Analysing the Performance of Hypervisor Type-2 on VMware Workstation and Oracle Virtual Box.

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***Abstract*— Virtualization is one of the key concepts of cloud computing and the most emerging and popular solutions in the field. Virtualization has many types and levels of virtualizing it. Processing virtualization is virtualizing the processor and desktop features for the OS, it can be categorized as hypervisor type 1 & 2. In this paper I will be evaluating the performance of hypervisor type 2 software, VMware and virtual box. I will attempt to run benchmarks tools and compare the scores of these two solutions on windows 10 and with the experiments conducted, it can be concluded that VMware workstation performs better than oracle virtual box in every aspects of the virtualized layer.**

Keywords*— *VMware, Virtual box, Performance, testing, analyzing, hypervisor type 2.

I. Introduction

Virtualization is growing exponentially and is one of the emerging concepts of cloud computing and increases the growth rate of the organization. Virtualization can be defined as, the methodology of dividing and virtualizing the different layers of the computer hardware such as, CPU, memory, storage etc. It creates a virtualized environment of the computer physical hardware and lets other OS and instances to run in that environment as its hardware. Virtualization always has been an important part of cloud computing and is gaining much more popularity and importance in this field. There are many types of virtualization and each type focuses on virtualizing a type and feature of the computer hardware devices such as, storage, network, application, processing virtualization. In this paper I will be focusing on processing virtualization, it is a concept where the processor of the computer is virtualized, and the cores of the CPU are assigned of a virtualized environment.

Processing virtualization can be done on the bare metal of the computer that is hypervisor type 1 and inside a hosted OS using a software solution, this is hypervisor type 2. In this paper I will be evaluating the performance of the top 2 players in the market for type 2 hypervisor they are, VMware workstation pro and oracle virtual box.

In the following sections of the paper, I will be explaining the process and background studies in performance evaluation of these two tools and processing virtualization. The second section is problem definition and background, in this I will be explaining the problems in these tools and background of these tools in providing processing virtualization solutions. Literature review section contains the reviews of papers and experiments conducted to analyse the performance of these tools. Experiment section contains the experiments conducted on the tools and windows 10 running in them using benchmark tools for CPU, memory and storage. The security section has the security features provided by the tools and some issues in security on the virtualized environments. The last section is analysis and conclusion, this where I conclude the experiments conducted and give results and analyse which tool performs better and give better results.

II. Problem Defination and Background

Virtualization first came into light in the late 1950s and 1960s, it was developed by IBM. IBM invested a lot of time and effort in developing this technology and thanks to them this technology is widely used by many organizations and companies to offer solutions to their customers and users. Virtualization is mainly used in data centers, where they have many systems and multiple instances running in each server all by using this technology. Emergence in data centers and more demand and less supply lead to the development of virtualization technology. Virtualization was developed to fully utilize and use all the resources of the computer's hardware. A single server can host multiple instances in it and efficiently offer each instance to different users and customers and the customers can login to the system from any where around the world. This technology really has been one of the major contributors in bringing cloud computing to light in the market and optimize the way the systems were used and offered.

Virtualization has many pros and advantages that it can offer and make things easier and efficient. However, it still has some drawbacks and problems that needs further research and improvement.
Virtual instances running on the servers are always prone to vulnerabilities and has security concerns to be considered all the time. If the host hypervisor or the host OS is attacked or sabotaged by an attacker, it would it turn make all the virtual

instances running in it vulnerable and the attacker would have access to them. If the virtual network is not secure and has malicious traffic coming in can also be dangerous for the virtual machines. If the hypervisor or the host OS has some issues with it, can make the virtual machines unstable and create problems for the user.
New security may arise everyday for these kind of solutions as having online access to a network is always not fully secure. Some of the known problems and issues in the hypervisor type 2 tools like, VMware workstation pro and oracle virtual box are listed below:

- Switching tabs in the console of workstation does not run while 3D applications are running.
- Multiple 3D applications running simultaneously may crash the workstation.
- Graphical performance issues.
- VTX errors.
- Optical drive errors.
- Network adapter driver problems.

Although virtualization has some drawbacks, its pros and advantages are way more and the cons are negligible in some cases. These problems might get fixed by the software solutions in their upcoming versions of the tools and update to the tools.

