DEVELOPMENT OF A ROBUST VIRTUAL LOCAL AREA NETWORK (VLAN) FOR COMMERCIAL BANKS

Ikedi Anyalewechi[a], B.C. Asiegbu[b], Charles Ikerionwui [c], E.C. Amadi[d], Chinenye C. Oparai[e]

[a,,b,c,d]*Department of Information Technology, School of Computing and Infromation Technology, Federal University of Technology Owerri.*
[e]*Department of Computer Science, Godfery Okoye University Enugu.*
[a]*ikedi.anya@yahoo.com*

Abstract

The banking industry continues to be vulnerable to network security breaches caused by the red team (network sniffers or hackers) due to the adoption of the star network topology. A robust Virtual Local Area Network (VLAN) can help reduce the menace caused by the red team. In this paper, a robust VLAN was developed using VLAN technology for commercial banks. The implementation was simulated using packer tracer 7.0; a cisco network simulation tool. Prototype development methodology was adopted. The performance indicators used to measure the effectiveness of proposed network are; security, flexibility, network performance, network cost and network management. The proposed VLAN network successfully overcame the bottlenecks posed by the existing network platform. To improve security, flexibility, to reduce the network cost, to improve the network management, network performance, and the network scalability of computer networks, it is very important to employ an effective and efficient computer network method such as the one (Robust VLAN) used in this project. The result from the research showed that the proposed system has a 0% loss at TTL of 127 with average speed within the range of 6-19m/s which gives a good network performance. Therefore, banking industries, and financial organizations in Nigeria should implement this robust Vlan for Quality of Service (QoS) and as well for efficient computer Network.

Keywords: Cisco Network Simulation, Packet Tracer, Virtual Loca Area Network (VLAN);

1. Introduction

Local Area Network (LAN) is known as a branch of computer network which covers a small area or location such as hospitals, homes or offices. It transmits higher data rate due to its area of coverage and also requires less telecommunication facilities.

On the other hand, Virtual Local Area Network (VLAN) is the logical grouping of resources and Network connected to a network in order to adequately define the operations of active ports on a particular network. (Bassey D.E 2016). VLAN is a switch network technology that enables workstations or devices from different LAN segments logically grouped together regardless of their geographical location. Local Area Network (LAN) are relatively low cost means of sharing expensive resources. LANs allows multiple users in a relatively small geographic area to exchange files and messages and to access shared resources such as files services. LAN have rapidly evolved into support systems that are critical to communication within an organization. Commercial banks have a major role in the economic development of Nigeria (Ama, R.M., & Bennetto, H. P, 2011). They are the major financial intermediaries between the sources of funds and the users of funds, and in order for them to carry out their roles; they depend on application of IT to all aspect of banking. Therefore, commercial banks in Nigeria have embedded the culture of technology for efficiency. Information and data transfer within banks and their branches nationwide is possible by the application of specific IT application and networks. Several area of application have made LAN became increasingly congested and overburdened, due to several factors, switching technology evolved, which offers a solution to these challenges. In contrast to the networks of yesterday that were based on collapsed backbones, today's network design is characterized by a flatter architecture which was made possible by the use of switches. The addition of switches to networks can provide a means to maximize the speed and efficiency of LANs by reducing congestion and increasing bandwidth and maximizes the overall performance of the network (Kuma et al. 2013). However, by default, switches breakup collision domains and not broadcast domain (only routers break up broadcast domains by default) so, in other to break up broadcast domains in a pure switched internetwork like the bank network we have to create a Virtual Local Area Networks (VLANs).

When we create VLANs, we have given the ability to create smaller broadcast domains within a layer 2 switched internetworks by assigning different ports on the switch to different sub networks. A VLAN is treated like its own subnet or broadcast domain, meaning that frames broadcast onto the network are only switched between the ports logically grouped within the same VLAN, by default hosts in a specific VLAN cannot communicate with hosts that are members of another VLAN. So, if the bank want inter –VLAN communication a router will needed. Virtual LANs can be created using switches.

2. Literature Review

In a study published by Meier (2010) on capability of VLANs on dynamic end-host behaviors was based on VLAN technology incorporating GVRP registrations, enabling dynamic creation of VLANs in the network. This work explains the behavior of VLANs in wireless end-host roaming in the network with dynamic exhibition of GVRP properties. On the other hand, Sun, and Rao (2011) surveyed four campuses' network to better understand and illustrate how VLANs are used in practice. Their analysis showed that VLANs are used for many objectives that they were not intended for, and are often ill-suited for the task. They also asserted that the use of VLANs complicates network configuration management and believed that future enterprise networks should look at ways to minimize the use of VLANs and explore more direct ways to achieve the network administrator's objectives with the goal of making management easier for campuses and enterprise administrators. They also argued that VLANs are ill-suited for some areas it was applied, for example they said VLANs are often used to realize access control policies, but constrain the types of policies that can be expressed, but they did not suggest a better option to VLAN. Zhai, Long, Zhong, and Cui (2012) designed a VLAN communication experiment with virtual demonstration mode to solve the problem of VLAN communication experiment, one of the most important teaching difficult points computer network technology causes Their work breaks the barrier of traditional experiment. It did not only show the process of experiment with reality, lifelines, and intuition but also supplies a kind of virtual learning environment for experiments. In another work by Odi, Nwogbaga, and Ojiugwo (2013) adequately discussed the need of implementing Virtual Local Area Network (VLAN) and Inter-VLAN routing technologies in Ebonyi state University network, in contrast to manually flat LAN architecture, where every hosts are connected without segmentation. Odi, Nwogbaga, and Ojiugwo (2013) broke a large broadcast domain by creating Virtual Local Area Network (VLAN) which was deployed in Ebonyi state university network and made great impact to their work by exhaustively showing the benefits of VLAN and inter-vlan routing in managing and maintaining Ebonyi state university networks. But Verma (2013) in his work showed the security measures that arise due to inter-VLAN communication both locally and remotely, and issues in using VTP in an enterprise network. Solutions proposed to secure inter-VLAN communication and to address VTP issues using simulated network configuration. They proposed an access-list based security on layer 3 to prevent unauthorized access to different VLANS and security solutions due to VLAN hopping attacks by deactivating the native VLAN 1 which is the root cause of such type of attacks. They concluded by asserting that for secured remote administration the management VLAN should not have to be the same as the native VLAN or default VLAN. Absar, Alam, and Ahmed, (2014) in their work (Performance Study of Star Topology in Small Internetworks) studied the performance of star topology in small internetwork. Simulation was performed in their work using OPNET IT GURU Academic edition simulator. They analyzed the network performance using several simulation graphs and their result shows that shows that the server load of a small internetwork (star networks) is dependent on the simulation time and number of nodes. Moreover, Reddy Kamal TejaGurramkonda (2015) investigated the performance of VLAN and an API of SDN in the context of establishing dynamic link, in switching set up for the purpose of comparing the dynamic behavior of the both protocols in layer-2 context by measuring the network level performance metrics of each protocol. It was therefore observed that Open Flow resulted in performing relatively better when compared to dynamic VLANs. On the other hand, the analytical study on the two protocol reflects the simplicity exhibited by dVLANs over Openflow. In another work by Ali, Hossain and Parvez (2015) proposed the design and implementation of a secure campus network. They suggested the use of VLANs to achieve increased bandwidth and for better network performance and better security of campus network and reducing broadcast in their work. *Prasad,* Reddy, Amarnath, and Puthanial (2016) In their work determined the communication between different Virtual-LANS and to learn more about VLAN Trunking and its operations. In their research, they configured INTER-VLAN routing to connect different VLANs in a network using some of the routing protocol, such as RIP and OSPF in order to secure connections in an organization using a single network. Finally, In a study by (Al-khaffaf, 2018) analyzed and evaluate the performance of LAN and VLAN networks in different scenarios. Measuring key performance indicators such as traffic sent, traffic received, average delay and throughput. The simulation was carried out by employing OPNET 17.5 Student Version. Two different scenarios are presented to observe the performance of LAN and VLAN networks. The simulation results illustrated that there is more existing traffic without VLAN technology. Hence, VLANs prohibit the access to the network resources of other departments. Also, VLAN has half average queuing delay compared with no VLAN scenario. Therefore, VLANs can improve bandwidth utilization, power, speed and security.

