UNIVERSITY OF EDUCATION, WINNEBA

ASSESSMENT OF VLAN FOR THE IMPLEMENTATION OR EXPANSION OF A LAN USING CISCO PACKET TRACER: THE CASE OF SEFWI BEKWAI SENIOR HIGH SCHOOL

KINGSLEY OFORI

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A thesis in the Department of Information Technology Education, Faculty of Applied Science and Mathematics Education, submitted to the School of Graduate Studies in partial fulfilment of the requirements for the award of the degree of Master of Science (Information Technology Education) in the University of Education, Winneba

DECEMBER, 2022

DECLARATION

STUDENT'S DECLARATION

I, **Kingsley Ofori**, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE:……

DATE: ……

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

PROF. EBENEZER BONYAH

SIGNATURE:……

DATE: ……

DEDICATION

This work is dedicated to my son, Israel Ofori Winston and my dear wife, Hagar Nkansah.

ACKNOWLEDGEMENT

Because of the aid and participation of so many people, this work has been a success. My heartfelt thanks go to God first and foremost for how far He has taken me. This would not have been possible without the intervention of God. My heartfelt gratitude goes to my supervisor, Prof. Ebenezer Bonyah, for his unwavering direction, constructive criticism, patience, encouragement, and key suggestions that have helped to make this research a success and worthy endeavor. I want to thank Mr. Samuel Konney for editing this work and correcting all of the grammatical mistakes in it. Another group to thank is the staff and students of Sefwi Bekwai Senior High School, whose cooperation and involvement enabled me to obtain the information needed to carry out my research. Many people deserve to be recognised, but time and space would not allow me to do so. I simply pray that the all-powerful God bless them wherever they are. God's blessings!

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LIST OF ACRONYMS

ACL - Access Control Lists

AGP - Autonomous Gateway Protocol

AL - Application Layer

AVI - Audio Video Interleave

BGP - Border Gateway Protocol

BGP - Border Gateway Protocol

BMP - Tagged Image File Format

CIDR - Classless Inter-Domain Routing

CISCO - Commercial and Industrial Security Corporation

CVI - Content Validity Index

DEC - Digital Equipment Corporation

DHCP - Dynamic Host Configuration Protocol

DLL - Data Link Layer

DNS - Domain Name Services

DOD - Department of Defense

DoS - Denial of Service

EIGRP - Enhanced Interior Gateway Routing Protocol

EIGRP - Enhanced Interior Gateway Routing Protocol

FDDI - Fiber Distributed Data Interface

FTP - File Transfer Protocol

GBPS - Gigabits or Gigabytes per Second

HDLC - High Data Link Control

HTML - Hypertext Markup Language

HTTP - Hypertext Transfer Protocol

IANA	- Internet Assigned Numbers Authority
ICT	- Information and Communication Technology
ID	- Identification
IEEE	- Institute of Electrical and Electronics Engineers
IGRP	- Internal Gateway Routing Protocol
IGRP	- Interior Gateway Routing Protocol
IP	- Internet Protocol
IPv4	- Internet Protocol Version 4
IPv6	- Internet Protocol Version 6
IPX	- Internetwork Packet Exchange
IPX	- Intrusion Prevention System
IS-IS	- Intermediate System Intermediate System
ISP's	- Internet Service Providers
IT	- Information Technology
JPEG	- Joint Photographic Experts Group
LAN	- Local Area Network
LLC	- Logic Link Control
MAC	- Media Access Control
MBPS	- Megabits Per Second
MPEG	- Moving Picture Experts Group
MTU	- Maximum Transmission Unit
NAT	- Network Address Translation
NAT	- Network Address Translation
NetBEUI	- NetBIOS Extended User Interface
NetBIOS	- Network Basic Input/Output System

NFS - Network File System

NIC - Network Interface Card

NL - Network Layer

NNI - Network-to-Network Interface

NT - New Technology

OGP - Outdoor Gateway Protocol

OSI - Open Systems Interconnection

OSPF - Open Shortest Path First

OSPF - Open Shortest Path First

P2P - Point to Point

PC - Personal Computer

PDAs - Personal Digital Assistants

PL - Physical Layer

PPP - Point-to-Point Protocol

PRL - Presentation Layer

RIP - Routing Information Protocol

RIPv2 - Routing Information Protocol Version 2

RPC - Remote Procedure Call

RSPAN - Remote Span

RSVP - Resource Reservation Setup Protocol

SEBESS - Sefwi Bekwai Senior High School

SHS - Senior High School

SL - Session Layer

SPX - Sequenced Packet Exchange

SQL - Structured Query Language

STP	- Spanning Tree Protocol
TCP	- Transfer Control Protocol
TFTP	- Trivial File Transfer Protocol
TIFF	- Tagged Image File Format
TL	- Transport Layer
UDP	- User Datagram Protocol
UNIX	- UNiplexed Information Computing System
VLAN	- Virtual Local Area Network
VoIP	- Voice over Internet Protocol
VTP	- Virtual Trunk Protocol
WAN	- Wide Area Network
WAPs	- Wireless Access Point
WASSCE	- West African Senior School Certificate Examination
WAV	- Waveform Audio File Format
WiFi	- Wireless Fidelity
WLAN	- Wireless Local-Area Networks
WMAN	- Wireless Metropolitan-Area Networks
WPAN	- Wireless Personal-Area Networks
WWAN	- Wireless Wide-Area Networks
WWW	- World Wide Web
XML	- Extensible Markup Language

ABSTRACT

In today's technological environment, the internet is the most resourceful repository of knowledge. Students at all stages of school may use the internet to obtain a wide range of information. That is, there is direct relationship between internet access and instructional resources. Using Cisco packet tracer, this research assesses VLAN for the establishment or extension of LAN at Sefwi Bekwai Senior High School (SEBESS). The study first established a link between internet and students' learning by examining network availability and accessibility at the SHS. The investigation was carried out utilising a cross-sectional design, a questionnaire, and interview methodologies on a sample of 263 people. The Pearson Correlation analysis approach was performed by the researcher to determine if pupils' learning was linearly connected with online resources. The study determined that availability and accessibility to online resources are desired since the computer laboratory with internet access is timetabled and the majority of the PCs are also malfunctioning. The VLAN was then investigated in order to establish or expand the internet to reach the entire school. The study found that internet availability and accessibility impact SEBESS students' learning, and so there is a need to expand the current internet or network from the computer laboratory to include the entire school.

CHAPTER ONE

INTRODUCTION

1. 0 Introduction

Proper implementation of technology is faster and more accurate than the human mind. Technology has changed the way we do our things. Some of the areas technology has affected are: Agriculture, Health, Security, Education, Communication, Transportation, Manufacturing. A school's computer network performs so many functions such as connecting students with the school, teachers, faculty, administrators or school management and the school library. As a result, computer networks play an important role in education by facilitating effective communication in the classroom setting. Installing networks in an educational institution depends on the budget of the institution, which differs from one institution to another. Despite their limited resources, many schools strive to provide capacity comparable to the most famous educational institutions. As a result, this design will concentrate on improving the computer network for an educational institution with a limited budget so that it may compete well with another computer network for an educational institution with enough financial resources.

1.1. Background of the Study

Technology has become an integral part and distinct feature of modern societies (Fraillon et al., 2014). There is no doubt that over the decade, information technology has been beneficial to the human race. Taking a critical look at the level of development at countries like; the US, UK, Canada, Germany and China, their economy is technology driven. The Covid-19 pandemic further emphasized the crucial role of technology in our daily lives especially for teaching and learning in schools at home

(Seufert et al., 2021). That is, technology has change the ways of teaching and learning in this our modern societies. This means every academic institute in this modern societies needs to change the way teaching and learning is done from the basic traditional way of always face – to – face learning to the new modern ways of integrating technology most especial internet into the teaching and learning process. According to (Dimitrios et al., 2013) the traditional methods of teaching and learning are: Reading texts and problems, Formulate questions, Attending lectures, Monitor discussions, Writing and reply brief or extensive questions and objective type questions, Solving short or lengthy unstructured problems and cases and Oral presentation of topic and reply to short questions from the audience. And the modern technology integrated teaching and learning methods are: Downloading and watching on the internet, Video Watching, Attendance and participation in lectures online and Reading online materials.

In Ghana, where there is an educational gap between the urban and rural dwellers. It is through the use of technology that will bridge that gap if not reduce it completely. Due to this, since the country begun its educational reforms the provision of Information Technology Infrastructure to schools in the country have become a challenge and this has advisedly affected the educational sector in the teaching and learning processes which inversely has an impact on the Ghanaian economy. The innovative policy of the Ghanaian government to provide a medium (WIFI) whereby students get access to educational and learning resources through the ministry of Communication and Technology was to provide internet facilities in schools in order for these schools to set up computer networks to enhance teaching and learning. The sitting up of these computer networks in the various schools in the country is dependent on the school's

budgetary allocation from the Ministry of Education. Sefwi Bekwai Senior High School (SBESS) is among the schools whose computer network is dependent on its budgetary allocation. Again an observation in SBESS reviewed that almost all of their teaching and learning activities were through the traditional means. Discussion with some of the students, teachers and administrator of SBESS reviewed that, teaching and learning in the school was mostly traditional because the school lacks the necessary tools and equipment to integrate technology into teaching and learning. Again internet facility was only available at the school library and the computer laboratory which only give students limited or no accessibility outside those geographical locations. The assistant head master of the SBESS said, the school cannot afford the cost of networking materials like routes and switches to network the entire campus because it comes with high cost. Especial with the number of departments and hostels in school like SBESS with small budget or financial status cannot buy networking materials for every department and hostel.

1.2. Statement of the Problem

The study of several civilizations throughout history has revealed the importance of education as it applies to societal economic growth and recognizing the importance of learning, and the fact that continuing growth through knowledge is a powerful tool for maintaining elite status globally. There is a direct relationship between internet access and instructional resources accessed by a student through the school's computer network (Chanboualapha & Islam, 2012). Networking is a matter of imagination, and it's hard to track the movement of packages in a real-time environment (Pal & Pal, 2013). Therefore, different network concepts can be explained by creating a virtual environment that will display the momentum of packets exactly as they would in real

time. Several methods of setting up a computer network have been discussed but SBESS, where the school administration (Headmaster and the Assistant Headmaster) said, computer network in the school is dependent on the school's limited budgetary allocation from the Ministry of Education. The concept of VLAN will be developed to provide computer network services to student at SBESS. A Virtual Local Area Network (VLAN) is a type of local network. In this type of network, a host group provides a set of general communication requirements. According to (Shaffi & Al-Obaidy, 2012), Virtual Local Area Networks (VLANs) have lately been a component of all major LAN equipment. With a VLAN, each port can be configured on a switch in a given VLAN. The switch will only allow devices configured in the same VLAN to communicate.

