

**STUDY OF TOTAL COST OF OWNERSHIP VERSUS
PERFORMANCE OF INFORMATION TECHNOLOGY SYSTEM
USING VIRTUALIZATION TECHNOLOGY**

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Thematic Paper
entitled
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USING VIRTUALIZATION TECHNOLOGY**

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**STUDY OF TOTAL COST OF OWNERSHIP VERSUS PERFORMANCE OF
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ABSTRACT

Businesses can be changed due to new technologies and innovations. Along with these changes, businesses need to adapt their strategies as well as their operations to keep a competitive edge. These strategies include changing the order processing, credit processing, sales operations, marketing operation, and more.

This research studied a business development company that maintains online business services. This company develops online systems and installs server machines for transactional online service systems in a data center that is located in their main office in Bangkok. This research was to study the major factors in Total Cost of Ownership (TCO) and performance-investment ratio of virtualized servers compared to non-virtualized servers. The researcher defined TCO to cover the total length of ownership including investment costs, operational costs, maintenance costs, and unplanned costs until the system was removed from production environment.

This research used VMware 2.0 to simulate two Web servers on a physical server and simulated transactional loads by using Load Runner to simulate customer services. The comparing factors were the performance of the system and its TCO in virtualized web server with two existing web servers

The results showed that Web servers with Virtualization technology can efficiently replace the existing servers based on the results of comparison of CPU utilization, memory utilization TCO.

**KEY WORDS: VIRTUALIZATION / TOTAL COST OF OWNERSHIP /
WEB SERVER**

81 pages

การศึกษามูลค่าการดำเนินงานของระบบสารสนเทศโดยวิธีการเปรียบเทียบประสิทธิภาพกับเทคโนโลยีคอมพิวเตอร์แบบเสมือน

STUDY OF TOTAL COST OF OWNERSHIP VERSUS PERFORMANCE OF INFORMATION TECHNOLOGY SYSTEM USING VIRTUALIZATION TECHNOLOGY

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บทคัดย่อ

ปัจจุบันนี้การดำเนินงานด้านธุรกิจมีการเปลี่ยนแปลงเทคโนโลยีใหม่และนวัตกรรมใหม่ ซึ่งการเปลี่ยนแปลงนี้ทำให้การดำเนินธุรกิจต้องมีการปรับเปลี่ยนกลยุทธ์แนวทางให้สามารถดำเนินงานและมีความได้เปรียบในการแข่งขัน เช่น การดำเนินงานด้านการการสั่งซื้อ, การให้สินเชื่อ, การขาย, แบบออนไลน์ เป็นต้น

การศึกษาในครั้งนี้เป็นการศึกษาริษัทที่ดูแลและพัฒนาระบบธุรกิจแบบออนไลน์ โดยทางบริษัทจะพัฒนาระบบออนไลน์และทำการติดตั้งบนเครื่องคอมพิวเตอร์แบบแม่ข่ายที่ศูนย์ข้อมูลหลักของบริษัท การศึกษานี้จะทำการศึกษาและเรียนรู้ใน 2 ปัจจัย คือ มูลค่าตลอดอายุการให้บริการระบบออนไลน์และประสิทธิภาพการทำงานของเครื่องแม่ข่ายที่ไม่ใช่เทคโนโลยีคอมพิวเตอร์แบบเสมือนกับเครื่องแม่ข่ายที่ใช้เทคโนโลยีแบบเสมือน โดยจะคำนวณจากมูลค่าในการดำเนินงาน. การศึกษานี้จะหามูลค่าในการลงทุนตลอดอายุการดำเนินงานประกอบด้วย, ค่าใช้จ่ายในการดำเนินงาน, ค่าใช้จ่ายในการบำรุงรักษา, และค่าใช้จ่ายต่าง ๆ ที่ไม่ได้ใช้ในการวางแผนจนถึงเวลาที่เครื่องแม่ข่ายไม่ได้นำมาให้บริการอีกต่อไป

การศึกษานี้จะใช้โปรแกรม VMware server 2.0 เพื่อจำลองเครื่อง Web server จำนวน 2 เครื่องบนเครื่องหลัก 1 เครื่องและทำการจำลองการใช้งานผ่านหน้าเว็บ ด้วยโปรแกรม Load runner เพื่อจำลองการทำงานของลูกค้าที่เข้ามาใช้บริการ โดยเปรียบเทียบประสิทธิภาพการทำงานและมูลค่าตลอดอายุการดำเนินงานระหว่างเครื่อง Web server ที่ให้บริการในปัจจุบันและเครื่องที่ใช้เทคโนโลยีคอมพิวเตอร์แบบเสมือน

ผลของการศึกษาเครื่องแม่ข่ายที่ให้บริการเว็บเพจ ที่ใช้เทคโนโลยีคอมพิวเตอร์แบบเสมือนสามารถทำงานทดแทนเครื่องคอมพิวเตอร์ที่ให้บริการในปัจจุบันซึ่งไม่ได้ใช้เทคโนโลยีคอมพิวเตอร์แบบเสมือน โดยทำการเปรียบเทียบในส่วนทั้งการทำงานของ CPU, Memory และมูลค่าตลอดการดำเนินงาน

CONTENTS

	Page
ACKNOWLEDGEMENTS	iii
ABSTRACT (ENGLISH)	iv
ABSTRACT (THAI)	v
LIST OF TABLES	viii
LIST OF FIGURES	xi
CHAPTER I INTRODUCTION	1
1.1 Introduction and Statement of Problems	1
1.2 Objective	3
1.3 Scopes of Study	3
1.4 Expected Results	3
CHAPTER II LITERATURE REVIEW	5
2.1 Virtualization Technology	5
2.2 Load Testing Tool	10
2.3 Service Level Agreement	12
2.4 Total Cost of Ownership	13
2.5 Operating support	14
2.6 Multi-tier architecture	15
2.7 Three-tier architecture has the following three tiers	15
2.8 Related Researchs	16
CHAPTER III MATERIALS AND METHODS	20
3.1 Research Methodology and Procedures	20
3.2 Materials	34
3.3 Research Schedule	35

CONTENTS (cont.)

	Page
CHAPTER IV RESULTS	36
4.1 The existing servers	36
4.2 Virtualization Server	48
4.3 Resource Utilization comparisons	63
4.4 Cost Benefit analysis	66
CHAPTER V CONCLUSIONS	76
5.1 Conclusions	76
5.2 Recommendation	77
REFERENCES	79
BIOGRAPHY	81

LIST OF TABLES

Table	Page	
2.1	General Information Virtualization tools	7
2.2	Futures Virtualization tools	9
2.3	Load Testing tools Function	11
2.4	Load Testing tools General	11
2.5	Load Testing tools Agents	11
2.6	Load Testing tools Controller	12
2.7	Downtime per year, month, week	13
2.8	TCO Cost Catalog	13
3.1	Monitoring Server	22
3.2	Web server Bank A	23
3.3	Application server Bank A	23
3.4	Database server Bank A	24
3.5	Web server Bank B	24
3.6	Application server Bank B	25
3.7	Database server Bank B	25
3.8	F5 Load balance	26
3.9	Virtual Machine Layer	27
3.10	Web Server Virtual Machine Test Environments	27
3.11	Linux Application Server Test Environments	28
3.12	Database Server Test Environments	29
3.13	Monitoring Server	30
3.14	Method of calculate maintenance cost	31
3.15	Method of calculate electricity cost	31
3.16	Hardware cost of existing server	32
3.17	Hardware cost of virtual machine server	32
3.18	Software cost of existing server	32

LIST OF TABLES (cont.)

Table	Page
3.19 Software cost of virtual machine server	33
3.20 Operating System cost of existing server	33
3.21 Operating System cost of virtual machine server	33
3.22 Research Schedule	35
4.1 CPU utilization of the existing servers	45
4.2 Memory utilization of existing server	45
4.3 Concurrent users of the existing servers	47
4.4 Summary of the concurrent users of the existing servers	48
4.5 Concurrent of virtual server	59
4.6 CPU utilization of virtual server	60
4.7 Memory utilization of virtual server	61
4.8 Average CPU utilization of existing server and virtualization server	62
4.9 Average memory utilization of existing server and virtualization server	62
4.10 Maximum concurrent utilization of existing server and virtualization server	63
4.11 TCO Cost Catalog	66
4.12 Direct cost of the existing servers	67
4.13 Rate of electricity cost	68
4.14 Calculate of electricity cost	68
4.15 Maintenance server price list	69
4.16 Maintenance operating system price list	69
4.17 Cost of the existing servers per month	70
4.18 Grand total cost of the existing servers within 3 year	70
4.19 Direct cost of the virtualization server	71
4.20 Calculate of electricity cost	72

LIST OF TABLES (cont.)

Table		Page
4.21	Maintenance operating system price list	73
4.22	Cost of Virtualization server per month	73
4.23	Grand total cost of virtualization server within 3 year	74
4.24	Grand total cost of virtualization server within 3 year	75
5.1	Comparison existing server and virtualization server	76

LIST OF FIGURES

Figure		Page
2.1	Physical machine compare with virtual machine	5
2.2	Virtualization Tools	6
2.3	How load testing work	10
2.4	Overview of a three-tier application	16
3.1	Framework	20
3.2	Infrastructure systems with non-virtualization technology	26
3.3	Infrastructure systems with virtualization technology	30
4.1	Infrastructure systems with virtualization technology	36
4.2	CPU utilization of web server of Bank A	37
4.3	Memory utilization of web server of Bank A	38
4.4	Storage utilization of web server of Bank A	38
4.5	CPU utilization of web server of Bank B	39
4.6	Memory utilization of web server of Bank B	39
4.7	Storage utilization of web server of Bank B	40
4.8	CPU utilization of application server of Bank A	41
4.9	Memory utilization of application server of Bank A	41
4.10	Storage utilization of application server of Bank A	42
4.11	CPU utilization of database server of Bank A and B	43
4.12	Memory utilization of application server of Bank B	43
4.13	Storage utilization of application server of Bank B	44
4.14	Infrastructure systems with virtualization technology	48
4.15	CPU utilization of database server of Bank A sand B	49
4.16	Memory utilization of application server of Bank B	49
4.17	Storage utilization of application server of Bank B	50
4.18	CPU utilization of database server bank A and B	51
4.19	Memory utilization of application server of Bank B	51

LIST OF FIGURES (cont.)

Figure	Page
4.20 Storage utilization of application server of Bank B	52
4.21 CPU utilization of database server bank A and B	53
4.22 Memory utilization of application server of Bank B	53
4.23 Storage utilization of application server of Bank B	54
4.24 CPU utilization of database server of Bank A and B	55
4.25 Memory utilization of application server of Bank B	55
4.26 Storage utilization of application server of Bank B	56
4.27 CPU utilization of database server of Bank A and B	56
4.28 Memory utilization of application server of Bank B	57
4.29 Storage utilization of application server of Bank B	58
4.30 Running virtual user web server of Bank A	58
4.31 Running virtual user web server of Bank B	59
4.32 Comparison of CPU utilization the existing servers and VT server	64
4.33 Comparison of memory utilization existing server and VT server	65
4.34 Graph cost comparison	74
5.1 Graph comparison costs of existing servers and virtualization server	77

CHAPTER I

INTRODUCTION

1.1 Introduction and Statement of Problems

Business can be changed due to new technologies and innovations. With these changes, businesses need to adapt their strategies as well as their operations to stay on competitive edge. It means that anything - such as order processing, credit processing, sell operation, marketing operation, etc. -can be effected and need to be changed.

In present, Internet known as a major large interconnecting public network has been effecting to both personal and business lifes. Internet is a good example of how new technology & innovation can change how business is operated. The effect is profound. Behavior of household consumers, such as in media & entertainment retail business, finance & credit business, communication & mobile phone business, are also effected because of new technology & innovation. To stay as a leader in their own sector, business entities must change themselves to the changes of their customers by using new technologies & innovations that are available as well as affordable.

This research is studying in the company which is developed and maintain online service business. The company develop online system and install server machines for transactional online service systems in data center that are located at main office, Customers can online access to any transactional system as many time as they need.

This research was focused on a company that its main operation can be classified as e-commerce business for Business-to-Business (B2B) service. Due to a non-disclosure agreement signed by the researcher, the name of company cannot be revealed. The company cooperates with commercial banks to develop websites for providing services to customers via online networks. The providing services are credit online, payment online etc. The company also provides services of web application development, application hosting, application installation, system configuration, and

system maintenance. All service servers as well as development servers are located in the company's data center at downtown Bangkok, and the systems are operating 24 hours non-stop. By having one location, the company can reduce a cost of maintenance and a cost of network leasing.

To invest on new servers, there are many factors that need to be considered such as performance, suitability, durability, cost etc. There are two types of investment of servers: New investment and replacing investment. New investment is an investment of new server mostly for new services and/or new customers. Replacing investment is an investment to replace an aging server.

An online service via web server machine has to run continuously so that the company can archive a high performance investment on server machines and network systems. These machines are normally in service for 3 years and needed to be replaced after that. If number of users increases and services cannot be provided smoothly due to insufficient of hardware performance, then the company is responsible for resolving problems. The solutions can be upgrading the server or replacing with a new server. In order to maintain cost-to-performance ratio in this business, new technologies must be constantly posted for the company's consideration and must also response positively to Total Cost of Ownership (TCO).

Nowadays, virtualization technology becomes more popular because it is not only help cutting a cost of investment and maintenance but also increase utilization of the machines by running multiple operating systems on a single computer. However, there are many factors that need to be studied, which is the main reason of conducting this research. This research is to study major factors in Total Cost of Ownership (TCO) and Performance-investment Ratio of virtualized server and non-virtualized server. TCO of system is computed by whole cost. Researcher define in total length of ownership to include investment cost, operational cost, maintenance cost, and any unplanned cost until the system is removed from production. The result of this research can be used as a guideline for any e-commerce company with B2B type service to select suitable solution for server investment.

1.2 Objective

1.2.1 To study performance of web service server on identical transactional load using virtualization comparing to non-virtualization in B2B type e-commerce company.

1.2.2 To study Total Cost of Ownership (TCO) and performance to investment ratio of web service server with virtualization comparing to non-virtualization in B2B type e-commerce company.

1.2.3 To develop a guideline for investment of web service server in B2B type service e-commerce company.

1.3 Scopes of Study

1.3.1 To study the performance of web service server using virtualization technology comparing to non virtualization technology in term of CPU, Memory, Storage Utilization.

1.3.2 This research uses a load generator program to mimic real transactional load in order to measure load capability of both systems virtualization and non-virtualization technology.

1.3.3 To study Total Cost of Ownership (TCO) and Performance Investment ratio of Web service server using virtualization technology comparing to non virtualization technology based on simulated transactional load.

1.4 Expected Results

1.4.1 Result of Performance comparison of web service server on identical transactional load Virtualization comparing to non- virtualization in B2B type e-commerce Company can be analyzed.

1.4.2 Total Cost of Ownership (TCO) and performance to investment ratio of web service server with virtualization comparing to non- virtualization in B2B type e-commerce company can be analyzed.

1.4.3 A guideline for investment of web service server in B2B type service e-commerce Company can be developed.

CHAPTER II

LITERATURE REVIEW

2.1 Virtualization Technology

Virtualization Technology is a software, which give high performance and good to investment because it allows a server to run multiple operating systems (OS) individually.

Virtualization technology works under virtual machine technology by managing of resources in a server to run multiple OS as if there are multiple independence computers in one physical server. The virtualized core system controls utilization & allocation of central processing unit (CPU), Main Memory a.k.a RAM, Storage, and network interface card (NIC) for each virtualized server using virtualization tool.

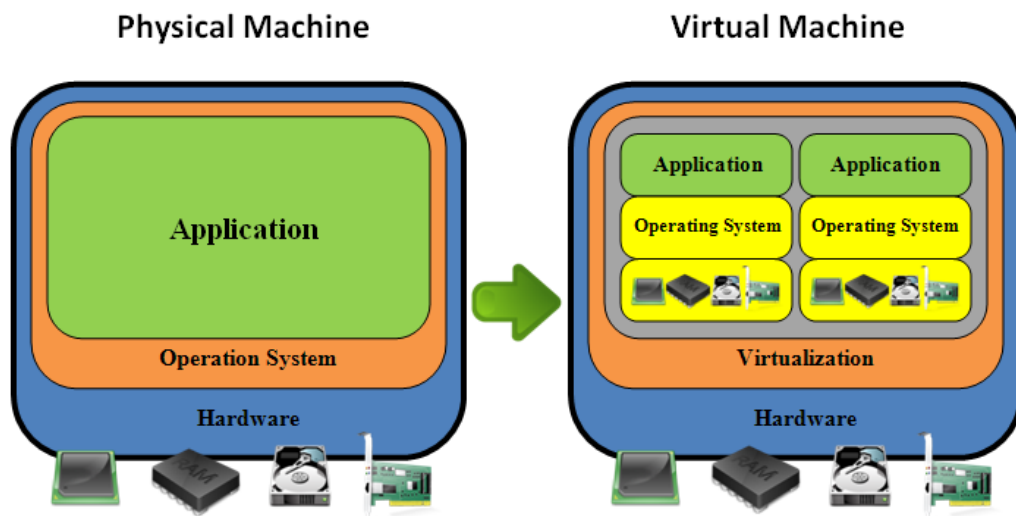


Figure 2.1 Physical machine compare with virtual machine [1]

Virtualization tool

Virtualization tool is a software, which uses physical resources of physical machine and divides the resource up into virtual resources. Virtualization tool creates a uniform platform for managing OS and application updates, enabling an easy migration to new OS while running legacy applications safely.

Virtualization tool allows multiple operating systems and applications to run concurrently in virtual machines on a single computer. Since virtualization software allows multiple hardware configurations and operating systems to co-exist and be easily updated. [2]



Figure 2.2 Virtualization Tools [3]

Popular virtualization software products in today market are shown in the following table.

