

Network Performance through Virtual Local Area Network (VLAN) Implementation & Enforcement on Network Security for Enterprise

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ABSTRACT

The aim of this paper was to enhance an enterprise network performance through VLAN implementation by simulating an existing LAN and rectify LAN using VLAN at, in two different scenarios. To rectify the drawbacks of existing enterprise network using virtual local area network. To simulate and compare the new (VLAN) and existing (NO_VLAN) enterprise network performance Virtual LAN technology can also be used to mitigate vulnerability surface for hackers by reducing the traffic request to servers, network visualization leads to ease of administration. There were more benefits of network virtualization through the implementation of VLAN. Thus, VLANs improved bandwidth utilization, power, speed and security. However, nowadays the high-speed network makes people to sense that network is a much more powerful tool to enhance in any business enterprise and make the company running more efficient. The main purpose of the network ability in the universities is to support learning, teaching, research and sharing of information. Unfortunately, even though the capacity of the bandwidth considered to be sufficient, the network can appear slow and inconsistent due to some factors like: the poor network design, the number of devices on the network, local network protocols (MAC Protocol) and misuse of the bandwidth by accessing to bandwidth hungry websites and applications (Dhurgham , 2018).

Keywords: VLAN, Network, Enterprises, Security.

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I. BACKGROUND OF THE STUDY

In modern and global world, the importance and added values provided by Network infrastructure is evident whether it is for government entities, business enterprises or educational institutions particularly universities. It contributes to achieve important goals such as more efficiency, productivity, acquire knowledge, collaboration. Increased use of Information technologies in the university requires a robust technical infrastructure and adequate network architecture (Yoloye, 2015). Computer Networking enables modern world to exchange information through an interconnection of systems with the purpose of exchanging information regardless of the locality by implementing certain set of rules which are defined within the system, different systems can connect in various ways to achieve certain objectives (Grandhi, 2014).

Globally, academics including scientists and professors use the internet extensively and this explains why educational institutions were early adopters of the internet (ORIKE, 2017). The strengths of the internet for academic work include currency of online information sources, accessibility to multimedia resources and information that is not limited by distance or time constraints. With improved internet connectivity, academic institutions in developing countries for example USA, China, UK are tapping into the many opportunities offered modern information societies (Neema-Abooki, 2015). The increased use of the internet in worldwide academic institutions means that educational researchers recognize the significance and understand how and why students use it.

In developed countries, LAN infrastructure on majority of the campuses has been upgraded from 100 Mbps to a fully redundant and scalable 1 Gbps backbone (Kezar, 2014). New models are being used to leverage existing

infrastructure, add enhanced services and support the total infrastructure. Many new services have emerged to realize ubiquitous computing environments, owing to the increasing supply of mobile devices and more widespread Internet and wireless network facilities (Kezar, 2014). With an effective availability of network infrastructure, users (students and lecturers) can get the information content whenever they want, in any media, over any facilities, anywhere implying that research and education networks have been established.

In Africa the establishment of Education Networks started later when the universities that introduced or pioneered access to the Internet (using TCP/IP) in South Africa followed by Zambia in the university of Zambia establishing ZAMNET, the country's first ISP and Mozambique by Eduardo Mondlane University (Penard, 2015). According to (Penard, 2015), the lack of appropriate network infrastructure that allows for easy access to information within institutions is a great limitation to the educational system in sub-Saharan countries.

Majority of these higher education institutions have limited access to connectivity due to their obsolete or lack of appropriate network design in place. According to ITU statistics on ICT penetration, while penetration of fixed broadband is growing on an average rate of twelve percent (12%) in developed countries, African stands at a less than half percent. In spite of the fact that the usage of internet resources in lessons preparations and learning is a necessity in improving quality of business, these resources the usage of these resources, the enterprise network resources accessibility. This is due to several barriers that affect usage of the said resources such as: slowness of the internet, network unreliability, lack of consistent technical support, poor network design which limit access to resources and old technology equipment (Adeleke, 2016). The main factors of unreliability, slowness and network congestion in higher education is related to poor network design, misuse of bandwidth and it is based on these that this study will focus on enhancement of enterprise network performance through virtual local area network implementation.

II. STATEMENT OF THE PROBLEM

The world has undergone a technological revolution with the internet and web becoming an important part in lives since it provides many effective services in many fields of life (Walaa , Norah, & Badryah , 2016) A university campus network (Wired and Wireless local area network) is an important instrument for communication and facilitating collaborative research which are key factor to build a strong knowledge culture and efficiently support academic mission (Martinez Rivera, 2015). The implementation of Campus University Network help universities becomes more a collaborative center, which helps achieve their goals and provide development of higher level of knowledge for the students (Rawat, 2016). Reliable internet connectivity has become a prerequisite for universities to provide quality education and undertake

quality research works, despite these considerable investments, some universities continue to find themselves having slow and unreliable network (Akpah, Mireku-Gyimah, & L Aryeh, 2017). However, nowadays the high-speed network makes people to sense that network is a much more powerful tool to enhance in any business enterprise and make the company running more efficient.

The main purpose of the network ability in the universities is to support learning, teaching, research and sharing of information. Unfortunately, even though the capacity of the bandwidth considered to be sufficient, the network can appear slow and inconsistent due to some factors like: the poor network design, the number of devices on the network, local network protocols (MAC Protocol) and misuse of the bandwidth by accessing to bandwidth hungry websites and applications (Dhurgham , 2018). Modern organizations are facing problems related to poor network s design which affects services in many fields that leading the responsible Categories to interested in improving network local area performance by measuring the quality of services for the network (Walaa et al, 2016).

