

Performance Analysis of Different Available Virtualization Platforms using Mixed Methodology

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Abstract: Nowadays Virtualization plays major roles in varied applications such as e-Learning, business-to-business communication, social networking, and computer simulation and enterprise development. These advances are due to the availability of high-speed computers, fiber-optic-enabled internet connections and advanced virtualization programs. However, a very few studies have been available to measure the performance of various virtualization platforms in a single framework. Here in this study, we will measure the performance of different available virtualization platforms, such as VMware Workstation 7 and Oracle VM VirtualBox 4 using MS Windows 7 guest-and host-operating systems using a mixed research methodology based on both qualitative and quantitative.

Keywords: Vmware, Hypervisor, network security, Virtualization, Effects of virtualization.

I. INTRODUCTION

Enterprises have saved billions of dollars and resources such as electricity and manpower through using virtualized based infrastructure. They may have reduced their hardware but they are still able to reach their desired results as before with virtualization technologies. Unfortunately, many small businesses do not have enough financial resources, time and manpower to spend on researching performance of various virtualization programs available on the market before acquiring one.

Motivation for doing this research was to examine and evaluate the performance of major virtualization programs on Windows 7. This research provides valuable information regarding performance differences of major virtualization programs such as VMware Workstation and VirtualBox on Windows 7. Section 2 describes about research methodology chosen and the data gathering methods and data analysis techniques

Section 3 describes about Experimental Surveys presents the methods for studying the performance of different virtualization programs and describes the creation of the experiment environment includes the experimental setups and their purpose. Section 4 describes about experimental results and subsequently conclusion and future directions have been depicted lastly.

II. RESEARCH METHODOLOGY

The objective of this research is to study and investigate the performance of different virtualization programs. Various experiments regarding performance have been performed on different virtualization platforms. The quantitative data collected from the experiments were converted into graphs and the qualitative results were thoroughly studied.

In research methodology various steps have been discussed which will be used to carry out research successfully. Research methodology is not just about choosing an appropriate method for study but it is also about covering the reasons and logic behind choosing a particular method. Kothari argues that research methods are methods and techniques which are used by researchers to conduct research.

Hypothesis

According to Kumar hypotheses bring unambiguousness and a focus to a research problem. The research hypothesis will help to understand the research problems.[2].

According to Kumar the scope of research methodology is broader than research methods, therefore research methodology not only covers research methods but it also covers logic behind choosing a particular research method [3].

For this research the empirical approach was used. According to Marczyk, DeMatteo and Festinger the scientific method is strongly based on the empirical approach. The empirical approach is based on evidence, which means to gain new knowledge it is necessary to observe and experiment. In the empirical approach the researcher makes scientific decisions based on information which is gained from observation and experimentation. . According to Henrichsen, Smith and Baker there are many different ways to conduct empirical research such as [4]:

- Questioning
- Studying behaviour
- Observing and explaining
- Experimenting

In this study experimenting, observing and explaining were used. Kothari describes empirical research as a type of research which relies on experiment and observation. Conclusions which are made through empirical research can be validated by observation or experiment.

Creswell describes three different types of research design: qualitative, quantitative, and mixed method.

Research Strategies

- Quantitative Strategies
 - Experimental research - seeks to discover if a specific action changes the result . It is a research design approach which uses manipulation and controlled results from a testing environment to understand a particular process .
- Qualitative Strategies
 - Case study - is a strategy in which the researcher investigates in-depth “*a program, event, activity, process, or one or more individuals*”.
 - Literature review - is a strategy for finding and summarizing studies about a particular research topic.
- Mixed Methods Strategies
 - Sequential mixed methods - this process consist of elaborating on or expanding on outcomes of one method with another method. The researcher begins the study with a qualitative method and then advances the study with a quantitative method. Alternatively, the researcher can start the study with a quantitative method and then use qualitative methods .

