

Redesign UTP Gigabit Ethernet Network with SMLT

By

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CERTIFICATION OF APPROVAL


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A project dissertation submitted to the
Information Technology Programme
University Teknologi PETRONAS
in partial fulfillment of the requirement for the
BACHELOR OF TECHNOLOGY
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Approved by,




(Mr. Anang Hudaya Muhammad Amin)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
MAY 2005

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the reference and acknowledgements, and that the original work contained herein has not been undertaken or done by unspecified sources or persons.



Ahmad Razlan Jalil

ABSTRACT

This paper is the documentation of the UTP “redesigned” network with Nortel’s SMLT feature. A simulation will be produced at the end of this project. The network design will use full-utilization of the network devices in the campus.

The simulation of this network designed will be constructed by using the OPNET network simulation software. The network will be designed with an SMLT (Nortel’s Split Multi Link Trunking) feature. The SMLT feature provides a reliable enterprise network environment. Moreover, this feature will have a lot of advantages which might overcome the network transmission problems. These will be discussed later in this document.

This official documentation starts with the background study and the problem statement of this project. It will also provide reviews from multiple sources such as magazines, internet and reference documents. The Gantt chart also is provided in order to guide this project systematically.

The advantage of redesigning the network is to provide a quality service for the campus. The network will be used maybe for more than a decade. In order to get make it future wise, Split Multi Link Trunking will provide the perfect solution to overcome the clients needs. Moreover, Fast Ethernet is a bit too slow for a large campus, a Gigabit Ethernet network is the most popular type of network for campus right now. It completes the need of Universiti Teknologi Petronas technological evolvment.

Logically, implementing a new network type into ‘UTP’ might be costly, but the writer has decided to reuse the hardware which is now used in the Fast Ethernet network. Redesigning the network by using the same hardware will save costs but maybe the redistributed links of points will be the raw cost for this project.

The writer has chosen the network hardware brand 'Nortel' as it is used now. Although there a lot more other network products by different manufacturers available, it is best to reuse the available products to cut cost. After all , this SMLT feature has proven it's 99% uptime, reliable and satisfies the quality of network performance as it has been used by major Petronas departments through out the country.

This document describes only the simulations for the proposed network. Real time simulations and testing cannot be done for this project because of insufficient time and sources to complete it. Recommendations and conclusions of this project are provided at the end of this document for researches to view and maybe for future research continuity.

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TABLE OF CONTENTS

CERTIFICATION	1
ABSTRACT	4
ACKNOWLEDGEMENT	5
CHAPTER 1:	INTRODUCTION	11
	1.1	Background study	.	.	.	.	.	.	11
	1.2	Problem statement	.	.	.	.	.	.	12
	1.3	Objectives and scope of study.	.	.	.	.	.	.	14
CHAPTER 2:	LITERATURE REVIEW AND THEORY	.	.	.	.	.	.	.	17
CHAPTER 3:	METHODOLOGY / PROJECT WORK	.	.	.	.	.	.	.	20
	3.1	Procedure Identification	.	.	.	.	.	.	21
	3.2	Tool required	.	.	.	.	.	.	24
	3.3	Project Timeline	.	.	.	.	.	.	24
CHAPTER 4:	RESULTS AND DISCUSSION	.	.	.	.	.	.	.	26
	4.1	Result.	.	.	.	.	.	.	26
	4.2	Discussion	.	.	.	.	.	.	51
CHAPTER 5:	CONCLUSION AND RECOMMENDATION	.	.	.	.	.	.	.	52
	5.1	Conclusion	.	.	.	.	.	.	53
	5.2	Recommendation	.	.	.	.	.	.	54
REFERENCES	.	.	.	.	.	.	.	.	55
APPENDICES	.	.	.	.	.	.	.	.	56

LIST OF FIGURES

Figure 3.1 Project Work Flow

Figure 3.3: Gantt chart Project Time Line

Figure 4.0 : Graph Network condition feedbacks

Figure 4.1 Sample Questionnaire

Figure 4.1.a: UTP v3,v4,v5 recent network estimation design.

Figure 4.1.b: v3, v4, v5 GE network design with SMLT.

Figure 4.2a. The Residential Network with SMLT

Figure 4.2.1 Graph packet throughput over seconds in residential network v3,v4,v5.

Figure 4.2.2 Graph Point to point utilization in the residential network v3,v4,v5.

Figure 4.2.3 Graph the network delay on time average of the Residential Network.

Figure 4.2.4 Graph: bit error rate and packet loss ratio .

Figure 4.3a. Academic Network design.

Figure 4.3.1 Graph : Academic Network packets throughput.

Figure 4.3.2 Graph : Academic Network utilization.

Figure 4.3.3 Graph : network delay on time average for Academic Network.

Figure 4.3.4 Graph: bit error rate and packet loss ratio.

Figure 4.4a Lembaran Network design.

Figure 4.4.1 Graph : Lembaran network throughput (packets per second)

Figure 4.4.2 Graph : Lembaran Network Utilization – packets per second.

Figure 4.4.3 shows the network delay on time average of the Lembaran Network

Figure 4.3.4 Graph: bit error rate and packet loss ratio.

Figure 4.5 UTP Gigabit Network design with SMLT

LIST OF TABLES

Table 3.3: Gantt chart Details Table

Table 4.1 Questionnaire feedbacks

Table 4.1a. Switch location, VLAN ID and IP address

Table 4.2a. . Switch location, VLAN ID and IP address

Table 4.2b. Link names types for v3,v4,v5 residential network.

Table 4.3. Switch location , VLAN ID and IP address

Table 4.4a : Hardware , VLAN and location description

Table 4.4b Link, location and type details

Table 4.5a : List of hardware details.

Table 4.5b : List of link details.

ABBREVIATIONS AND NOMENCLATURES

PPMSB – Petronas Penapisan Melaka Sdn. Bhd.

FYP – Final Year Project

SMLT – SPLIT MULTI LINK TRUNKING

DMLT – DUAL MULTI LINK TRUNKING

MLT – MULTI LINK TRUNKING

GE – Gigabit Ethernet

CHAPTER 1

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND STUDY

The UTP campus is now using the Fast Ethernet local area network. Lately, the network has become unbalance and not reliable. Since the total of network users in this campus is quite enormous, the local area network can be considered as an “Enterprise Network”.

After some investigation and researches, it is proved that the campus’ local area network is generated by the Nortel Network’s hardware. Multiple Baystack switches and router Passports are used to make this network alive. Since the Gigabit Ethernet type of network is one of the most popular type of network today, eliminating the hitches of ATM network, it has been proved that this type of network can provide the fastest, most reliable and the least down time of network evolvement today.

Although there are multiple manufacturers which provides the devices for this network but each of them has their specialties. In order to make the GE network the best in town, making full utilization of the manufacturers’ feature might produce the optimum performance of the network.

This project also will cover up the linking methods between the network devices. Hopefully, the proper type of links will be implemented within the system, by calculating the distance between each element.

Basically, this project will concentrate more on the SMLT feature, which is implementing 2 trunks between core switches which will be the backbone of the network. Moreover, the SMLT design will be powered up by MLT and DMLT where this type of links will cover up certain link or hardware failure. The implementation of these features will positively boost up the network performance and eliminate rare network challenge.

1.2 PROBLEM STATEMENT

1.2.1 Problem Identification

The network condition in Universiti Teknologi Petronas has not been very satisfying lately. This problem might be caused of certain network design disadvantages, such as the Single Point Failure which lies in a 'Spanning Tree Protocol' based network. This situation will affect the network when hardware between the switches and the core switch fails to communicate (technical failure) and the connection comes to a 'lossy' situation.

Each week , almost each block will encounter at least 1 network problem from each block. Although there are reported network problem cases to the IT department, but most of the users tend to keep it for themselves and use their own hubs! These problems occurs due to hardware and design problems ; links, switches , ports and memory utilization.

The network links have problems; the links are not properly assembled. Improper choice of backbone link type causes a major role in slowing down the network transmission.

Furthermore, the allocation of each core network router and switches was placed irrelevantly. Therefore, this results a network failure by groups, where a certain group of network will not respond to packets as the route to their connection is lost.

1.2.2 Significant of the Project

There will be a need to design a network to counter these challenges. This redesigned network must be capable to make full utilization of the network hardware's specialties which is provided by the manufacturers. Hopefully, it will boost the network performance and eliminate the single point failure and make the network reliable and has the least down-time. Furthermore, the project should be useful for a lengthy worth of time and expandable through the technology evolvement.

Implementing the SMLT feature provides a 99% uptime , which has the down time of 4 ms (approximately). Network trunks will be used for this feature design which will provide backups for the links to increase link uptime duration.

1.3 OBJECTIVES AND SCOPE OF STUDY

1.3.1 OBJECTIVES AND SCOPE OF STUDY

The main objective of this project is mainly to develop a network design that is able to provide optimal service with the least challenges faced. Therefore, the Nortel's Split Multi Link Trunking is will be implemented in the network design since it is the best feature that is provided by the manufacturer.

Secondly, is to study the method of designing a campus network with the hardware's and the total users available. The proper utilization and proportion of hardware connection is the most important asset to make this project successful.

1.3.2 The relevancy of the project

The Gigabit Ethernet network is a very popular type of network, which being used widely through out the IT world. Even the best "Enterprise network" is using this type of the network. However, in order to achieve the best of this Gigabit Ethernet network, the design must be different but still useful. Network manufacturers are on a tight competition of marketing their products, which had led researches to improve its capabilities and functions. This will be a good contribution to help in some IT working area. It will be the fundamental to a more functional network. Therefore, a network design which uses the best out of the manufacturer specialties might produce the optimal network performance for its users.

1.3.3 Feasibility of the project within scope and time frame

The project had started of with researches about the Gigabit Ethernet network and Nortel Network products. It will be the starting point in understanding the components involved in building the network design. With the help of these researches, the project will then concentrate more on building a simulation of the network design using simulation software (OPNET). All the information can be find from books in the library and from the internet. With all the resources provided, it will be a feasible project in the time given.

CHAPTER 2

CHAPTER 2

LITERATURE REVIEW

The campus network that University Teknologi Petronas is using right now basically is the same as the Petronas Penapisan Melaka (PPMSB) network. On February 2004, PPMSB has upgraded their network from ATM-based network to a GE network.

All the GE network devices are from Nortel Networks products. Furthermore, the engineer who designed their network adds the SMLT (Split Multi Link Trunking) feature in this network.

Although their plant is quite big, PPMSB managed to utilize their network by only using 2 core switches (Passport 8600 routing switch) and many normal switches (Baystack 470T – 24 and 48 ports). The implementation of this GE network was done on the live network. The switches were transferred while the system was alive. As a result, PPMSB is now running a network with a very small downtime which is less than 4 milliseconds.

Basically, the main idea of implementing SMLT feature in the network design is to minimize the down time of an enterprise network. This can be done by eliminating the single point failure. In order to replace this challenge, the network was designed to link in circles where multiple links are created at each end point. Therefore, the links will have backups and can still run if there is technical failure on the linkage.

Typical resilient Ethernet networks consist of wiring closet (edge) switches dual homed to network center aggregation (core) switches in a building or campus. More and more, network servers are being multi-homed to server switches—enabling higher bandwidth availability and improved resiliency.

Similarly, in carrier and Internet Service Provider (ISP) environments, customer premises equipment (CPE) devices may also be dual homed to two aggregation switches at a point of presence (POP) to realize the same benefits.

Such implementations, however, require the use of the Spanning Tree Protocol to protect the network against loops of the network to eliminate all single points of failure.

The challenge of designing a resilient network involves not only eliminating single points of failure, but doing so without ending up with unused (and costly) capacity. The network must also be able to reroute around failures—with typical requirements in the sub-5-second range.

SPLIT MULTILINK TRUNKING.

What is Routed Split Multi-Link Trunking?

In many cases, core network convergence is dependent on the time that routing protocols require converging. This can cause network interruptions ranging from seconds to several minutes, depending on the actual routing protocol.

With Routed Split Multi-Link Trunking (RSMLT), Nortel Networks introduces a feature that allows rapid failover for core topologies by providing an active-active router concept to core SMLT networks. Supported scenarios include SMLT triangles, squares, and SMLT full mesh topologies with routing enabled on the core VLAN. Routing protocols can include any available routing protocol such as IP Unicast Static Routes, RIP1, RIP2, OSPF, BGP, and IPX RIP. In the case of core router failures, RSMLT takes care of the packet forwarding, thereby eliminating the possibility of packets being dropped during routing protocol convergence.

Reasons to Deploy SMLT/RSMLT

As networks grow ever more critical, there is an increasing demand for multiple paths from all wiring closet switches into the core of the network to eliminate all single points of failure.

The challenge of designing a resilient network involves not only eliminating single points of failure, but doing so without ending up with unused (and costly) capacity. The network must also be able to reroute around failure with typical requirements in the sub-5-second range.

As voice and data convergence becomes more prevalent, today's network managers are seeking reliable and scalable solutions that focus on high network availability and optimal use of bandwidth. Solutions must be simple to implement, as transparent as possible, and have the ability to interoperate with the majority of existing devices. The SMLT solution succeeds in addressing all of these requirements where previous efforts have failed.

Minimizing down time during scheduled network maintenance, such as system upgrades or configuration changes, is also a key requirement of today's networks. Providing network operators with tools that allow them to apply network changes during working hours, rather than after hours, can lead to significant cost savings over time. The SMLT/RSMLT solution provides a simple way of upgrading aggregation/core devices without impacting overall network availability.

CHAPTER 3

METHODOLOGY

3.1 PROCEDURE IDENTIFICATION

The research will be based on a simple methodology. This methodology was design to have a basic view of the project and a preparation for this research. Figure 3.1 shows the methodology that will be used in developing this project. This method is the same as the waterfall concept.