1.3. Aim and Objectives

The aim of this thesis is to simulate an educational institution (Senior High School) network with VLAN concepts. The objectives of this project are:

i. To find out the need for expansion of the school LAN to enhance learning.
ii. To reduce the need for the provision of routers in a network to contain broadcast traffic.
iii. To increase the level of local area network security and improve network performance.

1.4. Research Questions

This study seeks to find answers to the following research questions:

i. What are the needs for the expansion of the SBESS LAN to enhance learning?
ii. How will VLAN lead to reduction in the need for routers in a network to contain broadcast traffic?

iii. How will VLAN increase the level of LAN security and improve network performance?

1.5. The Study's Scope and Limitations

The purpose of the research was to use Packet Tracer to mimic a corporate network using VLAN technology. The main drawback of this research was that other networks such as Metropolitan Area Network or Wide Area Network, are incompatible with virtual technologies since VLAN elements generally share routing and switching.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter provides a review of the research on the fields of study based on the objectives. In addition to previous research on school networks (internet) and learning, the chapter reviews fundamental network ideas.

2.1 Education and the Internet

Figure 2.1 depicts taxonomy of various research methodologies to the use of the Internet in continuous training and education ranging from the use of the network to supply organized learning content to collaborative learning methodologies (Trentin, 2001).

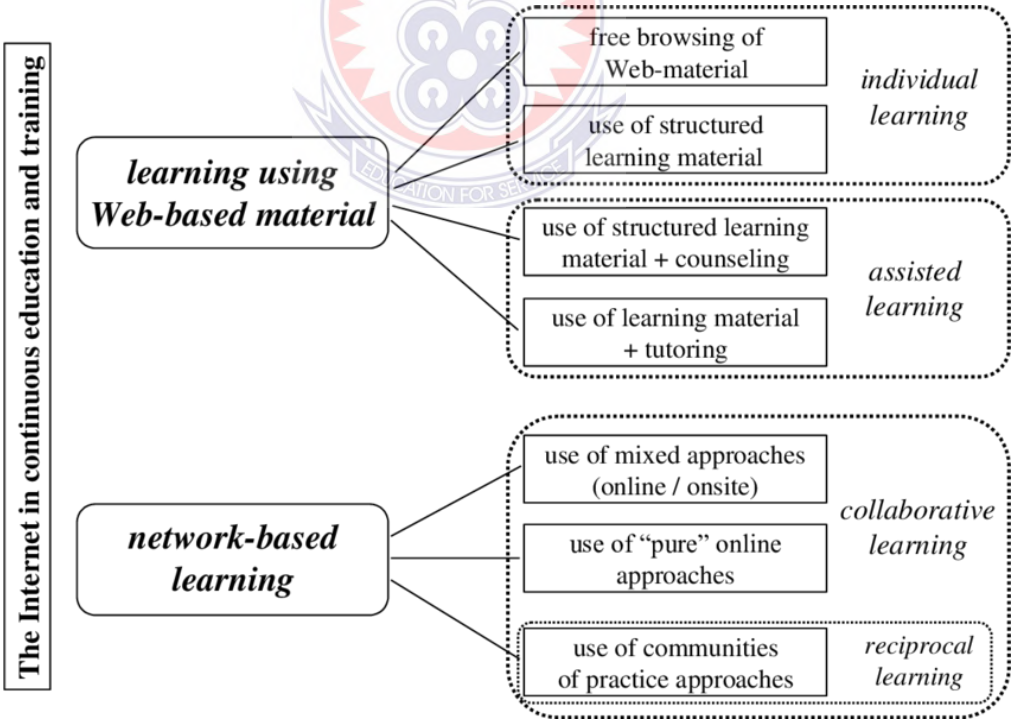

Figure 2.1: The possible uses of the Internet in continuous education and training (Trentin, 2001)

According to (Trentin, 2001) there are numerous options, including:

1. Free and open usage of the network to obtain unstructured content in order to pursue a specified educational route (similar to walking into a massive library to search up material on a certain topic);
2. Use of organized learning materials created specifically for remote self-study;
3. Use of content structured for remote education (mainly self-learning), but with some provider help (counseling);
4. Use of learning material that is not necessarily structured into a self-learning course, with assistance from the provider's tutors and teachers (who may also function as organizers of events such as brief online workshops/seminars on course themes);
5. Employing a hybrid strategy that includes complementing stages of face-to-face instruction and online learning activities;
6. Utilization of "pure" online techniques based on extensive, distant contact among all process players (learners, instructors, experts);
7. Use of communities of practice techniques, which result in the establishment of collaborative groups made up of, for example, course graduates or professionals who share their experiences, knowledge, and best practices for the aim of collective progress.

2.2 Related Literature

This section presents the literature related to the objective of the study.

2.2.1 Availability of school LAN and Student's learning

The availability of contemporary computers, peripherals, networking, and resources within an increasingly wide variety of technologies is a crucial aspect of learning and teaching in the twenty-first century for instructors and their students. ICT is an input in

the student learning process that should contribute to improved learning outcomes. The availability of ICT resources can improve learning by reducing reliance on varying instructor quality and making education possible at home throughout the day (ViralSangat, 2013). It is argued that the usage of ICT can help pupils learn more effectively (Chollampatt & Ng, 2018). Furthermore, the availability and usage of ICT can assist students in taking advantage of vast opportunities for gaining knowledge for educational purposes, as well as increasing learning through communication (Lynch et al., 2021). Students are more engaged and conceptual comprehension is reinforced when visual digital technology (such as animation, simulation, and moving visuals) is available (Patel, 2019). ICT use also promotes the transition from a teacher-focused or teacher-led paradigm to a more student-focused model in which students collaborate, make their own decisions, and participate actively in learning (Prosser & Trigwell, 2014). According to Sampaio and Almeida, greater availability of ICT is especially beneficial for children with learning impairments since ICT use helps teachers to more efficiently develop appropriate assignments for specific requirements for each person (Sampaio & Almeida, 2016). Computers are a subset of the information and communication technology facilities required in schools, and even then, they must be equipped with quality accessories, installed with appropriate software, and linked to necessary networks to allow access to rich resources outside the school rather than serving as a resource for minor typesetting and other word processing activities. While the preceding research sought to explain how the availability of ICT impacts learning in general, they did not examine how computer networks or the internet obviously impacted students' learning.

2.2.2 Accessibility of school LAN and students learning

Effective ICT integration in schools would necessitate the networking of a whole institution to guarantee access to multimedia and learning-rich materials via the school's Intranet and the Internet wherever students and teachers are, in or out of school. The computer laboratories and classroom computers must be adequate in quantity to provide students and staff easy access to most disciplines across the school. A variety of peripheral and remote working equipment, including video-conferencing, are available and integrated into the curriculum. Both large and small group presentation facilities are available (Mutula, 2003). Despite the desired scenario, most African institutions confront challenges to successful ICT integration in the teaching and learning process, including poor infrastructure in terms of appropriate physical conditions of laboratories and subsequent access to resources (ICT) by learners. Many commercial and academic instructional multimedia providers have concentrated largely on information availability and presentation (Trelease, 2016). The accessibility and usage of ICT helps students to conduct more in-depth investigations into the actual world (Eneje, 2020). They have easier access to information sources outside of the classroom and can utilize tools to evaluate and comprehend it. Information can be accessed via internet platforms or data logging systems (Anshari et al., 2017). They may obtain feedback, develop their comprehension, gain new information, and transition from school to non-school situations thanks to the technology (Bransford et al., 2004). Accessibility and infrastructure are the main barriers to ICT adoption and integration into learning. Placing computers in centralized laboratories may offer students with equal and efficient technology exposure, but it greatly limits the accessibility of technology for education (Baş et al., 2016). Labs limit instructors' ability to decide when to introduce technology into education and may give the message to students that technology is not

vital to learning or activities in their classrooms. The researcher agrees with the Ministry of Education in Ghana's assertion that, in general, governments and training institutions appear to grasp the need of using ICT in education and training. As much as students and employees require ongoing training in contemporary required skills to effectively exploit the ICT environment in their various roles, awareness skills alone may not be sufficient; rather, continual access to ICT resources would fare far better. Continuous access to ICT tools makes instructors feel more safe in their ICT use during lessons, gives them the confidence to experiment more, and so allows them to successfully incorporate ICT into teaching. Many studies also show that the influence on learning will grow over time as teachers and students get more experience with computer use (Kim, 2020). Whereas the preceding research examined the accessibility of ICT resources in institutions of learning, critical information on how to extend access to internet or ICT resources within and outside the school campus for schools with low financial resources was never examined.

2.3. Review of Network Fundamental Concepts

2. 3.1 Hierarchical Network

Cisco hierarchical (3 - layer) networking model is generally used in developing a low cost, scalable and reliable internet work. It comprises of layers like core, distribution and access and their function in the network model (Onopreychuk, 2018).

2.3.1.1 Network Requirements

Grouping networks depending on a number of devices is very necessary in designing a network.

- ***Small network***: This is used for networking devices up to two hundred devices and below.

- ***Medium-size network***: This is used for networking devices within the range of two hundred to one thousand devices.
- ***Large network***: This is used for networking devices from **1,000** devices and above.

Network design is based on device numbers and specifications of the organisation. That is, the networking infrastructure requirements of a smaller organisation of a few devices will be less complex compared to the networking infrastructure needs of a large organisation with many devices (Cisco Press, 2014).

2.3.1.2 Principles of Structured Engineering

According to Cisco Press (2014), irrespective of network devices or specifications, the correct execution of network architecture adheres to formal engineering standards. This contains the following:

- **Hierarchy**: Hierarchical networking architecture may be used to construct a dependable network system. It deconstructs the dynamic network architecture to make it simpler and easier to handle.
- **Modularity**: The existence of features that occur while dividing network into segments simplifies network architecture. Cisco divides networks into units. Enterprise campuses, data center, service block, in addition to internet edge are a few examples.
- **Resilience**: The network should be usable under both abnormal and normal situations. Hardware and program glitches, high traffic levels, unusual traffic, denial – of – service (DoS) incidents, and other unpredictable events comprise abnormal circumstances. Normal environments consist of traffic movements and patterns as well as maintenance activities planned in windows.