3. Analysis and Design

In this work, analysis of existing Commercial Banks in Nigeria such as Access Bank, Citibank, Diamond Bank, Eco bank, Fidelity Bank, First Bank, First City Monument Bank, Guaranty Trust Bank, Heritage Bank Plc, Skye Bank Plc, Sterling Bank, Union Bank, United Bank for Africa, Wema Bank and Zenith Bank were carried out. These commercial banks are core users of computer network technology (centralized network architecture – star topology network) for business processes. Based on the analysis of the existing system, a control matrix assessment evaluation was used to determine the gab in the existing system using the information retrieved from experts in these commercial banks as illustrated in table 1 below:

Table 1: Control Matrix Assessment for Existing System

Performance Indicator	Extremely Low	Low	Neutral	High	Very High	Rank
Likert scale Grade	**1**	**2**	**3**	**4**	**5**	
Security	5	62	37	11	9	**2**
Flexibility	9	58	26	18	13	**2**
Scalability	8	49	30	25	12	**2**
Network Performance	4	51	35	24	10	**2**
Network Cost	9	46	31	23	15	**2**
Network Management	5	60	28	20	11	**2**

From the assessment, the performance indicators is identified as weak by the information consumers and the independent experts (IC, and IE) are: Security, Flexibility, Scalability, Network Performance, Network Cost, and Network Management. Hence, the proposed system is aimed at improving the weaknesses of the existing system. The Data flow diagram of the proposed system shows and orderly flow of information and steps to develop a robust VLAN for these commercial banks as illustrated in figure 1 below:

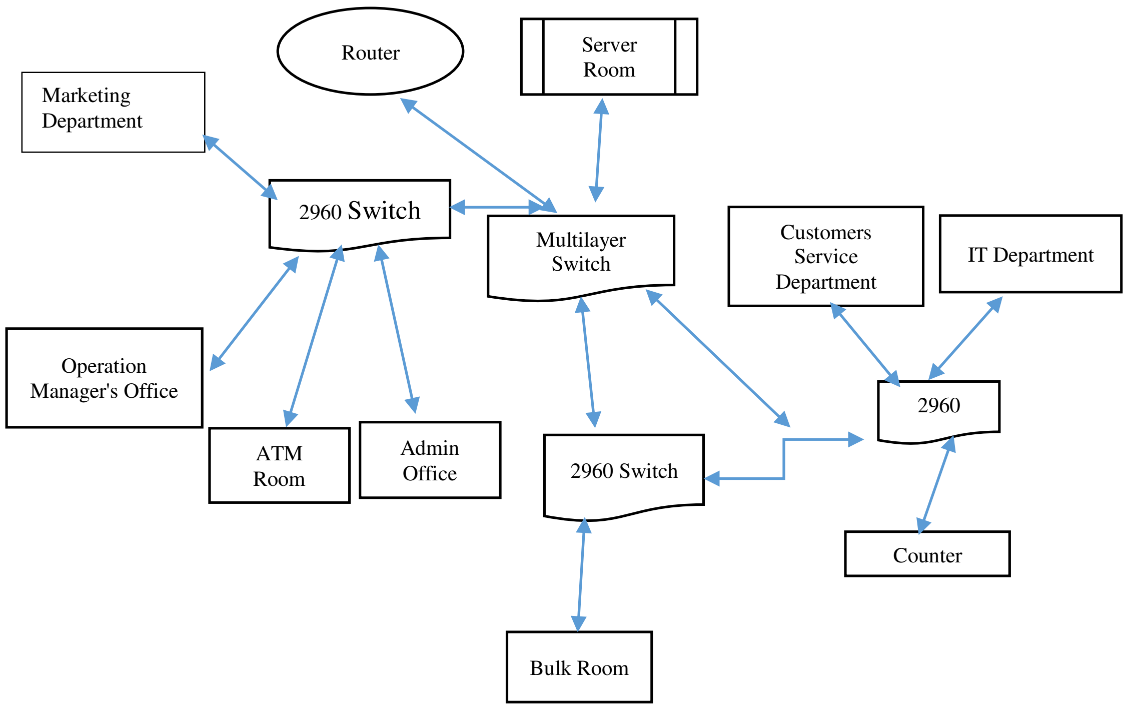


Fig 1. Data Flow Diagram of the Proposed System

The flow diagram shows a well structural flow of different functional modules and phases of the system as follows.

- Broadcast Control : Broadcasts are required for normal functioning of a network, many protocols and applications depend on broadcast communication to function properly .A layer 2 switched network is a single broadcast domain and broadcast can reach the network segment which are too far where a particular broadcast has no scope and consume available network bandwidth, in this stage A router(layer 3) device is used to segment a broadcast domain and the large LAN was segmented to smaller VLANS thereby reducing broadcast traffic as each broadcast will send to a relevant Vlan only.

- Enhanced Security: The second phase has to do with enhancing a network security such that malicious users can no longer just plug their workstation into a switch port and sniff the network using packet sniffer. This is achieved in this stage by creating broadcast domain such that administrators can have control over each port and users.

- Physical Layer Transparency: This stage Vlans are transparent on the physical topology and medium over which the network is connected.

- Virtual Workgroup: In this phase, data flows such that it is easier to place members of a workgroup together, without VLAN the only way this would be possible is to physically move the members of the workgroup closer, the design shows that members in each Vlan can communicated with another number in a different physical location, bridging gap of physically grouping staffs together.

3.1. Architectural Diagram of the Proposed System

The system has graphical user interfaces (GUI) which consist of the input / output designs as well as the command line interface (CLI) for the inputting of IP addresses on the various network nodes and the configuration of essential network utilities (Access-list, Clans, routing protocols etc). The system architecture consists of four different Vlans (The marketing department, ATM Room, and Administrative office belongs to the first Vlan, the bulk room belongs to the second Vlan, the customer service department, IT department and counter belongs to the third Vlan, and finally the server room belongs to the fourth Vlan. Connectivity amongst network nodes in the four different Vlans is assured and as such there is effective sharing and managing of resources. The figure 2 shows the system architecture of the proposed system.