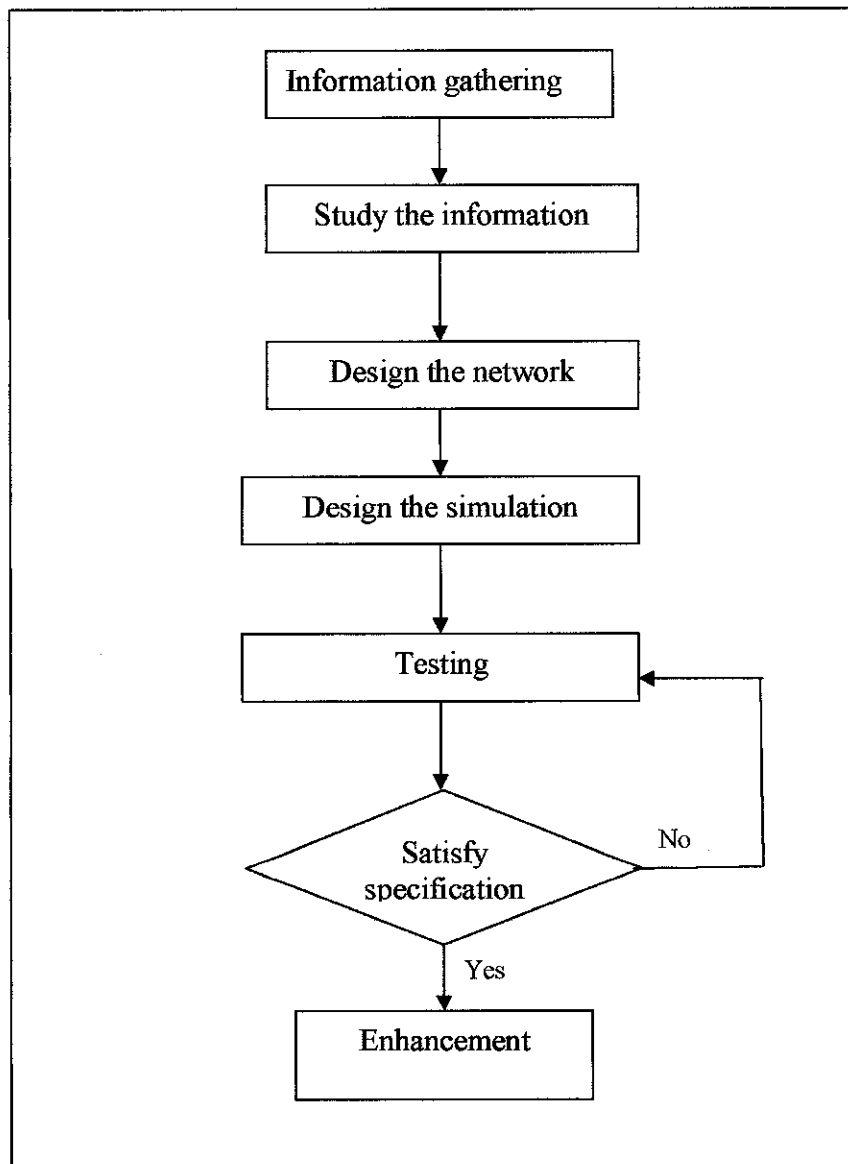


Figure 3-1 Project work flow

3.1.1 Project Work Flow

The project will start with information gathering from books, journals, magazines and the internet about Gigabit Ethernet Local Area Network and Nortel's Split Multi Link Trunking. This is to prepare and have basic understanding of the project. Then, the information from the researches will be gathered and the best feature will be picked for the design. These components needed to be studied to understand the relation of each component. With the design of the network, the Split Multi Link Trunking feature can be slotted in to integrate with the hardware. The simulation design phase will be difficult and will be using a longer period to achieve the specification needed.

3.1.1.1 INFORMATION GATHERING

This phase has already completed. All needed information has been gathered with the help of journals, internet and interviews. All information are recorded and will be analyzed for future use. The critical information was the network problems within the campus. The questionnaire was a big help to determine the problems and the feedbacks was very positive.

3.1.1.2 STUDY THE INFORMATION

All the gathered information was studied their cause and effect. This phase has already completed and the project is on its way to the designing phase. This is to ensure the proper elements are chosen for the design.

3.1.1.3 DESIGN THE NETWORK

The design phase is done by allocating the switches and other devices, The VLANs , network type , network link type, IP address and locations will be determined in detail.

3.1.1.4 DESIGN THE SIMULATION

The simulation was done by designing the network in OPNET IT Guru Simulator. The Simulation has Nortel Networks module and the latest link types which their attributes are almost the same with the reality object.

3.1.1.5 TESTING

The testing phase totally depends on the OPNET IT Guru software. The testing duration will be for an hour. The OPNET Guru simulator only supports 20 trunks in a design. Therefore, the full design will be parted to 3 parts for testing which is the residential network , academic network and the lembaran network.

3.1.1.6 ENHANCEMENT

In this phase, the hardware from the residential network was moved to the academic network. The queue priority was not balanced since the previous design will not provide any equal specialties between the networks.

3.2 TOOL REQUIRED

3.2.1 Hardware:

- Personal Computer Pentium-class processor, Pentium 300 MHz minimum
- Hard disk space 1.5GB minimum
- 128 MB RAM minimum

3.2.2 Software:

- Platform Windows XP.
- OPNET IT Guru Network Simulator
- Microsoft Excel

3.3 Project Time Line

Below is the Gantt chart, estimation of time to finish this project.

	Task Name	Duration	Start
1	Information Gathering	5 days	Mon 1/24/05
2	Anlayze the information	23 days	Mon 1/31/05
3	Design the network	11 days	Tue 3/8/05
4	Develop network simulation	14 days	Wed 3/23/05
5	Testing	12 days	Tue 4/12/05
6	Enhancement	7 days	Thu 4/28/05
7	Presentation	7 days	Mon 5/9/05

Table 3.3: Gantt chart Details Table

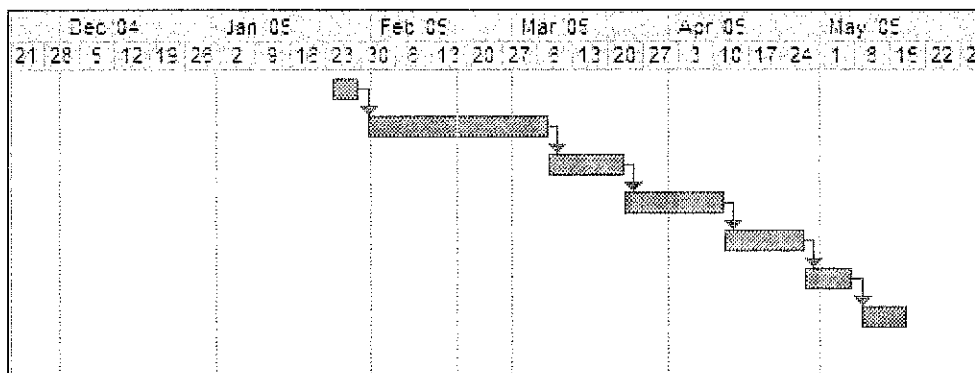


Figure 3.3: Gantt chart Project Time Line

CHAPTER 4

RESULTS AND DISCUSSION

4.1.1 INFORMATION GATHERING

Task 1: Gathering information by questionnaire.

As for a kick start of this project, the simplest way to gather data is by observing the network users. Therefore, questionnaires are distributed to students. All the data and comments are analyzed.

The sample questionnaire is included in the Appendices.

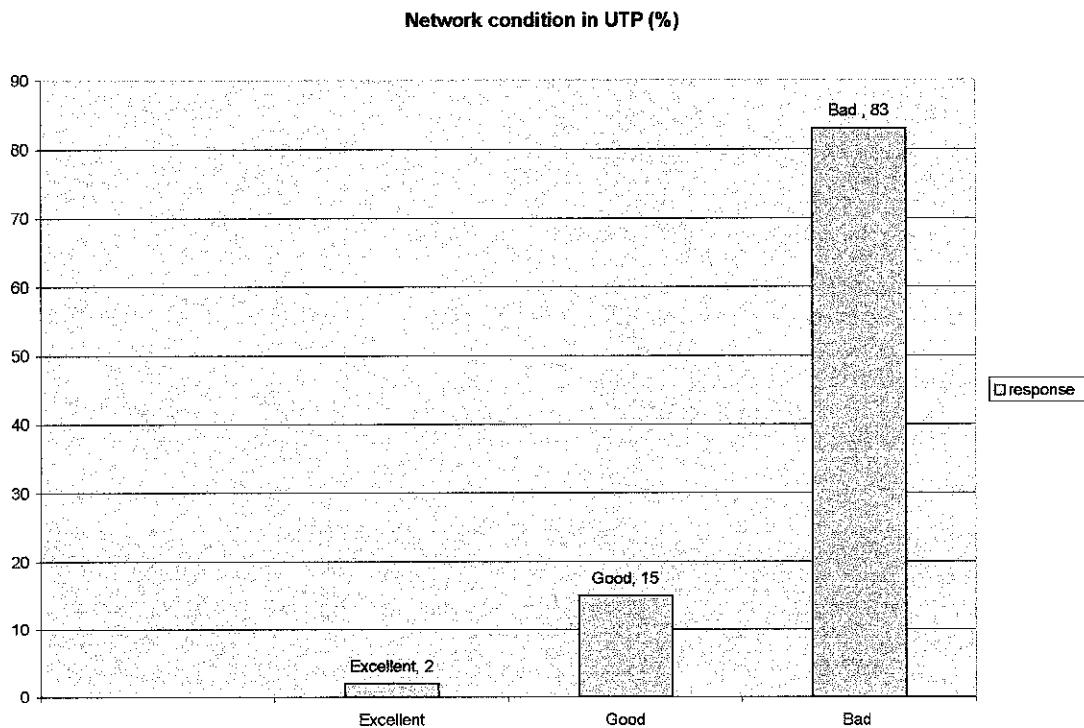


Figure 4 : Graph Network condition feedbacks

The graph shows the result of the questionnaire feedbacks. Based on the feedbacks we have concluded that 83 % network is bad, 15% says it's good and 3% says the network is in excellent condition.

Questionnaire for FYP project

Hello there, it will just take a second to fill in these questionnaires.

Please underline the choices of your answers.

1. Are you a network user in UTP?

- Yes
- No

2. If yes, how do you describe the network connection in this campus?

- Excellent
- Good
- Bad

3. Briefly, please give your comments on question 2.

4. Do you think UTP network conditions should be improved?

- Yes
- No

5. Briefly , please give your comments on question 4.

Figure 4.1 *Sample Questionnaire*

Table 4.1 Questionnaire feedbacks

Respondents	Q1	Q2	Q3	Q4	Q5
1	Yes	Bad	Need Improvement	Yes	
2	Yes	Bad	Need Improvement	Yes	
3	Yes	Bad	Need Improvement	Yes	
4	Yes	Bad	Need Improvement	Yes	
5	No	Good	Satisfied	No	
6	Yes	Bad	Need Improvement	Yes	
7	Yes	Bad	Need Improvement	Yes	
8	Yes	Bad	Need Improvement	Yes	
9	Yes	Bad	Need Improvement	Yes	
10	Yes	Bad	Unhappy	Yes	
11	Yes	Bad	Need Improvement	Yes	
12	Yes	Bad	Need Improvement	Yes	
13	Yes	Bad	Need Improvement	Yes	
14	Yes	Bad	Need Improvement	Yes	
15	Yes	Bad	Unhappy	Yes	
16	Yes	Bad	Unhappy	Yes	
17	Yes	Bad	Unhappy	Yes	
18	Yes	Bad	Need Improvement	Yes	
19	Yes	Bad	Need Improvement	Yes	
20	Yes	Bad	Need Improvement	Yes	
21	Yes	Bad	Need Improvement	Yes	
22	Yes	Bad	Unhappy	Yes	
23	No	Bad	Unhappy	No	
24	Yes	Bad	Unhappy	Yes	
25	Yes	Bad	Need Improvement	Yes	
26	Yes	Bad	Need Improvement	Yes	
27	Yes	Bad	Need Improvement	Yes	
28	Yes	Bad	Need Improvement	Yes	
29	Yes	Bad	Unhappy I	Yes	
30	No	Good	Unhappy	No	

Task 2: Gather information on GE and it's components

What is Gigabit Ethernet LAN?

Gigabit Ethernet is a high-performance, Ethernet networking solution for servers and workstations. Furthermore GE runs at Triple speed 10/100/1000 Mbit/s, a Full-duplex operation at 10/100/1000 Mbit/s and half-duplex operation at 10/100 Mbit/s but there is no half-duplex support for 1000 Mbit/s. The auto negotiation feature is available to the highest link speed.

Network Trunks

Network 'trunks' is a technique to increase communication bandwidth by connecting multiple Ethernet NICs (especially 100Base/T Ethernet). To realize network trunking communication, multiple Ethernet NICs on one PC and Ethernet switches for the Ethernet NICs are needed.

PM/Ethernet manages multiple NICs using a unit number and only NICs with same unit number on cluster nodes can communicate with each other. Moreover, Ethernet MAC address is directly used on PM/Ethernet communication, NICs with the same unit number must be installed on the same Ethernet network as well as each node can communicate with the other nodes using Ethernet address directly.

Task 3 & 4: Gather information on SMLT

Definition of Split Multi Link Trunking (SMLT)

SMLT is Nortel Networks architecture that helps eliminate single points of failure and creates multiple paths from switches to the core of the network. It also works to reroute failures as quickly as possible. SMLT improves redundancy and resiliency by fully utilizing DMLT .

Task 5: Gather information on Virtual Local Area Network

VLAN is also known as a virtual highway which is determined by ports which will enhanced network communication within links as there will be less collision and loop back.