- **Flexibility**: This refers to the potential to change parts of the network, add additional facilities, or expand capacity without requiring a significant forklift upgrade (i.e., replacing major hardware devices).

According to the fundamental design goals, a network should be designed on architecture that allows for both versatility and expansion.

2.3.2. Network Hierarchical Design

The connectivity, delivery, and center layers are the 3 major layers of the network hierarchical design. Figure 2.1 depicts the network hierarchical architecture.

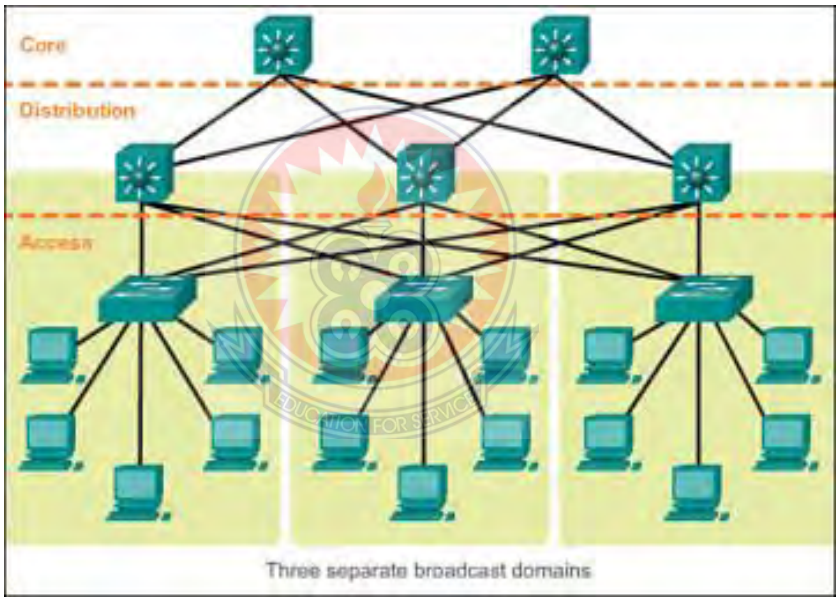

Figure 2.2: Hierarchical Networks (Cisco Press, 2014)

From Cisco Press (2014), the architecture of a network hierarchy involves layering the network. Each layer of the hierarchy performs unique roles that describe its position in the whole network. This enables the network builder to elevate and pick the appropriate network hardware, applications, and functions to fulfil various network layer tasks. Hierarchical models can be used in both WAN and LAN architecture.

One of the benefits of splitting networks into smaller and more accessible blocks is that local traffic stays local. Two, only traffic intended for other networks is transferred to a higher tier. The network is split into three distinct broadcast realms in Figure 2.1.

A traditional enterprise hierarchical LAN campus network architecture involves the three layers stated below:

- **Access layer**: This provides network access to users and work groups.
- **Distribution layer**: It provides policy-based communication and manages the distinction between the core and access layers.
- **Core layer**: This also offers high transport via distribution switches on the business campus.

2.4. Enterprise Networks

Architecture of Enterprise network (2013) defines enterprise network as networking platform for connecting many computer devices. When using this platform setup, no user or group is isolated. This means, through the platform, all systems can link with all other systems without foregoing security, reliability and performance.

This has been achieved by the use of Internet protocols and Web technologies which provide greater performance at a reduced cost and with less configuration issues than enterprise device versions. TCP/IP is a single network protocol that enables organisations to communicate to the internet by connecting local networks to work groups and territories. Web protocols (HTTP, HTML, and XML) enable organisations to build intranets by combining user interfaces, apps, and data (internal Internet). A web browser functions similarly to a universal client and web servers can provide data to one of these clients. Web servers are deployed across machine models spread across the enterprise. Multilevel implementations are used in which Web client links Web

server and the Web server connects to back-end data sources such as mainframes. A business network connects all isolated utility or networks to a corporate network allowing computer users within an organisation to access information or computing services. This will allow interoperability between autonomous and heterogeneous systems with the end goal of reducing the number of communication protocols used.

2.4.1. Enterprise Network Requirements

Here are examples of an enterprise network's quality by (Zunino et al., 2020):

i. **Scalability**: The degree to which networks can be scaled in capacity and load. This involves scaling on both the horizontal and vertical axes. Horizontal is the system's ability to be quickly scaled by adding additional resource units (for example, more servers). Vertical scaling is the expansion of one or more capital (for example, memory, processors).

ii. **Dependability** - What is its resistance or error tolerance in a variety of conditions and stimuli?

iii. **Flexibility** - How does the system react to convergence or implementation in various locations?

iv. **Availability** - Is the system's dependability consistent?

v. **Simple to maintain** - It is simple to handle code and machine elements.

vi. **Usability** - Are interfaces intuitive and desirable?

2.4.2. Campus Network

Cisco Press (2014) explains campus network as a substructure of a corporate network that provides end users and computers with access to network services and services that include a single geographical location. It may be a single structure or a set of structures scattered over a large geographical region. Typically, the enterprise that operates the

campus network owns the actual wires installed on campus. As a result, network engineers typically want to boost the campus component of the business network in order to achieve the quickest usable structural architecture that operates on high-speed physical networks (1/10/40/100 Gbps). Furthermore, companies may have several campus blocks within the same geographical area depending on the number of users, business priorities, and business existence.

According to Tao, et. al. (2012), campus network refers to a cohesive network that combines teaching, science, administrative, educational administration and general management roles. It has inline functions such as internet services, remote education services, electronic bulletin boards, video conferencing, and off-campus data networking services as well as other necessities. Rapid growth and wider use of computer technology, network technology and the campus network in school learning and administration is a success as well as an increasingly important position for tutors and learners' job. Research and living affords an excessive convenience for modifying conventional teaching and management models.

2.5. Network Protocol

Network Protocols are described in "Computer Network Demystified: The TCP/IP Reference Model" as rules that enable computers communicate with one another (Alotaibi et al., 2017). A protocol specifies how computers in a network understand one another, what shape data transfer should take, and how data at its final destination should be treated. The protocol also specifies how to handle data loss and corrupted transmissions. Today's network protocols include TCP/IP (for Windows NT, UNIX, Windows 95, besides others), DEC net (designed for networked machines; Digital Equipment), IPX (designed for Novell NetWare), AppleTalk (designed to be used on

Macintosh computers), NetBIOS / NetBEUI (for LANs) Manager and Windows NT. It is important to remember that while each network protocol is unique, they all use the same physical cables. This corporate method of accessing the physical network allows for the peaceful coexistence of numerous protocols on network sustenance and allows the network designer to split the same hardware across many protocols.

2.6. Network Devices

2.6.1. Router

Norberk (2014) defines a router as the physical network interface that connects many network parts to network or a wide network to subnets. Routers operate on the OSI model's network layer three combining multiple physical network parts into a single simple logical network by determining how a sender's traffic should be routed to its destination. This means that the protocols used have a strong grip on the routing operation. Knowing routing, therefore, necessitates knowledge of network layer protocol operation. A router directs a packet to its network or Internet endpoint through routing protocols for exchange of data and monitor routing decisions. Routing takes place on an intranet between routing machines and in the ISP's network between border gateway routers.

Routers control routing tables which are queried if a packet has to be transmitted from one section to another. Routers may be manually applied to routing table - very stable but less manageable way (based on the network size). Routing table can also be modified automatically using the following routing protocols (Freewimaxinfo, 2021):

a. **RIP** (Routing Information Protocol) / RIPv2

b. **IGRP** (Internal Gateway Routing Protocol)

c. **EIGRP** (Enhanced Interior Gateway Routing Protocol)

d. (**OSPF**) Open Shortest Path First, Border Gateway Protocol (**BGP**)

e. Outdoor Gateway Protocol (**OGP**)

f. Intermediate system Intermediate system (**IS-IS**)

Routing protocols uses several methods to avoid routing loops. Routing loop is when a packet is redirected indefinitely without finding the destination. Some of these methods are (CertificationKits, 2017):

a. Counting to infinity
b. route poisoning
c. split horizon

It is important to consider how routing protocols function in order to prevent problems such as:

i. A hacker sends a routing upgrade to your network and poisons a critical route resulting in a denial-of-service situation.
ii. Create routing loop that overloads the router, slowing down and overloading the network. When a path is modified, all incoming traffic is routed to another host which then forwards it to the ISP for successful interception or interception attack.

Figure 2.3: Router (Netgear, 2021)

2.6.2. Switch

Switches are the connectivity ends of Ethernet network according to (Zhang, 2010). Twisted-pair cabling connects devices to switches with a cable for a device. The distinction between hubs and switches is about how the systems handle the data they collect. A hub sends data to all of the device's ports while a switch sends it only to the port that connects to the destination device. It accomplishes this by first learning the MAC addresses of the machines that are attached to it and then matching the destination MAC address in the data it receives. Figure 2.4 depicts the operation of a switch.

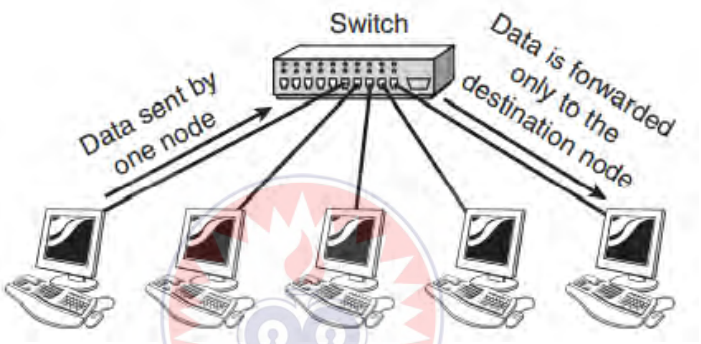

Figure 2.4: How a Switch works

The switch will boost network efficiency in two ways (Singh, 2016). That is, by forwarding data only to the connections that should receive it. Then, by forming a direct path between two machines and controlling their connectivity. It can also greatly reduce the number of network collisions. On Ethernet networks, collisions occur as two systems try to transmit at the same time. Due to no crashes, switches can connect with devices in full-duplex mode. Devices will receive and transmit data from the switch at a particular time in a full-duplex system. However, contact can only take place at one direction pair a time with a half-duplex. Full-duplex transmission speeds are twice as fast as a half-duplex link. As a result, a **10Mbps** link becomes a **20Mbps** connection and then **100Mbps** connection becomes **200Mbps** connection.

As a result of these steps, switches may provide substantial performance improvements over hub-based networks particularly when network utilisation is high.

