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ANALYSING SERVER PERFORMANCE IN CLOUD COMPUTING ON VIRTUAL NETWORK INFRASTRUCTURE; USING RIVERBED SIMULATOR

BY

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(BED. INFORMATION TECHNOLOGY)

A Thesis Submitted to the Department of Computer Science, Kwame Nkrumah University of Science and Technology in partial fulfillment for the degree of

MASTER OF PHILOSOPHY

IN

INFORMATION TECHNOLOGY

AUGUST, 2016

ACKNOWLEDGEMENT

First and foremost, i want to acknowledge the lord God Almighty by whose grace and kindness he has been able to come this far, Ebenezer.

Again i would like to thank his supervisor Dr. Michael Asante for his tireless efforts in directing his thoughts to help put this piece of work in shape.

Furthermore, I would like to acknowledge the head of Computer Science department; Dr James Hayfron Acquah whose direction has helped in shaping this thesis.

Need I also thank all my lecturers especially Mr Panford and Mr Twum.

Also, I would like to acknowledge my late father, Mr. Ben Asuah whose advices and foundational support through God had increased and prospered his efforts.

Lastly but not least, I would like to extend my warmest gratitude to my fellow friends and college coarse mates more especially to Mr. Enoch kofi Okoh for his criticisms which in diver's ways had contributed positively towards the state of this treatise.

I say to you all, God bless you.

DECLARATION

I hereby declare that this submission is my own work and that to the best of my knowledge and believe, it contains no material previously published or written by another person nor has been accepted for an award of degree or diploma in Kwame Nkrumah University of Science and Technology, Kumasi, or any other institution except due acknowledgement is made in the thesis.

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DEDICATION

I dedicate this piece of treatise to the Almighty God whose strength and grace has brought me this far. I would like to dedicate it also to my late father, Mr. Samuel Ben Asuah and late step mother, Mrs. Comfort Asuah, through whom the lord granted to give me that foundation needed to start off in life. Lastly, i singularly dedicate this work to all orphans and step children in the world, all my siblings, and my wife and future children.

ABSRACT

The research work here is expected to investigate the performance and relations for distributed systems in server use for cloud storage on virtual platforms. With most organizations opting for web based services, the use of virtual networking infrastructure in cloud storage does not only reduce cost and eliminates hardware failures and security risks such as theft of physical components in real world, but also provides a graphical user interface for the topology design allowing for realistic simulation of networks and high performance displaying modules as an added advantage for modern enterprises. This thesis seeks to analyze the behavior and efficiency of server performances in three different scenarios in cloud network using Riverbed Edu 17.5 edition as a virtual network platform simulation tool. Networks with three different server scenarios simulated against time in the network were modeled. The focus was on the server performance at different loads and processing speeds. The simulation was configured for about 100 workstations in a manner that all the applications and users can access the parameters; database, file transfer protocol, hypertext transfer protocol, and email response times on cloud utilization throughputs in two directions. The results for server performance in efficiency and viability is analyzed and evaluated with conclusions drawn as a guiding principle for organizations and companies considering the use or using servers for cloud storage.

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IBM - INTELLIGENT POWER MANAGEMENT

VM - VIRTUAL MACHINE

CP - CONTROL PROGRAMME

CMS - CONSOLE MONITOR SYSTEM

LAN - LOCAL AREA NERWORK

MAC- MATHEMATICS AND COMPUTATION/ MULTIPLE ACCESS COMPUTERS

IBM- INTERNATIONAL BUSINESS MACHINES

VMM- VIRTUAL MACHINE MONITOR

PVM- PARA VIRTUAL MACHINE

ADSL- ASYMMETRIC DIGITAL SUBSCRIBER LINE

VDI - VIRTUAL DESKTOP INTERFACE

SSL - SECURE SOCKETS LAYER

SMB'S - SMALL AND MEDIUM SIZE BUSINESSES

QOS - QUALITY OF SERVICE

CCN - CONTENT CENTRIC NETWORK

CDN - CONTENT DELIVERY NETWORK

VPN - VIRTUAL PRIVATE NETWORKS

ROI - RETURN ON INVESTMENTS

TCO - TOTAL COST OF OPERATIONS

NVP - NETWORK VIRTUALIZATION PLATFORM

SAN / NAS - STORAGE AREA NETWORK / NETWORK ATTACHED STORAGE

CHAPTER ONE

1.0 Introduction

This paper presented research into virtual networking offered as part of a cloud service. It followed a model of virtual resource interconnect, where resources are dynamically deployed and migrated in a cloud.

Visualization means extracting hardware from existing software. The extraction process can be done in various ways and these include the use of operating systems such as Hyper-V, making visualization through terminal systems or using App-V and with organizations such as Cisco and Hewllet Packard which runs both network and visualization storage. Currently, most organizations have embraced the visualization operating systems installing it at their workstations to enhance the delivery of their daily activities.

Turban et al (2008), also defines virtualization as the act of designing the real virtual variety of an item like the device storage, resource network, operating system (OS) and hardware platform with the physical outlook of a computer symbolizing a whole machine incorporating and encompassing both subjective and objective point of view in a non-questionable manner. Subjectively, the virtual electronic gadget is whole or complete whereas from an objective perspective, they are just a collection of files which operates on a physical machine. To them virtualization means creating a model of objects but the difference between it being a model and actual is that, this time the model can be used to produce something different that is useful.

From the global front, the virtualization technology has been widely accepted and has become part of daily life owing to its attractiveness. The virtualization technology and operative techniques allows for easy sharing of information among separate virtual machines (VM) enhancing the maximum use of hardware's. The flexibility with the use of virtual machines makes its management easy and has also generated new paradigms of efficiently operating the system. All systems like the virtual models have their own dynamisms creating a system flaw within the cloud computing which contains all other operating software.

The availability of constant and efficient network virtualization has made it possible for multiple layer networks to be created through NVP which allows individuals to access network devices like routers, switches among others. Assembling these logical devices can be done by using security and monitoring policies and join them in a systemic manner using the NVP application protocol interface. In a more subtlety view, virtualization is indispensable in operating cloud computing without which cloud computing would appear odd. Clearly, virtualization has made IT cheaper and a global commodity.

The solid foundations of cloud computing are built on the prowess of virtualization which has cost effective use of the model with emphasis on scalability and the rate at which the service is demanded. This is geared toward the efficient facilitation of networked computing environment, resource networking need to be addressed together to achieve optimization of the system. This calls for the virtual resource being delivered in a more dynamic way, located within the network clouds, making revisit resource mapping through algorithms and channel the App to a composite virtual resource mapping program.

1.1 Background

Infrastructure virtualization has dominated the IT industry in recent times but emphasis must be made that the virtualization concept has been in existence years ago. It should be noted that, the concept of virtualization became known around the globe in the 1960s where they were used to maximize highly expensive but limited computing resources. Conversely, the emergence of Intel-based servers and personal computers accounted for the low prices of the virtualization technology. As the popularity and the usage of servers and PCs grew, prices become less expensive in terms of managing and using these resources.

Centers for storing data has become continuously complex and varied leading to high cost of its management. However, virtualization maintains standards and enhance the use of IT resources. Intel-based servers are known to be the most preferred data storage center tagged with virtualization. The analogy was to design a multiple application system which can operate on a single hardware. Through the adaptation of this multiple application system, challenges confronting the under-utilization of resources were resolved through by IT. Moreover, data that were not safe and the management of application were grouped in one center which was installed on PCs that are used in various homes to execute complex obligations.

Citrix system has been the highest market share holder offering unified desktop virtualization resolutions that enable domestic businesses to access efficient use of the system. IT developers intends to advance the virtual system so that material can be viewed at the machine level.

There were two forms or ways proposed; hosted and hypervisor. With regards to the Hosted method, the virtualization software was mounted as an application on the host OS for support from devices which provides a direct device and resource management support. The Hosted and hypervisor approaches are all efficient but the hypervisor is more efficient as a result of its' direct interface with the hardware. IT technicians are able to maximize efficiency and boost the performance of the device when virtualization is at the machine level. Virtualization technology is at the heart of cloud computing. Unlike other paradigms, cloud computing has not gained common grounds regarding its definition due to the fact that its parameters are constantly expanding and changing. Nonetheless, the US National Institute of Standards and Technology (USNIST) have provided a concise definition as; "Cloud computing is an IT architecture that provide more convenient services to user on their computers which requires minimal supervision from provider to operate" (NIST, 2011).

The cloud system provides a common platform for easy access, operating and managing resources. Similarly, Kaufman (2009) added that cloud computing constitutes the tendency to use scalable and shared IT platform within the parameters of an internet. Several features have been added to the cloud system since its inception in the 1960s and were first used by JCR Licklider in his Advanced Research Project Agency of which he coined the term "intergalactic computer network". The aftermath of this saw an exponential advancement in the development of cloud computing.

The importance of cloud computing is increasing with the rising popularity of cloud services. To create a cloud computing service, virtual servers, virtual storage, and virtual networks are required. Therefore, virtualization is the core technology used for cloud computing and has been studied in many fields. Virtualization can ensure diversity, which is a major advantage for cloud computing, and allows various types of cloud services to coexist on a physical network. To make such advantages possible among the different types of virtualization technologies available, network virtualization used for creating a virtual network is a particularly important technology for supporting cloud computing in future Internet environments. The design of a virtual network for cloud computing requires the consideration of many criteria, such as scalability, availability, reliability, flexibility, and utilization. In terms of diversity, network virtualization can help ensure that these criteria are selected suitably for cloud computing by supporting variable network topologies that facilitate various cloud services.

Network virtualization technology is used to create a virtualized network through both router and link virtualization. A virtual router services several isolated routers exclusively but spontaneously whereas linked virtualization services only one IT device. To create a virtualized network, virtualized routers are required, and the use of a software router has been suggested as one possible option. Recently proposed software routers that can overcome existing hardware limitations can also support many services such as content-centric network (CCN) and content delivery network (CDN). Nonetheless, the low performance of these routers remains an arguable problem. On the other hand, many studies on network virtualization have focused on large servers and storage systems. There have also been a few analyses on network variety. However, there has been insufficient research on the coexistence of various virtualized networks for various cloud services with relatively low cost.

For the coexistence of various virtual networks to deliver varying and diverse tasks, two issues need to be considered. Segregating virtual networks and ensuring convenient and easy performance of the system. Segregation is needed due to the characteristics of isolated virtual networks differing for different cloud performance.

There is the existence of resource sharing among virtual networks. This means that if each product draws on separate protocols, there is therefore the need for segregation to maintain integrity within the cloud system. Moreover, in order to deliver quality service, adapting bandwidth is important due to the fact that different approaches are required for different bandwidth. There are some IT developers such as Apple, Google and among other who have developed their own cloud systems to enhance user preference. This thesis suggests that a virtual network platform was appropriate to be used for cloud computing.

1.2 Statement of the Problem

With the problems associated in the use and adoption of traditional methods of network storage and hosting, this research work seeks to assess the technologies, advantages, cost effectiveness and deployment efficiency of virtualization infrastructure employed in cloud computing systems in today's computing over traditional platforms. The research was intended to achieve this by involving a scoping visit to some telecommunication companies and stakeholders in the country to better understand the technologies and application platforms used in virtual-cloud technologies.

1.3 The Study Objectives

The study seeks to meet the following objectives:

- Analyze the performance of servers on virtual cloud network
- Design a cloud network using Riverbed modeller as a virtual platform to create three scenarios.
- Assess the advantage(s) of using virtual platform for cloud storage over traditional storage infrastructures.
- Study the applications (db query, e-mail, http and ftp) performances within the servers.

- Study the behavioural pattern of the applications regarding link utilization among the servers on the ip cloud.

1.4 Research Questions

- How does server(s) perform on a virtual platform over cloud network?
- Which tool would be appropriate to design virtual network infrastructure for cloud?
- What are the advantages of using virtual platform for cloud storage over traditional storage infrastructures?
- What are the behaviour of applications (db query, e-mail, http and ftp) within the servers?
- What are the behavioural patterns of applications within the servers especially link utilizations?

1.5 Significance of the Study (Justification)

In an ever changing environment where security has become the subject matter for all, scholars within the IT world seeks to develop technology systems devoid of security flaws and in doing so, proper and adequate isolation of main stream drivers such as OS, user settings and various applications need to be secured in their protected paths when operating synchronously. Majority of IT wizards extrapolated their ideas from the tabletop computers to advance their developments in both hardware and software.

This study will be significant to the country's I.T industries as well as telecommunications companies and other emerging information technology industries in the country. Also to the populace as in those who use the services of Virtual-Cloud computing.

