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Plan, Design and Simulation of University Network

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Abstract

Computer network in the recent time has continued to evolve and has gone beyond just a collection of interconnected devices. Networking is a process of connecting computers, printers, routers etc. over a medium for the purpose of sharing information/resources. It is a very viable tool in the day-to-day running of an organisation. Research in data communication and networking has resulted in new technologies in which the goal is to be able to exchange data such as text, audio, video etc. Recently, no good establishment can effectively and efficiently work without a good computer network or internet. In Nigeria, virtually every establishment has got one but how these networks are managed, the quality of service and the general performances of these networks are questionable. In this paper, we present; plan, design and simulation of computer network, a case study of Federal University of Technology Owerri (FUTO). The result of the work clearly showed that the simulated network has an edge over the existing real time network in reliability. Approximately 96% of data sent were received successfully on the simulated network and only about 4% were lost. In the existing real time network about 67% packets were received successfully while about 33% got lost on transit. This paper when implemented will solve problems we have identified with the university network.

Keywords

Computer, Networking, Communication, LAN

1. Introduction

A network is any collection of unities that exchange information or goods. The nervous system of an animal or human being is an example of a network that aids the information to be pass to and from the brain and the other parts of the body. A system is called a network if it facilitates the movement of information, goods or things from one point to another. The telephone lines are also a network. They allow people to communicate and transfer information all from source to destination. A computer network is no different than any of the networks mentioned above.

A computer network exchanges information between computers and other network devices. The term "Internet" as it is popularly called today is a vast network made up of millions of smaller networks called LAN's or Intranets. Two or more computers connected together with a network device can communicate with each other in some way. Such computers are also called nodes or stations and run software that initiate and manage their interaction in sharing files and other resources. A computer network is a network that links computers and other network devices to enable communication and data exchange between systems, software applications, and users. Devices are assumed to be networked if they are able to exchange information. With appropriate configuration, a combination of cable or wireless media, interconnection of computers and networking hardware devices a computer network is established.

The resulting outcome of inadequate or lack of affordable connectivity is that universities in Nigeria are unable to satisfy the information needs of students, researchers, professors, scientists and libraries with tools needed to be involved in building a knowledge economy. It is established fact that in the present world the use of internet as a tool for teaching, learning and research cannot be overemphasised [1]-[4].

2. Related Work

A number of related works exist in literature on the internet development and application in Nigeria and other developing countries. In 2010, Echezona el tel. [3] tries to investigate the state of computer network or internet in Africa as it concerns institution of

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learning and the corresponding libraries as a hub of the institutions. It outline the cause as the challenges posed by the lack of ICT infrastructure, power supply, government policy and low bandwidth are also discussed. The authors believes that their propose recommendations could launch African university libraries into the global information and research interchange. The recommendations include:

- Liberalization of telecommunication market will reduce high cost of Internet connectivity bandwidth.
- Government should pay attention to ICT infrastructure facilities provision in their policy and budget, and sought for foreign project aids and partnership that will target African Universities Bandwidth management should be incorporated into the institutional objectives of African Universities.

In 2010, Inoanusi [5] proposed two models: Fixed and Cellular wireless, for providing internet services to the sparse rural communities in Nigeria with a state of art technologies. For those who don't own a personal computer, there is need to set-up a Cybercafé. He also suggested a possible partnership of government and corporate organisation with GSM operators to reduce the cost of internet services to the rural duellers. To reduce the operational cost as practiced in most developed countries, operators of cellular wireless will be required to implement site sharing or co-location.

I'm of the opinion that cellular wireless should provide a better coverage and quality services if government should partner with the cellular operators as suggested by the author. The use of fixed wireless like VSAT will have limited coverage and poor quality network due to its low speed and narrow beam.

In 2012, Bolu el tel. [6] formulated network access transport problem as a mathematic linear programming problem and solution by using a MATLAB linear programming to generate a model to solve the access network problem of connecting buildings across the University for Clustered User were developed. The work determines the required bandwidth to be supplied and minimised the cost of distribution through the model developed [7].

Though the result shows an optimized cost, model developed is environmental specific and for clustered user. Therefore, the use of integer or dynamic programming for better bandwidth allocation and network planning can be developed to include un-clustered users as a future work. Explore.

3. Network Planning

3.1 Existing Network

The question to be answered here is to ascertain whether there is already a network (wired or wireless) in place? For this network there is an existing infrastructure but is mainly on wireless network. The documentation of the previous site surveys, current topology of the existing network was analyzed and facility maps to aid the current project.