Table 2.1 General Information Virtualization tools

Name	Creator	Host CPU	Guest CPU	Host OS(s)	Guest OS(s)	License
Virtual Server 2005 R2	Microsoft	Intel x86, AMD64	Intel x86	Windows 2003, XP	Windows NT, 2000, 2003, Linux (Red Hat and SUSE)	Proprietary
Virtual PC 2007	Microsoft	x86, x86-64	x86	Windows Vista (Business, Enterprise, Ultimate), XP Pro, XP Tablet PC Edition	DOS, Windows, OS/2, Linux (Suse, Xubuntu), OpenSolaris (Belenix)	Proprietary
VMware ESX Server	VMware	x86, x86-64	x86, x86-64	no host OS	Windows, Linux, Solaris, FreeBSD, Virtual appliances, Netware, OS/2, SCO, BeOS, Darwin, others: runs Arbitrary OS ^[2]	Proprietary
VMware Server	VMware	x86, x86-64	x86, x86-64	Windows, Linux	Same as VMware ESX Server	Proprietary
Xen	Citrix Systems	x86, x86-64 and IA-64	(Same as host)	NetBSD, Linux, Solaris	FreeBSD, NetBSD, Linux, Solaris, Windows XP & 2003 Server (needs vers. 3.0 and an Intel VT-x (Vanderpool) or AMD-V (Pacifica)-capable CPU), Plan 9	GPL

Table 2.1 General Information Virtualization tools (continue)

Name	Guest OS SMP available	Runs arbitrary OS	Supported guest OS drivers	Method of operation	Typical use	Speed relative to Host OS	Commercial support available	Needs administrative rights
Virtual Server 2005 R2	No	Yes	Yes	Virtualization (guest calls trapping where supported)	Server, Server Farm	Near native with Virtual Machine additions	-	
Virtual PC 2007	No	Yes	Yes	Virtualization (guest calls trapping where supported)	Hobbyist, Developer, Business workstation	Near native with Virtual Machine additions	-	
VMware ESX Server 3.0	Yes (Add-on) (up to 4 way)	Yes	Yes	Virtualization	Enterprise Server Consolidation, Business Continuity, Dev/Test	Up to near native	Yes	Needs
VMware Server	Yes (2-way)	Yes	Yes	Virtualization	Server/Desktop Consolidation, Dev/Test	Up to near native	Yes	Needs
Xen	Yes	Yes	Not required with the exception of the networking drivers where a NAT is required. A modified guest kernel or special hardware level abstraction is required for guest OSs.	Para virtualization and Porting or Hardware Virtualization	-	Up to near native speed. Substantial performance loss on some workload (network and disk intensive especially)	Yes	

Table 2.2 Features Virtualization tools

Name	Can boot an OS on another disk partition as guest	USB	GUI	Live memory allocation	3D acceleration	Snapshot of running system	Live migration
Microsoft Virtual Server 2005 R2	-	No	Yes	No	No	Yes	No
VirtualPC 2007	No	No	Yes	No	No	-	-
VMware ESX Server 3.0	Yes	Yes	Yes	Yes	No	Yes	Yes
VMware Server	Yes	Yes	Yes	Yes	No	Yes	-
Xen	Yes		Yes	Yes	Supported with VMGL	-	Yes

Virtualization tool, which is applied and tested in this study, is VMware Server version 2.0 because it is a popular tool and low cost.

2.2 Load Testing Tool

The principle of a load-testing tool is to simulate a behavior of real users with "virtual" users. The load-testing tool can then record the behavior of the system under the load and give information on the virtual users' experiences

Load testing tool replaces human users with virtual users. Virtual users emulate the actions of human users working on testing application or website. A scenario can contain tens, hundreds, or even thousands of virtual users.

The actions that a virtual user performs during the scenario are described in a virtual user's script. To measure the performance of the system, we define transactions. A transaction represents end-user business processes that you are interested in measuring. [4]

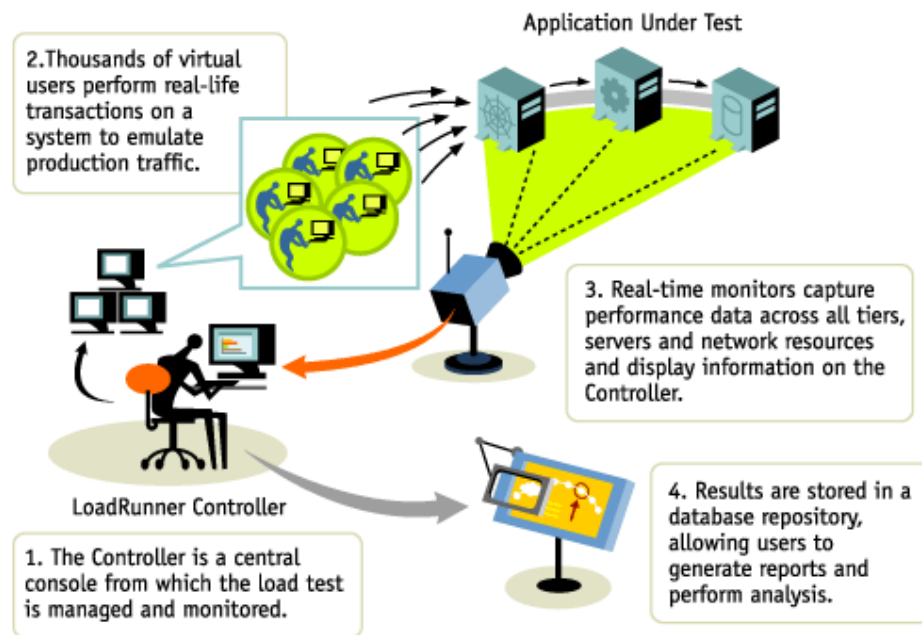


Figure 2.3 How load testing work [5]

Popular Load Testing tools include:

- Load Runner
- JMeter
- The Grinder

The details of popular load-testing tool are shown in the following tables.

Table 2.3 Load Testing tools Function [6]

Item	Load Runner	JMeter	The Grinder
Solaris Monitoring	No	neutral	neutral
Unlimited Load generation	No	Yes	Yes
Supports IP spoofing	Yes	No	Yes
Large download performance	Yes	No	No*

* Multiple workarounds are being investigated; including calling native code for the most intensive downloads.

Table 2.4 Load Testing tools General [6]

Item	Load Runner	JMeter	The Grinder
Server monitoring	mixed	neutral	neutral
Batch Mode	No	Yes	Yes
Ease - Installation	No	Yes	Yes
Ease – Script Authoring	Yes	Yes	mixed
Ease – Running Tests	neutral	Yes	neutral
Results Reporting	Yes	No	No
Agent Management	Yes	Yes	No
Cross Platform	Yes	Yes	Yes
Cost	Yes	Yes	Yes
Technical Level	Yes	Yes	No
Stability/Bugginess	neutral	No	neutral

Table 2.5 Load Testing tools Agents [6]

Item	Load Runner	JMeter	The Grinder
Transaction power	Yes	neutral	Yes
Custom protocols	Yes	Yes	Yes
Out-of-the-box protocols	Yes	neutral	No
Transaction aggregation	Yes	No	Yes
Scalability of Agent	Yes	neutral	neutral
Slow sockets	Yes	neutral	No
External libs usable	Yes	Yes	Yes
Load Scheduling	Yes	Yes	No
Ease of porting JCS	No	neutral	Yes

Table 2.6 Load Testing tools Controller [6]

Item	Load Runner	JMeter	The Grinder
Scalability of Controller	neutral	No	Yes
Real-time test monitoring	Yes	No	neutral
Real-time load adjustment	Yes	No	No
Script management	Yes	Yes	No
Script Development Environment	Yes	Yes	No

Load runner is software, which is applied in this research for load testing.

2.3 Service Level Agreements

Service Level Agreements (SLA) are defined them in a number of different ways, There are agreements between a supplier of services and the users of that services. The details of SLA cover legal and technical contents as follows:

- The availability of the services to the users
- The performance target of various components of the user's workloads
- The bounds of guaranteed performance and availability
- The measurement and reporting mechanisms
- The cost of the services

Service Level Agreement states a common understanding on services, priorities, responsibilities, guarantees and warranties. Each area of services scope should have the 'level of service' defines. Service Level Agreement (SLA) may specify the levels of availability, service ability, performance, operation, or other attributes of the services. The 'level of service' can also be specified as 'target' and 'minimum', which allows customers to be informed what to expect (the minimum), while providing a measurable (average) target value that shows the level of organization performance.

The following table shows an example detail of SLA from a given availability percentage to a corresponding amount of time a system would be unavailable per year, month, or week. [7]

Table 2.7 Downtime per year, month, week

Availability %	Downtime per year	Downtime per month*	Downtime per week
90%	36.5 days	72 hours	16.8 hours
95%	18.25 days	36 hours	8.4 hours
98%	7.30 days	14.4 hours	3.36 hours
99%	3.65 days	7.20 hours	1.68 hours
99.50%	1.83 days	3.60 hours	50.4 minutes
99.80%	17.52 hours	86.23 minutes	20.16 minutes
99.90%	8.76 hours	43.2 minutes	10.1 minutes
99.95%	4.38 hours	21.56 minutes	5.04 minutes
99.99%	52.6 minutes	4.32 minutes	1.01 minutes

* For monthly calculations, a 30-day month is used.

2.4 Total Cost of Ownership (TCO)

Total Cost of Ownership (TCO) is sometimes referred to as “total cost of operation”. TCO is an attempt offering a statement on financial impact of deploying an information technology product over its life cycle. Some of TCO elements that can be considered in the deployment of technology, include the costs of

Table 2.8 TCO Cost Catalog [8]

Acquisition Cost	Administration Cost	
	Control Cost	Operation Cost
-Hardware	-Implementation of	-Support
-Operating System	Centralization	-Evaluation
-Software	-Implementation of	-Upgrade
-Application	Standardization	-Training
		-Downtime
		-Futz Factor
		-Auditing
		-Security
		-Power Consumption

TCO analyzes a life cycle costs and benefits for several competitive operating systems, server platforms, and application configurations over three years of analysis period based on, a typical useful life of business critical servers.

The analysis quantifies all of the costs of a particular solution including the initial investment requirements, ongoing expenses, change costs, and downtime costs of each solution –comparing and contrasting the costs for head-to-head assessments. Measuring a total costs over time assures that decisions are made not just on initial purchase price, but on total life cycle costs of the Information Technology (IT) environment. [9]

2.5 Operating support

Maintenance

Maintenance is defined as work on existing buildings undertaken with the intention of

- Re-instating physical condition to a specified standard
- Preventing further deterioration or failure
- Restoring correct operation within specified parameters
- Replacing components at the end of their useful/economic life with modern engineering equivalents
- Making temporary repairs for immediate health, safety and security reasons (e.g. after a major building failure)
- Assessing buildings for maintenance requirements (e.g. to obtain accurate and objective knowledge of physical and operating condition, including risk and financial impact for the purpose of maintenance). [10]

2.6 Multi-tier architecture

In multi-tier architecture (N-tier architecture) is a client-server architecture in which presentation, application processing, and data management are logically separate processes.

N-tier application architecture provides a model for developers to create flexible and reusable applications. By breaking up an application into tiers, developers only have to modify or add a specific layer, rather than have to rewrite the entire application over. There should be a presentation tier, a business or data access tier, and a data tier.

The concepts of layers and tiers are often used interchangeably. However, one fairly common point of view is that there is indeed a difference, and that a layer is a logical structuring mechanism for the elements that make up the software solution, while a tier is a physical structuring mechanism for the system infrastructure.

Typically, an user interface runs on a desktop PC or workstation and uses a standard graphical user interface (GUI). Functional process logic may consist of one or more separate modules running on a workstation or an application server, and database server or mainframe contains a computer data storage logic.

2.7 Three-tier architecture has the following three tiers

2.7.1 Presentation tier

This is the top most level of an application. The presentation tier displays information related to such services as browsing merchandise, purchasing, and shopping cart contents. It communicates with other tiers by outputting results to the browser/client tier and all other tiers in the network.

2.7.2 Logic tier

The logic tier is pulled out from the presentation tier and, as its own layer; it controls an application's functionality by performing detailed processing.

2.7.3 Data tier

This tier consists of database servers. In this tier, information is stored and retrieved. This tier keeps data neutral and independent from application servers or business logics. Which allows data to contain in its own tier. This allows an improvement in scalability and performance of an overall system.

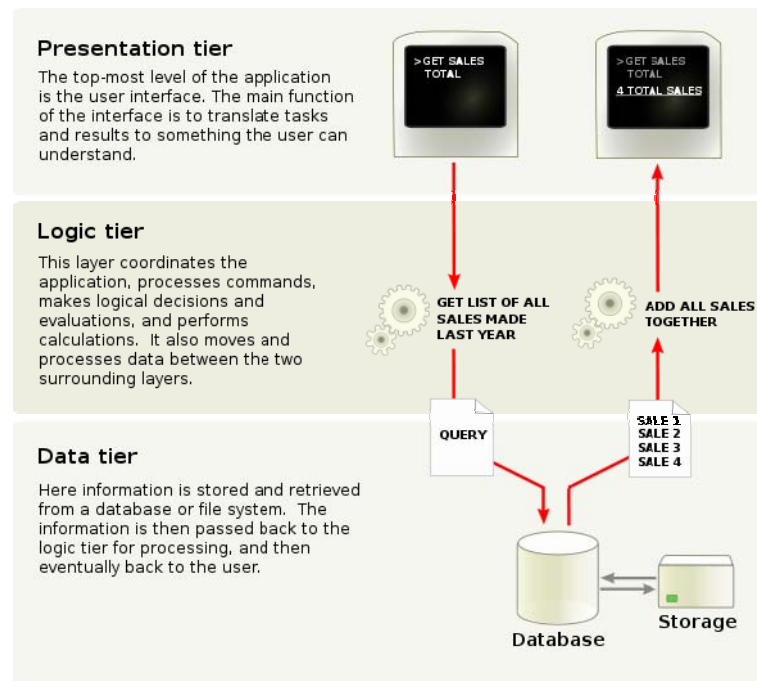


Figure 2.4 Overview of a three-tier application

The architecture of the system/application of company in this study is composed of three tiers as Presentation tier, Logic tier, Data Tier as shown in figure 2.4

2.8 Related Researchs

2.8.1 TCO Reduction [11]

Illustrated the approaches taken by Global Technology Development Group (GTDG) Penang to reduce the Total Cost of Ownership (TCO) and to move the business towards a more economical infrastructure and operating practices. By using

this approach, the saving was about 30.3K (USD) a year This did not include qualitative benefits achieved through better security, manageability and up times. TCO approach was the future approach of Global Engineering Computing and Penang Engineering Computing team was leading the way in this area.

The objective of the above project was to reduce TCO by using other tools, which could keep on the performance of the businesses. The Tools are considered from upgrades, maintenances, availability, and uptime. In this research , virtualization server was choose to apply and also TCO knowledge was also described.

**1 USD/32.0 BAHT

2.8.2 Analysis on energy consumption and cost in deployment of server virtualization technology [12]

Consumption of energy is increasing everyday regarding emerging and high adoption of technology and it has become one of the factors that cause global warming. Many organizations around the world use information technology in order to help them keep their business running effectively. Therefore, using virtualization technology will reduce a energy consumption problem while provide effectiveness and high utilization of the new systems. In [12], it contained a comparison of cost of investment of the technology and management between an existing system, which included 5 servers, and a new system. The new system was installed as a virtual server.

In this work, it studied electrical energy consumption of an old server system which contain five physical servers comparing to a new system which contain only one server using virtualization technology (VT). The controlled parameters were CPU, RAM, and Storage utilizations. The study shown that by using VT on the new system can reduce energy consumption without degradation of system performance. Even though, this work computed saving cost of using VT, it did not discussed TCO in the research.

2.8.3 Total Cost of Ownership: Issues around Reducing Cost of Support in a Manufacturing Organization Case [13]

Total Cost of Ownership (TCO) is an interest issue to both business and academic communities because it expands the understanding of the real cost of technology beyond purchase cost. The dominant Gartner Group model describes 'hard' and 'soft' costs, including acquisition, control and operational costs. Such metrics though tend to focus on conventional, abstract categories of cost defined by accounting and management literatures, rather than cost as it is understood in the thick of the everyday work of actual organizational members. Our research attempts to address this, examining one particular group of costs, break-fix, in terms of how costs arise and are reasoned about in actual working practice. This work described these costs and related them to wider issues of TCO. It highlighted the barriers that existed to the implementation of a successful break-fix strategy and suggest technologies that facilitated such a strategy.

This work presented how the concept of TCO unfolds when applying it to the case of printer manufacturing companies. There were many attributes that could be referred to TCO. This work further selected the one of supporting cost and presented the variety of dimensions where such cost could be affected. It focussed analysis by presenting areas for improvement in those support dimensions, on the base of some field studies that had been highlighted the multiplicity of areas where one could intervene.

2.8.4 Business-oriented Virtualization of Web Services - A Case Study [14]

In addition to enabling controlled sharing and isolation, the virtualization mechanism can help to provide users a single image, and to realize a more abstract and uniform view from a set of fine-grained, heterogeneous and un-ordered instances.

This work explores ways of business-oriented service abstraction, web service virtualization as well as practical effects thereof in an e-science environment for bioinformatics research. It can drawn the following conclusions based on hand-on experiences: 1) In reusing and synthesizing web service resources, it was more effective to align them to the stable and cohesive domain-specific functionalities; 2)

The differences and variability of web services realizing similar business functionality were inherently unavoidable. It was, thus, important to allow users to configure and compose. Feature analysis techniques could be of helpful; 3) Better scalability could be one of the most promising feature of the VINCA approach. The business-level abstractions could remain stable while the web service resources scale and undergo changes. 4) In practice, it found that the given approach currently had very demanding prerequisites, such as a domain-wide categorization and modeling of business functionalities and related metadata. It was only applicable when the trade-off between pre-investment and later reuse and scalability was well analyzed and accepted.

