A thin client is a computer that runs from resources stored on a central server instead of a localized hard drive. Thin clients work by connecting remotely to a server-based computing environment where most applications, sensitive data, and memory, are stored.

II. RELATED WORK

M. Klement [1] explored ways of integrating virtualization in education, the costs and benefits from it. A. Gaspar, S. Langevin, W. Armitage, R. Sekar and T. Daniels [2] explored the role virtualization has in education while mostly focusing on virtualization of the IT classroom and laboratory from two perspectives: the perspective of the system administrator and the perspective of the instructor.

Chandra and Malaya [3] were focused on how cloud computing and virtualization can help with the increasing pressure educational institutions have to deliver more for less

and the need to find ways to offer rich, affordable services and tools. High energy costs and IT equipment costs are also one of the biggest problems facing IT in education, the Erskine and Füstös [4] in their case-study, researched solutions such as using thin-clients instead of full desktop computers, delivering educational desktop environments to students home or dorm room computers and so on. Anderson, Joines and Daniels [5] study might be one of the most interesting articles currently because of the problems students and universities are facing not being able to provide education in computer labs on campus with the current COVID-19 situation.

Other studies such as the ones from Karlov [6], Barriounevo, Gil, Giribaldi, Suarez and Taffernaberry [7], Xu, Yang and Lei [8], Lundsford [9] and Sultan [10] have also inspired and improved the research in this paper.

III. USE-CASE SOLUTION ARCHITECTURE

This paper focuses on the use of virtualization technologies in during a IT course. Usually, educators use a dedicated computer laboratory with computers isolated from the campus networks for IT courses; however, in case a dedicated computer laboratory was not available due to construction delays. As a result, this educator decided to test the use of virtualization technologies in this course.

The computer laboratory used for this course consisted of student workstations and an educator's workstation connected to the campus network. Students used the computer laboratory heavily throughout the day. Most classes made full use of the computer laboratory with all available computers taken. As a result, it was not possible to dedicate some computers to this course. Fortunately, the educator's workstation had sufficient resources to run VMWare Workstation 12. The educator's workstation consisted of an Intel 6-core Xeon Processor (3,20 GHz) with 32 GB RAM, 512GB Solid State Drive, 23,8" flat-panel display, and an Internet connection via a local area network. The student's workstations are meant only to be used as Remote Desktop Connection clients. Each computer consisted of an Intel dual-core processor (2.90 GHz) with 2 GB RAM, an 120 GB Solid State Drive, 21,5" flat-panel display, and a restricted Internet connection via a local area network. Using Remote Desktop Connection, each student can connect in a personalized hosted virtualization environment depending on the lesson, employing hardware virtualization on the educator's workstation to enable desktop virtualization.

This IS educator selected VMWare Workstation as the virtualization platform for several reasons. First, VMWare provides a range of virtualization products, including server

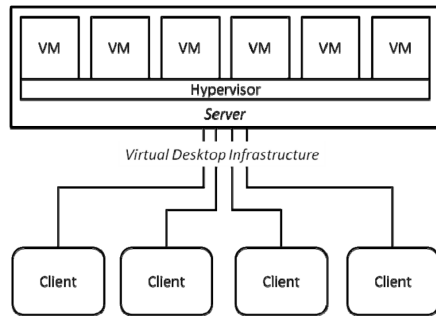


Fig. 1. Computer Lab (Classroom) Virtualization Architecture

and desktop virtualization. Second, VMWare Workstation supports a range of hardware, including universal serial bus (USB) 2.0 storage devices natively, while other virtualization products require the user to setup a shared folder with the host operating system to access these devices. Third, VMWare Workstation supports a wide range of guest operating systems, including most versions of Microsoft Windows, Linux distributions, and several other operating systems. Fourth, VMWare has an active user community providing an assortment of virtual appliances, which are pre-configured virtual machines for various applications. Finally, VMWare operates an academic program (<http://www.vmware.com/partners/academic/>) that makes select VMWare products available to the academic community free of charge for instructional purposes.

Most virtual machines used in the course were pre-build ones, specially designed for the course. These virtual machines are designed to be a closed environment where students don't have many permissions. Though sometimes students work in a virtual machine of their own creation, they have complete control over the virtual machine. This is desirable in settings where the student is acting as a system administrator; however, this can also make it difficult for the educator to monitor the students' activities or assist students in solving some problems. In other settings where the student does not require administrator control over the virtual machine, the IS educator may choose to distribute a virtual machine with a pre-defined student account with the appropriate level of access. In this course all students were authenticated using their Active Directory authentications or a predefined password.