Most universities is facing some challenges Due to inconsistent and slow network, students and staff are being affected for not doing their daily activities for accessing on books, doing their research, sharing information and other resources this brings frustration to both sides as long as the network is down nothing can be done. Université Lumière de Bujumbura is lagging behind poor network design and a lack a virtual local area network to improve the existing network architecture.

To help Université Lumière de Bujumbura solve problems related to poor network performance, a virtual local area network can improve the network performance by restructuring the network infrastructure design, configuration of network devices and network interface capacity. The research was intended to enhance enterprise network performance through virtual local area network implementation that helped to solve the issues related to inconsistent and slow network access at Université Lumière de Bujumbura.

III. CONCEPTUAL REVIEW

The computer network is composed of a computer use and communication facilities, that is, the use of various means of communication, the geographical dispersion of the computer together to achieve mutual communication and sharing software, hardware and data resources and other systems (Yunzhou, Xianglin, & Jianbin, 2018). The computer network according to its computer distribution range is usually divided into local area network and wide area network (Yunzhou, Xianglin, & Jianbin, 2018). Enterprise network or Local area network coverage of the geographical range is small, usually in the number of meters to tens of kilometers (Yunzhou, Xianglin, & Jianbin, 2018). VLAN is a set of users in different isolated logical LANs or broadcasting domains, they are communicated as a same LAN i.e., same broadcasting domain (Dhurgham , 2018). A local area network (LAN)

is a group of computers that are connected together in a small geographic area to communicate with one another through wired or wireless link and share resources such as printers and network storage (Hameed , A; Mian, A N, 2015). A local Area Network can be defined as a group of users or workstations that are located in the same physical area and has the same broadcasting domain (Dhurgham , 2018). the local area network (LAN) is a group of computers and associated devices that share a common communication line or wireless link and typically share the resources of a single processor or server within a limited geographic area (Abid & Yousif, 2016). interconnection of computers and network devices within a geographical area and providing shared access to printers, file servers and other network devices (Grandhi, 2014). A virtual local area network (VLAN) is defined as a local area network configured by software, not by physical wiring (Gyan & Sadhana, 2018). According to Nwaso (2018) A VLAN is a logical grouping of network users and resources connected to administratively defined ports on a switch.

A Local Area Network (LAN) is usually defined as a broadcast domain which means that all connected devices are in the same physical LAN can communicate without the need for a router (Sarah Ali Abdullah, 2016). Virtual LANs (VLANs) which regularly defined as a set of devices on different physical LAN segments which can communicate as if they have a common LAN segment. Switches using VLANs to divide the network into separate broadcast domains without having the latency problems (AL khaffaf & D A J, 2018).

IV. EMPIRICAL REVIEW

According to Dhurgham (2018) tried to Alleviate the end-to-end delay by using the VLAN technology to enhance the network performance, measuring key performance indicators such as traffic sent, traffic received, average delay and throughput by employing OPNET 17.5 Student Version, he found that there is more existing traffic without virtual local area network technology, hence, virtual area networks prohibit access to the network resources of other departments.

The objective of this research was to look at the benefits of network virtualization through the implementation of Virtual Local Area Network using cisco Packet tracer to simulate the network architecture, the network was enhanced when the network broadcast domain is segmented into separate Layer 2 broadcast domains because, if a broadcast is not well contained in a network, it may lead to collision (Isiaka & Akeem , 2015).According to Munam et al (2016) aimed to enhance network performance without incorporating additional hardware cost, OPNET Modeler 14.5 simulator has been used to first implement the entire network infrastructure, observed that the proposed design significantly performs better using VLANs.

The research was interested in improving quality of service using VLAN technology by overcome delay

problem using OPNET simulator the simulated results show how to select a good way in designing network to reduce the value delay for improving the quality of service (Walaet al , 2016).

In 2016 Sarah divided one physical network into multiple broadcast domains where Different scenarios were designed and simulated, step by step procedure using the workspace of OPNET is given, the results obtained show a large reduction in traffic carried by the switch with more secure and efficient bandwidth utilization.

V. OVERVIEW OF ENTERPRISE NETWORK (LAN)

A local area network (LAN) or enterprise network is a group of interconnected computers which inter-operate and allow users to share resources, obviously no more than 1,000 feet of cable. A Local Area Network (LAN) is generally the network of computers located in the same area. Today, Local Area Networks are defined as a single broadcast domain (Jayan & Kshama, 2017).

This means that if a user broadcasts information on enterprise network or Local area network, every user will receive the broadcast. on the Local area broadcasts are prohibited from leaving a Local area network by using a router. The drawback of this technique is for the incoming data routers usually take more time to process compared a switch or to a bridge. More significantly, formation of broadcast domains depends on the physical connection of the devices in the network. VLANs were developed as another solution for using routers to contain broadcast traffic.

The increase in the number of devices on LAN become paramount as we populate the network with more switches and workstations, since most workstations tend to be loaded with existing operating system, it results in unavoidable broadcasts being sent occasionally on the network, Unfortunately, each host on such network cannot escape from the effects generated by such uncontrollable broadcast which decreases network performance (Nweso & al, 2015). A local area network (LAN) is a group of computers that are connected together in a small geographic area to communicate with one another through wired or wireless link and share resources such as printers and network storage (Hameed & A, 2015).

VI. VIRTUAL LAN AND NO_LAN WITH NETWORK PROTOCOLS AND DESIGN

Understanding virtual local area networks, firstly it is essential to have an understanding of local area networks. A Local LAN can normally be defined as a broadcast domain. Hubs, bridges or switches in the same physical segment (s) connect all end node devices. End nodes can communicate with each other without the need for a router. Communications with devices on other LAN segments requires the use of a router.

