Virtual Machine Benchmark Tests

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Abstract:-

Virtualization in Operating Systems refers to the act of running a virtual machine on top of a host Operating System. It is a method of dividing the computer resources in such a way that both the host Operating System and the Virtual machine's Operating System can utilize them in an efficient manner. To be able to run a virtual machine on a host Operating System we require a Virtual Machine Monitor (VMM) that creates and runs virtual machines. Our work here consists of taking some of the popular Virtual Machine Monitors and compare them using benchmark metrics. Our main areas of testing were Memory mark, Disk mark, CPU mark and 2-D graphics mark. The virtual machine's performance will then be compared to the baseline performance as a comparison with the real world. Thus, we have tried to incorporate some of the major information that the users takes into account before considering a Virtual Machine Monitor to run a Virtual Machine and make a comparison based on these between the different Virtual Machine Monitors available.

Keywords:

Virtualization, Virtual Machine Monitor, Benchmark Testing, Baseline.

1. Introduction

The Virtual Machine Monitors used for comparison in our work are VM Ware, Oracle Virtual Box and Microsoft Hyper-V. The testing areas include CPU, Disk, Memory and 2-D Graphics as they provide the most relevant information to a user. Performance Test conducts a series of different tests and then averages the results together to determine the Pass Mark for a system.

CPU Mark: To ensure that the full CPU power of a PC system is realized, Performance Test runs each CPU test on all available CPUs

We have shown the results of:

- Integer Math Test
- Floating Point Math Test
- Compression Test
- Single Threaded Test
- Encryption Test
- String Sorting Test

Where each test will be described later in the detailed content.

Memory Mark: It is again one of the major concerns of a user when it comes to running a virtual box with limited memory resources. A user always wants that the memory management should be efficient in order to get a proper functioning of the virtual machine. The different memory tests performed are:

- Memory Read (Cached)
- Memory Read (Un-cached)
- Memory Write
- Available RAM

Disk Mark: For each test a file is created on the drive under test. The file size needs to be large in order to get an accurate measurement. The test file size is 200MB and the read or write block sizes used are 16KB. Each test runs for at least 20 seconds. These standard tests have been stated below:

- Disk Sequential Read
- Disk Sequential Write
- Disk Random Seek

2-D Graphics Mark: Several GUI's including Operating Systems are based on 2D graphical concepts. This test ensures that the visual environment provided by Operating System is capable enough to handle the following cases:

- Fonts and Texts
- Image Filters
- Image Rendering

2. Methods

The tests were performed on a Lenovo ThinkPad (L430) with 8GB of DDR3 RAM and i5 processor with 4 cores. The guest OS was provided with 4GB of RAM and 2 cores of CPU. The host Operating System was Windows 10 and the Virtual Machine Operating System was Windows 7. The software used for benchmark testing was Pass Mark which is recommended by the official website of VM Ware.

3. Problem Statement

Virtual Machines allow you to be able to run a particular Operating System on top of your currently installed Operating System by taking up your computer's resources. When users want to install a virtual machine on their computer they are often faced with the problem of which Virtual Machine Monitor (VMM) to install. Is it going to be the Oracle Virtual Box? Or is it going to be VM Ware or the Microsoft Hyper V? Well, all three have been the big names in Virtual Machine Monitor Systems. So many to choose from! When a user allocates his computer resources to a VMM he/she wants those resources utilized efficiently used by the Virtual Machine to be able to experience a lag free environment. Thus, the Virtual Machine Monitor plays a big role as it is the one that takes care how the resources of the host OS are shared and managed for the proper execution and functioning of the Virtual Machine.

4. Related and Proposed Work

Virtual Machine Performance Benchmarking an article in Journal of Digital Imaging October 2011 by Steve Langer and Todd French is a work similar to ours. They performed trials on VMWare Player 7, VMWare ESXi Server V 4.0, Sun Virtual Box V3.1.2, Red Hat KVM V5.4, and Xen and the areas of testing included Local Disk Performance, Network Performance, Web Read performance, CPU Integer Performance and CPU Float Performance. So, how is our work different? The various Virtual Machine soft wares used by us are VM Ware, Oracle Virtual Box and Microsoft Hyper V. Since, these are the most commonly used Virtual Machines we decided to make a comparison between them so that it would be beneficial for the users to decide which machine to use in order to properly utilize their computer resources. Also, the tests performed by us are CPU Mark, RAM Mark, Disk Mark 2D Graphics Mark, which are the tests that the users generally look upon before considering a VM for their PC. Thus, our work here focuses totally on the basic tests and the main Virtual Machines out there and not taking into account the machines which are not much used and the tests which are not relevant to the users.