If a link is complete or half-duplex, the switching procedure governs how the switch interacts with the data it receives. The procedures or approaches are as follows (Singh, 2016):

- **Cut-through**: By using this process, the packet is forwarded just after it is sent. This approach is really quick but errors will spread all over the network due to no error testing.
- **Store-and-forward**: This form receives entire packet and checks for errors before forwarding. This approach has the advantage of not propagating errors across the network. The disadvantage is error checking procedure takes long time making store-and-forward swapping even slower.
- **Fragment Free**: This approach reads enough packets to determine if the packet has been involved in a collision. Packet is forwarded as soon as the collision status is determined. This approach uses the error checking of store-and-forward switching while also providing performance values comparable to cut through switching.

2.6.2.1 LAN Switching

A switch is the core segment of a network (A. Kumar, 2019). Switches allow multiple network devices to communicate with one another. Switches include a series of concurrent, parallel, point-to-point networks between pairs of computers. Advantages of LAN switches:

- Scalability of the network: As the company grows, the network can quickly extend.

- Enhanced bandwidth performance: This is critical in environments where users run multimedia programmes or communicate with client/server databases frequently.
- Multiple concurrent connections: Many data transfers will occur at the same time between two devices attached to switch ports. For hub-based networks, this is not feasible.
- Congestion and communication delivery delays are minimised resulting in more reliable access to business applications. It is important to understand that network segmentation is used to reduce the number of users vying for LAN bandwidth on each segment.
- There is no single point of failure in the network: Network failure is reduced with good network architecture.
- Network security and maintenance was enhanced with virtual LANs (VLANs): VLANs divide network members into rational work groups based on shared interests. Data transmissions are limited to a subset of the group's members (also called the broadcast domain). VLANs allow businesses to transfer workers around physically while maintaining functional connections without requiring network reconfiguration. A small to medium-sized enterprise can choose from a variety of switches. The following are the most common options:

Layer 2 switches: They are sometimes referred to as desktop or workgroup switches.

Layer 3 switches: These are also known as routing switches or multilayer switches.

2.6.2.2 Virtual Local Area Networks (VLANs)

Tarkaa, et al. (2017) posit that VLANs are a modern LAN architecture that make use of intelligent and high-speed switches. Unlike other types of LANs which physically connect computers to LAN sections, VLANs assign computers to LAN sections by

software. **IEEE802.1q** and **IEEE802.1p** have been used to standardise VLANs. VLANs are divided into two types. These are Single-switch VLANs and Multi-switch VLANs. Figure 2.5 illustrates the Single-switch VLANs architecture and Figure 2.6 also displays the Multi-switch VLANs architecture.

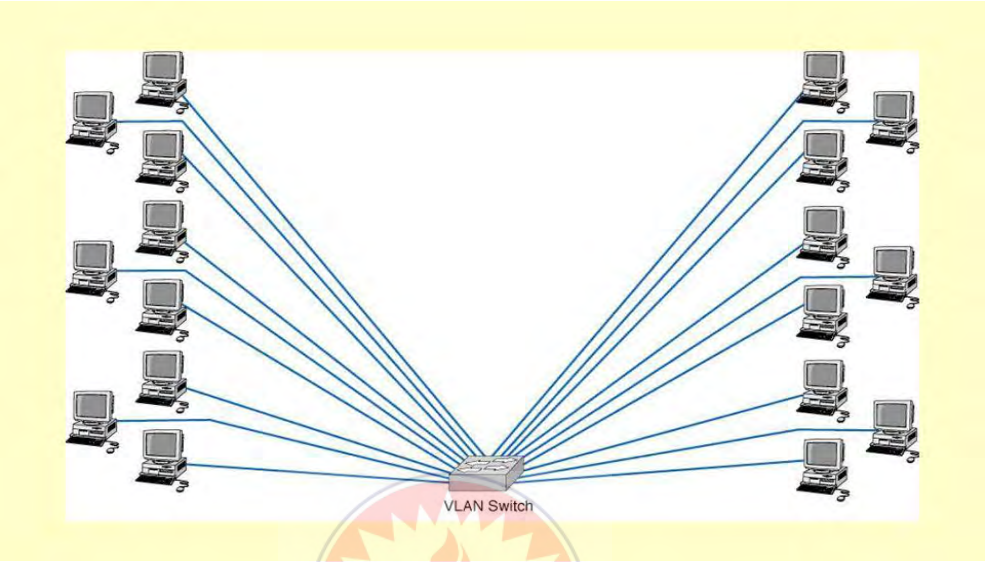

Figure 2.5: Single-switch VLAN architecture

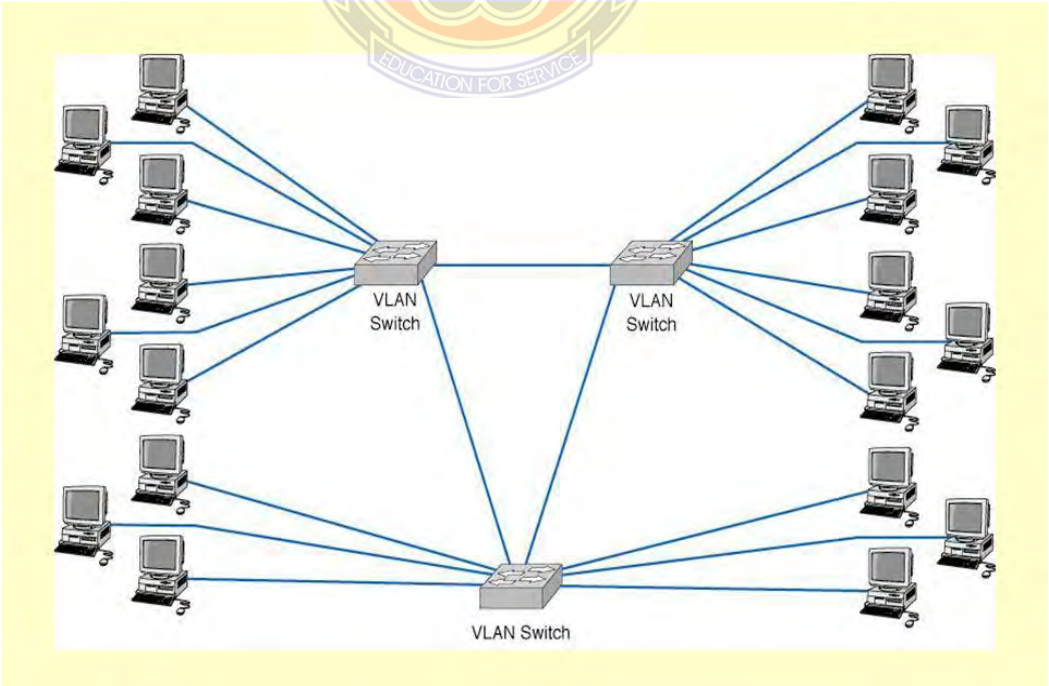

Figure 2.6: Multi-switch VLAN architecture

2.6.2.2.1 Single-switch VLANs

Computers are allocated to VLANs via special software and are physically linked together by a physical switch in this VLANs configuration (Tarkaa et al., 2017). VLANs may be assigned to computers in four ways:

- **Port-based VLANs**: This VLAN design assigns computers dependent on the VLAN switch port which they are attached to.
- **MAC-based VLANs**: This VLAN design assigns computers based on each computer's data link layer address.
- **IP-based VLANs**: This VLAN design assigns computers based on their IP-address.
- **Application-based VLANs**: This VLAN design assigns computers dependent on the application usually used by the computer. The advantage of this VLAN architecture is that it allows for specific allocation of network bandwidth.

2.6.2.2.2 Multi-switch VLANs

Multi-switch VLANs send packets between multiple switches making VLANs with segments in separate locations possible. When a frame is sent between switches, it is modified and includes a tag field carrying VLAN information field. Before the frame is transferred to its target screen, the tag field is deleted as it hits the final switch. Multi-switch VLANs can also prioritise traffic using the **IEEE802.1p** standard in the hardware layers and the RSVP standard in the internetwork layers. **IEEE802.1p** works with the **IEEE802.11ac** frame definition which includes a special priority field (Tarkaa et al., 2017).

According to (A. Kumar, 2019), VLAN provides Virtual Splitting up of Broadcast Domain in the network. Devices connected to the same VLANs will communicate with one another. Devices on separate VLANs can only connect with one another through a router. With VLAN, different VLAN devices will use different network addresses. VLAN provides the following advantages:

- **Security**: Groups containing personal data are isolated from the rest of the network increasing information security.
- **Reduction of cost**: Saving is realised as a result of less costly network enhancements and more effective usage of current bandwidth and uplinks. Some of the savings are reduced by administrative costs needed for IT staff to configure VLANs into switches.
- **Higher efficiency**: Segmenting flat layer 2 networks into logical workgroups reduces overall network consumption while increasing performance.
- **Broadcast storm mitigation**: By splitting a network into multiple smaller logical networks, the vulnerability to broadcast storms is reduced.
- **VLANs simplify project or application management**: By organising the necessary players in a manner that makes project management simpler.
- **Improved IT workers efficiency**: The network becomes extremely adaptable to shifts. Time of network officers is freed up for constructive network management.

2.7 WAPs (Wireless Access Point)

A WAP is networking interface that connects wireless devices with wired networks. Setting up networking devices via cables and wires is even more complex than setting up networking devices via WAP installation (Cisco Systems, 2021).

2.7.1 Wireless Networks

According to (Shi et al., 2014), wireless networks use radio waves to link devices but not with cables or wires. Desktop computers, hand – held computers, cellular phones, personal digital assistants (PDAs), pen – based computers and portable computers are some of the devices used for wireless network. Both wired and wireless network work in the same way only that with wireless network, information signals must be converted to a form suitable for transmission in the air. Wireless networks are used as cable replacements nevertheless they can also be used to provide network from remote locations.

Setting up wireless network is easier, simpler, and less expensive than setting up wired network (Shi et al., 2014). The time and effort saved by having access to the global network of information translates into riches on a local scale since more work can be completed in a short period of time with some effort. Wireless networks can link remote devices whether they are a few feet or many kilometers apart. There is also no need to cut holes in walls to feed wires or install connectors. Due to this, the usage of this technology has become quite popular and is fast spreading. Wireless technologies differ in transmission frequency, speed, and range.

2.7.2 Wireless technologies

Wireless networks can be put into four specific groups thus the area of application and the signal range. Hence, Wireless Personal-Area Networks (WPAN), Wireless Local-Area Networks (WLANs), Wireless Metropolitan-Area Networks (WMAN), and Wireless Wide-Area Networks (WWANs) (Sharma & Dhir, 2014). These four types are depicted in Figure 2.6.