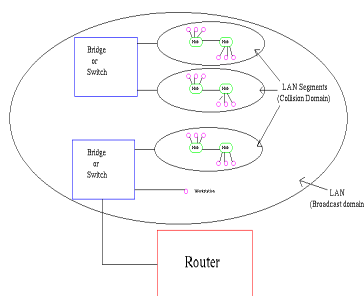


Figure 2-0-1: Physical view of a LAN

Virtual local area networks can be viewed as a group of devices which are on different physical local area network segments which can communicate with each other as if they were all on the same physical LAN segment. Switches using virtual local area networks create the same division of the network into isolated broadcast domains but don't have the latency problems of a router. Switches are equally an extra cost-effective solution.



Figure 2-0-2: Logical View



Figure 2-0-3: Physical and logical view of a VLAN

The most commonly protocol used nowadays to configure Virtual LANs is IEEE 802.1Q. The committee of IEEE defined this technique of multiplexing Virtual LANs in an effort to provide multivendor virtual Local area network support. Previous introduction of the 802.1Q standard, several proprietary protocols existed, such as Cisco's ISL (Inter-Switch Link) and 3Com's VLT (VLAN Trunk). Cisco also implemented VLANs over FDDI by carrying Virtual LAN information in an IEEE 802.10 frame header, opposing to the purpose of the IEEE 802.10 standard.

Both ISL and IEEE 802.1Q tagging is done "explicit tagging" - the frame itself is tagged with Virtual LAN information. ISL uses an external tagging process that does not modify the existing Ethernet frame, while 802.1Q uses a frame-internal field for tagging, and thus does change the Ethernet frame. This internal tagging is what allows IEEE 802.1Q to work on both access and trunk

links: frames are standard Ethernet, and so can be handled by product hardware.

Under IEEE 802.1Q, the maximum number of Virtual LANs on a given Ethernet network is 4,094. This doesn't impose the same limit on the number of IP subnets in such a network, meanwhile a single virtual local area network can contain multiple IP subnets. The VLAN limit is expanded to 16 million with Shortest Path Bridging (Rik, 2014).

Primary network designers frequently configured virtual LANs with the purpose of reducing the size of the collision domain in a large single Ethernet segment and consequently improving performance. When Ethernet switches made this a non-issue in consideration turned to reducing the size of the broadcast domain at the MAC address layer. A virtual LAN can also serve to restrict access to network resources without regard to physical topology of the network, although the strength of this method remains debatable as VLAN hopping (Rik, 2014) is a means of bypassing such security measures. Virtual local area network bouncing can be mitigated with proper switch port configuration.

VII. DRAWBACKS ENTERPRISE NETWORK (LAN)

A local area network is a computer network design approach that aims to reduce cost in terms of administration and maintenance. local area networks are designed to reduce the number of switches and routers on connecting the devices to a single switch computer network instead of separate switches, or by using network hubs rather than switches to connect devices to each other. The topology of a local area network is not separated or segmented into different broadcast areas by using switches and routers. Unlike VLAN design, the network is logically separated into different broadcast domains. Normally, on local area network all devices belong to the same broadcast area. It is believed that if these problems are properly addressed, network performance could be significantly improved.

Wrong choice of routing protocol: RIP is a distance vector protocol which uses only hop count for the best path selection, RIP is configured as routing protocol; however, RIP suffers from many disadvantages such as slow convergence and lost periodic updates.

No access policies: if there are no user access policies enforced which is allowing user to download or upload personal media files during the peak hours, thus causing lack of bandwidth to legitimate user.

Manual Load Balancing: the description of NOC the backup link is only used when the primary internet link fails. So, a manual switching between the ISP links is performed.

No firewall configured: A CISCO firewall is there to protect the network from malicious activities but the

firewall is not configured or installed to protect the network from incoming internet traffic, the network performance can be affected.

Traffic Bottleneck: the major problem which causes local and internet network traffic bottleneck i.e. when the main Cisco 3500 series switch is deployed in NOC is limited to twelve 10/100BaseT Ethernet ports using a fast Ethernet connection (100Mbps). Having 100Mbps network interface at this point of network which redirects internal and external traffic causes traffic bottleneck.

Poor security: It is not possible to segment the networks into sections and prevent users from accessing certain parts of the network Because traffic travels through one switch. unauthorized persons are easier to intercept data on the network.

No redundancy: It is possible for the switch to fail Subsequently when there is usually one switch, or a few devices. the network will become inaccessible and computers may lose connectivity because there is no alternative path.

Scalability and speed: When connecting all the devices to one central switch, either through hubs or directly, increases the possibility for collisions (due to hubs) and also reduce speed at which the data can be transmitted, additional time for the central switch to process the data. It also scales severely and increases the high chance of the network failure.

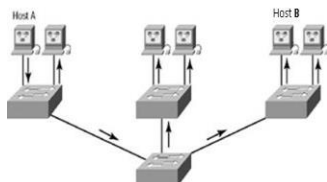


Figure 2-0-4: Broadcast Flow on Flat Network structure

Source: Mega Guide, CCNA 640-802,

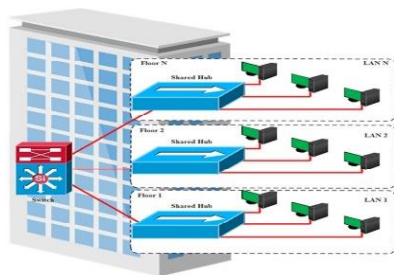


Figure 2-0-5: Traditional LAN Segmentation

VIII. OVERVIEW ON VIRTUAL LOCAL AREA NETWORKS

A virtual LAN is the abstracts design of the LAN; A VLAN might comprise a subset of the ports on a single switch or subsets of ports on multiple switches, By default, systems on one VLAN don't see the traffic associated with systems on other VLANs on the same network (Jayan & Kshama, 2017).