Task 6 : Gather information on type of links.

The Ethernet network runs at the speed of 10/100/100Mbps. There are a few types of links that can support this network medium speed. The 10 Base T which carries 10 Mbps is also called the Twisted Pair Ethernet. The 100 Base T link is the Networking standard for twisted-pair cabling capable of carrying data at 100Mbps is also called Fast Ethernet. The 100 Base FX is the networking standard for fiber-optic cabling capable of carrying data at 100Mbps. The 1000 BASE SX carried data at 1000Mbps(max) over short haul multimode fiber optic cabling.

Task 7 :Designing the network for v3 , v4 and v5 residence.

The simulation design was done by using the software OPNET IT GURU. The software is able to provide statistical report on the network design.

Firstly, the UTP network design was analyzed, an estimation of the network design was assumed by the result of interview with IT staffs. By using certain networking method, I have discovered that, each of the village residence has a Nortel Passport 8010 routing switch. These villages have 5 blocks with each of them having different VLANS, I supposed that there are at least 15 VLANS implemented in this design.

The figure below shows the design of the recent v3 , v4 ,v5 network.

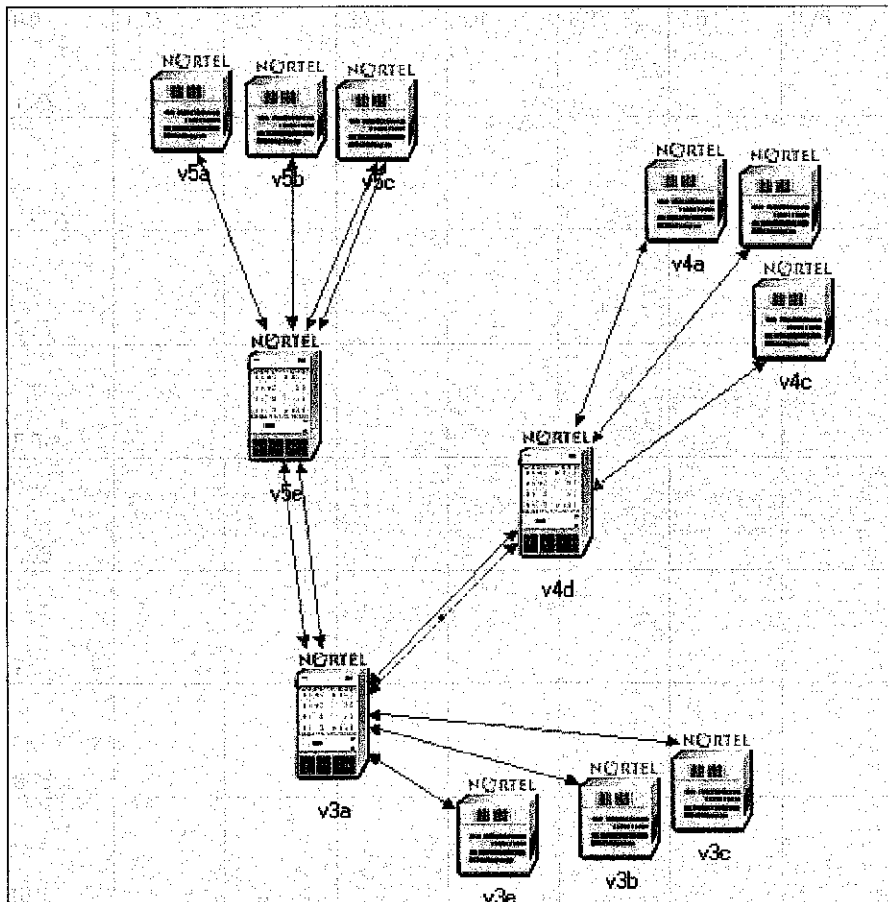


Figure 4.1.a: UTP v3,v4,v5 recent network estimation design.

Two links were created from v5e passport to v3a passport and v4d passport to v3a passport because it is estimated that the previous network designer did implemented MLT in this design. However all the other switches is the Baystack 450 – 48 T. It is all connected to the Passport routing switch with the 100BASE FX link type.

Below shows the redesigned GE network for V3, V4, and V5 with the SMLT feature.

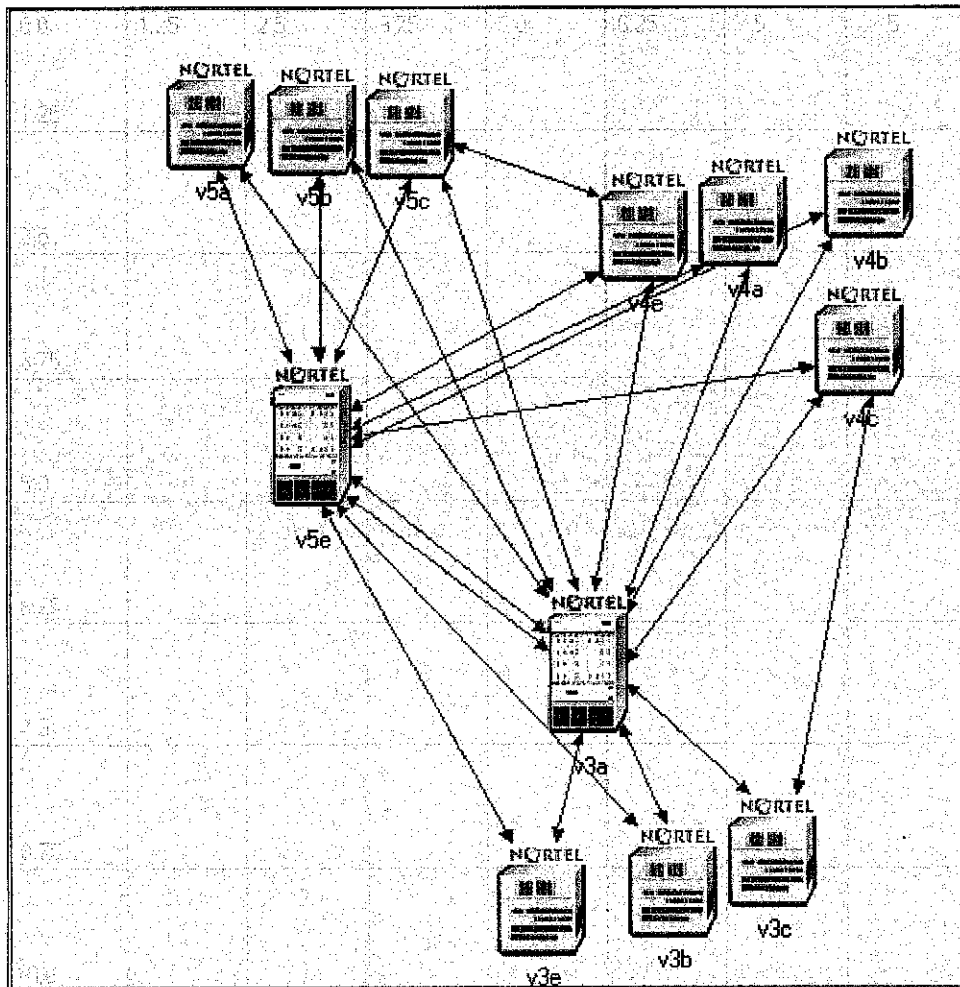


Figure 4.1.b: v3, v4, v5 GE network design with SMLT.

For this design, v4d routing passport was switched to a switch. The IST(Inter Switched Trunking)link was created between v3 and v4 passport and a jump link is available from v3c switch to v4c switch, v4e switch to v5c switch, and v3e to v5e switch. The other links are all generated by the MLT (multilink feature). Each of this link is called the SMLT link, where each switch has 2 links , which is for v3 passport and 5 passport.

Task 8 : Determining the VLANS for the design.

Since SMLT is configured by port, it is dependent on the VLANS to make it work; the VLANS are determined by the guide of the previous IP address from the recent UTP network. However, SMLT is limited to only 32 VLANS. The full network might have more than 32 VLAN but only the core VLAN will be included in the SMLT feature

Task 9 : Designing the full network

A major change has to be done to the v3, v4 v5 design because it is not appropriate to put both core switches at the residential network. The passport in v4e will be transferred to the Academic network so that both sides will have equal communication status. The Academic block provides internet connection and other important data to the network design, therefore it is not appropriate to plant a powerful machine at a total-user site.

An enterprise switch (Nortel Baystack 470 – 48T) will take over the Passport 8010 at v4e which will add up another SMLT link in this network. *Figure 1a* show the residential network design. The residential network is connected to the Passport in the Chancellor building. All the colored links are the pairs of SMLT in this design.

In order to make sure that this network is working, the graph result was checked on the issue of packet throughput. Graph 1 shows the result of packet throughput for the residential network. Graph1 1b shows the average utilization of the network.

Residential network design which covers v3, v4 and v5 network.

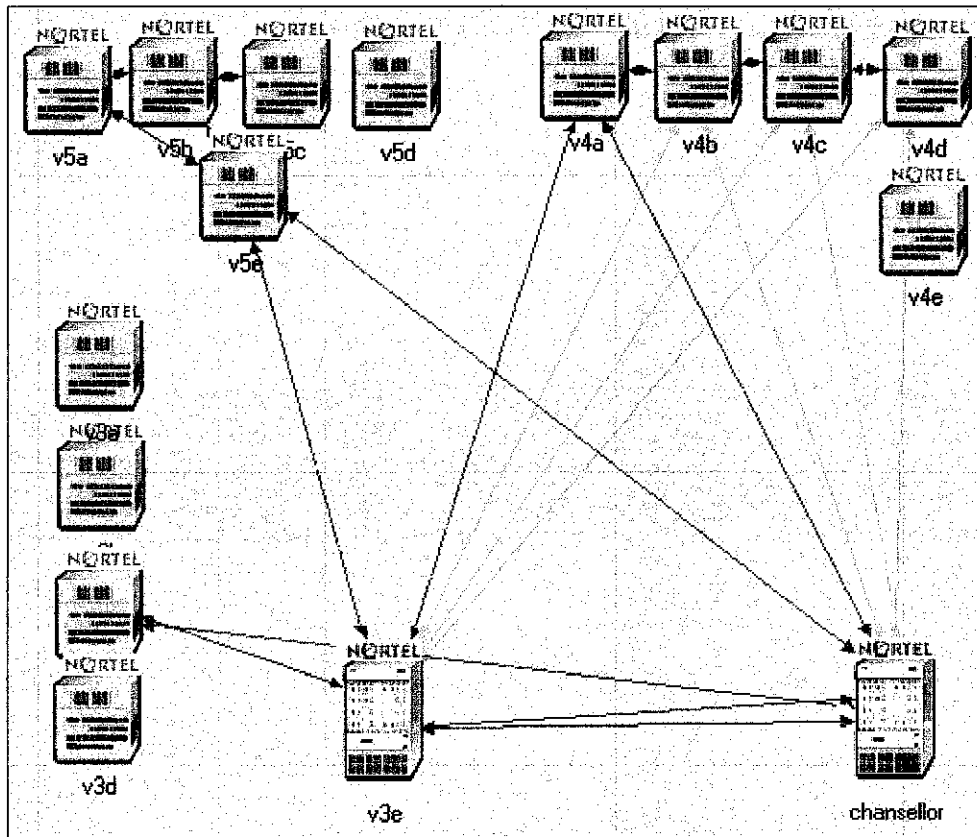


Figure 4.2c. The Residential Network with SMLT

**All the colored links are the pairs of SMLT.*

Simulating The network

The network was simulated by using the OPNET IT guru network simulator. Graph * shows the point to point through put in the network and graph * show the network utilization.

Results simulated by OPNET.

Simulation Completed - Collating Results.

Events: Total (8570), Average Speed (22853 events/sec.)

Time: Elapsed (1 sec.), Simulated (1 hr. 0 min. 0 sec.)

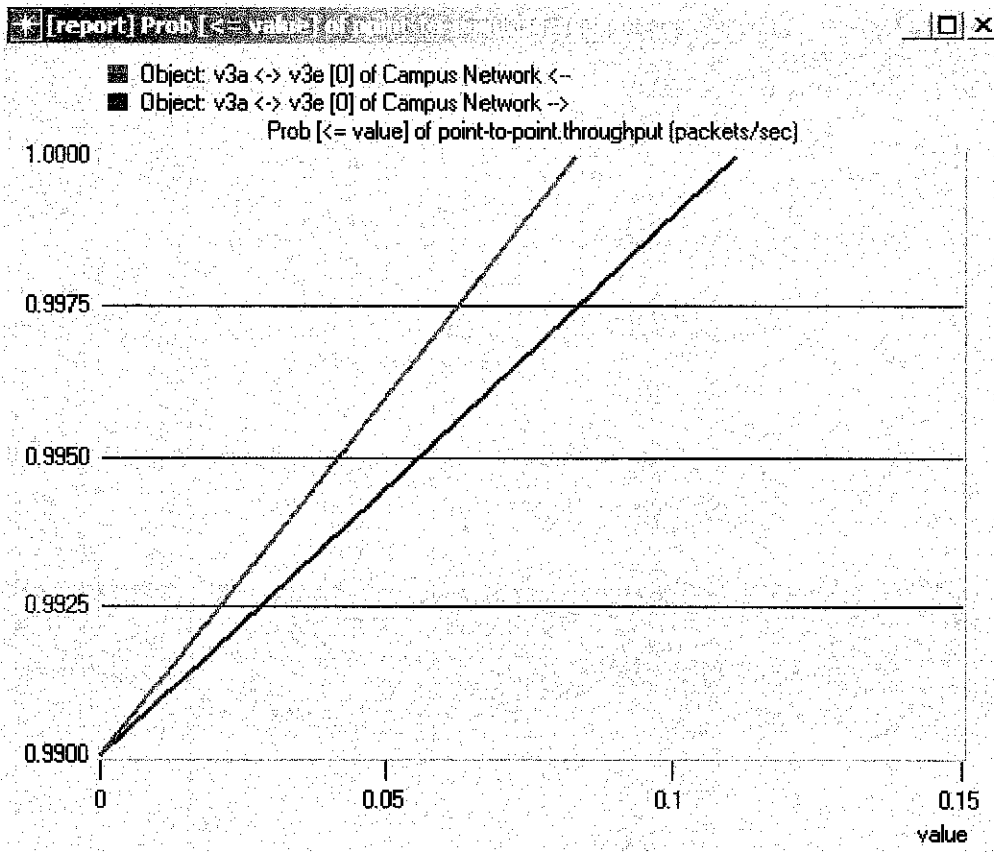


Figure 4.2.1.:Graph packet throughput over seconds in residential network v3,v4,v5.

