Comparative Study of Virtual Machine Software Packages with Real Operating System

Arunkumar Jayaraman
Pavankumar Rayapudi

This thesis is submitted to the School of Computing at Blekinge Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science in Electrical Engineering. The thesis is equivalent to 20 weeks of full time studies.

Contact Information:
Author: Arunkumar Jayaraman
E-mail: arunbtheespring@gmail.com

Author: Pavankumar Rayapudi
E-mail: rpk216@gmail.com

University Advisor:
Prof. Lars Lundberg
School of Computing
Blekinge Institute of Technology
Email: lars.lundberg@bth.se

University Examiner:
Dr. Patrik Arlos
School of Computing
Blekinge Institute of Technology
Email: patrik.arlos@bth.se

ABSTRACT

Virtualization allows computer users to utilize their resources more efficiently and effectively. Operating system that runs on top of the Virtual Machine or Hypervisor is called guest OS. The Virtual Machine is an abstraction of the real physical machine.

The main aim of this thesis work was to analyze different kinds of virtualization software packages and to investigate their advantages and disadvantages. In addition, we analyzed the performance of the virtual software packages with a real operating system in terms of web services. Web Servers play an important role on the Internet. The response time and throughput for a web server are different for different virtualization software packages and between a real host and a virtual host.

In this thesis, we analyzed the web server performance on Linux. We compared the throughput for three different virtualization software packages (VMware, QEMU, and Virtual Box). The performance results clearly indicate that the real machine performance is better than the performance of the virtual machines. VMware has the better performance compared to other virtual software packages.

Keywords: Virtualization, Virtual Machine, Performance, Web Server, VMware, Hypervisor

ACKNOWLEDGEMENTS

We are highly indebted to our supervisor Prof. Lars Lundberg for his motivation, guidance and suggestion throughout this project. We would like to thank all the interview participants those who contributed for the interview part on this thesis work. We would also like to thank our family and friends for their tremendous support. We would like to express our special gratitude and thanks to Dr. Patrik Arlos for his valuable information on thesis work.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

I/O   Input/output

VM   Virtual Machine

OS   Operating System

AFS   Andrew File System

NFS   Network File System

VMM   Virtual Machine Manager

SAN   Storage Area Network

SQL   Server Query Language

CPU   Central Process Unit

RAM   Random Access Memory

IBM   International Business Machine

IEEE   Institute of Electrical and Electronics Engineering

ACM   Association for Computer Machinery

HTTP   Hyper Text Transfer Protocol

PC   Personal Computer

GB   Giga Byte

GHZ   Giga Hertz

USB   Universal Serial Bus

LAN   Local Area Network

WLAN   Wireless Local Area Network

GUI   Graphical User Interface

1   INTRODUCTION

Virtual Machine (VM) is one of the main research areas in the telecommunication industry. The most important function of VM is to run multiple operating systems on the same computer and each operating system runs separately, not coinciding with the other on the host. The instruction set architecture is executed by the VM. Virtual Machine works like a real operating system and provides high level function to the end user [1].

Devi Prasad conducted a study to analyze the performance of sequential programs on a virtual machine. His study clearly shows two different virtual machine behaviors while executing sequential programs. VMware and QEMU virtual machines are implemented on the host OS. The host OS and the guest OS are connected through a bridge network interface [2].

Performance of storage systems on the real machine and the virtual machine are analyzed using three different storage methods such as direct attached disk, SAN and Raid array. Virtual machine functions fine when compared to the real machine storage systems. The I/O interface throughput will be same as the real server [3].

Roxana Geambasu conducted a study of VM performance on network file systems. She reported that the conventional use of remote access in a VM is accomplished by using the network file systems to access a VM image. Andrew File System (AFS) and Network File System (NFS) network filters are good at handling VM images. When the network and power management conditions are poor, AFS network filter utilizes large block size. This can be implemented when the network has a large latency. Roxana suggested using either NFS or tuned AFS-based network scheme, depending on the network conditions [4].

Performance evaluations are carried through some sort of workloads. Evaluating the workload under a specific computer model provides valid information about the computer architecture [5]. Performance of reading a file from disk varies from a real machine disk to a virtualization machine disk. Large files reading functions have been analyzed with real machines and VM. Large files are important for scientific and multimedia systems. Previous results indicate that the performance change is based on access modes data size and request size [6].

Guest OS and real OS performances have been evaluated using Windows XP, Windows Vista, and Windows 7 and guest OS was Windows Vista. This analysis of the performance of the three OS with the same guest OS virtual operating system shows that the best performance is obtained with Windows 7 [7].

SQL server performance tests have been conducted with real machines and virtual machines. This was done through installing multiple servers on virtual machines, which are executed by a single host machine. The SQL server works well on virtual machines. The virtual machine performs better without any special tuning of the SQL server [8].

1.1   Aims and Objectives

The main aim of this thesis work is to study different virtualization software packages. Our focus will be on performance of web services in virtualization software packages on top of a real operating system.

1.2   Research Questions

The following are the thesis research questions:

1. What are the most-used virtualization software packages?

2. What are the advantages and disadvantages with virtualization software packages?

3. What is the web service performance in terms of throughput for this software packages compared to real operating systems?

2   BACKGROUND

2.1   Virtualization

Virtualization technology is one of the main research areas in the field of computing. This was introduced and developed by IBM Corporation. IBM created several virtual machines on one physical mainframe. By using this virtualization technology, organizations can provide different services without increasing their network resources [9].

Virtualization techniques provide services same as the real machine services. The computer hardware can run only one operating system at a time; due to this limitation vast amounts of resources are underutilized. Hence by using virtualization technology the same computer hardware can run different types of operating systems on one physical machine. The virtual machines run on top of the host machine and share resources from the host machine. The virtual machines function without interfering with any other virtual machines on the same host [10].

Virtualization software packages make it possible to obtain a virtual representation of the underlying hardware. The represented hardware contains static memory, dynamic memory, and other resources like the real hardware machine. The OS can be installed using this hardware setting. It works like a physical machine, and the OS functions as a real OS. It is not possible to run more than one OS on a physical machine without virtualization. Here the CPU is not utilized completely by the real operating system. In this scenario, virtualization provides a better solution to the represented hardware which we get from the virtual software. It can run different OS on the single CPU without interrupting any other OS on the same machine [11]. This can be achieved through virtualization computing. Based on this virtualization technology the operating system can run on virtual hardware. Virtual hardware can, for instance, be emulated as x86 processors. It contains all the resources the real computing hardware has, so it is possible to run an operating system which can provide services like a real computer service on this hardware. Virtual machine is controlled by a hypervisor. A hypervisor, also called virtual machine manager (VMM), manages the guest OS and their storage areas, memory and other resources. The so called hypervisor is the backbone of the virtualization technology. There are two major types of hypervisors namely Type 1 and Type 2[12].

- *Type 1 Hypervisor:* In this scenario, we can run different types of OSs without considering the real operating systems on the host machine. The performance of a guest operating system is lower when compared to the real host operating system, but this way we can achieve portability.

- *Type 2 Hypervisor:* In this scenario, the hypervisor is connected between the guest OS and real machine. This performs better when compared to Type 1 hypervisor. Virtual machines are coupled with physical machine. Virtual machine runs like an application in the host machine.
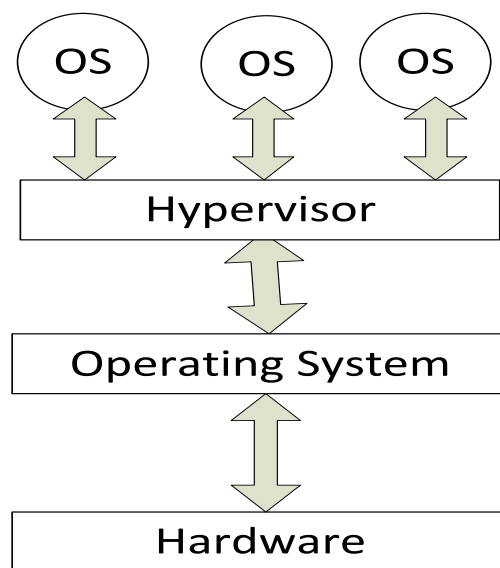
Figure 1- Type 1 Hypervisor
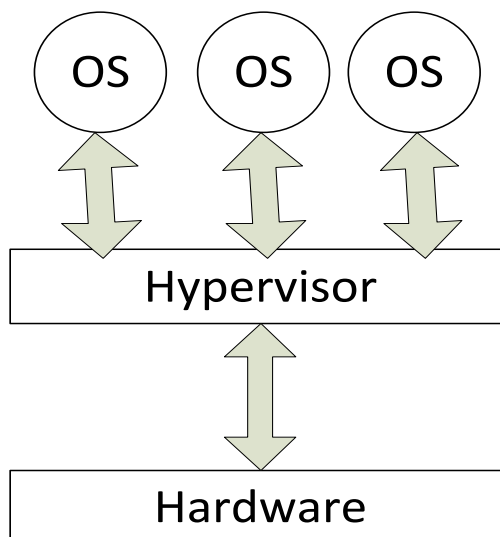
Figure 2- Type 2 Hypervisor

2.2   Virtualization Methods

2.2.1   Hosted Virtualization

In this scenario, this virtual machine is a complete abstraction of a real physical machine. It has the same features as a real physical machine including memory, operations, storage, etc. The complete virtualization can be achieved through abstract of underlying real host configuration emulation. The operating system running on the virtual machine and the real machine are called guest OS and host OS, respectively. VMware, Virtual Box, and Microsoft Virtual Server are a few examples of complete virtualization [13].

