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Performance Evaluation of Virtualization and Non Virtualization on Different Workloads using DOE Methodology

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Abstract—**Different workloads utilize system resources at different levels. Depending on the resource utilization pattern some workloads may be better suited for hosting on virtual platform. This study is intended to compare how different workloads such as Online Analytical Processing (OLAP), Online Transaction Processing (OLTP), Web and Email applications perform on virtual and non virtual environments. Performance testing is very important in the software development life cycle of a Product. This work gives very exposure to the Customer and software testing professional about the usage and effectiveness of the Design of Experiments in software testing.**

Index Terms— **DOE, Email, OLAP, OLTP, Virtualization Workload, Web load.**

I. INTRODUCTION

Server virtualization plays an important role in the Information Technology (IT) sector. Virtualization reduces the total cost of ownership, saves power, floor rental costs etc. Owing to these advantages many companies have adopted this technology to consolidate a number of physical servers to single virtual server. Server virtualization is been achieved by using virtualization software such as VMware [1], Xen [2], etc. These software runs as Virtual Machines (VM) in a shared physical environment. Virtualization allows two or more environments to run on the same physical machine such that the different environments are completely isolated from one another. This technology transforms physical systems into a pool of logical computing resources. System resources are dynamically allocated to any operating system based on need. This leads to high utilization of hardware and software resources.

Virtualization [3] technology offers many advantages to datacenter administrators and end users. A lot of research has been done in the area of analyzing the applications on the VMs. However, there has not been much research into the performance of applications in the VM and non VM environments. Hence, a comparative study of application performance in VM and non VM environment helps in understanding the kind of applications that are best suited. This study will also deal about the applications that would perform better in these environments. The resulting information will help decision makers to host applications appropriately and hence derive optimum benefits of virtualization. To perform such a study in a scientific manner, the Design of Experiments (DOE) [4] methodology has been used. For this purpose, four real-time application workloads namely Online Analytical Processing (OLAP) [5], Online Transaction Processing (OLTP) [6], Web and Email workload applications have been used. The work has been organized and enumerated as follows: Section II discusses the overview of DOE; Section III depicts workload characterizations; Section IV presents details of experimental setup; Section V discusses interpretation of the experimental results; and Section VI discusses conclusions and future work.

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II. AN OVERVIEW OF DESIGN OF EXPERIMENTS (DOE)

DOE is a structured method for conducting an experiment and analyzing the resultant data. This method uses experimental factors and its levels for generating the test runs. Sir Ronald A. Fisher, the renowned mathematician and geneticist, first developed this method in the 1920s and 1930s. As well, there have been many other contributors to DOE theory viz, George Box, Dorian Shainan, and Genichi Taguchi and others. DOE also called statistical experimental design; it is a tool for determining the main and interaction effects of different factors affecting process quality and for calculating optimal setting for controllable factors. A combination of the factors and its levels makes us to experiment the system with many factors at a time. There are many DOE methods, such as fractional factorial, Placket-Burman method, mixture design, response surface design, etc. A full factorial experiment gives complete information since it operates at higher resolution level; therefore the results are obtained by running all possible combinations of experimental runs. However, this method is not suggestible for experiments with several factors. Since the number of factors used in this study are less, a full factorial design [7] like DOE method, which uses the ANOVA [8] as foundation for data analysis and regression analysis , have been used for fitting the model in to the system.

III. WORKLOAD CHARACTERIZATIONS

In the present work of study two factors namely Application workloads and System types have been used. Application workloads are set to four levels namely, Online Analytical Processing (OLAP), Online Transaction Processing (OLTP), Web and Email work load applications. These application workloads are simulated by using IOmeter tool [9] and System type as a factor having two levels VM and nonVM.

A. Application workload

The application workload factor defines the different types of applications used for the study. Each of the application type is characterized by I/O of a particular nature. Each type of application workload forms a level and the four levels used in this study are given below.

