TELKOMNIKA, Vol.16, No.2, April 2018, pp. 803~810
ISSN: 1693-6930, accredited **A** by DIKTI, Decree No: 58/DIKTI/Kep/2013
DOI: 10.12928/TELKOMNIKA.v16i2.8461

Design and Analysis of a Broadcast Network Using Logical Segmentation

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Abstract

This study shows how the network performance of a flat switch network in the main library complex of Ambrose Ali University (AAU), Ekpoma can greatly be improved by logical segmentation. A survey of the flat switch network of the library complex was carried out to ascertain the physical and logical topology of the network and the number of hosts and network devices available. The kind of traffic transmitted over the network was also considered. Riverbed Modeler Academic Edition was used to simulate two replicas of the library network. One of the simulated networks was logically segmented by implementing Virtual Local Area Network (VLAN). Statistics like traffic dropped, traffic forwarded, traffic received, broadcast traffic dropped and traffic sent in bits/sec or packets/sec were collected from both simulations and the results were analyzed and compared. The results from the simulations showed that the application of VLAN immensely enhanced the network performance by about 75%(depending on the size of the network) because the logical segmentation increased the number of broadcast domain while reducing each of the broadcast size. This further implied that poor network design and large broadcast domain in a network, gravely affect the performance of a network.

Keywords*: broadcast domain; collision domain; logical segmentation; flat switch network; improved performance*

1. Introduction

As computer network grows in a campus environment, management of dozens, hundreds, or even thousands of computers become increasingly difficult. On a large, flat (Single Broadcast Domain), switched network, performance suffers and security concerns increases [1]. By default, switches forward broadcasts from one network to another. Consider a situation where you have 8 different devices connected to a switch. Since switches always forward broadcasts to all clients on the network even though the message is intended for one client, the network traffic is flooded, as the number of devices connected to the switch increases, the amount of bandwidth used by unnecessary broadcasts increases [2]. One way to structure a growing network is to divide it into segments called Virtual Local Area Networks, or VLANs. Computers of users who work together (workgroups) can be grouped into the same VLANs, even though they are not located in close physical proximity. Often organizations create separate VLANs for different departments or divisions [3]. The VLAN serves as a security boundary and improves performance by isolating broadcast and multicast traffic [4]. If users are grouped into multiple departments, there is no need for users not in their department to receive these broadcasts. Preventing those broadcasts from reaching unnecessary users can save a large amount of bandwidth [5]. Perhaps for security purposes, each department needs to be kept separate on the switch, such that the clients' systems in each department are not reachable from ports in other departments. VLANs allow this kind of logical grouping. Layer 2 switches will forward frames between ports in the same VLAN, but will not do so between ports not in the same VLAN [6].

By putting users whose jobs require constant use of the network to interact with a particular server on the same VLAN segment with the servers to which they need access [7] will prevent other users on separate VLANs from having their network transactions with other

Received December 31, 2017; Revised January 17, 2018; Accepted February 3, 2018

servers impacted by the high-usage users. Their network performance won't suffer, and the performance of the high-usage users will also improve. This important and useful arrangement is absent in AAU network, hence the need for this work [8]

2. Measurement Site/Environment

The library complex which covers about 25,000m2 of total usable area is some kilometers from the University Press. The building houses the Main Library, Socket Works, and ICT Center. The entire network topology spans these three departments [9]. Socket Works has the primary function of managing and maintaining the university's network. They are in charge of installation, troubleshooting, repairs and maintenance of the entire network. There are about ten workstations in the department, which includes servers and clients [10]. The Information Communication Technology (ICT) centre has the primary function of managing and maintaining the university's portal. They are also in charge of managing students' online registration and post-UTME registration [11]. There are about seven workstations in the department. The Main library comprises of the online (e-library) and the offline library. The offline library maintains an organized collection of printed materials such as manuscripts, books, newspapers, and magazines that is made available for users' access. With the online or e-library, staff and students can carry out research in various fields of learning. The center is also used to conduct UTME exams. The networks of the three departments are designed with Cat 5e Ethernet cables and are all in one broadcast domain. Each of the departments has at least a server making resources available on the network [12]. The services they make available includes internet services, print services, files and sharing services etc. The Operating Systems running on the servers are Microsoft, Linux or UNIX server OS. The client Operating Systems are either Windows XP, 7 or 8.