Therefore, for improving network performance and scalability VLANs provide a broadcast control to eliminate unnecessary broadcast traffic. Security allows administrators to implement access lists to control traffic between virtual local area networks by logically separating users and departments.

The VLANs allow a user or device to exit anywhere by removing the physical boundaries of the network. Often user network can be separated from the server network using virtual local area networks. Virtual local area networks technologies in Université lumière de Bujumbura (main campus) Network. Going by the normal flat local area network (LAN) infrastructure where every user belongs to one broadcast domain diverse series of network insecurities exist.

In the case of an enterprise network (LAN) having critical application servers, organizational databases, file servers and other confidential information, this mean that every user on the network would have equal access privileges to these resources.

Segmentation of the existing network into different broadcast domains using VLAN to successfully prevent such situations from operational network by restricting access at all level of network. In contrast to where all hosts are connected without segmentation in usually flat local area network architecture; a large broadcast domain into different sizes of broadcast domains is broken by creating VLANs. VLAN architecture is a logical grouping of network users and resources connected to organizationally defined ports on a switch when deploying in Network would be of enormous benefit as outlined in the work.

In this paper thoroughly show the benefits of VLAN over enterprise network or local area network in managing and maintaining of Networks.

Exactly what a VLAN is and how VLAN memberships are used in a switched network, Membership in a VLAN can be based on port members, MAC addresses, IP addresses, IP multicast addresses and/or a combination of these features, VLANs are cost and time effective, can reduce network traffic, and provide an extra measure of security (Gyan & Sadhana, 2013).

In this research the local area network was studied to better understand and illustrate how VLANs was used in practice to improve the performance. In this study of analyzing the local area network will indicates how VLANs will be used for many objectives that they are not originally intended for the use of VLANs complicates network configuration management.

IX. SECURITY AND PRIVACY

flooding traffic and broadcast also increase privacy and security concerns. Sending extreme broadcast traffic is an effective denial-of-service attack on the network. In adding, a malicious host can purposely overload switch forwarding tables by spoofing many source MAC

addresses forcing switches to flood legitimate traffic that can simply be monitored by the attacking host. ARP is similarly vulnerable to man-in-the-middle attacks, where a malicious host sends unsolicited ARP responses to impersonate another host on the local area network, thereby intercepting all traffic sent to the target. Network administrators can decrease these risks by constraining which users can belong to the same virtual local area network.

X. BENEFITS OF VIRTUAL LOCAL AREA NETWORK

In networking, a local area network has a single broadcast domain and the traffic from a workstation reaches other workstations on the Local Area Network through the broadcast, this is not desirable as certain classified information can be received by unauthorized parties. Also, if the broadcast is not well contained, it can lead to collision in the network (Syed, Joshi, Vikram, & Kuriakose, 2014). Therefore, network administrators normally protect the broadcasts from leaving an enterprise network with the aid of routers.

However, routers are usually taking more time to process the incoming data compared to switches and more expensive. VLAN developed as an alternative solution to using routers to contain broadcast traffic within a local area network. However, for broadcast filtering, employed routers in the virtual local area network topologies and also address summarization for traffic flow management.

A virtual local area network is a switched network that is logically segmented based on features such as service requirement, workgroup and protocol or application requirement rather than on a physical or geographical proximity (Isiaka & Akeem, 2015). With the implementation of VLAN, geographically dispersed workstations, servers and other peripheral devices used by a particular workgroup can be put on the same VLAN and communicate as if they are physically on the same location in the network (Alimi, Mufutau, & Ebinowen, 2015). This enables the network administrators to manage the network without the need for running new cables or making major changes in the network infrastructure (Isiaka et al., 2015). Therefore, virtual local area network is addressing that security, flexibility, scalability and network management issues which are associated with the traditional.

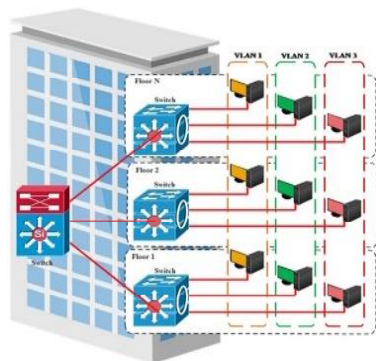


Figure 2-0-6: VLAN based LAN segmentation

Security: Virtual local area networks (VLANs) provide improved network security. In a virtual local network environment, in multiple broadcast domains, the network administrators have control over each port and user. A malicious attacker can no longer just plug their workstation into any switch port and sniff the network.

Creating Workgroups: A group of users that need a remarkably high level of security can be put into its own Virtual local area network so that users outside of that virtual local area network can't communicate with it. This suggests that in an enterprise each department can be made independent from another departments.

Scalability: Network moves, changes and adds are achieved easily by just configuring a port into the appropriate Virtual local area network and assigning hosts to the same Virtual local area network traffic using a packet sniffer. Network administrator controls each port and all resources VLAN is allowed to use. Virtual local area networks help to restrict sensitive traffic originating from an organization department within itself.

Cost effective: eliminating the need for additional expensive network equipment like switch, routers, can be cost savings to an organization. Virtual local area networks can also allow the network to work more efficiently by commanding a better use of bandwidth and resources.

Easy Troubleshooting: VLANs group the network users and resources into different VLANs, can emanate many problems in the network and can easily be identified and fixed by tracing group such hosts where belong to.

Integrity: Users are being logical grouped according to function, virtual local area networks can be considered independent from their geographic or physical locations. Thus, University data can be handled without comprise mostly to the universities that have branches.

