

Performance Measuring and Comparison of VirtualBox and VMware

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Abstract. Virtualization is a framework of dividing the resources of a computer into multiple execution environments. More specific it is a layer of software that provides the illusion of a real machine to multiple instances of virtual machines. Virtualization offers a lot of benefits including flexibility, security, ease to configuration and management, reduction of cost and so forth, but at the same time it also brings a certain degree of performance overhead. Furthermore, Virtual Machine Monitor (VMM) is the core component of virtual machine (VM) system and its effectiveness greatly impacts the performance of whole system. In this paper, we measure and analyze the performance of two virtual machine monitors VMware and VirtualBox using LINPACK and IPERF, and provide a quantitative and qualitative comparison of both virtual machine monitors.

Keywords: Virtual Machine Monitor, Performance, Comparison, Benchmark.

1. Introduction

Years ago, a problem aroused. How to run multiple operating systems on the same machine at the same time? The solution to this problem was virtual machines. Virtual machines monitor the core part of virtual machines sits between one or more operating systems and the hardware and gives the illusion to each running OS that it controls the machine. Behind the scenes, however, the monitor actually is in control of the hardware, and must multiplex running OSes across the physical resources of the machine. Indeed, the VMM serves as an operating system for operating systems, but at a much lower level; the OS must still think it is interacting with the physical hardware. Thus, transparency is a major goal of VMMs.

Today virtual machine has become popular due to various reasons. Server consolidation is one such reason. In many settings, people run services on different machines which run different operating systems (or even OS versions), and yet each machine is lightly utilized. In this case, virtualization enables an administrator to consolidate multiple Operating systems onto fewer hardware platforms, and thus lower costs and ease administration. Virtualization has also become popular on desktops, as many users wish to run one operating system (say Linux or Mac OSX) but still have access to native applications on a different platform(say Windows). This type of improvement in functionality is also a good reason. Another reason is testing and debugging. While developers write code on one main platform, they often want to debug and test it on the many different platforms that they deploy the software to in the field. Thus, virtualization makes it easy to do so, by enabling a developer to run many operating system types and versions on just one machine. It also serves for security, ease of configuration etc.

2. Related works

In [5,6,7,8,9,10], the importance and the architectural approaches of virtualization techniques have been discussed in detail. The VMM is in the control of the hardware. But these studies say that, the hypervisor should multiplex the loaded Operating systems across the system hardware resources. So transparency is the

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major goal of virtualization. In the field of hypervisor performance measurement and comparison, there has been few works like [1,2]. [1] talks about the analysis and comparison of the performance of two open source virtual machine monitors which are Xen and KVM using the benchmarks (LINPACK, LMBench and IOzone), and make a comparison of both virtual machine monitors. LMBench is a set of micro benchmarks which measure the bandwidth and latency values of hardware and Operating system resources. IOzone is a filesystem benchmark which creates and measures a number of file operations. The LINPACK benchmark takes the problem dimension details as the input and provides the output as GFLOPS. [3] and [4] talks about how this LINPACK should be used in order to attain the accurate measurements.

In [2], the analysis of hypervisors Xen, Kvm and VMware is done. The comparison is carried out using benchmarks which can measure the overall performance, performance isolation, and scalability of virtual machines running on these three hypervisors. The benchmarks used here are defined according to the SPEC and TPC standards. [11] gives a clear idea about the usage of a network performance benchmark called Iperf which creates server and client functionalities and tests the performance of the connection (TCP or UDP) between them. In [14] VirtualBox which is an Oracle product is introduced so that the flexible and effective usage of the hypervisor is guaranteed.

3. Virtual Machine Monitor

3.1. VMware

A hosted x86 virtualization monitor which can run a guest operating system unmodified with some performance loss. The x86 architecture offers four levels of privilege known as Ring 0, 1, 2 and 3 to operating systems and applications to manage access to the computer hardware. While user level applications typically run in Ring 3, the operating system needs to have direct access to the memory and hardware and must execute its privileged instructions in Ring 0. Virtualizing the x86 architecture requires placing a virtualization layer under the operating system (which expects to be in the most privileged Ring 0) to create and manage the virtual machines that deliver shared resources. Some sensitive instructions can't effectively be virtualized as they have different semantics when they are not executed in Ring 0. The difficulty in trapping and translating these sensitive and privileged instruction requests at runtime was the challenge that originally made x86 architecture virtualization look impossible. VMware resolved the challenge by developing binary translation techniques that allow the VMM to run in Ring 0 for isolation and performance, while moving the operating system to a user level ring with greater privilege than applications in Ring 3 but less privilege than the virtual machine monitor in Ring 0. It does not support Hyper Threading³ and requires a host operating system, which means an extra layer and additional overhead.