A.1 OLAP: Online Analytical Processing (OLAP) is characterized by the large data volumes and a lot of processing. Typical applications of this nature are in marketing, business performance management, budgeting and forecasting, financial reporting and planning. In this study, OLAP is characterized by having read/write ratio of 100:0 and ABS as 1024KBs.

A.2 OLTP: Online Transaction Processing Application (OLTP) is characterized by small I/O which is of random access nature. Typical OLTP applications with less transaction times such as Online Airline Reservation, e-Commerce and Supermarket Applications are also characterized by small I/O of random access nature. In this study, OLTP is characterized by read /write ratio of 70:30 and with Application Block Size (ABS) as 8KBs size.

A.3 Web load: Web workloads mix a variety of content and data-rich applications ranging from e-commerce and banking applications to CRM and self-service intranet applications. The Web load typically consists more of read than the write activity. In order to simulate the Web load, we have chosen read/write ratio as 90:10 and ABS as 16KBs.

A.4 Email load: The nature of Email load is usually random and inconsistent data size transaction activity. Many times the Email load comprises of more read and write-up activity. For this reason, to simulate the Email load the read/write ratio as 50:50 and ABS as 4KBs has been used.

B. System type

The System type factor defines the environment (VM or non VM) in which the application workload is applied. For the experimentation purposes, two levels for the assessment of the impact of virtualization on different workloads namely VM and non VM have been chosen.

B.1 VM: The Figure 1 shows the server virtualization in Storage Area Network (SAN) environment. This environment has VMware ESX3.5 server [10] on the hardware installed, thus a VM having Windows operating system has been created. The application loads mentioned in Section III.A is applied on the VM using IOmeter.

B.2 Non VM (NVM): The Non VM has Windows operating system installed on the hardware and IOmeter is used for generating different workloads as mentioned in Section III.A. The Table 1 given above classifies the summary of factors and levels as discussed in Section 3.

Table 1. Factors and Levels

Factors	Level1	Level2	Level3	Level4
Workload	OLTP	OLAP	Web load	Email Database
System Type	VM	NVM	-	-

IV. EXPERIMENTAL WORK

In this work, Server Virtualization setup is configured by using VMware, application, servers, HBA, SAN switch and storage array. The following Tables 2, 3, 4 and 5 shows the details of SAN components used for the experimentation purpose. The experimentation is done in VM and NVM environment.

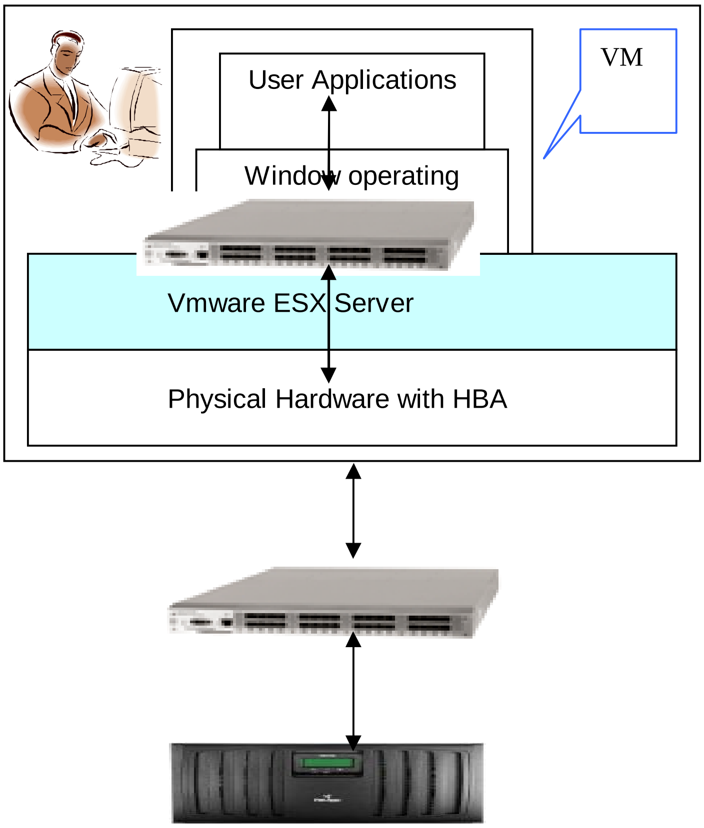

Figure 1. Show the server virtualization in SAN Environment.