It is envisaged to benefit those in the telecommunications sector as well as give impetus to other alternatives in receiving remittances from their relatives outside their vicinity or locality due to unavailability of network. This is to relief them of their burden of travelling to the urban centers for remittances due lack of networked infrastructure.

1.6 Scope of the Study

This study will be based on Server virtualization, desktop virtualization, its deployment and implementation and also consider an overview on cloud computing in recent days with virtual infrastructure to analyze server performance and reliability.

1.7 Limitation of the Study

The study faced a validity danger when the servers acted differently especially when the cloud network is poor and provide undesirable results. These challenges were bound to arise depending on the extent to which devices perform differently on a network than they should have done without it.

The study is also susceptible to external variables of which the researcher has no control and these variables have the capacity to influence the findings of the study. Further manifestations of these happenings can cause the researcher to interpret wrongly, the correlation between two variables.

Again the researcher encountered some problems during the collection of data. They include the following: The acceptance of this technology as compared to the traditional form of computing from the institutions was a major challenge.

Again, there are a variety of these technologies on the market, some of which are very durable and expensive and others too can be said to be workable. Lastly, the setup and maintenance of these devices or systems requires expect knowledge in computer networking and security with some skills in computer hardware as an added advantage.

1.8 Research Methodology

The simulation was done for 300 work stations to evaluate server performance under the three server scenarios using the applications below.

- Data base (db) query time for the database application
- Email downloads response and uploads response time
- HTTP page response time is estimated for the web application
- Ftp downloads response and uploads response time
- Server db query response time and load in node level statistics
- Link level and utilization statistics are also estimated across the simulation process

Moreover, the topologies that would be deployed for the network are as follows:

Virtual LANs; - Is a logical Area Networks

Virtual Private Networks; -Consists of multiple remote end points (typical routers, Virtual Private Network gateways of software clients)

Virtual Private LAN Service;-Is a specific type of multipoint Virtual Private Network

VMware; –Is a program that enables computers to run multiple operating systems and applications infrastructure on virtual machines.

1.9 Organization of the Study

The study was grouped under five main chapters with the first chapter (chapter one) introducing background to the Study, followed by problem statement, Research Objectives, Justification of Study, Scope and limitations of the Study. Chapter Two reviews the relevant literature relating to the subject matter of the Study. Chapter Three gives a description of the methodology used, how data was collected and how it was analyzed. Chapter four involves analysis and interpretation of the data, followed by discussion which is mostly fused with the analysis. Finally, Chapter Five simply presents summary, conclusion and recommendation to the study.

CHAPTER TWO

REVIEW OF LITERATURE

2.0 Introduction

This chapter considered materials written by other authors in relation to IT infrastructure and virtualization in computing (server and desktop) as well as the need and how to virtualize computer systems for cloud technology in any organization in order to cut down the amount of money spent on cloud storage.

There is unceasing advancement in technology making computer gadgets more portable and smarter than it used to be. This has changed the performance of computers in executing an action thus they are much affordable (Leandro, 2012).

Organizations need to eliminate all complexities that seem to hinder efficient optimization of virtualization performances or lay emphasis on both servers and desktop virtualization. Nevertheless, these assumptions cannot be generalized as far as industries are concerned. The objective of this study is to evaluate server and desktop virtualization as a method in cloud technology and it's applicability to the institutions/industry by calculating the Return on Investment (ROI) and the Total Cost of Operation (TCO) to determine if virtualization for cloud is profitable for industries to invest equity (Murukutla, 2011) . At the institutional level, the virtual technology is a new phenomenon whereas other industries have long embraced the technology. Even though (Dorion, 2010)predicted that the virtual system will gain popularity by 2010, virtual technology retailers are putting much effort to enhance its popularity and using cloud computing as its main drivers. In the coming years, majority of organizations are expected to migrate unto this system as a remedy for recovering during disasters and to safe guard their data.

2.1 Data Collection Methods and Instructions

The researcher gathered primary data from the various mobile telecommunication companies and other stakeholders in the country. Again he used software setup design with experimental analysis to collect data as deemed appropriate for the study.

Data collected was coded in tables and analyzed with appropriate tools using records of speed and time averages. Results from the analysis were discussed to draw conclusions on the study.

Though cloud computing is an emerging technology, pundits and analyst believed it is one of the most powerful IT tools to have hit the world of IT. It is of no surprise it has attracted attention from industry players and policy makers and with the incorporation of small and medium-sized businesses to have access to cloud around the world, it will enable them to look, act and feel like an enterprise.

Cloud scalability, for example, enables companies to easily expand or contract to meet fluctuating traffic and workload demands. The flexibility of the cloud also allows small companies to support a large workforce, whether they are on-site or work remotely.

The cost effectiveness of the cloud is another reason why so many SMBs are beginning to migrate to the virtual environment. The cloud can substantially reduce operational expenses and capital expenditures because companies can minimize labor and maintenance costs associated with managing on-site equipment. Meanwhile, cloud uses a pay-as-you-go pricing model, enabling companies to only pay for the services they use.

2.2 History of Virtualization

Computers have grown with rapid changes in technology, and they have become increasingly faster than ever to the extent that users of microcomputers are said to be under utilizing the potentials of their computer systems both at home and in the offices or work place. The virtualization concept sprung up from the sixties and seventies.

The concept of allowing individual sessions to run independently on a server while showing outcomes for the user or terminal has existed for a long time when they were applied to only mainframes in the 1950s. The cost of purchasing a mainframe was very high that not all companies or organizations could afford to go into such a venture (Leandro, 2012).

Conroy (2010) states that in the early 1960's IBM was the market leader in term of computer systems which were distinct it its own way due to its generation. Computers at that time were capable of doing only one thing at a time. So, because of the varied hardware requirements, IBM started work on the S/360 mainframes and its peculiar task was to maintain backwards compatibility.

In July 1, 1963 MIT (Massachusetts Institute of Technology) came out with what they called the Project MAC which stood for Mathematics and Computation and later named it as Multiple Access Computer. The importance of this system was to specifically deal with the areas of Artificial Intelligence, Operating Systems and Computational Theory. They further went on to research into a new computer hardware which was able to perform multiple programs per the choice of GE as their vendor chose to ignore IBM due to IBM's reluctance.

(Elliott, 2010)In the evolution of IBM Mainframes and VM says that, when IBM realized that that opportunity was lost, they decided and designed the CP-40 mainframe so as to also stay in the competition, thus, there was demand for the kind of systems that MIT and GE built. Later, IBM designed the CP-67 system which happens to be the first commercial Main Frame to sustain Virtualization. Its operating system was called CP/CMS whereby the CP denotes Control Program, and CMS also known as Console Monitor System. Conroy (2010) states that, "CMS as a system was designed to enhance interaction". CP is the IT system that created the main virtual machine.

In contrast, the main significant advantage an individual enjoys when operating virtual machines as per time sharing operating system is that the systems were used efficiently because the total resources of the mainframe were put to use instead of having the resources divided between users. Security of the systems and data was also a criterion since users had their own operating system to operate and this increased the systems reliability because no one user could crash the whole system, but rather, each individual was limited to his/her own operating system.

2.3 Definition of Virtualization

Turban et al (2008), defines virtualization as the act of designing the real virtual variety of an item like the device storage, resource network, operating system (OS) and hardware platform with the physical outlook of a computer symbolizing a whole machine incorporating and encompassing both subjective and objective point of view in a non-questionable manner. Subjectively, the virtual electronic gadget is whole or complete whereas from an objective perspective, they are just a collection of files which operates on a physical machine. To them virtualization means creating a model of objects but the difference between it being a model and actual is that, the model can be used to produce something different that is useful.

Turban et al (2008), further explains virtualization as a fragment part of current happenings in the world of IT which uses automated computing. The system was intended to manage itself on the basis of perceived computing while the processing power of computer is recognized on utility basis where individuals and organizations only pay to obtain and use it. The basic objective of the virtual technology is converging all administrative duties, enhance scalability, operational flexibility, and ensure cost effectiveness and the efficient utilization of hardware resources. This will allow for several operating devices or programs to be used spontaneously using the same CPU. This multiple parallelism has aided in the reduction of cost by running multiple tasks on the OS.

There is fierce competition among businesses who seeks to be the market leader in order to maximize profit. As a result of this business entities want to deliver first hand services in a more convenient way to satisfy or delight the customer so as to develop consumer retention which is healthy for the growth of businesses both small and large. When this tension is resolved by implementing the desktop virtualization solution with other client software, the end product is delivering services in a more relaxed, flexible, and comfortable and result oriented business environment. Moreover, the advent of this will allow users to access and function at any time and at anywhere. By creating IT departments, they help to harmonize and centralize all the business operations in a centralized system to secure sensitive information and data and also promote performance, scalability and storage via internet (EDGAR, 2010).

2.4 Types of Virtualization

There are so many types of virtualization in computing but for the purpose of this research, only two of them are mentioned and explained below:

2.5 Server Virtualization

Gachhayat's (2011) described virtual servers as unique technologies that run using system servers abstracting the method and incorporating the OS, attaching devices and varied physical servers which are joined to a mother server which allows the system to appear as a single system. Regarding Gachhayat's definition of server virtualization, the server is said to have so many resources that are available for users to use. Not all these resources are easily/user-friendly for the virtual IT environment when a single server is used to service multiple segregated virtualized environments. Among the terminologies used to describe virtual environment are partitions, containers, emulations, instances and guests.

Therefore, organizations or institutions attempting to reduce their spending on IT infrastructures which is the main motivation behind the development of the virtual specialized system which is capable of supplying several other servers from a source and its' beneficial in terms of maximizing its' usage, cost effective and scalability benefits. The virtual server makes it possible to recover valuable data in terms of disasters.

2.6 Types of Server Virtualization

Caprio (2011), states that in order to virtualize resources or materials, there should be virtual machine (VM) models, OS stage virtualization as well as Para-virtual machine models. The research analyzed and chose amongst alternatives. There are different types of server virtualizations on the IT markets. Management has to decide on the one which best suits the institution's processes in order to achieve the much needed efficiency gains from server virtualization most importantly on the cost saving advantage that comes along with virtualizing systems.

2.7 Virtual Machine Based Virtualization

The virtual machine virtualization server runs on virtual machine monitor or can also use the hypervisor in transmitting command to and receiving information from the CPU and this is done without any extra modifications. Subsequently, VM (Virtual Machine)-based Server Virtualization give protection to the hardware layer, partition can be done within the server while running on separate operating systems without any guest application systems and knowing that they are all running on a mother OS (Saunders et al, 2009).

2.8. OS Level Virtualization

Operating System Level Virtualization is attained through the mother OS running on an isolated system and through the management and controlling of guest OS functionalities. This means that virtual level operating systems draws from the creation of segregated containers in unified physical servers while using each segregated entities to work separately of the partitions (Baburajan, 2011)

2.9 Desktop Virtualization

Leandro (2012), describes desktop virtualization also known as customer virtualization as that which isolates individual desktop computers from the real machine using the customer technique of computing. Networkworld in (2010) also described desktop virtualization infrastructure which is also called desktop virtualization interface which allows for data and information to be assessed or viewed on the desktop incorporating both software and hardware (Cloud-based desktops a reality, 2010) which assists the virtual world (Rooney, 2010.)

Due to security precaution measures, most business organizations prefer to store virtualization unto desktops from a central remote server rather than the usual individual local storage. This means that all the operations of organizations' employees are saved on the central system and all applications operate directly from the source. In the wake of these advancements coupled with smart devices such as phones, employees can access and work at all time and at anywhere.

A significant benefit of operating on a virtualization system is that it allows a person to run several virtual machines simultaneously on a personal hardware such as laptops with the use of hypervisor technology. Images on virtual machine are mostly saved in centralized server and propagated to employees' machines. This capitalizes on the portability of local hypervisors to manage and perform complex tasks. However, this technique requires the use of VM images like personal computers coupled with a well-designed hardware.

Advancement in technology has led to the development of machines that are installed without server components which allows for optimum utilization while enhancing flexibility on a multiple desktop VMs with an isolated hardware.

2.10 Types of Desktop Virtualization

Frontier Networks (2013), stated four types of VDI operation and among them are;

- o Hosted (mostly used in the form of a server)
- o Centralized

- Remote Synchronization
- Client-Hosted

In order to sustain the Hosted as well as the centralized modes, there is the need for the continuous supply of uninterrupted network when connected to server with the VDI running. This technological technique is in line with the concept of thin clients which also depends on uninterrupted internet service whereas the remote synchronization allows individuals to copy VDI system and operate it on another machine without connection. With this model individuals access images from central server which is copied and later used on personal computers when making a journey. This form of uninterrupted access to and working on work pages at anywhere and at all times have their own merits and demerits.