3. Statistics Used To Investigate Network Performance

To obtain useful results specific statistics were used to generate this information. These statistics were collected after running the simulation. Statistics could either be collected from individual nodes in the network (object statistics) or from the entire network as a whole (global statistics) [13]. In order to get more detailed results, object statics were obtained. Information about both networks with and without VLANs was obtained. Each of the simulations was run over a period of an hour. Due to large number of workstations in the e-library department, statistics were collected from the main switch of the department for both simulations. The following were the statistics collected

a. Traffic Dropped: This is the total traffic in bits/sec that are received but not forwarded by the switch because the destination host is unreachable [14]
b. Traffic Forwarded: This is the total traffic that is received and forwarded by the switch to the appropriate destination in bits/sec or packet/sec [15].
c. Traffic Received: This is the total traffic received in bits/sec or packet/sec by a specific output queue of a specific port of the node for enqueuing and forwarding. The queue may not be able to accept all this traffic for enqueuing since its buffer may be full at the arrival of some of the traffic. It is also the amount of traffic received in bits/sec per VLAN. This statistic doesn't include any VLAN traffic that is filtered (dropped) at the input port due to ingress rules [16]
d. Broadcast Traffic Dropped: This is the number of broadcast packets dropped by the switch in bits/sec or packet/sec. The switch applies VLAN rules to discard packets, i.e. a packet is dropped when it doesn't belong to the same VLAN as its destination [17].
e. Traffic Sent: This is the total traffic sent which can be expressed in bits/sec or packet/sec per VLAN. It could also be referred to as the throughput. That is, the total amount of traffic sent or received per time [17].

4. Simulation/Measurement Software

Riverbed Modeler provides you with a modeling and simulation environment for designing Communication protocols and network equipment. Network technology designers that use Modeler gain a better understanding of design trade-offs earlier in the product development process. This reduces the need for time-intensive and expensive hardware prototyping. Riverbed Modeler Academic Edition is a limited-feature version for educational users who want to utilize simulation software for networking classes. Riverbed Modeler Academic Edition incorporates tools for all phases of a study, including model design; simulation, data collection, and data analysis. Simulations in Modeler are run by representing real world devices as nodes and links. Modeler provides an environment on which attributes of these nodes and links can be configured and used as inputs in the simulation run, after which results are analyzed. When creating a new network model, you must first create a new project and scenario. A project is a group of related scenarios that each explores a different aspect of the network. Projects can contain multiple scenarios. A scenario can then be edited in the project editor where subnets, nodes, links, utilities, and application traffic can be included for the simulation study [17].

5. Simulation of the Library Complex Topology

The entire network topology is a switched network with one large broadcast domain. A simulated replica of the network is shown in Figure 1. Each department consists of switches, clients, servers and computer accessories.

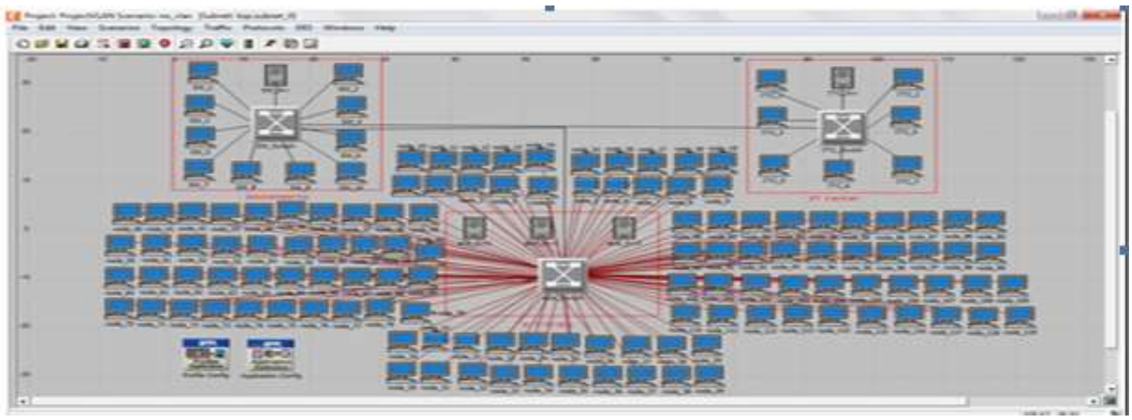

Figure 1. Simulation of the main library network

In Figure 1 each department are connected through their switches with Cat5e Ethernet cables. With this flat network design, if any host sends broadcast requesting for a specific resource, every host in the network receives the broadcast but only one with the resource responds with a unicast to the host that sent the broadcast. Figure 2 shows the kind of network traffic simulated across the entire network.