5. Architecture

The architecture does not change with the test conducted thus, the general architecture is described and shown below:

Hypervisor is classified into two types:-

1) Native or bare-metal hypervisor
2) Hosted hypervisor

1) Native Hypervisor:-
It runs directly on hardware unlike hosted hypervisor which needs to be installed on the host OS.
In this type, hypervisor is loaded before the OS and it directly interacts with the kernel due to which it gives highest possible performance. It is generally used for enterprise applications or cloud computing.
Example: - Microsoft Hyper-V.

2) Hosted Hypervisor: -
It is a hypervisor that is installed on a pre-installed operating system. It can be used to run multiple VMs at the same time. This hypervisor can be

started and closed according to our needs and when we quit the hypervisor, it will free up all the resources it was using before.

It is generally used for personal use.

Example: - VM Ware, Oracle Virtual Box.

Standard Hosting Architecture   Bare Metal With Hyper
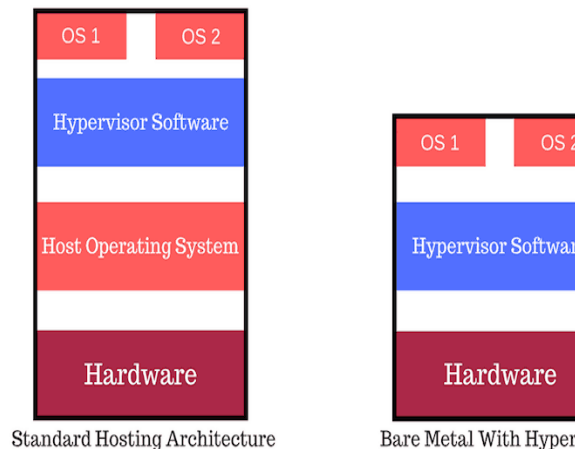
6. Modules

The paper is divided into four modules where each module is a test conducted which includes the algorithm used for that particular test, the observation (result of the comparison between the different virtual machines) and the winner of that test. We have here a very general algorithm for benchmark testing where we simply describe how the test takes inputs, performs various operations depending on the test and then output the results.

6.1 CPU Mark Test

Algorithm:

In CPU mark testing, where we perform integer and floating point based tests, our input

1. Select which test you want to perform, i.e. CPU, Memory, Disk, 2-D Graphics.
2. Select the subcategory

CPU:

Integer, Floating Point, Compression, Encryption, String Sorting, Single Threaded.

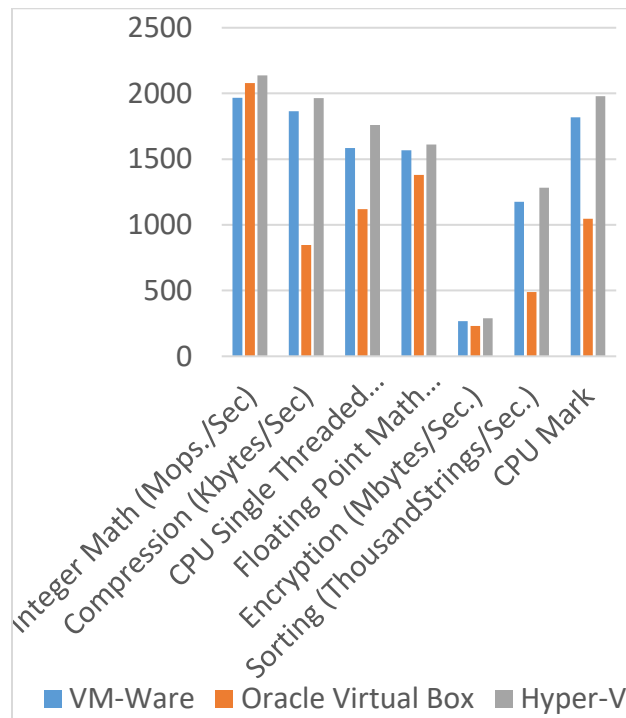   a) Integer and Floating Point are somewhat similar tests where we perform mathematical operations and on numbers. In Integer Tests, the numbers are only integers whereas in Floating Point we also deal with decimal values.

b) String Sorting Test uses Quicksort Algorithm as it is the fastest among all sorting algorithms, to sort random strings and see how fast the computer can sort them.

c) Encryption is the process of mapping a string to a value with the help of an encoding function and generate an encryption key. It tests the ability of the computer to create hash values of the data to be encrypted and then again decrypt it with the help of the key.

Data → Encrypted Word → Encrypted Word + Key → Decrypted Word.

d) Single Threaded test is an aggregate of the floating point, string sorting and data compression tests.

e) The Compression algorithm is described in detail below:

Suppose we have to compress this message: "hello".

