Comparative Analysis of Performance of Hub with Switch Local Area Network (LAN) Using Riverbed in University of Technology (Utech),Jamaica.

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Abstract

Hubs and switches have been actively used devices in computer networks vision, over two (2) decades. As results, numerous approaches have been used with varying degrees of success to evaluate the performances of these devices in computer networks. A class of approach that shown substantial promise is one that gives clear and predictive results regarding the numbers of workstations, servers and categories of cables used in the network is by riverbed academic edition, version 17.5. A common theme in this green technique, to this approach is by creating two scenarios. In the first scenario, about seven (7) to ten (10) workstations were connected to web server via a hub. The relevant performance statistics were collected at both workstations and the server. The same was done in the second scenario except that the hub was replaced with a switch, which will facilitate the connections between the workstations and the server. Simulations in the laboratory-using riverbed version 17.5, was done to obtain the statistical comparative results of these two scenarios. This approach has shown to outperform other existing methods in comparative analysis of performance of hub with switch in a local area network (LAN).

Keywords :

hub; riverbed; simulations*; *switch; workstation;

I INTRODUCTION

The goal of this paper is to compare the performance of a pure hub, (LAN), which a switched (LAN) at University of Technology, Jamaica, campus network with about ten (10) workstations using riverbed 17.5.in labouratory 1AX of Networking and Communication Labouratory.

Hubs and switches serve as a central connection of computer network equipment and allow transfer of data called frames.

Hub is a layer one device of open system interconnectivity (OSI) model, and can be passive or active device, while switch is a layer Two (2) device of OSI model [7].

In comparison, switch is more advanced than hub. A hub can broadcast frames everywhere on the network, while a switch checks for the destination MAC address and forward it to the relevant

port to reach a particular computer meant to receive the frame [6]. A switch as an active or an intelligent device reduces traffics and divide the collision domain into segments.

It also protects frames from being sniffed by other computers sharing the same segment [2].

A 10 base-T cable, which is a twisted pair wire, that is, a physical media specified in IEEE 802.3 standard for Ethernet LAN, which supports 10Mega bits per seconds (Mbps) transmission speed for normal internet was used to set up the LAN.The system servers were comprised of both profile and application server were used to make all standard network applications such as HTTP, FTP, E-Mail and Database available for use in the topology, while the profile server was configured as a web user.

The approach in this paper included connecting the ten (10) workstations, with 10 base-T cable with hub and servers before configuration of the entire network. After the configuration, we chose the statistics that ought to be collected during the simulations. It was possible to compare two (2) statistics simultaneously, between the hub and switch and the results were displayed accordingly.

This approach by using riverbed academic version 17.5 yielded almost 100% results.

The use of Ethernet hubs and switches in the networking sectors has played an important role across the world by allowing basic devices to communicate with each other within computer networks. Hubs and switches are commonly used to connect segments of a Local area Network (LAN) which can be viewed as sub-networks of a larger interconnected entity. Hubs and switches both play important roles in connecting networks.

However, switches tend to be chosen over hubs because of its reliability and its ability to handle heavy network traffic in daily operations. In spite of this, hubs should not be disregarded because they tend to perform fairly well in computer networks such as small business offices and also typical home networks. Hubs operate on the first layer (physical layer) of the Open System Interconnect (OSI) model. The physical layer's main purpose is for proper transmission of raw bits across the computer network. Switches operate on the second layer (data-link layer) of the OSI model. The data-link layer's main purpose is to deliver frames between devices on a given Local area Network (LAN).

Based on previous researches, several questions are always raised when comparing the two network devices. These questions include; which one of the devices is more intelligent? In what scenario can an Ethernet hub be considered better in a computer network? What are the security concerns as it relates to the network devices?
This research also introduces the Riverbed Modeler Academic Edition 17.5 software which will conduct the necessary simulation for the network topologies which are set to be designed. The software is introduced by Riverbed Technology, an American Information Technology company that develops products to improve application performance across computer networks.

II. BACKGROUND

Graduate students, researchers, and practitioners in the field of computer networking often require a firm conceptual understanding of one or more of its theoretical foundations [3]. Knowledge of performance optimization, available bandwidth, channel capacity, data rate, bit rate, transmission time, propagation time and throughput should be known otherwise assumed by researchers in this field.

Since, 10 base-T, according, to IEEE 802.3 standard for Ethernet LAN, supports transmission speed of 10 Mbps, we shall assume that the available channel capacity of the network is 10Mbps and we can calculate the available bandwidth based on Shannon's law with a given signal to noise ratio (SNR).

$C = B \times \text{Log}_2 (1+SNR)$ (1)

SNR = average signal power/average noise power (2)

Throughput = No. of Frames in bits / time in seconds (3)

Propagation time = Distance in meters /speed in meters per second (4)

Transmission time = message in bits /bandwidth (5)

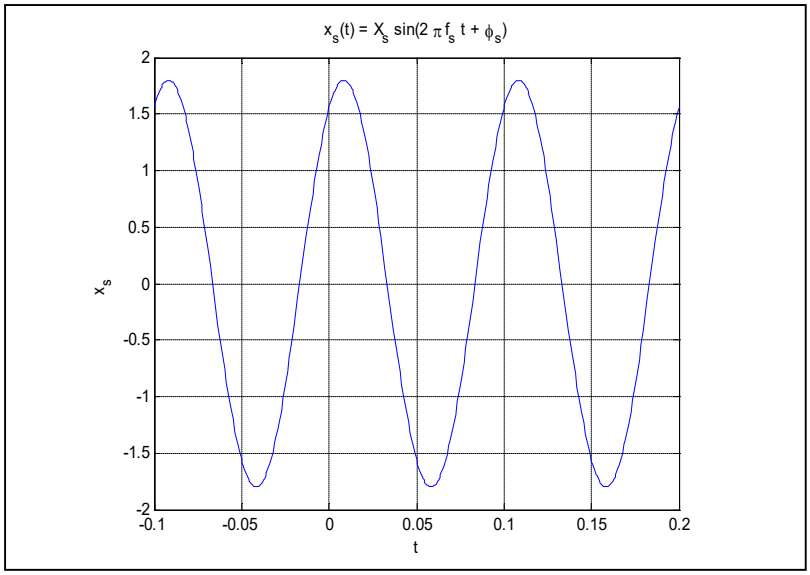
Computer network allows the sharing of data and resources in timely and an efficient manner. The devices used in computer network may be wired or wireless. A computer network is a special arrangement of computers, printers, scanners etc. along with network devices such as hubs, switches, routers etc. to communicate data packets over internet[4].

In this work, we looked at those statistics that ought to be collected during simulation run. Under client hypertext transfer protocol (HTTP), we looked at object response time, page response time, traffic sent and traffic received, as well as user cancellation connections. Under server HTTP, we considered, load, traffic received and traffic sent. Under Transmission control protocol (TCP), we also considered, connection aborts, delay and retransmission count.

A communication network is composed from communication links. This is a widely used approach to transferring information over a wired or wireless link to continuous analogue carrier signal to represent the symbol values '0' and '1' as digital data. The carrier analogue signal is sinusoidal, which is associated with a time T, such that at time t, the amplitude of the signal is described by the function Xs (t).