Experimental Survey:

Experimental Environment

Physical Machine

The experimental environment is based on a personal, desktop computer with the following hardware and software features:

- Hardware
 - Intel(R) Dual-Core CPU 3.00GHz

- 2.00 GB of Memory
- 500 GB Hard Disk Space
- NVIDIA GeForce 9600 GT Graphic Card
- Software
 - Windows 7 Ultimate 32-bit Edition OS
 - VMware Workstation 7
 - Oracle VM VirtualBox 4
 - Microsoft Windows Virtual PC

The experimental environment is organized into two different layers: the physical layer and the virtual layer. The physical layer consists of the physical hardware, the host OS and the virtualization programs.

The virtual layer on the other hand consists of virtual hardware, guest OSs and third party applications. Table shows hardware, software and the order in which the experimental environment's layers are organized. Table 1 shows hardware, software and the order in which the experimental environment's layers are organized.

Table 1: Experimental Environment Layers

Virtual Layer	Third Party Applications (GNU Image Manipulation Program, Mozilla Thunderbird and Pidgin)
	Guest OSs (Windows 7 Ultimate 32-bit Edition OS and Linux Mint 32-bit OS)
	Virtual Hardware (CPU, Memory, Network Interface Controller and Hard Disk)
Physical Layer	Virtualization programs (VMware Workstation, VirtualBox and Virtual PC)
	Host OS (Windows 7 Ultimate 32-bit Edition OS)
	Physical Hardware (CPU, Memory, Network Interface Controller and Hard Disk)

VMware Workstation, VirtualBox and Virtual PC each consists of two guest operating systems: Windows 7 Ultimate 32-bit Edition and Linux Mint 32-bit Edition. For testing purposes, each guest operating system will be configured and allocated the same amount of virtual system resources. Table 2 shows the resource distribution plan for the host and guest operating systems.

Table 2: Resource Distribution Plan

Resource Distribution Plan			
	Hard Disk	Memory	Processor
Windows 7 Host OS	500 GB	2 GB	2
VMware Workstation Windows 7 guest OS	20 GB	1 GB	1
VMware Workstation Linux Mint guest OS	20 GB	1 GB	1
VirtualBox Windows 7 guest OS	20 GB	1 GB	1
VirtualBox Linux Mint guest OS	20 GB	1 GB	1
Virtual PC Windows 7 guest OS	20 GB	1 GB	1
Virtual PC Linux Mint guest OS	20 GB	1 GB	1

To successfully complete the experiments the following hardware and software were used:

- A personal computer with Windows 7 as host OS
- A virtual machine created by VMware Workstation with Windows 7 as guest OS
- A virtual machine created by VMware Workstation with Linux Mint as guest OS

- A virtual machine created by VirtualBox with Windows 7 as guest OS
- A virtual machine created by VirtualBox with Linux Mint as guest OS
- A virtual machine created by Virtual PC with Windows 7 as guest OS
- A virtual machine created by Virtual PC with Linux Mint as guest OS
- Microsoft Windows Task Manager
- Linux Mint System Monitor
- NovaBench 3.0.4
- 7-Zip 9.20
- Linux Mint 11, Katya
- Microsoft Windows 7 SP1
- VMware Workstation 7
- Oracle VM VirtualBox 4
- Microsoft Windows Virtual PC
- A digital stopwatch

Installing Host OS

In this section information about installing the host OS on the physical machine is covered. To install Windows 7 on a physical machine first it is necessary to evaluate the whole process before starting installation. When Windows 7 setup is started it is necessary to supply the setup screen with necessary information regarding installation. Careful planning will make installing Windows 7 a breeze, and it will reduce common errors during the installation process. Moreover having the necessary knowledge about setup configuration will smooth the path to a successful installation.

Installing Guest Operating Systems

Choosing the right operating system as guest OS was essential. That is why many factors such as: operating system availability, cost, features and performance were considered before selecting an OS as a guest OS. As a result, for this study, Windows 7 Ultimate 32-bit Edition was selected as the main guest OS.

We are performing 22 experiments and after that we are analysing the result.

Experiment 1: Guest operating systems installation time

The purpose of this experiment was to measure Windows 7 and Linux Mint OSs installation time on the virtual machines created by VMware Workstation, VirtualBox and Virtual PC.