The figure 4.2.1 shows that throughput of the residential network. The Red line indicates the sending packets and the red shows the packets received. The Red line shows the packets which is moving from the residential building to the v3e Passport where the c buildings are using Passport and the Switch is receiving it. Therefore, the send packets(red line) ratio is higher than the received packets(blue line) because of the capability of the machine to utilize it's memory on their service.

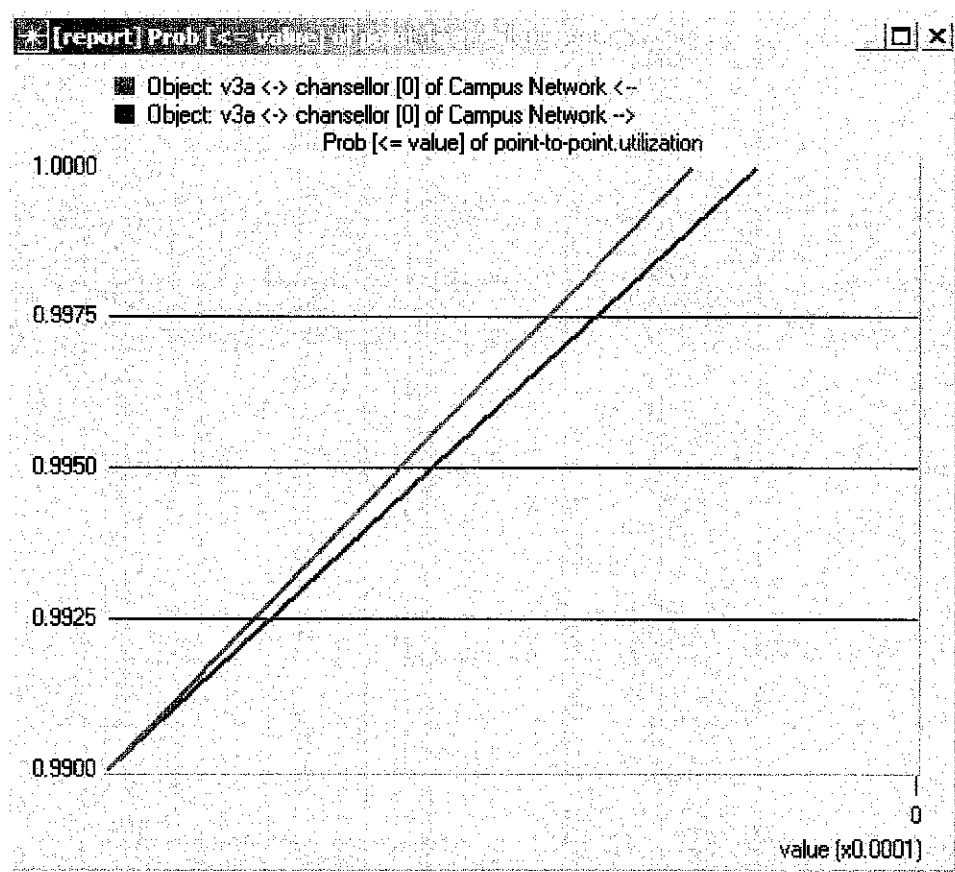


Figure 4.2.2 Graph Point to point utilization in the residential network v3,v4,v5.

The figure 4.3.2 shows that utilization of the network. The Red line indicates the sending packets and the red shows the packets received. The Red line shows the packets which is moving from the building to the Passports' where the buildings are using Passport and the switches is receiving it. Therefore, the send packets (red line) ratio is higher than the receive packets(blue line) because of the capability of the machine to utilize it's memory on their service.

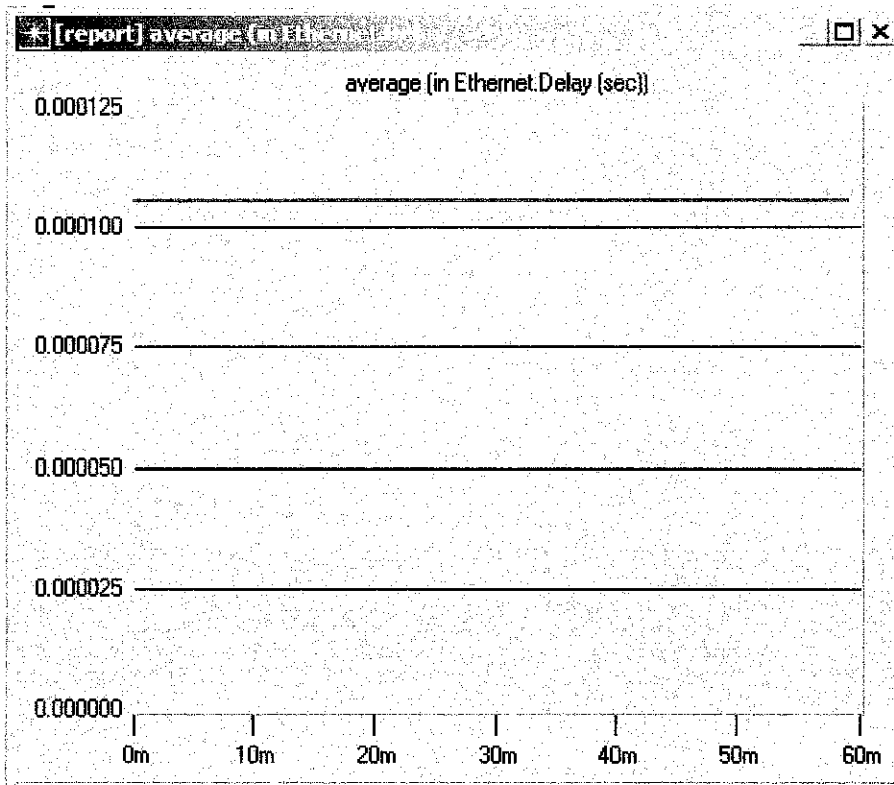


Figure 4.2.3 Graph the network delay on time average of the Residential Network.

The figure 4.2.3 shows the network delay on time average of the Residential Network.

The delay is at 0.00001091 seconds on time average and it remains constant. The value of delay is too small and it doesn't increase by time. It will not vary the network performance.

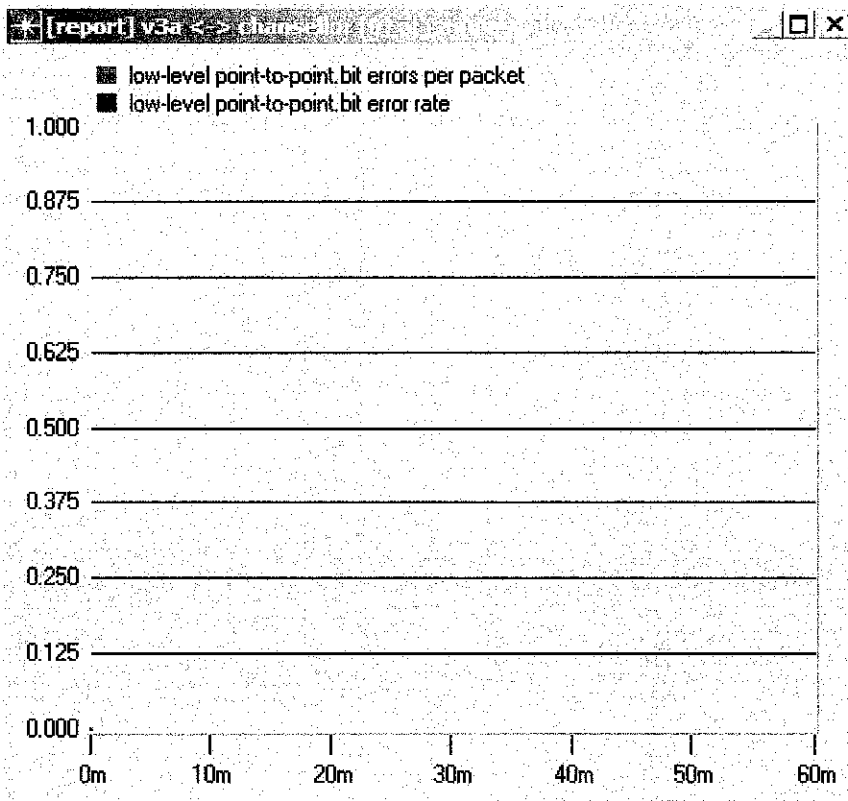


Figure 4.2.4 Graph: bit error rate and packet loss ratio .

There were no bit error rate or packet loss ratios detected in this network. Technically on paper, the result resumes to be none, but the real result may differ due to external factors ; virus and hackings.

Creating the academic network.

The Academic Buildings consists of 28 buildings where each of them has at least 128 users. Since the number of users is huge, the academic network will have a different architecture from the residential network design. Each department will have their network and will be connected together through a core switch.

Figure 1a show the academic network design. The academic network is connected to the Passport in the Chancellor building. No pairs of SMLT feature is included in this design.

In order to make sure that this network is working, the graph result was checked on the issue of packet throughput. Graph 1a. shows the result of packet throughput for the residential network. Graph1 1b. shows the average utilization of the network.

Figure 2a shows the Academic Network design. The design was done by using OPNET

The Academic Network design.

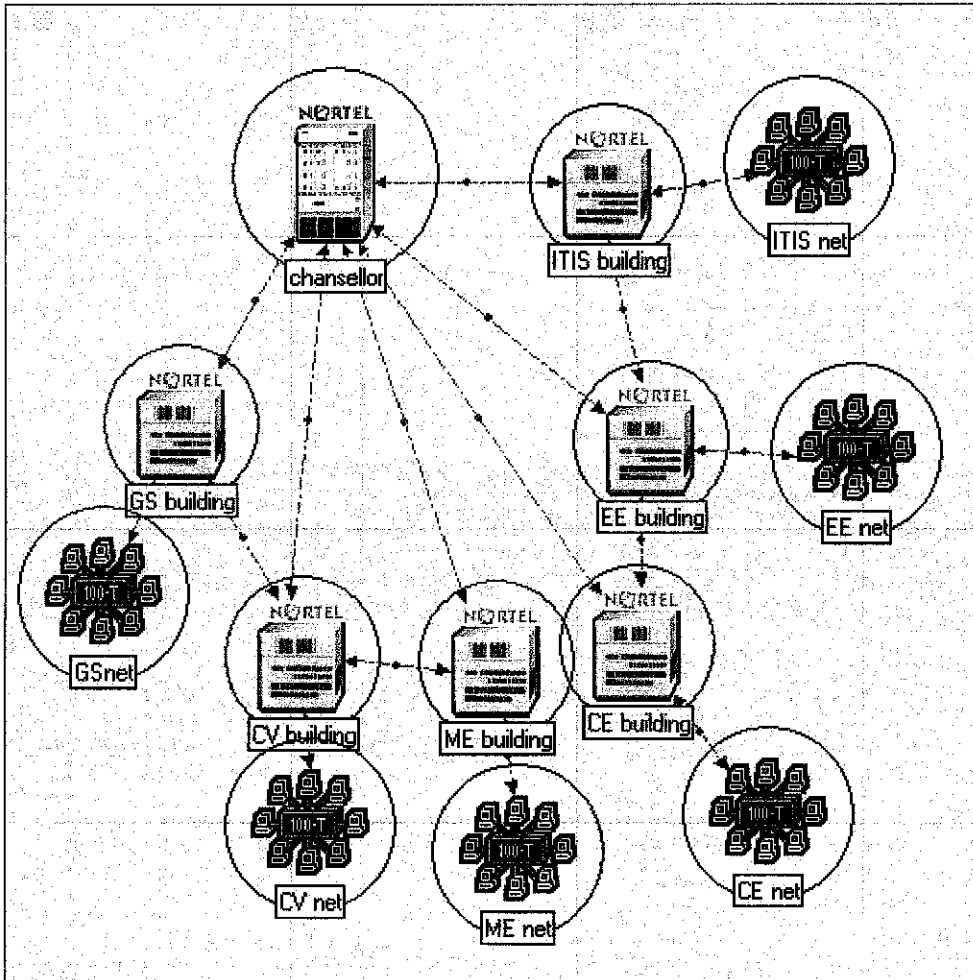


Figure 4.3a. Academic Network design.

Simulating The network

The network was simulated by using the OPNET IT guru network simulator. Graph * shows the point to point through put in the network and graph * show the network utilization.

Result simulated by OPNET

Simulation Completed - Collating Results.

Events: Total (5715), Average Speed (21484 events/sec.)

Time: Elapsed (1 sec.), Simulated (1 hr. 0 min. 0 sec.)