In VM environment VMware is used for creating VMs and upon that Operating system is installed. In this work, the window operating system standard edition has been used for the experimentation purpose. The Figure1 shows that the server virtualization setup connects with the storage array and the LUN of the storage array is mapped to the VM server.

The user application loads, as mentioned in Section 3.1 are submitted by using IOmeter tool. This IOmeter tool generates the application traces and dumps in it the storage array. Similarly, the same kind of experiment has been done on the physical server (without the VMware). A LUN of size 10GB in the storage subsystem has been created to reduce the time preparing and configuring the disk and an application load is simulated using IOmeter tool, as indicated in Table 2.

Table 2. Shows the description of experimental application profile

Work Load	R/W Ratio	Application Block Size in Kb	Application Type
OLTP	70:30	8	Random
OLAP	100:0	1024	Sequential
Web Load	90:10	16	Random
Email Database	50:50	4	Random

Table 3. Details of IOmeter

Application factors	Specifications
Percent of Access	100 %
No of Outstanding I/Os	32
Burstiness	0
Run Time	2 Minutes
Ramp Up Time	30 Seconds

Table 4. Details of the Server, HBA and SAN Switch

Server	
Operating System	MS Windows Server Standard Edition, service pack1/Vmware 3.5
No of Processor	1
Type of Processor	Intel Xeon
Processor Speed	3.0 GHz
RAM	8 GB
HBA	
Speed	4Gbit/s
Queue depth used	32
Frame	2048
SAN Switch	
Speed	4Gbit/s
No of ports supported	8
No of ports used	2

Table 5. Details of the storage system

Storage	
Disk Drive Interface	Fibre Channel(FC)
Storage Speed	2 Gbit/s
Controller	Dual
Disk Drive Speed	15000 RPM
RAID Level	RAID-5
No of Disks/ Topology used	2D+1P/
Disk Drive Total Capacity	267.295GB
LUN size used	8GB
Cache Memory	2048 MB
Read/Write Cache partition	1000/472 MB

A. Experimental Runs

As the number of factors and levels were low, a full-factorial design has been used to get the entire main and interaction effects of the factors. The analysis includes three replicates, i.e. three measurements for each unique run to reduce the pure error in the experiment. These runs were randomized to reduce the influence on the system state due to a previous run. The initial design provided by Minitab [12] with single block and three replicates gave a total of 24 test runs. These test runs for the experiment are shown in Table 6.

B. Measuring the Throughput

The system was configured with NVM and VM; where as VMware Virtual Center 2.5 was used to configure the VM. The application was pumped using the IOmeter tool for 30 seconds duration for ramping up and two minutes to collect the throughput readings. The results are tabulated in the Table 6.

Table 6. Experimental runs and throughput recordings

Trail no	Work Load	System Type	Throughput in MBPS
1	Email	VM	2.92
2	Email	Non VM	3.31
3	OLTP	VM	6.33
4	OLAP	VM	62.04
5	Web Load	VM	14.21
6	OLTP	Non VM	7.22
7	Web Load	VM	14.37
8	OLAP	VM	62.9
9	Email	Non VM	3.24
10	Web Load	Non VM	16.97
11	Web Load	VM	14.1
12	Email	Non VM	3.27
13	OLAP	VM	62.67
14	Web Load	Non VM	16.27
15	OLTP	VM	6.24
16	Email	VM	2.96
17	Web Load	Non VM	16.58
18	OLAP	Non VM	71.4
19	OLTP	VM	6.32
20	OLAP	Non VM	71.75
21	OLTP	Non VM	7.24
22	Email	VM	2.91
23	OLTP	Non VM	7.28
24	OLAP	Non VM	71.7

V. Interpretation of Experimental Results

Before analyzing the performance benchmarking of application work load, there is a need to check whether the response data is statistically sound.