3.2 Site Survey Equipments

In the most basic indoor cases, at least one access point is needed, a variety of antennas, antenna cables and connectors, a laptop computer (or PDA) with a wireless PC card, some site survey utility software, and some paper. There are some minor things that can be added to the mobile toolkit such as double-sided tape (for temporarily mounting antennas to the wall), a DC-to-AC converter and batteries (for powering the access point), spectrum analyzers, a digital camera for taking pictures of locations within a facility.

3.3 Site Survey

A Radio Frequency (RF) site survey is a map for successful implementation of a wireless network. A site survey is a task-by-task process by which the surveyor discovers the RF behaviour, coverage, interference, and determines proper hardware placement in a facility. The site survey's primary objective is to ensure that mobile workers – the wireless LAN's "clients"– experience continually strong RF signal as they move around their facility. At the same time, clients must remain connected to the host device or other mobile computing devices and their work applications. Proper performance of the tasks listed in this section will ensure a quality site survey and can help achieve a seamless operating environment every time you install a wireless network. Site surveying involves analyzing a site from an RF perception and determining what type of RF coverage a site needs so as to achieve the set objectives.

Site survey carried out provides detailed specifications addressing coverage, interference sources, equipment placement, power considerations, and wiring requirements. Furthermore, the site survey documentation serves as a guide for the network design and for installing and verifying the wireless communication infrastructure.

The under listed analysis were carried out during the process of site survey in

- Facilities Analysis
- Existing Networks
- Area Usage & Towers
- Bandwidth & Roaming Requirements
- Available Resources

3.3.1 Facility Analysis

The number of building in each section and divisions were taken into account and the number of possible users of both the wireless and wired network. Also the security requirements, bandwidth requirements, budget, etc. The number of buildings in each sub-network and the estimated number of computer systems needed to implement the project were carried out. The positions for the wiring closet were identified for each of the buildings.

3.3.2 Area Usage and Towers

The areas where the network will cover were ascertained and the various positions where towers should be erected were also ascertained. The towers/masts are used for mounting the routers' antennas in each of the sub-networks. The mast/tower will be raised high for a clear line of sight.

3.3.3 Bandwidth & Roaming Requirements

The technology to be used is 802.11a, 802.11n & 802.11g at 54Mbps and 100Mbps. The clients will be able to roam without losing connectivity from one access point to another.

3.4 FUTO Network

The computer network for Federal University of Technology Owerri will have six (6) sub-networks and each of them will have their own network. The six sub-networks include:

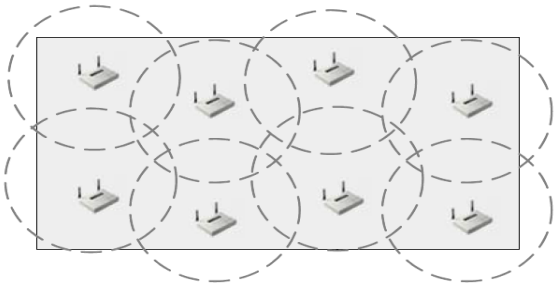

Figure 1: Access point overlapping to aid Roaming

- ICT Centre / SOS Building / Workshop 2 Workshop 3
- SEET Head / Library
- Hostel / Mechanical Building
- SAT / SMAT / School of Health
- Senate Building
- Medical Unit / 1000 Capacity Building

Each of the sub-networks will have a router. A total of six (6) routers will be used in the implementation of the computer network. The routers will be connected in ring topology. With this mode of connection, the router will be able to use the fastest link to forward whatever packet is to be forwarded. The domain name for the network will be "futo.edu". Each sub-network will have layer 2 switches connected to give wired connection for the nodes (hosts) and as well as the access points (AP) for wireless device.

3.5 Radio Frequency Antennas

An RF antenna is a device used to convert high frequency (RF) signals into radiated waves in the air. Beams or lobes are emitted electric field from antennas. There are three generic categories of RF antennas:

- Omni-directional
- Semi-directional
- Highly-directional

Two (2) highly directional antennas each will be mounted back-to-back on each sub network mast/tower in order to link the routers wirelessly. Highly directional antennas are to be used because of the distance between the towers and since the connection between each router is a direct one. Omni-directional and semi-directional antennas were used with the access points on the network.