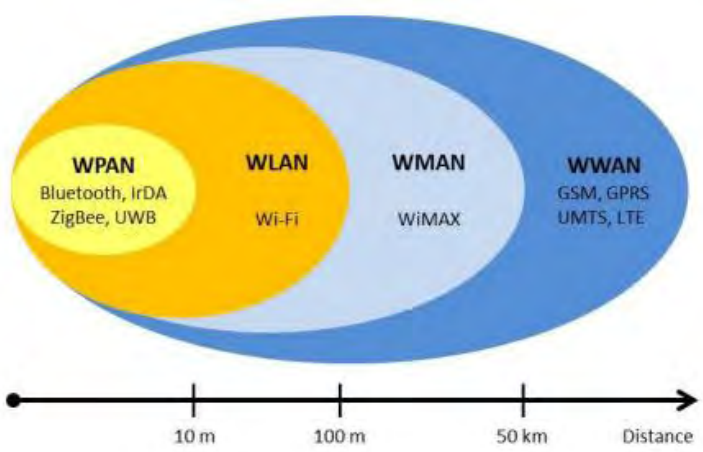

Figure 2.7: Wireless networks classification

2.7.2.1 Wireless Local-Area Network (WLAN)

According to (Sali et al., 2016) LANs provide wireless connection in areas with a typical range of up to **100** meters and are used mostly in homes, schools, computer laboratories, or office environments as diagrammatised in Figure 2.7 below. Users of WLAN can move around within a local coverage area and still be connected to the network. WLANs are based on IEEE **802.11standards** marketed under the Wi-Fi brand name. Because of competition, other standards such as Hiper LAN did not gain much implementation. The simple implementation of **IEEE 802.11** made it marketable.

IEEE 802.11 refers to a set of wireless local area network specifications. The **IEEE 802.11b** standard was the first to be accepted and it supported up to **11 Mbps** in the **2.4 GHz** unlicensed spectrum band. The **IEEE 802.11g** standard was then developed as a higher-bandwidth successor to the **IEEE 802.11b** standard. An **IEEE 802.11g** access point can connect to both **802.11b** and **802.11g** clients. Likewise, a laptop equipped with an **IEEE 802.11g** card will be capable of connecting to both current **802.11b** and new **802.11g** access points. That is because wireless LANs based on **802.11g** will use the same **2.4-GHz** band that **802.11b** uses. The highest transfer rate for the **IEEE**

802.11g wireless link is **54 Mbps** but it will automatically back down from **54 Mbps** when the radio signal is weak or when interference is detected.

Figure 2.8: WLAN Diagram

2.8. Voice over Internet Protocol (VoIP)

According to (DeSantis, 2008), VoIP is a communication method that allows phone calls to be made via broadband internet rather than traditional analog telephone lines. Simple VoIP connection often allows calls with other people also receiving calls via the internet. Interconnected VoIP allows calls to and from a landline number for a charge. Some VoIP services need the use of computers or specialised VoIP phone whilst others enable landline phones to make VoIP calls through a specific adaptor.

Figure 2.9: Voice over Internet Protocol

2.9 Access Control Lists (ACL)

According to Kaushik and Tomar (2004), ACL is a sequence or set of rules also called ACL entries. These rules state the kind of network traffic that can be passed or blocked via a router. ACLs are set up at almost all points of entrance in a private network and public internet. This means all outgoing and incoming packets are monitored. Examples of ACLs protocols in use are IPX, AppleTalk and many more. Packet encompasses a limited number of fields like destination or source port. IP address indicates the destination and source protocols type. All packets are matched with the rules of the ACL starting from rule number one to rule number two until it matches with the last rule. This pairing process states exactly how to apply the network security.

Structure of a typical rule using CISCO IOS notation might be:

permitip 10.1.2.0 0.0.0.255 host 10.2.2.1 eq http.

An ACL is made up of numerous rules. Conflicts can rise between these rules such as redundancy and shadowing. Due to this, the ACLs must be managed cautiously so as to resolve these conflicts. The key purpose of setting up ACLs is Network security (Kaushik & Tomar, 2014).

2.9.1 Types of ACLs

On the routers, ACLs configuration may be of two types (Kaushik & Tomar, 2014). They are as follows:

- **Standard ACL** – This permits or refuses packets depending on IP address of the source. The typical ACL ID range is **1** to **99** or a string.
- **Extended ACL** - This permits or refuses packets depending on protocol information as well as the destination and source IP addresses. Extended ACL IDs may be between **100** and **199** characters long or a string.

Depending on the originating IP address, standard ACLs allow or deny packets. You can configure up to **99** standard ACLs. On a device, you may configure up to **1024** unique ACL entries.

Extended ACLs let you allow or block packets depending on the following information:

- IP protocol
- Source IP address or host name
- Destination IP address or host name
- Source TCP or UDP port (if IP protocol is TCP or UDP)
- Destination TCP or UDP port (if IP protocol is TCP or UDP)

The ACLs can be used in filtering route advertisements and in implementing network policies such as traffic shaping and NAT (network address translation).

2.9.2 Reasons for Configuring ACL

Here are some reasons to configure ACL on a network:

a) It limits network traffic to increase network performance.

b) ACLs offer traffic flow control by limiting the provision of routing updates.

c) It may be employed as an extra layer of security.

d) It manages what traffic is to be blocked or routed by a router.

e) It has control over the locations that a client has access.

2.10. IP (Internet Protocol) Addressing

According to Kumar and Shinde (2016), an Internet IP address is a number assigned to every device (e.g., computer, Printer) on networks that use the Internet Protocol for communication. IP address is grouped into:

- **Internet Protocol Version 4 (IPv4)**: this is **32-bit** number.
- **Internet Protocol Version 6 (IPv6)**: this is **128-bit** number.

According to Salih & Alsarhan (2016), the internet protocol (IP) address is a **32-bit** number. Network address is made up of two parts; that is host address and network address. This division is called subnet mask or slash (/ + number) such as this **IP 255.255.224.0/19** which has subnet mask (/19). When converting the subnet from decimal numbers (Human numbers) to binary numbers (Machine numbers), it will become 1**1111111.11111111.11100000.00000000**. The number of "1s" in the previous example is **19**. This operation is called subnet mask since subnet mask is used to classify network address of an Internet Protocol address by implementing bitwise and operation on the mask. The network bits in Subnet Mask are represented by all **"1s"** whereas the host bits are represented by all **"0s".** There are two bits in network systems that are designated for certain purposes such as "0" and "1" addresses. The "0" address is not used for the host address since it serves as network address and the "255" address also is not used since it is reserved as a broadcast address. There two ways of assigning IP address in a network. These are:

(1) Using DHCP (Dynamic Host Configuration Protocol) and

(2) Static Assignment.

2.10.1 DHCP (Dynamic Host Configuration Protocol)

DHCP assigns computers an IP address drawn from a pool of IP addresses that are specified by the network administrator and maintained by DHCP server (Naaz, Sameena; Badroo, 2016). Because it is so simple to set up, DHCP IP address setup is commonly used by businesses and organisations. Most network devices available today are default to dynamic host configuration protocol (DHCP). In many commercial environments, network devices are configured through DHCP and this default setting is sustained when the network devices are set up. In other commercial network environments, qualified network administrators override the default DHCP and allocate

a Static Internet Protocol address, default gateway and subnet mask. This kind of IP address might change over a period of time. The least for DHCP configuration can last for seven days. A computer demanding an IP address must do so through DHCP server on the network. It is very important to note that the use of DHCP server increases the cost of a network.

2.10.2 Static Assignment

Static IP addressing is another technique of giving network end devices IP address(es). This IP address does not change. When IP address is issued to a machine using this approach, the address is reserved for that computer indefinitely (Jayakumar et al., 2012). This means that if the machine is switched off, its IP address will no longer be usable. This makes this technique of assigning IP addresses highly troublesome because machines do not stay in a network for the entire day and IP address will not be required by it 24 hours a day.

2.10.3 Classful Addresses

According to Bhardwaj (2021), IP address can be classified as classless or classful. First octet (23) in this IP address **23.24.25.26** determines the IP address class. The range of numbers that can be in the very first octet of each class is shown in Table 2.1 below.

Table 2.1: IP address range for each class

Class	Range in the first octet
Class A	1 to 126
Class B	128 to 191
Class C	192 to 223
Class D	224 to 239
Class E	240 to 255

The 127 which is missing from the above table is reserved as a loopback address. The **127** is a Class A number in the class IP addresses range. Loopback address is used for the testing of local NIC (Network Interface Card). The **127** loopback addresses were assigned by the Internet Assigned Numbers Authority (IANA) in **1981** when IP addressing was still in its early stages. Unluckily, IANA's decision to reserve a Class A number as the loopback wasted **16,777,214** possible addresses on the **127** networks. This explains the reason **IPv6** loopback wastes only one and it is 1. A network class will also determine the number of hosts. Table .2 summarises the host and network numbers for each class:

Table 2.2: Summaries of the host and network numbers of each class

Class	Networks	Hosts	Private address range
A	126	16777214	10.0.0.0 through 10.255.255.255
B	16384	65534	172.16.0.0 through 172.31.255.255
C	2097152	254	192.168.0.0 through 192.168.255.255
D			Not applicable
E			Not applicable

Class A, B, and C addresses are often used while class D and E are not usually used. This is because class D is for multicasting (distribution of information from one source to many receivers (such as cable television) or many sources to many receivers (such as group collaboration)) and Class E is reserved for research or government use. As seen in the table above, Class A has a small number of networks but a big number of hosts. Class C on the opposite side has a high number of networks but few hosts. Class B which is at the center of the two has roughly the same number of networks and hosts. Class A can be used for huge national scale networks (small networks with large hosts). Class B can be used for regional scale networks and Class C can be used for local area

networks (large networks with few hosts). The downside of utilising Classful Addressing is that host addresses are wasted. For example, the suggested network requires just **20** networks and **10,000** hosts. If Class C is employed, there will be address waste resulting in more network collisions and making network management more complex. This explains why the classless IP addressing system was created.