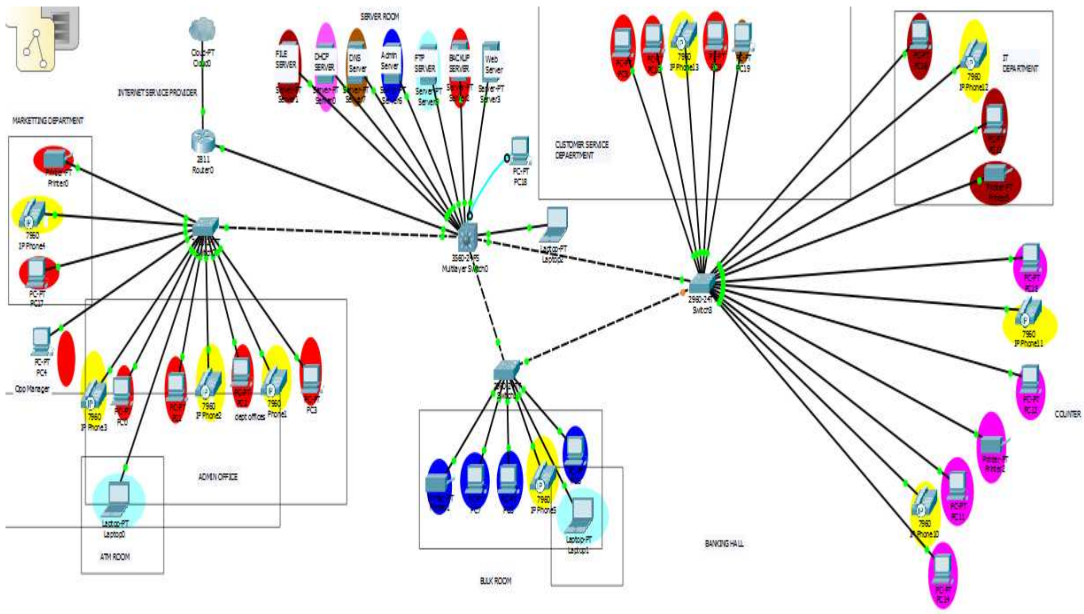


Figure 2. Architectural Diagram of the Proposed System

IP Addressing Scheme

Based on the total number of nodes for the departments, a Variable Length Subnet Mask is computed for each department to accommodate the nodes.

Table 2. Number of nodes per category

Categories	Number of nodes
Admin	7
Operations	11
Marketing	6
Customer Care	5
ATM Machine	3
Voice	9

The information on table 1 above, a class c Internet Protocol Address is chosen as described by the Internet Assigning Network Address (IANA). The chosen class C ip address is 192.168.0.0/24, which would be sub netted in order to create a network address for each of the various VLANS.

Table 3. Variable length subnet mask

Name	Subnet Address	Subnet Mask	Valid Host Range	Broadcast Address
Voice	192.168.0.0	255.255.255.240	192.168.0.1- **192.168.0**-14	192.168.0.15
Operations	192.168.0.16	255.255.255.240	192.168.0.17- **192.168.0.30**	192.168.0.31
Customer care	192.168.0.32	255.255.255.240	192.168.0.33- **192.168.0.46**	192.168.0.47
Marketing	192.168.0.48	255.255.255.240	192.168.049- **192.168.0.62**	192.168.0.63
Admin	192.168.0.68	255.255.255.240	192.168.0.65- **192.168.0.78**	192.168.0.79
ATM Machine	192.168.0.80	255.255.255.240	192.168.0.81- 192.168.0.86	192.168.0.87

3.2 Input Specification of the Proposed System

A. *Input Field for Printer Configuration*

This input field is used to enter configuration settings for the printers zero (0), one (1), and two (2). The input field for printer configuration is shown in figure 2a and figure 2b respectively:

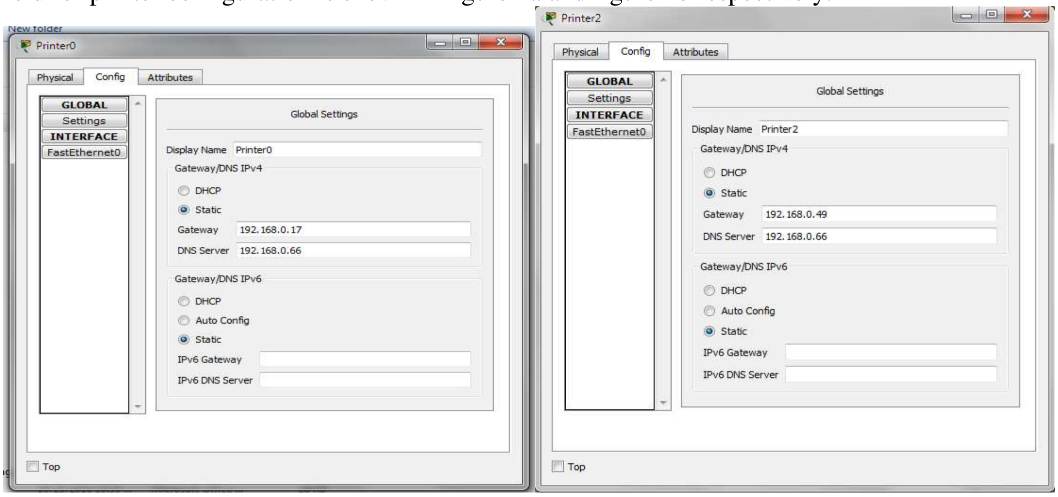


Figure 2a: Input field for printer 0 and printer 1

B. *Input Field for internet protocol phone configuration*

This input field is used to enter configuration settings for internet protocol phone one (1), two (2) and three (3) respectively. The input field for internet protocol phone configuration is shown in figure. 3a, 3b and figure c respectively.

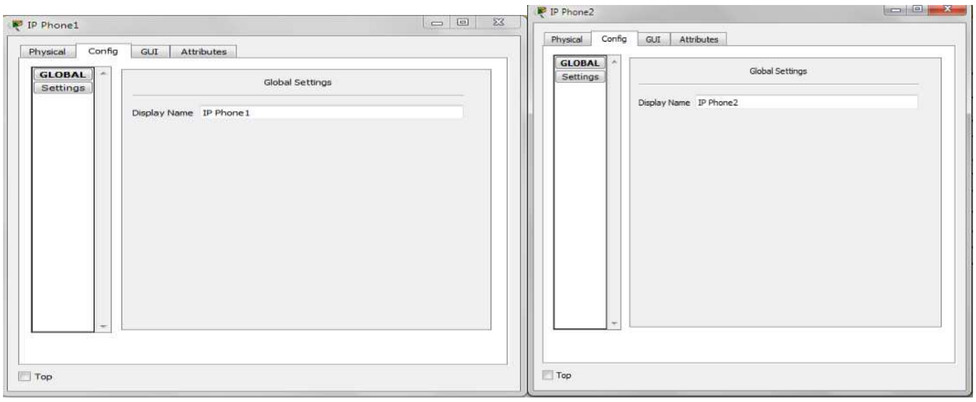
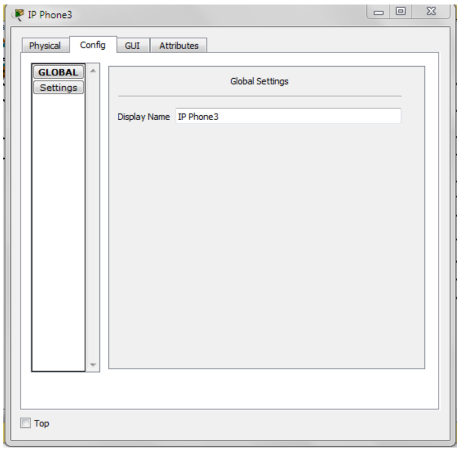