4. Layout of the Network

The layout of the network will be done in such a manner as to ensure effective communication between the connected nodes and sub-networks. All the computers in each department will be linked together, using wired and wireless media (star topology). The departments in each school (sub-network) will be linked together to each other using both wired and wireless media. Finally, each sub-network will be linked together using a wireless media (ring topology). The network will have six sub-networks and each of them will have their own network. The proposed sub-networks are:

- ICT Centre / SOS Building / Workshop 2 Workshop 3
- SEET Head / Library
- Hostel / Mechanical Building
- SAT / SMAT / School of Health
- Senate Building
- Medical Unit / 1000 Capacity Building

The layout diagram for Federal University Technology Owerri: The individual schools are linked wirelessly to each other using routers with antennas.

5. Networking the Main Sub-Network

The School of Engineering and Engineering Technology (SEET) is used as a case study here in that what will be done in this school will be replicated in other sub-networks.
Material/equipment that will be needed:

- Network interface card (NIC)
- Category 5 or 5e cable
- Computer systems
- Modems
- Routers
- RJ 45 connector
- Cable Tester
- Crimping Tool and cutter
- Patch Panel

5.1 Designing the Internet Addressing Plan

An Internet protocol IP address is a numerical identification (logical address) that is assigned to devices for participation in a computer network. Computer networks make use of the Internet Protocol for communication between its nodes. IP addresses are mainly presented in more human readable notations, such as 192.168.100.1 (for IPv4) and 2001:db8:0:123:567:1:1: (for IPv6) even though there stored as a binary numbers. The role of the IP address has been characterized as follows: "A name indicates what we seek. An address shows where it can be located. A route shows how to get to the location." The internet Protocol also is responsible for routing data packets between networks; and IP address specify the locations of the source and destination nodes in the topology of the routing system. An IP address can be private for use on LAN or public; for use on the internet or other WAN.

Assume the allocated IP Address range is 192.168.1.0/24 - 192.168.6.0/24. There will be need to subnet the IP Addresses because of the numerous sub-networks so as to fully utilize the range of IP addresses given. For the serial communication between the sub-networks the range of IP Address will be 192.168.1.0/24 which will be sub-netted to 192.168.1.0/30. It is shown below how the IP Addresses are allocated to the serial port of each router for communication between them [8].

This range of IP Addresses (192.168.3.0/24) is allocated to the ICT Centre/SOS/Workshop and there is a need to split this range of IP Addresses according to the required number of IP addresses required in each department. 192.168.3.0/24 range of IP address contains 256 addresses.

- The Network Address is 192.168.3.0 255.255.255.0
- Client Address is 192.168.3.1 - 192.168.3.254
- Broadcast address is 192.168.3.255

5.2 Assigning of IP Addresses to the Host Computer Systems

Assigning of IP addresses to the host computers can be done in two different ways;

I. A computer system can be assigned with static IP address
II. It can be assign with a dynamic IP address using a DHCP (Dynamic Host Control Protocol) server configured for such.

The Internet Protocol addresses were assigned to the host computers dynamically using a server configured to run DHCP. The DHCP server was configured to generate and allocate IP addresses to the host from the range of IP addresses it was configured to generate. The DHCP server itself is running on a static IP address [9][10].

5.3 Configuring the Routers

Each of the sub networks has their own router and the routers were configured for them to route packets effectively. The routers in each sub networks are configured to forward packets to each other wirelessly. The routers are configured to use dynamic routing to route. The routers in each sub networks are configured to forward packets to each other wirelessly. The routers are configured to use dynamic routing to route packets (RIP version 2)