Experiment 2,3 & 4: Guest operating system boot, shutdown and restart time

The purpose of this experiment was to measure the boot, shutdown & restart time of Windows 7 and Linux Mint guest operating systems based on VMware Workstation, VirtualBox and Virtual PC.

Experiment 5 & 6: CPU and memory usage of virtualization programs on host OS

The experiment process began by executing VMware Workstation, VirtualBox and Virtual PC and powering up guest operating systems in order to perform the experiment.

Experiment 7: Load time of third party applications on guest operating systems

The purpose of this experiment was to measure the load time of third party applications such as GNU Image Manipulation Program, Mozilla Thunderbird and Pidgin on the Windows 7 and Linux Mint guest operating systems based on VMware Workstation, VirtualBox and Virtual PC.

Experiment 8 & 9: CPU and memory usage of third party applications on guest operating systems

In this experiment the CPU and memory usage of third party applications such as GNU Image Manipulation Program, Mozilla Thunderbird and Pidgin on guest operating systems was monitored and recorded.

Experiment 10 & 11: Guest operating systems log off and log on time

The purpose of this experiment was to evaluate guest operating systems, log off and log on time. Windows 7 and Linux Mint guest operating systems were used based on VMware Workstation, VirtualBox and Virtual PC.

Experiment 12: Guest operating systems switch user time

The purpose of this experiment was to find out how fast a user on VMware Workstation, VirtualBox and Virtual PC using Windows 7 and Linux Mint guest operating systems can perform switch user.

Experiment 13 & 14: Time for a guest operating system to go to and to recover from a sleep state

The aim of this experiment was to test how fast Windows 7 and Linux Mint guest operating systems based on VMware Workstation, VirtualBox and Virtual PC can go to a sleep state and how to recover from a sleep state.

Experiment 15 & 16: Time taken for a guest operating system to go to and to recover from a state of hibernation

The purpose of this experiment was to test how fast Windows 7 and Linux Mint guest operating systems based on VMware Workstation, VirtualBox and Virtual PC can go to a state of hibernation and to recover from a state of hibernation.

Experiment 17: Time taken to compressed file on guest operating systems

The aim of this experiment was to evaluate how fast a compressed file can be unpacked on VMware Workstation, VirtualBox and Virtual PC using Windows 7 and Linux Mint guest operating systems.

Experiment 18: Drive/HDD Write Speed on guest operating systems

The objective of this experiment was to analyse drive write speeds on VMware Workstation, VirtualBox and Virtual PC using the Windows 7 guest operating system.

Experiment 19 & 20: CPU - Floating Point and Integer Operations on guest operating systems

The purpose of this experiment was to investigate how many floating point and integer operations can be executed on the Windows 7 guest operating system based on VMware Workstation, VirtualBox and Virtual PC.

Experiment 21: CPU - MD5 Hashing on guest operating systems

The aim of this experiment was to investigate how many MD5 hashing operations can be generated on the windows 7 guest operating system based on VMware Workstation, VirtualBox and Virtual PC.

Experiment 22: RAM Transfer Speed on guest operating systems

The intent of this experiment was to measure RAM transfer speed on the windows 7 guest operating system based on VMware Workstation, VirtualBox and Virtual PC running on the Win 7 host OS.

III. EXPERIMENTAL RESULTS

Results of the said experiments have been discussed as follows-

Experiment 1:

In this experiment, three different virtual platforms (VMware Workstation, VirtualBox and Virtual PC) were tested based on two different operating systems, Windows 7 and Linux Mint. More time was taken to install the Windows 7 guest OS while the Linux Mint guest OS took less time to install.

Experiment 2:

In this experiment, the average time each virtual operating system took to boot up. We get to know that more time was taken to start-up Windows 7 on the three of the virtual while Linux Mint performed slightly better on these three virtual operating systems.

Experiment 3 & 4:

In this experiment, nearly the same amount of time was taken to shutdown and restart both operating systems (Windows 7 & Linux Mint) on VirtualBox.