2.2.2   Para Virtualization

The guest operating system is not running on their virtual machine directly. It is not functioned as a complete virtualization. This virtualization is having the direct interface either with the hypervisor or with the VMM. This technique gives the enhancement of the guest operating system to improve its functionality, but it has some drawbacks that it does have to provide compatibility like complete virtualization. Para virtualization can be achieved through the hypervisor [14].

2.2.3   Desktop Virtualization

Desktop virtualization can provide desktop environment access through remote client so that the client can access the network resources from anywhere. The virtual desktop environments do not require a compatible system or any other hardware resources on the client side, but it requires only a network connection. The user can use the personalized desktop from a remote area through this connection [15].

2.2.4   Host Virtualization Desktop

The client host connects to the server virtual machine through personalized desktop or random assigning desktop method. The client connects to the data center through remote connection using client host login into the hosted virtual machine. The desktop virtualization application and services that are running on the server through this method provide greater security to data. The management of this virtual machine is also easy when compared to our traditional desktop methods [16].

2.2.5   Client Virtualization Desktop

In client virtualization model, the operating system is working on the portable device so that the device can carry and run into the system on a single host. This method is similar to the complete virtualization method. It provides greater security to data and also it is easy to manage the network. Protecting data and confidential information from hackers is important to any organization. Client virtualization provides greater reliability to data and it is easy to monitor each client activity [17].

Disadvantages of desktop virtualization

1. Providing high graphical interface to the client is a challenging task.

2. Requires a dedicated bandwidth for servicing clients.

3. Increased downtime in the event of network failures and bandwidth issues may lead to potential issues.

To overcome the above mentioned issues, it is better to provide higher bandwidth and reliable network connection which can handle the problems in the easiest way [18].

2.2.6   Memory Virtualization

Memory virtualization is a technique of using virtualization memory to run any form of virtual applications. To run multiple VMs on a system, it requires each VM to share and map its memory without coinciding with the other. The application performance is based upon the memory performance. If the application can access large amount of memory then it will increase the performance of the application [19].

2.2.7   Data Virtualization

Data virtualization is a collection of different data storages from different places. It provides a logical structure like a front end application. It can abstract dissimilar data sources through a single data access layer. It is easily portable and easy to manage the database with this data virtualization method. It helps user to access data with uninterrupted service [20].

2.2.8 Storage Virtualization

Storage Virtualization is collection of storages parts and presented as single storage. Virtualization storage appears as a single storage device from a central point of view. This storage technique is easy to manage; we can increase the storage amount without changing the network configuration. The storage places are dynamically allocated [21].

2.2.9 Network Virtualization

Network virtualization combines the entire network into a single mode and allocates its bandwidth, channels, and other resources based on its workload. All the devices in the network have some allocated resources so it is easy to manage the overall network and reliability of the computing is increasing by using this technology. This technology provides scalability to each group inside the network and increases the security to all devices participating in the network [11].

2.3 Virtualization Software Packages

2.3.1 VMware

VMware, Inc. is a company providing virtualization software, founded in 1998 and based in Palo Alto, California, USA. The company was acquired by EMC Corporation in 2004, and operates as a separate software subsidiary. VMware developed virtual software packages with a combination of binary translation and direct function on the processor for x86 based platforms; this provides a way to run virtual machine software packages. The software can run multiple guest OS simultaneously on the same physical host with virtualization software packages [22].

There are several software packages that VMware is delivering to the IT market; they are listed below:

1. VMware view

2. VMware Thin App

3. VMware Workstation

4. VMware vSphere

5. VMware vCenter Server

6. VMware studio

7. VMware vFabric Product Family

8. VMware vCenter Operations

9. Management suite

10. VMware Go.

2.3.2   Virtual Box

Oracle VM Virtual Box (formerly Sun Virtual Box) is an x86 virtualization software package, created by software company Innotek GmbH, purchased by Sun Microsystems, and now developed by Oracle Corporation as part of its family of virtualization products. Oracle VM Virtual Box is installed on an existing host operating system as an application; this host application allows additional guest operating systems, each known as a Guest OS, to be loaded and run, each with its own virtual environment.

Supported host operating systems include Linux, Mac OS X, Windows XP, Windows Vista, Windows 7, Solaris, and Open Solaris; there is also a port to FreeBSD. Supported guest operating systems include versions and derivations of Windows, Linux, BSD, OS/2, Solaris and others. Since release 3.2.0, Virtual Box also allows limited virtualization of Mac OS X guests on Apple hardware, though OSX86 can also be installed using Virtual Box.
Virtual Box supports software and hardware virtualization. The current version of Virtual Box is 4.1.6. [23]

2.3.3   QEMU

QEMU stands for "Quick Emulator" and is one of the virtualization software packages that rely on dynamic binary translation. QEMU was written by Fabrice Bellard and is free software. It can run guest operating system on host machines based on the dynamic binary translation technique. QEMU virtual machine has two operating modes:

1. User Mode Emulation
2. System Mode Emulation

In user mode emulation QEMU can launch processes compiled for one CPU to another CPU under the same operating system. All the systems call process are executed directly on the host machine. In system emulation mode QEMU emulates a full system, including one or

several processors and various peripherals. This user emulation method operating function is similar to the real host machine and proving good performance.

QEMU supports the emulation of various architectures, including IA-32 (x86) PCs, x86-64 PCs, MIPS R4000, Sun's SPARC sun4m, Sun's SPARC sun4u, ARM development boards (Integrator/CP and Versatile/PB), SH4 SHIX board, PowerPC (Prep and Power Macintosh), ETRAX CRIS and Micro Blaze architectures. Due to this vast feature QEMU is used to run on different machines with different operating systems based on the requirement of the end user. QEMU virtual machine software package emulates all peripherals required to run the operating systems. QEMU virtual hard disk images can be stored in a special format on the host storage device [24].

2.4   Benefits of Virtualization

2.4.1   Hardware Reducibility and Reusability

Virtualization ensures the efficient utilization of hardware without increasing the hardware resources in an organization. Virtualization utilizes hardware resources more effectively without wasting the resources from the existing hardware architecture. This feature can reduce the necessity to buy new hardware to the organization. Virtualization network architecture not only provides savings to the organization, but also potentially reduces the amount of physical space that an organization needs for its servers [9].

To allocate hardware for each server or application is time consuming and cost investment for companies. To maintain the hardware and resource allocation are the main roles and responsibilities for networks administrators. Virtualization technology overcomes all the major problems and provides a way to use the hardware resources to a maximum extent and bring the nearest performance of real machine through the virtual machine [25].

2.4.2   Cost Reduction

Expanding an existing IT infrastructure is expensive for organizations. It requires adding servers that requires more money investment. Virtualization in general reduces the IT sector investment cost for infrastructure; also it provides a way to use variety of operating systems, services application, different storage methods and servers [26]. The method of assigning individual server to each application is increasing the cost for an organization. Virtualization

network infrastructure has an ability to separate servers and applications from the hardware. It uses the server as a pool for all services to separate each service [27].

2.4.3   Disaster Recovery

Disaster recovery needs proprietary hardware resources, skilled operators, complex configurations, and complex testing process. Fulfilling the above needs require high cost investments, which limits the implementation options of disaster recovery. Thus virtualization is a cost-effective way for disaster recovery for many companies. Failure of the main server or else some crash on remote server is a big challenge for IT organizations. To recover the information with less time is one of the main motives during the disaster situation in the companies. Virtualization allows recovering the data from the servers and providing solutions with less downtime and minimal impact or no loss for the information from the server. After a disaster occurs, to run the services it mainly depends on the backup from the existing server or virtual server images quality. In this scenario, virtualization quickly copies the existing image from the servers with less downtime [28].

Double take protection software offers IT infrastructure protection, move and recover options. Double take provides full failover and data replication for business based servers similar to SQL and Microsoft Exchange [29].