Figure 4a: Input Field for IP phone 1. Figure 4b: Input Field for IP phone 2



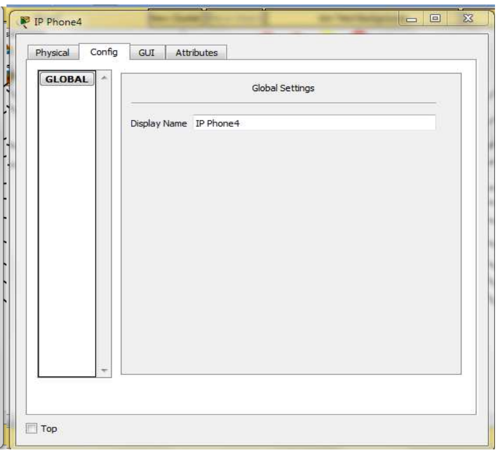
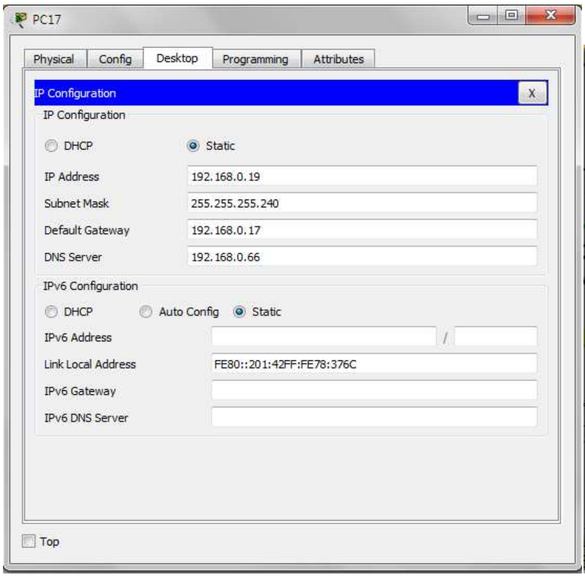


Figure 4c: Input Field for IP phone 3. Figure 4d: Input Field for IP phone 4

C. IP Configuration Interface

The IP Configuration interface is used to enter IP addresses for configuration of the personal computers. The IP Configuration interface of the marketing department, ATM Room, Administrative office, Bulk Room, Customer Service department, Counter and IT department are shown in figure. 5a, 5b, 5c, 5d, 5e, 5f, and 5g respectively.



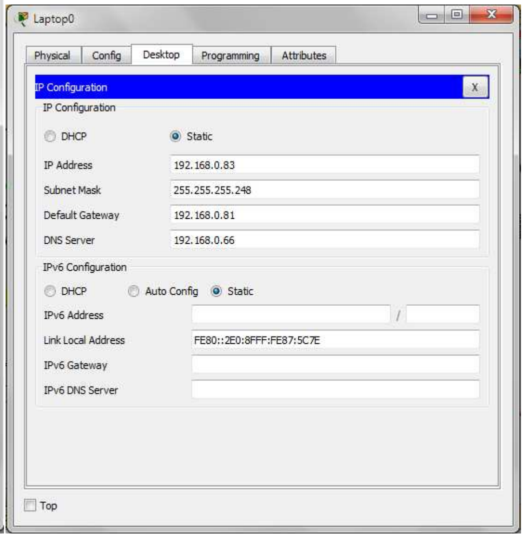
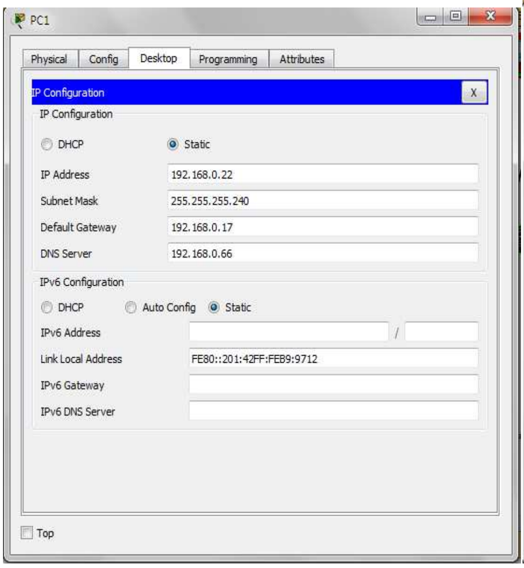


Figure 5a: Marketing Department. Figure. 5b: ATM Room

International Journal of Research Publications
ISSN: 2708-3578 (Online)



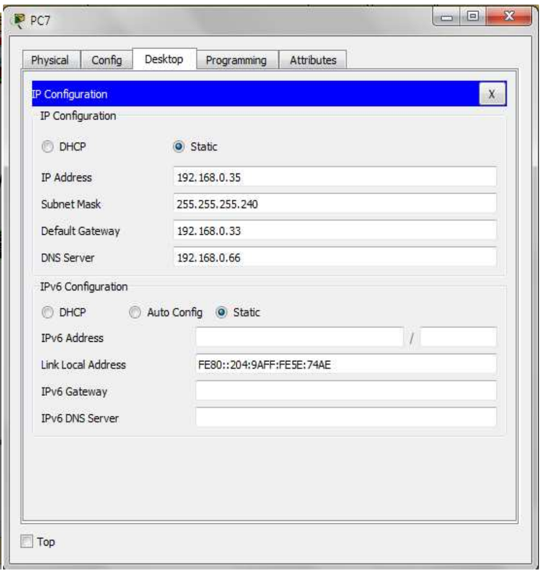
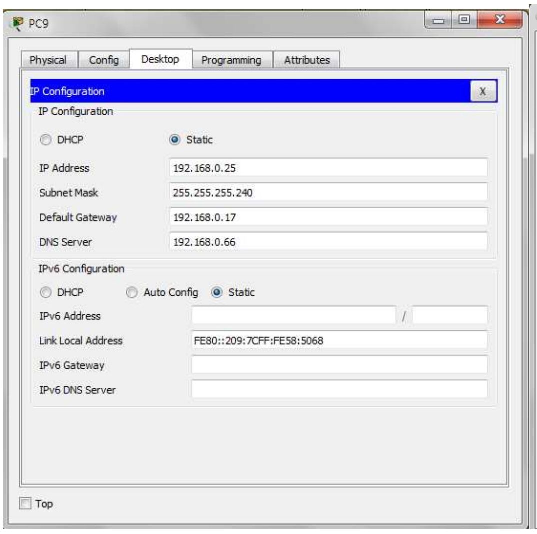


Figure 5c: Administrative office.