2.10.4 Classless Addresses

Classless addressing or CIDR (Classless Inter-Domain Routing) is intended to make the assignment of IP addresses as efficient as possible. CIDR subnets like Classful addressing divide the network from the host but this time the network component of the subnet mask borrows bits from the host portion providing a Class A, B, and C split (Eng et al., 2009). For instance, organisation demanding more than 254 hosts but far less than **65,533** hosts that a typical Class B will allow. Therefore, this is not possible with Classful addressing. With Classless, an organisation can choose anywhere between **254** and **65,533** allowing other organisations to use those addresses. **IPv4** addressing system can be used instead of moving to an **IPv6** scenario. One organisation might need only **2000** IP hosts. With Classful, this organisation must use Class B wasting **64,533** addresses (65533-2000=63533). With Classless addressing (CIDR), this same organisation can maintain the use of **IPv4** addresses and secure only what it needs wasting no IP addresses. CIDR successfully tackles the issue by giving a more adaptable approach to arranging addresses. As a result, the Classless addressing system will be used for this research.

2.11 Cisco Packet Tracer

Packet Tracer is a virtual networking simulation software developed by Cisco to study and grasp various concepts in computer networks (Honni et. al., 2018). Cisco Packet Tracer is a network simulation software suite that allows students to explore and ask questions about network behavior. Packet Tracer per Networking Academy full learning experience includes simulation, conception, authoring, evaluation, teamwork capabilities as well as facilitating the teaching and learning of difficult technical concepts. As illustrated in Figure 2.9, Packet Tracer offers a simulated environment in which operations between various networking devices like routers, switches, wireless access points, PCs, connections, and applications are visible with animations and simple explanatory descriptions. The virtual trunk protocol (VTP) has certain issues but little study has been done to identify whether complications exist in the VTP-based set up. Except for the optimum design of inter-VLAN routing, we focus a lot on various elements of security-related VLAN design that operate in combination with VTP to decrease overhead costs in this research. Packet Tracer supports teaching and learning of difficult technical ideas by enabling simulation, conception, authoring, assessment and collaboration. Packet Tracer supports the classroom's actual equipment by letting students to construct network with practically any number of devices, promoting practice, discovery and troubleshooting. Packet Tracer allows you to construct, configure and debug networks using virtual devices and simulated connections either alone or with other students. Packet Tracer allows you to construct your own virtual "network worlds" in which you may explore, experiment and teach network ideas and technology.

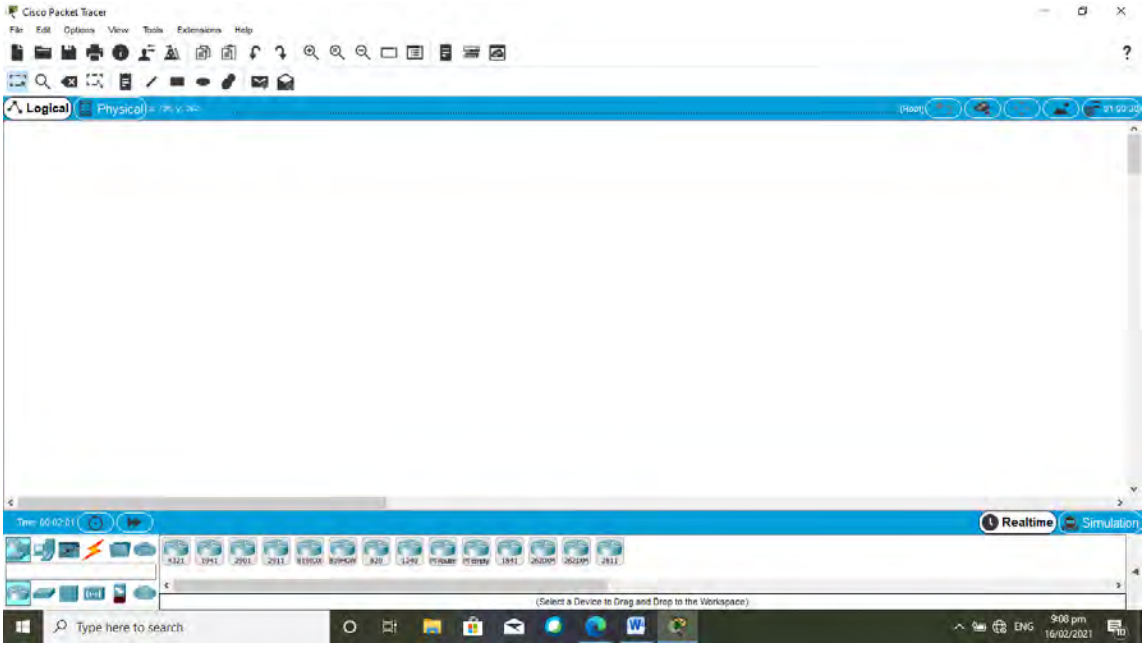

Figure 2.10: Cisco Packet Tracer Interface

2.12 Network Models

Data communication process depends on this model. There are two computer network models. They are:

1. OSI Model
2. TCP/IP Model

2.12.1 The OSI Model

The ISO (International Organisation for Standardisation) created the OSI (Open System Interconnection) standard in 1984 according to (Kayri, 2010). The OSI model is a system that summarizes complex network phenomena and situations on seven layers. OSI model deals with situations on the seven levels each of which is exposed in a different way. OSI model was formed to reduce network complexity, simplify network training and offer simple network troubleshooting. Figure 2.11 depicts the OSI model's layers.

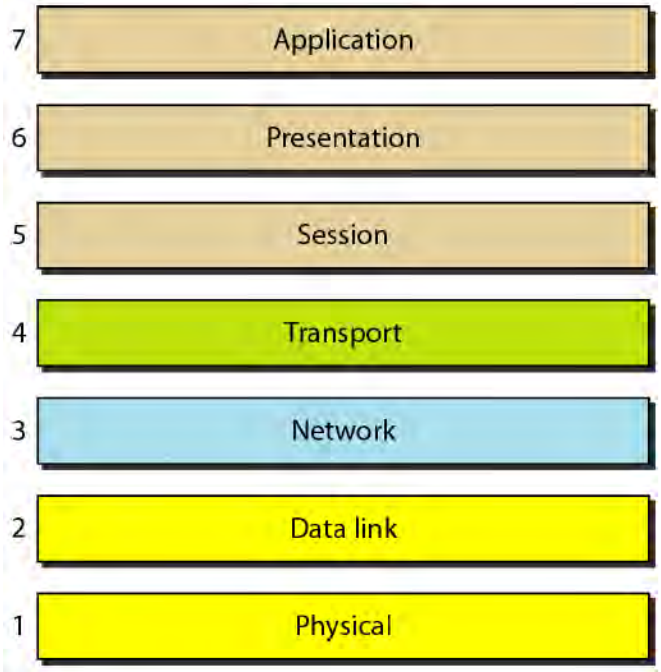

Figure 2.11: OSI Model

As depicted in Figure 2.11, OSI model is made up of 7 layers. Each layer provides data for the next layer. Any hardware and software components are tackled on the related layer.

2.12.1.1 Application Layer (AL)

Application layer provides an interface between computer application and network. Application layer is the layer where network software such as spreadsheet, word processor, FTP, TFTP, DNS and http are defined (Kayri, 2010).

2.12.1.2 Presentation Layer (PRL)

This layer identifies the type of data to be transferred to network settings. In this layer, the item to be transmitted whether it is a text, picture, video or sound file is identified in this layer. This means the presentation layer controls the nature and type of data to be transmitted (Kayri, 2010).

2.12.1.3 Session Layer (SL)

This layer maintains sessions between remote hosts. For example, once user/password authentication is done, the remote host maintains this session for a while and does not ask for authentication again within that time span. Layer 5 Session examples include: NFS, NetBios names, RPC, SQL (Kayri, 2010).

2.12.1.4 Transport Layer (TL)

Transport layer divides data into pieces or size of a network package. TCP and UDP protocols work in this layer. The protocols carry out tasks like error control. Transport layer functions as a means of top layer transfer and also increases quality of network service (QoS – Quality of Service). Data on this layer is divided into pieces called segments to be transported to the lower layer. Transport layer offers end-to-end data transfer. Error control is done and data transfer is checked (Kayri, 2010).

20.12.1.5 Network Layer (NL)

This layer is where telecommunication services are active and router activities are done. In this layer, data in segments are divided into packages and bit by bit transported to the lower layer. This layer directs data through routers. Messages are addressed at network phase and also reasonable addresses are changed into physical addresses. IP protocol starts on this layer (Kayri, 2010).

2.12.1.6 Data Link Layer (DLL)

Access techniques (such as Ethernet or Token Ring) begin at the data link layer. These access methods use their own protocols to analyse and send data from the database. During this stage, data is split into parts known as frames. Frames are data transmission packets that allow for regulated data transport. The majority of Data Link layer

activities are carried out within the network card. On Data Link Layer, the OSI model reports switching and bridging. This layer's tasks include identifying other computers in the network, determining whose user occupies the cable and protecting data from the physical layer against errors (Kayri, 2010).

2.12.1.7 Physical Layer (PL)

Physical Layer specifies the kind of data carried on the line. This layer transforms bits (1 and 0) into electrical, optical, or radio signals and determines how to transport them. On the data transfer side, physical layer turns 1s and 0s as electrical signals and sends them across the line while on the data reception side, physical layer converts signals from the line back into **1s** and **0s**. Active devices like hubs and modems exist in PL so as passive components such as cable and **0-1** (bits). As stated earlier, one of the most important functions of OSI model is modular network troubleshooting. OSI model according to divide – split – swallow philosophy network troubles are easily identified. This makes troubleshooting quicker since OSI model comprises of **7** layers. Network problems are dealt with in seven groups. It is important to note that Network trouble identification and troubleshooting are occasionally time-consuming. However, the established "Network Troubles Identification Model" will be adopted as a standard in network administration (Kayri, 2010).

2.12.2 Models of Network Troubles Identification Proposed

According to Kayri (2010), OSI model aids in the detection of network problems.

2.12.2.1 Application Layer Trouble Classification

The Application Layer is a layer that incorporates all network software but excludes hardware. We shall split network software into two categories. They are:

i) **Offline software** (word processors, spreadsheets, and so on)

ii) **Online software** (TFP, FTP, http, DNS and etc.)

This means that troubles on the Application Layer are grouped into two categories- "**Off-line Troubles**" and "**On-line Troubles**." Off-line troubles in network administration are problems within the host whereas on-line troubles are software flaws that influence computer sharing (Kayri, 2010).