Double take technique provides security to existing recovery method; improve the data security and loss with less impact on down time. To eliminate downtime on failover, the administrator can access the real time data copies of a secured application similar to database and email. The double take service is constantly monitoring the primary data. If any failover occurs, it automatically switches to secondary real time backup servers so that the services will not be affected during the situation. The end-user services are not interrupted in this method. Double take protection provides full security to the server on real time [30][29].

2.4.4   Server Migration

Server virtualization allows quick portability. Server migration is a common practice in organizations. Moving a physical server from one place to another place is still in practice but it requires lot of time. Hence the downtime of the server is increased due to the physical migration of servers from one place to another place. Virtualization allows migrating the server from remote site, offering simple solutions with less downtime. When the server load increases during the processing time, the data center manager can move the running virtual

machine server to another hypervisor in order to increase the processing capability of the server [31].

2.4.5   Power Consumption

Lowest power consumption is one of the main advantages of virtualization technology. It consumes less power for operating the virtual network infrastructure. This leads the company to become energy efficient to save fewer amounts on their electricity bills. Cooling the data centers also consumes more power for traditional physical machines, but virtualization network reduces the cost of cooling [32].

2.5   Challenges in Virtualization

2.5.1   Security Issues

Running multiple virtual machines on same physical hardware isolates the service on the underlying server without coinciding with other services on the same machine but the physical machine should guarantee that the machine is secured from threats. If the physical machine security fails, all virtual machines hosted on the physical server are at high risk. The security of the virtual machines based on the network infrastructure. The VM network mode should be more secured in order to keep the data safe from intruders. Virtualization provides more target nodes to malicious software and intruders. Information security providers need to understand the network more deeply to design security policies inside the network [33].

2.5.2   Physical Machine Failure

Virtualization networks consist of more virtual LAN on a single physical machine. In case of virtual machine failure in the LAN will not affect the other virtual machines in the same LAN. If the physical machine fails, it will affect the overall virtual machines that are hosted on the physical server. Hence it leads to massive shutdown of all the services offered from the physical machine [34].

2.5.3   Input/Output Request

Input/output request management is shared through shared storage from the physical machine. All I/O related commands need to access the command through host machine. If any of the I/O services command needs to execute, it uses the host resources. Virtualization

layer device communicates via host device layer. If virtual machine needs to perform any read or write operation, these commands executes through host device. The server level environment I/O accessing speed should be good in order to achieve better performance [35][34].

3   RESEARCH METHODOLOGY

Research Methodology
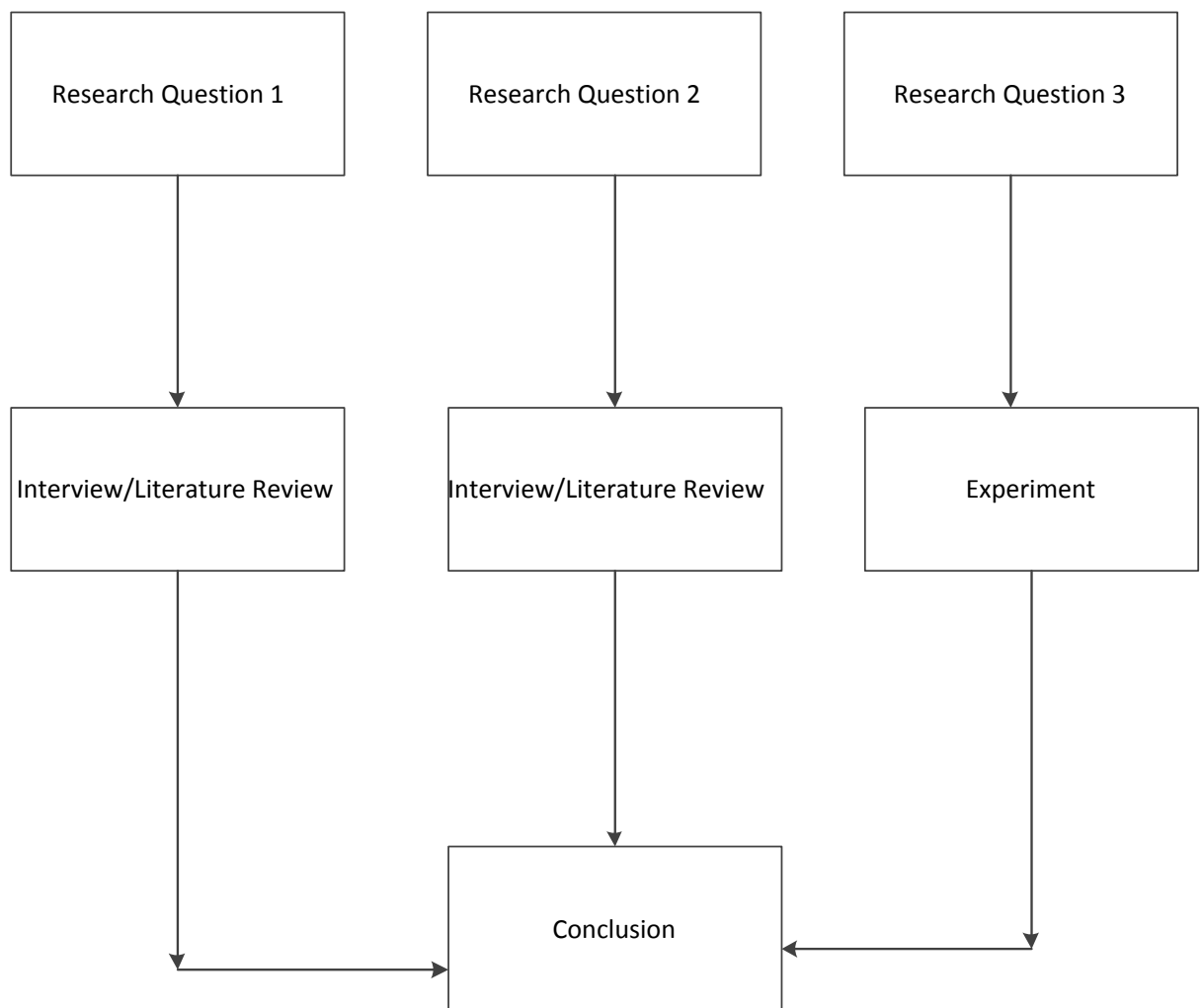
Figure 3- Research Methodology

3.1.1 Literature Review

Literature review is a key entry to research work. It helps finding the current research work and its related work on virtualization. We were identified the most-used virtualization software in the organization. We also investigated the advantages and disadvantages of their virtualization software.

We found the resources from databases like IEEE (Institute of Electrical and Electronics Engineer), ACM (Association of Computer Machinery), journals, articles and Google's scholar, etc.

We studied virtual software packages concepts and their recent development. This information is collected through our university library database. Furthermore, we accessed the information through internet search engines, based on this technical information; we designed our experimental model in order to answer our research questions. Later, we discussed the experimental setup with industrial experts as part of the interview. The model is evaluated, and results are observed.

We conducted an interview with industrial experts and we discussed about the real time situation based on our research questions. We collected the data from the interviews in order to validate our research.

3.1.2 Interview

The interview process helped us to gather information about virtualization software and their usage in organization environment. We have chosen semi-structured interview approach; the interview questions focused on research questions related to virtualization technology. The interview mode has been chosen based on convenience of the interviewee. The interviews were conducted through Skype and phone.

The interview questions have been formulated based on our literature review and related to our research questions. The questions have been reviewed with the help of our supervisor, after a brief discussion, we finalized our interview questions. During the interview, we have discussed about our research questions and interview questions, and the discussion has been carried related to our research area.