III. Literature Review

Many researches have been conducted on evaluating the performance of the hypervisor type 2 tools and solutions. In this section I will be reviewing some of these research papers and find the best tools and experimented results by the authors.

In this paper A. Elsayed and N. Abdelbaki [5] have evaluated the performance of the top players in the virtualization market. The top hypervisor selected by authors are VMware ESXI, Hyper-V, Citrix Xen, these tools are the top and most used hypervisor OS. The author is evaluating the performance of hypervisor type 1 solutions, which is installed on the bare metal hardware of the computer. These hypervisors can run multiple instances in them and provide wide range of features. The author conducts multiple tests on the CPU, memory and disk, storage to check their performance in different scenarios. The first test is conducted on the CPU utilization of these hypervisor, after the results obtained the CPU utilization was the lowest of Citrix xen hypervisor, it performed best followed by Hyper-V and then VMware. The next experiment was on the memory, in this test also it was found that Citrix xen hypervisor was again wining and followed by Hyper-V and VMware. For the disk performance also, Citrix performed better than another hypervisor. To conclude the authors work, Citrix xen hypervisor performed better than Hyper-V and VMware in all the test and experiments conducted. The paper is well presented, and the authors claims are well supported by the results shown in the paper and the sections are well constructed and well presented. The experiments conducted has enough evidence to reproduce the experiment and the research can further be continued.

Horalek, J *et al.* [7] has made a performance comparison between tools like VMware, Virtual PC and Virtual box. In this paper the authors have installed windows 7 in each of the tools and did run test to each of the guest OS created and on the host OS. The experiments conducted has been documented and the results are shown with the graphs shown in the article. The authors have conducted test on disk read and write and CPU performance and memory response. In the disk performance test, VMware performs the best with the highest read and write speed and next is followed by virtual box and virtual pc respectively. CPU encryption test, VMware did perform the best in this category as well followed by virtual box and virtual pc. The authors have also conducted test on the network performance of these tools, surprisingly virtual pc leads in this test with virtual box and VMware followed next. In computing API test virtual box takes the lead and performs the best. To conclude the authors work is well supported by the results included in the article and the claims are well supported. The test found that VMware performs the best, however, virtual box and virtual pc also beats VMware in some tests.

V. Timcenko *et al.* [6] have evaluated the performance of type 2 hypervisor tools and experiments on the tools and presented results. The authors have selected VMware, Virtual box, Microsoft Virtual PC like the authors in this article [7]. The tests are conducted on disk read and write capabilities and as well as the test on the host OS are well documented with graphical results. The authors have windows 7 as their guest OS with virtual configurations as intel Celeron 540 and 1gb of ram and 20gb of virtual disk. In test 1, they have checked the read and write speeds on file range 1B-1KB. VMware player leads the highest score in both read and write speeds and is followed by virtual box and virtual pc, VMware's score was almost the same of the host OS score. In the next test the file size was 1KB-10KB, VMware leads in this test as well followed by virtual box and virtual pc. In test 4 oracle virtual box leads in the file sizes 100KB-1MB and surprisingly VMware performs the least in this test. To conclude the authors work, they found VMware to be better in three of their test and virtual box better in one test. Overall VMware was consistent in its score and can be declared better than the other two tools. The authors claims are supported by the graphical results presented in the article. The experiments conducted can be reproduced and continued for further research.

In these articles and journal reviewed I found that for type 1 hypervisor solutions, Citrix xen performed the best and for type 2 hypervisor tools VMware performed the best.
In my research I will also be comparing VMware workstation and oracle virtual box for the overall performance in windows 10 as guest OS using multiple benchmark tools and will be presenting the results with graphs and charts.

IV. EXPERIMENT

In this section I will be conducting experiments on the virtual environments in this case OS is Windows 10 64bit, installed in each of the tools, VMware and virtual box. I have used multiple benchmark tools to get more accurate results and did run the tests multiple times to have better and accurate results from the tests.

A. Configurations of Virtual machines in tools.

I have used VMware workstation pro and oracle virtual box as the tools for hypervisor type 2 and in these tools, I have installed windows 10 64bit. The exact configurations of the virtual machines created are given below in the table.