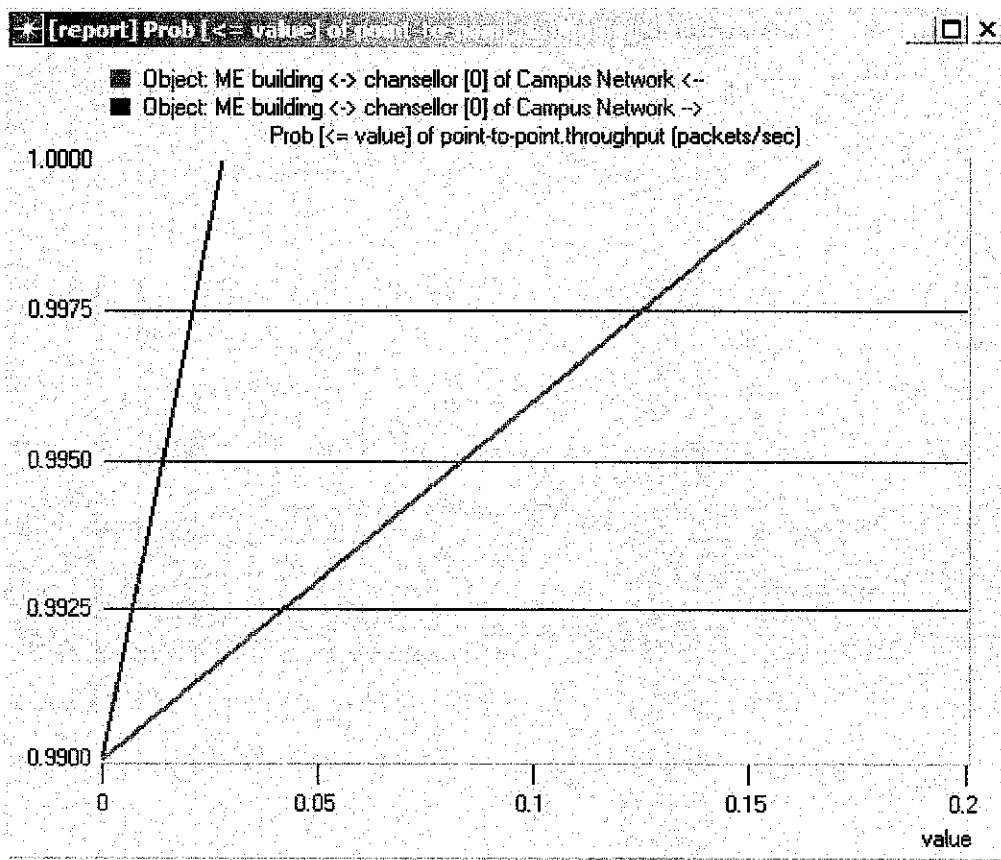


Figure 4.3.1 Graph : Academic Network packets throughput.

The figure 4.3.1 shows that throughput of the network. The Blue line indicates the sending packets and the red shows the packets received. The Blue line shows the packets which is moving from the building to the Chancellor hall where the buildings are using switches and the Passport is receiving it. Therefore, the received packets(red line) ratio is higher than the sending packets(blue line) because of the capability of the machine to utilize it's memory on their service.

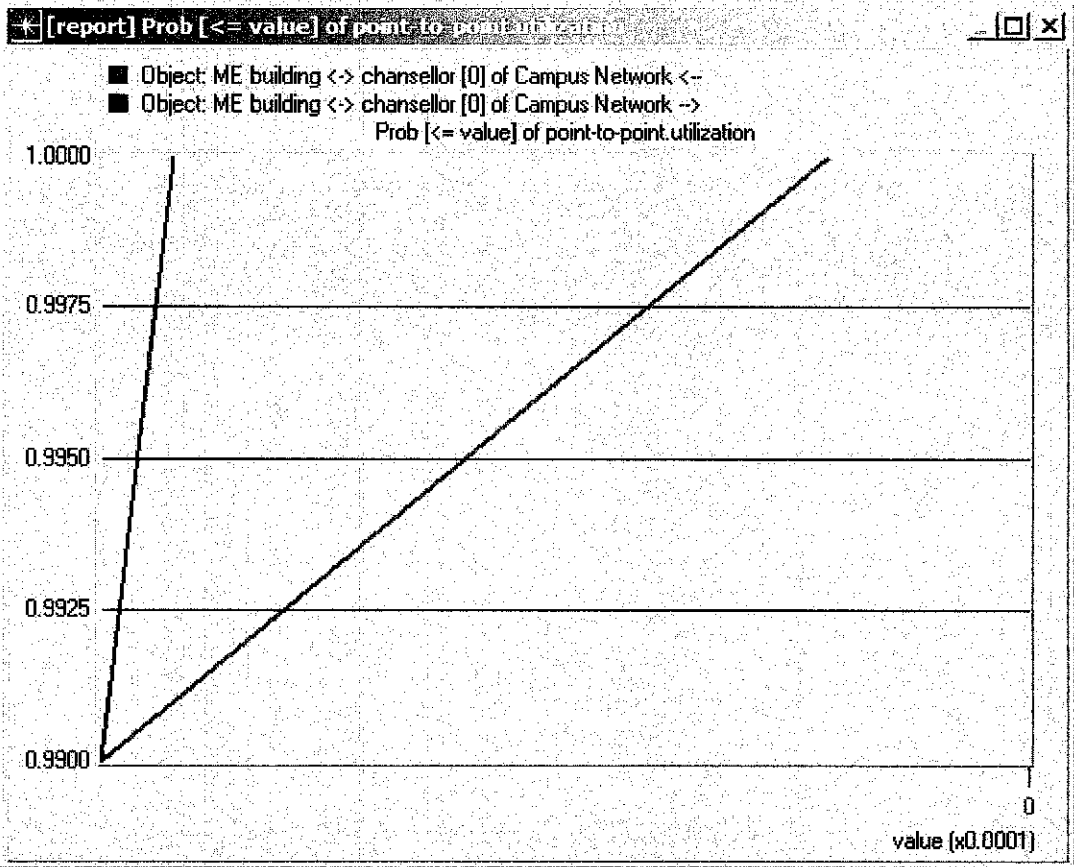


Figure 4.3.2 Graph : Academic Network utilization.

The figure 4.3.2 shows that utilization of the network. The Blue line indicates the sending packets and the red shows the packets received. The Blue line shows the packets which is moving from the building to the Chancellor hall where the academic buildings are using switches and the Passport is receiving it. Therefore, the received packets(red line) ratio is higher than the sending packets(blue line) because of the capability of the machine to utilize it's memory on their service.

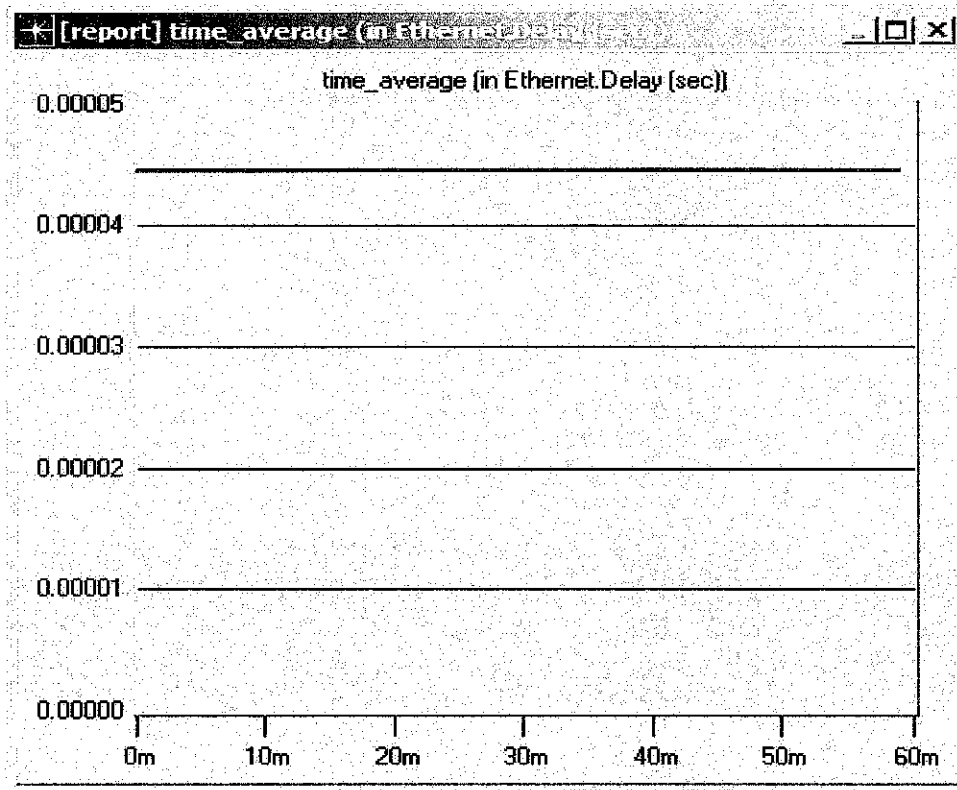


Figure 4.3.3 Graph : network delay on time average for Academic Network.

The figure 4.3.3 shows the network delay on time average of the Academic Network.

The delay is at 0.000044981 seconds on time average and it remains constant. The value of delay is too small and it doesn't increase by time. It will not vary the network performance.

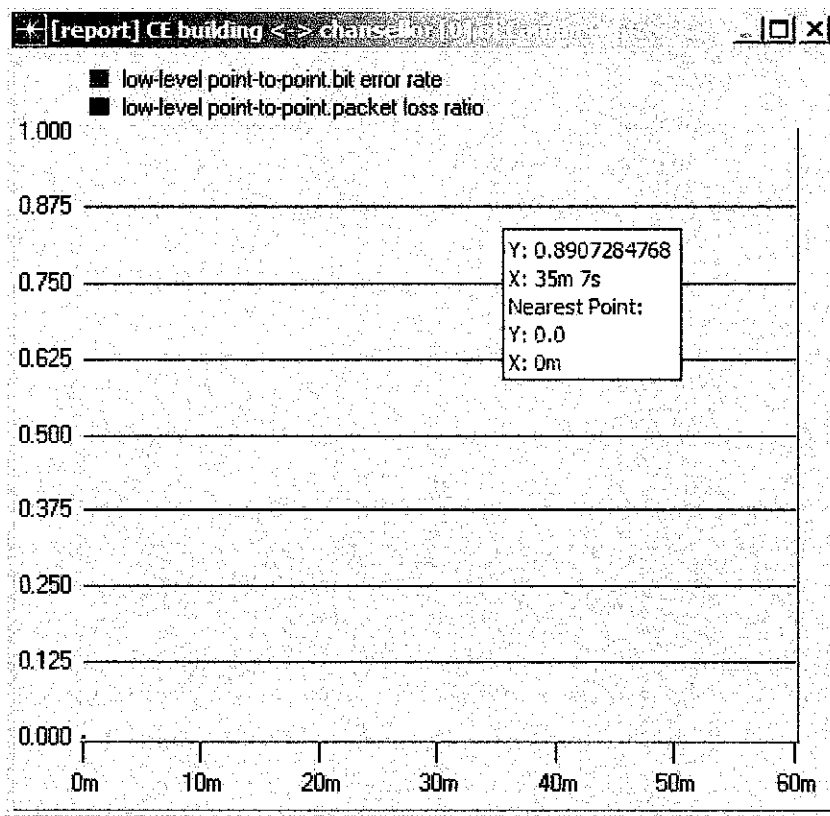


Figure 4.3.4 Graph: bit error rate and packet loss ratio.

There were no bit error rate or packet loss ratios detected in this network. Technically on paper, the result resumes to be none, but the real result may differ due to external factors ; virus and hackings.

Connecting Lembaran Network to the design

Lembaran is the latest residential network which has just been available for this semester. Since the distance is quite isolated from others, there will be just 1 SMLT link form Lembaran E to the core switches. The other switches will be the child of the Lembaran E switch as it functions to support other users only.

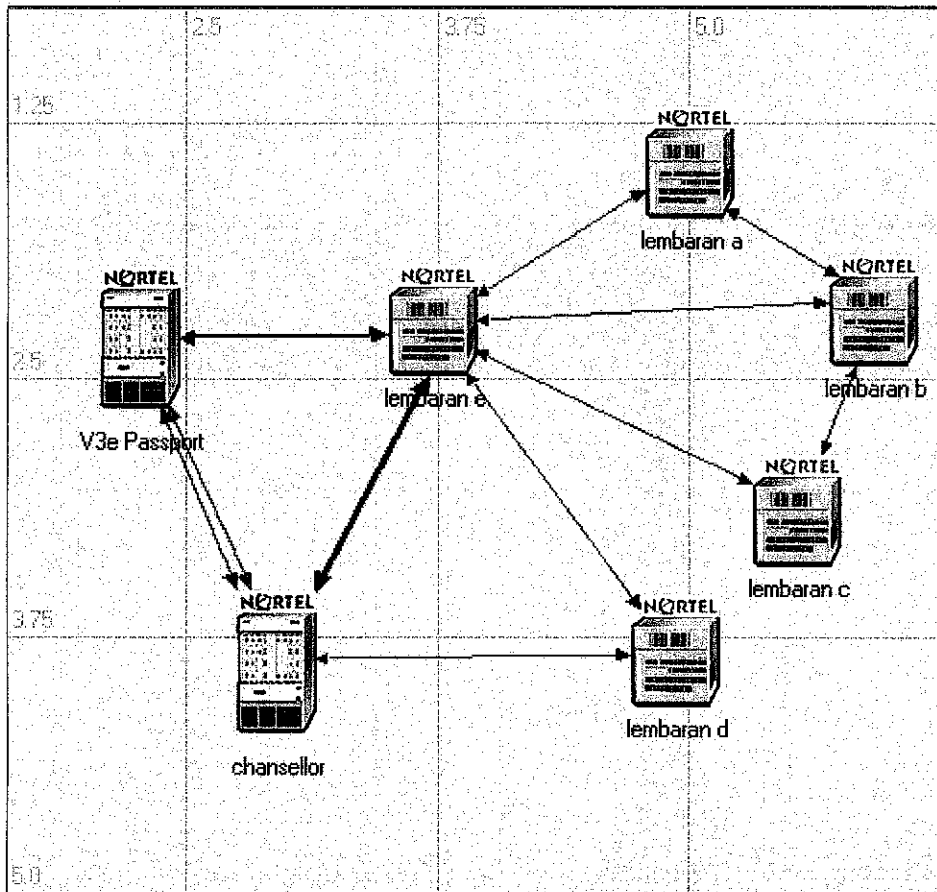


Figure 4.4a Lembaran Network design.