6. Simulations of the Improved Switch Network

Applying VLAN to the flat network didn't change the physical topology of the network. The effect of the VLAN was the logical grouping of host in each department. Three VLANs were created for each of the department. The VLANs created were VLAN10, VLAN20 and VLAN30 for Socket Works, ICT Centre and e-library department respectively. These three VLANs were all created in all the three switches in the three departments. This made it possible for all the hosts in a particular VLAN to be in the same broadcast domain with the other host in the same VLAN across the three switches in all the departments. With this kind of configuration, a host belonging to the e-library department will still be able to receive or send broadcast to the other host in that department irrespective of its physical location so long as it is still within VLAN30. The improvement on the switched network is presented in the succeeding chapter.

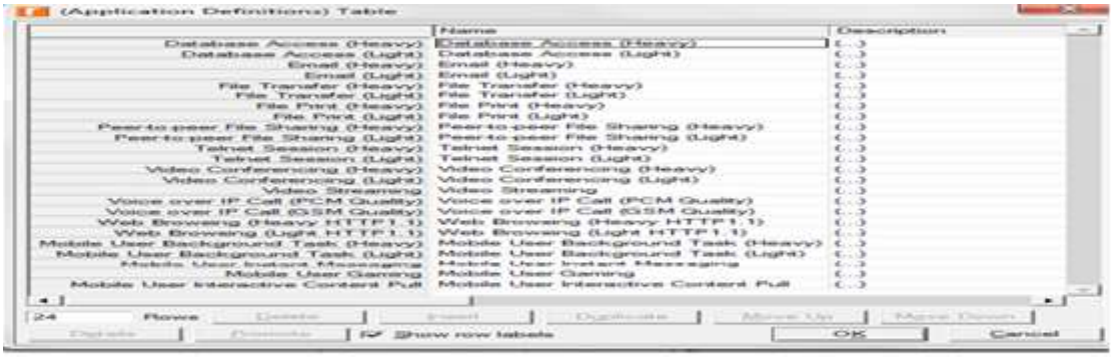

Figure 2. Traffic simulated across the network

7. Results and Discussion

Because of the large number of workstation in the e-library department, readings were taken from the main switch at the department. The following graphs show how the presence of VLAN immensely improved the performance of the network. Figure 3(a) and Figure 3(b) below shows the graphs of traffic dropped in packets/sec by the main switch at the e-library respectively before and after VLAN was applied. The graphs show the amount of traffic dropped within a period of time for both scenarios. From the graphs, it is obvious that no traffic was dropped by both scenarios, hence both graphs were blank. The reason for this is, under normal circumstances both networks would allow the flow of traffic to their respective destinations.

Figure 3(a). Traffic dropped (packets/sec) in the switch without VLAN

Figure 3(b) Traffic dropped (pockets/sec) in the switch with VLAN

Figure 4 shows the graphs of traffic forwarded in bits/sec by the main switch at the e-Library before and after VLAN was applied, the graph reveals the amount of traffic forwarded from the switch over a period of time. It can be seen from Figure 4(a) that high amount of traffic was forwarded as compared to Figure 4(b). The reason for the low amount of traffic forwarded in Figure 4(b) is because the VLAN logically grouped the forwarded traffic into the three existing VLANs. The graph only shows the traffic forwarded by VLAN30 in the switch. This logical grouping drastically reduced the high traffic by creating more broadcast domains with smaller broadcast size.