Experiment 5:

In this experiment, on all three virtualization platforms except on VirtualBox, Linux Mint guest OS used less CPU compared with the Windows 7 guest OS. VirtualBox using the Linux Mint guest OS used only slightly more CPU than VirtualBox using the Windows 7 guest OS.

Experiment 6:

Comparisons between the three virtualization platforms indicate that Virtual PC used the least amount of memory while VirtualBox performed slightly better than VMware Workstation as it used less memory.

Experiment 7:

A comparison among the three virtual platforms revealed that Mozilla Thunderbird performed differently on each virtual platform. VMware Workstation and Virtual PC performed slightly better using the Windows 7 guest OS, whereas VirtualBox performed slightly better using the Linux Mint guest OS.

Experiment 8 & 9:

However, results for the Linux Mint guest OS showed that Mozilla Thunderbird on Virtual PC using Linux Mint guest OS requires more CPU usage than the other two virtual platforms, VMware Workstation and VirtualBox.

Experiment 10 & 11:

According to these findings Virtual PC performed better than VMware Workstation and VirtualBox for log on time and for logging off, virtual box is better than other two.

Experiment 12:

A comparison between the two guest operating systems indicated that the Windows 7 guest OS performed much better than the Linux Mint guest operating system on all three virtual platforms (VMware Workstation, VirtualBox and Virtual PC).

Experiment 13&14:

Unfortunately the “sleep” feature was not available on the guest OSs based on VirtualBox and Virtual PC. Thus the tests were only performed on VMware Workstation using the Windows 7 and Linux Mint guest OSs. Evaluation of VMware Workstation using Windows 7 and Linux Mint guest OSs indicated that lowest amount of time was observed on VMware Workstation using the Linux Mint guest OS at approximately 6.33 seconds.

Experiment 15&16:

Unfortunately the “sleep” feature was not available on the guest OSs based on VirtualBox and Virtual PC. Thus the tests were only performed on VMware Workstation using the Windows 7 and Linux Mint guest OSs. Evaluation of VMware Workstation using Windows 7 and Linux Mint guest OSs indicated that lowest amount of time was observed on VMware Workstation using the Linux Mint guest OS at approximately 6.33 seconds.

Experiment 17,18:

A comparison between the two guest operating systems indicated that the Windows 7 guest OS performed much better than the Linux Mint guest operating system on all three virtualization (VMware Workstation, VirtualBox and Virtual PC).

Experiment 19,20:

A comparison between the three virtualization platforms showed that VMware Workstation outperformed better the other two virtualization platforms, VirtualBox and Virtual PC.

Experiment 21,22:

In this experiment it compares between the three virtual platforms showed that VMware Workstation outperformed the other two virtualization platforms, VirtualBox and Virtual PC. The results show that VMware Workstation performed better than VirtualBox and Virtual PC .

Virtualization Platforms and Their Rankings

Table- 3 shows virtualization platform with their ranking. Each virtualization platform received an asterisk mark for performing well in each experiment.

Table-3 Virtualization Programs and Their Rankings

	<i>VMware Workstation</i>	<i>VirtualBox</i>	<i>Virtual PC</i>
Experiment 1	*		
Experiment 2		*	
Experiment 3			*
Experiment 4			*
Experiment 5		*	
Experiment 6			*
Experiment 7	*	* * *	
Experiment 8	*	* * *	
Experiment 9	*	* *	
Experiment 10			*
Experiment 11		*	
Experiment 12			*
Experiment 13	*		
Experiment 14	*		
Experiment 15	*		
Experiment 16	*		
Experiment 17		*	
Experiment 18			*
Experiment 19	*		
Experiment 20	*		
Experiment 21	*		
Experiment 22	*		
Total Points	12	12	6

A detailed analysis of the experimental results which were obtained through conducting the experiments have been performed on various available and selected virtualization platforms. The results obtained from the analysis show that there are significant performance differences between VMware Workstation, VirtualBox and Virtual PC.