The pair of red links indicates the SMLT13 link. Other links are the MLT links.

Simulating The network

The network was simulated by using the OPNET IT guru network simulator. Graph * shows the point to point through put in the network and graph * show the network utilization.

Result simulated by OPNET

Simulation Completed - Collating Results.

Events: Total (2759), Average Speed (9818 events/sec.)

Time: Elapsed (1 sec.), Simulated (1 hr. 0 min. 0 sec.)

Graph Lembaran Network Throughput

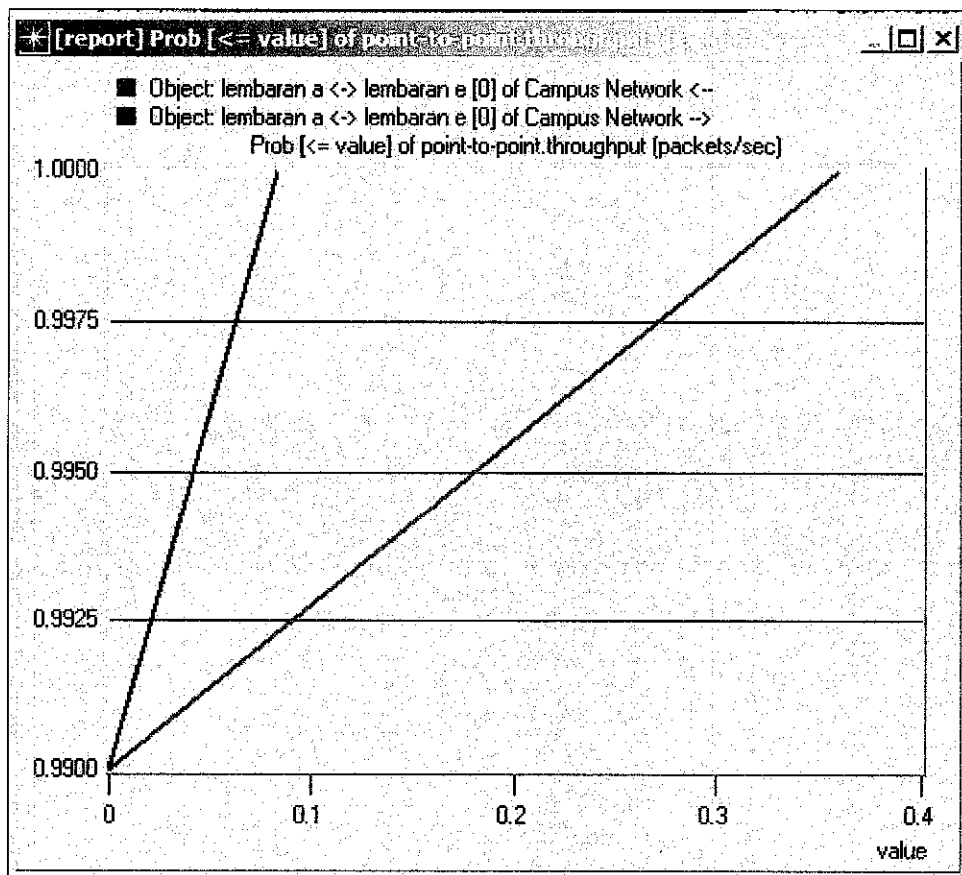


Figure 4.4.1 Graph : Lembaran network throughput (packets per second)

The figure 4.4.1 shows that throughput of the network. The Blue line indicates the sending packets and the red shows the packets received. The Blue line shows the packet which is moving from the lembaran buildings' to the Chancellor hall where the buildings are using switches and the Passport is receiving it. Therefore, the received packets(red line) ratio is higher than the sending packets(blue line) because of the capability of the machine to utilize it's memory on their service.

Lembaran Network Utilization Graph

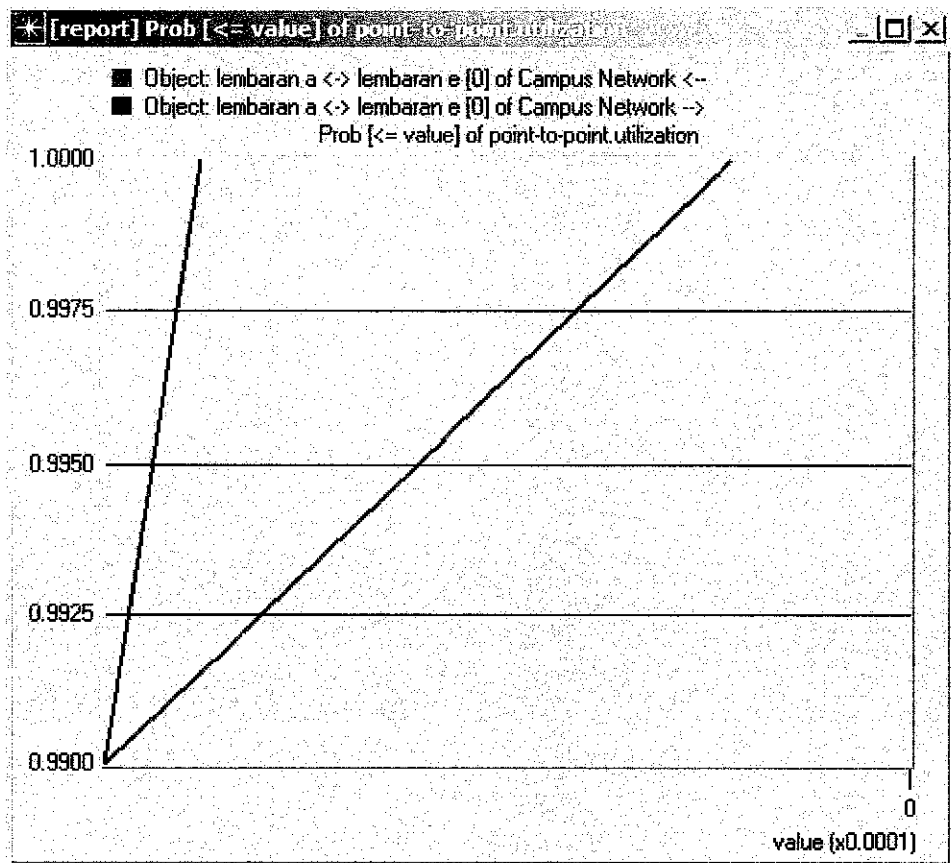


Figure 4.4.2 Graph : Lembaran Network Utilization – packets per second.

The figure 4.4.2 shows that utilization of the network. The Blue line indicates the sending packets and the red shows the packets received. The Blue line shows the packets which is moving from the building to the Chancellor hall where the lembaran

buildings are using switches and the Passport is receiving it. Therefore, the received packets (red line) ratio is higher than the sending packets (blue line) because of the capability of the machine to utilize its memory on their service.

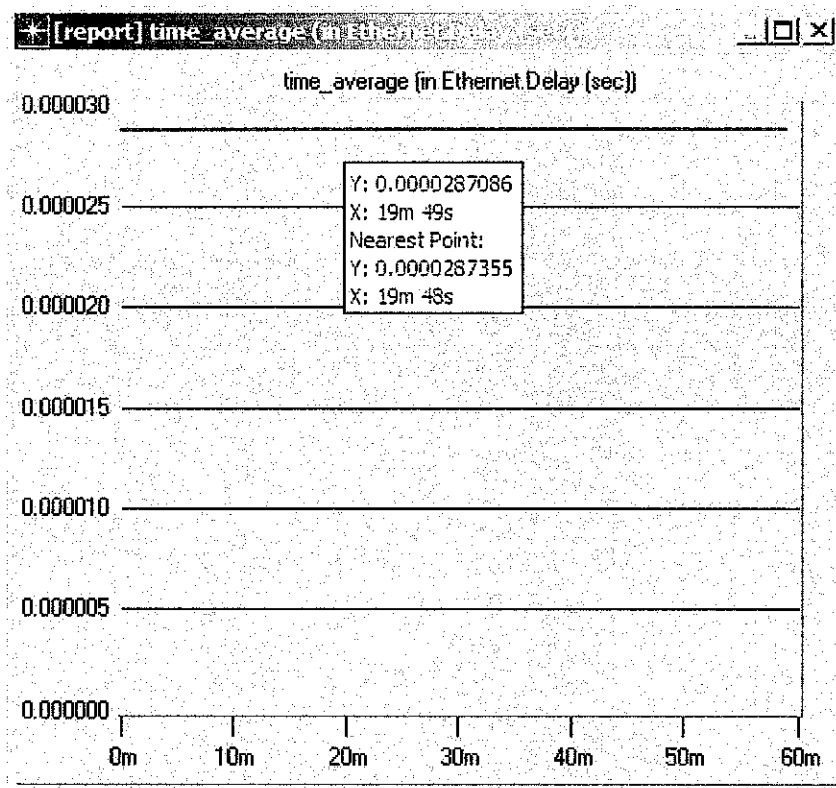


Figure 4.4.3 shows the network delay on time average of the Lembaran Network

The figure 4.3.3 shows the network delay on time average of the Lembaran Network.

The delay is at 0.0000287 seconds on time average and it remains constant. The value of delay is too small and it doesn't increase by time. It will not vary the network performance.

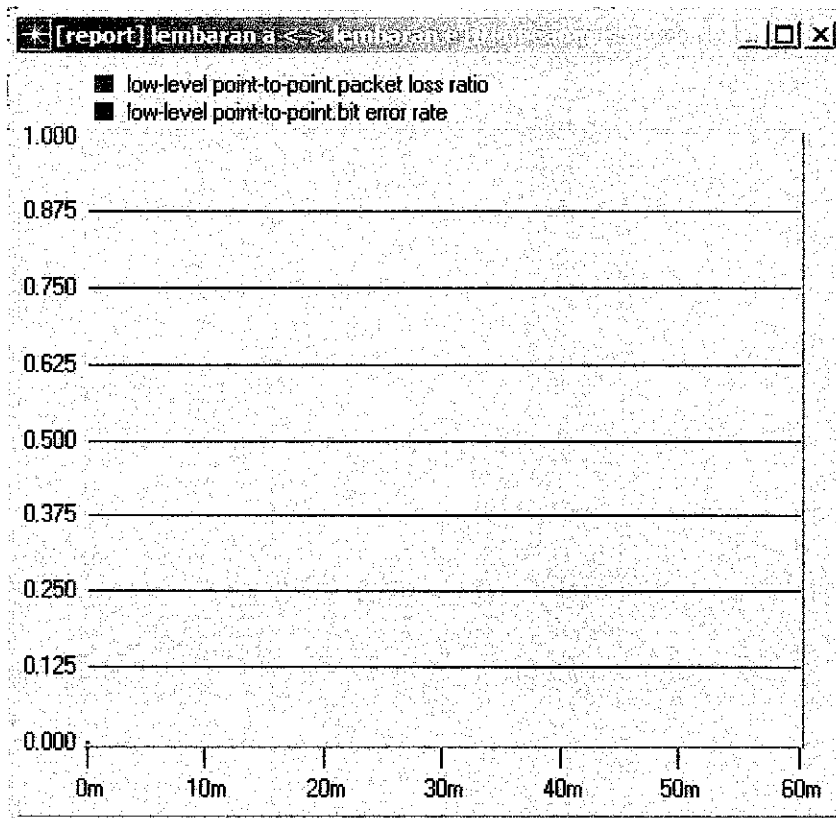


Figure 4.3.4 Graph: bit error rate and packet loss ratio.

There were no bit error rate or packet loss ratios detected in this network. Technically on paper, the result resumes to be none, but the real result may differ due to external factors ; virus and hackings.

UTP GE with SMLT design

The network design is the combination of previous designs ; residential network, academic network and the lembaran network. Due to some problems, the design cannot be simulated by OPNET IT Guru Software. The result of the partitions of this network is relevant enough to prove the network's stability

Full network design.