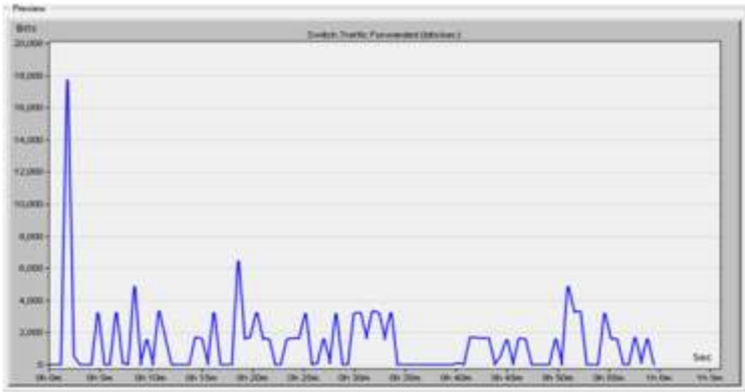

Figure 4(a) Traffic forwarded (bits/sec) in the switch without VLAN

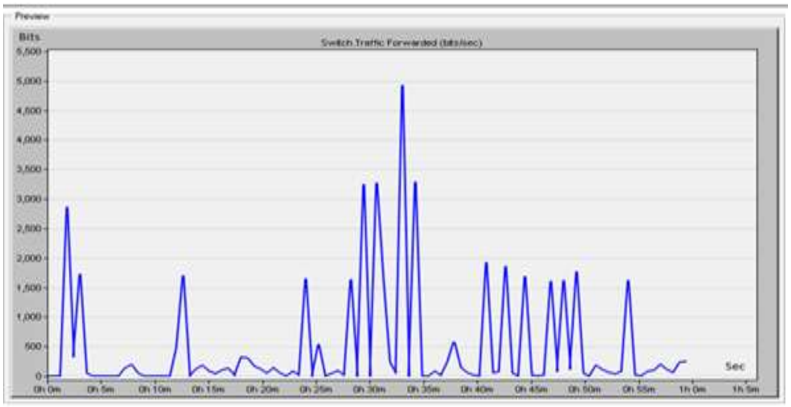

Figure 4(b) Traffic forwarded (bits/sec) in the switch with VLAN

Figure 5a and Figure 5b respectively shows the graphs of traffic received in bits/sec by the main switch at the e-library before and after VLAN has been applied. This received traffic can also be refers to as throughput, which represents the average number of bits successfully received per unit time. Again, from the figure, it can be seen that Figure 5(b) which has VLAN applied has lesser throughput. This is because all the traffic received has been logically grouped into the three VLANs. The Through put shown on the graph is the traffic received by one of the VLAN in the switch. The logical grouping or segmentation prevented the flooding of the entire switch with all the traffic as in the case of Figure.5(a) which has no VLAN applied. Figure 5(a) has high throughput in the entire switch due to the absence of the logical Segmentation by VLAN.

Figure 6 is a graph showing broadcast traffic dropped in the main switch at the e-library. The graph shows the amount of broadcast traffic dropped in the switch. From the graph it is clearly seen that no broadcast dropped over the period of time. Again, this is so because the VLAN prevented inter VLAN broadcast and confined the broadcast separately within the three VLANs. Though inter-VLAN broadcast was not allowed, inter-VLAV traffic still existed between each VLAN.