2.12.2.2 Presentation Layer Trouble Classification

Some networking issues are caused by file format. Text, audio, and video–graphic network data file formats are available. This means that network problems can be classified as "Text Troubles," "Audio Troubles," or "Video-Graphic Troubles." Text troubles are problems with the format of text-only files in Word, Excel, and other programs. Audio troubles are also conceivable in formats like "wav" and "avi." Problems with video graphics are caused by faulty file formats like "mpeg," "jpeg," "tiff," and "bmp." (Kayri, 2010)

2.12.2.3 Session Layer Trouble Classification

Session Layer initiates communication between computers and stops it after the data exchange is complete. When there are several connections, this might sometimes help with correct communication. Troubles in peer-to-peer model with two computers only are grouped under one category and troubles in multi-connection are grouped under another. This means troubles on Session Layer are grouped into **"Peer-to-Peer Troubles"** and **"Multi-Connection Troubles**" (Kayri, 2010).

2.12.2.4 Transport Layer Trouble Classification

Transport layer is where data to be transmitted is first divided into sizes necessary for segment to be transferred to the next terminal. This can be performed as one-way synchronous, two-way synchronous, or three-way synchronous. This division is possible with UDP (User-Datagram Protocol) or TCP (Transmission Control Protocol). TCP is reliable but slow whereas UDP is unreliable but fast. This means troubles on the transport layer can be grouped as "**UDP-Based Troubles**" and "**TCP-Based Troubles**". Buffer segment transfer setting troubles can also occur. This makes the network trouble at the transport layer three groups: **"TCP Troubles"**, **"UDP Troubles"** and **"Buffer Troubles"**. This makes network administration and troubleshooting faster (Kayri, 2010).

2.12.2.5 Network Layer Trouble Classification

It is the most active layer in the network and it is regarded as a location where telecommunication services and router devices are operational. On the Network Layer, IP, IPX/SPX also known as routed protocol is covered. On the Network Layer, routing protocols such as RIP (Routing Information Protocol), IGRP (Interior Gateway Routing Protocol), EIGRP (Enhanced Interior Gateway Routing Protocol), OSPF (Open Shortest Path First), AGP (Autonomous Gateway Protocol) and BGP (Border Gateway Protocol) are identified. This layer includes support for sending an echo message to complete a package exchange (inbound-outbound) or to test the next terminal reach. Obviously, this layer performs router, routed, and routing tasks. A router hardware troubleshooting standard may be termed "Hardware Troubles on Network Layer." Non-reachability issues caused by echo messages such as ping to the next terminal and traceroute may be classified as "Echo Message Troubles." Telecommunication system

problems in general may be classified as "Telecommunication Troubles on Network Layer." Troubles on the network layer produced by incorrect routing protocol structuring are referred to as "Routed Configuration Troubles" whereas problems on the network layer caused by incorrect routing protocol structuring are referred to as "Routing Configuration Troubles." Clearly, network layer problems in network administration cannot be handled in a single category and the fact that problems on one layer may change should be considered. As a result, problem standardisation through category is unavoidable (Kayri, 2010).

2.12.2.6 Data Link Layer Trouble Classification

On this layer, switches and bridges operate. Wide Area Network protocols include PPP (Point-to-Point Protocol), HDLC (High Data Link Control) and Frame Relay. This implies that problems on this layer can originate from both LAN and WAN. On the Data Link Layer, NIC (Network Interface Card) is a critical component for LAN connectivity. MAC (Media Access Control) refers to LAN framing based on NIC and LLC (Logic Link Control) and specifies the size of the connection between Data Link Layer and Network Layer. WAN problems might be standardised as "WAN Protocols DLL Troubles." Troubles with NICs are also referred to as "NIC Troubles" whereas problems with MAC addresses are referred to as "MAC Troubles." Troubles with LLC which allows transfers from DL to NL may be standardised as "LLC Troubles." This information allows a network administrator to instantly discover DLL problems (Kayri, 2010).

2.12.2.7 Physical Layer (PL) Trouble Classification

Data to be transmitted in network are converted into electrical signals on Physical Layer and this layer is the last phase where data are divided. As a result, there are active-passive components on PL like electrical signals, cables, modems and hubs. The majority of issues on this layer are electrical in nature. Physical Layer handles problems with cables such as UPT, STP, Coaxiel and RS-**232**, V.**35** which are commonly used in LAN and WAN. On PL cable-related issues, are labeled "Cables Troubles" whereas high voltage loadings are labeled "Overload Voltage Troubles." Again, problems with hub devices used on LAN are referred to as "Hub Troubles" whereas problems with modems utilised on WAN may be referred to as "Modem Troubles." Furthermore, broadcast issues in wireless settings should be handled at the Physical Layer. The "Wireless Wave Signal Troubles" standard may be susceptible to such issues. As a result, potential problems on the Physical Layer may be standardised and network management troubleshooting can be expedited (Kayri, 2010). The schematic method for network problem standardisation in Table 2.3 is developed as a result of the information presented above.

Table 2.3: Network Troubles Based on OSI Model (Kayri, 2010)

Layers	Troubles
Application	Off-line Troubles
	On-line Troubles
	Text Troubles
Presentation	Audio Troubles
	Video-Graphic Troubles
Session	Peer-to-Peer Troubles
	Multi-connection Troubles
	UDP-Based Troubles
Transport	TCP-Based Troubles
	Buffer Troubles
	Hardware Troubles on NL
	Echo Message Troubles
Network	Telecommunication Troubles on NL
	Routed configuration Troubles
	Routing configuration Troubles
	WANs Protocols Trouble on DLL
Data Link	NIC Trouble
	MAC Trouble and LLC Trouble
	Cables Troubles
	Overload Voltage Troubles
Physical	Hub Troubles
	Modem Troubles
	Wireless Signal Wave Troubles

2.12.3 TCP / IP Mod

Miry (2020) indicates that the original TCP/IP protocol suite is defined as having four layers: host-to-network, internet, transport, and application. The TCP/IP reference model was created by the U.S Department of Defense (DOD) in order to create a network that could withstand any conditions.

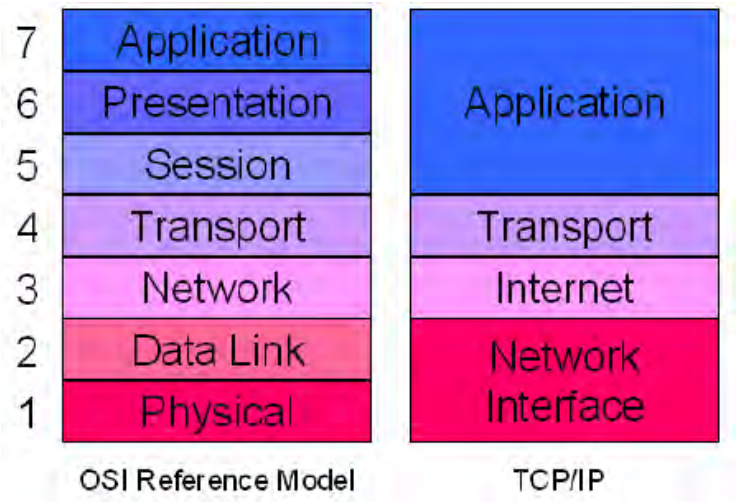

Figure 2.12: OSI model and TCP/IP model

From the above diagram (Figure 2.12), it can be seen and read that:

- TCP/IP combines the session and presentation layer into its application layer.
- TCP/IP combines the OSI data link and physical layers in one layer.
- TCP/IP seems simpler since it has fewer layers.

2.13 Computer Network

Computer network is a collection of computers that uses a set of standard communication protocols through digital links to share resources (Kizza, 2020). Interconnections between nodes are created using a wide range of telecommunication network technologies including physically wired, optical, and wireless radio-frequency techniques that may be configured in a diversity of network topologies. Computers, printers, servers, networking devices and other dedicated or general-purpose hosts are examples of nodes in a computer network. Hostnames and network addresses are used to identify computer network nodes. Hostnames serve as unique identifiers for nodes. Network addresses are used by communication protocols such as the Internet Protocol to identify nodes.

The transmission medium used to transmit signals, bandwidth, and communication protocols are used to arrange network traffic, network size, topology, traffic management mechanism, or organisational aim are all factors that may be used to classify computer networks.

Many services and applications are supported via computer networks including access to the WWW, digital music, digital video, shared use of application and storage servers, printers, fax machines and usage of email and instant messaging apps.

2.13.1 Internet

The Internet, according to (GCFGlobal, 2021), is a network of networks. It is the global collection of various computer networks. The Internet is a network that connects thousands of computer networks. It is capable of transferring information in an electronic format across geographical borders at a very quick rate. The internet is a vast repository of information. The Internet connections are computer networks that connect computer users all over the world so that they may share resources and interact with each other.

The “www” denotes the World Wide Web. Many people confuse the World Wide Web with the Internet. They are however not the same. While the Internet is a huge network of networks (hardware), the World Wide Web is a method of accessing the Internet's information. It is similar to the software required to execute programmes on your computer's hardware. As a result, the Internet is larger than the World Wide Web

The Web employs common communication protocols (rule sets) and specific languages. Hypertext Markup Language is one example (HTML). These custom languages serve as a link between machines that do not use the same or comparable

operating systems. This implies that a website can be accessed by devices running various apps. Besides the Web, there are other ways to disseminate information such as Email, File Transfer Protocol (FTP), and Telnet.

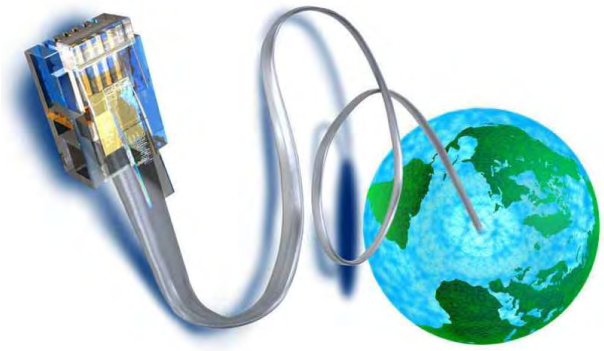

Figure 2.13: Internet

2.13.2 Intranet

According to (Edenius & Borgerson, 2003), an intranet is an internal application of technologies developed for the internet. The application of internet technology to a company, university, college, hospital, or any other entity results in an intranet. It is the way of technology adopted by an organisation to enhance its productivity by supporting its applications using Internet Standards. It is an “Internal Internet”. The term internet is used in contrast to extranet-a network between organisations.

2.13.3 Network Configuration Types

There are two types of network configurations: peer-to-peer networks and Client/Server networks.