Figure 5d: Bulk Room



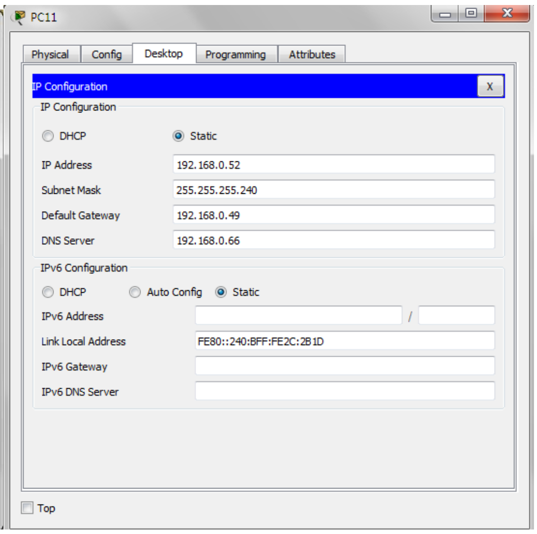


Figure 5e: Customer Service Department.

Figure 5f Counter

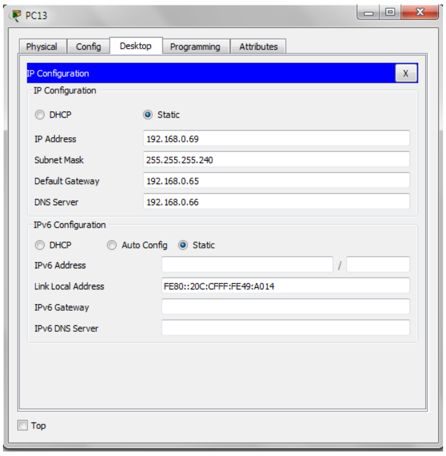


Figure 5g: IT Department

3.2. Output Design Specification

This module is used to convey information to the users. The output design screenshots are shown as follows:

A. Privilege Mode for Multilayer Switch 0

The privilege mode for multilayer switch 0 shows the configuration information of the multilayer switch.

.

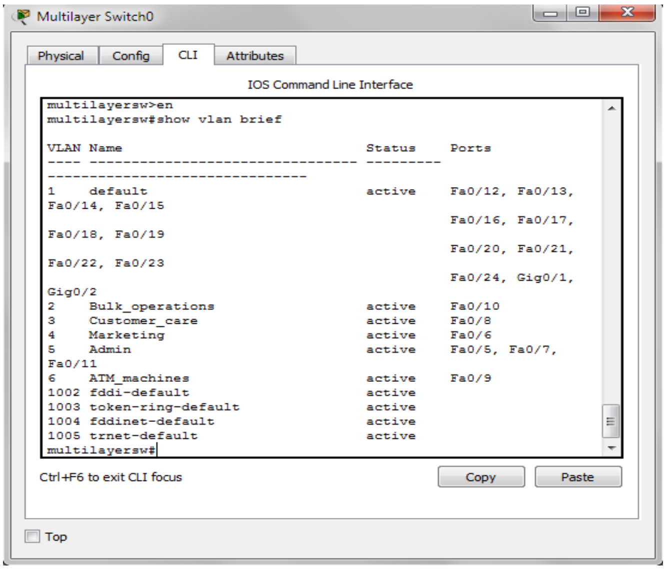


Figure 6: Privilege Mode for Multilayer Switch

4. Results and Discussion

The results of the new system was evaluated and tested using both Unit Testing for each Personal Computers (PC), System Testing and Router Testing. These results of each test was collated and illustrated in a table.

4.1 Unit Testing

The individual network nodes of the various department in the bank were tested to verify if they achieve the goal of successful network connectivity. A network node is said to have achieved successful network connectivity when it does receive an acknowledgement from the network node it pinged. The unit testing of these modules were shown in figure 7a, 7b, 7c, 7d and 7e respectively and they all show an acknowledgement from the respective network nodes they intend to communicate with. The successful testing results for the Operation Manager and the computer in the counter section of the bank was represented PC4 and PC14 as shown in figure 7a and 7b below;

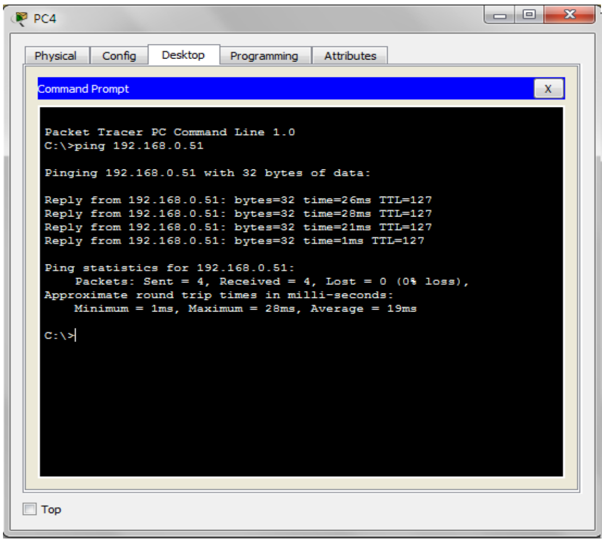


Figure 7a: Personal Computer 4

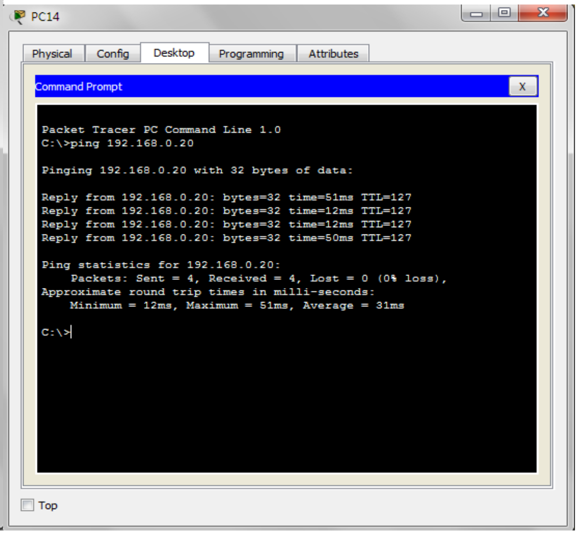
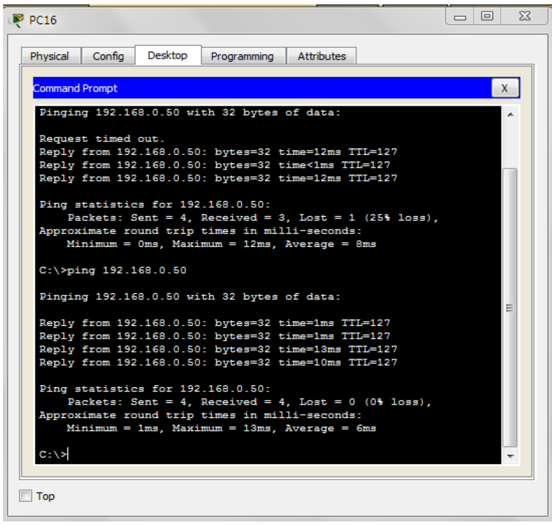


Figure 7b: Personal Computer 14

Personal computer 16 and Laptop 0 is one of the computers in the IT department and the ATM room of the bank. They were individually tested as regards to network connectivity and it was successful. The test result is shown in figure 7c and 7d respectively.