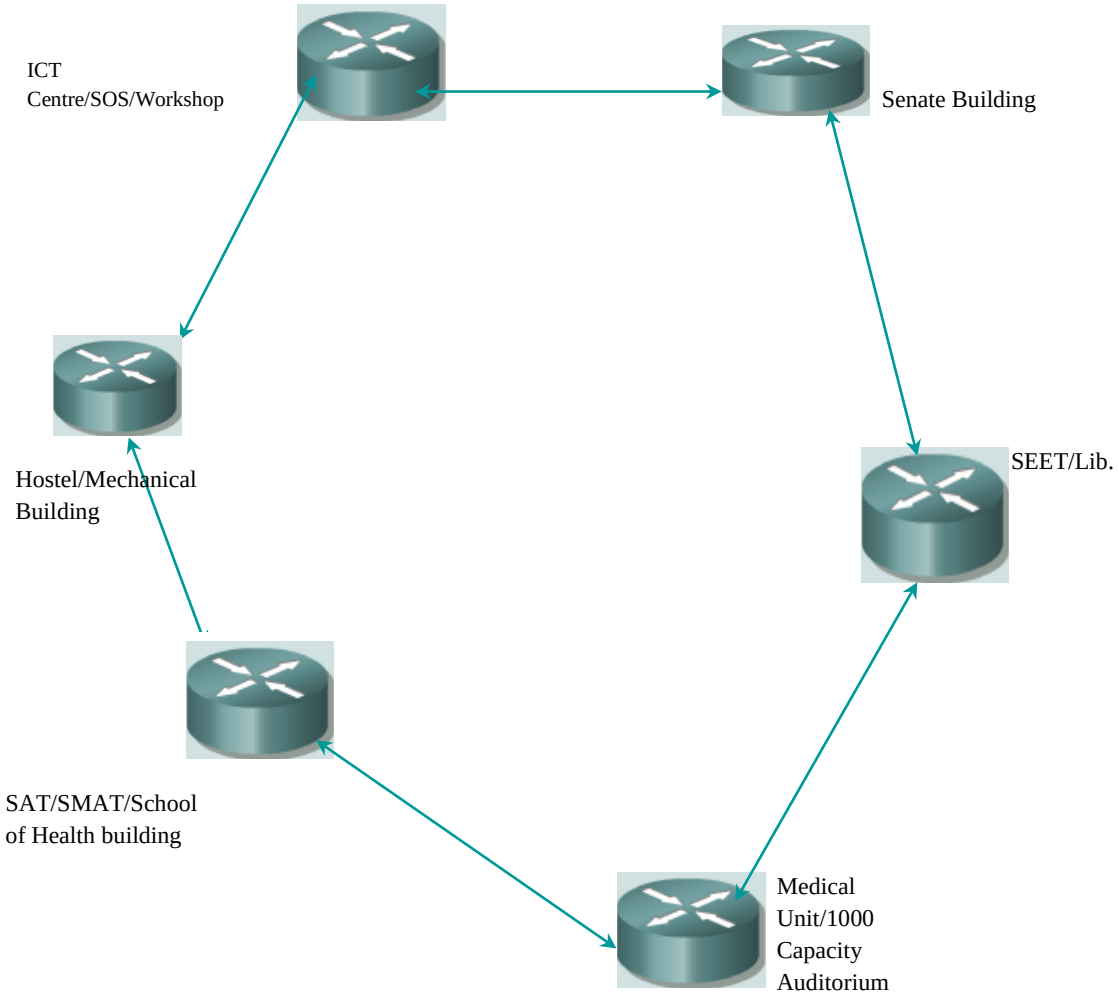

Figure 2: The backbone network design

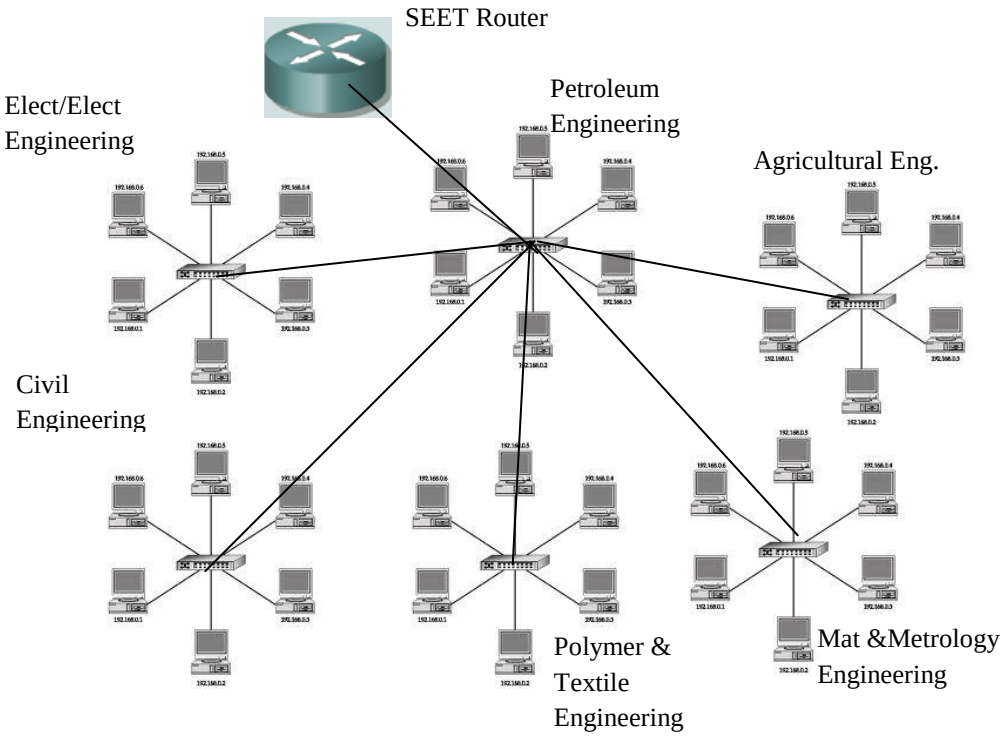

Figure 3: SEET Main Sub-network

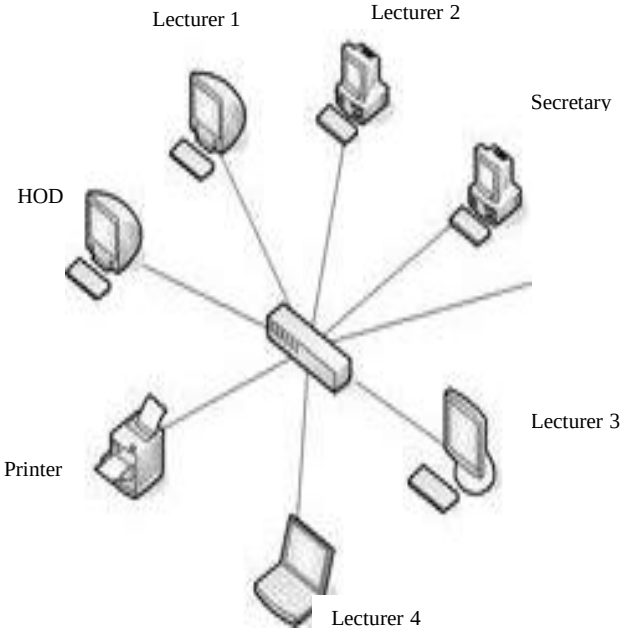

Figure 4: SEET sub unit

5.4 Routing Information Protocol (RIP)

RIP was originally specified in RFC 1058.

- As a distance vector routing protocol.
- Hop count is used as the metric for path selection.
- The packet is discarded only if the hop count exceed the preselected number.

We adopted the default 30 seconds broadcast of routing updates.

5.5 Security Measures for Securing the Network

There are so many security measures that can be implemented in a network such as the use of Anti-virus software which consists of programs developed to scan for and eliminate viruses and other malicious software (malware). Firewalls can also be used to prevent unauthorized access to the network. Firewalls are systems which help protect computers and computer networks from attack by blocking network traffic based on a set of rules defined by system administrator. Virtual LANs (VLANs) can also be used for securing the network. VLANs segment

switched networks logically based on a certain conditions regardless of the physical location or connections to the network. Access List can also be used to prevent unauthorized access to some particular resources of the network.