3.1.3 Experimental Model
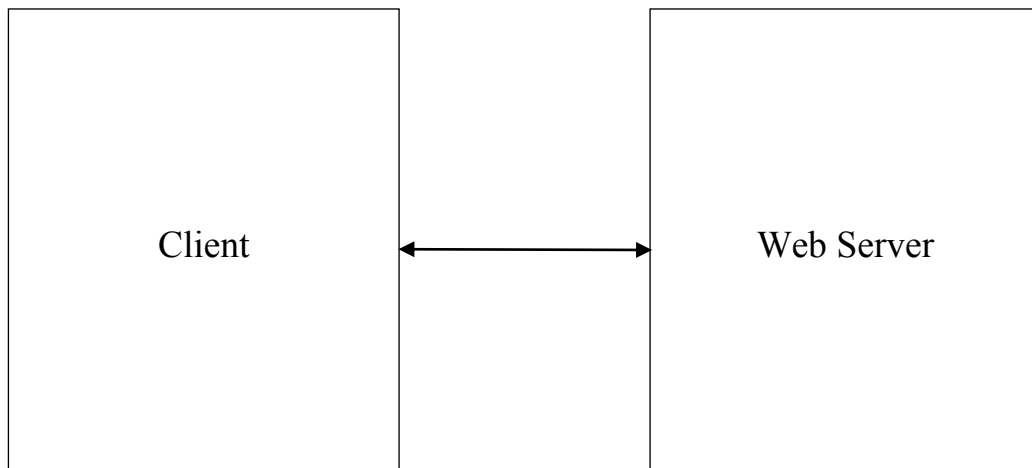
Figure 4- Experiment Model
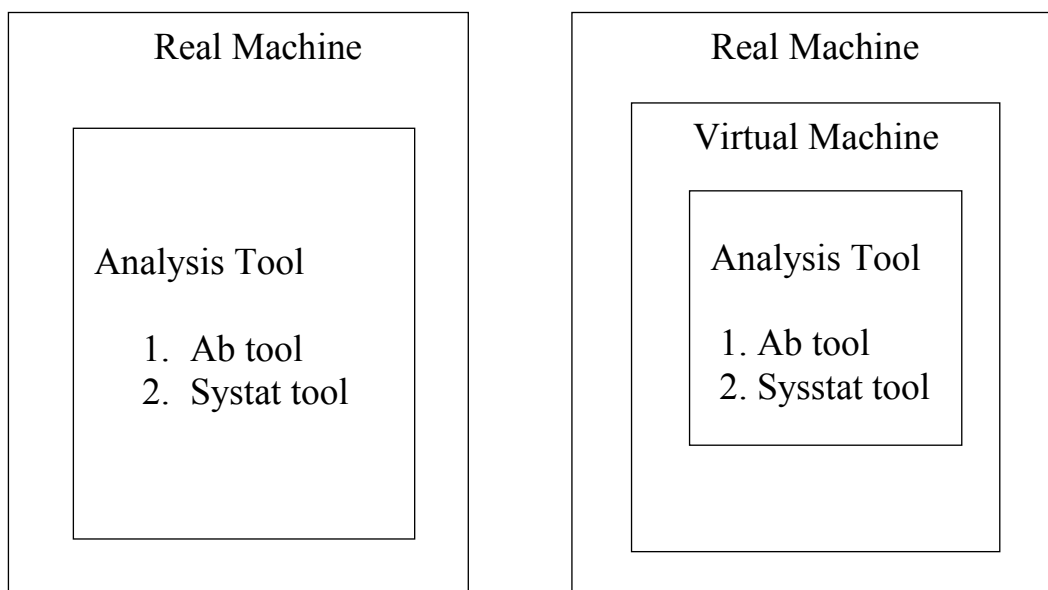
Figure 5– Experiment Model (Client Machine)

The results from the interviews and the literature studies provided the most familiar software in the organizations. We conducted an experiment to analyze the performance of web services both on virtual machines and real host machine.

In this section, a brief explanation about our experimental setup is described; we chose a computer with the following configuration: Intel Core 2 Quad Q6600 processor, 4 GB RAM, 2.4 GHZ and Dual core CPU.

We installed and configured Linux Fedora on a real machine and configured a server and a client with a wired connection. Apache web server was installed on the server machine. Web requests are sent from the client to the server. We closely monitored the request status, minimum connection time, maximum connection time, test total time, CPU I/O wait percentage and CPU user utilization percentage account as a measure.

We installed and configured the virtual software packages in the client machine. The packages have been chosen from literature review and interview results. We installed and configured the operating systems Linux Fedora on these virtual software packages. Later, we analyzed the performance of the web services on the guest OS.

Apache ab tool was used to measure the parameter's minimum connection time, maximum connection time, completed request, and total time. We choose this tool to analyze the performance of the mentioned parameters [39]. We analyzed the results with two different workloads Load 1 and Load 2. Load 1 consists of 1000 web requests and Load 2 consists of 2000 web requests.

In order to find the CPU I/O wait percentage and CPU user utilization percentage, we used a tool called Sysstat monitors packages. We run this tool simultaneously along with ab tool. CPU user utilization denotes the percentage of the CPU utilized by the user. The percentage of CPU usage is not same at all the time. It is used to vary depending upon the load on the system. The CPU user utilization percentage is not same for all the systems. It depends upon the physical configurations and the software architecture [40].

The CPU I/O time is one of the important factors that can influence the performances of the machine. It solely depends upon the system. If the system CPU I/O wait is high, it can degrade the performance of the machine. Virtual machines are accessing CPU services from the host machines. The virtual machines CPU I/O percentage is varied from virtual machine to virtual machine [41].

Completed Request is a parameter which we have taken to analyze the status of the web request. The entire http request was initialized from the client side. This parameter clearly denotes the status of the request [39]. Each request was sent from the client machine. The connection time is varying from machine to machine.

4   RESULT AND ANALYSIS

4.1   Experimental Results

4.1.1   Web Request

System	Completed Request (Load 1)	Competed Request (Load 2)
Real Host	1000	2000
QEMU	1000	2000
VMware	1000	2000
Virtual Box	1000	2000

Table 1- Request

Table 1 represents the Load 1 and Load 2 scenarios. It lists the number of web requests sent from the client systems and their status. Both Load 1 and Load 2 scenarios are implemented on the real host machine and the virtual machines and their responses are noted down.

The real host and the virtual machines completed all their requests successfully. The host machine and the virtual machines performance are same in this scenario. The requests are successfully completed on QEMU, VMware, and Virtual Box machines. The results are shows that all the virtual machines and real host performances are same in both of the loads.

4.1.2   Test Total Time

Machine	Load 1(sec)				Load 2(sec)			
	Min	Max	Mean	Std.dev	Min	Max	Mean	Std.dev
Real Host	1.24	1.27	1.25	0.01	2.50	2.61	2.52	0.04
VMware	1.70	2.14	1.93	0.27	2.97	3.70	3.34	0.32
Virtual Box	1.93	2.67	2,31	0.29	3.91	4.32	4.08	0.15
QEMU	1.89	2.12	1.96	0.09	3.27	3.97	3.60	0.25

Table 2 - Test Total Time

Table 2 represents the total time taken by the two loads. The table clearly shows that each machine's total time is varying and has a unique value. The Load 1 scenario of the real machine's total time is less compared to the total time of the virtual machines. Real machine is a step ahead on performance compared to virtual machines. Among the virtual machines, VMware is having less total time compared to Virtual Box and QEMU.

Load 2 scenario is reflecting the same performances among the virtual machines and the real machine. The values are varying from Load 1 to Load 2 scenarios, because the number of requests is doubled in Load 2 compared to Load 1.

 Real machine's total time is less when compared to other virtual machines. VMware performs better when compared the total time with Virtual Box and QEMU.

4.1.3 Maximum Connection Time

Machine	Load 1(ms)				Load 2(ms)			
	Min	Max	Mean	Std.dev	Min	Max	Mean	Std.dev
Real Host	2	3	2.2	0.44	4	5	4.6	0.54
VMware	2	4	2.8	0.83	5	7	6	1
Virtual Box	24	37	30.6	5.4	44	67	58.6	9.07
QEMU	23	26	24	1.41	43	60	47.8	6.97

Table 3– Maximum Connection Time

Table 3 represents web requests maximum connection time for Load 1 and Load 2 scenarios. Load 1 scenario real host and virtual machine's connection time are varying from one machine to another machine.

Real host and VMware connection time for Load 1 value is 2.2 ms and 2.8 ms. QEMU connection time is high in Load 1 scenario and Virtual Box value are less than QEMU and greater than real host and VMware.

The Load 2 scenario real host connection time is less compared to other machines. Virtual Box connection time is high among all machines. QEMU is lesser than Virtual Box. VMware value is less among all virtual machines. Both scenarios real host performance is best compared to other machines. VMware performance is best among all virtual machines.

4.1.4   Minimum Connection Time

System	Minimum Connection Time(ms)	
	Load 1	Load 2
Real Host	1	1
QEMU	1	1
VMware	1	1
Virtual Box	1	1

Table 4- Minimum Connection Time

Table 4 represents minimum connection time for http web requests in Load 1 and Load 2. Real host, QEMU, VMware and Virtual Box minimum connection time is one. The four machines minimum connection time is same in Load 1 and Load 2 scenarios.

4.1.5   CPU I/O Wait

Machine	Load 1(%)				Load 2(%)			
	Min	Max	Mean	Std.dev	Min	Max	Mean	Std.dev
Real Host	0.01	0.05	0.03	0.02	0.07	0.10	0.08	0.01
VMware	0.10	0.19	0.14	0.03	0.22	0.37	0.29	0.05
Virtual Box	0.47	0.67	0.52	0.08	1.10	1.97	1.22	0.10
QEMU	0.30	0.41	0.37	0.04	0.92	1.06	0.98	0.05

Table 5- CPU I/O Wait Percentage

The tables 5 representing the CPU I/O wait for each machine with respect to Load 1 and Load 2. The Load 1 scenario real host performance is good compared to virtual machine CPU I/O wait percentage. VMware CPU I/O wait is less among other virtual machines.