2.11 Hosted Virtual Desktop

Schultz (2013), the Hosted virtual desktops emanated from virtual desktop services provided by outsourcing to a third party which is paid based on usage. The Hosted desktop virtualization services incorporate managed personal OS configuration. Security issues become more real than abstract. The system of outsourcing the IT infrastructure changes the model from cost expenses to operating expenses which ensures cost effective, scalability, and also flexible when a company decides to either add or remove an employee (Leandro, 2012).

2.12 Centralized Virtual Desktop

Rajani (2013) observed that all VDIs can run on a centralized server which enables businesses and organizations to store data on the mother server. The VDI models operate on static and dynamic also known as persistent and non-persistent machines respectively. Rajani (2013) explained that the static mode operates on a one-to-one mapping of computers. This literarily means that an individual is to one desktop where they are responsible for managing and maintaining it. On the contrary, the dynamic mode gives the user an opportunity to manipulate data in the form of images and store them in multiple isolated systems which is independent of the desktop.

2.13 Remote Synchronized Virtual Desktop

Rouse & Madden (2013), asserted that VDIs assumes the concept of centralized data image which is retained by the IT department and offers the opportunity to work even when one is not connected to the internet. By so doing, the image is copied unto a personal computer which does not need to be connected to the server to operate. However, the only routine activity performed is the periodic checking of the image to ensure there are no disruptions.

This explains the fundamental basis why the system runs on the OS together with hypervisor and both jointly operate in an expedite rate on the VDI. Meanwhile they need advanced capacity in terms of CPU, the disk space and its memory on the VDI. Security is another major area of concern that needs to be addressed but this notwithstanding; it offers individuals who are always on the move to the luxuries of working while traveling without any internet connection.

Due to the fact that the model is locally modeled for local usage it usually beef-up security by using full disk encryption, remote kill capabilities and time-based lockout. In order to find a remedy for the problems associated with the local system, a type-1 individual hypervisor was recommended to take care of having to add extra operating system and hence reduce system demands and improve performance and security (Bramfitt, 2011).

2.14 Advantages of Virtualization

There are countless benefits to be derived from server and desktop virtualization:

- It reduces solid containers (servers) which cut down cost and expenses associated with maintenance.
- It allows for more space in the environment since physical hardware’s are less.
- Multiple tasks can be performed spontaneously on one platform.
- Data is always secured with the risk of losing them becoming minimal.
- Allowing employees to work using a common platform.

2.15 Disadvantages of Virtualization

- In desktop Virtualization, once the server shuts down, every work or user cannot operate.
- There is lack of user privacy, thus since all the processing is done by probably less or single servers remotely, everything or any task that a connected terminal does can easily be monitored.
- Sometimes users are restricted as to the number of tasks they can perform on the terminals or virtualized systems.

2.16 The Challenges in Virtualization

There are Virtualization “Laggards”, that according to Tao states, there are a group of individuals who are reluctant to conform to virtualization, considering it from the production point. Rather, they relinquish it to the point of testing and development or no application. These laggards do not recognize the fact that SME organizations or institutions have developed a model which allows them to use the virtual system in a more reliable and safe way

His second accession had to deal with economic barriers that are from the stand point of the pay as used cost which is deployed by virtual server operators. In furtherance, he lamented that its cost effective hence causing businesses, both large and small to buy into their package to reduce cost. Nevertheless, the costs of software and applications have increased, adding to total expenditure. In a summary, he lamented that economic barriers restrict some organizations from adopting the virtual system because they lack the required capital to migrate unto the server.

Anohina (2013) suggests that even with all the tools that virtualization provides IT simplification boosted computing power and increased server management efficiency. There are some key challenges that will keep virtualization from advancing into the next phase of technological advancement. He further gave some challenges facing virtualization:

His first challenge had to deal with Meeting the Demand of Virtualization Technology. The hard reality of virtualized server management is that the environment itself is highly dynamic. This is a complicated technology, which will require an advanced IT team to be able to understand and manage the virtualization system. Since the technology is always evolving, individuals maintaining the systems must stay informed on developments and breakthroughs in the industry.

Lastly, he talked about Infrastructure Issues. There are several selling points that make a virtual server environment attractive. Developing a virtual server is fairly easy, and deploying applications within this environment is even easier. The problem is that most organizations don't have the proper infrastructure in place to keep up with the demands of the constantly evolving virtualized environment that runs their servers. Upon the enormous benefits that organizations and institutions stands to achieve with server or desktop virtualization, the future challenge is a problem to be dealt with seriously if virtualization technologies and IT infrastructures would succeed old methods of storing data.

The challenges that have been provided by Cisco Systems, Matte, Hoard and Altman shows how IT departments even resist the change from keeping overcrowded/bulky datacenters with huge amounts of hardware and software at greater costs because of how complex the virtualization systems in its initial stages can be.

2.17 Cloud Technology and Cloud Computing

The term cloud computing is a new paradigm in the field of IT that has attracted attention from researchers, organizations such as the banking industry, educational institutions, SMEs among others (Luis et al., 2008). This model talked about is expanding at a faster rate and attracting various vendors and clients. The faster expansion of cloud computing is being geared by the emanating technologies which gives a clear and rational price use of computing structures and aggregate storage capacity. It lessens the need for huge investment in information Technology infrastructure. This computing model implicates procuring of computer properties with the ability of increasing resource capability of being scaled, on-demand supplying of less no leading IT cost of investing in infrastructure. The advantages in cloud computing is offered through three delivery models called infrastructure-as-a-service (Iaas), Platform-as-a-service (Paas) and software-as-a-service.

2.18 Cloud Infrastructure

Figure 2.1 Cloud Server on virtual desktop

2.19 Cloud Computing Services

Cloud computing services can be grouped into three categories:

Software as a service (Saas)

In delivering cloud computing as a service, users patronize the right to access the service for being hosted on the cloud system. Currently, Saas is been offered to individuals and organizations by IT giants such as Google, Microsoft, Sales force and among others. The system gives responsibility to users to patch and maintain the OS and the applications software.

Platform as a Service (Paas)

Paas offers cloud users the opportunity to access platforms as well as problem resolving stacks such as programming language, database, web servers and operating systems. Cloud users have the liberty to develop their own applications which operates on the cloud server. Among the popular Paas used are Google App engine, Force.com and others.

Infrastructure as a Service (Iaas)

Iaas offers fundamental storage and computing, which is done to standards as against the provision of network. Organizations and individual users are allowed to maintain and control their own applications, issues regarding storage, operating systems and network connections. Examples of Iaas are as follows; Amazon, GoGrid, 3 Tera etc.

2.20 Cloud Deployment Models

Adopting cloud computing by businesses and individual depends on the users' request. Organizations such as universities will choose a package different from the banking sector whereas that of sports will differ from agricultural research institutions. This basically means that there are unique and special package for each entities. There are four (4) basic models from which users can choose from;

Private Cloud

This type of cloud package is being offered to only one organization who is responsible for managing, patching and controlling the flow of information in and out of their device or they can allow a third party to manage it either from their own organization or from an external source.

Community cloud

This allows multiple organizations to access the same cloud systems who share the same requirements per the agreed terms of service.

Public cloud

This type of cloud system is always operated by a third party, which is open to the general public.

Hybrid Cloud

This cloud infrastructure combines two or more cloud systems like the private, community and/or public but operate through their own interface which allows for the transmission of data from one a system to another.

2.21 Factors that affect Server Performance on a Network

- **Dropped packets; -** It is the measure of percentage of packets lost as against those sent and its' occurs when the load is more than the server can contain. When content arrives for a constant period on a particular router, at a rate greater than it is possible to send through then there is no other alternative than to drop packet
- **Delays and Latency**; Similar in characteristics, they are referred to the amount of time it takes a bit to be transmitted from one end to the other. These delays could be caused by traffic congestion, transmission path protocols, errors (packet drops), transmission complexities and so forth in the following ways, transmission delays, queuing delays, propagation and processing delays.
- Propagation delays occur during data transmission to remote destination. That is the duration taken by the system to transmit a signal from the origin to the destination. These are ratio of transmission link length to the speed of propagation over a specified period.
- Processing delays defines the amount of time a transmitting medium will use in processing packet header.
- Queuing delays may be caused by several user requests at the same time in server processing (buffer systems fill up and traffic moves in queue requiring priority queuing)

- **Jitter;** -Jitter means variations in delay of packets received due to relative timings. It depends on the congestion of network. It is a quality of service factor in evaluating network performance.

- **Bandwidth; -**Estimates the quantity of data transmitted from source to destination within a specific time frame usually in seconds. Bandwidth used in estimating data movements are always measured in bits with its speed estimated in millions per bits (megabits) or billions per bits (gigabits).

CHAPTER THREE

METHODOLOGY

3.0 INTRODUCTION

The chapter employed Riverbed Academic Edu 17.5 Edition modeler Simulator as a tool in modeling three scenarios for server performance. The National Information Technology Agency satellite station in KNUST campus for example, operates cloud technology from remote servers. The functionality and efficiency of the network depends largely on the reliability of server performance in meeting user demands. However, if only one server is used for serving clients, the probability of system failure, inefficiency and poor network service or system shutdown is high on high user demands. There was the need to anticipate and incorporate multiple servers from remote stations to facilitate customer demands as a well as for-store system failure and consequent shutdown and thus the essence for this research.

3.1 Riverbed Edu as a Simulation Tool

Figure 3.1 Riverbed Edu 17.5 as a Simulation Tool

Riverbed Edu.version17.5 offers virtualization for development, analyzing and evaluating the capacity and performance of virtual systems which includes application servers and network topologies. Regarding this approach, it saves time whereas the development of the network itself consumes time in planning and testing it. Moreover, the model can check for problems, congestions and dysfunctions of the system. The nodes and objects listed are used to develop the system models such as case scenarios, applications, configuration of nodes, projects, objects, configuring node profile, routers and Ip32 cloud.

3.1.2 Running Start Up wizard

This is the first stage in riverbed modeler configuration. The option was chosen when the user is yet to save the project for the first time.

3.1.3 Naming the Project

This is the stage that the project has to be named to enable easier identification should more than one project is created, for example project1.

3.1.4 Naming the Scenario

At this stage the scenario on which the modeler is to be used for was given a brief description, for eg; Server Scenarios.

3.1.5 Creating the empty scenario

This stage is where the working environment usually referred as office space is chosen. It is appropriate choice since there was no existing applications are configured to be imported and worked on.

3.1.6 Choosing the network scale

The network scale was chosen at this stage to determine the size of the working space.

3.1.7 Choosing the map

Here the specific country map or global map was selected to determine the size of geographical area within which the network topology can be applicable.

3.1.8 Selecting Technologies

Selecting technologies enabled the user to determine the parameters appropriate for the right topology

3.1.9 The Project

The project is the working area where the objects are placed from the objects palette to be configured.

3.1.10 The Project objects to be used

This is where the objects needed for configuration is selected

3.2.0 Nodes to be used for setting up the network

To use each of the objects displayed , click on each of them from the object palletes and drag them unto the office workspace. Below are the steps to be followed for bringing each of the objects unto the networking space;

1 Click on the object from the object pallete, bring to the office space and click in an empty area.

3 Right click on the object to remove the highlight

Figure 3.2 Nodes for Configuration.

The Riverbed modeler, the working space, the objects palette, the nodes with the respective links and their configurations constitute the virtual network infrastructure in this thesis for testing server performances.

3.3 Configuring the scenarios

The configuration for the first scenario has one server introduced into the network within the setup of the distributed system to measure the performance metrics in the global, node and link statistics for the applications db query response times, server db response times, e-mail download and upload response times, e-mail server loads, http page response times, http server load, ftp download and upload response times, server ftp load and cloud utilizations.

Refer to Appendixes A,B,C for detailed configurations for the first, second and third scenarios respectively. The simulation was run for three consecutive times for each parameter in all three scenarios and the results obtained are as in the tables 3.1 to 3.22.

3.3.1 Result for Database Application

This section illustrates the result for the database application. It presents the elapsed time duration in-between transferring a request and accessing the outcome of the request. Estimation begins at the time when command was issued in a request to when the response come.

3.3.2 Database Requesting Response Time

The tables 3.1-3.22 showed the results obtained for database query response time for low, medium and high packet sizes, within the simulation time.