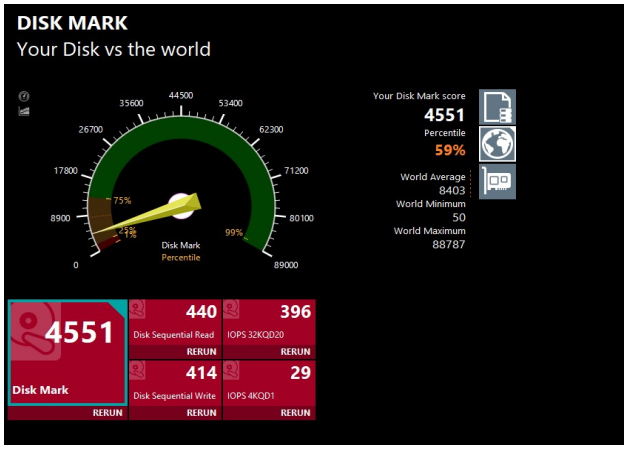
Tool Name.	CPU	Memory	Storage	OS
VMware workstation pro	Intel i5-8250U 2-cores	4 GB	30 GB	Windows 10 64bit
Oracle virtual box	Intel i5-8250U 2-cores	4 GB	30 GB	Windows 10 64bit

B. Tests on VMware Workstaion Pro.

I have used multiple benchmark tools to test the different aspects of the virtual instance and its performance. These tests are conducted multiple times to achieve better accuracy and results.
The following tests are conducted using Passmark benchmark tool: -

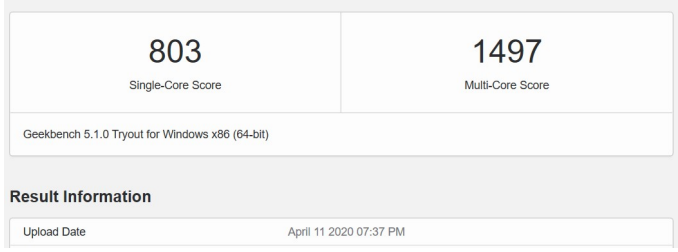
The CPU mark shows the benchmark obtained after conducting the test, it shows the scores in each of the different aspects of the CPU for ex: single threaded, cross platform mark, floating point math, sorting etc. The overall score obtained is 2970.

The memory mark shows the memory benchmark and performance of the memory in each task with read and write speeds of the memory assigned to the virtual machine. The total score of the memory mark is 1707.



Disk mark shows the disk and storage performance of the virtual machine. This runs test on the disk on read and write speeds and calculates the latency between them. The overall score obtained is 4551.

C. CPU single-core and multi-core score on VMware.



This score was obtained by using Geek benchmark tool on windows 10. This tool gives us a detailed benchmark of instructions on the processor and does the test separately for single core and multiple core of the processor.

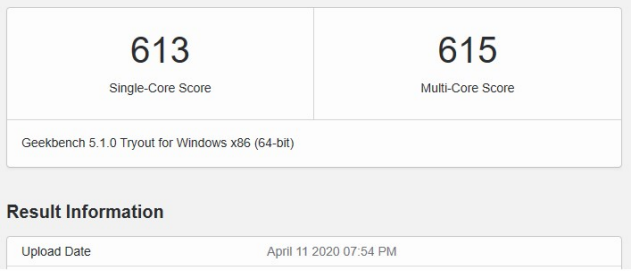
D. Tests on Oracle Virtual Box.

The same tools which were used to run benchmark test on VMware are used to test virtual box as well.

The CPU mark scores the performance of the processor in different tasks and gives a score. The score obtained by passmark tool in virtual box is significantly lower than the score obtained in VMware. The overall score obtained is 1210.

Disk mark score of both VMware and virtual box are close, because both the virtual disk created are stored in a single physical drive. The overall score obtained is 3847.

E. CPU single-core and multi-core score on Virtual Box.



This score was obtained by using Geek benchmark tool on windows 10. This tool gives us a detailed benchmark of instructions on the processor and does the test separately for single core and multiple core of the processor.

All these scores are cross-checked and are obtained by conducting multiple tests again and again to have better accuracy and results.

V. Security

Security is always one of the most important concerns when working with cloud and other online network services. VMware and virtual box both can work offline and as well as online letting users to connect to VM from anywhere around the world. Some of the security challenges of virtualization and its counter parts are listed below [3].