Virtual Box CPU I/O wait percentage is higher than the other machines. In the Load 2 scenario, real host performance is high compared to other machines. VMware CPU I/O wait percentage is low compared to Virtual Box and QEMU.

VMware percentage is good among the virtual machines, Real host CPU I/O wait percentage is better for Load 1 and Load 2 scenarios. Virtual Box utilization percentage is more among virtual machines.

4.1.6   CPU User Utilization

Machine	Load 1(%)				Load 2(%)			
	Min	Max	Mean	Std.dev	Min	Max	Mean	Std.dev
Real Host	0.61	1.25	0.89	0.23	1.48	1.81	1.58	0.13
VMware	1.56	2.01	1.82	0.17	3.63	3.96	3.76	0.16
Virtual Box	3.77	4.28	4.13	0.21	7.12	8.23	7.72	0.53
QEMU	3.12	3.82	3.57	0.30	5.92	6.27	6.07	0.21

Table 6- CPU User Utilization Percentage

CPU user utilization percentage is shown in the above table 6 for Load 1 and Load 2 scenarios. Load 1 scenario real host CPU utilization percentage is low among all machines. VMware percentage is low compared to other virtual machines. Virtual Box utilization percentage is more compared to real host and virtual machines.

The Load 2 scenario denotes the real host CPU user utilization time is low among all machines; VMware utilization is low among Virtual Box and QEMU. From the two loads, real host providing better performance than all other machines and the VMware provides best performance among virtual machines.

4.1.7   Analysis of Experiment Observations

The parameters that we monitored were: minimum connection time, maximum connection time, total time, number of request sent, completed request, CPU I/O wait time and CPU user utilization time. These parameters are observed based on the consecutive performance of the system.

The results shown from the two load tests clearly indicate that the performance of the real machine is outstanding when compared to the virtual machines. Although virtual machines cannot be compared with the real machines, the system resources can be utilized more effectively while using the virtual machines.

When we consider the total test time for the two loads, the real host machine's performance is better than the virtual machines' performance. The virtual machines total time is higher than the real machine because, virtual machine resources are directly depending on the real machine. All operations need to be executed via real host resources, so the parameters and their performances are not similar to real machines.

In virtual machines VMware performance is good, also it took less connection time among Virtual Box and QEMU. The parameter value of Load 2 is not exactly double as Load 1, but it's comparatively eighty-five percent higher than Load 1 value. The reason for this difference is the system network speed, CPU utilization time and I/O wait time and few more factors like power; network infrastructure can cause the difference between these results.

.

The connection time parameters also clearly shows that real machines performance is excellent compared to virtual machines. VMware maximum connection time is less value compared to other virtual machines. The real host machines and virtual machines web requests results are in same range.

CPU I/O wait is one of the factors that strongly influence performance of a system. The real host machine CPU I/O time is outstanding when compare to virtual machines. VMware CPU I/O wait time is less compared to Virtual Box and QEMU.

27

CPU user utilization percentage factor also clearly indicates that real machine usage is less along with virtual machines. Virtual Box user utilization percentage is high among virtual machines. VMware CPU utilization percentage is low compared to Virtual Box and QEMU.

4.2   Results from Interviews

4.2.1   Most Used Virtualization Software Packages

Most of the participants whom we interviewed during our thesis, took the name of VMware which they use very often. It is a virtualization software package delivered by VMware Inc. There are different versions of products from VMware Inc that are mainly based on the organization's requirements.

4.2.2   Virtualization Architecture

The commonly used architectures by these organizations is host virtualization and bare metal virtualization.. The virtualization methods can be chosen by the organizations, depending on their needs and services.

4.2.3   Advantages of Virtualization

Virtualization Software's are easy to manage when compared to real networking resources; also virtualization reduces the cost of the infrastructure management in IT. It allows using their physical resources effectively and more efficiently.

Virtual machines are easy to migrate from one place to another place, so if any failure arises, recovery can be done easily if the organization use virtualization software's. Virtualization is easy to upgrade from the existing version.

Virtual software packages provide ownership to the products with less cost. One physical machine can run multiple guest OS on a single processor. It allows dividing the physical memory into several parts and can use it for other applications, If any one of the guest OS create some problem, this will not affect other guest OS in the same processor. It can easily discard that particular guest OS without interrupting the other OS in the same machine.

Virtualization technology is used to test software's before introducing them into real word scenarios, by using this test they can analyze the performance of particular software to improve the reliability.

The servers need to be allocated for each service separately but, virtualization allows building the servers on a single physical machine so that the organizations can use several

servers with low cost. Virtualization allows designing their network with low cost with providing uninterrupted services to the organizations.

Server maintenance is made flexible while the organization uses virtualization technology; it allows servicing to the server without interrupting the existing servers in the same pool.

4.2.4 Problems in Virtualizations Software

Virtualization software is not compatible for all platforms. The physical host's failure in the organization can interrupt all guest machines which are installed on the host machine, so this is one of the high threats while using the virtualization technology.

The performance of virtualization is not same as real host machine. The structure of virtual machines is sometimes difficult to understand. It requires dedicated bandwidth connection to communicate on networks.

Some of the interviewees discussed that there are threats on security side of the virtual packages. The virtual machines need to be monitored very carefully from the intruders.

4.2.5 Virtualization Software Future

Virtualization is one of the most developing technologies in the field of computing. It supports various platforms and this feature leads to bright future in this field.

4.2.6 Performance Virtualization

Virtualization software provides good support and services in terms of web services. It depends mainly based on their services. It provides close performance to real machines.

4.2.7 Software Packages Types

Majority of the interviewees preferred commercial virtual software packages. Commercial software package providers offer many features on their products and also support their products for a specific time.

5   DISCUSSION

5.1   Validity Threats

Threats are common in all projects. There are several threats affecting the research findings. Here are the lists of threats that we faced while conducting the study.

1. Internal validity
2. External validity
3. Construct validity
4. Conclusion validity

5.1.1   Internal Validity

Internal validity is interventions of researchers while conducting research study and experiments. Our interview questions are mostly open-ended questions; we analyzed and noted down the main points from the interviewee. After the interview with the experts, we discussed the points from the entire interview. We discussed the points with the experts to confirm the validity of the information. All the interviews that we conducted are related to our core research area; furthermore, we conducted a literature review and the experiment. We analyzed all the factors, and we finally drawn few conclusions. These steps reduce the internal threats effectively [42].

5.1.2   External Validity

External validity is to make sure that the research approach and findings usually from the empirical and experimental data are generalized from other researches. We chosen the interview participants based on our core area of thesis work. We conducted seven interviews in different organizations that are relevant to our thesis. This reduces the level of external threats and increases the results to more generalized one [43].

5.1.3 Construct Validity

Construct validity is a relationship between the theory and observation of the results. Data Triangulation: In our study, we collected data from the literature review, interviews, and experiment results. It is quite difficult to analyze the results from the literature review, interviews, and experiment. To overcome this difficulty, we analyzed the results from three different modes and draw a conclusion very carefully. Primary Studies: The main motive of the literature review is to learn more relevant to virtualization software packages. Later we sorted out few virtualization software packages based on their types. [44].

5.1.4 Conclusion Validity

Conclusion validity is to validate the research results to be more reliable and reasonable. Prior to conducting the interview, we discussed few interview questions with our supervisor. After getting the feedback from our supervisor, we made necessary changes before conducting the interviews and also discussed the interview pattern and experiment model to avoid the maximum conclusion threat [44].

6   CONCLUSION

RQ1. What are the most-used virtualization software packages?

From literature review and interviews, we found the available virtualization methods and their virtualization software packages. In the interview process, we approached professionals currently working in the virtualization technology. They shared their views and experiences with us on the following aspects: most-used virtualization software packages in the industry and the reasons for choosing the software in their organization. From the interview and literature review, we found that the most-used virtualization software packages are VMware, Virtual Box, and QEMU.

RQ2. What are the advantages and disadvantages with virtualization software packages?

We used literature review and interviews to find the major advantages and disadvantages in virtualization software packages. We discussed with professionals about the software packages and their advantages and disadvantages. Virtualization software is easy to manage, and also reduce the cost of the infrastructure management in IT. It makes it possible to use physical resources effectively and more efficiently, and also it is easy to migrate from one place to another place. Disaster recovery is relatively easy, if the organization use virtualization software. It is also easy to upgrade a machine. It provides ownership to products at lower cost. A physical machine can run multiple guest OS and it is easy to divide the physical memory into several parts and can be used for different applications. If a guest OS creates some problem, this will not affect other guest OS on the same host and a particular guest OS can be stopped without interrupting the other OS on the same machine. Virtualization can also be used to test the software performance before introducing it to the real world. The organization can use several servers with low cost. The maintenance of servers makes them easy without interrupting the current services.