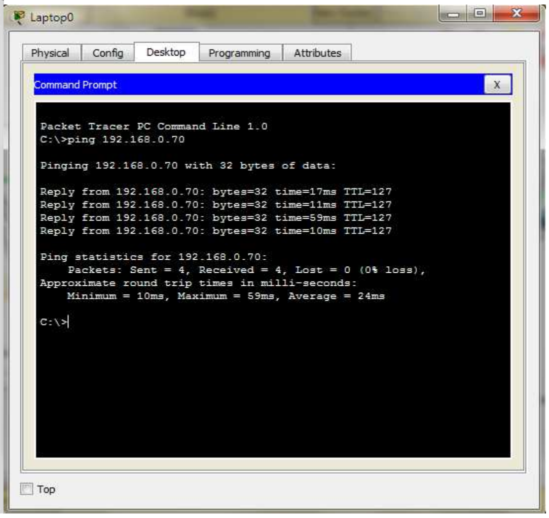


Figure 7c: Personal Computer 16

Figure 7c: Laptop 0

4.2 System Testing

The entire computer network as a whole was tested to verify if the proposed computer network meet the intended expectations. The proposed network system is said to have passed the system test when it gives immediate network responses without timing out. The system testing is shown in the figures.

A. Router Connectivity to ATM Room

The router which is the network access point, when tested showed a successful network ping (connectivity) with the network node in the ATM room. The successful ping result is shown in figure 8a

IJRP.ORG
International Journal of Research Publications
ISSN: 2708-3578 (Online)

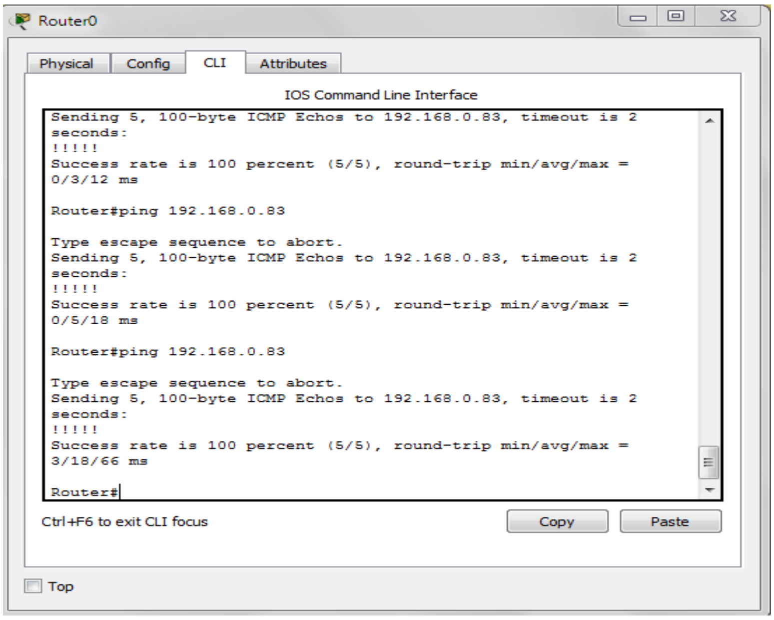


Figure 8a: Router Connectivity to ATM Room

B. Connecting To Administrative Department

The router which is the network access point, when tested showed a successful network ping (connectivity) with the network nodes in administrative department. The successful ping result is shown in figure 4.8b.

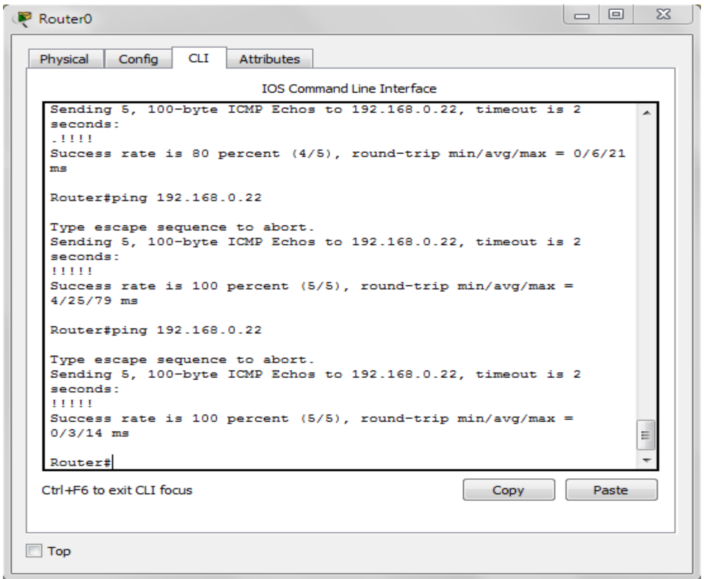


Fig. 8b: Router connecting to Administrative Department

*C. Router Connecting to Marketing **Department***

The router which is the network access point, when tested showed a successful network ping (connectivity) with the network nodes in the marketing department. The successful ping result is shown in figure 8c.

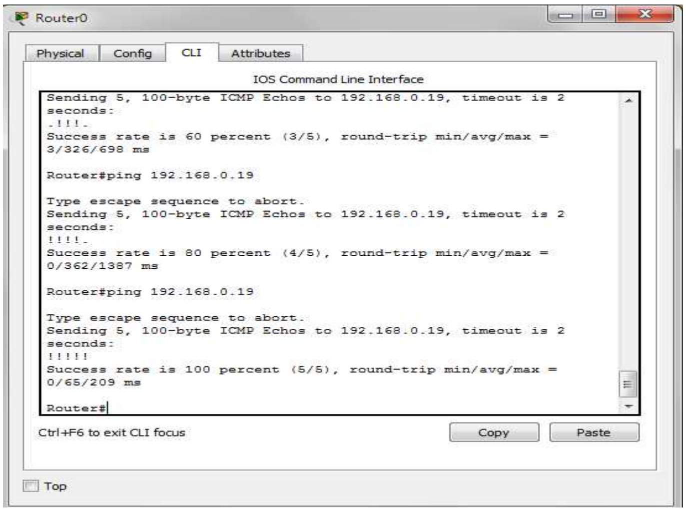


Figure. 8c: Router Connecting to Marketing Department

D. Router Connecting to Bulk Room

The router which is the network access point, when tested showed a successful network ping (connectivity) with the network nodes in the bulk room. The successful ping result is shown in figure 4.8d.

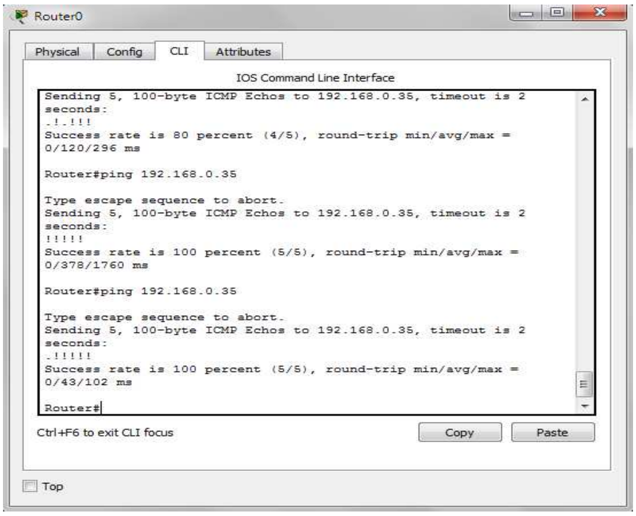


Figure 8d: Router Connecting to Bulk room

IJRP.ORG
International Journal of Research Publications
ISSN: 2708-3578 (Online)

E. Router Counter

The router which is the network access point, when tested showed a successful network ping (connectivity) with the network nodes in the counter section of the bank. The successful ping result is shown in figure 8e.