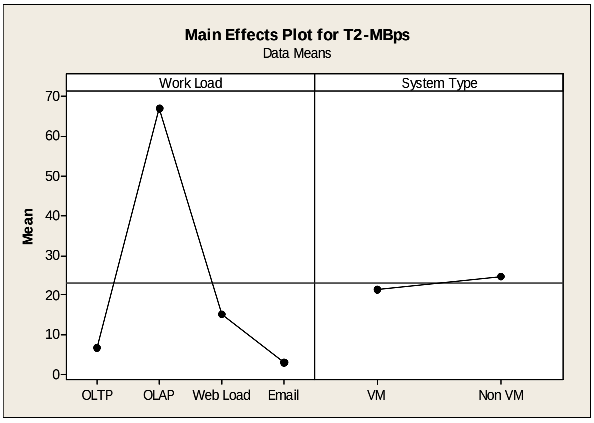

Figure 2. Main Effect of Workload and System type factors over throughput.

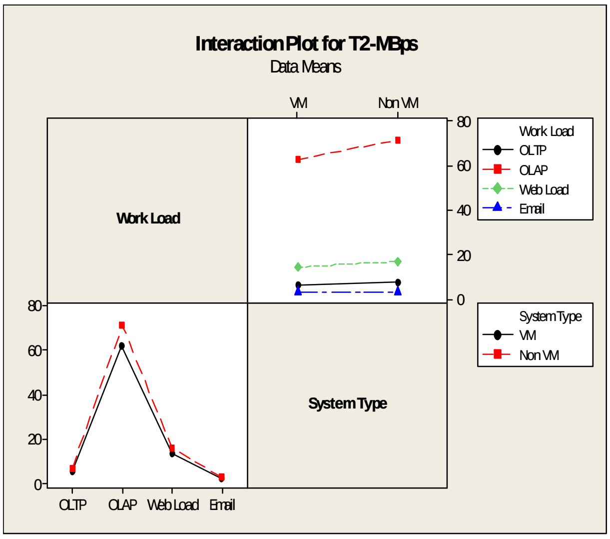

Figure 3 shows the interaction plot of the workload, System types.

There are some prime data analyses like check for outlier, check for normality, check for any pattern and presence of time trend with the residuals of the response data. The response (throughput) has passed the entire above mentioned statistical test and the data appeared to be faithful for further analysis. The main effects of application work load and system type graph in Figure 2 indicates that NVM gives better performance compared to VM. The actual performance improvement of NVM is 12.92 % with respect to VM over the mean throughput. It has been found in all interaction plots that, NVM outperforms the VM with respect to experimental work load factors. The relative performance results obtained from the interaction plots are helpful to ascertain clearly the performance level of the VM/NVM.

Application Type	System Type		Difference	Percentage of degradation
	NVM	VM		
OLAP	71.61	62.53	62.53	12.67
Web Load	16.60	14.22	14.22	14.33
OLTP	7.24	6.29	6.29	13.1
Email Database	3.27	2.93	2.93	10.39
System Type	24.68	21.49	3.19	12.92

- VM has more impact on the overall workload performance compared to NVM and overall it has 12.92% performance degradation
- NVM gives 12.67% better performance in OLAP compare to VM.
- NVM gives 14.33% better performance in Web load compare to VM.
- NVM gives 13.1% better performance in OLTP compare to VM.
- NVM gives 10.39% better performance in email database compare to VM

VI. Conclusions and Future work

There are several ways of doing testing. DOE is one of the cost-effective methods of conducting the software testing. This work presents two major contributions. Firstly, it has been proved as to which application would be better for VM and NVM environment and secondly, the estimation of level of application performance degradation on both VM and NVM were shown in scientific way. Thus, the future interests of this study are rooted in conducting the VMs performance analyses involving more factors at different component levels, like, HBA, SAN switches and SAN. Investigation is also being rooted into various techniques for performance modeling of the VM.

DISCLAIMER

The results described in this paper are derived from a particular benchmark configuration created specifically for this study; any extrapolation to other product comparison may not produce the same interaction graphs.

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