The virtualization software is not compatible for all platforms. Host machine failure can affect all the virtual machines running on that host. The performance of the virtual machine is not same as a real host machine, it requires dedicated bandwidth.

RQ3. What is the web service performance in terms of throughput for this software packages along with the real operating systems?

Parameters such as the number of requests; total test time, minimum connection time, maximum connection time, CPU I/O wait percentage and CPU user utilization percentage on web service application have been analyzed. The whole request is initialized from a client machine to the remote machine. The number of request parameter show that, all the machines completed their request successfully for the two work load scenarios that we considered. The performance is not the same for the real machine and the virtual machines. The total connection time parameter results point out that real machine took less total time to complete both Load 1 and Load 2. The virtual machine total time is higher compared to the real machine total time but VMware total time is lower than the total time for the virtual machines QEMU and Virtual Box. When we consider the connection time parameter, the real machine connection time is lower than the virtual machines. Among the virtual machines, VMware connection time is better than QEMU and Virtual Box. The two loads CPU I/O wait percentage indicates that real machine took fewer CPU I/O waits compared to the virtual machines. VMware has the lowest CPU I/O wait percentage among the virtual machines. The CPU user utilization for Load 1 and Load 2 is lower for the real machine compared to the virtual machines and VMware CPU user utilization is lower compared to Virtual Box and QEMU.

The analysis result clearly shows that real host performance is better than the virtual machines software packages web service performance. Virtualization software packages performance is not as high as for the real machine performance, but VMware performance is the best among other virtual machines when compared to Virtual Box and QEMU.

7   FUTURE WORK

This thesis focused and identified the most-used virtualization software packages with few advantages and disadvantages. The web service performances of these software packages are carried out based on accessing the web servers from virtual machines, and we noted down the parameters which we obtained from the experimental results.

To continue this work further, they can perform the network tests in these software packages and analyze their performance by varying the bandwidth capacity of the network.   Another continuity work from this thesis is, they can implement the Para virtualization platform for virtualization software packages and analyze web services in those software's.

8 REFERENCES

[1] Deshi Ye, Qinming He, Hua Chen, and Jianhua Che, "A Framework to Evaluate and Predict Performances in Virtual Machines Environment," *IEEE/IFIP International Conference on Embedded and Ubiquitous Computing, 2008. EUC '08*, 2008, vol. 2, pp. 375-380.

[2] D. P. Bhukya, S. Ramachandram, and A. L. Reeta Sony, "Evaluating performance of sequential programs in virtual machine environments using design of experiment," 2010 *IEEE International Conference on Computational Intelligence and Computing Research (ICCIC)*, 2010, pp. 1-4.

[3] I. Ahmad, J. M. Anderson, A. M. Holler, R. Kambo, and V. Makhija, "An analysis of disk performance VMware ESX server virtual machines," in *2003 IEEE International Workshop on Workload Characterization, 2003. WWC-6*, 2003, pp. 65- 76.

[4] R. Geambasu and J. P. John, "Study of Virtual Machine Performance over Network File Systems."

[5] L. K. John, P. Vasudevan, and J. Sabarinathan, "Workload characterization: motivation, goals and methodology," *Workload Characterization: Methodology and Case Studies, 1998*, 1999, pp. 3-14.

[6] Youhui Zhang, Gelin Su, Liang Hong, and Weimin Zheng, "On Virtual-Machine-Based Windows File Reads: A Performance Study," *Pacific-Asia Workshop on Computational Intelligence and Industrial Application, 2008. PACIIA '08*, 2008, vol. 2, pp. 944-948.

[7] G. Martinovic, J. Balen, and S. Rimac-Drlje, "Impact of the host operating systems on virtual machine performance," *2010 Proceedings of the 33rd International Convention MIPRO*, 2010, pp. 613-618.

[8] S. Bose, P. Mishra, P. Sethuraman, and R. Taheri, "Performance Evaluation and Benchmarking," R. Nambiar and M. Poess, Eds. Berlin, Heidelberg: Springer-Verlag, 2009, pp. 167–182.

[9] Yunfa Li, Wanqing Li, and Congfeng Jiang, "A Survey of Virtual Machine System: Current Technology and Future Trends," *2010 Third International Symposium on Electronic Commerce and Security (ISECS)*, 2010, pp. 332-336.

[10] Qiang Li, Qinfen Hao, Limin Xiao, and Zhoujun Li, "VM-based Architecture for Network Monitoring and Analysis," *Young Computer Scientists, 2008. ICYCS 2008. The 9th International Conference for*, 2008, pp. 1395-1400.

[11] Zhitao Wan, "A Network Virtualization Approach in Many-core Processor Based Cloud Computing Environment," *2011 Third International Conference on Computational Intelligence, Communication Systems and Networks (CICSyN)*, 2011, pp. 304-307.

[12] Y. Chubachi, T. Shinagawa, and K. Kato, "Hypervisor-based prevention of persistent rootkits," *Proceedings of the 2010 ACM Symposium on Applied Computing*, New York, NY, USA, 2010, pp. 214–220.

[13] Wei Chen, Hongyi Lu, Li Shen, Zhiying Wang, and Nong Xiao, "DBTIM: An Advanced Hardware Assisted Full Virtualization Architecture," *IEEE/IFIP International Conference on Embedded and Ubiquitous Computing, 2008. EUC '08*, 2008, vol. 2, pp. 399-404.

[14] J. LeVasseur et al., "Pre-virtualization: Soft layering for virtual machines," *Computer Systems Architecture Conference, 2008. ACSAC 2008. 13th Asia-Pacific*, 2008, pp. 1-9.

[15] Li Yan, "Development and application of desktop virtualization technology," *2011 IEEE 3rd International Conference on Communication Software and Networks (ICCSN)*, 2011, pp. 326-329.

[16] "Remote Desktop Virtualization Host." http://technet.microsoft.com/en-us/library/dd560648(WS.10).aspx.

[17]   Youhui Zhang, Xiaoling Wang, Gelin Hong Liang Su, and Dongsheng Wang, "Portable desktop applications based on user-level virtualization," *Computer Systems Architecture Conference, 2008. ACSAC 2008. 13th Asia-Pacific*, 2008, pp. 1-6.

[18]   R. Perez, L. van Doorn, and R. Sailer, "Virtualization and Hardware-Based Security," *IEEE Security & Privacy*, vol. 6, no. 5, pp. 24-31, Oct. 2008.

[19]   A. Agne, M. Platzner, and E. Lubbers, "Memory Virtualization for Multithreaded Reconfigurable Hardware," *2011 International Conference on Field Programmable Logic and Applications (FPL)*, 2011, pp. 185-188.

[20]   L. Weng, Gagan Agrawal, U. Catalyurek, T. Kur, S. Narayanan, and J. Saltz, "An approach for automatic data virtualization," *13th IEEE International Symposium on High performance Distributed Computing, 2004. Proceedings*, 2004, pp. 24- 33.

[21]   Zhang Qiang, Wu Yunlong, Cui Dong, and Dang Zhuang, "Research on the security of storage virtualization based on trusted computing," *2010 2nd International Conference on Networking and Digital Society (ICNDS)*, 2010, vol. 2, pp. 237-240.

[22]   J. Smith and R. Nair, *Virtual Machines: Versatile Platforms for Systems and Processes*, 1st ed. Morgan Kaufmann, 2005.

[23]   "VirtualBox." https://www.virtualbox.org/.

[24]   "QEMU." http://wiki.qemu.org/Main_Page.

[25]   R. Uhlig et al., "Intel virtualization technology," *Computer*, vol. 38, no. 5, pp. 48-56, May 2005.

[26]   C. Weltzin and S. Delgado, "Using virtualization to reduce the cost of test," 2009, pp. 439-442.

[27]   A. A. Semnanian, J. Pham, B. Englert, and X. Wu, "Virtualization Technology and its Impact on Computer Hardware Architecture," 2011, pp. 719-724.

[28]   T. Adeshiyan et al., "Using virtualization for high availability and disaster recovery," *IBM Journal of Research and Development*, vol. 53, no. 4, pp. 1-11, Jul. 2009.

[29]   www.vmware.com/pdf/vmware_doubletake.pdf "vmware_doubletake.pdf." .

[30]   http://www.vmware.com/files/pdf/DR_VMware_DoubleTake.pdf "DR_VMware_DoubleTake.pdf." .

[31]   G. Khanna, K. Beaty, G. Kar, and A. Kochut, "Application Performance Management Virtualized Server Environments," 2006, pp. 373-381.