By using matlab, the signal Xs (t) =A*sin ((2*pi*fs*t + Φs); can be plotted, as shown in Figure

1. Velocity



Time

Figure 1.The Sinusoidal analogue Signal of the of the network

III WHY USING RIVERBED ACADEMIC EDITION 17.5

Riverbed is a good tool for computer network designs, simulations and analysis. It runs on the backbone of Opnet IT guru Riverbed software equips researchers, teachers, students and industries with the most complete infrastructure visibility to optimize application performance and maximize business performance [8].

Riverbed offers instructor-led classroom training courses that feature in-depth lectures and hands-on installation, configuration, and optimization experience within the Riverbed eLab environment. Riverbed is the leader in application performance infrastructure, providing solutions for end-to-end application visibility, optimization, and control in hybrid IT environments.

Riverbed Technology [9], Inc. (Riverbed) is a provider of application performance infrastructure which offers a platform to deliver, control and optimize IT resources across the hybrid enterprise. The technology delivers application performance infrastructure solutions with a focus on two areas, which include application acceleration and performance management.

There are other technologies that are quite similar to that of the Riverbed Technology, Inc. (riverbed) such as Clearfield, Inc. and Plantronics .Clearfield, Inc. manufactures [9], markets and sells fiber management and enclosure platform that consolidates, distributes and protects fiber as it moves from the inside plant to the outside plant and all the way to the home, business and cell site.

IV RELATED WORKS

Other related works involving the use of riverbed academic edition 17.5 include;

1) Performance Analysis of Interior Gateway Protocol is study conducted by Kaur & Mir, (2014) to compare the routing protocols:
RIP, OSPF and EIGRP using Riverbed Modeler 17.5 as the simulation tool.

2) Comparative analysis of Hub vs Switch in a LAN using Riverbed at the University of Technology, Jamaica =is a study by Udeaghaet al., (2016) that does a comparative analysis of Switch vs Hub

3) Impacts of VPNs and Firewalls on Public Cloud Performance are a research Alqhtani, Aloboud, Altamimi, & Kurdi (2017), where Riverbed was used to build a public cloud model to evaluate the performance of the cloud considering the security schemes of firewalls and VPNs.

4) An approach in the analysis of communication-information system model in military operation is a study conducted by (Devetak, Karovic, & Tervic, 2017) that used Riverbed Modeler 17.5 as the method of simulation to analyze the communication information system in military operations.

V COMPARATIVE ANALYSIS OF HUB AND SWITCH IN A LOCAL AREA NETWORK (LAN).

An Ethernet hub can be categorized as follows;

i) A Passive Hub is used to create connection between various devices without amplifying the incoming signal.

ii) An Active Hub regenerates or amplifies incoming signals. Active hubs are also called multiport repeater.

iii) An Intelligent Hub performs the tasks of both active and passive hubs. It increases the speed and effectiveness of total network hence making performance of whole network fast and efficient.

In a computer network, Ethernet switch and hubs are used to connect network file servers, profile servers, and application servers, Printers and workstations. The primary difference between a hub and switch is how the nodes communicate with the network. The basic measuring characteristics of wired medium are:

I. Bandwidth: Switch is a layer 2 device that operates on 10/100 Mbps speed. On the other hand, hubs can have maximum data transfer speed 10 Mbps and all nodes share the bandwidths that are connected to the hub [4].

II. Collisions: A collision domain is a section of a network where data packets can collide with one another when being sent on a shared wired medium. The switch divides the wired medium into collision domains while hub does not. Hub always operates in half-duplex mode, for example, it cannot send and receive data at the same time. On the other hand, switch work in

full-duplex mode that means, it can send and receive data at the same time and no collisions occur in a full duplex switch.
III. Speed: The hubs operate on 10 Mbps speed and switches operate on 100Mbps speed. With switch, 100/10Mbps available with a network and switch allows devices on the network to reach

their full capacity. For example, hubs are not designed to handle this speed, which operates, by fiber optic cable.
IV. Network Failure: Unlike a switched network, hub networks are more exposed to network failures because a fault in a node can affect others nodes, but switched networks can contain and manage network work failures [4].
V According to webopedia.com, a hub is a common connection point for devices in a network. Hubs are commonly used to connect segments of a LAN. A hub contains multiple ports. When a packet arrives at one port, it is copied to the other ports so that all segments of the LAN can see all packets. An Ethernet hub is a very important piece of device and is use mostly in small networks. What hubs do (2013) brings out the point that hubs serves as a central connection for all of your network equipment and handles a data known as frames. Further mentions are that when a frame is received, it is amplified and then transmitted on the port of destination PC. Hallberg, (2010) explained a hub is seen as core device in computer networking because of its ability for connecting multiple Ethernet devices together and making them act as a single network segment. Mr. Hallberg further stated that this is where a hub is considered better as a device in computer networking because input/output(I/O) ports, in which a signal introduced at the input of any port appears at the output of every port except the original incoming.
VI According to (*Dean*, *Hallberg* & *Charles*, 2010) Most hubs detect typical problems, such as excessive collisions and jabbering on individual ports, and *partition* the port, disconnecting it from the shared medium. Thus, hub-based twisted-pair Ethernet is generally more robust than coaxial cable-based Ethernet (e.g. 10BASE2), where a misbehaving device can adversely affect the entire collision domain. Even if not partitioned automatically, a hub simplifies troubleshooting because hubs remove the need to troubleshoot faults on a long cable with multiple taps; status lights on the hub can indicate the possible problem source or, as a last resort, devices can be disconnected from a hub one at a time much more easily than from a coaxial cable

VI SIMULATION

For the simulation, we setup the local area network (LAN) in a star topology, using hub and switch in the first and second scenario respectively.

A) First Scenario: Using only Hub. In first scenario, we set up about seven (7) to ten (10) workstations, which are connected to serves via a hub in the construction area of riverbed as shown in the figure 2 below.

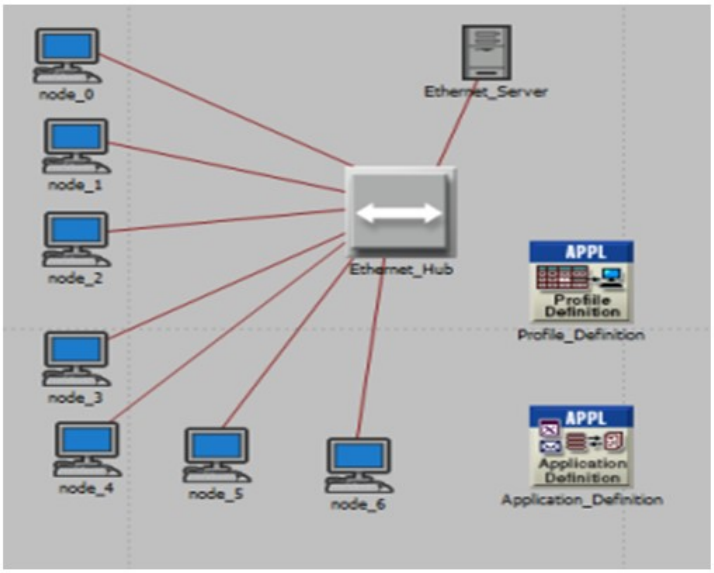


Figure 2: Hub Network Topology

In the figure 2 above, the seven (7) to ten (10) workstations are connected to an Ethernet hub and server with 10 base-T cable (10 x106 twisted pair cable).The profile and application servers are added .The configuration of application definition node made all standard network applications such as hyper text transfer protocol (HTTP), file transfer protocol (FTP), transmission control protocol (TCP), E-mail and database, available for use in the network topology. The configuration of profile definition node also created a new profile called web user, which was applied to the topology. After configuring both the workstations and the Ethernet sever, we chose the statistics that ought to be collected as follows:

1) Under Client HTTP: We chose object response time, page response time, traffic sent, traffic received and user cancellation abort.