Table 3.1 Database query response time with packed size of 50MB (low)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	0.26	0.27	0.28	0.27	0.22	0.23
Double Server	0.24	0.21	0.27	0.21	0.23	0.26
Triple Server	0.25	0.22	0.25	0.22	0.36	0.36

Table 3.2 Database query response time with packet size of 250MB (High)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	1.94	2.36	2.29	2.36	2.38	2.71
Double Server	4.43	6.79	4.43	3.13	3.98	4.09
Triple Server	2.42	2.28	2.61	1.97	22.53	16.65

3.3.3 Server Database Query Load

Table 3.3 Server database load with packet size of 50MB (Low)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	0.72	0.94	0.72	0.94	0.44	0.58
Double Server	0.53	0.58	0.53	0.58	0.36	0.50
Triple Server	0.69	0.69	0.69	0.69	0.33	0.58

Table 3.4 Server database load with packet size of 250MB (High)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	1.77	1.81	0.06	0.06	2.08	2.08
Double Server	2.64	2.64	0.06	0.06	2.10	1.25
Triple Server	2.18	2.05	0.00	0.08	0.69	0.78

3.3.4 Result for E-mail Application

This section lists the results for e-mail application after running the simulation for an hour.

3.3.5 E-mail downloads response time

Table 3.5 E-mail downloads response time with packet size of 50MB (Low)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	0.59	0.80	0.59	0.08	0.71	0.73
Double Server	0.76	0.99	0.76	0.99	0.66	1.03
Triple Server	1.03	0.97	1.03	0.97	0.87	0.92

Table 3.6 E-mail downloads response time with packet size of 250MB (High)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	1.27	1.23	1.27	1.23	1.10	1.16
Double Server	1.42	1.19	1.44	1.23	2.16	2.01
Triple Server	1.31	1.24	1.33	1.89	5.08	4.70

3.3.6 E-mail Upload Response Time

Table 3.7 E-mail Upload Response Time with packet size of 50MB (Low)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	1.19	1.00	1.19	1.00	0.45	0.79
Double Server	0.55	0.74	0.60	0.74	1.04	1.12
Triple Server	1.08	0.93	1.08	0.93	1.43	1.52

Table 3.8 E-mail Upload Response Time with packet size of 250MB (High)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	1.16	1.39	1.56	1.39	1.29	1.14
Double Server	1.12	1.35	1.11	1.27	3.34	2.61
Triple Server	1.48	1.46	1.38	1.42	4.85	4.89

3.3.7 Server E-mail Load

Table 3.9 E-mail server loads with packet size of 50MB (Low)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	0.00	0.00	0.00	0.00	0.00	0.03
Double Server	0.06	0.06	0.00	0.00	0.03	0.00
Triple Server	0.06	0.03	0.00	0.00	0.00	0.03

Table 3.10 E-mail server load with packet size of 250MB (High)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	0.06	0.06	0.06	0.06	0.11	0.08
Double Server	0.14	0.06	0.14	0.10	0.03	0.17
Triple Server	0.15	0.18	0.14	0.22	0.08	0.03

3.3.8 Http Page Response Time

Table 3.11 Http page response time with packet size of 50MB (Low)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	1.18	0.94	1.19	0.94	0.97	0.92
Double Server	1.10	1.10	1.10	1.11	1.21	1.23

Triple Server	0.99	1.04	0.99	1.04	1.34	1.32

Table 3.12 Http page response time with packet size of 250MB (High)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	12.36	12.58	12.42	12.58	2.89	2.89
Double Server	15.13	14.91	14.97	15.19	2.67	1.64
Triple Server	13.89	13.93	14.34	13.79	1.83	2.64

3.3.9 Server http Load

Table 3.13 Server http load with packet size of 50MB (Low)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	0.06	0.00	0.28	0.00	0.19	0.00
Double Server	0.22	0.00	0.28	0.31	0.03	0.17
Triple Server	0.14	0.03	0.14	0.03	0.36	0.03

Table 3.1 Server http load time with packet size of 250MB (High)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	1.87	1.14	2.19	2.19	2.89	2.89
Double Server	3.25	3.69	1.94	2.22	2.61	1.28
Triple Server	3.25	3.53	3.31	3.39	1.83	2.64

3.3.10 Result for Ftp Application

The results for the ftp application on the cloud network

3.3.11 Ftp Download Response Time

Table 3.15 Ftp downloads Response Time with packet size of 50MB (Low)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	0.74	0.61	0.74	0.61	0.85	0.52
Double Server	0.24	0.34	0.24	0.37	0.63	0.83
Triple Server	0.22	0.76	0.22	0.78	0.73	1.14

Table 3.16 Ftp downloads Response Time with packet size of 250MB (High)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	3.78	3.57	3.78	3.57	4.84	3.94
Double Server	4.83	3.67	4.74	3.78	7.36	6.76
Triple Server	3.62	4.06	3.04	3.41	14.49	13.32

3.3.12 Ftp Upload Response Time

Table 3.17 Ftp uploads Response Time with packet size of 50MB (Low)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	0.13	0.64	0.32	0.64	0.70	0.64
Double Server	0.65	0.95	0.65	0.95	0.74	0.64
Triple Server	0.82	0.85	0.83	0.83	0.89	1.03

Table 3.18 Ftp uploads Response Time with packet size of 250MB (High)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	4.04	3.94	4.01	3.94	4.38	4.20
Double Server	3.88	3.93	3.88	3.50	6.96	5.97
Triple Server	4.82	3.98	4.77	4.05	17.69	14.10

3.3.13 Server Ftp Load

Table 3.19 Server Ftp load with packet size of 50MB (Low)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	0.05	0.00	0.00	0.00	0.00	0.03
Double Server	0.05	0.00	0.00	0.02	0.00	0.00
Triple Server	0.05	0.00	0.00	0.00	0.00	0.00

Table3.2 Server Ftp load packet size of 250MB (High)

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	0.06	0.14	0.06	0.14	0.03	0.11
Double Server	0.06	0.06	0.06	0.03	0.03	0.03
Triple Server	0.10	0.08	0.07	0.08	0.08	0.00

3.4.0 Cloud Performance

Table 3.3 Cloud utilization with packet size of 50MB (Low) →

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	0.38	0.30	0.31	0.31	0.32	0.23
Double Server	0.32	0.26	0.22	0.24	0.38	0.28
Triple Server	0.36	0.29	0.26	0.21	0.54	0.47

Table 3.422 Cloud utilization with packet size of 250MB (High) →

Scenarios	10gb/s		2gb/s		30mb/s	
	10mins	50mins	10mins	50mins	10mins	50mins
Single Server	12.74	12.56	11.12	12.56	1.28	1.56

Double Server	19.63	12.49	21.27	13.31	1.45	1.30
Triple Server	39.78	38.16	44.76	53.10	2.36	2.20

3.4.1 Conclusion

In this chapter, the methodology for evaluating the network reliability against server performance was presented in tables. The different scenarios were simulated using riverbed academic edition 17.5 as a simulation tool simulated for one hour. The results of the simulation were analyzed and presented. In the next chapter, the results for the experiments are discussed.

CHAPTER FOUR

ESULTS AND EVALUATION

4.0 Introduction

In this chapter the results for the three scenarios were discussed and analyzed after running the simulation for an hour on 30mb/s ,2gb/s and 10gb/s loads for 100mb/s bandwidth in each case of the experiments. The three scenarios conducted in the lab are as follows;

i) One Server Scenario; where one server was used in the network with four applications and specified number of users (10-60) passing through the cloud and server to generate the required traffic across the system

ii) Two Server's Scenario; where two servers were introduced into the network for the same users for four applications distributed among servers to generate the required traffic across the distributed system

iii) Three Server's Scenario; where three servers were introduced into the network for the same users for four applications distributed among servers to generate the required traffic across the distributed system.

The database's execution, email, ftps and web applications were assessed in the light of the execution and parameters measured at all the three levels, to be specific, cloud/router measurements and connection measurement levels. Each one of the diagrams acquired was analyzed against the execution measurements and a critical examination was given.

4.1 Database Application Results

The database application was one of the applications that generated a lot of traffic that was measured against the response time.

4.2 Database Query Response Time: -This is the slipped by time between the end of a request, inquiry or interest on database server and the start of a request.

Database Query Response Time–One Server

This scenario allowed all the applications to pass through the LAN, router, the cloud and the server back and forth without any filtering or restriction to allow the flow of traffic to measure the performance of traffic flow in the system. The tables 3.1 and 3.2showed the database query response time when one server is implemented and the combined graph in Fig 4.2 showed the graphical representation and performance of the one server scenario.

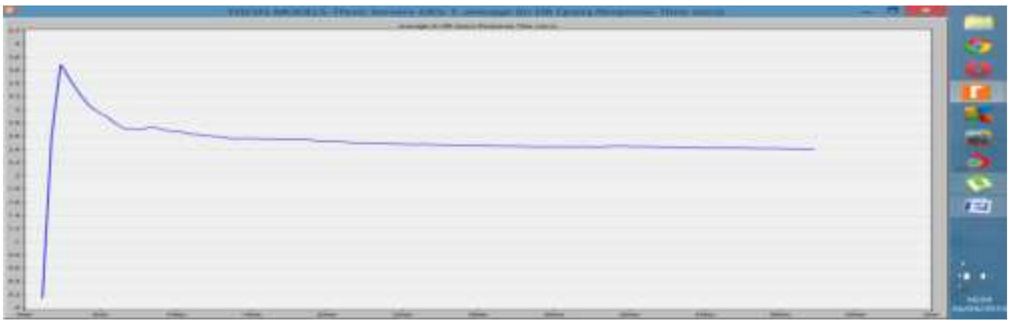
Database Query Response Time–Two Server Scenario

Tables 3.1 and 3.2 represented the performance of the two server scenario, and the combined graph in Fig 4.2 showed the graphical representation and performance of the two server scenario.

4.3 Database Query Response Time–Three Server Scenario

In the third scenario, another server was introduced. The tables 3.1- 3.2 showed the response time when other applications were diverted to other servers on the network by the Lan.

Averagedb response

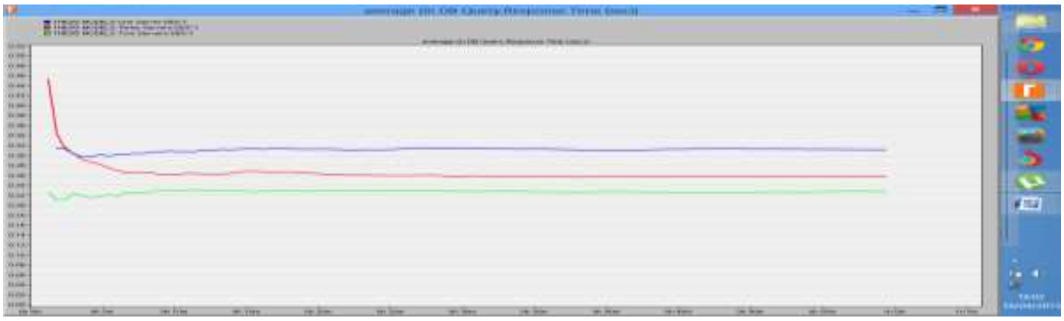


Time (sec)

Figure 4.1 Database Query Response Time–Three Server Scenario

From Fig 4.1, the databases query response time when other applications were diverted by LAN to the three servers within the cloud network. It can be seen that the traffic across the network had an initial low value of 0.18secs and then increased to 3.37secs for a packet size of high (250mb). It then declined from 3.37secs to 2.24secs and then maintained a constant value throughout the simulation period.

Average server db query loads



Time (sec)

Figure 4.2: Database query loads

Fig 4.2 showed the combined graph of all three scenarios. The differences in the effect are as shown in the graph.

4.4 Server Database Query Load

Server database load is the time taken for the database server to receive data from users across the network, process it back and forth across the cloud network.

Server Database Query Load–One Server Scenario

The values in tables 3.3-3.4 showed the server loads across the network when only one server was used. Refer to the combined graph in F ig4.4 for the graphical representation and performance of the one server scenario.

Server Database Query Load–Two Server Scenario

The result in tables 3.3- 3.4 showed the load on the server when two servers are used on the network. The combined graph inFig4.4 showed the graphical representation and performance of the one server scenario.

4.5 Server Database Query Load–Three Server Scenario

In the third scenario, all the four applications were passed through their destination servers and the load analyzed and evaluated on the cloud network. The tables 3.3- 3.4 showed how the loads performed in the network.

Figure 4.3 Server Database Query Load–Three Server Scenario

From the Fig 4.3, the server database query load had an initial load of 0.00secs and later increased to a high value of 0.725 secs and maintained that value throughout the simulation period at all packet sizes and data rates and in all three servers.