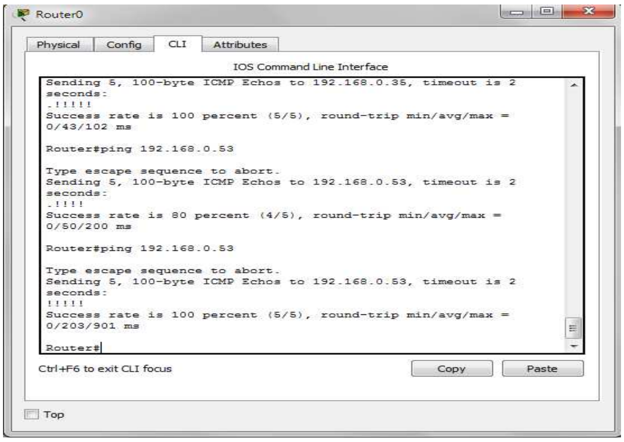


Figure 8e: Router Connecting to Counter

F. Router Connecting to Bulk Room

The router which is the network access point, when tested showed a successful network ping (connectivity) with the network nodes in the IT department. The successful ping result is shown in figure 8f.

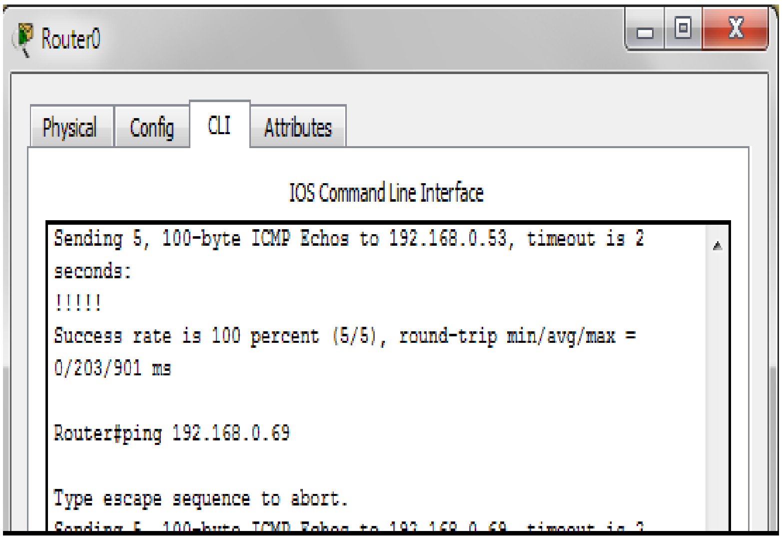


Figure 8f: Router Connecting to IT Department

G. Router Connecting to Bulk Room

The router which is the network access point, when tested showed a successful network ping (connectivity) with the network nodes in the Customer Service department. The successful ping result is shown in figure 8g.

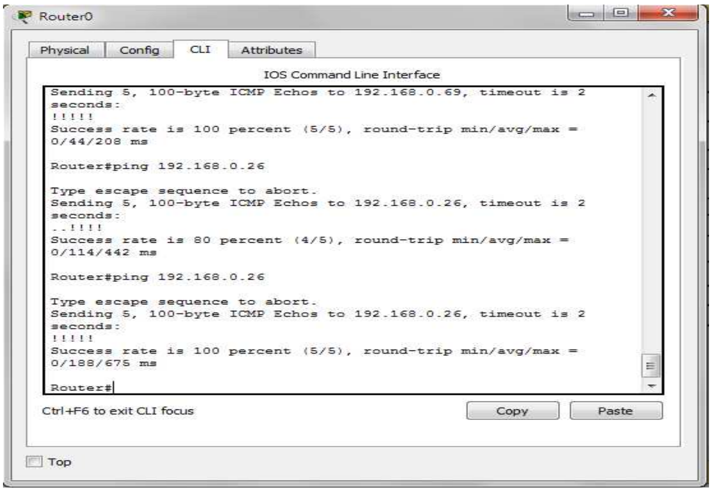


Figure 8g: Router connecting to Customer Service Department

Table 4. Simulation Result

DEPTS	NO OF NODS	AVERAGE SPEED	TIME TO LIVE	CONECTIVITY	FIGS	VLAN
Admin	7	14m/S	127-0%Loss	Active	4.2	Vlan6 Tick Red
Operation	11	19m/S	127-0%Loss	Active	4.3	Vlan5 Red
Marketing	6	15m/S	127-0%Loss	Active	4.5	Vlan4 Blue
Customer Care	5	13m/S	127-0%Loss	Active	4.6	Vlan 3 Pink
ATM MACHINS	3	6M/S	127-0%LOSS	Active	4.7	VLAN2 LIGHT GREEN
Voice	9	16m/S	127-0%Loss	Active	4.8	Vlan 1 Orange Color

4.3 Assessment Measurement of the New System

The new system was evaluated and assessed by the independent experts and Information Consumers. With respect to the evaluation and assessment, a third questionnaire was developed. The control matrix of the result from the evaluation is shown in Table 5.

Table 5. Evaluation of the New System

Performance Indicator	Extremely Low	Low	Neutral	High	Very High	Rank	Judgement
Likert scaleGrade	1	2	3	4	5		
Security	2	5	7	12	19	5	Strong
Flexibility	1	3	5	14	22	5	Strong
Scalability	0	1	8	10	26	5	Strong
Network Performance	2	4	6	13	20	5	Strong
Network Cost	1	3	9	11	21	5	Strong
Network Management	1	4	7	15	18	5	Strong

The proposed system has been thorough in addressing the weaknesses of the existing system. The following are the strength of the proposed system which are weaknesses (Odi, Nwogbaga and Ojiugwo, 2013; Absar, Alan and Ahmed, 2014; Ali, Hossain and Parvez, 2015; Tambe, 2015; Prasad, Reddy, Amaranth, and Puthanial, 2016; Zeng, Qi and Cheng, 2017) in the existing system. They include:

i. Broadcast Control: Broadcast is important for a computer network to function properly. However, broadcast consumes more network bandwidth. The proposed system segments a large LAN to smaller VLANs and as such reduce broadcast traffic.

ii. Security: The proposed system provides enhanced network security. With multiple broadcast domains, network administrators have control over each port and user. A malicious user can no longer just plug their workstation into any switch port and sniff the network traffic using a packet sniffer.

iii. Reduced Cost: The proposed system segmented a large VLAN to smaller VLANs which is very cost effective when compared to the existing system.

iv. Flexibility: The proposed system has improved flexibility when compared to the existing system.

v. Formation of Virtual Workgroup: With the proposed system it is easier to place members of a workgroup together. Without VLAN's, the only way this would be possible is to physically move all the members of the workgroup closer together and that method being used in the existing system.