CHAPTER III MATERIALS AND METHOD

3.1 Research Methodology and Procedures

This research is to compare Total Cost of Ownership versus performance of two types of server systems with and without virtualization technology (VT). Data from these two types of servers are analyzed based on performance, investment cost, operation cost, maintenance cost, and other related cost in order to identify if virtualization technology can be benefited to business in term of performance versus Total Cost of Ownership (TCO). The steps of studying and its methodologies are described as follows:

Research Framework

Research framework demonstrated work flow in case of the usage of resource utilization and Virtualization technology in both existing server system and virtual server system.

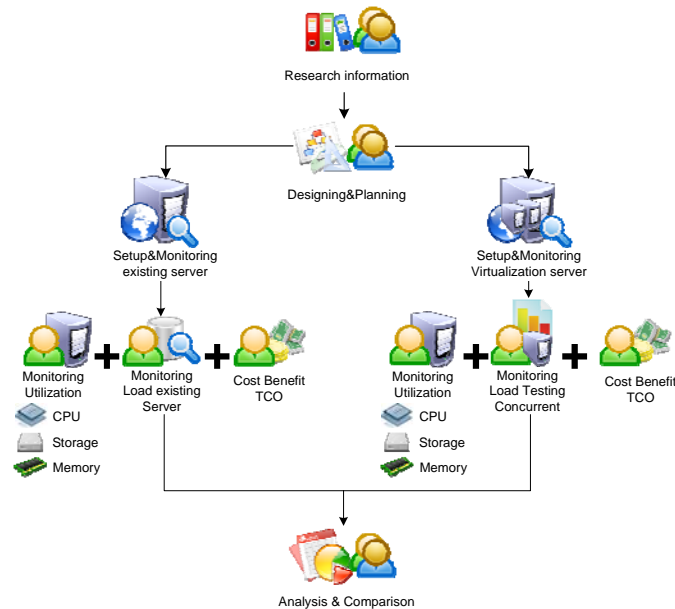


Figure 3.1 Framework

3.1.1 In this step, the researcher conducted full literature review from journal, white paper, and research database such as Science Direct, IEEEExplore, and ACM etc. on topics of

- Virtualization Technology Server
- Resource Utilization
- Cost of Benefit
- Virtualization tools
- Monitoring Tools
- Load Testing Tools


3.1.2 This step involved design experiment server systems and plan an implementation plan. Then, the systems were put for real test. The measurement of the systems performance was done in real time. The details of the test systems with and without virtualization technology are as follows:

3.1.2.1 Web Server with non-virtualization technology

3.1.2.1.1 Measure the performance and collect working data which are Central Processing Unit (CPU), Main Memory a.k.a RAM, Storage by using software named “AppManager Monitoring 9.0” as a monitoring tool.

Specification of server that work as monitoring server

Table 3.1 Monitoring Server

Monitoring Server		
	System	
	Server Type	Server
	Server Name	Monitoring Server
	Operation System	Windows Server 2003 Std
	Application	Application Manager 9
	Hardware Specification	
	CPU	Athon X2 3.0 GHz
	Memory	3 GB
	Storage	160GB
Power Supply	400W	

Specification of server with non-virtualization technology which is providing services to customers is defined by system functions as follows:

Servers Bank A

Table 3.2 Web server Bank A


Web Server Bank A		
	System	
	Server Type	HP DL380 G4
	Server Name	GeneralWeb
	Operation System	Linux RH2
	Application	Sunone 6.1 SP8
	Hardware Specification	
	CPU	Intel Xeon 3.4 GHz
	Memory	16 GB
	Storage	72.8 GB SCSI
	Power Supply	575 Watt x 2 Unit

Table 3.3 Application server Bank A



Application Server Bank A		
	System	
	Server Type	HP DL380 G4
	Server Name	GeneralWeb
	Operation System	Linux RH2
	Application	Sunone 6.1 SP8
	Hardware Specification	
	CPU	Intel Xeon 3.4 GHz
	Memory	16 GB
	Storage	72.8 GB SCSI
	Power Supply	575 Watt x 2 Unit

Table 3.4 Database server Bank A

Database Bank A		
	System	
	Server Type	Sunfire X4150
	Server Name	SANNODE
	Operation System	Windows 2003 Enterprise
	Application	Microsoft SQL Server 2005
	Hardware Specification	
	CPU	Intel Quad-Core Xeon 2.33GHz
	Memory	16 GB
	Storage	146 GB SAS
	Power Supply	650 Watt x 2 Unit

Server Bank B**Table 3.5** Web server Bank B


Web Server Bank B		
	System	
	Server Type	HP DL380 G4
	Server Name	Webpool01
	Operation System	Linux RH2
	Application	Sunone 6.1 SP8
	Hardware Specification	
	CPU	Intel Xeon 2.8 GHz
	Memory	4 GB
	Storage	73 GB SCSI
	Power Supply	575 Watt x 2 Unit

Table 3.6 Application server Bank B




Application Server Bank B		
	System	
	Server Type	HP DL380 G4
	Server Name	Apppool01
	Operation System	Linux RH2
	Application	JBoss 4.0.5 GA
	Hardware Specification	
	CPU	Intel Xeon 2.8 GHz
	Memory	4 GB
	Storage	73 GB SCSI
	Power Supply	575 Watt x 2 Unit

Table 3.7 Database server Bank B

Database Bank B		
	System	
	Server Type	Sunfire X4150
	Server Name	SANNODE
	Operation System	Windows 2003 Enterprise
	Application	Microsoft SQL Server 2005
	Hardware Specification	
	CPU	Intel Quad-Core Xeon 2.33GHz
	Memory	16 GB
	Storage	146 GB
	Power Supply	650 Watt x 2 Unit =1300 Watt

3.1.2.1.2 Gather the concurrent data of users who had access in period . This data is show the maximum number of users by use software “F5 Load balance” to collect and demonstrate the number of users.

Table 3.8 F5 Load balance

F5 Load Balance		
	System	
	Server Type	F5 Load balance
	Server Name	F5 BIG IP 2400
	Operation System	-
	Application	-
	Hardware Specification	
	Transport protocol	TCP/IP
	Data link protocol	Ethernet, Fast Ethernet, Gigabit Ethernet
	Connectivity	Cable

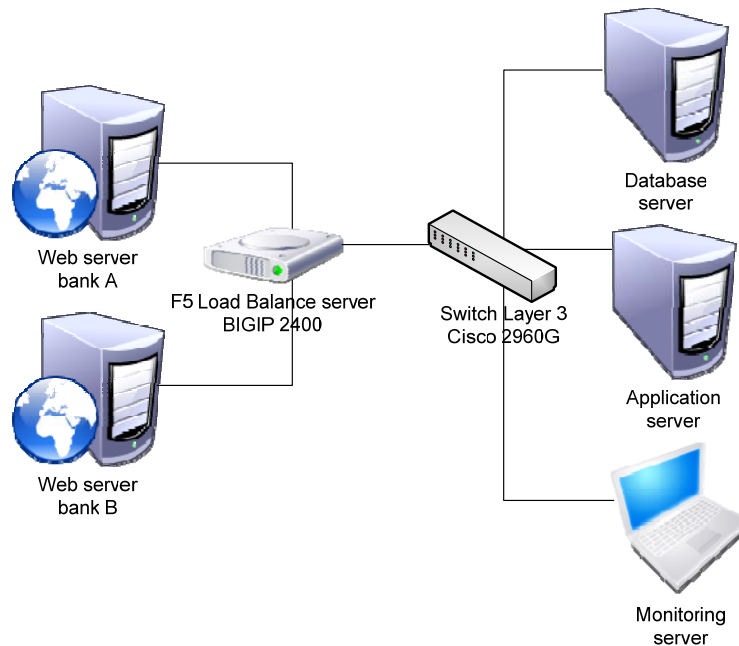


Figure 3.2 Infrastructure systems with non-virtualization technology

3.1.2.2 Web Server with integrated Virtualization Technology

3.1.2.2.1 Design and install Virtual machine

system into the server to let Bank A and Bank B can run on the web server

with integrated virtualization technology. In this step use a tool “VMWARE Server Version 2 (For Linux)” to test.

Details of virtual machine

Table 3.9 Virtual Machine Layer

Web Application A	Web Application A
Operating System A	Operation System B
Virtual Machine A	Virtual Machine B
Virtualization Layer	
Physical Hardware (CPU, Memory and Storage)	

Specification of servers with integrated virtualization technology that provided services to the customers are defined by system functions (Bank A and Bank B) can be described as below:

Table 3.10 Web Server Virtual Machine Test Environments


Web Server (VMWARE)		
	1.1 Linux Web Server (VMWARE Server)	
	System	
	Server Type	PC
	Server Name	LINWEB
	Operation System	RHEL 4
	Application	SUNONE 6.1, Java 1.5
	Hardware Specification	
	CPU	AMD Athlon core2 2.7 GHz
	Memory	8 GB
	Storage	500 GB

Table 3.10 Web Server Virtual Machine Test Environments (cont.)

Web Server (VMWARE)	
1.2 Windows Web Server (VMWARE Server)	
System	
Server Type	PC
Server Name	WINWEB
Operation System	Windows 2003 server
Application	SUNONE 6.1, Java 1.5
Hardware Specification	
CPU	AMD Athlon core2 2.7 GHz
Memory	8 GB
Storage	500 GB
Power Supply	400 Watt

Table 3.11 Linux Application Server Test Environments



Linux Application Server		
	System	
	Server Type	HP Pavilion A6378L
	Server Name	LINAPP
	Operation System	RHEL 4
	Application	JBOSS 4.0.4 GA, Java 1.5
	Hardware Specification	
	CPU	Athlon 64 X2 2.5 GHz
	Memory	4 GB
	Storage	250 GB
	Power Supply	400 Watt

Table 3.12 Database Server Test Environments


Database Server		
	System	
	Server Type	HP Pavilion A6378L
	Server Name	DBQA
	Operation System	Windows 2003 Server
	Application	MS SQL Server 2005 Std
	Hardware Specification	
	CPU	Athlon 64 X2 2.5 GHz
	Memory	4 GB
	Storage	250 GB
	Power Supply	400 Watt

3.1.2.2.2 This research use software named “Load Runner (HP)” as load simulator for testing. In this step has set the number of concurrent value as a number from F5 Load balance or bigger in number to test working and providing services of test environment .

3.1.2.2.3 Measure the performance and collect working data which are CPU, memory, Storage by using software “AppManager Monitoring 9.0” as a monitoring tool.

Specification of server with integrated virtualization technology which is providing services to customers is defined by system functions.

Table 3.13 Monitoring Server

1. Monitoring Server		
	System	
	Server Type	Atec Vegus 989
	Server Name	NBAtec
	Operation System	Windows XP SP2
	Application	Application Manager 9
	Hardware Specification	
	CPU	Pentium 4 1.8 GHz
	Memory	768 MB
	Storage	20 GB
	Power Supply	-

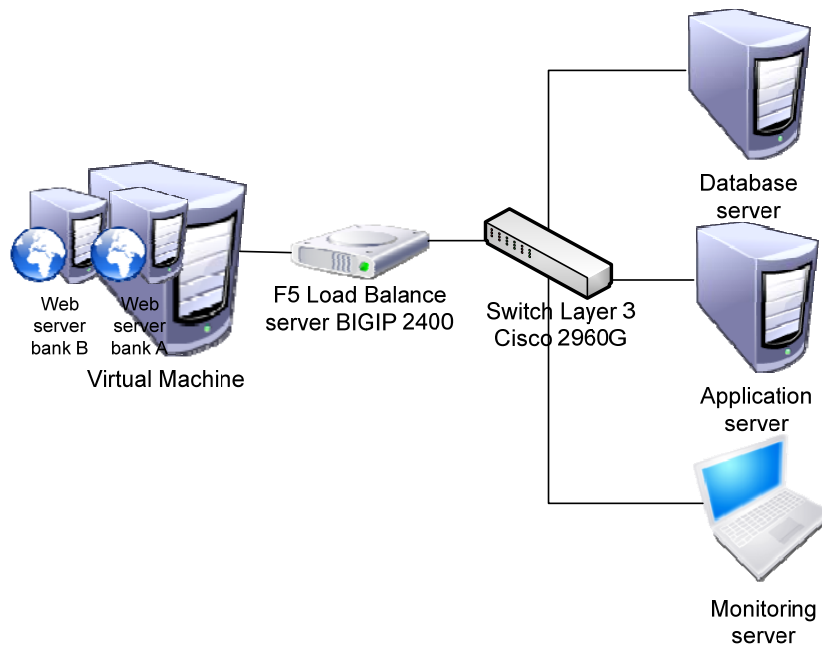


Figure 3.3 Infrastructure systems with virtualization technology

3.1.3 Gather working data from Existing Server and Testing Virtualization Server. Then compare working data between server with integrated virtualization technology and non-virtualization technology. Analyze data from these servers which

one is better to work as web server with integrated virtualization technology by analyze and compare total cost of owner ship as follow.

Operation Cost

- Evaluation cost
- Maintenance cost

How to calculate maintenance cost

Table 3.14 Method of calculate maintenance cost

$\text{Annual Maintenance Cost of Servers} = \text{Total Number of Servers} \times \text{Cost per Server} \times \text{Hardware Maintenance Rate}$
--

Table 3.14 Method of calculate maintenance cost (cont.)

Input	Description	Default Value	Data Source
Hardware Maintenance	Annual maintenance rates of servers as a percentage of initial purchase price	10%	AWS customer surveys reveal averages annual

- Electricity cost

How to calculate electricity cost

Table 3.15 Method of calculate electricity cost

<p>Step 1:</p> $\frac{\text{Electric Power (Watt)} \times \text{Hours per days} \times \text{Day per month}}{1,000} = \text{Unit}$
<p>Step 2:</p> <p>(1) $(\text{Unit} \times \text{Electricity tariffs of Thailand}) + \text{Service charge} = \text{Electricity charge}$</p> <p>(2) $\text{Unit} \times \text{FT} = \text{Energy adjustment charge}$</p>
<p>Step 3:</p> <p>$(1) + (2) + \text{VAT (7\%)} = \text{Electricity cost per month}$</p>

Acquisition cost

- Hardware cost

Hardware cost of existing server

Table 3.16 Hardware cost of existing server

Hardware	Quantity	Price(BAHT)	Total
Sun Fire Server x4150	1	299,500.00	299,500.00
HPDL380 G4	3	142,000.00	426,000.00
Monitoring Server	1	15,000.00	15,000.00
Switch Cisco 2960G	1	96,530.00	96,530.00
F5 Load balance	1	700,000.00	700,000.00

Hardware cost of virtual machine server

Table 3.17 Hardware cost of virtual machine server

Hardware	Quantity	Price(BAHT)	Total
HP Pavilion A6378L	2	22,500.00	45,000.00
Virtual Machine server	1	15,000.00	15,000.00
Monitoring Server	1	15,000.00	15,000.00
Switch Cisco 2960G	1	96,530.00	96,530.00
F5 Load balance	1	700,000.00	700,000.00

- Software cost

Software cost of existing server

Table 3.18 Software cost of existing server

Software	Quantity	Price(BAHT)	Total
SUNONE Web server	2	-	-
SQL Server 2005 Std	1	28,900.00	28,900.00

Software cost of virtual machine server

Table 3.19 Software cost of virtual machine server

Software	Quantity	Price(BAHT)	Total
VMware server 2.0	1	-	-
SQL Server 2005 Std	1	28,900.00	28,900.00
SUNONE Web Server	2	-	-

- Operating System cost

Operating System cost of existing server

Table 3.20 Operating System cost of existing server

Software	Quantity	Price(BAHT)	Total
MS Windows 2003 Std	2	23,500.00	47,000.00
Linux Redhat Ent v5.0	2	15,000.00	30,000.00

Operating System cost of virtual machine server

Table 3.21 Operating System cost of virtual machine server

Software	Quantity	Price(BAHT)	Total
MS Windows 2003 Std	2	23,500.00	47,000.00
Linux Redhat Ent v5.0	2	15,000.00	30,000.00

3.1.4 Analysis and Comparison

3.1.4.1 Analysis the data to compare the resource utilization of the existing server before and after implementing virtual machine on the server.

3.1.4.2 Analysis total cost of ownership between using existing servers and using virtual server in order to select the best solution.

3.1.5 Conclusion and Recommendation

Conclude the performance and investment of two type of servers. The results give the information to prepare the proper web server for replace the exists one.

3.2 Materials

3.2.1 Hardware

3.2.1.1 F5 Load Balance BIG IP 2400

3.2.1.2 HP Pavilion A6378L

3.2.1.3 Sun Fire x4150

3.2.1.4 HP DL 380 G4

3.2.1.5 Atec Vegus 989

3.2.2 Virtualization tools

3.2.2.1 VMware server version 2

3.2.3 System Monitoring Tools

3.2.3.1 Application Manager 9.0

3.2.4 Loading Test Tools

3.2.4.1 HP Load runner

3.3 Research Schedule

Table 3.22 Research Schedule

Task Name	Duration	Feb	Mar	Apr	May	Jun	Jul	Aug
1. Prepare Materials	60 Days	→	→					
2. System Monitoring	14 Days			→				
3. Submit Proposal	1 Days			→				
4. Cost Collection	15 Days			→				
4. Analysis & Comparison	60 Days				→	→		
5. Conclusions & Recommendations	30 Days						→	
6. Documentation	30 Days							→

CHAPTER IV

RESULTS

To collect data for this research, there were two activities that the research had to do as follows:

1. Gathering data from the existing servers by using ManageEngine Application tool for 1 month to analyze maximum concurrent users of these systems.
2. Simulating concurrent load on the virtualized server with setting of maximum concurrent users to be 150 units then gathering data to compare with the data of the existing servers.