- VM Escape – an application can bypass the virtual layer and get access to the host OS.
- Malicious code injection- injecting malicious code in the virtual machine or the host pc.
- Guest-to-guest attack- with admin privileges the attacker can access multiple guest OS.
- VM Spawl- managing many virtual instances in a single server can open vulnerabilities.
- Hypervisor hyper jacking- hypervisor is attacked and the attacker gets access to the host layer of the system.
- (DDOS) Distributed denial of services attack- This type of attack is the most dangerous and commonly occurred attack, in this the attack floods the network with many request and block services.

These problems can destroy the network and can deny services to the customers. However, the tools and solution have some counter measures in place and offer security features which can help the provider with some leniency and comfort. Some of the security features offered by VMware workstation pro and virtual box are listed below:

A. VMware workstation Security features.

- Microsoft virtualisation security support.
- Virtual trusted platform module (VTPM)
- UEFI Boot support
- UEFI secure boot support
- Create/manage encrypted VM
- Virtual network renames
- Run encrypted virtual machines.

These are some of the security features that are offered by VMware workstation pro and it also offers other security features such as VM cloning and running restricted VM on it and others.

B. Oracle Virtual Box Security Features.

Oracle virtual box offers only few security features and not much development and focus has been on improving the security of the solutions offered, as this software is an open source solution.

- Network security
- Remote desktop authentication VRDP
- Clipboard – to share data between guest OS and host.
- Shared folders
- Encryption
- Graphics acceleration security

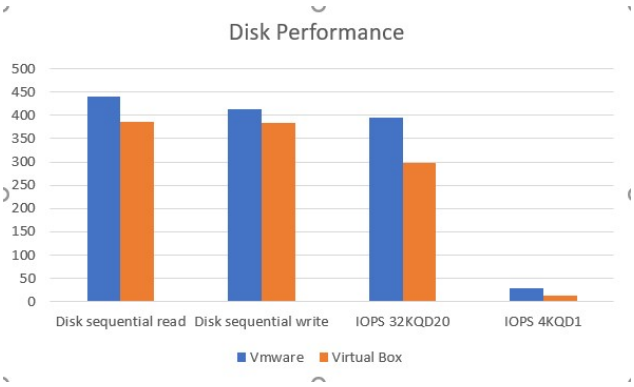
These are the security features of the virtual box. However, these does not make the virtual environment fully secure, as an attack on the host network may the guest OS vulnerable to attacks and can cause significant data loss and exposed privacy.

VI. ANALYSING THE RESULTS

In this section we will critically compare both hypervisor type 2 tools and conclude which tool is best in each case and in overall performance of the guest OS created inside these virtual environments.

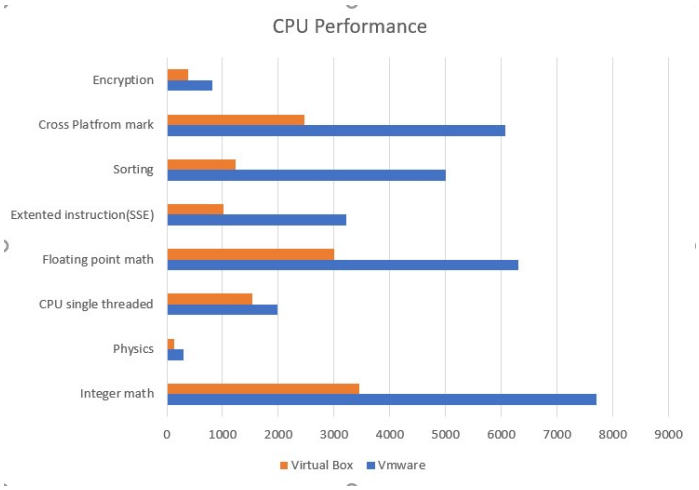
A. Disk Performance.

The below graph shows the comparison of benchmark scores obtained by the tests run on VMware and Virtual box. By looking at the graph we can see that the disk performance is slightly better in VMware than Virtual Box.



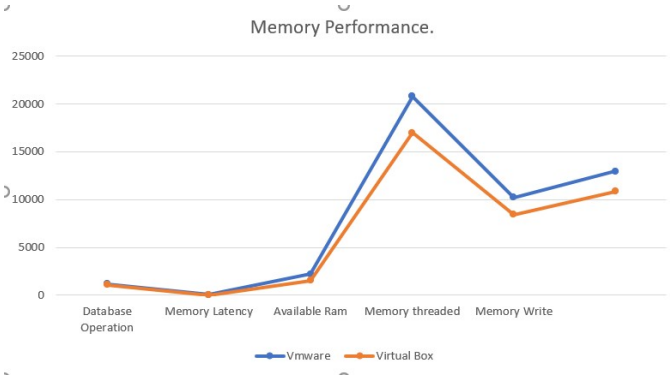
B. CPU Performance.