5. Conclusion

In this study, the identified performance indicators of the system was assessed and evaluated using the Expert Judgment method and the findings shows that the six (6) performance indicators evaluated on the new system were weak. These includes; security, flexibility, scalability, network performance, network cost, and network management. This led to the development of the proposed system (Robust virtual local area network for commercial banks) which proved to be more effective and efficient than the existing system. The enhanced virtual local area network for commercial banks achieved a higher security, flexibility, scalability, network performance, network cost, and network management. The financial analysis yielded a positive Net Present Value (NPV) and a very impressive Return on Investment (ROI). The result from the design of this network also showed that the proposed system has a 0% loss at TTL of 127 with average speed within the range of 6-19m/s which indicates a good network performance. Therefore, banking industries, and financial organizations in Nigeria should adopt this design for a robust Vlan for Quality of Service (QoS) and as well for efficient computer Network. Also in future research, a more robust VLAN with better security and flexibility can be introduced to control further Networks in other areas such as Institutions and Government bodies for a better service and more efficiency in the Network.

References

Jiang Y. et al. (2006). “Mutual authentication and key exchange protocols for roaming services in wireless mobile networks,” IEEE Transactions on Wireless Communications, vol. 5, no. 9, pp. 2569-2577.

Stalling W. (2010). Cryptography and network security: Principles and Practices, Third Edition, NJ: PrenticeCHall.

Agwu C. et. al..(2013). The Proposed Roles of VLAN and Inter-VLAN Routing in Effective Distribution of Network Services in Ebonyi State University. International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Alimi, A. and Mufutau, A. O. (2015). "Enhancement of Network Performance of an Enterprises Network with VLAN," vol. 1, no. 2, pp. 82-93, 2015.

Allan, David, Bragg, and Nigel .(2012). 802.1aq Shortest Path Bridging Design and Evolution: The Architects' Perspective. New York: Wiley. ISBN 978-1-118-14866-2.

Bizfluent.(2017). The Use of Computers in Banking Industries.

Blomberg. (2018). Company Overview of Citibank Nigeria Limited. https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=46884443

Citrix. (2010). Load balancing – Vlan Method. retrieved from https://www.citrix.com/blogs/2010/09/09/load-balancing-vlan-method/

Dmitry Gurendo.(2015). Software Development Life Cycle (SDLC). Spiral Model. https://xbsoftware.com/blog/software-development-life-cycle-spiral-model/Douglas, R. M. and Kevin J. S. (2001). Essential SNMP (1st ed.). Sebastopol, CA: O’Reilly & AssociatesCCNP BCMSN Official exam certification guide. By-David Hucaby, ISBN 978-1-58720-171-4,ISBN 1-58720-171-2 "Configuring Private VLANs". Cisco Systems. Retrieved 2014-08-28.

Gangjun Z. et. al. (2012). Design and Research of VLAN Communication Experiment Based on the WEB Environment. 2012 International Workshop on Information and Electronics Engineering (IWIEE).

GTbank.(2018). Banks around the world. https://www.relbanks.com/africa/nigeria/guaranty-trust-bank.

Gyan Prakash Pal and Sadhana Pal.(2013). Virtual Local Area Network (VLAN). International Journal of Scientific Research Engineering & Technology (IJSRET). Faculty of Electronics & Communication Engineering Department, SIT, Meerut, VGI, Greater Noida (India).

JDSU.(2007). Triple-Play Service Deployment. [book auth.] Jon Beckman, Robert Flask, Eli Kerch, Jerome Laferriere, Mirna Mekic, Jim Nerschook , Nisha Parbhakar, Thad Ward, John Williams Assaji Aluwihare. A Comprehensive Guide to Test,Measurement, and Service Assurance. s.l. : JDS Uniphase Corporation, 2007, pp. 1-308.

Kenneth, E. L.(1987). THE PROTOTYPING METHODOLOGY. http://www.manageknowledge.com/prototyp.html

Lawrence, W. D, Virgilio, A.F. Almeida, D.A. and Menasce.(2004)."Performance by Design: Computer Capacity Planning by Example", 2004, ISBN 0-13-090673-5

Leon-Garcia, A. and Widjaja, I. (2004). Communication Networks: Fundamental Concepts and Key Architectures. New York : McGraw-Hill.

Meier, R. C.(2010). "Mobile Virtual LAN," 7,724,715, 2010.

Minlan Yu , Jennifer Rexford, Xin Sun and Sanjay Rao, and Nick Feamster.(2011). A Survey of Virtual LAN Usage in Campus Networks. Topics in network and service management.

Mohammed Nadir Bin Ali, Mohamed Emran Hossain, and Masud Parvez. (2015). Design and Implementation of a Secure Campus Network. An International Journal of Emerging Technology and Advanced Engineering.

Moneyhub. (2018). First City Monument Bank plc. http://www.moneyhub.net/scripts/cgiip.wsc/globalone/htm/quote_and_news.r?pisharetype-id=15325

Mugenda, O. M., & Mugenda, A. G. (2003). Research methods: Qualitative and Quantitative Approaches. Nairobi: Acts Press.Mugenda, O. M., & Mugenda, A. G. (1999).Research methods: Quantitative and Qualitative Approaches.Nairobi: Acts Press.

Ngcareers.(2018). Sterling Bank Plc. https://ngcareers.com/company/147/sterling-bank-plc-147

Ngcareers.(2018). Wema Bank Plc. https://ngcareers.com/company/164/wema-bank-plc-164

Ogula, P. A. (2005). Research methods. Nairobi: Catholic University of Eastern Africa Publications.

Owens, L. K. (2002). Introduction to survey research resign. SRL Fall 2002 Seminar Series. Retrieved May 31, 2013 from http://www.srl.uic.edu

Prasad, N.H. Reddy, B.K. Amarnath, B. and Puthanial, M.(2016). Intervlan Routing and Various Configurations on Vlan in a Network using Cisco Packet Tracer 6.2. IJIRST –International Journal for Innovative Research in Science & Technology| Volume 2 | Issue 11 | April 2016.

Reddy Kamal Teja Gurramkonda.(2015). Performance Analysis on Dynamic VLAN and OpenFlow. Department of Communication Systems Blekinge Institute of Technology SE-371 79 Karlskrona Sweden.

Saad Mneimneh.(2017). Computer Networks A gentle introduction to queuing theory. Computer Science Hunter College of CUNY New York.

Saikat Sarkar. (2017).M.sc Computer Science & Computer Networking, Banaras Hindu University

Shan Zeng, Fazhi Qi and Gang Chen.(2017). Design and deployment of an elastic network test-bed in IHEP data center based on SDN. IOP Conf. Series: Journal of Physics: Conf. Series 898 (2017) 082028 doi :10.1088/1742-6596/898/8/082028.

Sincoskie, W.D.(2002)."Broadband packet switching: a personal perspective." IEEE Commun 40: 54-66

Sincoskie, W. D. and. Cotton, C. J. (1988)."Extended Bridge Algorithms for Large Networks" IEEE Network, Jan. Close] IEEE Std. 802.1Q-2003, Virtual Bridged Local Area Networks (PDF; 3.5 MiB). ISBN 0-7381-3663-8.

Sundarapandian, V. (2009). "Queueing Theory". Probability, Statistics and Queueing Theory. PHI Learning. ISBN 8120338448.

Tiberius, Mwania, and Mwinzi, (2016). The Influence of Financial Resources on the integration of the National Goals of Education. International Journal of Education and Research Vol. 4 No. 9 September 2016.

Yasusi Kanada. (2014). Providing Infrastructure Functions for Virtual Networks by Applying Node Plug-in Architecture. International Workshop on Software Defined Networks for a New Generation of Applications and Services (SDN-NGAS-2014).