IV. Conclusions and Future Research

From the research objectives, aims and organizational structure, it is understood that use of virtualization technology in information technology infrastructure is essential and it is being widely adopted by many organizations. Based on the findings of the literature review and considering factors such as cost, compatibility and features, VMware Workstation VirtualBox and VirtualPC were selected for study and experimentation.

To obtain accurate and relevant results from this study, a mixed research methodology was adopted i.e. both quantitative and qualitative research methodologies. Qualitative research methodology has been used to obtain qualitative data from the literature and make qualitative comparisons. However, quantitative research methodology has been used to obtain quantitative data and make quantitative comparison. The mixed research methodology allowed us to study and analyze performance of VMware Workstation and VirtualBox and VirtualPC on Windows 7. A detailed experimental design which includes the process, objectives and description of the experiments have been discussed and subsequently the experimental results and an analysis on performance of VMware Workstation and VirtualBox and VirtualPC on Windows 7 host OS.

Based on the research outcome it is understood that the use of virtualization technologies and programs is necessary to overcome common problems and barriers in implementation of scalable information technology infrastructure. Performance differences were observed in the different virtualizations programs. The advantages and benefits of VMware Workstation and VirtualBox over Virtual PC were noticed. With regard to the question of cost of virtualization programs available on

the market, the results of this research study show that VirtualBox has demonstrated itself to be a successful virtualization program in relation to both cost and performance. Over recent years, implementation of VirtualBox in different environments is rapidly increasing. However, still the majority of businesses use VMware products because of its support for vast range of virtualization programs available for different purposes and its long standing commercial support. As more businesses and organizations use virtualization programs, rapid development and improvement are observed from different vendors.

Through the conducting of various experiments on the virtualization programs, a deeper understanding of the performance of various virtualization programs such as VMware Workstation, VirtualBox and Virtual PC has been obtained. The preliminary results gave a clear indication of which virtualization program performed better on Windows 7. Based on the results it was observed that, VMware Workstation and VirtualBox performed close to each other and better than Virtual PC. The discussion in Chapter 5 indicated the performance differences between VMware Workstation, VirtualBox and Virtual PC. The findings demonstrated that, Virtual PC lacks both features and performance, but it is a very good product for home users who may like to use different versions of Windows OS together.

Some minor limitations were observed with VirtualBox and Virtual PC. Both VirtualBox and Virtual PC did not support hibernate and sleep features on guest OSs.

Future research directions

This research study provides a necessary baseline for conducting further studies in the area of virtualization performance. Use of virtualization technology in information technology infrastructure is increasing rapidly and adoption of virtualization technology in different environments and settings is becoming a very challenging task. Future research may include the following:

Use of 64-bit guest and host operating systems: In this study only 32-bit guest and host operating systems were used. However, nowadays new laptops usually use 64-bit operating systems. Thus it is worthwhile to study the performance of virtualization programs using 64-bit host and guest OSs. Also, it is important to know some businesses use 64-bit guest operating system as part of their information technology infrastructure. Studying performance of virtualization programs using 64-bit guest operating systems can produce promising results and also guide businesses to select the most appropriate 64-bit host and guest operating systems for better performance.

Conducting experiments using different type of workloads: In this study workloads of GIMP, Pidgin and Mozilla Thunderbird on virtualization programs were measured. Future experiments could include other types of workloads. Future experiments could focus on measuring the workloads of Java based applications, web servers, mail servers and database servers on virtualization programs. For instance, evaluating workloads of Java based applications on virtualization programs is helpful because many businesses use Java based applications. Knowing on which virtualization program, Java based applications can perform well, can guide businesses to select the most appropriate virtualization program to use.

Use diverse host and guest operating systems: In this study Windows 7 was used as host and guest operating systems. However, for future experiments Linux and Mac OS X operating systems could be used as host and guest operating systems. Studying diverse host and guest operating systems are important because better performance results can be obtained by using a particular operating system. There are many different operating systems available to use, however each can have different performance. Studying performance of diverse host and guest operating systems with virtualization programs can produce interesting results regarding OS performance in relation to virtualization program and can guide businesses to choose the most appropriate guest and host operating systems to use with the virtualization program.

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