Combining the graphs for the three scenarios gives the resultant graph in Fig 4.4

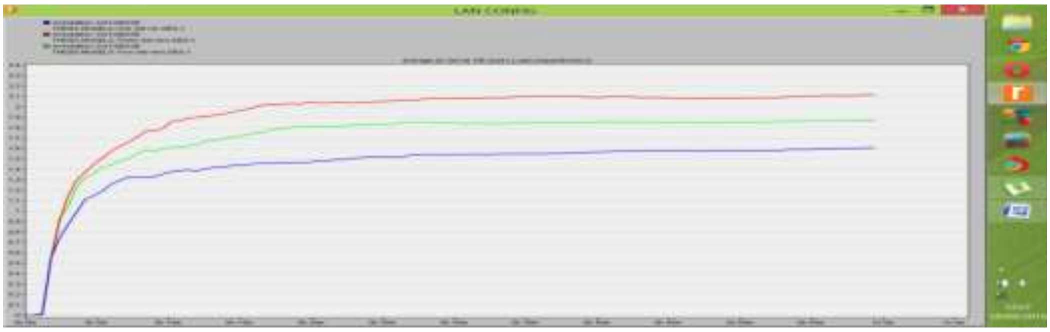


Figure 4.4 Server Database Query Load

From Fig 4.4, it can be seen that the load on servers is almost equal in all packet sizes. It could be seen that, the load on the server one was less than on servers two and three. It took more time to process user requests in the second and third scenarios because more time was spent to route applications to their destination servers.

4.6 Results for E-mail Application

Server performance was analyzed and evaluated in this section against the email downloads and uploads response time when the three scenarios were considered. E-mail with packet size of low (50mb), medium (150mb) and high (50mb) were used in link speeds of 10gbps, 2gbps and 30Mbps configured and evaluated against the performance metrics.

E-mail Download Response Time–One Server Scenario

The tables 3.5-3.6 showed the e-mail download response time when one server was used on the network and the combined graph inFig 4.6showedthe graphical representation and performance of the one server scenario.

E-mail downloads responses time–Two Servers Scenario

The result of the download response time for two servers was used on the network are shown in tables 3.5-3.6. The result shows an increase in downloads response time when data packet sizes increased.

4.7 E-mail downloads response time–Three Server Scenario

In the third scenario, the email application was diverted to its preferred destinations in the LAN across the routers and cloud to the servers in the network. Table 3.6 showed the results when email application was analyzed and evaluated against the performance metrics among the three servers in the network.

Average e-mail downloads

Time (sec)

Figure 4.5 E-mail downloads response time–Three Server Scenario

From Fig 4.5, the e-mail response time which is the time taken for the web server to process user requests across the cloud network back and forth, was evaluated against the performance metrics within the three servers. From the graph, it could be deduced that the load had a low value 0f 0.8secs at high (250mb) and medium (150mb) packet sizes to 1.8secs and then declined to 1.2secs and maintained a constant value throughout the simulation period. It was concluded that the e-mail response time was high when the load on the network was high and vice versa. The combined graph inFig4.6showed the graphical representation and performance of the three scenarios.

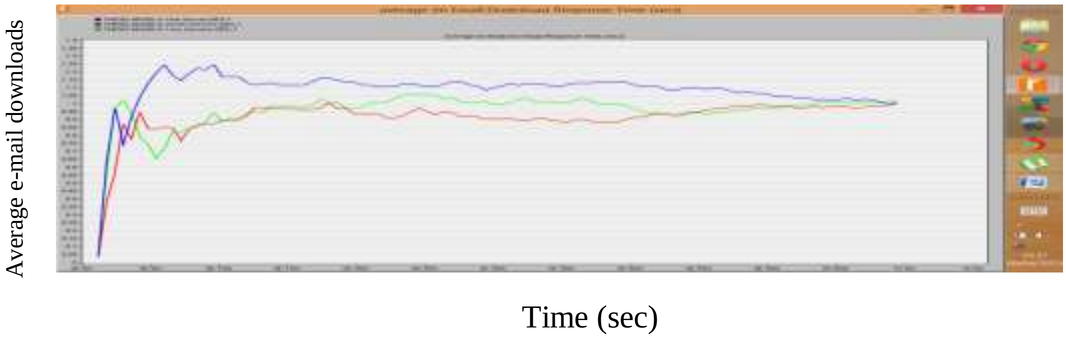


Figure 4.6: E-mail downloads response times

Fig 4.6 gives account of all three scenarios for e-mail downloads response times.

4.8 E-mail Upload Response Time

This is the response time taken for data to be uploaded unto a cloud network.

E-mail Upload Response Time–One Server Scenario

The upload response time was evaluated in this section. The tables in 3.7-3.8 showed the upload response time when one server was used on the network. The graph in Fig 4.8 showed the performance of the one server scenario.

E-mail Upload Response Time–Two Servers Scenario

The tables 3.7-3.8 showed the values when two servers were implemented on the network. A packet latency of 0.05secs was enforced to introduce delay into the system. Refer to the combined graph inFig4.8for the graphical representation and performance of the two server scenario.

4.9 E-mail Upload Response Time–Three Servers Scenario

In the third scenario, the email application was routed by the routers to the three servers on the network. The results in tables 3.7-3.8 showed the response time when email was uploaded across the cloud network.

Average e-mail uploads response

Time (sec)

Figure 4.7: E-mail uploads response time–Three Servers Scenario

From Fig 4.7, e-mail upload response time had an initial low value of 0.008secs to a high value of 1.155secs due to routing protocols before reducing to an appreciable value of 0.05secs and then maintained a constant value throughout the simulation period

4.10 E-mail uploads response time for the Scenarios

It is the e-mail response time received by the server when users make a request to the e-mail server back and forth across the network. Combined effects of the three scenarios is as represented in Fig 4.8.

Average e-mail uploads response

Time (sec)

Figure 4.8 E-mail Upload Response Time

Fig 4.8 showed the simulation results when all the three scenarios were considered. It can be seen from graph that the upload response time was high when one server was used on the network than when two and three servers were used.

4.11 Server E-mail Load

The load on the email server was evaluated in this section under all three scenarios

Server E- mail load–One server Scenario

The tables 3.9-3.10 showed that the load on the e-mail server when one server was used in the cloud network and the combined graph in Fig 4.10 showed the graphical representation and performance of the one server scenario.

Server E-mail load–Two Servers Scenario

The table's 3.9-3.10 was investigated for e-mail server load on the network against the three performance metrics in the network. Refer to the combined graph in Fig 4.10for the graphical representation and performance of the one server scenario.

4.12 Server E-mail load–Three Servers Scenario

From the tables 3.15, it could be seen that the load on the network was generally low.

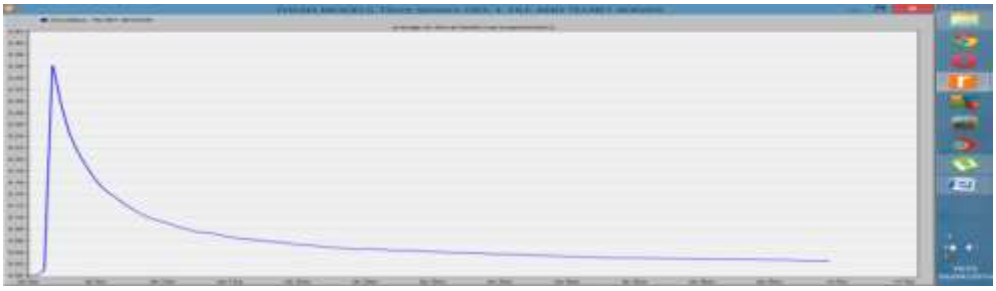


Figure 4.1 Server E-mail Load- Three Servers

It can be observed from Fig 4.9 that the load on the server was high when three servers were used. A lot of user request gets to the server, so the server takes time to grant each request hence the load on the server with an initial high value. The Combined effects of the three scenarios is as represented in Fig. 4.10.

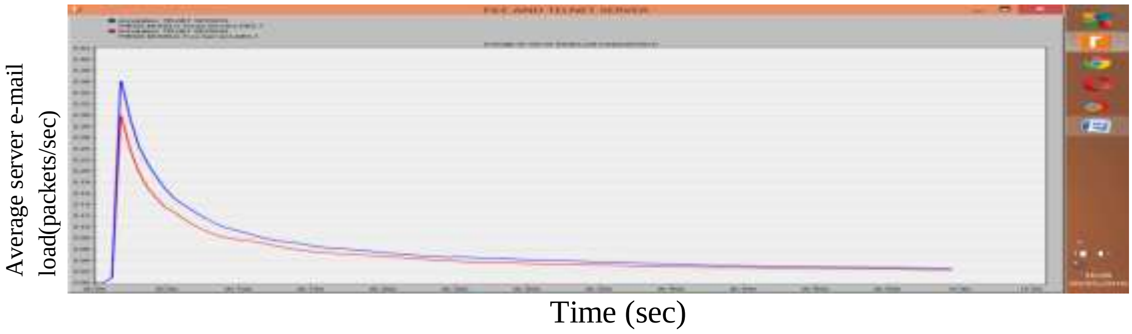


Figure 4.10 Server E-mail loads

From the graph in Fig 4.10, all three scenarios fairly had initial high value between 0.32 to 0.36secs before declining to 0.03secs and maintained a constant value to the end

4.13 Results for Http (web) Application

The web application was one of the important applications that generated traffic across the network and its performance estimated against the page response time.

Http Page Response Time –One Server Scenario

Tables 3.11-3.12 showed the page response time when one server was used on the network.

The table represented the performance of the one server scenario. Refer to the combined graph in Fig 4.12 for the graphical representation and performance of the one server scenario.

Http Page Response Time –Two Servers Scenario

The tables 3.11-3.12 showed the page response time when two servers were introduced into the network. The server added introduced some delay into the network. Refer to the combined graph in Fig 4.12 for the graphical representation and performance of the two server scenario.

4.14 Http Page Response Time–Three Servers Scenario

The page response time when the other applications were diverted to three servers in the network are shown in tables 3.11-3.12.

Average http page response

Time (sec)

Figure4.2 Http Page Response Time-Three Server Scenario

The Fig 4.11 showed the page response time when three servers were introduced to the network. It had an initial high value of 3.80secs to 19.0secs peak before declining to a final value of 14.00secs with a constant value. Combining the three scenarios produced a graph as shown in Fig 4.12.

Average http page response times,

Time (sec)

Figure 4.32 Http Page Response Time

From Fig 4.12, it was observed that the page response time was high when more servers were used on the network. Due to the overhead routing applications to servers, and the packet latency delay enforced in the cloud, it introduced extra processing times which lead to an increase in page response time, thereby degrading system performance. In the case where there was one server, the page response time was reduced as shown in Fig 4.12.

4.15 Server Http Load

The load on the web server was evaluated in this section under the three scenarios considered in the simulation exercise.

Server Http Load–One Server Scenario

The tables 3.13-3.14 showed the server http load for user request per second when one server was used on the network. Refer to the combined graph in Fig 4.14 for the graphical representation and performance of the one server scenario.

Server Http Load–Two Servers Scenario

The results when two servers were introduced into the network are shown in the tables 3.13-3.14. Refer to fig 4.14 for the graphical representation of two server scenario performance as shown in the combined graph.

4.16 Server Http Load-Three Servers Scenario

In the third scenario three servers were introduced to the network. The tables 3.13-3.14 give accounts of the network performance.

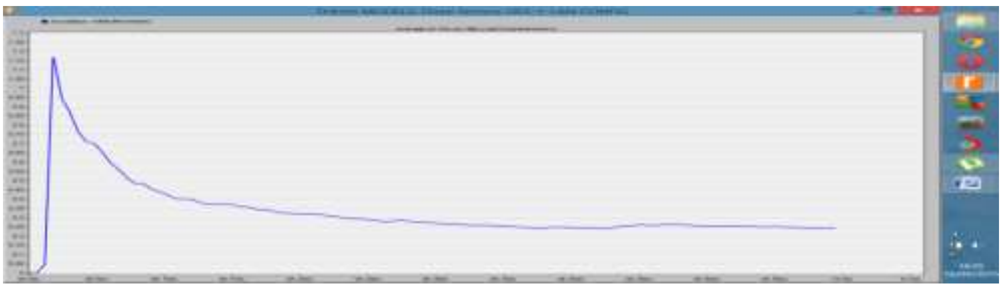


Figure 4.13 Http (web) Server Load-Three Server Scenario

From Fig 4.13, it was evident that the load on the web server was less when more servers were introduced on the network as compared to when one server was implemented as shown in Fig 4.14. In the third scenario the web application was concurrently processed by servers on the network hence the values 0.255secs on the server load.