2) Under Server HTTP: We chose load, traffic received and traffic sent.

3) Under TCP: we chose connection aborts, delay and retransmission. We run the simulation by choosing configuration run to examine the results.

B) Second Scenario: Using only Switch. To find a useful contrast, in the second scenario, it was very convenient to duplicate the entire topology of hub scenario into the construction area of riverbed, and we replaced Ethernet hub with an Ethernet switch as shown in figure 3 below.

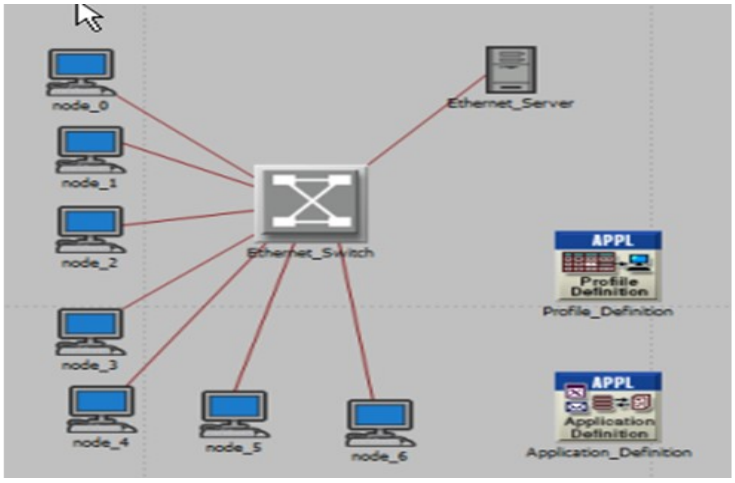


Figure 3: Switched Network Topology.

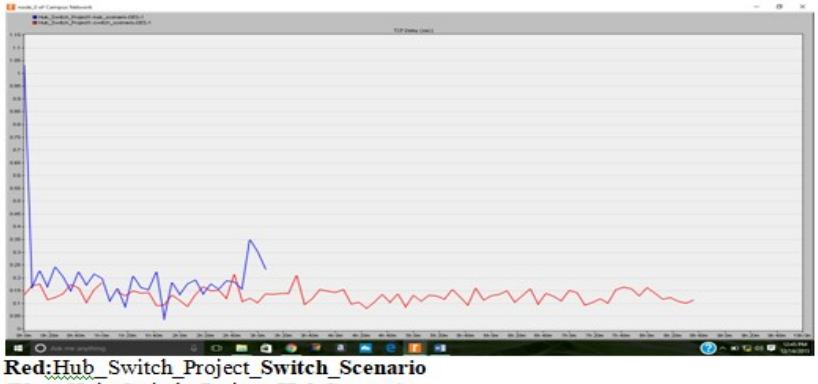
In figure 3, above, since we used the same 10base-T cable as in the first scenario, we need not to re-configure the network again. Rather, we run the simulation with the same statistics that were selected for the hub scenario. It was possible to compare the results of the two statistics simultaneously and view them on the same graph paper by selection all scenarios option. Different colors are used for different data and these results help us to determine the performance of hub over switch in an Ethernet network.

VII ANALYSIS OF THE RESULTS OF THE SIMULATIONS

The results of all the statistics collected from both scenarios such as page response time, TCP and HTTP, are analyzed below:

A) TCP Delay

B) Figure 4a: TCP Delay.



Red: Hub_Switch_Project_**Switch**_Scenario
Blue: Hub_Switch_Project_**Hub** Scenario

From the results on the graph on figure 4a, above it can be seen that the blue line represents the hub and it takes a longer time delay in the network, while the red line represents the switch takes about 0.1 sends delay. The performance hub has more time fluctuations when compared with switch

C) Average TCP Delay

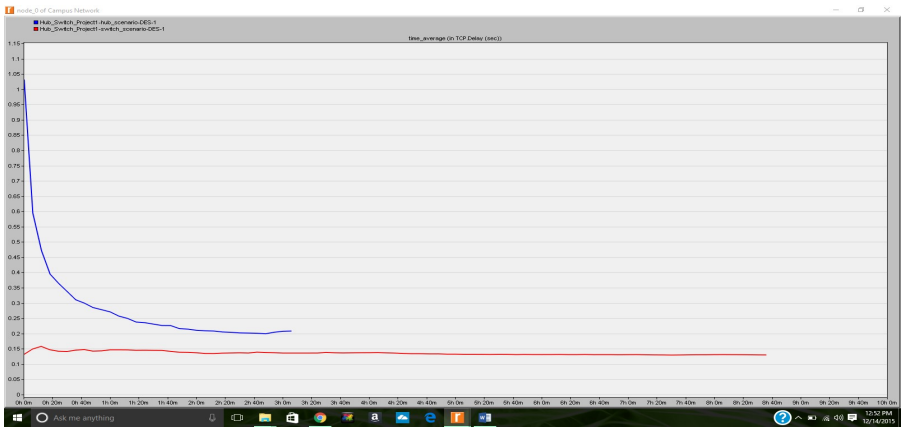
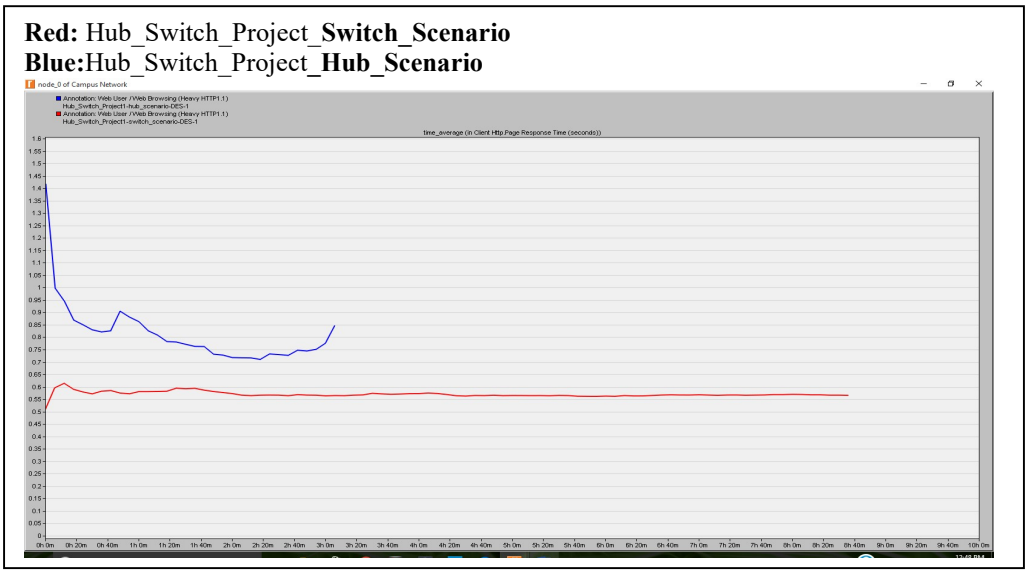