Broadcast Control: The management of broadcast network can be controlled by creating many virtual local area networks which always increases the number of broadcast domains while decreasing their size.

XI. VLAN ARCHITECTURE

With the creation of virtual local area networks many problems can be forgotten. In order to create VLANs, a layer 2 switch is needed that can support such protocol (Agwu & al, 2015). A. the misconception of many new people in networking field that it's a matter of just installing additional software on the clients or switch, in order to "enable" VLANs throughout the network, it is completely incorrect. It is not true, rather have virtual local area network enabled switches like cisco catalysts switches for the cisco system. VLANs involve millions of mathematical calculations, they require special hardware which is built into the switch and your switch must therefore support VLANs at the time of purchase,

otherwise you can't create VLANs on it (Nweso & al, 2015). A switch is a separated network on Each VLAN created on. by default, network broadcasts, are filtered from all ports on a switch that are not members of the same virtual local area network. This is the reason why network a virtual local area networks are very important in today's large network, they can help segmentation and poorly design firewalls can extremely compound the problem already caused by these broadcast intensive applications (Ojiugwo & al, 2015). A. Network design presents a lot of new challenges for administrator by using all this new dimension of network design.

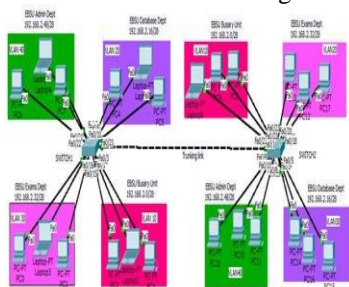


Figure 2-0-7: VLAN Infrastructure

Target population

The target population is the group of individuals that the intervention intends to conduct research in and draw conclusions from (Louise & Nghiem, 2018). the unit of analysis of this research was the staff in the ICT, students, faculty and administration staff at universities. The population of this study were comprised 1864 students and staff, two ICT staff were collected on data using structured interview which were network and system administrators and questionnaires were on students and administration and faculty staff on sample size.

XIV. SAMPLE SIZE

Sample size is a count the of individual samples or observations in any statistical setting, such as a scientific experiment or a public opinion survey (Jon, 2018).The Slovene's formula will be used to determine the minimum sample size of the study of the target population. The sample size will determine by using Slovene's (1960) formula which is as follow:

$$n = \frac{N}{1 + (Ne^2)}$$

n= sample size

N= population size

$$E = \text{level of significance} = e^2 = 0.05 \quad e = (0.05)^2 = 0.0025$$

The sample size from students and staff: it was $1864 / 1 + (1864 * 0.0025) = 329$.

XII. SAMPLE TECHNIQUE

This is a primary concern in statistical sampling, the sample that was obtained from the population was represented the same population. This was accomplished by using purposive non random sampling method.

XIII. DATA ANALYSIS

The choice of qualitative method emphasized on understanding the phenomena and it is verbal more than

being numerical in data collection generally refers to qualities over quantities. data collection is based on analysis rather than a statistical form. It is important to remember pre-existing theory, previous empirical research or own expectations that may influence the choice of a qualitative study.

In order to avoid misunderstandings with the analysis of the interview data and questionnaire data the available recordings were wisely recorded into text. The purpose of recording into text minimized interpretation errors and allowed to conclude afterward.

Additionally, the data that was collected from the interviews and questionnaires was also link in order to make overviews to the body of knowledge to construct theory. the data analysis was an iterative approach, where data collection and analysis were occurred simultaneously in order to remain open to all options. This enables for suggestions of new questions to ask in the interviews.

XV. ETHICAL CONSIDERATIONS

The entire research was conducted due to respect of ethical consideration in research. The research obtained the consent of respondents to participate in the study. ethics are very significant in conduct of research and the way in which research is always under examination. There is a need to make sure succeeding issues are perceived while doing the research. In general, the high degree of openness regarding the purpose and nature of the research was observed in this study.

XVI. INFORMED CONSENT

Informed consent is the major ethical issue in conducting research. According to Armiger (1997) it means that a person knowingly, voluntarily and intelligently, and in a clear and manifest way, gives his consent. Participants will contribute willingly without being forced by the researcher, but agreement was before they can participate in the research. The process was needed for the research to be successful. This research was not threatening the security of the participants in any way whatsoever.

XVIII. DECEPTION

Participants were participated knowingly and willingly; agreement was first happening and everything was explained properly to in detail before the participants did anything in the research.

XIX. ANONYMITY AND CONFIDENTIALITY

The researcher must guarantee the confidentiality and anonymity of the data that was provided by the participants during the research time. the data was used only for the purpose of this particular research only. Protection of the respondents must be there during and after the research study.

XX. RIVERBED MODELER ACADEMIC EDITION 17.5 (OPNET)

OPNET (Optimized Network Engineering Tool) Modeler is a powerful tool which evaluates the network efficiently and accurately and predicts the network behavior before implementation in real environment. OPNET Modeler was selected because most of the wired and wireless network components are available and very important tool for network designing and simulation OPNET modeler is a very powerful for the network modeling and simulation and It is there to optimize efficiency cost, performance, viability and scalability characteristics of the network.

Network simulation is designed for characterizing, creating and validating the communication solutions, computer networks and distributed or parallel systems, it enables predicting network behavior and network performance, one can create, run and analyze any desired communication scenario (Northforge Innovations, 2015).

XVII. IMPLEMENTATION OF ULB ENTERPRISE NETWORK DESIGN INTO RIVERBED MODELER ACADEMIC EDITION (OPNET) 17.5

Implementation of enterprise network was simulated by using Reverbed modeler academic edition 17.5 or OPNET (Optimized Network Engineering Tool), which was used for performance analysis and the implementation of network.