3.2. VirtualBox

Oracle VM VirtualBox is an x86 cross platform open source virtualization software package, now developed by Oracle Corporation as part of its family of virtualization products. VirtualBox is a so-called "hosted" hypervisor. To a very large degree, VirtualBox is functionally identical on all of the host platforms, and the same file and image formats are used. This allows you to run virtual machines created on one host on another host with a different host operating system; for example, you can create a virtual machine on Windows and then run it under Linux.

VirtualBox primarily uses software virtualization to run virtual machines. This is the default behavior for any virtual machines (with the exception of 64-bit guest operating systems) created within the VirtualBox environment. VirtualBox does, however, provide the option to enable hardware virtualization on a per virtual machine basis when running on AMD-V and Intel-VT capable CPUs. On more recent

CPU designs, VirtualBox is also able to make use of nesting paging tables to improve virtual machine performance. Support for USB and RDP is missing.

4. Benchmarks

4.1. LINPACK

LINPACK (LINear system PACKage) contains a number of FORTRAN subroutines based on BLAS (Basic Linear Algebra Subprograms) library to work out different linear equations and linear least-squares problems written by Jack Dongarra, Jim Bunch, Cleve Moler and Pete Stewart. LINPACK was designed for applying to supercomputers in the 1970s and early 1980s and now acts as one of the most authoritative benchmarks in high performance computers. The TOP 500 computers in the world are sorted by the LINPACK's result. To follow the development of computer architectures, LINPACK evolves into EISPACK and LAPACK. EISPACK mainly dedicates to numerical computation of the Eigen values and eigenvectors of matrices. LINPACK measures the actual peak value of float-point computing power indicated in giga of float-point operations per second (GFLOP/s or GFLOPS).

4.2. Iperf

Iperf is a network benchmarking tool which is used to measure the bandwidth and quality and was developed by NLANR/DAST. This tool is check the health of the link and gives output in terms of network parameters. Iperf is written in c++ and is available for both windows and Linux. In this we have a client and server functionalities and can measure the throughput between them. Both TCP and UDP connections are possible between this client and server. Here, client sends data to the server. If the connection is TCP, bandwidth will be the output. If the connection is UDP, jitter and loss datagram will be the prime outputs. The quality of a link can be tested using 3 parameters. Latency (response time or RTT) can be measured with the normal Ping command. Jitter (latency variation) can be measured with an Iperf UDP test. Datagram loss can be measured with an Iperf UDP test.

5. Performance Measurement

Here we have done a comparison of VMware and VirtualBox by benchmarking virtual machines using LINPACK and Iperf. The virtual machines were created on VMware and VirtualBox. The configurations were as follows: Processor: Intel i3. Memory: 1GB. CPU frequency: 1.344 GHz. Number of CPUs: 1. Number of cores: 1. Number of threads: 1.4 virtual machines were created. Two on VMware and two on VirtualBox each with the above configuration. Out of the two virtual machines on VMware one contain Windows XP Dark edition as guest OS and the other one contains Ubuntu 10.10 as guest OS. Out of the two virtual machines on VirtualBox one contain Windows XP Dark edition as guest OS and the other one contains Ubuntu 10.10 as guest OS. Each virtual machine was created with Ubuntu 10.10 as the host operating system. In the first experiment we ran LINPACK to compare the floating point operations of virtualized XP and Ubuntu in VMware and virtualized XP and Ubuntu in VirtualBox. The input to the LINPACK tool were the problem size, this indicates the number of equations to be solved, the leading dimensions of array, number of trials and the data alignment value in Kbytes. The output is the number of GFlop operations per second. 5 tests were performed with problem sizes 1000, 3000, 5000, 7000, 10000 their corresponding leading dimensions being 1000,3008, 5000, 7008 and 10000 respectively. The number of trials being 1,2,2,3,2 respectively with data alignment value of 4 KB. Ubuntu on VMware surpassed all other virtual machines in performance. As shown in fig.1, the least performance is shown by Ubuntu on VirtualBox. But XP on VMware and VirtualBox shows almost equal performance. So from this experiment we can conclude that VMware performs better than VirtualBox.