5.6 Access Control List (ACL)

An access list is a sequential series of commands or filter that instructs a router on types of packets to accept or deny based on some specified conditions. Access control lists are applied on the router's interfaces. A router checks every packet based on specified conditions in the ACL and decides whether the packet should be forwarded or dropped.
Some ACL decision points are:

- IP source address
- IP destination addresses
- UDP or TCP protocols
- Upper-layer (TCP/UDP) port numbers

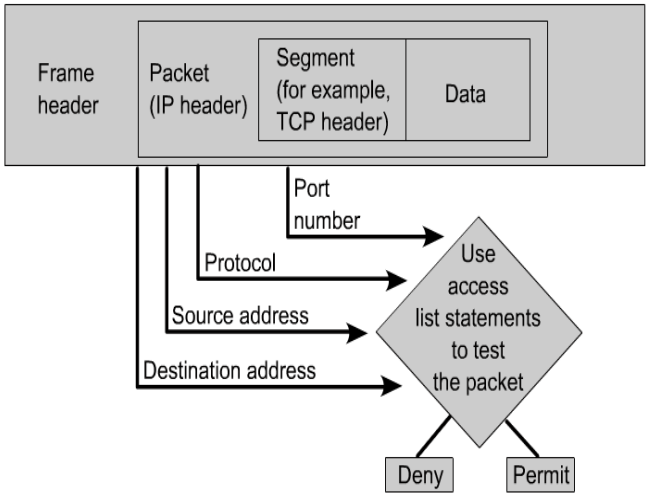

Figure 5: Access List (ACL) decisions base

An ACL is a set of conditions that decide if a packet is accepted or rejected coming into an interface or leaving an interface. If the ACL condition is true, the packet is allowed else it is dropped and the rest of the ACL statements are not checked. Access List is be used to ensure the security of the Result Server, i.e. to prevent unnecessary access to the files. Access list needs to be applied on the SEET router in order to permit only the heads of department (HODs) from the School of Engineering access to the Result server and preventing other users from school of Engineering Network access to the Server.