The aim of this research was modelling, configuring and performance analysis of the customized network using riverbed modeler (OPNET). Modeler provided high fidelity modeling, scalable simulation and detailed analysis of a broad range of wired and wireless networks with application traffics. We are going to present the project with the network simulation software Riverbed modeler which is able to efficiently analyze the performance of the protocols and technologies in network infrastructure models of realistic scale.

This section presents the technical setup of an enterprise network which was used to setup the entire network at ULB. In this research, the researcher wanted to find out the difference between the enterprise network performance with VLAN and with no VLAN. This means that enterprise network with VLAN is the independent variable and enterprise network with no VLAN is the dependent variable. As such the implementation in OPNET outlined what happens in enterprise network performance with no VLAN and after VLAN implementation in an enterprise network. This research provides two scenarios, the objective of these scenarios is to compare the performance for enterprise network with VLAN and with no VLAN.

Riverbed modeler academic Edition 17.5 (OPNET) was used to simulate the enterprise network (LAN) and VLAN with different application over the network for comparing the performance of both LAN (NO_VLAN) and VLAN. Two scenarios with VLAN and NO_VLAN

communication were tested, discussed and showed the results in the following subsection.

The following tools that were used in the creation of enterprise network

- Ethernet switch
- Wireless routers and ethernet router
- Nodes/100BaseT_LAN
- Ethernet server
- Links (100BaseT and PPP_28K)
- Ip Cloud
- Firewall
- Application Interface
- Profile interface



Fig 4.6.1 Shows internet tools box in riverbed modeler

XXII. APPLICATION CONFIGURATION PARAMETERS

In Model every object (application, profile, node and server) had a different and specific set of parameters. Generally, application parameter was an application attribute definition that was used to specify the required application among the available applications such as FTP, HTTP, DATABASE. applications attribute that was created to produce the traffic on this ULB network, there were three applications in both scenarios as FTP (File Transfer Protocol), HTTP (Hypertext Transfer Protocol) and DATABASE application. Applications performance was used with both NO_VLAN and VLAN scenarios.

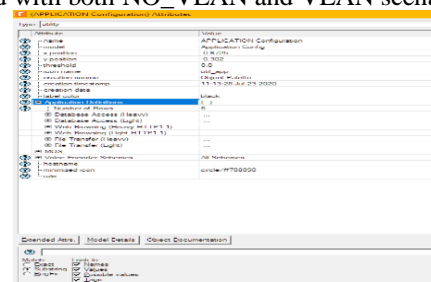


Figure 4-6-3-1: Application configuration

XXI. PROFILE CONFIGURATION PARAMETERS

Profile parameter was used to create user profiles/client, these profiles were specified on different nodes/LANs in the network designed to generate the application traffic, profile configuration described as the activity of application which used by users throughout a time period. Student's clients, Department clients and administration clients were used as profiles on HTTP, FTP, DATABASE as application, they were used in sever (Web, File and Database) parameters respectively to support the services

that being requested by the clients. All profiles were configured to run together to allow more than one application to work at same time.

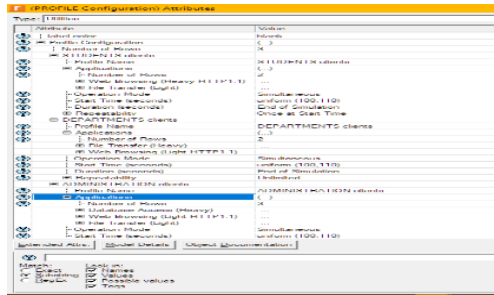


Figure 4-6-3-2: Profile configuration

XXIII. SERVERS CONFIGURATION PARAMETRES

Server parameters in each server supported services that are based on the user profiles that support HTTP, FTP and DATABASE. The profile configuration was defined in clients as students, departments, administration clients, this configuration profiles helps the clients to receive the services from the servers that are being requested by the clients.

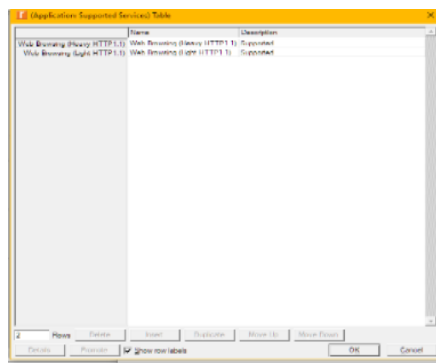


Figure 4-6-3-6: Web server configuration

WEB server was configured to run the HTTP services by right clicking on the server model and choose: edit attributes-application supported services-HTTP server. the web server was running both heavy and light web browsing traffic, this was illustrated in the figure above.

XXIV. GLOBAL STATISTICS SIMULATION RESULTS FOR UNIVERSITIES ENHANCEMENT ENTERPRISE NETWORK WITH NO_VLAN

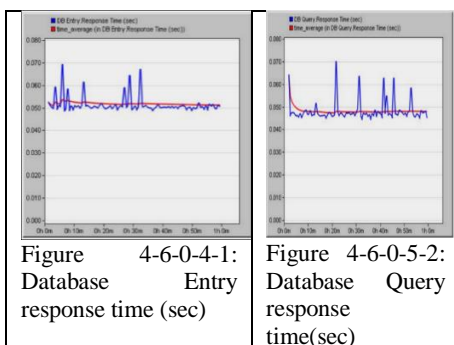


Figure 4-6-0-4-1: Database Entry response time (sec)

Figure 4-6-0-5-2: Database Query response time(sec)