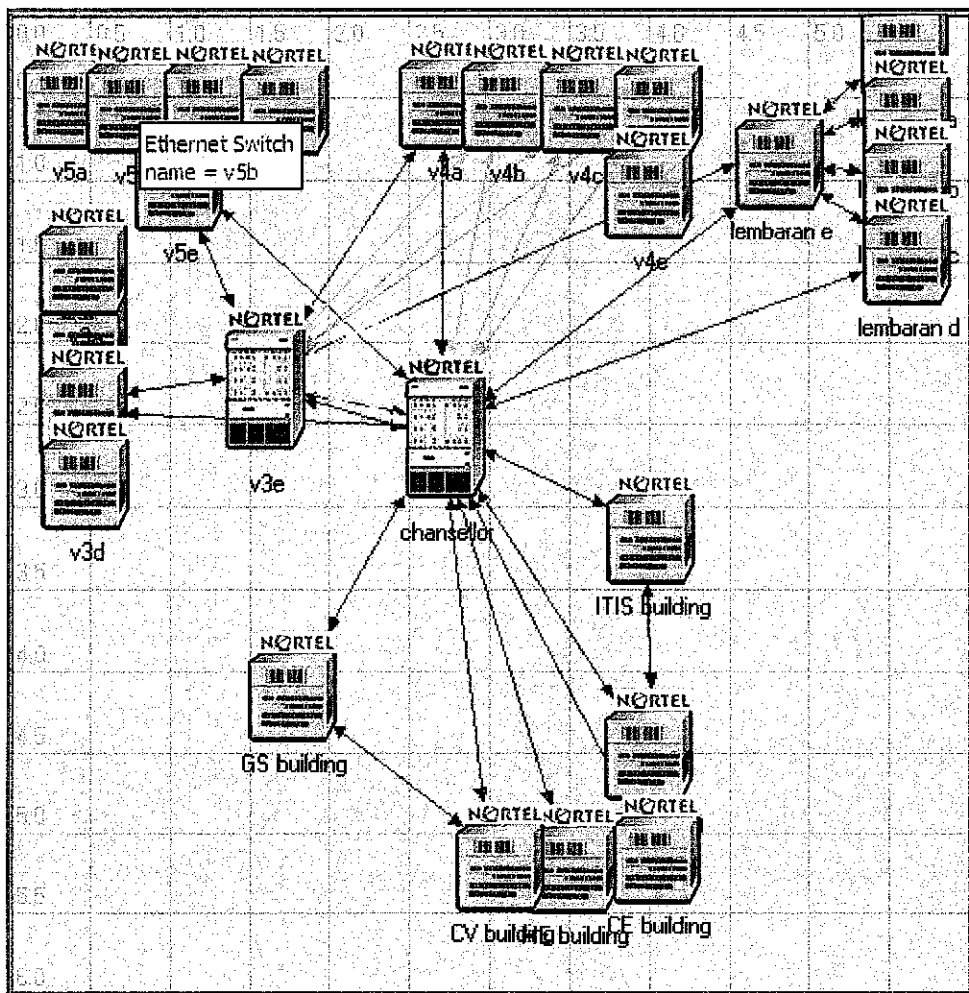


Figure 4.5 UTP Gigabit Network design with SMLT

4.2 DISCUSSION

The primary need of the system is to have a stable network and less challenge on providing service. The best network for UTP campus is Gigabit Ethernet; furthermore the implementation of SMLT feature in this system will surely enhance the network stability.

The STP (spanning Tree Protocol) was not the best solution for the network. Although it is a very basic component for the network but the risk of having looping packets are very high. Thus, the STP should be eliminated to reduce the possibility of wandering packets in the network.

The main discussion here is about the SMLT, which is one of the greatest features created by Nortel. SMLT covers up the trunk between core switches which is the backbone for the network. However, SMLT limited to only 32 VLAN's. In this case, each VLAN's will represent MLT. MLT is pair of links that will connect the network device to the core switch (passport).

Since the MLT is limited 32 pairs only, the network design will be supported by 'jump' links. Jump links is the connector form a network devices to two different end points. It is similar to MLT but jumping will cause the link to hop to the nearest end point which will transport them to the core switch by using other links.

In the case of choosing the link type, the IST is the most important link for this network design, Since the IST will be connecting the core switches with each other; it is preferred to use the 1000 BASE SX. 1000 BASE SX uses a multimode fiber type connector and can cover from 550 meters to 5 kilometers (full duplex mode). Since the core switches might be allocated far from each other, it is relevant to use the 1000 BASE SX to connect them.

The 100 BASE T will be used for all other links. Since the GE should be running on full duplex mode, there is no need to implement 10 BASE T. It is estimated that the network will be running 100 Mbps for users.

Limitations of the project are as the followings:

1. The OPNET simulator cannot simulate a network design with more than 20 trunk nodes.
2. The SMLT feature is only limited to 32 VLAN.
3. The OPNET simulator does not have a detail specification on the link types.
4. The OPNET simulator does not have a Bystack470 module, simulation was done with the Baystack 450.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This project explores the potential of Gigabit Ethernet type network to provide service to Universiti Teknologi Petronas. The study concludes that forecast is this network type will be able to substitute the recent network which is not at its optimal condition. This has met the first objective of the project, which is to study the UTP recent network and compare it with the Gigabit Ethernet with SMLT feature network.

The study also discovers that the method of trunk links can be effectively mapped into the network design, thus enabling the VLAN rule to be executed. The SMLT feature depends on the VLAN rule as it is generated by multiple trunks but with some laws. A prototype was developed using the OPNET network simulation software. The network design was tested with known results, as in packet transfers and loss. The result was at satisfactory but the legitimacy of the testing can be questioned. Valid test results can be acquired from field experiment setup but unfortunately could not be achieved due to time and cost constraint. Moreover the calibration of switch memory , CPU and backplane utilization cannot be tested by OPNET as the feature is not supported.

5.2 RECOMMENDATION

Suggested next moves are as the followings:

1. Revise the knowledge base so that it will consider more forecast factors and thus accuracy.
2. Acquire experts' feedback on the acceptance of the network design.
3. To further develop the prototype for field testing. Only the experts can testify whether the prediction of the network is accurate.
4. The switch memory , CPU and backplane utilization should be tested by testing a live network.
5. If the project proceeds , the 'wasted' router can be traded in to buy backup power hardware to fulfill the uptime of the network.

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APPENDICES

(This page is intended to be empty. Please refer to the next page.)

Sample Questionnaire.

Questionnaire for FYP project

Hello there, it will just take a second to fill in these questionnaires.

Please underline the choices of your answers.

1. Are you a network user in UTP?
 - Yes
 - No

2. If yes, how do you describe the network connection in this campus?
 - Excellent
 - Good
 - Bad

3. Briefly, please give your comments on question 2.

4. Do you think UTP network conditions should be improved?
 - Yes
 - No

5. Briefly , please give your comments on question 4.

Hardware Details for Academic Network.

Name	Location	IP Address	vlan	Hardware Name	Total	Stack
Ch.Pp8010	Chancellor	160.0.100.254	100	Passport 8010	1	No
Lb.bs470.1	Library	160.0.50.254	50	Baystack 470 - 48t	1	Yes
Lb.bs470.2	Library			Baystack 470 - 48t		
IT.bs470.1	IT Building 1	160.0.51.254	51	Baystack 470 - 48t	4	Yes
IT.bs470.2	IT Building 1			Baystack 470 - 48t		
IT.bs470.3	IT Building 1			Baystack 470 - 48t		
IS.bs470.1	IT Building 2	160.0.52.254	52	Baystack 470 - 48t	4	Yes
IS.bs470.2	IT Building 2			Baystack 470 - 48t		
IS.bs470.3	IT Building 2			Baystack 470 - 48t		
IS.bs470.4	IT Building 2			Baystack 470 - 48t		
CE1.bs470.1	CE Building 3	160.0.53.254	53	Baystack 470 - 48t	2	Yes
CE1.bs470.2	CE Building 3			Baystack 470 - 48t		
CE2.bs470.1	CE Building 4	160.0.54.254	54	Baystack 470 - 48t	2	Yes
CE2.bs470.2	CE Building 4			Baystack 470 - 48t		
hse.bs470.1	Building 5	160.0.55.254	55	Baystack 470 - 48t	1	No
ee1.bs470.1	building 22	160.0.56.256	56	Baystack 470 - 48t	3	yes
ee1.bs470.2	building 22			Baystack 470 - 48t		
ee1.bs470.3	building 22			Baystack 470 - 24t		
ee2.bs470.1	building 23	160.0.57.254	57	Baystack 470 - 48t	2	yes
ee2.bs470.2	building 23			Baystack 470 - 24t		
gs1.bs470.1	building 21	160.0.58.254	58	Baystack 470 - 48t	2	Yes
gs1.bs470.2	building 21			Baystack 470 - 48t		
me1.bs470.1	building 20	160.0.59.254	59	Baystack 470 - 48t	2	Yes
me1.bs470.2	building 20			Baystack 470 - 48t		
me2.bs470.1	building 19	160.0.60.254	60	Baystack 470 - 48t	1	no
me3.bs470.1	building 18	160.0.61.254	61	Baystack 470 - 48t	1	no
ptD.bs470.1	Pocket D	160.0.62.254	62	Baystack 470 - 48t	1	no
cv1.bs470.1	building 17	160.0.63.254	63	Baystack 470 - 48t	1	no
cv2.bs470.1	building 16	160.0.64.254	64	Baystack 470 - 48t	2	Yes
cv2.bs470.2	building 16			Baystack 470 - 48t		
cv3.bs470.1	building 15	160.0.65.254	65	Baystack 470 - 48t	1	no
ptC.bs470.1	Pocket C	160.0.66.254	66	Baystack 470 - 48t	1	no
Total					32	

Table 4.3. Switch location , VLAN ID and IP address

Hardware details for all network

Name	Location	IP Address	VLAN	Hardware Name	Total	Stack
v3a.bs470.1	v3a	160.0.101.254	101	Baystack 470 - 48t	2	Yes
v3a.bs470.2	v3a			Baystack 470 - 48t		
v3b.bs470.1	v3b	160.0.102.254	102	Baystack 470 - 48t	2	Yes
v3b.bs470.2	v3b			Baystack 470 - 48t		
v3c.bs470.1	v3c	160.0.103.254	103	Baystack 470 - 48t	2	Yes
v3c.bs470.2	v3c			Baystack 470 - 48t		
v3d.bs470.1	v3d	160.0.104.254	104	Baystack 470 - 48t	2	Yes
v3d.bs470.2	v3d			Baystack 470 - 48t		
v3e.Pp8010	v3e	160.0.105.254		Passport 8010	1	No
v4a.bs470.1	v4a	160.0.106.254	106	Baystack 470 - 48t		
v4a.bs470.2	v4a			Baystack 470 - 48t		
v4b.bs470.1	v4b	160.0.107.254	107	Baystack 470 - 48t	2	Yes
v4b.bs470.2	v4b			Baystack 470 - 48t		
v4c.bs470.1	v4c	160.0.108.254	108	Baystack 470 - 48t	2	Yes
v4c.bs470.2	v4c			Baystack 470 - 48t		
v4d.bs470.1	v4d	160.0.109.254	109	Baystack 470 - 48t	2	Yes
v4d.bs470.2	v4d			Baystack 470 - 48t		
v4e.bs470.1	v4e	160.0.110.254	110	Baystack 470 - 48t	2	Yes
v4e.bs470.2	v4e			Baystack 470 - 48t		
v5a.bs470.1	v5a	160.0.121.254	121	Baystack 470 - 48t	2	Yes
v5a.bs470.2	v5a			Baystack 470 - 48t		
v5b.bs470.1	v5b	160.0.122.254	122	Baystack 470 - 48t	2	Yes
v5b.bs470.2	v5b			Baystack 470 - 48t		
v5c.bs470.1	v5c	160.0.123.254	123	Baystack 470 - 48t	2	Yes
v5c.bs470.2	v5c			Baystack 470 - 48t		
v5d.bs470.1	v5d	160.0.124.254	124	Baystack 470 - 48t	2	Yes
v5d.bs470.2	v5d			Baystack 470 - 48t		
v5e.bs470.1	v5e	160.0.125.254	125	Baystack 470 - 48t	2	Yes
v5e.bs470.2	v5e			Baystack 470 - 48t		
lma.bs470.1	lembaran a	160.0.130.254	130	Baystack 470 - 48t	2	Yes
lma.bs470.2	lembaran a			Baystack 470 - 48t		
lmb.bs470.1	lembaran b	160.0.131.254	131	Baystack 470 - 48t	2	Yes
lmb.bs470.2	lembaran b			Baystack 470 - 48t		
lmc.bs470.1	lembaran c	160.0.132.254	132	Baystack 470 - 48t	2	Yes

lmc.bs470.2	lembaran c			Baystack 470 - 48t		
lmd.bs470.1	lembaran d	160.0.133.254	133	Baystack 470 - 48t	2	Yes
lmd.bs470.2	lembaran d			Baystack 470 - 48t		
lme.bs470.1	lembaran e	160.0.134.254	134	Baystack 470 - 48t	2	Yes
lme.bs470.2	lembaran e			Baystack 470 - 48t		
Ch.Pp8010	Chancellor	160.0.100.254		Passport 8010	1	No
Lb.bs470.1	Library	160.0.50.254	50	Baystack 470 - 48t	1	Yes
Lb.bs470.2	Library			Baystack 470 - 48t		
IT.bs470.1	IT Building 1	160.0.51.254	51	Baystack 470 - 48t	4	Yes
IT.bs470.2	IT Building 1			Baystack 470 - 48t		
IT.bs470.3	IT Building 1			Baystack 470 - 48t		
IT.bs470.4	IT Building 1			Baystack 470 - 48t		
IS.bs470.1	IT Building 2	160.0.52.254	52	Baystack 470 - 48t	4	Yes
IS.bs470.2	IT Building 2			Baystack 470 - 48t		
IS.bs470.3	IT Building 2			Baystack 470 - 48t		
IS.bs470.4	IT Building 2			Baystack 470 - 48t		
CE1.bs470.1	CE Building 3	160.0.53.254	53	Baystack 470 - 48t	2	Yes
CE1.bs470.2	CE Building 3			Baystack 470 - 48t		
CE2.bs470.1	CE Building 4	160.0.54.254	54	Baystack 470 - 48t	2	Yes
CE2.bs470.2	CE Building 4			Baystack 470 - 48t		
hse.bs470.1	Building 5	160.0.55.254	55	Baystack 470 - 48t	1	No
ee1.bs470.1	building 22	160.0.56.256	56	Baystack 470 - 48t	3	yes
ee1.bs470.2	building 22			Baystack 470 - 48t		
ee1.bs470.3	building 22			Baystack 470 - 24t		
ee2.bs470.1	building 23	160.0.57.254	57	Baystack 470 - 48t	2	yes
ee2.bs470.2	building 23			Baystack 470 - 24t		
gs1.bs470.1	building 21	160.0.58.254	58	Baystack 470 - 48t	2	Yes
gs1.bs470.2	building 21			Baystack 470 - 48t		
me1.bs470.1	building 20	160.0.59.254	59	Baystack 470 - 48t	2	Yes
me1.bs470.2	building 20			Baystack 470 - 48t		
me2.bs470.1	building 19	160.0.60.254	60	Baystack 470 - 48t	1	no
me3.bs470.1	building 18	160.0.61.254	61	Baystack 470 - 48t	1	no
ptD.bs470.1	Pocket D	160.0.62.254	62	Baystack 470 - 48t	1	no
cv1.bs470.1	building 17	160.0.63.254	63	Baystack 470 - 48t	1	no
cv2.bs470.1	building 16	160.0.64.254	64	Baystack 470 - 48t	2	Yes
cv2.bs470.2	building 16			Baystack 470 - 48t		

cv3.bs470.1	building 15	160.0.65.254	65	Baystack 470 –48t	1	no
ptC.bs470.1	Pocket C	160.0.66.254	66	Baystack 470 –48t	1	no
Total					69	

Table 4.5a : List of hardware details

The table shows the IP address, VLAN ID and the hardware details for v3, v4 and v5 network.