4.1 The existing servers

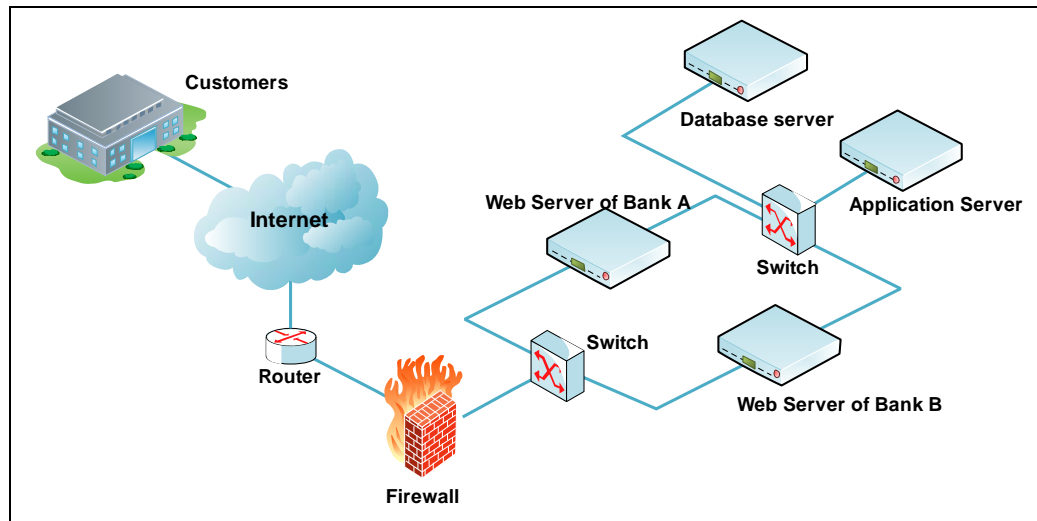


Figure 4.1 Diagram infrastructure systems with existing servers

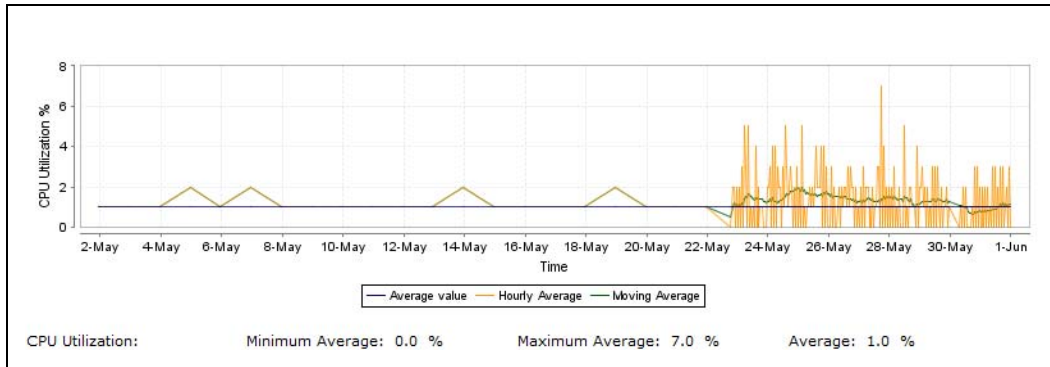
The data were collected using tools mentioned earlier, and the data collection period were between May 2, 2010 to June 1, 2010

4.1.1 Resource utilization monitoring

This is the top most level of an application. The presentation tier displays information related to such services as browsing merchandise, purchasing, and shopping cart contents. It communicates with other tiers by outputting results to the browser/client tier and all other tiers in the network.

4.1.1.1 Web Server of Bank A

CPU utilization



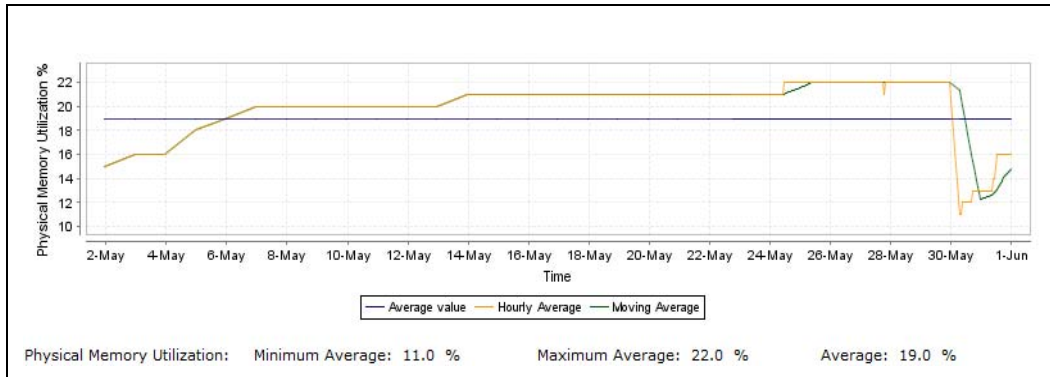
Minimum value in %	Maximum value in %	Monthly Average value in %
0.0	7.0	1.0

Figure 4.2 CPU utilization of web server of Bank A

The result from CPU utilization of Web server of Bank A is shown minimum value = 0.0%, maximum value = 7.0% and the average = 1.0%

From above, idle time in CPU is high but in worst case idle time is 93.0%.

Memory utilization



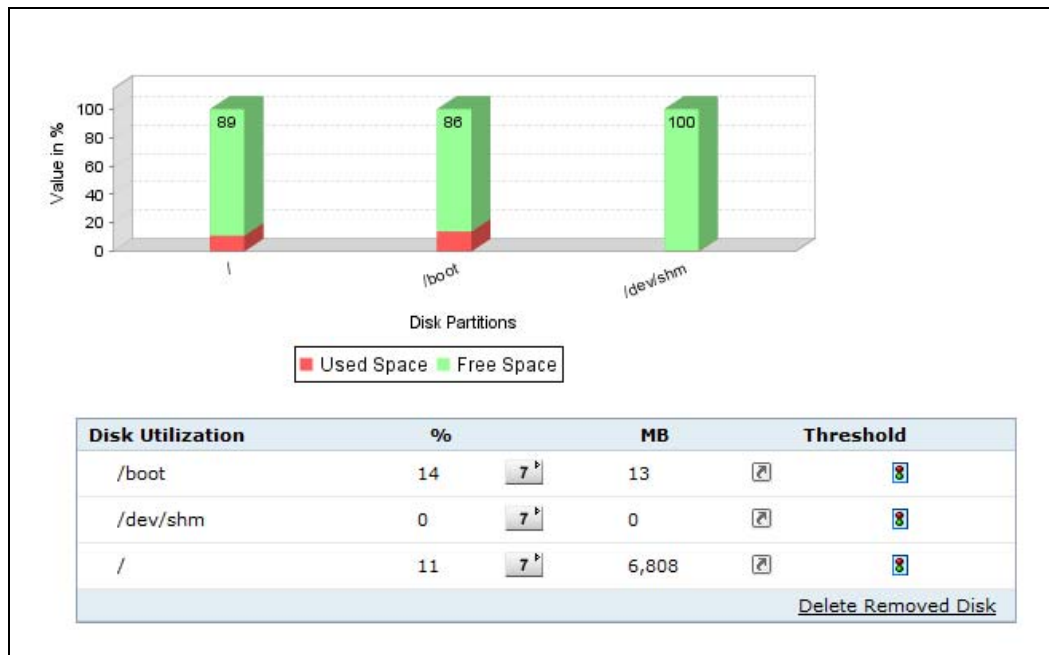
Minimum value in %	Maximum value in %	Monthly Average value in%
11.0	22.0	19.0

Figure 4.3 Memory utilization of web server of Bank A

The result from Memory utilization of Web server of Bank A is shown minimum value = 11.0%, maximum value = 22.0% and the average = 19.0 %

From above physical memory has high free space but in worst case there’s still 78% of free memory. Web server in service uses high amount of memory due to high numbers of customers who access to web

Storage Utilization



Disk Utilization	Disk Used Space (%)
/boot	14
/dev/shm	0
/	11

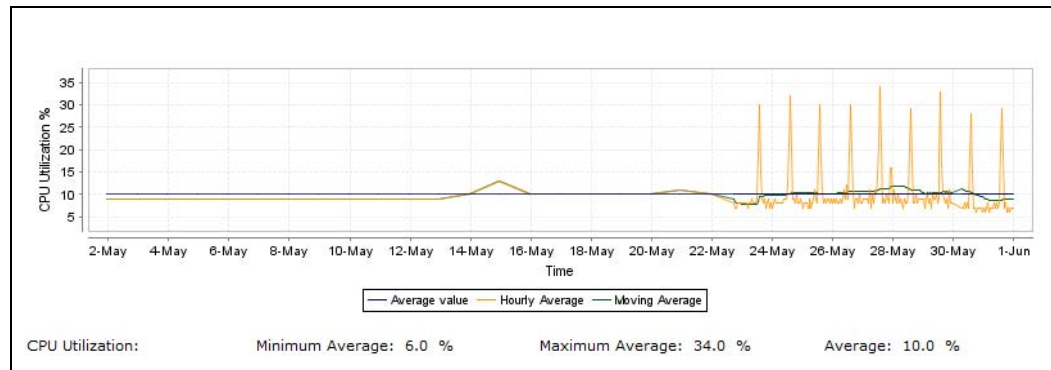
Figure 4.4 Storage utilization of web server of Bank A

The result from Storage utilization of Web server of Bank A is shown that Disk Used Space is /boot = 14.0%, /dev/shm = 0% and / = 11.0%,

Disk function is separated into 3 parts as “/boot” is collecting files in initial of system, “/dev/shm” is collecting data of share memory in the system and “/” is collecting data and files of operating system.

4.1.1.2 Web Server of Bank B

CPU utilization



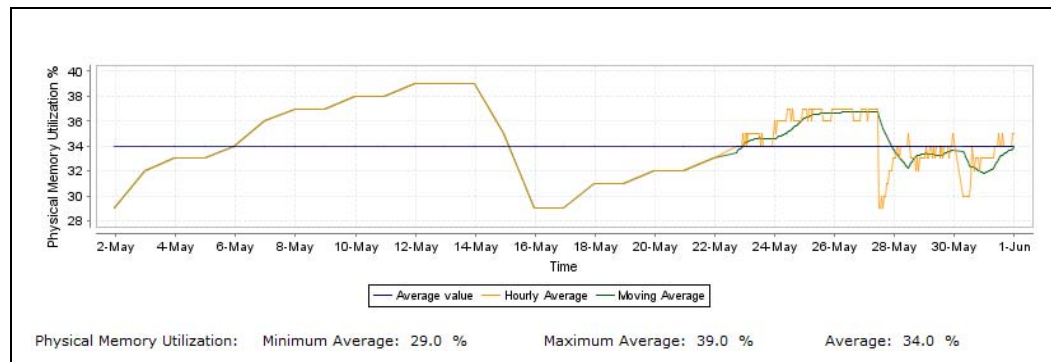
Minimum value in %	Maximum value in %	Monthly Average value in %
6.0	34.0	10.0

Figure 4.5 CPU utilization of web server of Bank B

The result from CPU utilization of Web server of Bank B is shown minimum value = 6.0%, maximum value = 34.0% and the average = 10.0%

From above, idle time in CPU is high but in worst case idle time is 66%.

Memory utilization



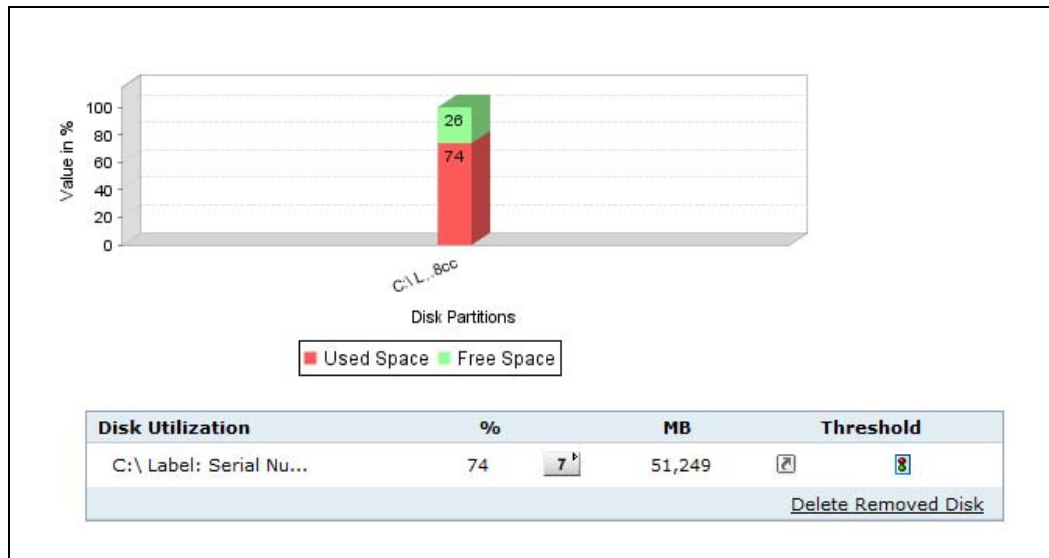
Minimum value in %	Maximum value in %	Monthly Average value in %
29.0	39.0	34.0

Figure 4.6 Memory utilization of web server of Bank B

The result from Memory utilization of Web server of Bank B is shown minimum value = 29.0%, maximum value = 39.0% and the average = 34.0%

From above, Physical memory has high free space but in worst case there’s still 61% of free memory. Web server in service uses high memory due to high numbers of customers who online access to web.

Storage Utilization



Disk Utilization	Disk Used Space (%)
C:	74

Figure 4.7 Storage utilization of web server of Bank B

The result from Storage utilization of Web server of Bank B is shown Disk Used Space = 74%.

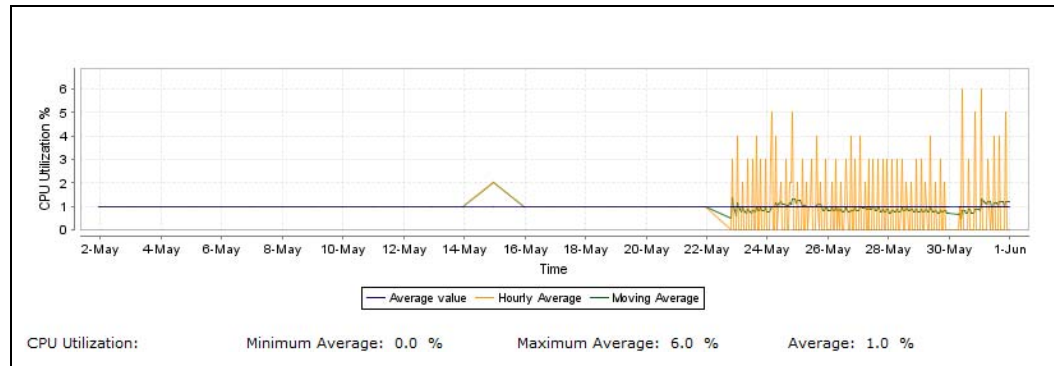
Disk C: is for operating system and data of server including Web contents.

4.1.1.3 Application Server

The logic tier is pulled out from the presentation tier and, as its own layer; it controls an application’s functionality by performing detailed processing.



CPU utilization



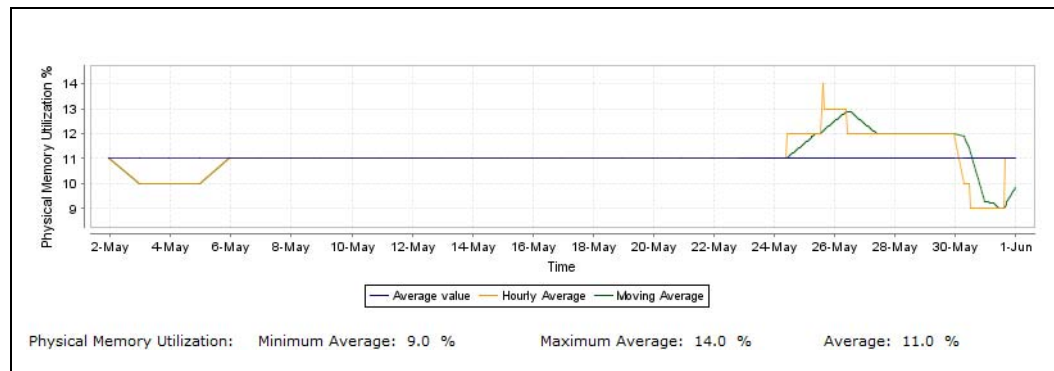
Minimum value in %	Maximum value in %	Monthly Average value in%
0.0	6.0	1.0

The result from CPU utilization of Application server is shown minimum value = 0.0%, maximum value = 6.0% and the average = 1.0%

From above, idle time in CPU is high but in worst case idle time is 94.0%

Figure 4.8 CPU utilization of application server of Bank A

Memory utilization

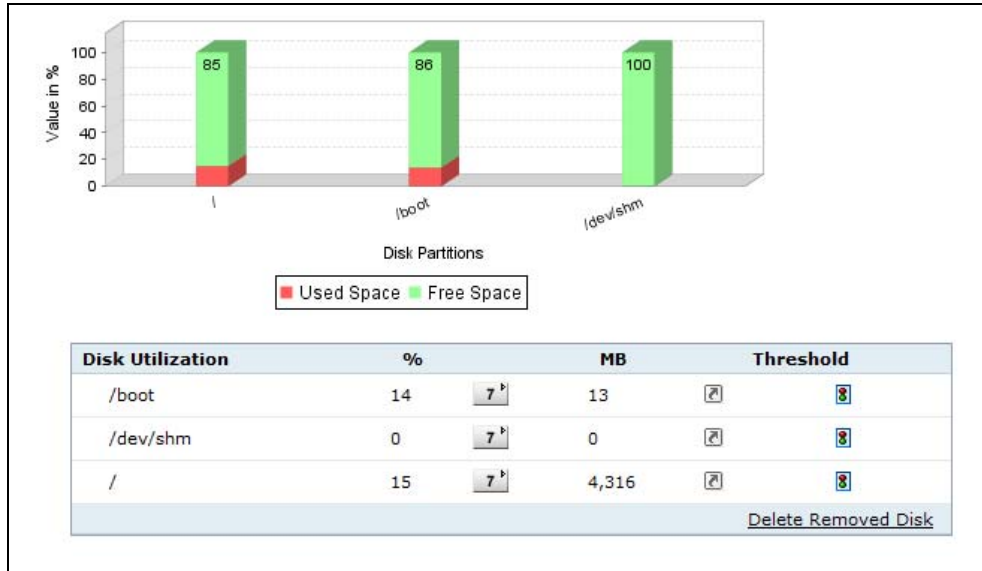


Minimum value in %	Maximum value in %	Monthly Average value in%
9.0	14.0	11.0

Figure 4.9 Memory utilization of application server of Bank A

The result from Memory utilization of Application server is shown minimum value = 9.0%, maximum value = 14.0% and the average = 11.0%

Physical memory has high free space but in worst case there's still 86.0 % of free memory.