Figure 4b: Average TCP Delay

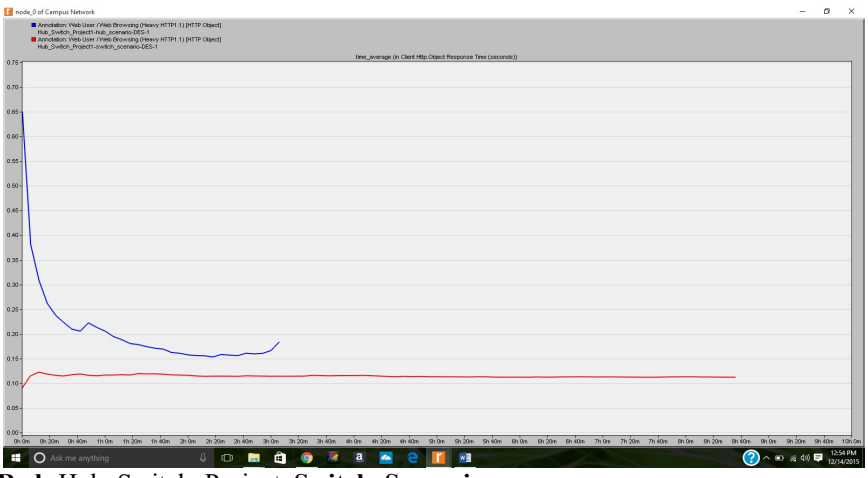
Based on results on figure 4b, above, the switch performance is smooth and stable with about 0.1 seconds time delay, while performance of hub is slope with more than 1-minute time delay.

D) Average Page Response Time



In figure 4c, the average page response time for switch is 0.5 seconds while the average page response time for hub is 1.4 second, which shows that performance of switch is better that hub. Switch is more stable than hub, which fluctuates.

4D) Average Response Time

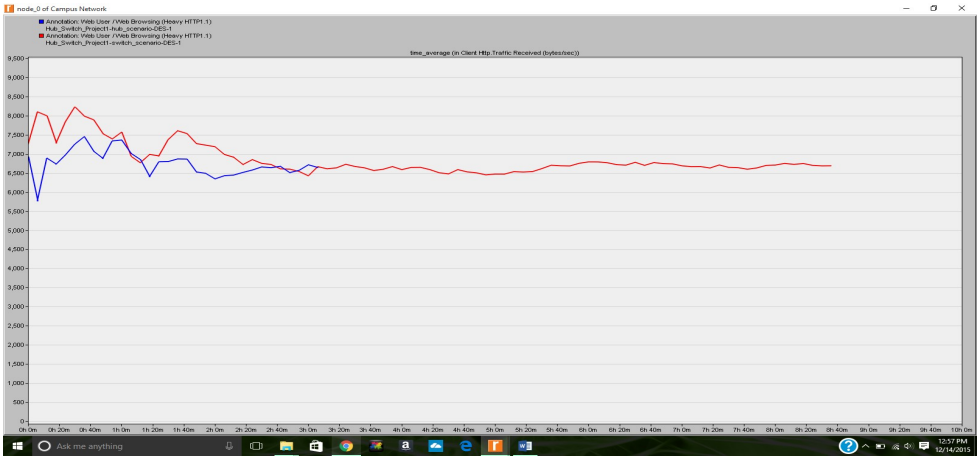


Red: Hub_Switch_Project_**Switch_Scenario**
Blue: Hub Switch Project **Hub Scenario**

Figure 4d: Average Response Time

From figure 4d, above, the performance of switch is better than hub, because the average page response time for switch is 0.10 seconds, while that of hub is 0.65seconds.The switch has also a smooth average response time unlike hub.

4E) Time Average of Traffic Received

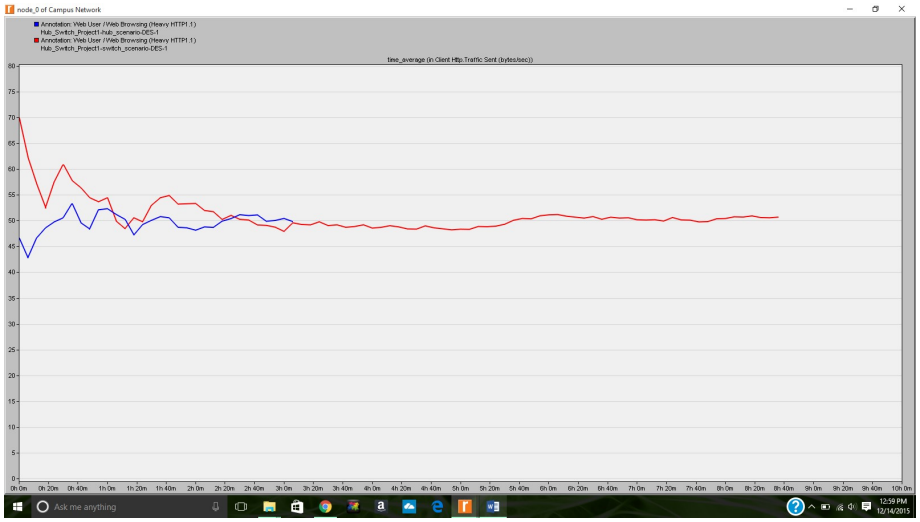


Red: Hub_Switch_Project_**Switch_**Scenario

Figure 4e: Average time of Traffic Received

Based on the results in figure 4e, above, switch received more traffic than hub, while hub received less traffic. Hub will send data packets to all other output lines, which means that when one receives a packet on an input line, the hub will forward the packets to all other nodes, while switch will send the received packet to the dedicated line from all other nodes.

4F) Time Average of Traffic sent

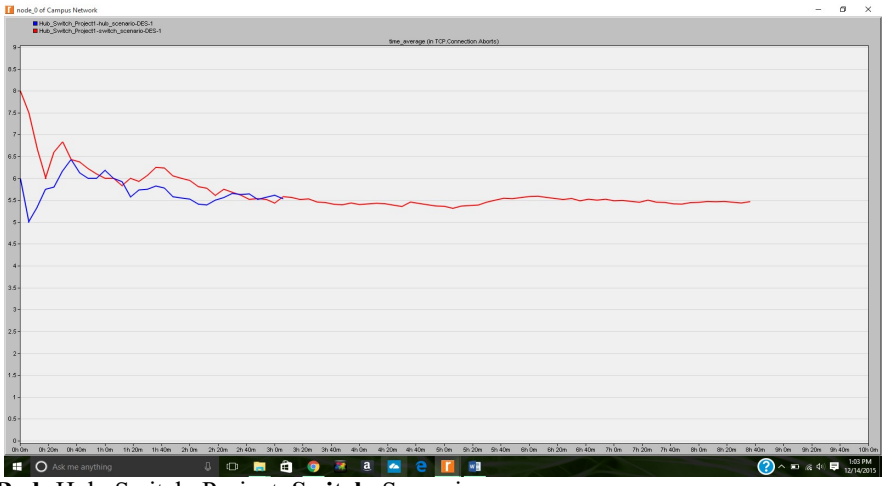


Red: Hub_Switch_Project_**Switch**_Scenario
Blue: Hub_Switch_Project_**Hub**_Scenario

From figure 4f, above, switch received more traffic and sent out more traffics than hub,
While hub received less traffic and sent out less traffics and it has more collision problem than switch. Switch as an active device deals with collision domain.

4G) Average Time of TCP Connection Aborts

Bar graph 1.1: Showing the gender of the participants



Red: Hub_Switch_Project_**Switch**_Scenario
Blue: Hub Switch Project **Hub** Scenario

Based on the results in figure 4g, above, switch still have better performance in average time connection aborts, as compared with hub. Hubs are exposed to problems of collisions, congestion and packet loss, where as switch handles collisions and congestion problems, without packet loss.