The below chart shows the scores of the CPU tasks obtained by the Passmark benchmark tool. The chart clearly shows that VMware is much better than virtual box in terms of CPU performance.



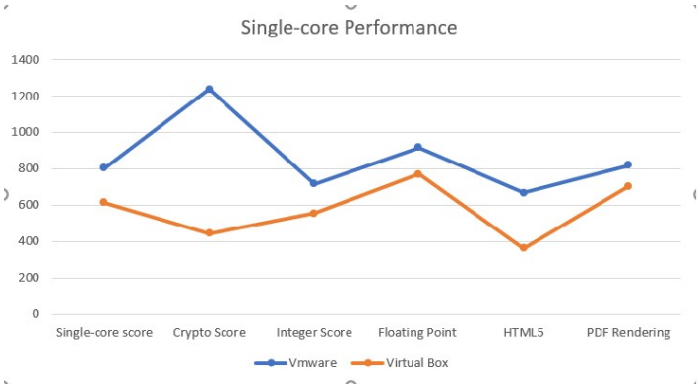
C. Memory Performance.

The memory performance is almost the same for both VMware and Virtual Box. However, VMware seems to perform better in memory read and memory write than virtual box.



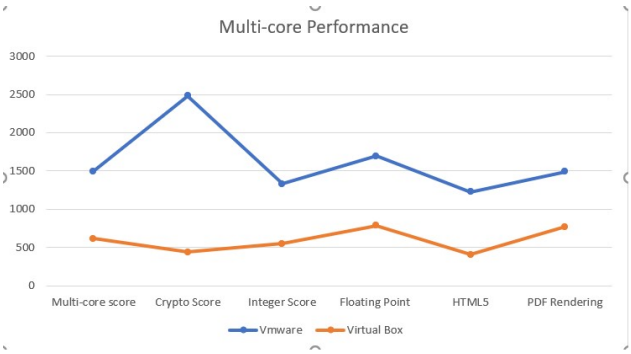
D. CPU Single-Core Performance.

This test was done by geek benchmark tool, in which it calculates the performance of the single-core processor in solving tasks and gives a score for the tasks achieved and time taken to complete. In this test as well, VMware performs much better than virtual box in all the tasks.

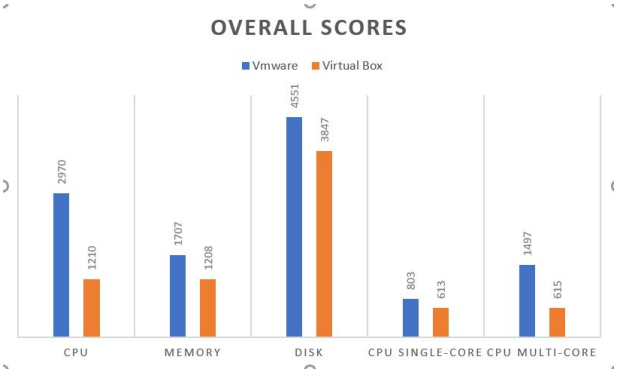


E. CPU Multi-core Performance.

This test was done by geek benchmark tool, in which it calculates the performance of the multi-core processor in solving tasks and gives a score for the tasks achieved and time taken to complete. In this test as well, VMware performs way much better than virtual box in all the tasks.



VII. CONCLUSION.



Processing virtualization is one of the important and most popular type of virtualization, this includes two hypervisor types 1 & 2. In this paper I discussed the hypervisor 2 and two best tools in the market for that. VMware and oracle are the two major players in this field. VMware workstation and oracle virtual box are the tools used with windows 10 running in them. By running multiple benchmark tools and multiple test we can see the results very clearly. I have conducted experiments on windows 10 installed on both the tools virtual environment. The results in the above bar graph show us that VMware workstation performs much better in all the aspects of the virtual computer, CPU, memory, disk and other graphical performances. I can conclude that out of these two tools VMware turns out to be the better performer and gives better results in running guest OS in it and is one of the best tool for type 2 hypervisor.

VIII. REFERENCES

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