Storage Utilization

Disk Utilization	Disk Used Space (%)
/boot	14
/dev/shm	0
/	15

Figure 4.10 Storage utilization of application server of Bank A

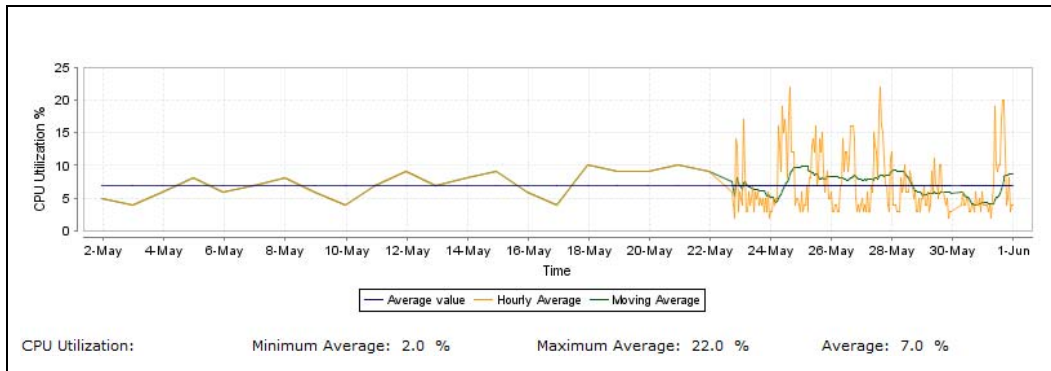
The result from Storage utilization of Application server of Bank A is shown Disk Used Space that /boot = 14.0%, /dev/shm = 0% and / = 15.0%.

Disk function is separated into 3 parts as “/boot” is collecting files in initial of system, “/dev/shm” is collecting data of share memory in the system and “/” is collecting data and files of operating system.

4.1.1.4 Database Server

This tier consists of database servers. In this tier, information is stored and retrieved. This tier keeps data neutral and independent from application servers or business logics. Which allows data to contain in its own tier. This allows an improvement in scalability and performance of an overall system.

CPU utilization



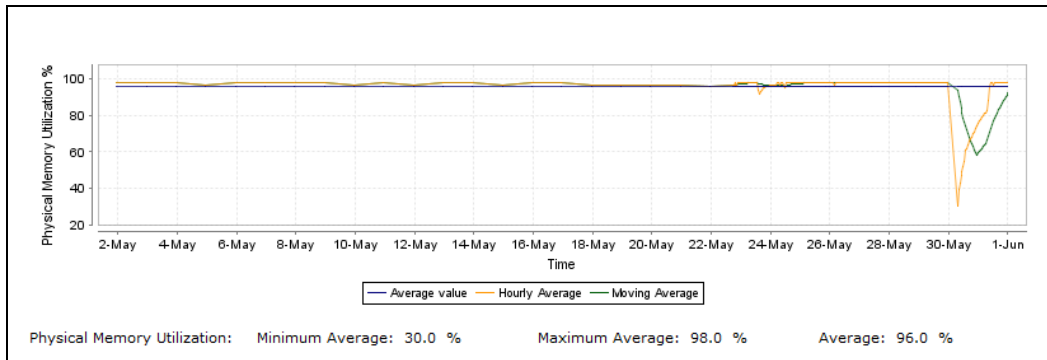
Minimum value in %	Maximum value in %	Monthly Average value in%
2.0	22.0	7.0

Figure 4.11 CPU utilization of database server of Bank A and B

The result from CPU utilization of Database server is shown minimum value = 2.0%, maximum value = 22.0% and the average = 7.0%

From above, idle time in CPU is high but in worst case idle time is 78.0%.

Memory utilization



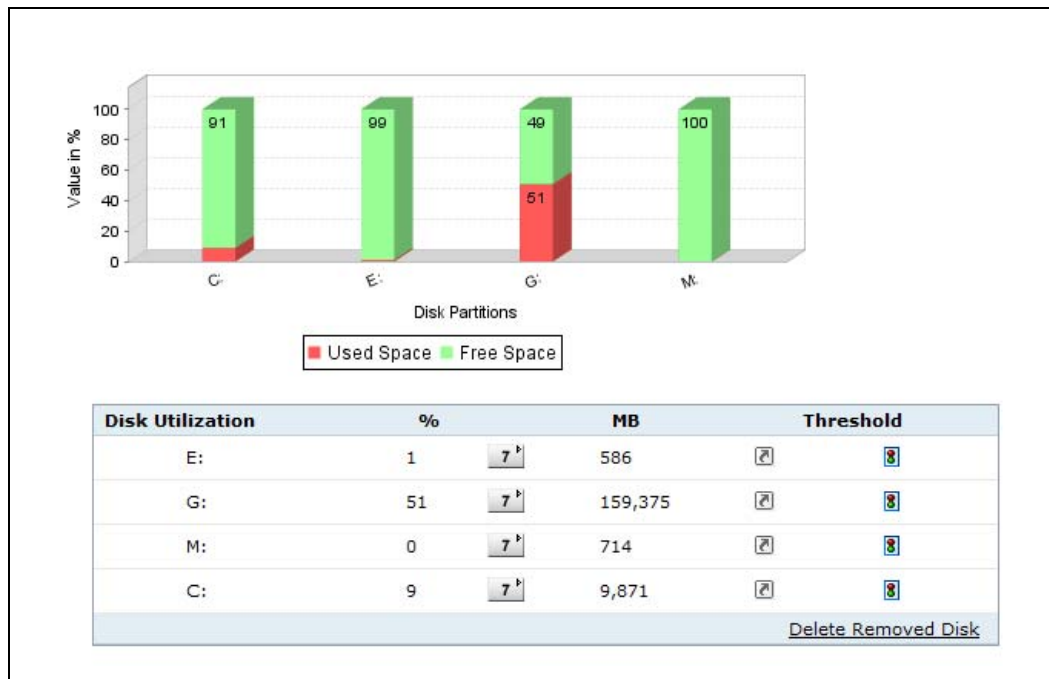
Minimum value in %	Maximum value in %	Monthly Average value in%
30.0	98.0	96.0

Figure 4.12 Memory utilization of database server of Bank A and B

The result from Memory utilization of Database server is shown minimum value = 30.0%, maximum value = 98.0% and the average = 96.0%

Physical memory has high free space but in worst case there's still 2.0% of free memory.

Storage Utilization



Disk Utilization	Disk Used Space (%)
C:	9
E:	1
G:	51
M:	0

Figure 4.13 Storage utilization of database server of Bank A and B

The results from Storage utilization of Database server of Bank A and B are shown that Disk Used Space C = 9%, E = 1%, G = 51% and M = 0%.

Disk are separated by function as Disk “C:” is located of operating system and data of server, while Disk E:, G: and M: are collecting of Database.

4.1.2 Summary of information of the existing servers

The summary of the performance information acquired from the existing servers are demonstrated in the tables as follows:

CPU Utilization

Summary of CPU unitization from the existing server

Table 4.1 CPU utilization of the existing servers

Server Name	Minimum (%)	Maximum (%)	Monthly Average (%)
Web server of Bank A	0.0	7.0	1.0
Web server of Bank B	6.0	34.0	10.0
Application server of Bank A and B	0.0	6.0	1.0
Database server of Bank A and B	2.0	22.0	7.0

The results from CPU utilization of existing server of servers are as below

- Web server of Bank A is shown Minimum = 0% , Maximum = 7.0% and average = 1.0%
- Web server of Bank B is shown Minimum = 6.0% , Maximum = 34.0% and average = 10.0%
- Application server of BankA and B are shown Minimum = 0% , Maximum = 6.0% and average = 1.0%
- Database server of Bank A and B are shown Minimum = 2.0% , Maximum = 22.0% and average = 7.0%,

In conclusion, Server A and B are high in idle time so probability of replacing the existing system with virtualization will be possible.

Memory Utilization

Summary of Memory unitization from existing server

Table 4.2 Memory utilization of existing server

Server Name	Minimum (%)	Maximum (%)	Monthly Average (%)
Web server of Bank A	11.0	22.0	19.0
Web server of Bank B	29.0	39.0	34.0
Application server of Bank A and B	9.0	14.0	11.0
Database server of Bank A and B	30.0	98.0	96.0

The results from Memory utilization of existing server of servers are as below

- Web server of Bank A is shown Minimum= 11.0% , Maximum = 22.0% and average = 19.0%
- Web server of Bank B is shown Minimum = 29.0% , Maximum = 39.0% and average = 34.0%
- Application server of Bank A and B are shown Minimum = 9% , Maximum = 14.0% and average = 11.0%
- Database server of Bank A and B are shown Minimum = 30.0% , Maximum = 98.0% and average = 96.0% ,

In conclusion, Server A and B have free memory more than 50% (Bank A is 88% and Bank B is 61% at least.) so Virtualization can be implementable.

Concurrent user of the existing servers

Resource utilization collected data from 13 February 2553 to 13 March 2553

Table 4.3 Concurrent users of the existing servers

Date	Concurrent user of Bank A	Concurrent user of Bank B
13/02/2010	23	101
14/02/2010	20	76
15/02/2010	91	112
16/02/2010	57	112
17/02/2010	79	105
18/02/2010	73	88
19/02/2010	65	89
20/02/2010	20	82
21/02/2010	22	84
22/02/2010	81	87
13/02/2010	74	87
24/02/2010	72	91
25/02/2010	82	99
26/02/2010	76	85
27/02/2010	82	80
28/02/2010	11	73
01/03/2010	27	72
02/03/2010	83	98
03/03/2010	78	90
04/03/2010	71	89
05/03/2010	75	96
06/03/2010	28	83
07/03/2010	81	87
08/03/2010	78	98
09/03/2010	66	85
10/03/2010	66	111
11/03/2010	58	87
12/03/2010	105	84
13/03/2010	25	80

Table 4.4 Summary of the concurrent users of the existing servers

Web Server	Minimum	Maximum	Monthly Average
Bank A	11	112	61
Bank B	72	105	90.04

The concurrent data of existing servers of servers are as below:

Web Server Bank A is shown Minimum = 11, Maximum = 112 and Monthly Average = 61

Web Server Bank B is shown Minimum = 72, Maximum = 105 and Monthly Average = 90.04

This information is to study customer behavior on servers for Bank A and Bank B that will be studied in real world. This information was also used for simulating load in Virtual machine of this research by use Load Stress Test.

4.2 Virtualization Server

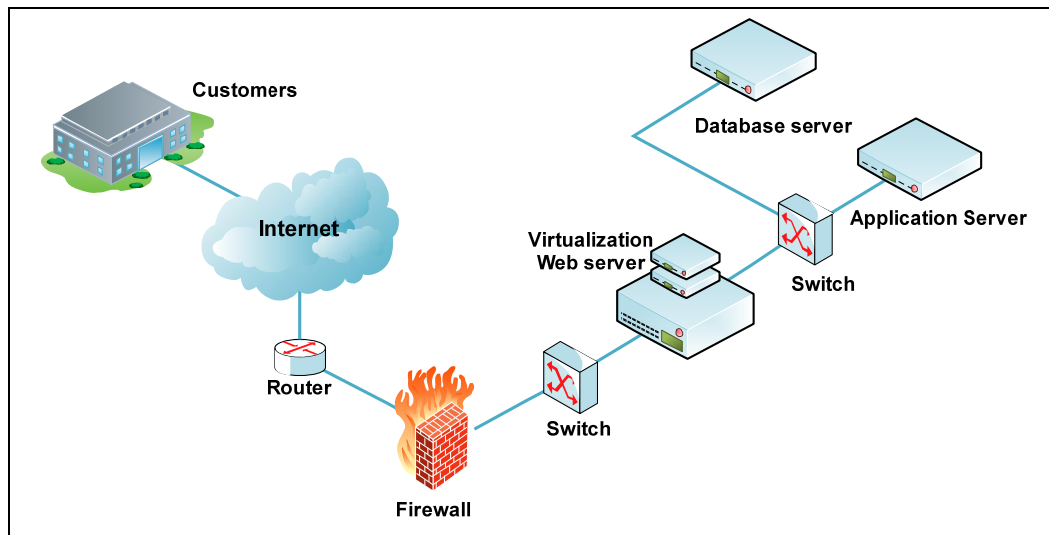


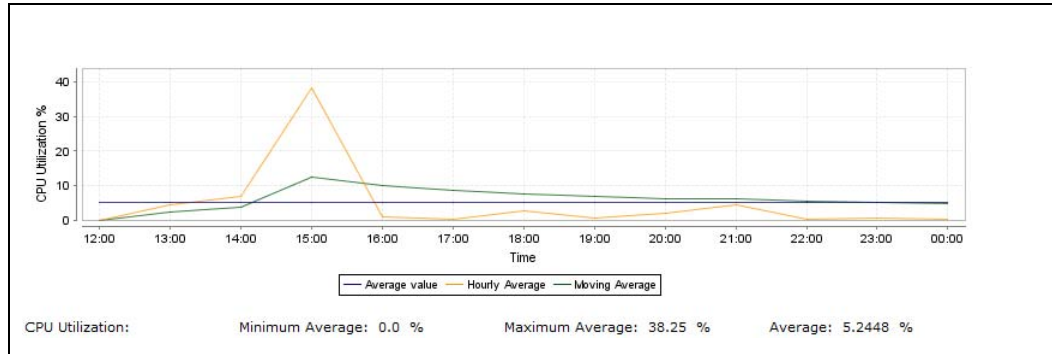
Figure 4.14 Diagram infrastructure systems with virtualization technology

Figure 4.14 is to demonstrate how Virtualization Web Server which two web servers are installed on single physical server installed. This is different from existing server that has to be installed individually shown in Figure 4.1.

4.2.1 Resource utilization monitoring

4.2.1.1 Web Server of Bank A

CPU utilization



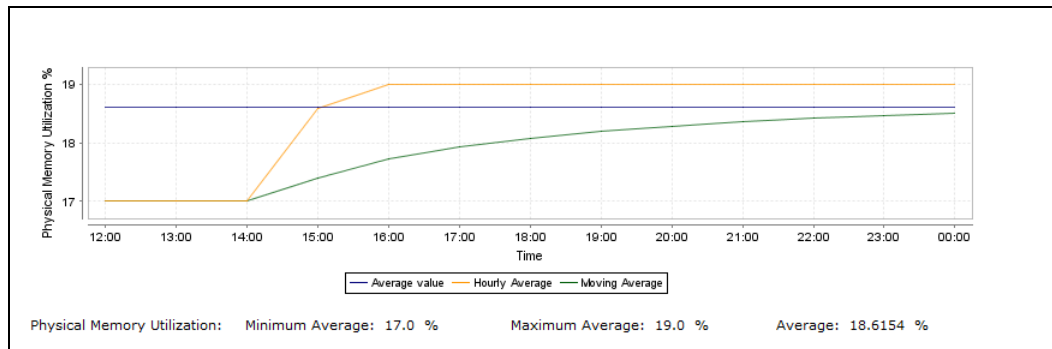
Minimum value in %	Maximum value in %	Monthly average value in %
0.0	38.25	5.25

Figure 4.15 CPU utilization of Web server of Bank A

The result from CPU utilization of Web server is shown minimum value = 0.0%, maximum value = 38.25% and the average = 5.25%

From above, working together between web server A and B effect to CPU of Bank A from 7% to 38.25% due to management of virtualization system and Simulate load testing.