➔ In this message '**l**' is repeated 2 times in this message.

➔ So using the LZ77 method, we see that the second occurrence of 'l' is after <1, 1> where the first one is representing the distance from the first occurrence and the second 1 is representing the length of the repeated word.

➔ Now after the compression is done by using LZ77 method, by using Huffman coding, the literals and lengths are stored in a single Huffman code and the distances are stored in another Huffman code.

➔ In this way, using LZ77 method, the compression is done and to ensure that data loss is not occurred and also while decompressing, the data is decompressed as it was before compressing, Huffman tree is used.

➔ The PassMark algorithm uses this DEFLATE algorithm and gives the output in Kbytes/Sec.

➔ The more Kbytes the CPU can compress per second, more is its compression score.

Observations:

Chart categories (x-axis): Integer Math (Mops./Sec), Compression (Kbytes/Sec), CPU Single Threaded..., Floating Point Math..., Encryption (Mbytes/Sec.), Sorting (ThousandStrings/Sec.), CPU Mark

Legend: VM-Ware, Oracle Virtual Box, Hyper-V

Observations:

Chart categories (x-axis): Memory Read(Uncached)..., Memory Read(Cached)..., Available RAM(Megabytes), Memory Write (Mbytes/Sec.), Overall Memory Mark

Legend: VM Ware, Oracle Virtual Box, Hyper-V

Winner: Microsoft Hyper V although VM Ware gave a tough competition but Oracle Virtual Box was nowhere to be seen.

Winner: VM Ware and Microsoft Hyper V performed equally while Oracle Virtual Box still remained below the two.

6.2 Memory Mark Test

Algorithm:

Memory tests check how fast the VM can read from the memory and write to the memory. The read and write algorithms are the same as Disk tests but in this case we write and read to and from the memory instead of the disk.

- For this test, the passmark software creates a large test file which the OS reads several times and reports the results in MB/sec.
- Similarly, for checking the memory writing ability it writes a file of about 500Mb from start to end.

6.3 Disk Mark Test

Algorithm: Disk Sequential Read, Disk Sequential Write

- Disk Sequential Read creates a large test file. Reads the file several times and reports the result in MB/sec.
- Similarly for Disk Sequential Write a large test file of 500Mb is written from start to end.

Observations:

VM Ware ■ **Oracle Virtual Box** ■ **Hyper-V**
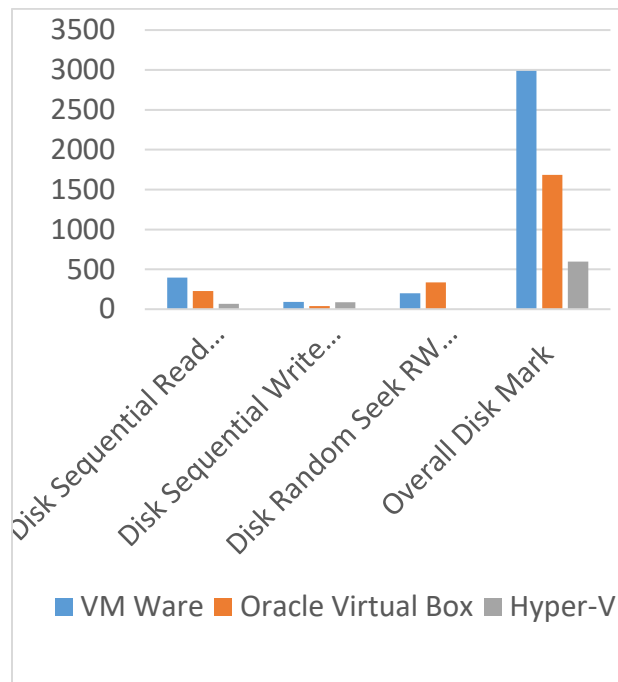
Winner: VM Ware was a clear winner while Oracle Virtual Box and Microsoft Hyper V were way behind.

6.4 2D Graphics Mark

Algorithm:

- Fonts and Text:-
  This test takes a sample text and then changes the font size from lowest possible font size available to the biggest font size available. It also takes a sample image and then it increases & decreases size of image and then records the performance of the video card based on this test.
- Image Filter:-
  This test takes a sample image and then applies several different image filters (for example: black and white filter or any other filter) and records the video card performance.
- Image rendering: -
  It checks how many images it can generate using a 2D model. Output is given in thousand images per second.