4.17 Results for Ftp Application

Ftp application was evaluated against download response time and upload response time. The load on the ftp server was evaluated to investigate the performance of the network under the three different scenarios.

4.18 Ftp Download Response Time

This section discussed the time taken for user requests to be sent to the server for processing and back.

Ftp Download Response Time–One Server Scenario

The results in the tables 3.15-3.16 showed the ftp download response time when one server was used on the network. Refer to the combined graph inFig4.15for the graphical representation and performance of the one server scenario.

Ftp Download Response Time–Two Servers Scenario

Tables 3.15-3.16 showed the download response time when two servers were implemented, and the combined graph in Fig 4.15 showed the graphical representation and performance of the two server scenario.

4.19 Ftp Download Response Time–Three Servers Scenario

In the third scenario, the ftp application was designated to three servers, passing through the router and the cloud network with latency packet of 0.05secs delay. The results are as shown in tables 3.15-3.16.

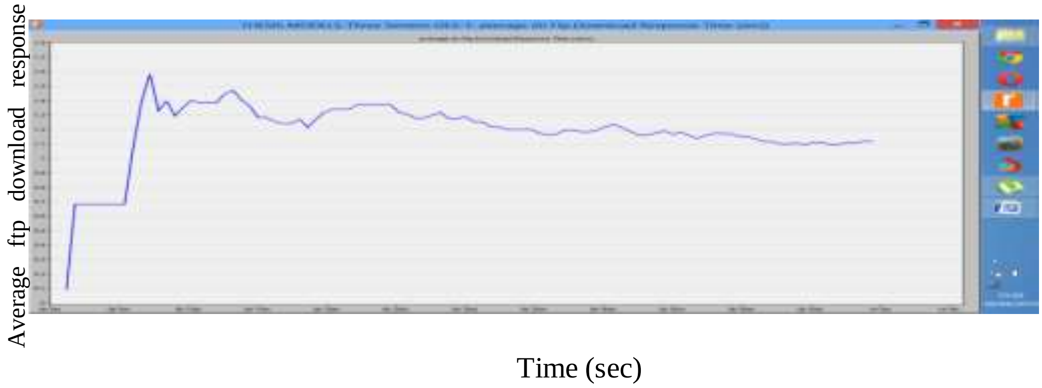


Figure 4.14 Ftp Download Response Time–Three Severs Scenario

From the Fig 4.14, it could be observed that the download response time had an initial high value of 1.00 secs when a packet size of 50mb was considered. The high value was as a result of the overhead encounter by the LAN, router and the cloud when processing the request and also the packet latency of 0.05 imposed to induce some delay into the system.

The combined effects of ftp response time for the three scenarios is as shown in Fig 4.15

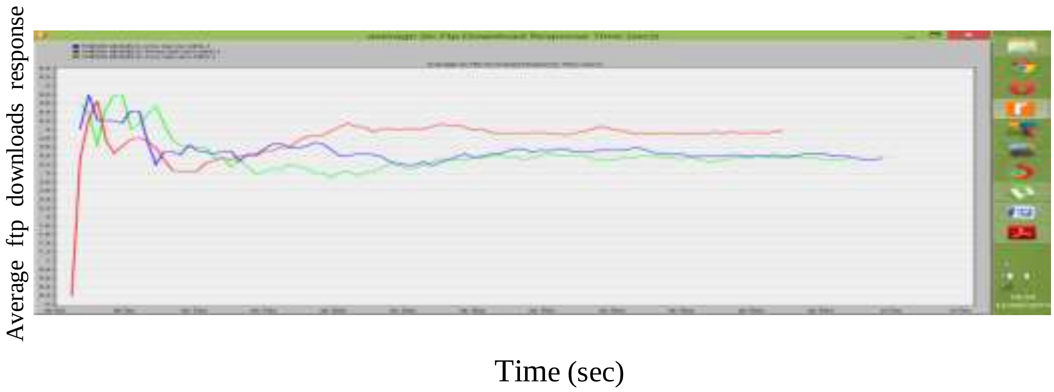


Figure 4.15 Ftp Download Response Time

From Fig 4.15, it could be seen that, the download response time is high when one server was used on the network as in the two servers. It can also be observed that, the ftp download response time decreased with increased servers introduced in the network for the traffic flow.

4.20 Ftp Upload Response Time

The upload response time was discussed under this section.

Ftp Upload Response Time-One Server Scenario

In the first scenario, one server was used on the network. Tables 3.17-3.18 showed the ftp upload response time. Refer to the combined graph inFig 4.17 for the graphical representation and performance of the one server scenario.

Ftp Upload Response Time–Two Servers Scenario

In the second scenario, another server was introduced to the network and a packet latency of 0.05 set so as to experience some delay in the distributed system to avoid traffic congestion. Tables 3.17-3.18 showed the results when packets routing was being enforced on the network

4.21 Ftp Upload Response Time–Three Servers Scenario

In the third scenario, three servers were introduced on the network to enforce diversion of applications to preferred server destinations across the cloud network. Tables 3.17-3.18 showed the results when three servers were introduced to the network.

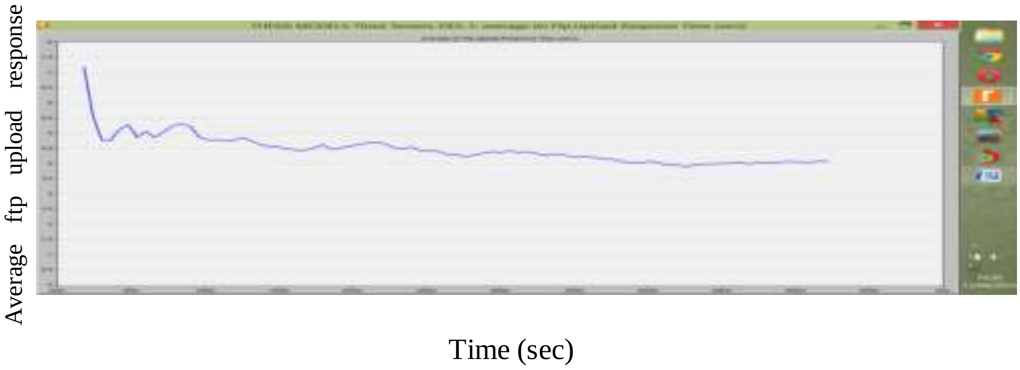


Figure 4.16 Ftp uploads response time–Three Servers Scenario

Fig 4.16 showed the graphical display of the upload response time when three servers are introduced into the network to enforce routing of applications to preferred server destinations across the cloud network. From the graph, it could be deduced, that the initial value was high at 7.25secsbefore having an appreciable decline of 4.55secs, then to a peak value of 3.55secs; and the maintained a constant speed throughout the simulation. Taking the three scenarios into consideration produced the Fig 4.17.

4.22 Server Ftp Load

Tables 3.19-3.20 showed the load on the ftp server in all the three scenarios.

From the tables, it was evident that the load was more when one server was used on the network.

Average ftp uploads response

Time (sec)

Figure 4.17 Ftp Server load

It is evident from Fig 4.17 that, when some applications were diverted to access the ftp server, it leads to poor response time. Using two servers recorded a high value in the upload response time due to packet latency enforced to ensure delay on the network to avoid congestion than when a single server was used. But the upload response time was very low in the case of three servers as a result of concurrent processing of server loads by user requests in the cloud network.

4.23 Cloud Utilization Performance

This section discussed about the cloud utilization. It was evaluated against the point to point utilization. Network utilization is the proportion of current network traffic to the maximum traffic that the port can work with. It indicates the bandwidth use in the network. While high network use indicated the network was busy, low network utilizations indicated the network was idle. At the point when system usage surpassed the limit under ordinary condition, it would cause low transmission speed, intermittence and request delays. The tables 3.21-3.22 showed the link utilization for applications on the network and Fig 4.18 showed the link utilization across the three scenarios

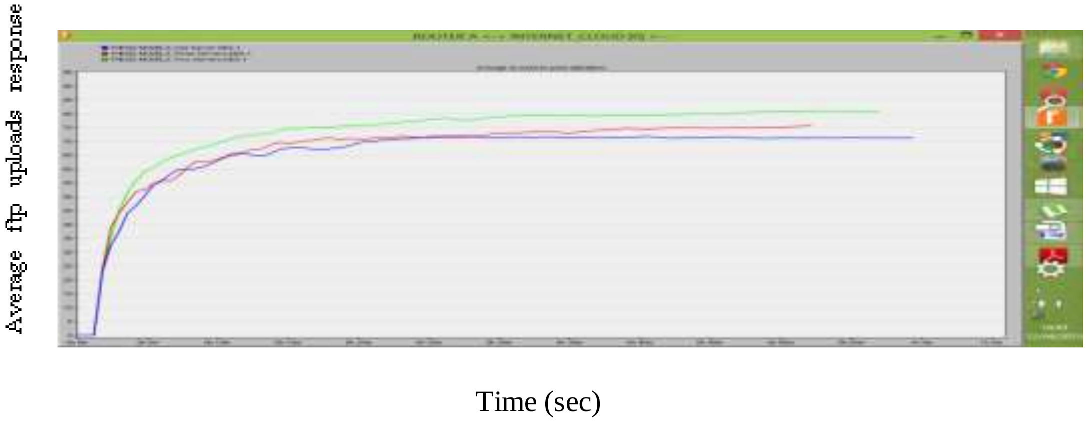


Figure 4.18 Average point to point utilization of router-cloud link

It was observed from Fig 4.18 and tables 3.21-3.22 that the total point to point use of cloud was better when there were three servers over the network because the cloud needed to work on the database, email, ftp, and http packets continuously. As the nodes (LAN, switches and the cloud) were imposed, some authentication policies and delays were observed. This resulted in packet diversions and cloud utilization was reduced. In the third scenario where the web, ftp and email traffics are routed, synchronized and delayed, the full utilization of the cloud network was observed as shown in Fig 4.18. As the traffics are designated, the servers had adequate time to process the database packets and the total utilization is reduced improving server performance. Thus at the end of analysis, it could be estimated that the total utilization of the cloud can be optimized when less servers are in the network.

Summary of Analysis and Evaluation

The simulation experiment was used to measure the following:

i. Database query response times, ii. Server database query response time

iii. Email/Ftp download and upload response times, iv. Server e-mail loads

v. Http page response times vi. Server http loads vii. Point-to-point link utilizations

The simulation results given in Fig 4.1 and Fig.4.2, showed the database response to user requests under the three different scenarios. Response times were high in the first and third scenarios than the second scenario. Introducing nodes (hardware) increased response times. When other application traffics were directed to the server in the third scenario, the database response time improved over the ***one server and two server scenarios*.** Refer to Fig. 44.11 and Fig 4.12. However, ***Server one and three server scenarios*** were very close and had a low response time.

Similarly, Fig 4.12 and Fig 4.15 showed the result for the ftp and http applications. Again the download/uploads response times was very close. It was low for the ftp and http applications when one and three servers were used in the cloud network by diverting applications to designated servers. It was evident from the results that, the chosen performance metrics increased with an increase in data size with the same speed at different data rates. This increased the network performance since users saw a quick response to their request. The chosen performance metrics had a higher value when two servers were used on the network. This meant that when nodes were introduced to the network with a packet latency delay, the network performance degraded initially before it picked up again.

CHAPTER 5

CONCLUSIONS, FINDINGS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Based on the findings, the following conclusions were drawn based on the research questions

- Riverbed Modeller 17.5 Edu. Simulator was used as a virtual platform because it had an advantage over using real machines as a traditional method.
- The general analysis of the results revealed that, the proposed server model was well utilized for improving the user applications.
- In the simulation, four applications were used including the database, email, ftp and http.
- The utilizations demonstrated that, the total performance of database application was improved when the web traffic was given a separate server. Again when there was heavy browsing across the network, the total cloud utilization was increased and thus the server performance was low and vice versa.
- The general conclusion was that, server performance and network performance are inversely related, which implies that introducing more servers on the network correlates to increase in the network utilization performance but degrades server performance due to packet delays.