Memory utilization



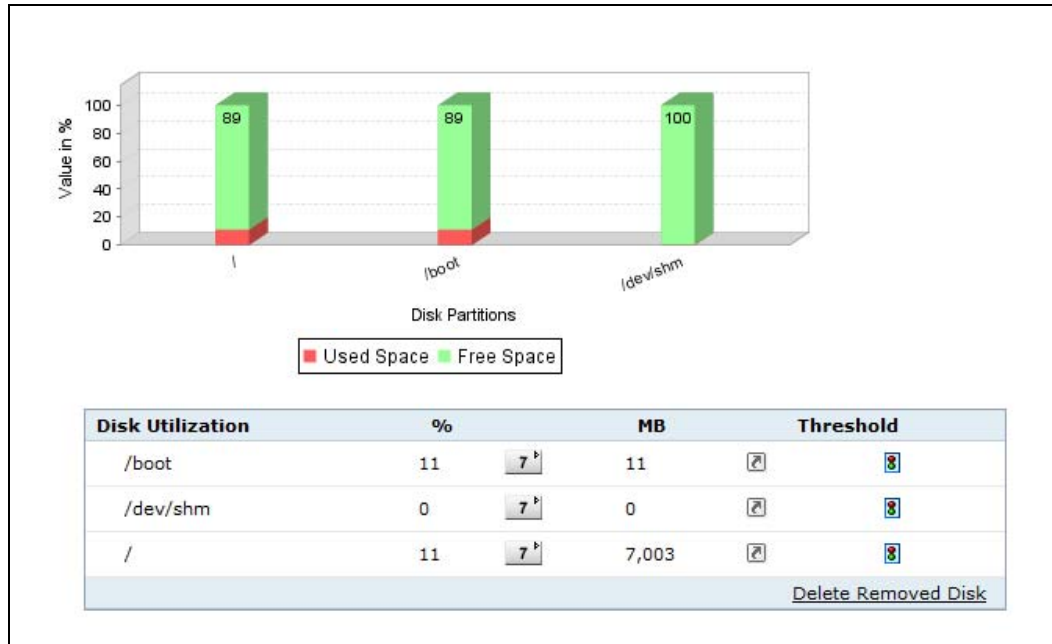
Minimum value in %	Maximum value in %	Monthly average value in %
17.0	19.0	18.62

Figure 4.16 Memory utilization of Web server of Bank A

The result from Memory utilization of Web server of Bank A is shown minimum value = 17.0%, maximum value = 19.0% and the average = 18.62%

From above, working together between web server A and B effect to CPU of Bank A from 19.0% to 22.0% due to management of virtualization system and Simulate load testing.

Storage Utilization



Disk Utilization	Disk Used Space (%)
/boot	11
/dev/shm	0
/	11

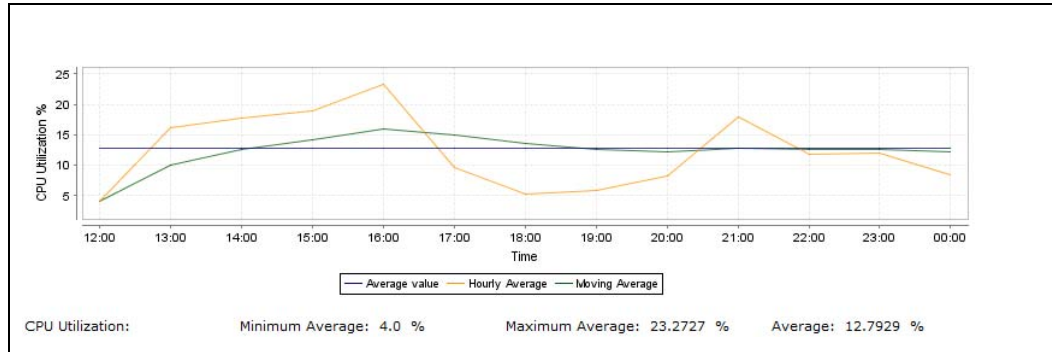
Figure 4.17 Storage utilization of Web server of Bank A

The result from Storage utilization of Web server of Bank A is shown that Disk Used Space is /boot = 11.0%, /dev/shm = 0% and / = 11.0%

Disk function is separated into 3 parts as “/boot”collecting files in initial of system, “/dev/shm” collecting data of share memory in the system and “/” collecting data and files of operating system.

4.2.1.2 Web Server of Bank B

CPU utilization



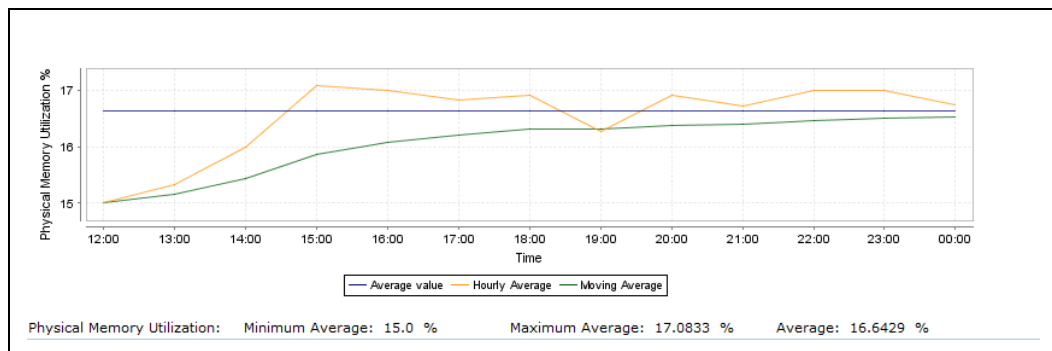
Minimum value in %	Maximum value in %	Monthly average value in %
4.0	23.28	12.80

Figure 4.18 CPU utilization of Web server of Bank B

The result from CPU utilization of Web server is shown minimum value = 4.0%, maximum value = 23.28% and the average = 12.80%

From above, working together between web server A and B effect to CPU of Bank B from 34.0% to 23.28% due to management of virtualization system and Simulate load testing.

Memory utilization



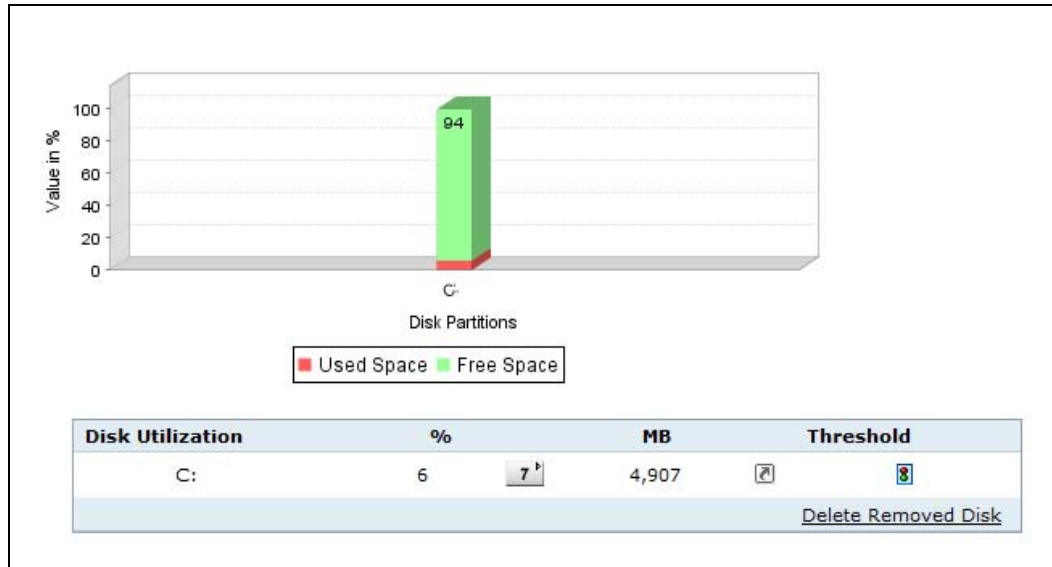
Minimum value in %	Maximum value in %	Monthly average value in %
15.0	17.09	16.65

Figure 4.19 Memory utilization of web server of Bank B

The result from Memory utilization of Web server of Bank B is shown minimum value = 15.0%, maximum value = 17.09.0% and the average = 16.65%

From above, working together between web server A and B effect to CPU of Bank B from 39.0% to 17.09% due to management of virtualization system and Simulate load testing.

Storage Utilization



Disk Utilization	Disk Used Space (%)
C:	6

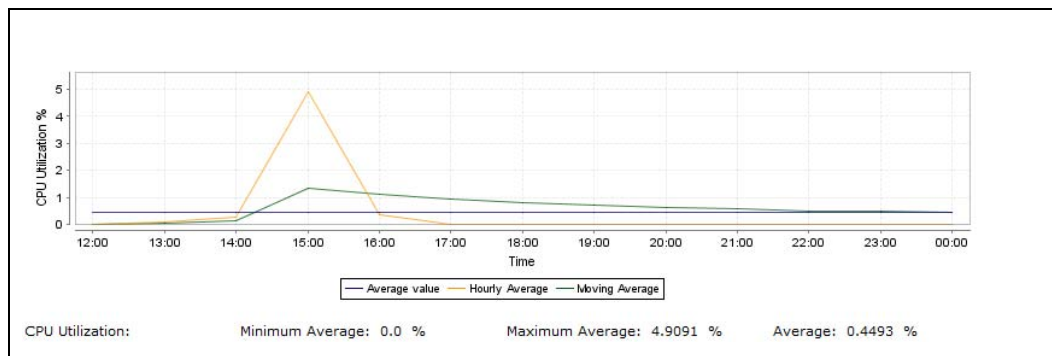
Figure 4.20 Storage utilization of Web server of Bank B

The result from Storage utilization of Web server of Bank B is shown that Disk Used Space of Disk C: = 6%

Disk C: contained of operating system and data of server including Web contents.

4.2.1.3 Application Server

CPU utilization

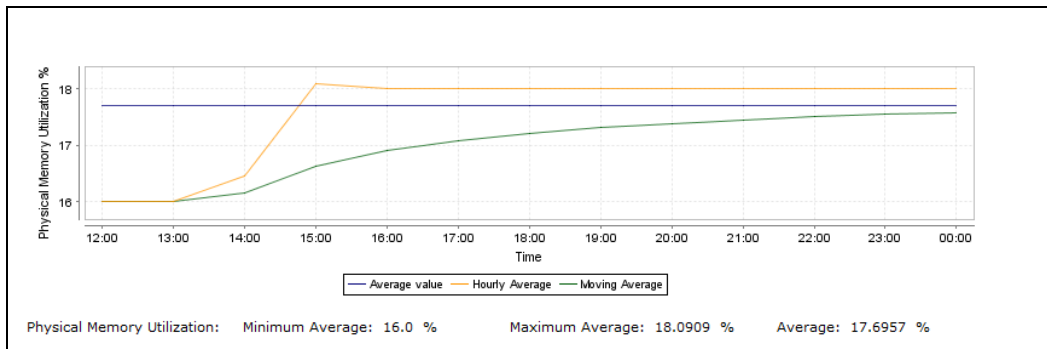


Minimum value in %	Maximum value in %	Monthly average value in %
0.0	4.91	0.45

Figure 4.21 CPU utilization of Application server Bank A and B

The results from CPU utilization of Application server of Bank A and B is shown minimum value = 0.0%, maximum value = 4.91% and the average = 0.45%

Memory utilization

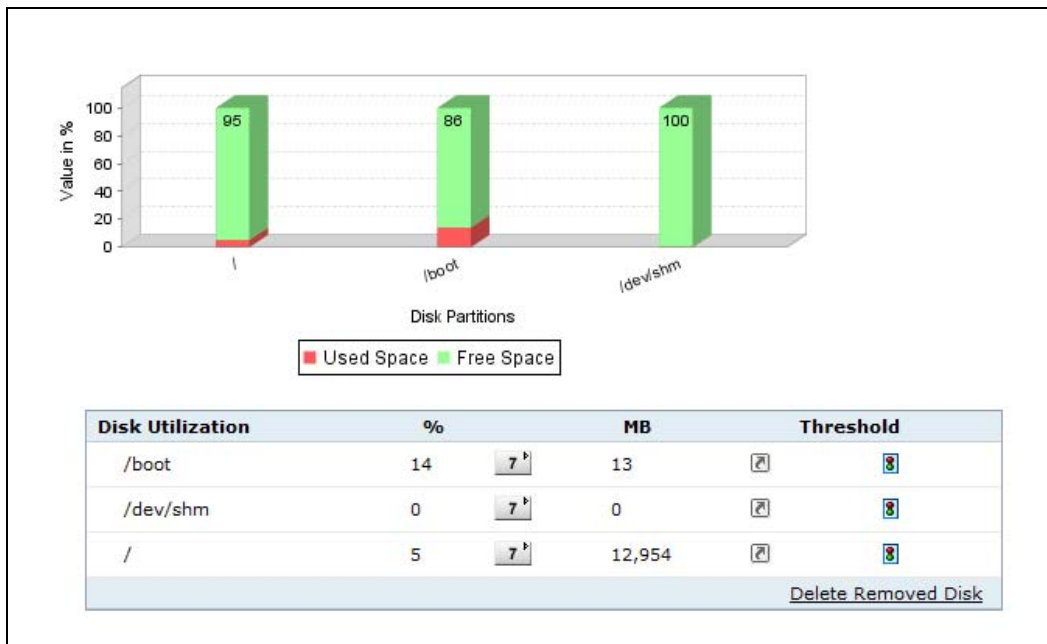


Minimum value in %	Maximum value in %	Monthly average value in %
16.0	18.10	17.70

Figure 4.22 Memory utilization of application server of Bank A and B

The results from Memory utilization of Application server of Bank A and B is shown minimum value = 16.0%, maximum value = 18.10% and the average = 17.70%

Storage Utilization



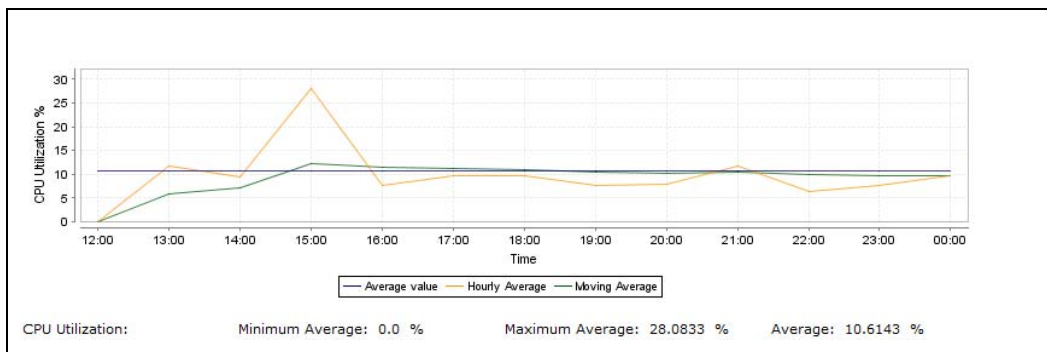
Disk Utilization	Disk Used Space (%)
/boot	14
/dev/shm	0
/	5

Figure 4.23 Storage utilization of application server of Bank A and B

The results from Storage utilization of Web server of Bank A and B is shown that Disk Used Space is /boot = 14.0%, /dev/shm = 0% and / = 5.0%

4.2.1.4 Database Server

CPU utilization

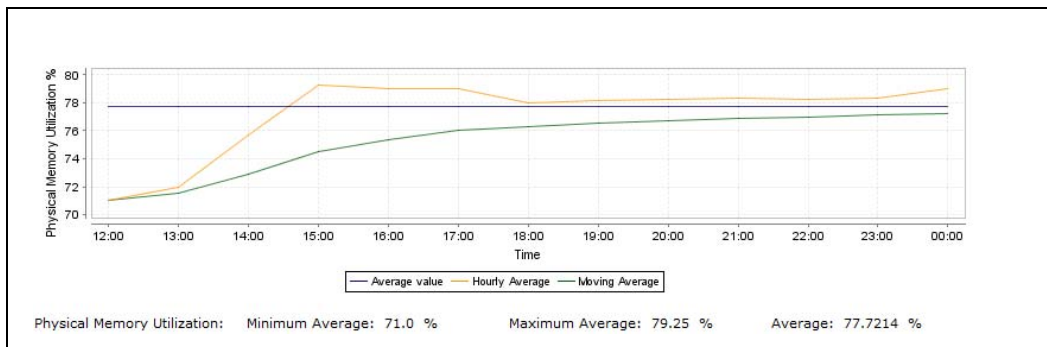


Minimum value in %	Maximum value in %	Monthly average value in %
0.0	28.09	10.62

Figure 4.24 CPU utilization of database server of Bank A and B

The results from CPU utilization of Application server of Bank A and B is shown minimum value = 0.0%, maximum value = 28.09% and the average = 10.62%

Memory utilization

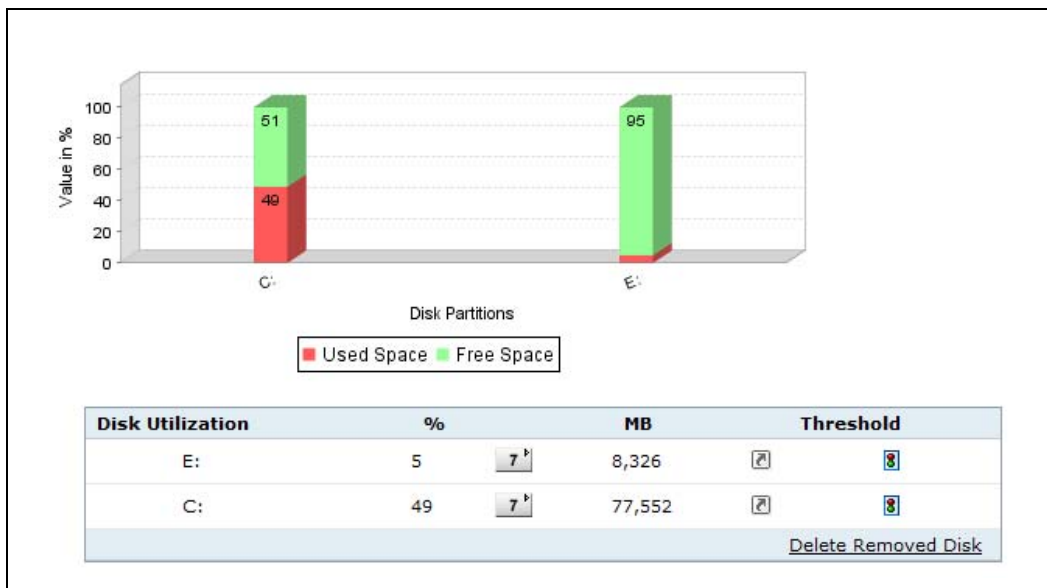


Minimum value in %	Maximum value in %	Monthly average value in %
71.0	79.25	77.73

Figure 4.25 Memory utilization of database server of Bank A and B

The results from Memory utilization of database server of Bank A and B is shown minimum value = 71.0%, maximum value = 79.25% and the average = 77.73%

Storage Utilization



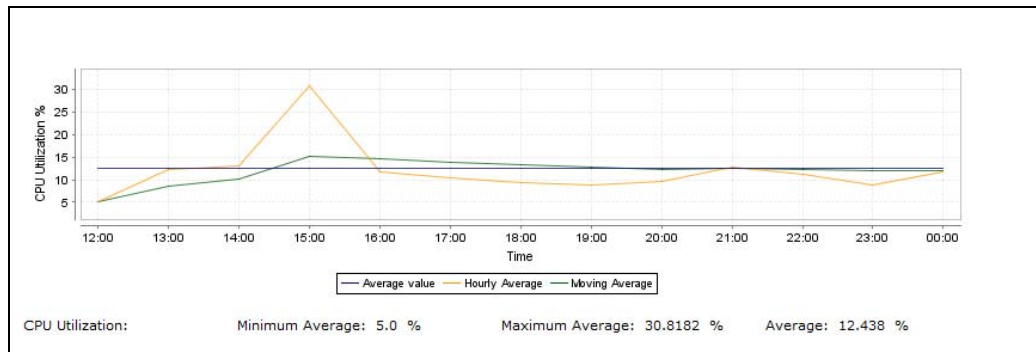
Disk Utilization	Disk Used Space (%)
C:	49
E:	5

Figure 4.26 Storage utilization of database server of Bank A and B

The results from Storage utilization of database server of Bank A and B is shown that Disk Used Space of Disk C: = 49% and E: = 5%.