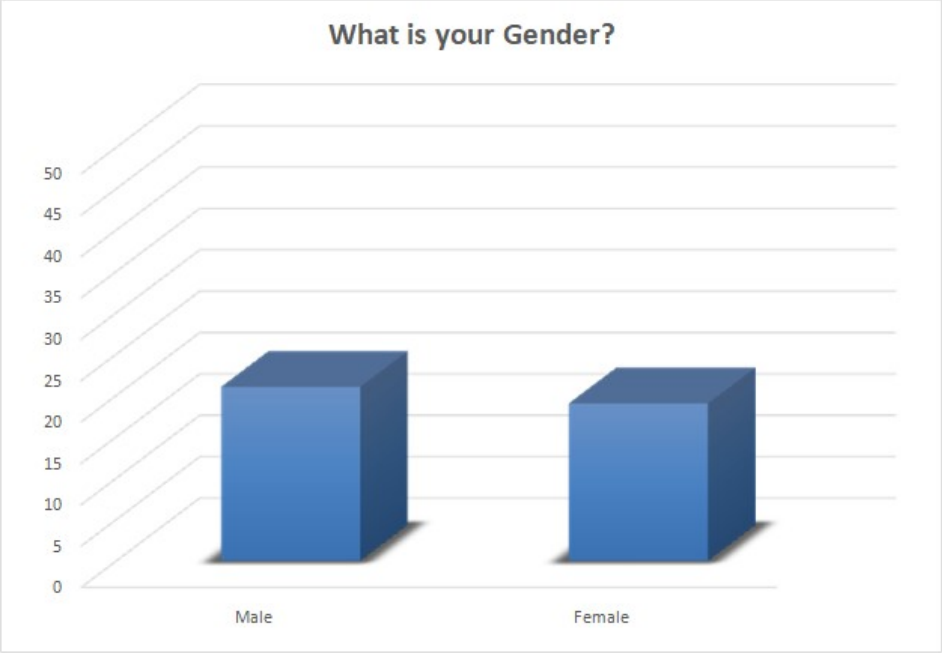
VIII ANALYSIS OF THE RESULTS BASED ON DATA COLLECTED

This section represents the analysis of our data collected based on the questionnaires and our discussions in relation to the results obtained. A total of 40 questionnaires were distributed. For the complete analysis of our findings, graphical aids such as tables, bar charts and pie chart were used as shown below.

Table1: Shown educational level of the participants

What is your highest level of Education	Responses
Bachelors	32
Masters	1
Certification	6
Phd	1

Table 1, above displays the variances in the level of education between the participants who were involved in the survey. As illustrated above, thirty-two (32) of the participants were pursuing a bachelor in engineering and computing , one (1) participant each had a Masters and Doctor of Philosophy (PhD) engineering science respectively and a the remaining six (6) participants had a certificate in the technical field of networking.

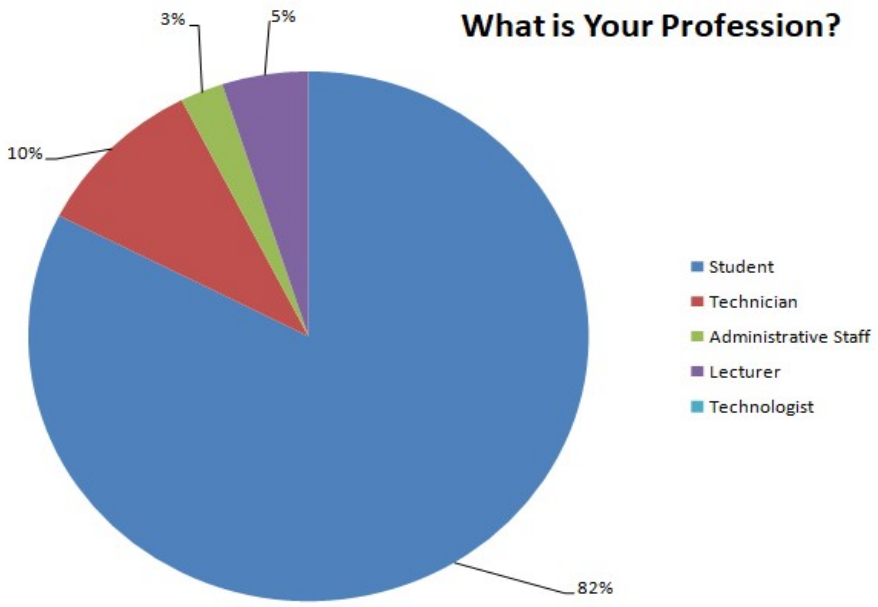


Bar graph 1.1: Showing the gender of the participants

The bar graph, above displays the different genders who participated in the survey. Twenty-one (21) of the individuals were males and the remaining nineteen (19) individuals were females.

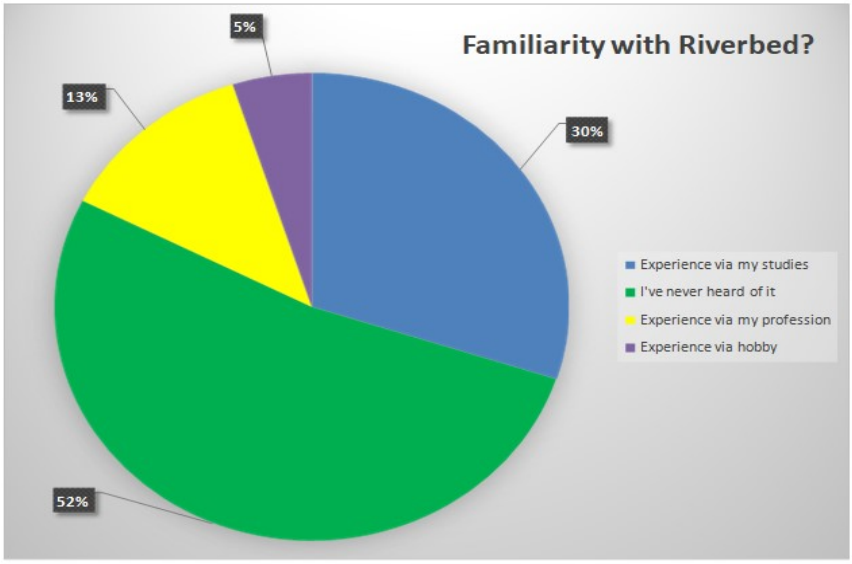
Pie Chart 1.1: Showing the profession of the participants

Pie Chart 1.1, above illustrates the different professions which participated in the survey. Eighty-Two percent
(82%) of the individuals were students, ten percent (10%) of the individuals were technicians, three percent (3%) of the individuals were from the administrative staff and the remaining five percent (5%) of the individuals were lecturers.