5.2 FINDINGS

Based on the information gathered, analyzed and evaluated, the research came up with the following findings presented in accordance with the research questions formulated.

o Riverbed simulator was used as a virtual platform because it had an advantage over using real machines as a traditional method.

o Again, the design network setup had loud storage situated on the virtual platform.

o The performance of servers and applications on the virtual network was studied, analyzed and evaluated efficiently.

o Lastly, the behavioural patterns of the applications and link utilizations among servers in the ip cloud had all been achieved as stated in the objectives of this treatise.

o *The overall analysis was that, using one server had an initial low value but a higher value at end of the evaluation than using two or more servers. Using two or more servers had an initial higher value due to routing protocols of applications to destination servers coupled with synchronization protocols of the additional server node on the network but a lower value at the end of simulation than using a single server. Ref. to Appendix D*

o *It also came to light that, using more than one server in a company's network had an initial high cost due to purchasing devices and installation overheads but has an overall cost effectiveness, operational efficiency and user performance than using a single server.*

o *Again, when one server in the network goes down, the other servers in the network can serve customers without a shutdown until the faulty server is restored. Samples of Average performance showed a clear distinction of the server performances.ref. to Appendix E.b*

o *Nonetheless, at a point where the servers or nodes are beyond more than required on the network, there would be the possibility of poor system performance. This is because of transmission and routing protocol complexities in processing of user requests by the servers causing delays, congestions and consequent packet dropping.*

5.3 RECOMMENDATIONS

By the findings in this research, it was recommended that companies who would want to test their server performance, efficiency and reliability should consider using a virtual simulator. This is because apart from mitigating foreseeable installation problems and avoiding theft of physical components, it is also cheap and has an operational efficiency compared to using real machines.

In recommending for future work, there are some future scopes to be touched such as given below;

- A number of applications other than database, e-mail, http and ftp should be used to evaluate the performance of the server models which my research could not cover.

- Anyone trying to embark on a similar project should give attention to the network security such as firewalls for which my research failed to highlight.

- The graphical analysis measurements should be done in 10mins and 50mins to give vivid accounts at all times to be able to capture for variations in values due to the rise and fall at certain times which the table measurements fail to do.

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LIST OF APPENDIXES

APPENDIX A

CONFIGURATION PROCEDURES AND FEATURES

A.1 First Scenario-One Server Scenario

The scenario is to check the viability of a single, double and tripple servers for a network with the same workload to ascertain the reliability or effectiveness of server performances or othewise to advise a company on the suitable network or topology to adopt.Refer to Apppendix D for one Server Scenario configuration feature

A.2 Application Configurations

Application configurations define the applications that will be used on the network..For Apps. config. node, refer to chapter 3, page 30.

Below are the steps taken to configure the four applications to be used on the network

1. Activate the application config object and right click on the object and register on attributes
2. In the dialogue box opened, set a name for the object and Set the number of applications to run on the network in the rows box
3. In the value column,click to expand the aplication definitions and register on edit
4. Name the number of applications to be deployed on the network one after the other.
5. Describe each application named by clicking on the description column
6. Click on edit and choose the expected value performance of each application as displayed.Remember to set one expected value performance for each application

A.3 Application Configurations

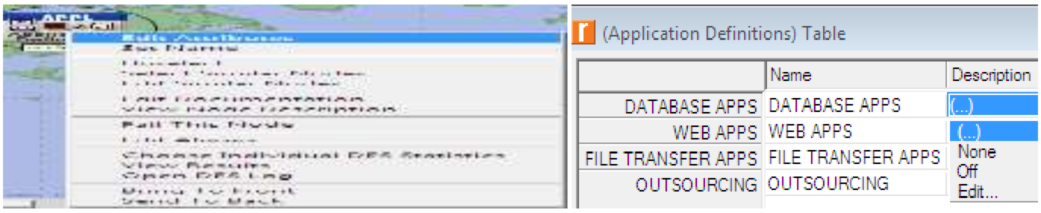


Figure a1: Application Configuration

A.4 Profile configurations

For Profile Config. node, refer to chapter 3, page 30.

To activate the profile object, follow the steps below

1. Activate the profile node by right clicking on the object and register on attributes

2. In the dialogue box opened, set the profile name for the object

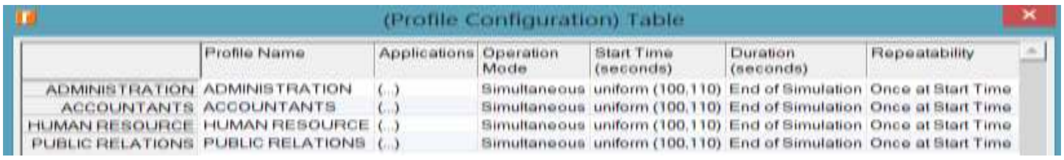
3. In the value column,click to expand the aplication definitions and register on edit

4. Set the number of applications to run on the network in the rows box

5. Write the names of the users to access the network in profile name column

6. Set each of the operation mode for the users to simultaneous, then ok

A.5 Profile configurations



(Profile Configuration) Table

	Profile Name	Applications	Operation Mode	Start Time (seconds)	Duration (seconds)	Repeatability
ADMINISTRATION	ADMINISTRATION	(...)	Simultaneous	uniform (100,110)	End of Simulation	Once at Start Time
ACCOUNTANTS	ACCOUNTANTS	(...)	Simultaneous	uniform (100,110)	End of Simulation	Once at Start Time
HUMAN RESOURCE	HUMAN RESOURCE	(...)	Simultaneous	uniform (100,110)	End of Simulation	Once at Start Time
PUBLIC RELATIONS	PUBLIC RELATIONS	(...)	Simultaneous	uniform (100,110)	End of Simulation	Once at Start Time

Figure a2 Profile Config

A.6 Lan Configurations

For LanConfig. node, refer to Chapter 3, page 30.

1. Activate with a right click on the Lan object, then register on attributes and In the dialogue box opened, set a name for the object

2. Click on the applications and expand applications supported profiles in the value column

3.Register on edit and set the number of profiles to access the network in the rows box

4. Name the profiles to be used on the network, then ok

Also configure for the applications to access the network as follows;

1. Click on the applications and expand applications supported services in the value column

2. Register on edit and set the number of application services to access the network in the rows box

3. Name the services to be used on the network, set all services in description to supported,then ok

Again for the amount of load and the number of nodes(workload) in the network, set it as follows;

1. Click on the Lan(within the Lan) to expand it, In the number of workstations, set it at 100 in the values column

2. In the switching speed, set the amount of data to pass through the network at 10,000,000,000 bytes(10GB) as packet size, Apply, then Ok

A.7 Configuring the Router(s)

For Router config.node, refer to Chapter 3, page 30.

1.Right click on the ethernet4_slip8_gtwy and rename as router 1 (or A),click to expand the performance metrics

2. Click to expand interface metrics and expand the traffic statistics and set the number of rows at 4 in the value column

3. Repeat the process for the other router to be used in the network and name it as 2 (or B)

A.8 Configuring the Cloud

For Cloud config. node, refer to Chapter 3, page 30

1. Right click on the Ip cloud and register on attributes, Rename the object as internet_cloud in the name value column.

2. Click to expand the performannce metrics and Click in the value column against packet latency(secs) and register on edit.

3. Set the duration of the simulation at constant 0.05secs (50m), Apply then ok

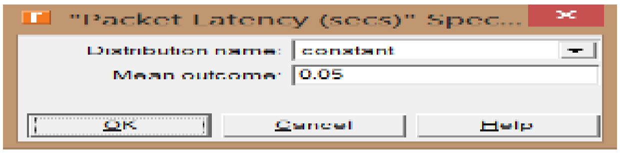


Figure a3 Packet Latency Settings

A.9 Configurations in the Server (Database)

For Ethernet Server Config. node, Refer to Chapter 3, page 30.

1. Right click on the ethernet_server and register on attributes

2. Rename the object with the preffered application name (database) in the name value column.

3. Click to expand the applications, Click to expand the application supported profiles in the value column then Register on edit and set the number of profiles to 4 in the rows box

A.10 Application Services Configuration

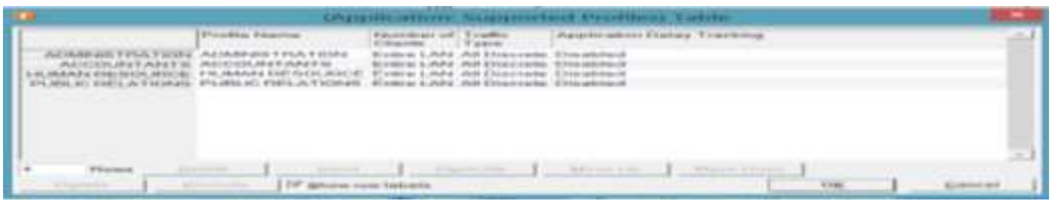


Figure a4: apps supported profile config icon

Also for the number of services;

1.Click to expand the application supported services then Register on edit and set the number of services to 4 in the rows box

2. Name the applications to be used in the network one after the other then set all descriptions to supported then ok.

A.11 Apps Supported Services Config

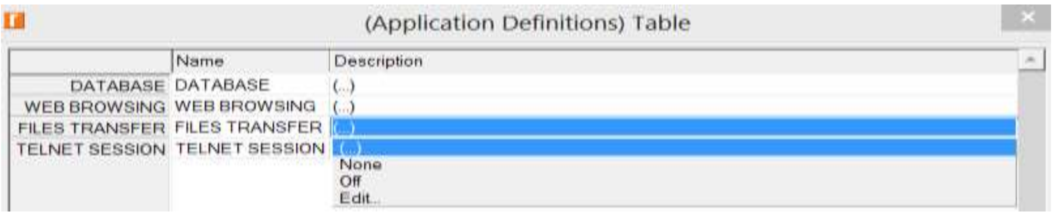


Figure a5 Apps Supported Services Config icon

A.12 Linking the Objects (Nodes) in the network

For 10 baseT link Config. node, refer to Chapter 3, page 30.

1.Click on the ethernet 10baseT link, Click on the Lan(workstations) and the switch to connect then Click also on the switch and router to connect, right_click to deselect then click on the ppp_ds1 link.

2. Click on the router 1(or a) and the internet_cloud, then from the internet_cloud to the router B (or 2), Right click in an open space to deselect.

For PPP DS1 link node, refer to page 28

1. Click on the ethernet 10baseT link , register on the router b (or 2) then on the sever to complete the connections

To Verify the links and connections;

1.Pull down the topology menu then Register on verify links, then ok

NB; A brake in any of the node links with a ×sign suggest a wrong connector used for the connection.

A.13 Configuring Measurements for Performance Metrics

A.13.b Introduction

To evaluate the performance of cloud against the database, web, file transfer and telnet applications few parameters are required. Riverbed Edu provides three levels of performance evaluation such as the global level, node level and link level in which all of them are used in the simulation procedure.

The following steps configure the performance metrics;

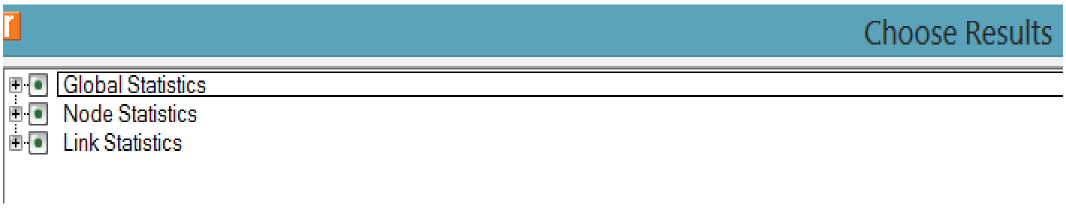


Figure a6 performance metrics

A.14 Global Statistics

1. Right click in an empty space or pull down the DES menu and register on choose individual statistics

2. Click the plus sign against global statistics, then the plus sign against db to expand it

3. Check mark the response time(sec), traffic received(packets/sec), and traffic sent(packets/sec)

4. Click to expand ethernet to measure the delay in the network then Click on the plus sign against e-mail to expand it

5.Check mark the download response time(sec), traffic received(packets/sec),traffic sent(packets/sec) then on the upload response time (sec)

6.Click to expand the ftp and check mark download response time (sec),traffic received(packets/sec), traffic sent(packets/(sec) then on upload response time(sec)

7.Click to expand the http and check mark the object response time (sec),page response time(sec),traffic received(packets/sec) and the trffic sent(packets/sec)

For Global Stats parametric feature refer to Fig. a15 for performance metrics feature

A.15 The Nodes Statistics

1. Click to expand the plus sign against the node statistics then scroll down the task pane

2. Click to expand the plus sign against server db query and check mark the load (requests/sec), task processing(sec), traffic received(packets/sec) and traffic sent (packets/sec) on the database traffic

3. Click to expand the server e-mail and check mark the load(requests/sec), task processing time(sec), traffic received(packets/sec) and the traffic sent(packets/sec) then on the web traffic

4. Click to expand the the plus sign against server ftp and check mark the load(requests/sec), task processing time(sec), traffic received(packets/sec) and the traffic sent(packets/sec)

5. Click to expand the server http and check mark the load(requests/sec), task processing time(sec), traffic received(packets/sec) and the traffic sent(packets/sec)

For Node Stats Parametric feature, refer to Fig. a6 performance metrics feature.