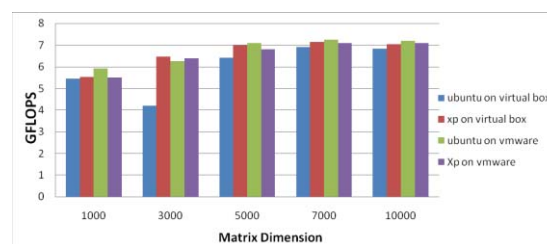


Fig. 1: Performance in different environments and cases in LINPACK

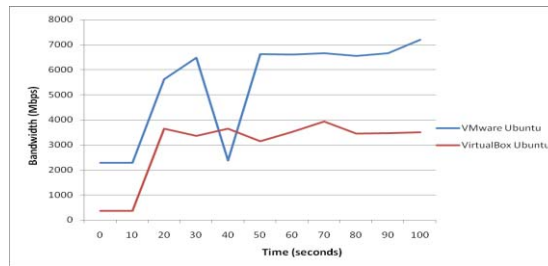


Fig. 2: Bandwidth of both Hypervisors in Ubuntu in Iperf

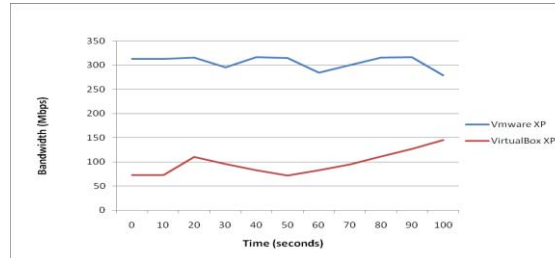


Fig. 3: Bandwidth of both Hypervisors in XP in Iperf

Now we use Iperf which is a network testing tool to compare the response of each virtual machine. The client sends the data to the server and Iperf checks the speed and the quality of the networking. Here, we have the same system as the client and server. Server receives the packets from a port which is different from the port from where the client sent the data. The connections can be TCP or UDP. The bandwidth values are calculated during the TCP connection. The packet loss and jitter time, which refers to the quality of the network, are calculated during the UDP connection. Round trip time is also calculated as a quality measure. The experimental data of the bandwidth during TCP connection is as in fig.2 and fig.3. The graph in fig.2 denotes Ubuntu in VMware and Virtual Box. The graph in fig.3 denotes Windows XP in VMware and Virtual Box. The blue line in both graphs indicates VMware and the red line indicates VirtualBox.

Table 1: Quality measurement of network in Iperf

	Avg. RTT(ms)	Avg. jitter(ms)
VMwareUBUNTU	.0624	.0159
VMware XP	1.5	3.4086
VirtualBoxUBUNTU	.1952	.0181
VirtualBox XP	.75	.446

6. Conclusions

Firstly we described the basic knowledge about VMware and VirtualBox and two benchmarks LINPACK, IPERF and conducted experiments to measure the performance of virtualized Ubuntu, XP on VMware and VirtualBox. We measured the processing speed (in the basis of number of floating point operations per second) and the network response (in the basis of bandwidth in TCP connection and quality of the network in UDP connection) for those Operating systems on the virtual machine monitors. Significant results were produced with which the comparison can be done.

7. References

- [1] J. H. Che, Q. M. He, Q. H. GAO and D. W. Huang, "Performance Measuring and Comparing of Virtual Machine Monitors". In International Workshop on End-User Virtualization on IEEE/IFIP International Conference on Embedded and Ubiquitous Computing (EUC2008), 2008.
- [2] Xianghua Xu, Feng Zhou, Jian Wan Yucheng Jiang. "Quantifying performance properties of virtual machine". International Symposium on Information Science and Engineering.2008.
- [3] [3] J.J. Dongarra, P. Luszczek and A. Petitet. "The LINPACK Benchmark: past, present and future". Concurrency and Computation Practice and Experience, 15(9):803–820, 2003.

- [4] Edward Anderson, Z. Bai, C. Bischof, Suzan L. Blackford, James W. Demmel, Jack J. Dongarra, J. Du Croz, A. Greenbaum, Sven Hammarling, A. McKenney, and Danny C. Sorensen. LAPACK User's Guide. Society for Industrial and Applied Mathematics, Philadelphia, PA, Third edition, 1999.
- [5] M. Rosenblum and T. Garfinkel. "Virtual Machine Monitors: Current Technology and Future Trends". IEEE Computer, 38(5), 2005.
- [6] R. Uhlig, G. Neiger, D. Rodgers, et.al. Intel Virtualization Technology. IEEE Computer, 38(5), 2005.
- [7] VMware Inc. Understanding Full Virtualization, Paravirtualization and Hardware Assist. White paper. 2007.
- [8] P. Padala, X. Zhu, Z. Wang, S. Singhal and K. Shin. "Performance Evaluation of Virtualization Technologies for Server Consolidation". Technical Report HPL-2007-59, HP Labs, April 2007.
- [9] V. Inc. A Performance Comparison of Hypervisors. Technical report, VMWare Inc., 2007.
- [10] Jon dugan. Iperf Tutorial Summer JointTechs 2010, Columbus, OH
- [11] P. Apparao, R. Iyer, X. Zhang, D. Newell and T. Adelmeyer, "Characterization & analysis of a server consolidation benchmark". In Proceedings of the 4th ACM SIGPLAN/SIGOPS International Conference on Virtual Execution Environments (VEE'08), USA: ACM New York, pages 21-30, 2008.
- [12] R. Shiveley, Enhanced Virtualization on Intel R Architecture-based Servers. Technology, 2005.
- [13] Oracle VM VirtualBox User Manual. <http://virtualbox.org>.
- [14] L.H. Seawright and R. A. MacKinnon. VM/370—A Study of Multiplicity and Usefulness. IBM Systems Journal. 18(1):4–17, 1979.