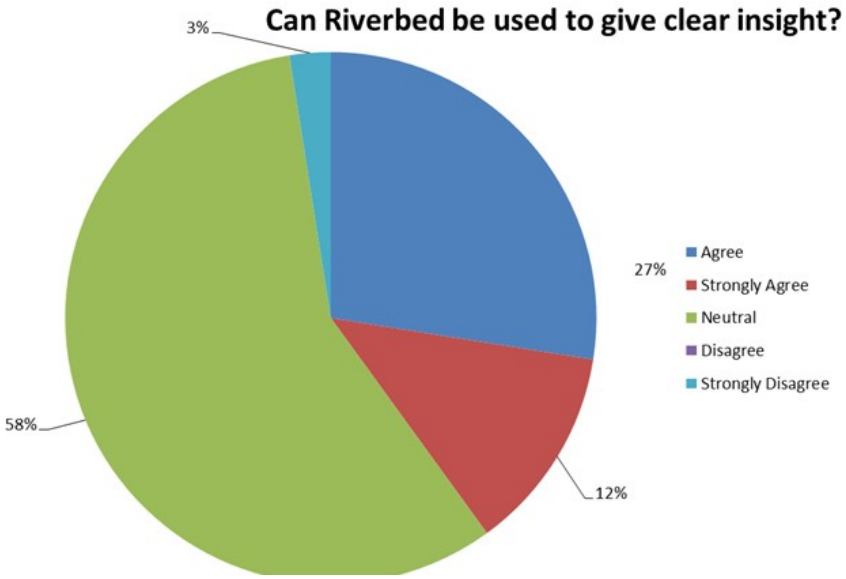


Pie Chart 1.2: Showing the experiences of the participants with riverbed.

Pie Chart 1.2, shown above highlights the individuals who had some form of familiarity with the Riverbed network simulation software. Fifty-Two percent (52%) of the individuals stated that they had never heard of the software, thirty percent (30%) of the individuals had experience with the software via their studies, thirteen percent (13%) of the individuals had experience with the software via their profession and five percent (5%) of the individuals had experience with the software via hobby.

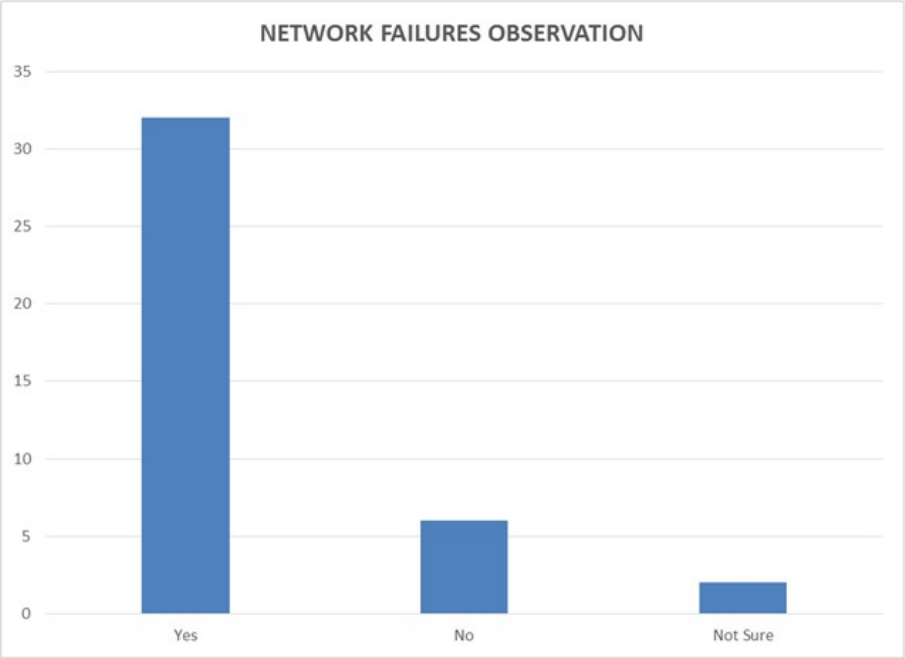


Pie Chart 1.3: Showing if riverbed can be a useful tool predict the result



Pie Chart 1.3, above illustrates the individuals who thought the Riverbed networking simulation software could give clear insight in predicting results.. Fifty-eight percent (58%) of the

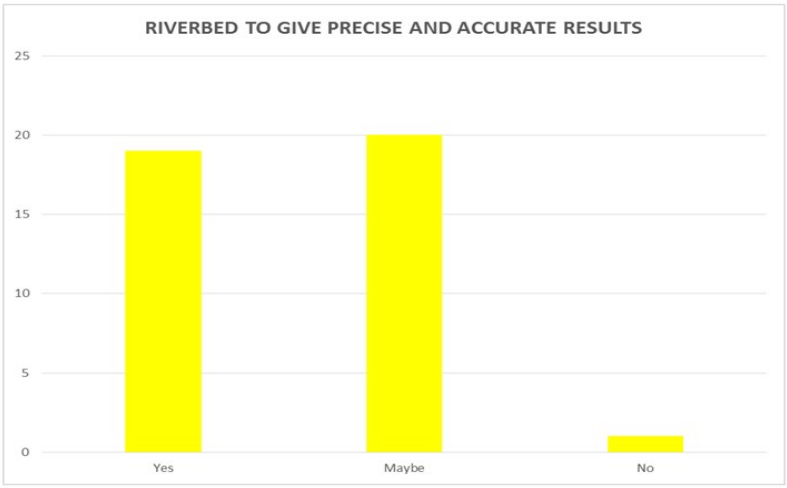
individuals remained neutral, twenty-seven percent (27%) of the individuals agreed, twelve percent (12%) of the individuals strongly agree and the remaining three percent (3%) disagreed.



Bar Graph 1.2: Showing network failure observation

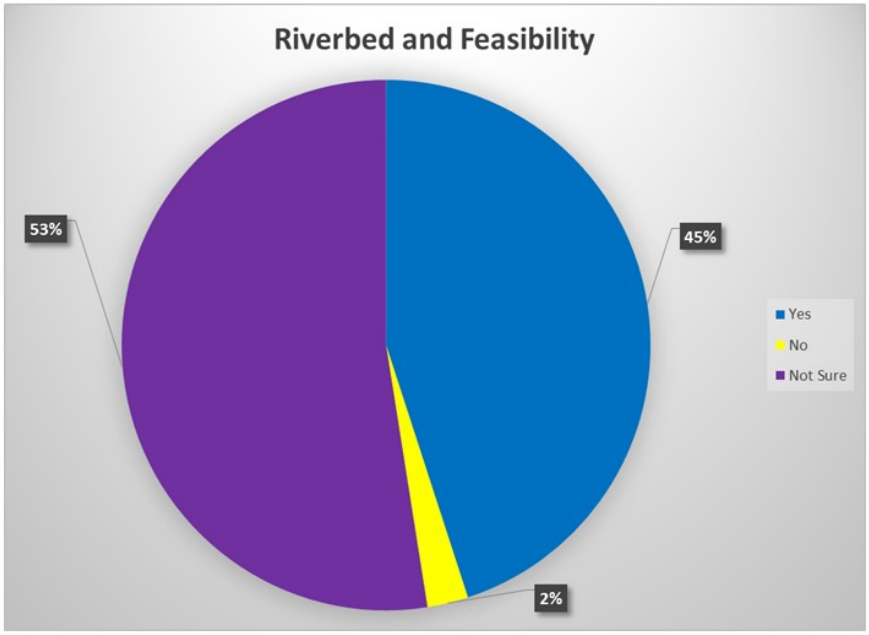
Bar Graph 1.2, above displays the results gathered from the individuals who observed the network failures in the system. Thirty-two (32) individuals stated that they were aware of the network failures; six (6) individuals stated that they were not aware of the network failures and the remaining two (2) individuals stated that they
were not sure.