A.16 The Link Statistics

1. Click to expand the link statistics then the plus sign against point-to-point

2. Click to check mark the queuing delay(sec) →, queuing delay(sec) ←,throughput(packets/sec) →,throughput(packets/sec) ←, utilization→, and utilization←,then ok

For link utilization metrics, refer to performance metrics feature in fig. a6.

A.17 Configuring and Running the simulation

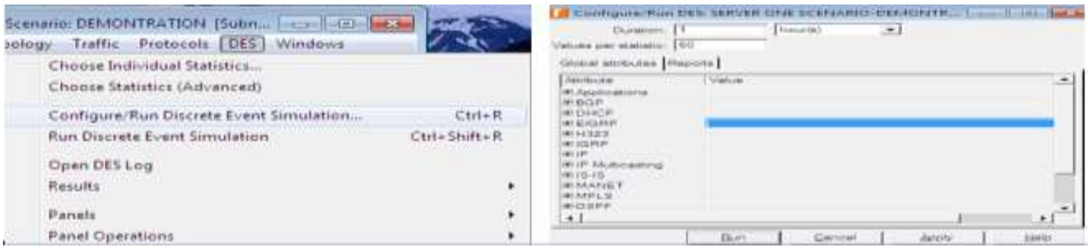


Figure a7 Simulation Configuration feature

1. Pull down the DES menu and register on configure/run discrete event simulation.

2. In the dialoque box, set the duration to 1hr and values per statistics to 100(mb/s) bandwidth. 2hrs or more hours may render long delays on the network.

3. Scroll down the task pane and click to expand simulation efficiency

4. Set the value against OSPF sim efficiency to disabled,

5. Click to expand traffic and the background traffic delays value column to 30, then apply

A.18 Running the Simulation

1. Click on run to run the simulation, Check the simulation log for possible error corrections and re-run the simulation., Refer to Fig B1 for live simulation features.

APPENDIX B

B.1 SECOND SCENARIO -TWO SERVERS

Refer to Apppendix D for Two Server Scenario configuration feature

Verify the links and connections as steps ;

Refer to appendix A on verying links procedure

B.3 Configuring the Web Server

Refer to Apppendix A for Apps Supported Profile Config and Apps Supported Services Config configuration procedures and Features.

B.4 Configuring Measurements for Performance Metrics

Parametric configurations details are as in server one scenario., Ref. to Appendix A

B.5 Running the Simulation

Refer to Appendix A for simulation procedure and to Fig. B1 for live simulation results feature.

APPENDIX C

C.0 THIRD SCENARIO-THREE SERVERS

Refer to Apppendix D for three Server Scenario configuration features and Apppendix A for Apps Supported services Config Feature.

C.3 configuring measurements for performance Metrics

Refer to Appendix B for parametric configuration details as in one server scenario.

APPENDIX D

D.1 List of Scenarios and Samples of Simulation Results

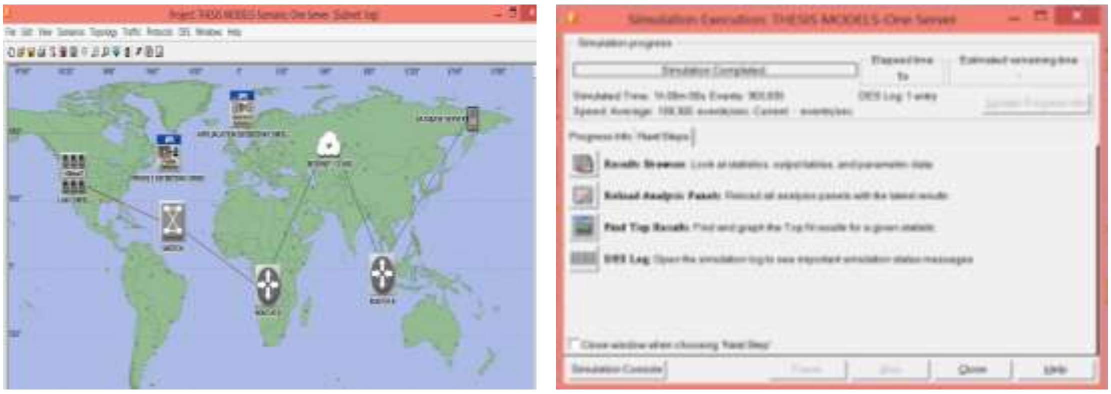


Figure D1: One server Scenario feature, First simulation Results

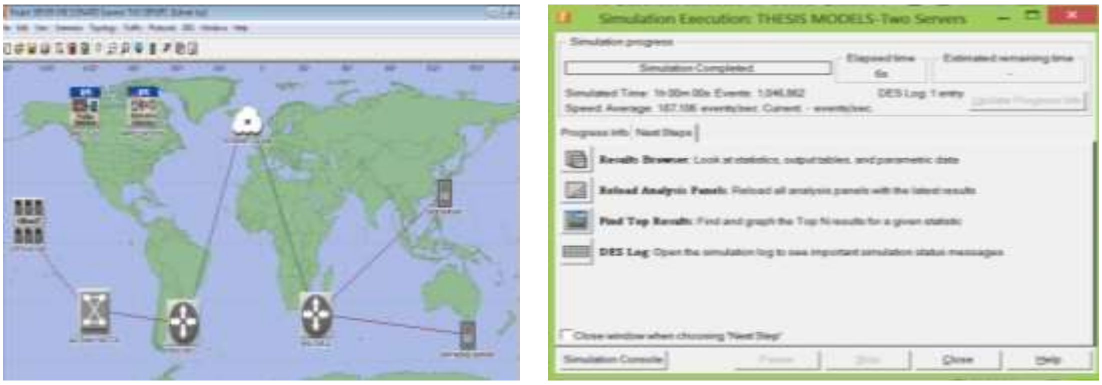


Figure D2: Two Servers' Scenario feature, Second Simulation Results

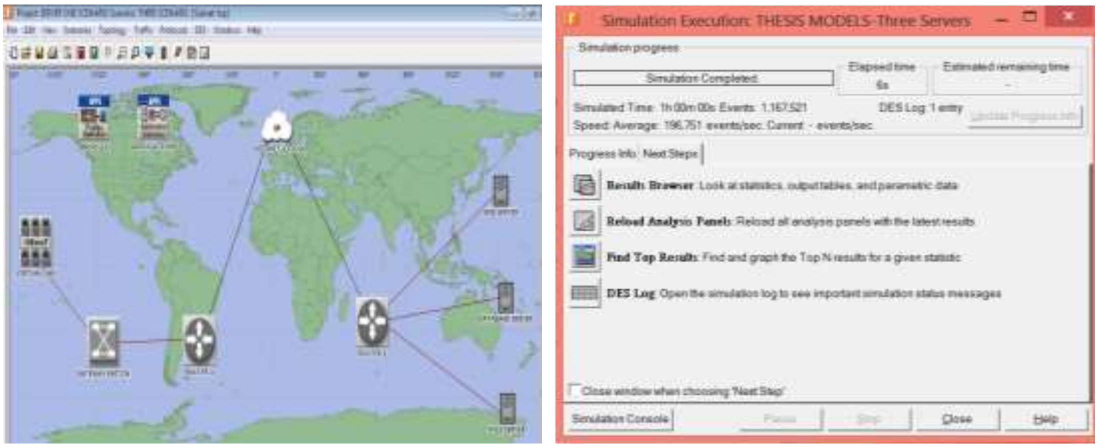


Figure D3: Three Server's Scenario feature, Third simulation Results

APPENDIX E

E.1 Samples of live Simulation Results and General average performances for the scenarios

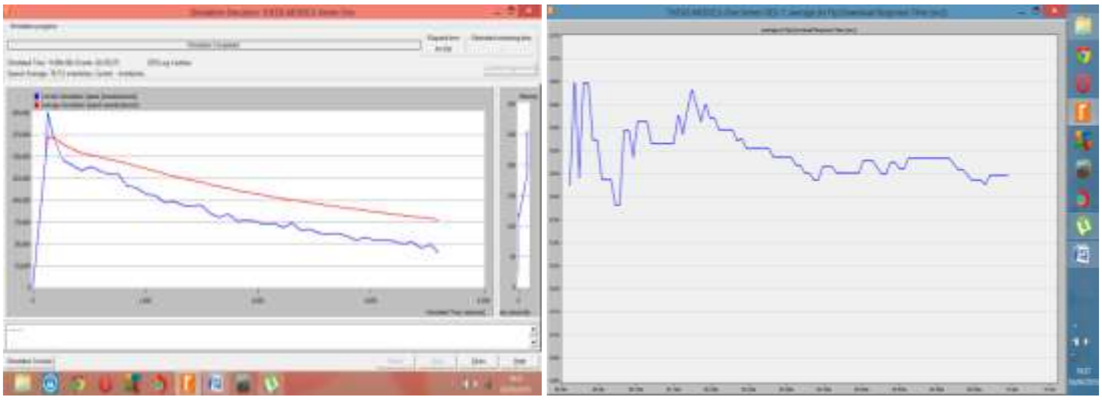


Figure E1: Live simulationResults-One Server, General Average Performance-One Server

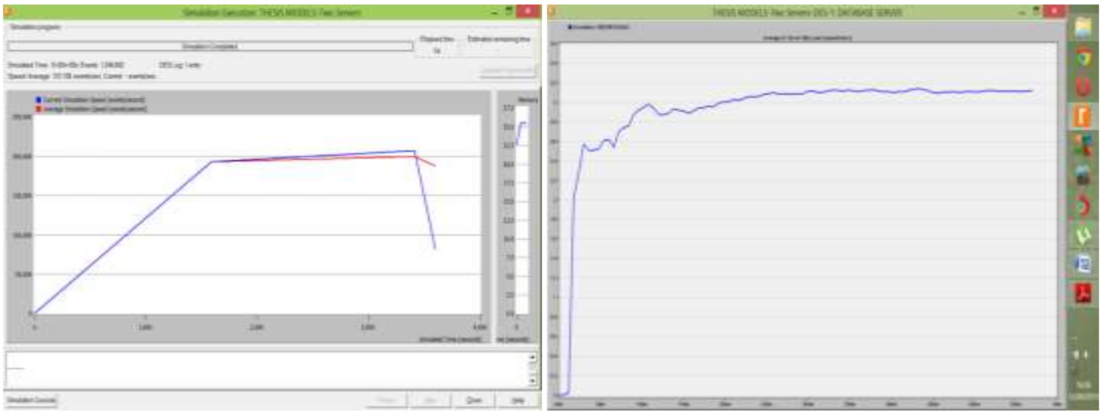


Figure E2: Live simulation Results -Two Servers   General Average Performance-Two Server's

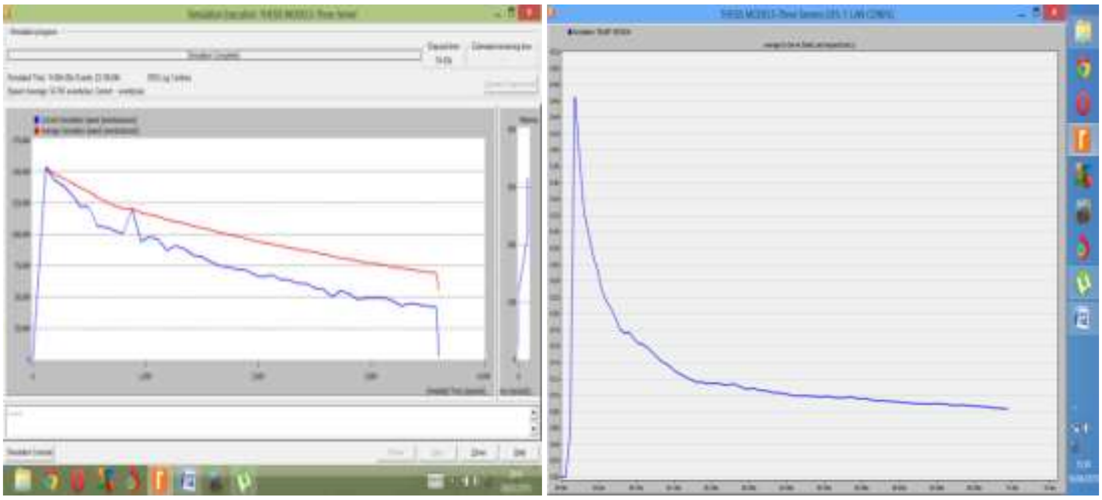


Figure E3: Live simulation Results -Three Servers, General Average Performance-Three Server's