IV. DISCUSSION

For the duration of this research the our experience with involved parties was: The school's administration benefited and expressed satisfaction with the lower costs for energy and IT equipment, they were satisfied that they can use their current equipment and network infrastructure for virtualization. The educator benefited and expressed satisfaction with the course and the use of virtual machines. In addition to the ease of management of the student lab and monitoring of the student activities, he experienced better results from students. The class preparation was much easier because the educator needed to prepare only several virtual machines for the course, instead of a dedicated computer for each student. The also students expressed satisfaction with the course and the use of virtual machines. In addition to developing technical skills, the students demonstrated an increased

level of confidence in working with advanced features of Windows and other applications over the course. One student commented that the student felt using the virtual machine helped the student become more comfortable and confident with existing and new skills, because of the bigger freedom.

The main benefits from using virtualization in education are:

- Using a centralized system for Operating System & application updates;
- Migration can be done regularly by a IT technician at the data center collectively for a group of virtual desktops;
- Desktop Virtualization solutions integrate with corporate directories like Active Directory and User Access Policies can be applied to all users based on their role, location, type of device, etc.;
- Enhanced security as the administration is centralized – Antivirus/ Firewall policies can be applied and monitored from the data center. For example the applications that can be accessed and run by the students can be restricted and even tracked;
- Faster, reliable and easier backup/ recovery of all the user data is possible due to centralized hosting and administration;
- Desktops, Laptops, Thin-Clients, Tablets or even Smart Phones could be used by users (where ever they are) to access the centralized hosted applications and desktop environments;
- For applications that require heavy CPU or GPU processing, the performance with Desktop Virtualization might be better, as the applications are now being processed by the more powerful server processors, than the desktop processors;
- Desktop Virtualization software generally has settings to allow administrators to allocate or limit server resources that can be used per user, so that an individual user doesn't over-consume resources.

While most of the experiences by everyone involved were generally positive, the use of virtual machines in an instructional setting introduces some challenges and limitations over the use of dedicated computers.

The main disadvantages from using virtualization in education are:

- The educational institution needs to buy the Desktop Virtualization Software licenses, Servers, Centralized Storage infrastructure, Upgrade Network infrastructure to support more bandwidth, etc. in addition to buying computers or thin-clients for each user;
- IT administrators and teachers need to learn how to manage the Virtualization software which can be difficult for some and professional training can be expensive for the educational institution;
- There is no reduction in the number of end-user client machines that are needed in the network;
- The licenses for Operating Systems, applications, etc., still needs to be bought for each user (mostly) and there is no reduction of costs there (except in some application that benefit from discounts for Educational purposes);
- The thin-clients are sometimes as expensive or even more expensive than individual computers;
- The network infrastructure needs to be able to handle all the extra bandwidth that Desktop Virtualization is going

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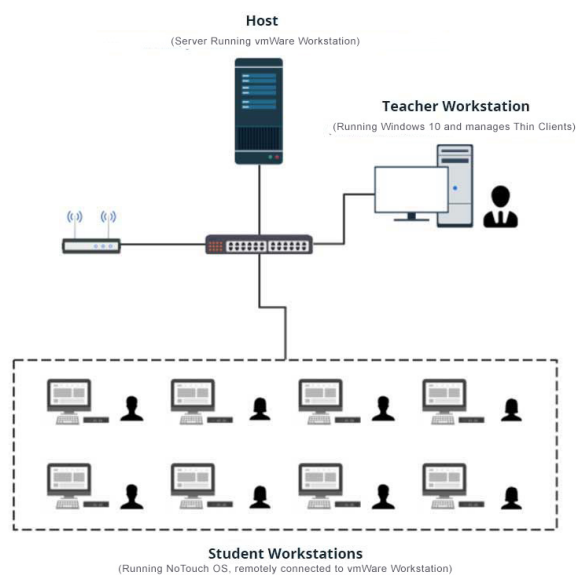


Fig. 2. Complete schema of the setup used on the test site, with a server, workstation PC for the teacher and thin clients as student workstations all of them connected by a Local Area Network (FTP Cat6A)

to introduce. Otherwise, it has to be upgraded (which can be costly);

- The WAN links need to have sufficient bandwidth to handle all the remote users, as well;
- If the bandwidth on the remote end is not sufficient or if there is congestion in Local Area Network, the display quality may not be as good as processing and viewing applications directly from a desktop;
- Its difficult to handle graphics and high-definition video with Desktop Virtualization.

V. CONCLUSION

Information Technologies are the future of education and Virtualization and moving to the cloud is the future for Information Technologies. Both students and teachers can benefit from the introduction of Virtualization and Cloud technologies to the classroom, but this need to be done right with carefully planned needs and resources, proper budgets for the equipment and licenses and professional training for everyone involved. The school's administration needs to understand the benefits and disadvantages of Virtualization and then decide if they are ready to go "cloud". While our experience was mostly positive and new technology was easily adopted and appreciated by most, the use of virtual machines in an educational setting still left a small number of people sceptical.

In our final meetings with the school's administration and IT personnel we discussed doing a "Phase 2" of this research where they could try and move their current applications that they use in their finance, archive, library and educational departments to the cloud. They also provided a lot of interest in applying desktop virtualization to their Android based tablets for students and teachers that are currently not utilized enough by students because of the operation system restrictions.

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