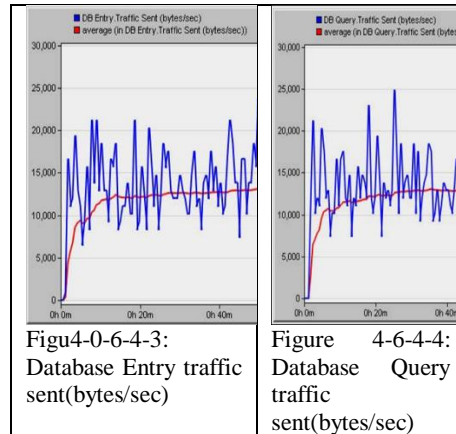


Figure 4-6-4-3: Database Entry traffic sent(bytes/sec)

Figure 4-6-4-4: Database Query traffic sent(bytes/sec)

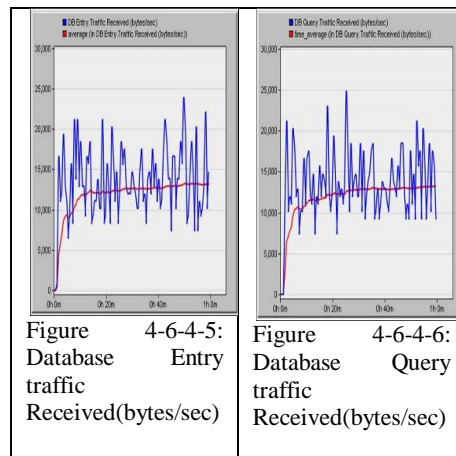


Figure 4-6-4-5: Database Entry traffic Received(bytes/sec)

Figure 4-6-4-6: Database Query traffic Received(bytes/sec)

Global statistics	Minimum	Maximum	Average time
1. DB Entry response time (sec)	0.0485985 062868	0.0694791 734469	0.051194583 4623
2. DB Query response time(sec)	0.0444101 892368	0.0701269 191489	0.047952866 3348
3. DB Entry traffic sent(bytes/sec)	0.0	24,035.555 5556	13,164.08888 89
4. DB Query traffic sent(bytes/sec)	0.0	24,960	13,182.57777 78
5. DB Entry traffic Received (bytes/sec)	0.0	24,035.555 5556	13,164.08888 89
6. DB Query traffic Received(bytes/sec)	0.0	24,960	13,182.57777 78

Table 4-6-4-1: Database entry and query with NO_VLAN global statistic data

In this table explain the simulation results of global statistics at enterprise network, it showed that traffic sent and received in database query and entry were the same but the response time for database entry and query were

different. In database entry response time, the minimum and average time results were higher than database query response time, but maximum database query response time was higher than the entry response time.

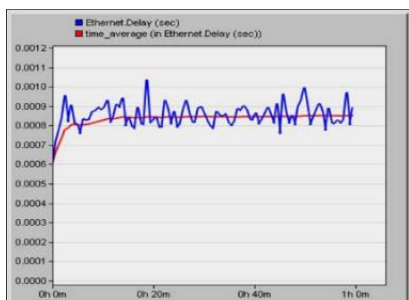


Figure 4-6-4-7: Ethernet Delay (sec)

Global statistics	Minimum	Maximum	Average time
7. Ethernet delay (sec)	0.00060685468432	0.00103659364566	0.000850873310869

Table 4-6-4-2: Ethernet delay with NO_VLAN global statistic data

This Table 4.6.4.2 showed the global statistics simulation results of enterprise network performance for all applications on this entire network. the red curve showed average time delay and the blue curve showed the ethernet delay which is measured in second, the ethernet delay showed the performance of the time delay of the global statistics for ULB enterprise network.

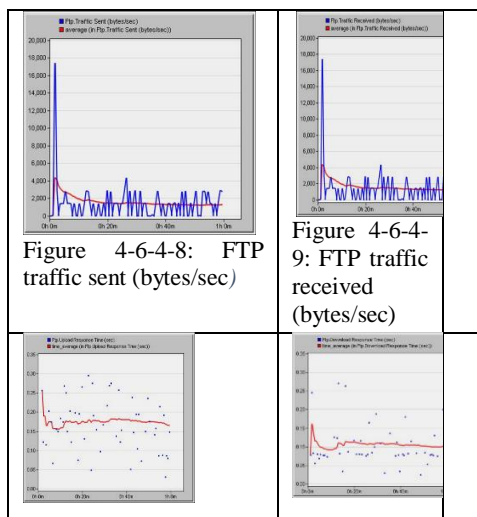


Figure 4-6-4-8: FTP traffic sent (bytes/sec)

Figure 4-6-4-9: FTP traffic received (bytes/sec)

Figure 4-6-4-10: FTP download response time(sec)
 Figure 4-6-4-11: FTP upload response time(sec)

Global statistics	Minimum	Maximum	Average time
8. FTP traffic sent (bytes/sec)	0.0	17,408.2222222	1,280.93777778
9. FTP traffic received (bytes/sec)	0.0	17,408.2222222	1,280.93777778
10. FTP download response time(sec)	0.0253783996459	0.270075329652	0.10090825247
11. FTP upload response time(sec)	0.0308728549885	0.295512491191	0.165057092442

Table 4-6-4-3: FTP global statistic data with NO_VLAN

Global statistics results presented in Table 4.5.4.3 traffic sent and received (bytes/ sec) showed the same results in the minimum, maximum and average for both sent and received traffic. However, FTP upload response time (sec) took higher response time than FTP download response time.