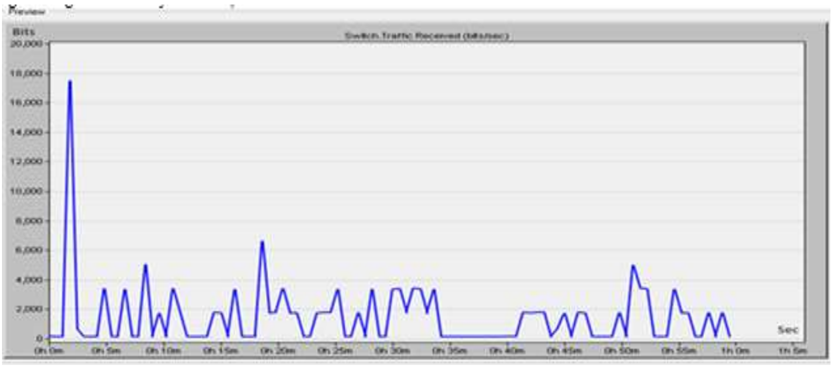

Figure 5(a). Traffic received (bits/sec) in the switch without VLAN

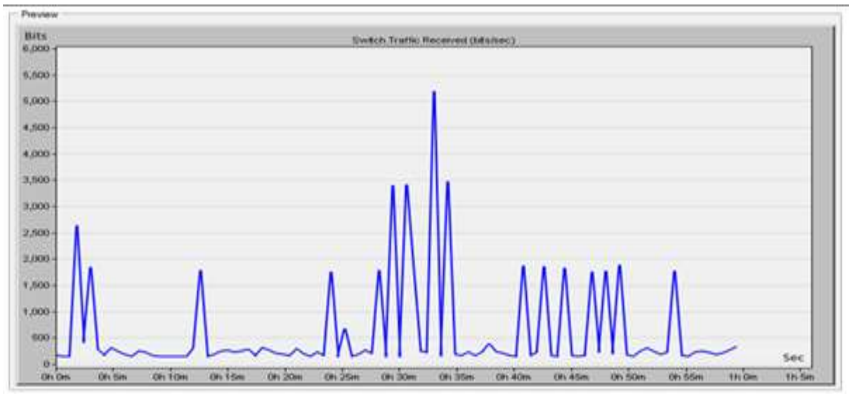

Figure 5(b) Traffic received (bits/sec) in the switch with VLAN

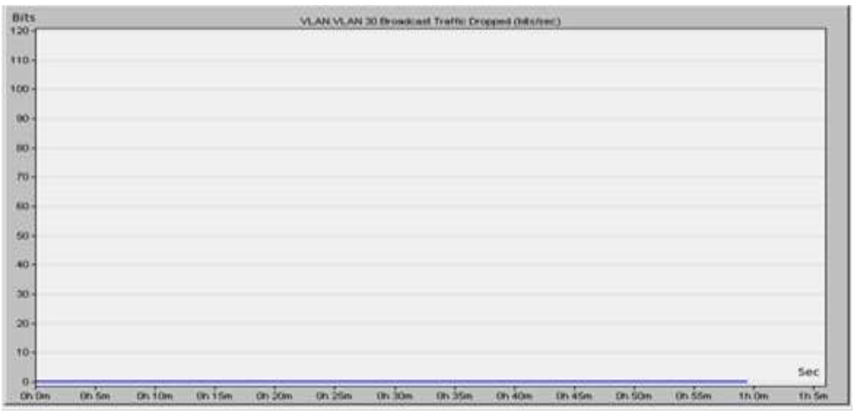

Figure 6. Broadcast traffic dropped (bits/sec) in the switch with VLAN

Figure 7 shows traffic dropped in the main switch at the e-library. The figure shows the amount of traffic dropped by the switch. These are traffic with unknown or unreachable destination. This is very important because this kind of traffic could either be security threat to individual host on the network or to the entire network

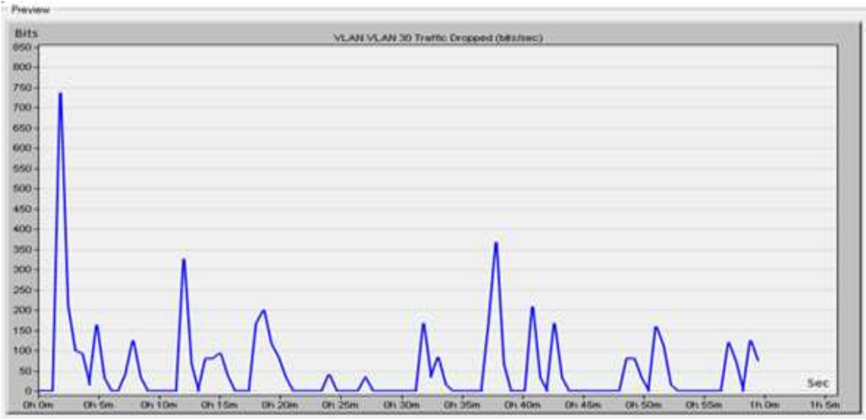

Figure 7. Traffic dropped (bits/sec) in the switch with VLAN

8. Conclusion

This work has shown that though increase of bandwidth, network restructuring, reducing the number of workstations in the network, increasing the number of network devices or upgrading them, are some of the ways network congestion that can result to low network performance can be controlled. Logical network segmentation has been seen to be one of the best and seamless methods of improving the network performance of AAU main library complex. This is so because it had the list amount of cost implementation like the purchase of additional devices, installation or migration of workstation from one location to another. Hence instead of physically moving the workstations to another switch or department, it was much easier and quicker to move them by implementing VLAN. It logically segmented the original AAU flat network design into three VLANS thereby reducing the broadcast domain which initially resulted to network congestion.

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