4.2.1.5 Physical web server of Bank A and B

CPU utilization



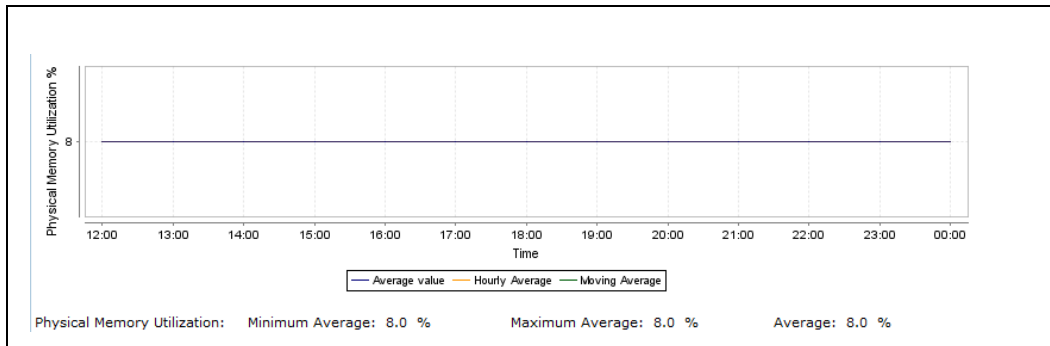
Minimum value in %	Maximum value in %	Monthly average value in %
5.0	30.82	12.44

Figure 4.27 CPU utilization of Physical web server of Bank A and B

The results from CPU utilization of Physical web server of Bank A and B is shown minimum value = 5.0%, maximum value = 30.82% and the average = 12.44%

From above data, comparisons of CPU of existing and virtualization server which existing one (Bank A+ Bank B) is 61.51% and virtualization one (CPU of Bank A and B) is 30.82% due to resource management of Virtualization technology and simulate load testing.

Memory utilization



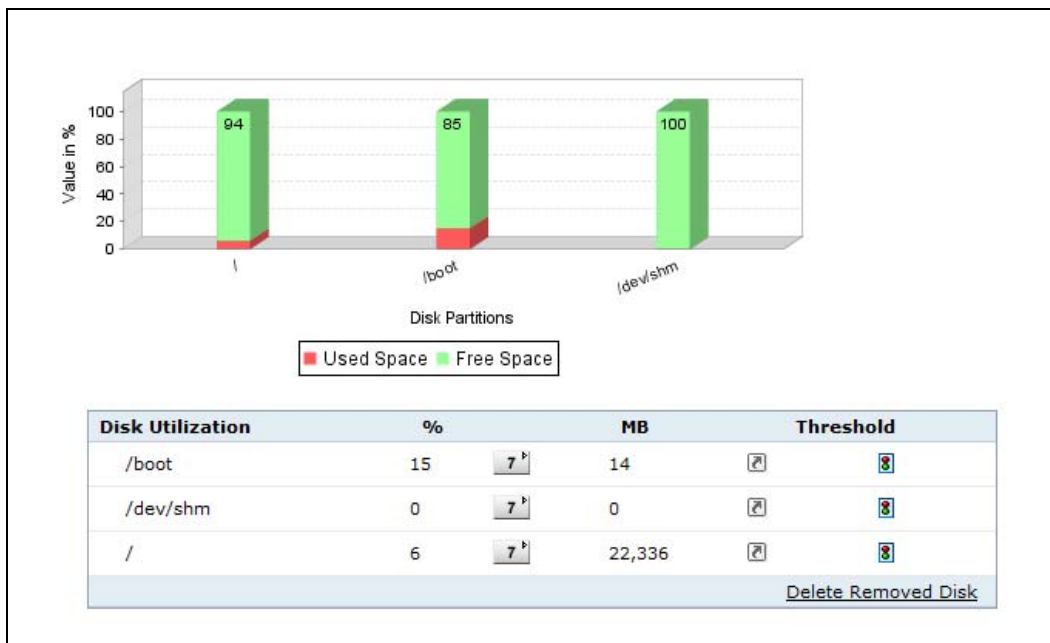
Minimum value in %	Maximum value in %	Monthly average value in %
8.0	8.0	8.0

Figure 4.28 Memory utilization of Physical web server of Bank A and B

The results from CPU utilization of Physical web server of Bank A and B is shown minimum value = 8.0%, maximum value = 8.0% and the average = 8.0%

From above data, comparisons of memory of existing and virtualization server which existing one (Bank A+ Bank B) is 36.09% and virtualization one (CPU of Bank A and B) is 8.0% due to resource management of Virtualization technology and simulate load testing.

Storage Utilization



Disk Utilization	Disk Used Space (%)
/boot	15
/dev/shm	0
/	6

Figure 4.29 Storage utilization of Physical Web server of Bank A and B

The results from Storage utilization of Physical server of Bank A and B is shown that Disk Used Space is /boot = 15.0%, /dev/shm = 0% and / = 6.0%.

Disk function is separated into parts as “/boot” is collecting files in initial of system, “/dev/shm” is collecting data of share memory in the system and “/” is collecting data and files of operating system.

Load Testing Tools of Virtualization server

Concurrent users of Virtualization server of Bank A

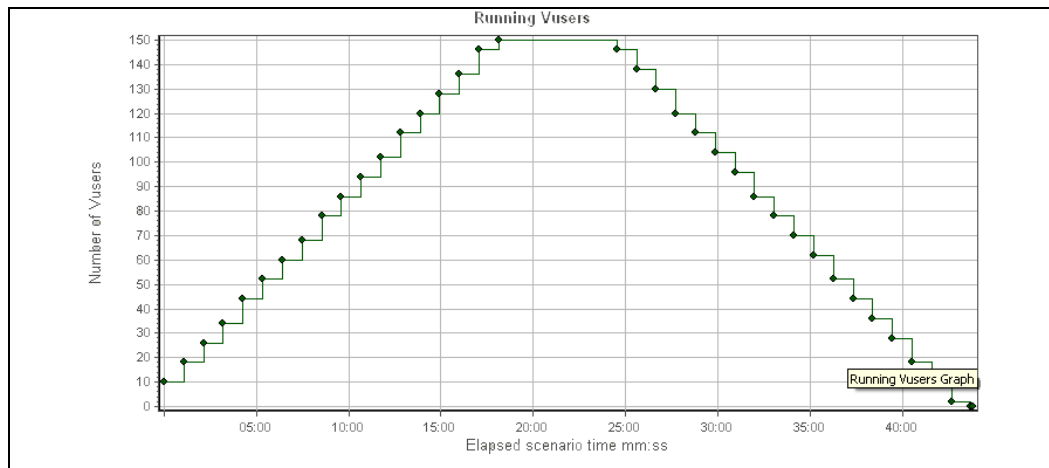


Figure 4.30 Running virtual user web server of Bank A

The result of virtual user testing by Load Runner of web Server of Bank A with 150 concurrent.

Virtual user web server of bank A was tested concurrently at 150 numbers of users and this was higher than numbers of users in real world.

Concurrent users of Virtualization server of Bank B

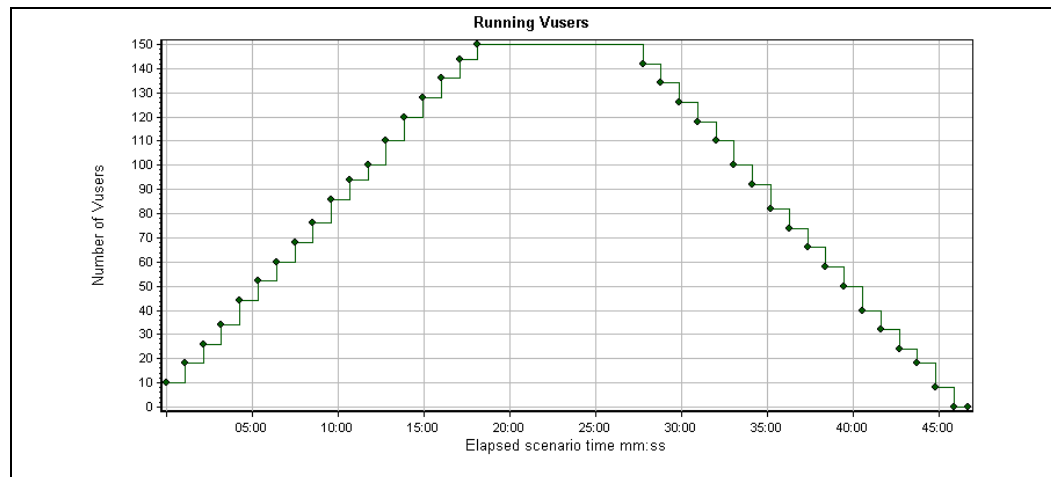


Figure 4.31 Running virtual user web server of Bank B

The result of virtual user testing by Load Runner of web Server of Bank B with 150 concurrent.

Virtual user web server of bank B was tested concurrently at 150 numbers of users and this was higher than numbers of users in real world.

Table 4.5 Concurrent of virtual server

Web Server	Maximum
Bank A	150
Bank B	150

The maximum concurrent users of virtual servers were set at 150 concurrents due to numbers in real situation is not over 150.

4.2.2 Summary of virtual server

The summary of Virtual server is demonstrated as tables below.

CPU Utilization

Summary of CPU unitization from Virtual server

Table 4.6 CPU utilization of virtual server

Server Name	Minimum (%)	Maximum (%)	Monthly Average (%)
Virtual Web server of Bank A	0.0	38.25	5.25
Virtual Web server of Bank B	4.0	23.28	12.80
Physical server of Bank A and B	5.0	30.82	12.44
Virtual Application server of Bank A and B	0.0	4.91	0.45
Virtual Database server of Bank A and B	0.0	28.09	10.62

The results of CPU utilization of virtual server are shown that

- Virtual Web Server of Bank A has Minimum value = 0%, Maximum value = 38.25% and Average = 5.25%
- Virtual Web Server of Bank B has Minimum value = 4.0%, Maximum value = 23.28% and Average = 12.80%
- Physical Virtual Web Server of Bank A and B has Minimum value = 5.0%, Maximum value = 30.82% and Average = 12.44%
- Virtual Application Server of Bank A and B has Minimum value = 0.0%, Maximum value = 4.91% and Average = 0.45%
- Virtual Database Server of Bank A and B has Minimum value = 0.0%, Maximum value = 28.09% and Average = 10.62%

Memory Utilization

Summary of Memory utilization from Virtual server

Table 4.7 Memorutilization of virtual server

Server Name	Minimum (%)	Maximum (%)	Monthly Average (%)
Virtual Web server of Bank A	17.0	19.0	18.62
Virtual Web server of Bank B	15.0	17.09	16.65
Physical server of Bank A and B	8.0	8.0	8.0
Virtual Application server of Bank A and B	16.0	18.10	17.70
Virtual Database server of Bank A and B	71.0	79.25	77.73

The results of Memory utilization of virtual server are shown that

- Web Server of Bank A has Minimum value = 17.0%, Maximum value = 19.0% and Average = 18.62%
- Web Server of Bank B has Minimum value = 15.0%, Maximum value = 17.09% and Average = 16.65%
- Physical Virtual Web Server of Bank A and B has Minimum value = 8.0%, Maximum value = 8.0% and Average = 8.0%
- Application Server of Bank A and B has Minimum value = 16.0%, Maximum value = 18.10% and Average = 17.70%
- Database Server of Bank A and B has Minimum value = 71.0%, Maximum value = 79.25% and Average = 77.73%

4.2.3 Resource Utilization comparisons

CPU Utilization

Comparison of CPU unitization from existing server and virtualization server

Table 4.8 Average CPU utilization of existing server and virtualization server

Server Name	Monthly average utilization of the existing servers	Monthly average utilization of Virtualization server (%)
Web server of Bank A	1.0	5.25
Web server of Bank B	10.0	12.80
Application server of Bank A and B	1.0	0.45
Database server of Bank A and B	7.0	10.62

Conclusion of average CPU utilization of existing server and virtualization server are as Web Server of bank A is 1.0% and 5.25% , Web Server of bank B is 10.0% and 12.80% , Application server of Bank A and B is 1.0% and 0.45% and Database server of Bank A and B is 7.0% and 10.62%.

Memory Utilization

Comparison of memory unitization from existing server and virtualization server

Table 4.9 Average memory utilization of existing server and virtualization server

Server Name	Monthly average utilization of the existing servers	Monthly average utilization of Virtualization server
Web server of Bank A	19.0	18.62
Web server of Bank B	34.0	16.65
Application server of Bank A and B	11.0	17.70
Database server of Bank A and B	96.0	77.73

Conclusion of average memory utilization of existing server and virtualization server are as Web Server of bank A are 19.0% and 18.62% , Web Server of bank B are 34.0% and 16.65% , Application server of Bank A and B are 11.0% and 17.70% and Database server of Bank A and B are 96.0% and 77.73%.

Load testing concurrent users of the existing servers and the virtualization server

Table 4.10 Maximum concurrent utilization of existing server and virtualization server

Server Name	Maximum concurrent users of the existing servers	Maximum concurrent of Virtualization server
Web server of bank A	112	150
Web server of bank B	105	150

The results of Maximum concurrent utilization of existing server and virtualization server of web server of Bank A are 112 and 150 and Bank B is 105 and 150.

4.3 Resource Utilization comparisons

The environment of the existing servers and the virtualized server were simulated to compare workloads of CPU, Memory and storage. The following details discussed the result of comparison based on their environment utilizations with respected to normal level of workloads.

4.3.1 Comparison of the CPU Utilization

The CPU Utilization of the virtualized server compared with the CPU utilization of the existing server for Bank A and Bank B

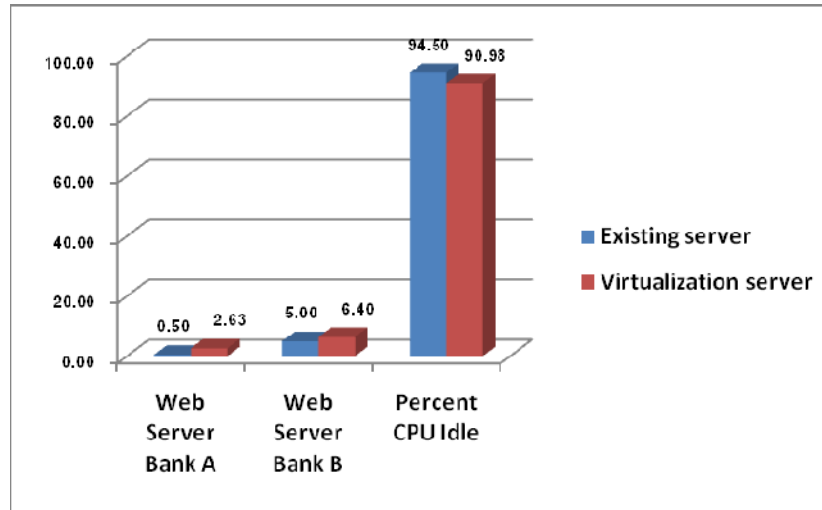


Figure 4.32 Comparison of CPU utilization the existing servers and VT server

Comparison of CPU in the machines, which are function as Web servers of two servers (Figure 4.32), shows that the monthly averages of CPU idle are 94.50% and 90.98% for the existing servers and virtualization server, respectively.

Work of CPU Utilization between Virtualization server and the existing servers are insignificantly different as (3.52%). As a result, the virtualization server can replace existing server and decrease costs of maintenance and electrical cost etc.