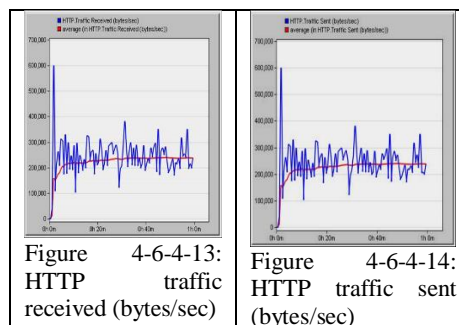


Figure 4-6-4-13: HTTP traffic received (bytes/sec)

Figure 4-6-4-14: HTTP traffic sent (bytes/sec)

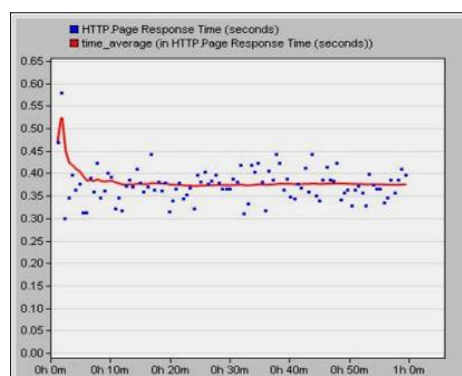


Figure 4-6-4-12: HTTP page response time(sec)

Global statistics	Minimum	Maximum	Average time
12. HTTP page response time(sec)	0.2999696 19033	0.5786711 87558	0.374898135245
13. HTTP traffic received (bytes/sec)	0.0	599,544.4 7222222	237,261.350555 56
14. HTTP traffic sent (bytes/sec)	0.0	599,626.5 8333333	237,663.2819444 44

Table 4-6-4-4: HTTP with NO_VLAN global statistics data

In this Table 4.6.4.4 the global statistics simulation results of the hypertext transfer protocol page response time (sec) from minimum to maximum has taken almost twice time of the response time. The traffic sent (bytes/sec) was higher than traffic received in HTTP and traffic received and sent has almost the same simulation statistic data, they were all started form zero.

XXV. OBJECT STATISTICS SIMULATION RESULTS FOR ENHANCEMENT ENTERPRISE NETWORK WITH NO_VLAN

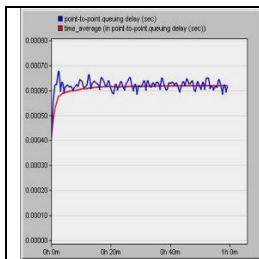


Figure 4-6-5-1: Students queuing delay (sec) →

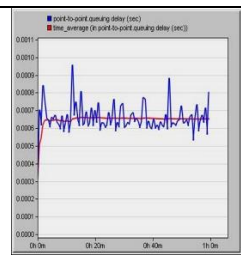


Figure 4-6-5-2: Departments queuing delay (sec) →

Object statistics	Minimum	Maximum	Average time
1. Students queuing delay (sec)→	0.0004060 39687747	0.000678808 086534	0.00061822399 6928
2. Departments queuing delay (sec)→	0.0003075 75550157	0.000957151 456589	0.00065245362 3063
3. Administration queuing delay (sec)→	0.0003548 9299559	0.001820034 52083	0.00123289451 776

Table 4-6-5-1: Queuing delay → (forwarded traffic) object statistics data

In the object statistics for the outgoing data students queuing delay took much minimum time on the entire network followed by administration queuing delay and last the departments subnetwork queuing delay, however the administration subnetwork has higher queuing delay, the next is departments subnetwork and students has the lower queuing delay than the rest. Therefore, average queuing delay time is respectively as the previews of maximum queuing delay, start with administration, departments and students queuing delay.

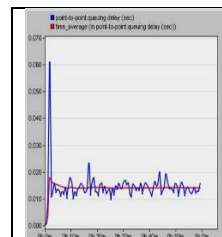


Figure 4-6-5-4: Students queuing delay (sec) ←

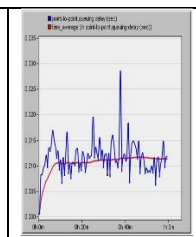


Figure 4-6-5-5: Departments queuing delay (sec) ←

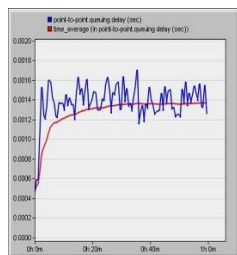


Figure 4-6-5-3: Administration queuing delay (sec)→

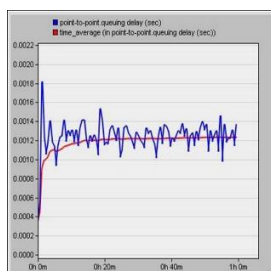


Figure 4-6-5-6: Administration queuing delay (sec) ←

Object statistics	Minimum	Maximum	Average time
4 Students queuing delay (sec)←	0.0004150 82581562	0.06116034 29427	0.014055816 9895
5 Departments queuing delay (sec)←	0.0004979 26177654	0.02863416 56191	0.011311225 3334
6 Administration queuing delay (sec)←	0.0004617 76637034	0.00170705 905103	0.001368600 7295

Table 4-6-5-6: Queuing delay ← (received traffic) object statistics data for NO_VLAN

For the incoming data for the object statistics data, the departments queuing delay had the highest minimum time, the administration queuing delay came the second for the higher number and the last is students queuing delay for incoming or received statistics data. For the maximum students queuing delay took much time followed by departments queuing delay and the lowest maximum queuing delay were for administration, but the average time object statistics data the students took much average time than the others. The departments had the second higher and the lowest was the administration queuing delay time, once there is much data traffic on maximum object statistics there should be a queuing delay is higher.

CONCLUSION

Findings show that on average, respondents said they were unsatisfied with enterprise network performance (NO_VLAN) as the mean average lied in the interval 1.81-2.60. Furthermore, standard deviation (SD) was used to gauge the level of consistence of the satisfaction and responses. It was found out that the respondents were not consistent as the standard deviation was above 1. This simply means that on average, the respondents were unsatisfied with universities enterprise network performance.

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