Bar Graph 1.3: Showing, if riverbed can give precise and accurate results



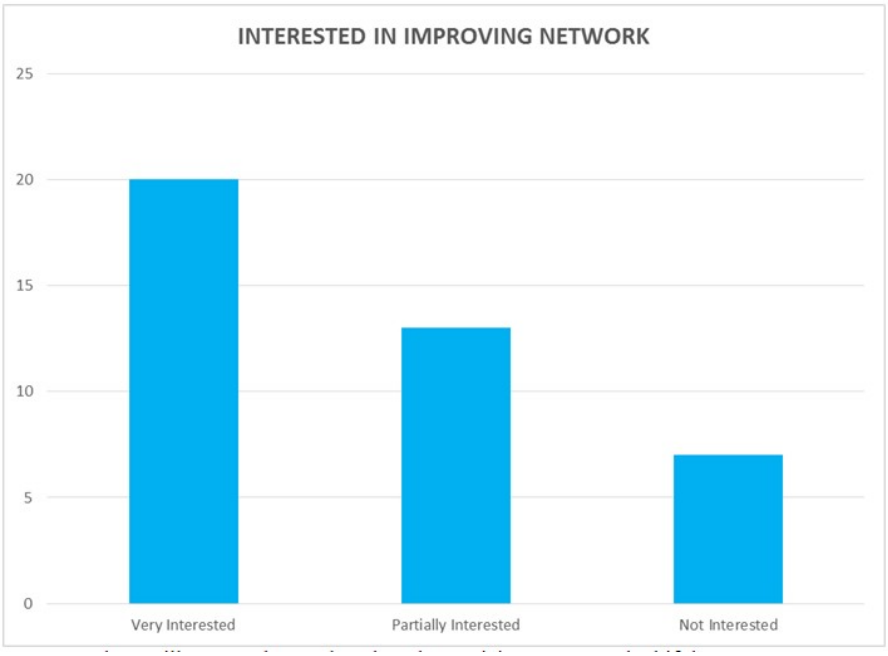
Bar Graph 1.3, shown above illustrates the participants who thought the Riverbed networking simulation software could produce precise and accurate results. Twenty (20) of the participants were not sure, nineteen (19) of the participants said yes and the remaining individual stated no.

Pie Chart 1.4: Showing riverbed and its feasibility

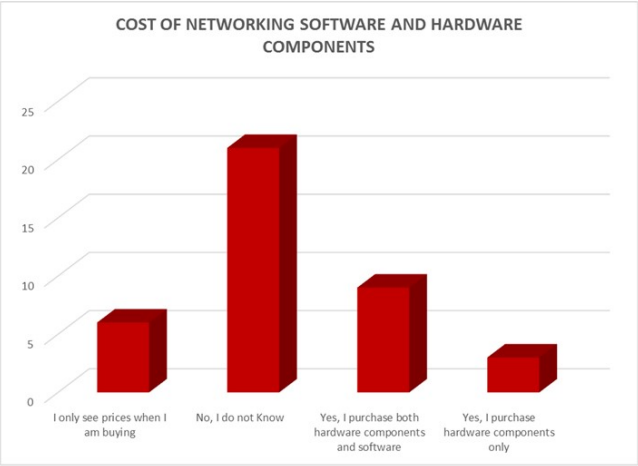


Pie Chart 1.4, displayed above is concerned with Riverbed and its feasibility in a networking environment.

Fifty-three percent (53%) of the individuals were not sure, forty-five percent (45%) stated yes and the remaining two percent (2%) stated no. Bar Graph 1.4:Showing how interest the participants have in improving network performance in the campus

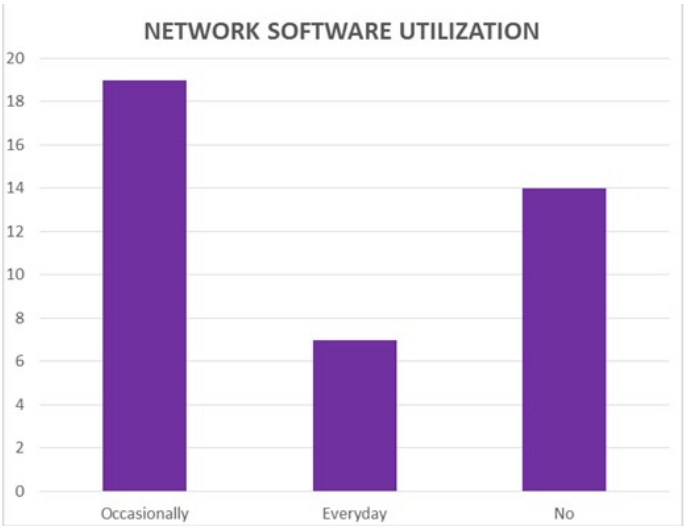


Bar Graph 1.4, illustrates the results when the participants were asked if they were interested in the improving the computer network at the university. Twenty (20) of the participants stated that they were interested, thirteen (13) were partially interested and the remaining seven (7) participants were not interested.Bar graph 1.5: Showing if the participants have cost awareness of software and hardware



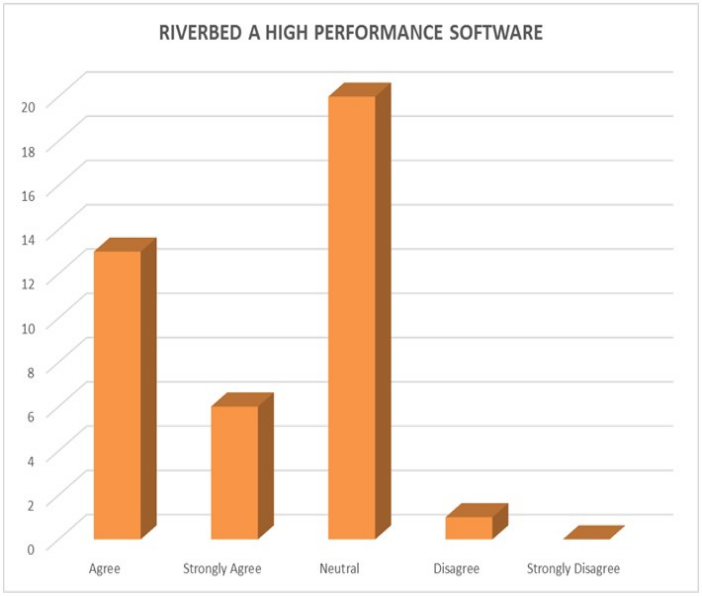
Bar Graph 1.5, illustrates participants' answers pertaining to the cost of the networking software and hardware components. Twenty-one (21) stated that they do not know, nine (9) of the respondents stated that they both purchase hardware and software components, six (6) participants stated they only see prices and the remaining
three (3) stated that they only purchase hardware components.