[32]   M. Pedram and I. Hwang, "Power and Performance Modeling in a Virtualized Server System," 2010, pp. 520-526.

[33]   A. van Cleeff, W. Pieters, and R. J. Wieringa, "Security Implications of Virtualization: A Literature Study," 2009, pp. 353-358.

[34]   M. Rosenblum and T. Garfinkel, "Virtual machine monitors: current technology and future trends," *Computer*, vol. 38, no. 5, pp. 39-47, May 2005.

[35]   J. Kirkland, D. Carmichael, C. L. Tinker, and G. L. Tinker, *Linux Troubleshooting for System Administrators and Power Users*, 1st ed. Prentice Hall, 2006.

[36]   "The Essence of Research Methodology." ISBN 978-3-540-71658-7.

[37]   P. I. Newman, P. C. S. Ridenour, and C. Ridenour, *Qualitative-Quantitative Research Methodology: Exploring the Interactive Continuum*, 1st ed. Southern Illinois University Press, 1998.

[38]   S. E. Hove and B. Anda, "Experiences from conducting semi-structured interviews in empirical software engineering research," *Software Metrics, 2005. 11th IEEE International Symposium*, 2005, p. 10 pp.-23.

[39]   "Welcome to The Apache Software Foundation!" http://www.apache.org/.

[40]   "Linux Administration Handbook : Evi Nemeth, Garth Snyder, Trent R. Hein: Books." ISBN 0130084662..

[41]   H. Takahashi, H. F. Ahmad, and K. Mori, "Layered memory architecture for high IO intensive information services to achieve timeliness," *2008 IEEE 11th High-Assurance Systems Engineering Symposium, 3-5 Dec. 2008*, Piscataway, NJ, USA, 2008, pp. 343-9.

[42]   "Internal Validity." http://www.socialresearchmethods.net/kb/intval.php.

[43] "External Validity -- Educational Research -- Del Siegle."
        http://www.gifted.uconn.edu/siegle/research/Samples/externalvalidity.html.
[44] "Conclusion Validity." http://www.socialresearchmethods.net/kb/concval.php.

APPENDIX A

Interview Questions

Beginning of the Interview

1. What is your name?
2. What is your company name?
3. What is your designation at your company?
4. What is your designation role in your company?

Interview questions relevant to thesis work

1. Does your organization use virtualization software?

2. What is the name of the virtualization software?

3. What kind of virtualization architecture implementing in your organization?

4. What are the main reasons for using virtualization software?

5. How virtualization software can helpful to an organization?

6. What are the major problems in virtualization software?

7. How this can affect the organization?

8. What is the future of Virtualization Software?

9. What is the performance of Virtualization Software in terms of services?

10. Which type of Virtualization Software packages do you prefer?

    A. Open Source

      Why do you prefer open source?

    B. Non Open Source

      Why do you prefer non open source?

11. What is the performance of Virtualization Software services compared to real host operating system services?

APPENDIX B

Interview Transcription

Interview 1

Interview has been conducted from Balagi, IBM Corporation, Singapore. His designation in the company is advisory IT specialist and his role in the organization is optimizing the virtualization technology.

The interview has been conducted with two main motives. The first section of the interview, we have discussed about the various virtual software packages used in his organization. The interviewee mentioned a virtual software package called VMware and kernel based virtual machine QEMU. He discussed about the VMware virtual software package, which is one of the main software packages being used by most of the organizations.

He mentioned that VMware package is the most widely used product in their organization. We further continued questioning about architecture usage of the VMware in IBM, and his answer was there are different types of virtualization architectures available, but they are implementing full virtualization and Para virtualization architectures. We have asked about the services they are offering to their client or end-users, he told based on this architecture, their organization provide virtual servers to end-users.

Later, we discussed about main reasons to use the virtualization technology in their organization. He answered "We are using the virtual software packages in our organization to reduce cost of the physical resources, it is easy to maintain and manage the network infrastructure, and also it is easy to migrate from one place to another place. If any disaster occurs in the network infrastructure, virtualization allows usage of the physical resources effectively. These are the main reasons to use the virtual machines''

The only major drawback he mentioned about virtualization software was high-end server cannot be able to implement as a virtual machine, also when it comes to a security concern virtual machine is not good.

According to his point of view about the future of the virtualization software, he told virtualization is having a good future in the IT organizations. This technology is being developed and providing lot of services and it can be used without considering about real machine resources. The future of the virtualization is a boom according to his point of view.

He also mentioned that performance of the virtual machines in terms of services, is really good until and unless it has a proper design for the virtual machines. If tune-up of the system and design procedure is optimized, it can provide good services to the end users.

The major advantage he mentioned about the virtualization software's are, it reduces the cost of the resources, reduces the man power, power consumption and is easy to manage the data centers. He preferred the commercial software packages instead of open source packages. He also mentioned commercial packages provide support and services on time and it has more features compared to non-commercial virtualization software packages.

Interview 2

This interview was conducted with an employee of HCL Corporation and his name was Mullapudi. He is working as a senior IT specialist and his role is system administrator and also responsible for managing UNIX servers and virtual machines.

Interview has been conducted in two parts. In the first part of the interview, we have been discussing about most used virtualization software packages in organizations. The second part of the interview we have discussed about the virtualization software package advantages and their disadvantages. When we discussed about most used virtualization software packages in organization, he mentioned VMware for most of the applications on client side as well as server side.

Later, we continued discussing about the virtualization architecture being used in their organization; He told that they are using host based virtualization architecture, also he mentioned they are not using bare metal architecture based virtualization.

When we discussed with him about main reasons to use virtualization software in their company, He told that "we are using the virtualization software packages because it consumes less space, and cost of the packages is also less when compared with real resources. Virtual software is easy to maintain and manage. We can increase the number of servers based on the requirement without considering much about the physical resources.

The end user did not have any clue while they are using virtual server or real server, also compatibility wise and their performance wise, virtualization technology is very good".

He told that there can be few problems arising while using virtualization software packages for example, if any problem occurs in the host machine server, it may affect the whole organization. This can l lead the organization to shutdown the whole process until the problem gets rectified.

According to his point of view, the future of the virtualization software packages has good scope since it has been optimized by new versions. According to customer point of view it reduces cost of the resources. He mentioned virtualization software packages have good impacts in IT sector.

He told that open-source software packages are fine. . The open-source software can be chosen according to companies need; also, he mentioned that commercial packages are good to get support for the companies

Mullapudi mentioned virtualization software is good to use, and it has some good features. This virtualization leads to less maintenance and flexible network infrastructure. He is very satisfied with the VM ware virtualization product compared to other virtualization packages.

Interview 3

Mohan Karuppanan a system administrator from IBM Corporation, Chennai, India and his role is to support and maintain virtual servers, he had shared some of his views with us and they are as follows.

This interview has been focused into two major aspects; we have discussed about and most-used virtualization software's in organization and their advantages and disadvantages of these software packages. When we discussed about the most-used virtualization software packages, he mentioned a software package called VMware. He told that VMware is one of the virtualization software's which is used by most of the organizations.

He mentioned bare metal virtualization architecture is used by clients' of their organizations. We have continued discussing reasons for adopting virtualization technology in IT organizations, He told it reduces cost of the resources and with less cost, the company people can purchase more products, and virtualization software packages are easy for main physical resources when compared to real physical resources. He mentioned an example that

virtualization product has easy portability in disaster situations, we can migrate the virtual machines from one place to another, and this can provide uninterrupted services to the clients. It simplified the network infrastructure of the IT organization.

When we discussed about the problems raised while using virtualization software packages, he told that there are few flaws in virtualization technology, for instance, he told that if any of the host servers went down this will affect the services of the virtual machines, so this is one of the main problems   existing in virtualization technology according to his point of view.

 He mentioned that virtualization technology will have good impact in computing filed. It has some strong advantages, for example, management service, cost based and service based, and power consumption. Due to these positive advantages of this technology, definitely it will be grown in the field of computing.

He told us that the performance of the virtual machines are good, also the services like web services, and database services are performing well when it has been configured in a certain standard level.

According to his point of view, we discussed about commercial packages and open source of the virtualization machines. He strongly emphasis commercial packages virtual machines are good when compared with non-commercial packages. The Commercial packages are providing excellent services when compared with non-commercial virtual software packages. In organizations services and product support are playing import aspects to choose a product.

He told us that the performance differences between the real machine and the virtual machine is not same, since virtual machine cannot be replaced with real machines, always real physical machine performance is unbeatable when compared with virtual machine performance, but some virtual machine products provide nearest performance to real machine.

He told about his opinion about the virtual machine to use, it provides lot of features and also cost of the virtual software packages is less when compared with real physical resources. He told virtual machines are going to make large impact in IT sector.