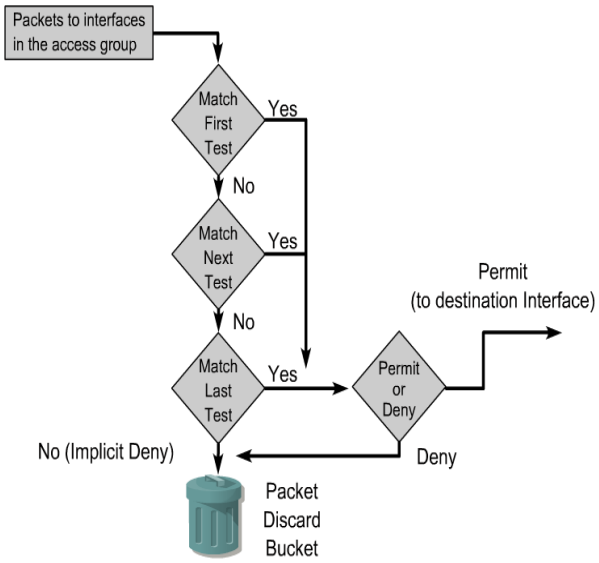

Figure 6: Access List Filters

The computer systems of the Head of Departments is SEET will be implemented on the fast Ethernet 0/1 port of the SEET/Library Network. This ensures that only the HODs of the listed departments in the school of Engineering have access to the Result server. Unauthorized personnel though may have access to any other client or server in the SEET/Library network but will not be able to access the result server on same network [10]-[14].

6. Simulation and Result

6.1 Evaluation of the Simulated Network

The computer network for Federal University of Technology Owerri (FUTO) was simulated according to the design of the network. The routers and the computer system were configured accordingly. Packets were sent from one computer to the other and the transmission of such data to their destination was successful. Through the network, Memos, emails and files can be sent and received by staff and students of the institution. The simulated network was tested to be ok just like a real computer network. This shows that the computer network for FUTO will work perfectly when implemented.

6.2 Comparative Analysis of a Real-time Network with the Simulated Network

The simulated network was compared with a similar real time computer network by running some basic utility tools such as PING on both networks to check connectivity. The simulated network when compared

with a similar real time network has many things in common. The table below shows the ping result obtained from the simulated network and a similar real time computer network.

From the table above it was cleared that the simulated network has an edge over the existing real time network in reliability. Approximately 96% of data sent were received successfully on the simulated network and only about 4% were lost. In the existing real time network about 67% packet were received successfully while about 33% got lost on transit.

Since the existing network is a smaller network compared to the simulated network, the time taken to route packet from one end of the network to another is naturally expected to be higher in the simulated network.

7. Summary and Recommendation

From the comparative analysis taken from table1 we can see that the percentage of received packet from the simulated network is 95.83% as against 66.67% from the real network. Also a decrease in percentage of packet lost to just 4.17% as against 33.33% shows that the simulated network outperformed the real time computer network. The result of the simulated network of Federal University of Technology Owerri, when implemented will perform better in speed, higher throughput and security. We therefore recommend an upgrade on the network using the simulated network design.

For future work, we recommend the inclusion of networks such as Voice over IP (VoIP), video conferencing, etc. and other features that will aid e-learning in a university.

Table 1: Ping result obtained from the simulated network and a similar real time computer network

REAL TIME NETWORK				**SIMULATED NETWORK**			
Packets sent	Packets Received	Packets Lost	Time (msec)	Packets sent	Packets Received	Packets Lost	Time (msec)
4	0	4	1	4	4	0	10
4	2	2	1	4	3	1	10
4	4	0	1	4	4	0	10
4	2	2	12	4	4	0	10
4	4	0	10	4	4	0	11
4	4	0	13	4	4	0	10
Average	**2.67**	**1.33**	**6.33**	**Average**	**3.83**	**0.17**	**10.16**
%	**66.67%**	**33.33%**		**%**	**95.83%**	**4.17%**	

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