Name	Location	IP Address	VLAN	Hardware Name	Total	Stack
v3e.bs470.1	v3a	160.0.101.254	101	Baystack 470 - 48t	2	Yes
v3e.bs470.2	v3a			Baystack 470 - 48t		
v3b.bs470.1	v3b	160.0.102.254	102	Baystack 470 - 48t	2	Yes
v3b.bs470.2	v3b			Baystack 470 - 48t		
v3c.bs470.1	v3c	160.0.103.254	103	Baystack 470 - 48t	2	Yes
v3c.bs470.2	v3c			Baystack 470 - 48t		
v3d.bs470.1	v3d	160.0.104.254	104	Baystack 470 - 48t	2	Yes
v3d.bs470.2	v3d			Baystack 470 - 48t		
v3e.Pp8010	v3e	160.0.105.254	105	Passport 8010	1	No
v4a.bs470.1	v4a	160.0.106.254	106	Baystack 470 - 48t		
v4a.bs470.2	v4a			Baystack 470 - 48t		
v4b.bs470.1	v4b	160.0.107.254	107	Baystack 470 - 48t	2	Yes
v4b.bs470.2	v4b			Baystack 470 - 48t		
v4c.bs470.1	v4c	160.0.108.254	108	Baystack 470 - 48t	2	Yes
v4c.bs470.2	v4c			Baystack 470 - 48t		
v4d.bs470.1	v4d	160.0.109.254	109	Baystack 470 - 48t	2	Yes
v4d.bs470.2	v4d			Baystack 470 - 48t		
v4e.bs470.1	v4e	160.0.110.254	110	Baystack 470 - 48t	2	Yes
v4e.bs470.2	v4e			Baystack 470 - 48t		
v5a.bs470.1	v5a	160.0.121.254	121	Baystack 470 - 48t	2	Yes
v5a.bs470.2	v5a			Baystack 470 - 48t		
v5b.bs470.1	v5b	160.0.122.254	122	Baystack 470 - 48t	2	Yes
v5b.bs470.2	v5b			Baystack 470 - 48t		
v5c.bs470.1	v5c	160.0.123.254	123	Baystack 470 - 48t	2	Yes
v5c.bs470.2	v5c			Baystack 470 - 48t		
v5d.bs470.1	v5d	160.0.124.254	124	Baystack 470 - 48t	2	Yes
v5d.bs470.2	v5d			Baystack 470 - 48t		
v5e.bs470.1	v5e	160.0.125.254	125	Baystack 470 - 48t	2	Yes
v5e.bs470.2	v5e			Baystack 470 - 48t		
				Total	27	

Table 4.1a. Switch location, VLAN ID and IP address

Link details for all network

Link Name	Source	Location	VLAN	Destination	Location	VLAN	Type
IST1	v3e.Pp8010	v3e	105	Ch.Pp8010	Chancellor	100	1000 Base S
IST2	Ch.Pp8010	Chancellor	100	v3e.Pp8010	v3e	105	1000 Base S
SMLT1	v3a.bs470.1	v3a	101	v3e.Pp8010	v3e	105	100 Base FX
SMLT1	v3a.bs470.2	v3a	101	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT2	v3b.bs470.1	v3b	102	v3e.Pp8010	v3e	105	100 Base FX
SMLT2	v3b.bs470.2	v3b	102	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT3	v3c.bs470.1	v3c	103	v3e.Pp8010	v3e	105	100 Base FX
SMLT3	v3c.bs470.2	v3c	103	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT4	v3d.bs470.1	v3d	104	v3e.Pp8010	v3e	105	100 Base FX
SMLT4	v3d.bs470.2	v3d	104	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT5	v5e.bs470.1	v5e	125	v3e.Pp8010	v3e	105	100 Base FX
SMLT5	v5e.bs470.2	v5e	125	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT6	v5d.bs470.1	v5d	124	v3e.Pp8010	v3e	105	100 Base FX
SMLT6	v5d.bs470.2	v5d	124	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT7	v4a.bs470.1	v4a	106	v3e.Pp8010	v3e	105	100 Base FX
SMLT7	v4a.bs470.2	v4a	106	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT8	v4b.bs470.1	v4b	107	v3e.Pp8010	v3e	105	100 Base FX
SMLT8	v4b.bs470.2	v4b	107	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT9	v4c.bs470.1	v4c	108	v3e.Pp8010	v3e	105	100 Base FX
SMLT10	v4c.bs470.2	v4c	108	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT10	v4d.bs470.1	v4d	109	v3e.Pp8010	v3e	105	100 Base FX
SMLT11	v4d.bs470.2	v4d	109	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT12	v4e.bs470.1	v4e	110	v3e.Pp8010	v3e	105	100 Base FX
SMLT12	v4e.bs470.2	v4e	110	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT13	lme.bs470.1	lembaran e	134	v3e.Pp8010	v3e	105	100 Base FX
SMLT13	lme.bs470.2	lembaran e	134	Ch.Pp8010	Chancellor	100	100 Base FX
MLT 1	lme.bs470.1	lembaran e	134	lma.bs470.1	lembaran a	130	100 Base T
MLT 1	lma.bs470.2	lembaran a	130	lme.bs470.2	lembaran e	134	100 Base T
MLT 2	lme.bs470.1	lembaran e	134	lmb.bs470.1	lembaran b	131	100 Base T
MLT 2	lmb.bs470.2	lembaran b	131	lme.bs470.2	lembaran e	134	100 Base T
MLT 3	lme.bs470.1	lembaran e	134	lmc.bs470.1	lembaran c	132	100 Base T
MLT 3	lmc.bs470.2	lembaran c	132	lme.bs470.2	lembaran e	134	100 Base T

Table 4.5b : List of link details.

Hardware Description Table

Name	Location	IP Address	VLAN	Hardware Name	Total	Stack
lma.bs470.1	lembaran a	160.0.130.254	130	Baystack 470 - 48t	2	Yes
lma.bs470.2	lembaran a			Baystack 470 - 48t		
lmb.bs470.1	lembaran b	160.0.131.254	131	Baystack 470 - 48t	2	Yes
lmb.bs470.2	lembaran b			Baystack 470 - 48t		
lmc.bs470.1	lembaran c	160.0.132.254	132	Baystack 470 - 48t	2	Yes
lmc.bs470.2	lembaran c			Baystack 470 - 48t		
lmd.bs470.1	lembaran d	160.0.133.254	133	Baystack 470 - 48t	2	Yes
lmd.bs470.2	lembaran d			Baystack 470 - 48t		
lme.bs470.1	lembaran e	160.0.134.254	134	Baystack 470 - 48t	2	Yes
lme.bs470.2	lembaran e			Baystack 470 - 48t		
Total					10	

Table 4.4a : Hardware , VLAN and location description

Link Description Table

Link Name	Source	Location	VLAN	Destination	Location	VLAN	Type
SMLT13	lme.bs470.1	lembaran e	134	v3e.Pp8010	v3e	105	100 Base FX
SMLT13	lme.bs470.2	lembaran e	134	Ch.Pp8010	Chancellor	100	100 Base FX
MLT 1	lme.bs470.1	lembaran e	134	lma.bs470.1	lembaran a	130	100 Base T
MLT 1	lma.bs470.2	lembaran a	130	lme.bs470.2	lembaran e	134	100 Base T
MLT 2	lme.bs470.1	lembaran e	134	lmb.bs470.1	lembaran b	131	100 Base T
MLT 2	lmb.bs470.2	lembaran b	131	lme.bs470.2	lembaran e	134	100 Base T
MLT 3	lme.bs470.1	lembaran e	134	lmc.bs470.1	lembaran c	132	100 Base T
MLT 3	lmc.bs470.2	lembaran c	132	lme.bs470.2	lembaran e	134	100 Base T
MLT 4	lme.bs470.1	lembaran e	134	lmd.bs470.1	lembaran d	133	100 Base T
MLT 4	lmd.bs470.2	lembaran d	133	lme.bs470.2	lembaran e	134	100 Base T

Table 4.4b Link, location and type details

Hardware Details Table for V3,v4,v5 network.

ame	Location	IP Address	VLAN	Hardware Name	Total	Stack
3e.bs470.1	v3a	160.0.101.254	101	Baystack 470 - 48t	2	Yes
3e.bs470.2	v3a			Baystack 470 - 48t		
3b.bs470.1	v3b	160.0.102.254	102	Baystack 470 - 48t	2	Yes
3b.bs470.2	v3b			Baystack 470 - 48t		
3c.bs470.1	v3c	160.0.103.254	103	Baystack 470 - 48t	2	Yes
3c.bs470.2	v3c			Baystack 470 - 48t		
3d.bs470.1	v3d	160.0.104.254	104	Baystack 470 - 48t	2	Yes
3d.bs470.2	v3d			Baystack 470 - 48t		
3e.Pp8010	v3e	160.0.105.254	105	Passport 8010	1	No
4a.bs470.1	v4a	160.0.106.254	106	Baystack 470 - 48t		
4a.bs470.2	v4a			Baystack 470 - 48t		
4b.bs470.1	v4b	160.0.107.254	107	Baystack 470 - 48t	2	Yes
4b.bs470.2	v4b			Baystack 470 - 48t		
4c.bs470.1	v4c	160.0.108.254	108	Baystack 470 - 48t	2	Yes
4c.bs470.2	v4c			Baystack 470 - 48t		
4d.bs470.1	v4d	160.0.109.254	109	Baystack 470 - 48t	2	Yes
4d.bs470.2	v4d			Baystack 470 - 48t		
4e.bs470.1	v4e	160.0.110.254	110	Baystack 470 - 48t	2	Yes
4e.bs470.2	v4e			Baystack 470 - 48t		
5a.bs470.1	v5a	160.0.121.254	121	Baystack 470 - 48t	2	Yes
5a.bs470.2	v5a			Baystack 470 - 48t		
5b.bs470.1	v5b	160.0.122.254	122	Baystack 470 - 48t	2	Yes
5b.bs470.2	v5b			Baystack 470 - 48t		
5c.bs470.1	v5c	160.0.123.254	123	Baystack 470 - 48t	2	Yes
5c.bs470.2	v5c			Baystack 470 - 48t		
5d.bs470.1	v5d	160.0.124.254	124	Baystack 470 - 48t	2	Yes
5d.bs470.2	v5d			Baystack 470 - 48t		
5e.bs470.1	v5e	160.0.125.254	125	Baystack 470 - 48t	2	Yes
5e.bs470.2	v5e			Baystack 470 - 48t		
				Total	27	

Table 4.2a. . Switch location, VLAN ID and IP address

Link Name	Source	Location	vlan	Destination	Location	VLAN	Type
IST1	v3e.Pp8010	v3e		Ch.Pp8010	Chancellor		1000 Base SX
IST2	Ch.Pp8010	Chancellor		v3e.Pp8010	v3e		1000 Base SX
SMLT1	v3a.bs470.1	v3a	101	v3e.Pp8010	v3e	105	100 Base FX
SMLT1	v3a.bs470.2	v3a	101	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT2	v3b.bs470.1	v3b	102	v3e.Pp8010	v3e	105	100 Base FX
SMLT2	v3b.bs470.2	v3b	102	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT3	v3c.bs470.1	v3c	103	v3e.Pp8010	v3e	105	100 Base FX
SMLT3	v3c.bs470.2	v3c	103	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT4	v3d.bs470.1	v3d	104	v3e.Pp8010	v3e	105	100 Base FX
SMLT4	v3d.bs470.2	v3d	104	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT5	v5e.bs470.1	v5e	125	v3e.Pp8010	v3e	105	100 Base FX
SMLT5	v5e.bs470.2	v5e	125	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT6	v5d.bs470.1	v5d	124	v3e.Pp8010	v3e	105	100 Base FX
SMLT6	v5d.bs470.2	v5d	124	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT7	v4a.bs470.1	v4a	106	v3e.Pp8010	v3e	105	100 Base FX
SMLT7	v4a.bs470.2	v4a	106	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT8	v4b.bs470.1	v4b	107	v3e.Pp8010	v3e	105	100 Base FX
SMLT8	v4b.bs470.2	v4b	107	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT9	v4c.bs470.1	v4c	108	v3e.Pp8010	v3e	105	100 Base FX
SMLT10	v4c.bs470.2	v4c	108	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT10	v4d.bs470.1	v4d	109	v3e.Pp8010	v3e	105	100 Base FX
SMLT11	v4d.bs470.2	v4d	109	Ch.Pp8010	Chancellor	100	100 Base FX
SMLT12	v4e.bs470.1	v4e	110	v3e.Pp8010	v3e	105	100 Base FX
SMLT12	v4e.bs470.2	v4e	110	Ch.Pp8010	Chancellor	100	100 Base FX

Table 4.2b. Link names types for v3,v4,v5 residential network.