Interview 4

This interview was conducted with Srinivas Rao from Vijay Electricals, India. He is working as a System Administrator. His responsibility is to manage the network systems in the organizations.

This interview is carried based on two main aspects.

1. To find the most used virtualization software packages in his organization.

2. The advantages and disadvantages of the virtualization package.

When we asked about virtualization software details in his organization, he mentioned that they are using the VMware virtualization product. When we discussed about the virtualization architecture, he told that they are using host based virtualization in his organization. He told that virtualization software packages provide easy network management. The cost of the virtualization products is less when compared with real resources. It reduces physical resources in the companies also it decreases the power usage and virtualization technology requires less manpower to maintain.

He told that virtualization software is more helpful when compared with physical resources, for instance, if any disaster occurs, it is easy to recover, and it can be migrating from one workplace to another workplace.

When we questioned about the problems associated along with virtual software packages he told each software has some advantages and disadvantages; virtual software's also have some problems, if the host machine went down during the operation time it has large impact on company services. The virtual machines are not having enough security when compared to real machines.

He told that future of the virtualization is very good. It is one of the booming technologies in this real computing field; a lot of companies are adopting virtual Software packages into their organizations. It clearly shows that virtualization is adopting into computing sector.

Later, we continued discussion about virtualization performances; Interviewee told that performance wise virtualization machine is good. It has been proving good services as per his experiences.

He told that virtual machines are performing well in real word, but it has not been proving performance equal to real machines. The impacts are acceptable in the computing field. He strongly emphasis commercial virtualization software packages are good, and it is providing better services and good features.

Virtualization technology provides a lot of advantages and few disadvantages, but it can get ownership of virtual machines with less amount of cost, and also it occupies less space. These major features cannot be replaced by real machines according to his view.

Interview 5

The interview has been conducted with Sundar at Patni Organization India. He is working as a test engineer. His role is to maintain and monitor the network resources in the company.

The interview is taken from him for two main purposes. The first is to identify the most used virtualization software packages in organizations, and the second reason is to identify the major advantages and disadvantages with these software packages.

When we asked about virtualization software, he told VMware and QEMU virtual machines. In his organization, they are using VMware software package. He told that they are using Para virtualization architecture in their organization.

He told that organizations are using virtualization software because it is good to use since it reduces the company resources investment cost. It requires less space to implement. It is possible to increase the network resources without considering about company physical space and investment cost. It is easy to maintain the network infrastructure. When there is a need to increase the network area in the organization or increase the servers, user's virtualization provides better functionality in such cases. If there is any problem that occurs in the virtual machine, it will not affect the other virtual machines which are residing in the same host machine.

Later, we questioned him about the virtualization software disadvantages, he told that if any problem occurs on the host machine, it will severely impact the virtual machines hosted in the host machine. The security point of view we should monitor the network resources carefully from the intruders in the way he mentioned upon his view of virtualization software disadvantages.

He described the performances of the virtual software packages, According to his view, performance of the virtual machines are good and also it provides better services for applications that run on virtual machines.

The performance of the virtualization software is not same as real host performance, but it provides minor difference with real host based machines. The feature of virtualization machines is it offers a way to choose virtualization software instead of real physical resources.

When he talked about the type of the virtualization packages, he preferred commercial packages. The reason he mentioned to choose commercial packages was, they provide services when it's necessary.

According to his view, he supports virtualization software in IT organizations. Since it has lot of features as he mentioned above, this is one of the adopting technologies in the IT organization.

Interview 6

The Interview has been conducted with Ramakrishna Raveela at CGI, India. He is working as a senior software engineer. His role in the organization is developer and system maintainer. In the interview, we have discussed about two main areas of virtualization technology. In the first part of interview we have discussed about the most used virtualization software packages in his organization. The second part of the interview we have discussed about the advantages and disadvantages of these software packages.

He told that they are using the VMware at his organization. VMware is one of the software, which is used by most of the companies

When we started discussing about the virtualization architecture, he told they are using host based virtualization and bare metal virtualization technology. He continued mentioning few reasons to use virtualization technology at his organization. The cost of the physical resources is high, virtual software package's costs are less when compared with real resources. The real resources occupy more physical spaces in the company. While using virtualization it reduces to use more physical host at work place. The man power required to maintain the resources is less if the virtualization technology is used. It has portability, thus it provides flexible environment for users.

Later, we continued discussion on virtualization software problems; he mentioned that as per security point of view virtualization software is not recommendable. The security engineers must have to carefully monitor the virtualization software activities. The virtual machine cannot be replaced with physical machine performances, but it can perform well.

The future of the virtualization technology is good. This technology is being accepted and implemented by most of the organizations. If the security issues are fixed in the virtualization, this development will be huge.

He would like to prefer commercial software packages instead of open sources software packages. He told that commercial packages features are well organized when compared to non commercial products.. He personally recommended choosing commercial packages.

When we asked about the personal summary of the virtual machines, he mentioned that virtualization technology is good. It provides more features to use the IT services more effectively. The VMware products are good as per his experience.

Interview 7

The interview is taken from Suscheel from IBM, Singapore. This interview has two aspects. The first part of the interview, discussion about the most used virtualization packages. The second part we have discussed about the advantages and disadvantages on the virtualization software packages.

He mentioned about the virtualization software packages named Virtual Box and VMware. VMware is the most used virtualization packages at his organizations according to his work experiences on virtualization.

When we discussed about the reasons to use the virtualization technology, he mentioned that.
1. Virtualization offers, to use the resources effectively and efficiently.
2. Virtualization reduces cost of the resource's investment.
3. It is very convenient to implement and it is flexible to maintain the network.
4. It provides ownership of the product with less amount of cost.
5. Easy to upgrade the virtual machine.
6. The performance of the virtual machine is good.

Later, we discussed about the problems that may arise while using the virtual machines. He told that virtual machines are not capable of implementing high processing application server. Virtual machine is purely dependent on the host machine resources. He told that the performance of the virtual machine is good in terms of web services and database services applications.

Virtualization commercial packages are good and convenient to use in an organization, since it has lot of good features and application oriented when compared to non commercial software packages.

He told that the future and growth of the virtualization software will increase gradually due to virtualization benefits. The company that is using the virtualization technology in their organizations has good progress in terms of services, when considering customer satisfaction Virtualization fulfills almost all the requirements. When we discussed about the virtual machine performance along with real machine performance, He concluded virtual machines performance is not equal to real machines.

APPENDIX C

1. Total Test Time

	Load 1(sec)					Load 2(sec)				
Real Host	1.26	1.25	1.24	1.25	1.27	2.50	2.53	2.57	2.51	2.61
VMware	1.89	1.70	1.78	1.89	2.14	3.70	2.97	3.18	3.67	3.18
Virtual Box	2.52	2.11	1.93	2.35	2.67	3.91	4.12	4.32	3.97	4.11
QEMU	1.89	1.97	2.12	1.97	1.89	3.27	3.57	3.51	3.71	3.97

2. Maximum Connection Time

	Load 1(ms)					Load 2(ms)				
Real Host	2	2	2	2	3	5	5	4	4	5
VMware	2	3	3	4	2	5	7	7	6	5
VirtualBox	24	26	33	37	33	44	63	67	63	56
QEMU	23	26	23	23	25	47	45	60	43	44

3. Minimum Connection Time

System	Minimum Connection Time(ms)	
	Load 1	Load 2
Real Host	1	1
QEMU	1	1
VMware	1	1
Virtual Box	1	1

Minimum connection time is same for Load 1 and Load 2. The values are not varying for repeated experiment.

4. Completed Request

System	Competed Request	Competed Request
Real Host	1000	2000
QEMU	1000	2000
VMware	1000	2000
Virtual Box	1000	2000

Completed request is same for load1 and load2. The values are not varying for repeated experiment.

5. CPU I/O wait percentage

	Load 1(%)					Load 2(%)				
Real Host	0.05	0.05	0.01	0.01	0.05	0.07	0.09	0.09	0.10	0.07
VMware	0.17	0.13	0.13	0.10	0.19	0.28	0.22	0.37	0.30	0.32
VirtualBox	0.67	0.49	0.47	0.47	0.53	1.10	1.97	1.37	1.28	1.19
QEMU	0.30	0.38	0.40	0.41	0.37	1.01	1.06	0.96	0.95	0.92

6. CPU user utilization percentage

	Load 1(%)					Load 2(%)				
Real Host	1.25	0.91	0.76	0.61	0.95	1.56	1.50	1.56	1.48	1.81
VMware	1.91	1.87	1.56	1.77	2.01	3.96	3.91	3.57	3.63	3.77
VirtualBox	3.77	4.12	4.28	4.27	4.23	7.12	7.92	7.18	8.23	8.17
QEMU	3.41	3.12	3.82	3.81	3.73	5.92	6.17	6.22	5.78	6.27