Bar Graph 1.6: Showing network software utilization in the campus



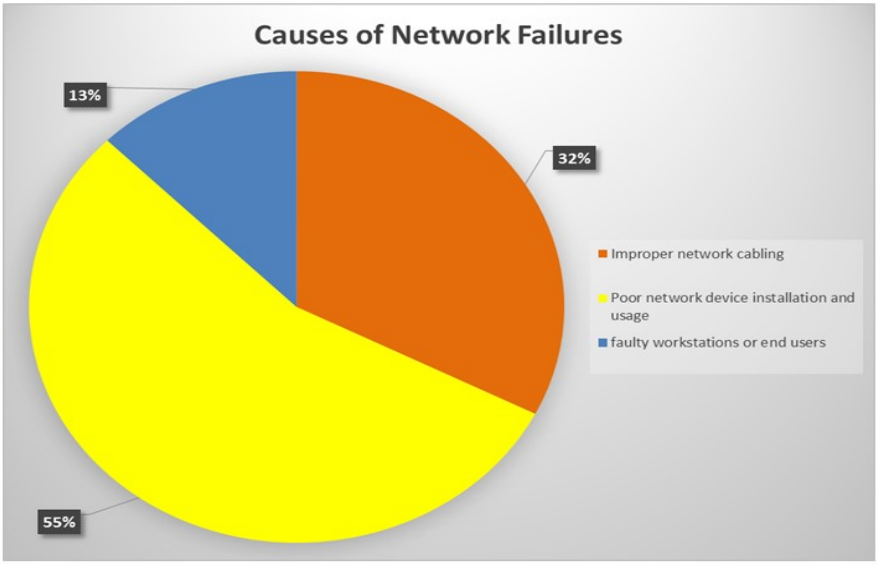
Bar Graph 1.6, how each participant utilizes network software. According to the results obtained, nineteen (19) of the respondents stated occasionally, seven (7) stated every day and the remaining fourteen (14) stated that they do not utilize networking software.

Bar Graph 1.7: Showing if riverbed is a high performance software



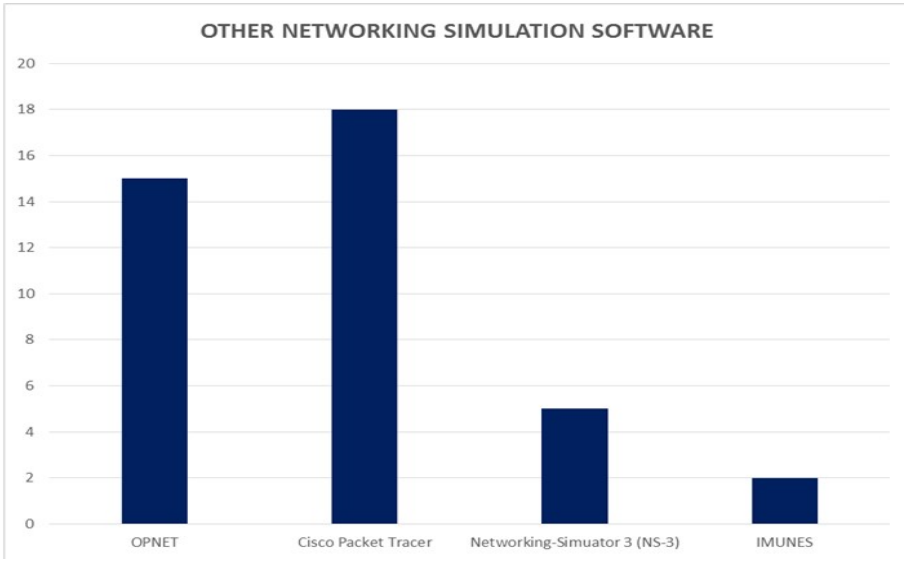
Bar Graph 1.7, provides on the participants 'answers on Riverbed as a high performance software. Twenty (20) of the participants remained neutral, thirteen (13) agreed, six (6) strongly agree and the remaining one (1) participant strongly disagreed.

Pie Chart 1.5: Showing causes of network failures



Pie Chart 1.5, illustrates the main reasons of network failures stated by the respondents. Fifty-five percent (55%) stated that failures were due to poor network device installation and usage, thirty-two percent (32%) stated improper network cabling and the remaining thirteen percent (13%) stated faulty workstations or end users.

Bar Graph 1.8: Showing other network simulating software



Bar Graph 1.8 addresses other networking simulation software which is known to the participants. Fifteen(15) persons declared to have known OPNET, eighteen (18) stated Cisco Packet Tracer, five (5) stated Networking-Simulator 3 (NS-3) and the remaining two participants stated IMUNES.

IX DISCUSSION

After the analysis of the results based on the data collected from the questionnaires and the interviews, it was noted that the Riverbed networking simulation software was not known to many individuals. Approximately 52% of the participants stated their lack of knowledge towards the software. Unsurprisingly, this predicament was evident because the Riverbed networking simulation software was freshly release in the year of 2012 and was the successor of the Opnet IT guru networking simulation software.

Approximately 37% and 45% of the participants were knowledgeable of OPNET and Cisco packet tracer respectively.The research questions which were highlighted during the course of the project were, “Can Riverbed Modeler identify network risk and make suitable analysis of the performance of the computer network?” and “Is it possible that the use of Riverbed can help to improve the University of Technology’s network challenges?”

In relation to the first research question, several queries were produced to generate the necessary feedback from participants of the questionnaire. Thirty-nine percent (39%) of the individuals who participated stated that Riverbed can be used to give clear insight of a computer network.

Forty-seven percent (47%) of the individuals stated that Riverbed networking simulation software could produce precise and accurate results. Based on simulation conducted in the previous chapter, results have shown that the individuals were actually correct from their earlier assumptions. The Riverbed networking simulation software produced real-time networking results which included: TCP Delay, Connection Aborts and Response Time. Due to these characteristics, it has been concluded that the Riverbed networking simulation has the ability to diagnose network issues, analyze network problems and solve networking concerns using simulations before the actual implementation.

With regards to the second research question, which addresses the overall improvement of the present network topology of University of Technology, Jamaica, the Riverbed networking simulation software is embedded with features which allows for the proper duplication of a given network topology. Network administrators would be given the opportunity to change networking components such as the type of Ethernet cables or the network devices (hubs or switch) used. Eighty percent (80%) of the respondents stated that they were aware of the network failures which the university encounters. Fifty-five percent (55%) and thirty-two percent (32%) of the respondents stated that the main cause of a network failure is because of the inappropriate installation and usage of a network device, and the improper network cabling respectively.

X. CONCLUSION

Hubs and switches have been actively used devices in computer networks vision, over two (2) decades. However, based on the results of the simulations, the performance of switches over hub cannot be over emphasized. Switch as both active and intelligent device has less TCP time delay, better average page response time, and better average response time. Though hub is a passive device, with higher time average, it is still useful in a very small network of computers.

In general, hub will send data packets to all other output lines, which means that when one node receives a packet on an input line, the hub will forward the packets to all other nodes, while switch will send the received packet to the dedicated line from all other nodes [7]. This functionality of switch helps in increasing its performance, throughput and latency. More so, hub is more exposed to collisions leading to packet loss.

Switches are smarter devices than hubs, though both devices are used to connect segments in a network, they both have their advantage and disadvantages. They are the central connection for all of your networked equipment and handle data type called frames. Frames carry your data. When a frame is received, it is amplified and then transmitted to the destination port. However, on the other hand the main disadvantage of the hub is that the data/packet transmitted is being seen by all the other systems connected to the hub (D.Loug, 2009). A hub is a device that connects PCs together. In general, what is called a hub in today's market is a "dumb" device (R.Deal, 2008). In a hub, when one PC sends data onto the wire, the hub simply forwards the packets to all the other devices connected to it. Hubs works on the physical layer (R.Deal, 2008) because it does not use any address and it just broadcasts to all the systems connected.

The switches are able to inspect the data packets and determine its source address and its destination address and delivered to its respective destination (W.Stallings, 2007). But the switch also has another feature, when it receives a packet, it will learn the port from where the packet came and next time when a packet needs to be transmitted to the same port, it will remember that

port because it previously saw a packet coming from that port. The switch operates on the layer 2- Data link layer (R.Deal, 2008).

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