4.3.2 Comparison of the utilization Memory

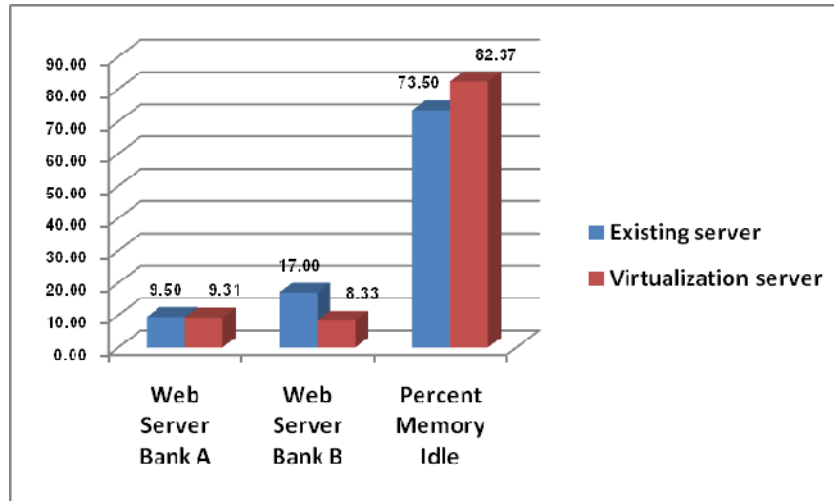


Figure 4.33 Comparison of memory utilization existing server and VT server

Comparison of memory in the machines, which are function as Web servers of two type servers (Figure 4.33), the monthly averages of memory idle are 73.50% and 82.37% for the existing servers and the virtualization server, respectively.

Different of performance of memory between virtualization server and the existing servers are as 8.8% which is insignificant. As a result servers can be replaced by the VT server. Which can help to reduce cost of electrical power and maintenance.

4.3.3 Comparison of the utilization Storage

Comparison of utilization storage cannot be done because the virtualization server was using tools for simulating customer behavior, which is different from real production environment in term of storage utilization. However, the performance of storage is not effect to the Total cost of ownership (TCO) calculation, and storage cost, ratio (MB/cost) is decreasing so it can be added to the production system using VT at anytime.

4.4 Cost Benefit analysis

Total Cost of Ownership can be separated as follows:

1. Direct cost: It is including acquisition costs, which are composed of hardware, operating system, and application costs.
2. Indirect cost: It is including administration cost, which are composed of implementation, service, and maintenance cost

Table 4.11 TCO Cost Catalog

Acquisition Cost	Administration Costs	
	Control Cost	Operation Costs
-Hardware -Operating System -Software -Application	-Implementation	-Service and Maintenance -Power Consumption

For online customer services, there are two types of the server systems

1. Service provides by usage of the existing servers.
2. Service provides by replacing the existing servers with the virtualized server.

For the existing servers, total cost of ownership is only indirect cost but for maintenance cost in it is higher than replacing system with the virtualized server.

4.4.1 Cost of the existing servers for Bank A & Bank B using as Web Servers.

4.4.1.1 Direct cost

Table 4.12 Direct cost of the existing servers

No	Server name	Acquisition cost	Detail	Price (Baht)
1	Web server Bank A	Hardware	HP DL380	142,000.00
		Operating system	Windows 2003 Std	23,500.00
		Application	Sunone 6.1 SP8	0.00
2	Web server Bank B	Hardware	HP DL380 G4	142,000.00
		Operating system	Linux RH2	0.00
		Application	Sunone 6.1 SP8	0.00
Summary before VAT				307,500.00
VAT (7%)				21,525.00
Total Summary				329,025.00

4.4.1.2 Indirect cost

Calculation of indirect cost is composed of electricity cost and maintenance cost of the existing server

4.4.1.2.1 Electricity Cost

Power Consumption of each Web Server = 575

watt / server

Demonstration of electricity cost equation (unit/month)

$$\text{Unit} = \frac{\text{Electric Power (watt)}}{1,000} \times \text{Usage house per day} \times \text{Usage day per month}$$

Service charge: Baht 40.90 per month, FT: 0.925 (Update 05 March 2010)

$$\text{Unit} = \frac{575}{1000} \times 24 \times 30 = 414$$

Electricity cost of each existing sever = 414 units / month

So, the total electricity cost of the existing of servers is equal to 414x2 = 828 units

Table 4.13 Rate of electricity cost

First 150 kWh	(1 st -150 th)	1.8047 Baht	Per kWh
Next 250 kWh	(151 st -400 th)	2.7781 Baht	Per kWh
Over 400 kWh	(up from 401 st)	2.9780 Baht	Per kWh

Service charge: Baht 40.90 per month, FT: 0.925

Table 4.14 Calculate of electricity cost

Part 1. Calculate of electricity cost:			
First 150 kWh	150 x 1.8047	270.70	Baht
Next 250 kWh	250 x 2.7781	694.53	Baht
Over 400 kWh	428 x 2.9780	1,274.58	Baht
Service charge		40.90	Baht
Summary		2,280.71	Baht
Part 2. Calculate of energy adjustment charge: (FT)			
FT (0.925)	828 x 0.925	765.90	Baht
Part 3. Calculate of VAT			
VAT (7%)	$(2,280.71+765.90) \times 7/100$	213.26	Baht
Part 4. Total Summary			
Total summary	$2,280.71+765.90+213.262$	3,259.88	Baht

Summary of electricity cost with VAT is 3,259.88 Bath/Month

4.4.1.2.2 Maintenance server price list

Table 4.15 Maintenance server price list

No.	Server	Server Type	Description	Application	Qty	MA Price/Monthly	
1	HP	DL380	Web Server	SunOne	1	1,267.00	Baht
2	HP	DL380	Web Server	SunOne	1	1,267.00	Baht
Summary						2,534.00	Baht
VAT (7%)						177.38	Baht
Total Summary						2,711.38	Baht

Summary of maintenance cost with VAT is 2,711.38 Bath/Month

4.4.1.2.3 Maintenance operating system price list

Table 4.16 Maintenance operating system price list

No.	OS	OS Type	Version	Vendor	Qty	MA Price/Monthly	
1	Linux	Server (Ent)	5.0	Redhat	1	3,083.33	Baht
2	Windows	Server (Std)	2003	Microsoft	1	0.00	Baht
Summary						3,083.33	Baht
VAT (7%)						215.83	Baht
Total Summary						3,299.17	Baht

Summary of maintenance cost with VAT is 3,299.17 Bath/Month

4.4.1.2.4 Cost of the existing servers per month

Table 4.17 Cost of the existing servers per month

Cost	Details	Price (Baht)
Direct Cost	Hardware	0.00
	Operating System	0.00
	Software	0.00
	Application	0.00
Indirect cost	Electricity	3,259.88
	Service and Maintenance Server	2,711.38
	Service and Maintenance Software	3,299.17
	Grand Total (Baht)	9,270.43

Summary cost of existing server with VAT every month is 9,270.43 Bath/Month

4.4.1.2.5 Grand total cost of the existing servers within 3 year

Table 4.18 Grand total cost of the existing servers within 3 year

No.	Cost	Years/Baht	Year 2/Baht	Year 3/Baht
1	Direct Cost	329,025.00	0.000	0.00
2	Indirect Cost	111,245.16	111,245.16	111,245.16
Cost in each year		440,270.16	111,245.16	111,245.16
Cumulative		440,270.16	551,515.32	662,760.48

Summation of Direct cost and indirect cost of virtualization server in year1 as 440,270.16 baht, year2 as 551,515.32 baht and year3 as 662,760.48 baht.

4.4.2 Cost of the virtualization server

4.4.2.1 Direct cost

Table 4.19 Direct cost of the virtualization server

No	Server name	Acquisition cost	Detail	Price (Baht)
1	Web server of Bank A	Operating system	Windows 2003 Std	23,500.00
		Application	Sunone 6.1 SP8	0.00
2	Web server of Bank B	Operating system	Linux RH2	0.00
		Application	Sunone 6.1 SP8	0.00
		Application	Sunone 6.1 SP8	0.00
3	VMWare Server 2.0			0.00
4	Sunfire x4150			210,344.83
Summary before VAT				233,844.83
VAT (7%)				16,369.14
Total Summary				250,213.97

4.4.2.2 Indirect cost

Calculation of Indirect cost is composed of electricity cost and maintenance cost of virtualized server

4.4.2.2.1 Electricity Cost

Power Consumption of the virtualized server for Bank A&B = 650 watt

Demonstration of electricity cost equation (unit/month)

$$\text{Unit} = \frac{\text{Electric Power (watt)}}{1,000} \times \text{Usage house per day} \times \text{Usage day per month}$$

Service charge: Baht 40.90 per month, FT: 0.925 (Update 05 March 2010)

$$\text{Unit} = \frac{650}{1000} \times 24 \times 30 = 468$$

Electricity cost of the virtualized = 468 unit / month

Rate of electricity cost

First 150 kWh	(1 st -150 th)	1.8047 Baht	Per kWh
Next 250 kWh	(151 st -400 th)	2.7781 Baht	Per kWh
Over 400 kWh	(up from 401 st)	2.9780 Baht	Per kWh

Service charge: Baht 40.90 per month, FT: 0.925

Table 4.20 Calculate of electricity cost

Part 1. Calculate of electricity cost:			
First 150 kWh	150 x 1.8047	270.70	Baht
Next 250 kWh	250 x 2.7781	694.53	Baht
Over 400 kWh	68 x 2.9780	202.50	Baht
Service charge		40.90	Baht
Summary		1,167.73	Baht
Part 2. Calculate of energy adjustment charge: (FT)			
FT (0.925)	468 x 0.925	432.90	Baht
Part 3. Calculate of VAT			
VAT (7%)	$(1,167.73+432.90) \times 7/100$	112.04	Baht
Part 4. Total Summary			
Total summary	$1,167.73+432.90+112.04$	1,712.67	Baht

Summary of electricity cost with VAT is 1,712.67 Bath/Month

4.4.2.2.2 Maintenance operating system price list

Table 4.21 Maintenance operating system price list

No.	OS	OS Type	Version	Vendor	Qty	MA Price	
1	Linux	Server (Ent)	5.0	Redhat	1	3,083.33	Baht
2	Windows	Server (Std)	2003	Microsoft	1	0.00	Baht
Summary						3,083.33	Baht
VAT (7%)						215.83	Baht
Total Summary						3,299.17	Baht

Summary of maintenance cost with VAT is 3,299.17 Bath/Month

4.4.2.2.3 Cost of Virtualization server per month

Table 4.22 Cost of Virtualization server per month

Cost	Details	Price (Baht)
Direct Cost	Hardware	0.00
	Operating System	0.00
	Software	0.00
	Application	0.00
Indirect cost	Electricity	1,712.67
	Service and Maintenance Server	0.00
	Service and Maintenance Software	3,299.17
Grand Total (Baht)		5,011.84

Summary cost of virtualization server in first month is 5,011.84 Bath/Month

4.4.2.2.4 Grand total cost of virtualization server within 3 year

Table 4.23 Grand total cost of virtualization server within 3 year

No.	Cost	Years/Baht	Year 2/Baht	Year 3/Baht
1	Direct Cost	250,213.97	0.00	0.00
2	Indirect Cost	60,142.08	60,142.08	60,142.08
Cost in each year		310,356.05	60,142.08	60,142.08
Cumulative		310,356.05	370,498.13	430,640.31

Summation of Direct cost and indirect cost of virtualization server in year1 as 310,356.05 baht, year2 as 370,498.13 baht and year3 as 430,640.31 baht.

4.4.3 Summary of cost benefit

This graph demonstrated total cost of ownership between the existing web servers and the virtualization web server, which compare cost of servers for 3 years in both direct and indirect cost.

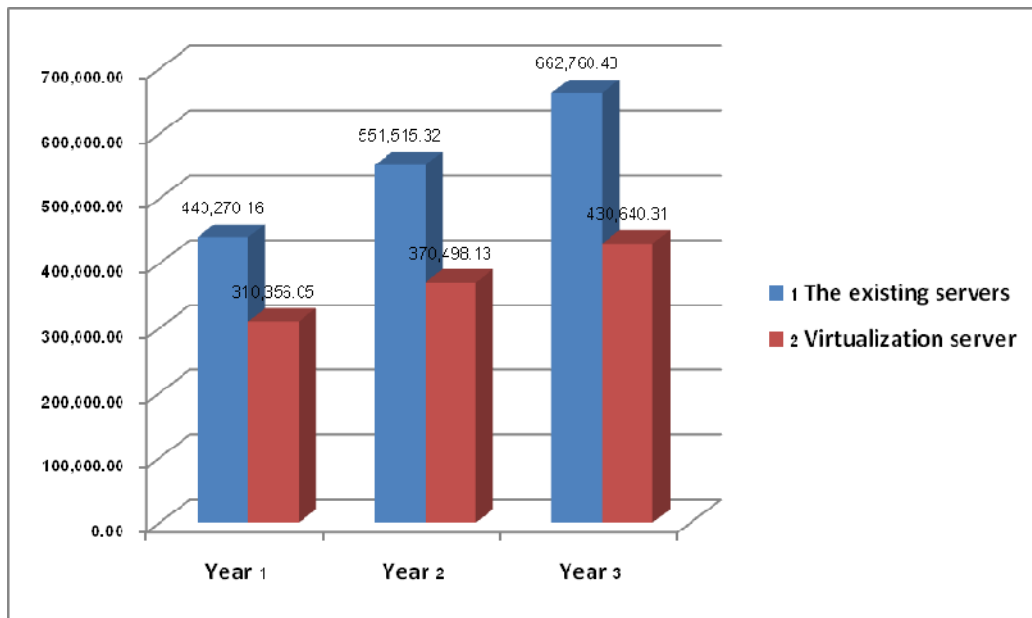


Figure 4.34 Graph cost comparison

Table 4.24 Grand total cost of server within 3 year

No.	Cost of	Year 1	Year 2	Year 3
1	The existing servers	440,270.16	551,515.32	662,760.48
2	Virtualization server	310,356.05	370,498.13	430,640.31

From the research that study on web server machine which is provided online transactions for customers. This study compared performance of works and costs between the existing servers and virtualization server in periods of three years.

The result shown that Web server with Virtualization technology can be efficiently replaced the existing servers based on the resulted of comparison of CPU utilization and memory utilization at 150 concurrent users.

For costs of investment, the virtualization machine shown that it is higher than the existing servers in the first year. Due to specification of the physical servers should support virtualization technology but these will decrease beginning from year 2. This is different from the existing servers that their costs will increase beginning from year 2 and it will keep increasing.

CHAPTER V

CONCLUSION

5.1 Conclusion

This research was aimed to study and to compare performance of two server environments: server environment with virtualization technology and non-virtualization technology (VT). The study factors were composed of performance indicators versus total cost of ownership (TCO). The performance indicators were CPU utilization and money utilization while TCO included both direct cost and indirect cost of using the systems. The result of this study can be used as a guideline for any organization being considered of using or investing in the virtualized environment. The study shown that VT can reduce TCO without degrading the system performance under the real production load.

From the comparison of results of the two server environments. The virtualization server can perfectly replace the existing servers because the data shown that the differences of CPU & Memory utilization of both systems are insignificant.

TCO comparison of the existing servers and the virtualization server for 3 years is demonstrated in the following table

Table 5.1 Comparison existing server and virtualization server

Year	The existing servers	The Virtualization Server	Saving cost
1	440,270.16	310,356.05	129,914.11
2	551,515.32	370,498.13	181,017.19
3	662,760.48	430,640.31	232,120.17
Total	1,654,545.96	1,111,494.49	543,051.47

The results from Table 5.1 is shown that virtualization server can save cost for 129,914.11 baht in first year , 181,017.19 baht in second year and 232,120.17 in third

year. In three years, the virtualization server is can save cost of investment and operating the system for 543,051.47 baht comparing with the existing servers

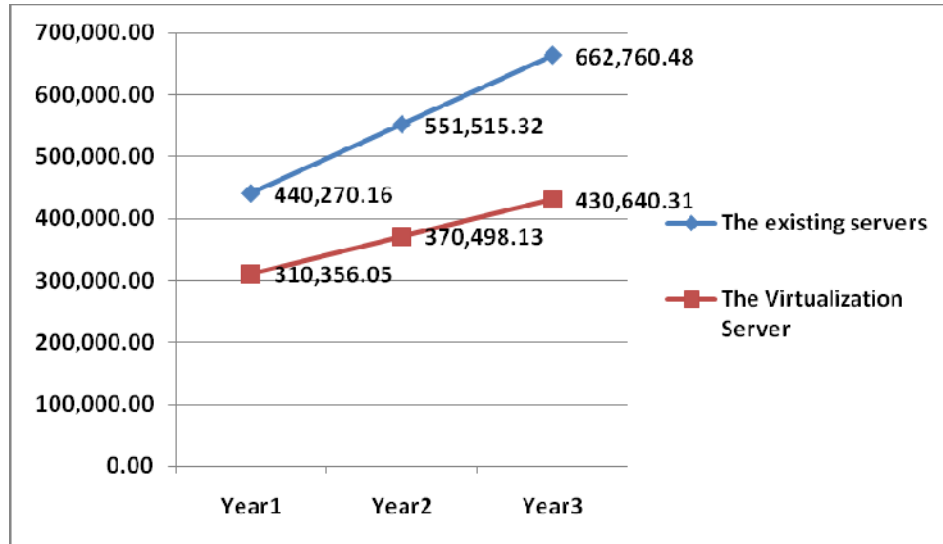


Figure 5.1 Graph comparison costs of existing servers and virtualization server

In addition, software costs as operating system and other software which are installed on existing and virtualization server are not different because they are calculated from number of software licenses and virtualization technology is not decrease this cost.

5.2 Recommendation

For virtualization technology and existing server analyzing is a comparison in B2B system which is an e-commerce via web online. This test is done by simulating customer behavior using Load testing tool software which may be different from the real situation due to program cannot simulate all types of customer behavior.

This research was focused to study and compare performance of web servers servicing in the e-commerce system. If virtualization technology will be adapted with other types of systems, the performance of server such as CPU utilization and memory utilization should be considered. The performance of CPU utilization and

memory utilization which are on existing servers should not over 50% during runtime due to virtualization servers will reduce the performance of physical machine which cause decreasing of server performance.

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