Observations:

VM Ware ■ **Oracle Virtual Box** ■ **Hyper-V**
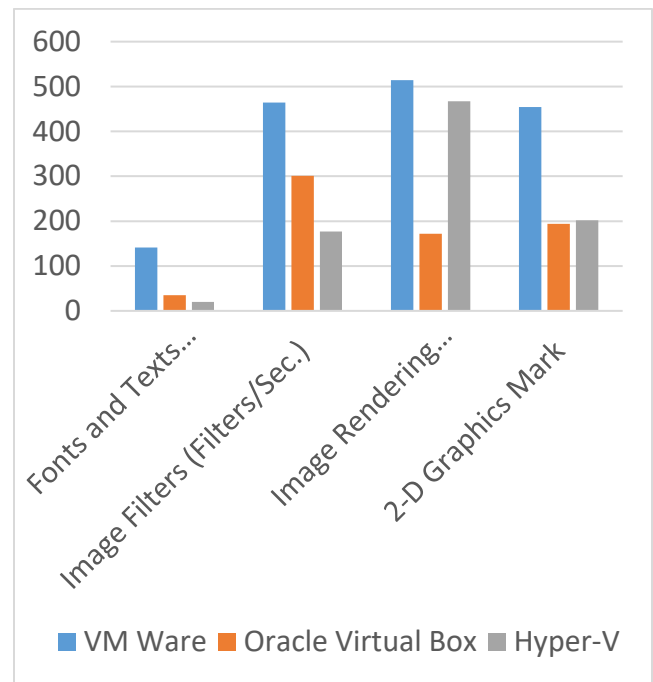
Winner: VM Ware once again was a clear winner while Microsoft Hyper V and Oracle box performed equally but far below VM Ware.

7. Problems Faced

Once we found the 3 virtual machines to compare with, we had this challenge of how are we going to test several features in each of the virtual machines. After some research, we finally got a solution which using the passmark software to perform several tests such as CPU tests, 2D test, Disk and memory tests.

While testing, we faced problems during the "Font and texts" testing in 2D features. Virtual machine became(Microsoft's Hyper-V as well as in Virtual Box)became unresponsive during the execution of the test since the operations/second was very low in case of both these virtual machines due to which the virtual machine began to stay unresponsive for some time. However, we got the result after some time of unresponsiveness.

We were unable to record the 3D test results since we got the result for VM-Ware and not in case of Hyper-V and Virtual Box. The software "passmark" ran

smoothly in case of VM-Ware but when we performed the tests in Hyper-V and Virtual Box, the software crashed and the process ended. So we had to exclude the 3D testing in case of Hyper-V and Virtual Box since our main goal was to compare particular tests on the three different virtual machines.

8. Results

Following is the comparison with Average Scores i.e. our system performance comparison with the World and also the comparison between the different Virtual Machines we used:-
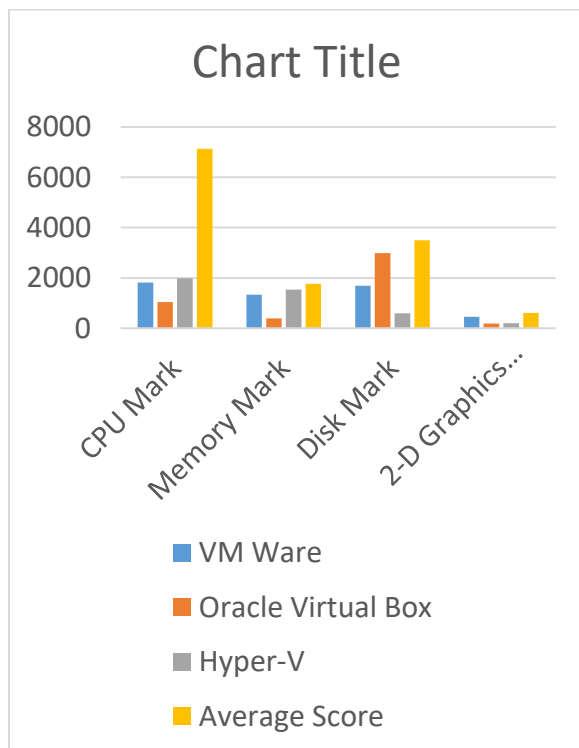
9. Conclusion

After performing the tests, we arrived at a conclusion that **VM Ware is the best** virtual machine since it gave the best performance in 2-D test, it was very close to the other virtual machine's performance in case of CPU, Memory and Disk tests and it was not as buggy as Hyper-V.

The second best is Hyper-V since it also gave a very good competition to VM Ware but gave a very low score in case of Disk test.

The worst Virtual Machine is Virtual Box since it came out with a very low score for all the tests except Disk test.

10. Acknowledgement

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