A. Peer-to-peer Networks

According to (M. B. D. Kumar & Deepa, 2017), peer-to-peer networks are commonly implemented where less than ten computers are involved and where strict security is not necessary. All computers have the equal status thus the name "peer" and relate with

others on an equal basis. Files may be transferred throughout the network and every computer on the network can share devices like printers and scanners. Figure 2.14 represents how the computers are connected in peer-to-peer networks.

Some networking applications that use peer-to-peer technology are: iTunes, BitTorrent, and Skype is a P2P telephone "system."

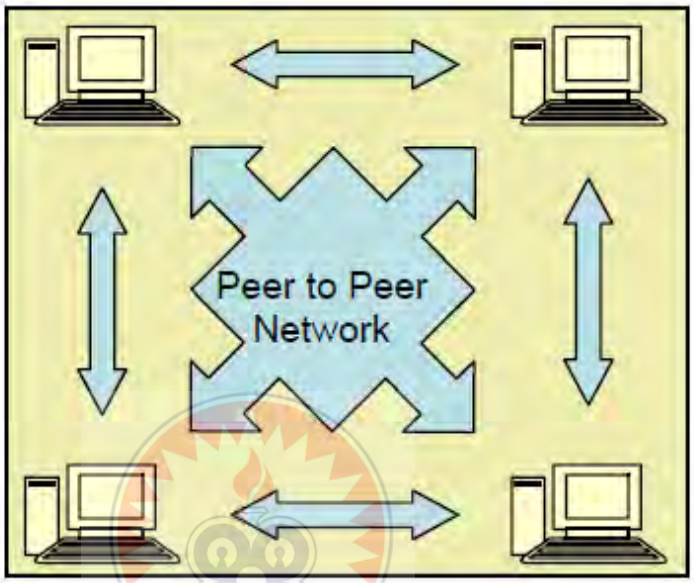

Figure 2.14: Peer-to-Peer Networking

B. Client/Server Networks

M. B. D. Kumar and Deepa (2017) explain that client/server networks are more suitable for larger networks. A central computer (server) stores files and applications shared on the network. Usually, the server is more sophisticated than the other computers (client) on the network. The server also controls access to the network and network resources of the client computers. Only the network administrator will have access to the server others will not. Others are only permitted to use client PCs. Figure 2.15 represents how the computers are connected in a client/server network.

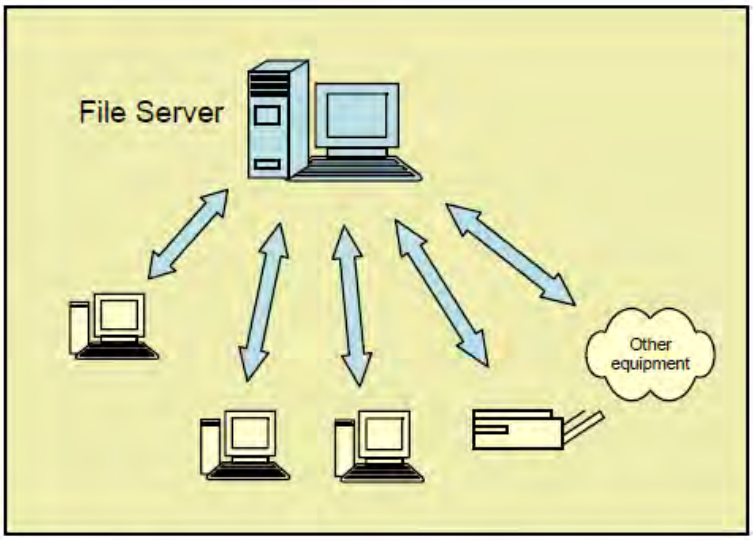

Figure 2.15: Client/Server Networking

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter outlines the research methods that were used to explore the research questions. The major components of this chapter are the research design, study population, sampling strategies, data collection Instruments, data quality control, research procedure, data analysis techniques and the network design

3.1 Research Design

Research design is the way the study is planned and conducted (Akhtar, 2016). The procedure and techniques that are employed to answer the research problem, explain the pattern the study intends to follow so as to control variance due to independent variables, eliminate or reduce influence of extraneous variables, minimise error variance and also ensure the testing of findings for implication.

The study employed a cross-sectional research design. Cross-sectional design permits the population checking at a particular time and the change between the groups in the population to be matched. Again, it provided for the scrutiny of the co-relationship between accessibility to network or internet and students learning in the context of Sefwi Bekwai Senior High School seeking the views of students, teachers and administrators. The selection of this design is dependent on the variables to be studied.

3.2 Population

Population is a large collection of all subjects from where a sample is drawn (Majid, 2018). The target population or the unit of observation is a group of individuals, or objects that a sample is drawn for measurement.

The targeted population for the research was Senior High students of Sefwi Bekwai High School (SEBESS) to check the effect of computer network or internet on their learning. SEBESS had a numerical staff strength of **76** of which **6** were administrative, **70** academic staff, with a total student population of **1000**. The students were considered the true representative population and they come from different departments within the institution. Teachers and administrators also formed part of the study because of their roles in the teaching and learning process in the school.

3.3 Sample Selection

The research site was SEBESS. The sample population comprised 263 respondents across the school. The categories and size of the respondents that participated in the study are herein presented in Table 3.1.

Table 3.1: Sample selection

Categories	Number	Sample	Percentage
Students	1000	250	95.06%
Teachers	70	10	3.80%
Administrators	6	3	1.14%
Total	**1076**	**263**	**100%**

Teachers form part of the study because they are involved in the teaching and learning. The administrators were considered policy implementers and directly connected to the effect of computer network or internet on learning. The students were considered the true representative population since they were the target of this investigation.

3.4 Sampling Strategies

Sampling is considered an important element in every research based on Verma and Mallick (1999), assertion that regardless of the process used for collecting data, some strategy is required for deciding which units ought to be measured and included in a study and which ones ought to be excluded from the research population. However, Bahadur, A., & Tanner, T. (2014) argues that in deciding on this, the sample must be representative of the population from which it was drawn.

Hence, it is imperative that selecting the manner of obtaining data and from whom the data will be acquired, be done with sound judgment, since no amount of analysis can make up for improperly collected data. The process of taking the sample from the population is crucial in a research. Ideally, a sample is taken randomly to avoid having a biased sample in the sense that no member of the population has more chances of being selected as the sample than any other member.

Finally, a total of two hundred and sixty-three (263) respondents made up of students, teachers and administrators were randomly selected for the study. The study also relied on stratified, purposeful and convenient sampling strategies. (Taherdoost, 2018) opines that stratified sampling is where the population is separated into strata and a sample is randomly taken from each sub group. Convenience sampling is selecting participants because they are often readily and easily available. Maxwell (1996) posits that purposive sampling is a technique in which particular settings, persons or events are selected deliberately in order to provide important information that cannot be obtained from other choices. Stratified sampling will help identify the stratum in the population. The researcher recognises students, teachers and administrators as the relevant stratum

and their actual representation in the population. Sufficient number of subject from each stratum was been selected. Stratified sampling ensures equal representation in an event where particular strata or many strata within the population will have a small incidence relation to other strata. Simple random sampling is used to attain the appropriate number of student's representation in the study. Simple random sampling that was for picking students for the study gives every student equal chance of taking part in the study and also helps to prevent partiality. The students represent the widest variety of perspective in respect of network or internet and learning in Sefwi Bekwai Senior High School. Convenient sampling would help identify the teachers and administrators that form part of the study. That is, convenient sampling was suitable for the teachers because they are mostly unavailable on campus and are only available in the school only when they have lessons. There, convenient sampling was used to collect information from the teachers who were available on school campus at the time of collecting the data.

3.5 Data Collection Instrument

Data gathering is crucial in research, as it is meant to contribute to a better understanding of a theoretical framework (Tongco, 2007). According to (Saleh & Sohn, 2001) the term instrument means equipment for collecting the data. Based on this statement, instrument plays a vital role in conducting a research that is for gathering the data accurately. An instrument is a tool designed to measure knowledge, attitude and skills. (Parahoo & Mccaughan, 2001) argues that a research instrument is a systematically prepared form or document purposely designed through compilation of questions to elicit responses from respondents with the aim of collecting data. Data collection instruments refer to devices used to collect data such as questionnaires, tests,

structured interview schedules, via telephone and checklists (Seaman, 2008). Data collection procedures vary in time cost of money or many resources at the disposal of the researcher (Megel & Heermann, 1994). In line with these explanations, the data collection in this study was done through the assessment of a secondary data gathered by the method of analysis of documents. Such documents included official records, newspaper accounts, reports, and published items. Primary data was also obtained directly from the field and collected via observation and self-administered questionnaires.

3.5.1 Questionnaires

A questionnaire was deemed appropriate for the study as it gives an opportunity to carry out an inquiry on specific issues on a large sample and makes the study's findings more dependable and reliable (Baride et al., 2003). Questionnaire designs were one such that each question relates to a given research question and the topic. Both closed and open ended questions were used. Open ended questions would supplement the information given in the closed ended questions and help in obtaining more complete data. Questionnaires are chosen since it would give perfect and definite responses and aid respondents provided their views generously particularly teachers who do not have ample time for interviews.

3.5.2 Observation Guide

Observation of participants in the context of a natural scene was made. Observation provides information within the location where the events occur and permits the researcher to see things that participants themselves might not be conscious of.

3.6 Data Quality Control

Data quality control describes routine measures to assure data quality (Public Health Scotland, 2020). The following was how data quality control was ensured:

3.6.1 Validity

Validity is the degree to which an instrument measures what it is expected to measure (Public Health Scotland, 2020). To create validity, the questionnaires were subjected to the scrutiny of two experts who evaluated the significance of all items in the instruments to the objectives. The experts rated every item on a scale. Their recommendations determined finally the modification of questions and the format of the tools that solicited the expected data. Senior High students, teachers and heads of departments are the relevant subjects that were given the questionnaires, observed or interviewed to obtain data. Relevant documents were obtained from the library at the school. Once the questionnaires were designed and rated, content validity index (CVI) was then computed using the formula below:

$$CVI = \frac{\textbf{Agreed items by both judges as suitable}}{\textbf{Total number of items being judged}}$$

3.6.2 Reliability

According to (Public Health Scotland, 2020), an instrument is considered reliable when it is able to elicit the same responses each time it is administered. Reliability is the consistency of measurement despite the changing conditions. A pre-test was conducted after establishing the validity. Twenty respondents from Sefwi Bibiani Senior High School were used in the pre-test to answer the questionnaire. This was because Sefwi Bibiani SHS has similar characteristics like Sefwi Bekwai SHS. The reliability of the tools of data collection was conducted during the pre-test to determine where the results

produced were achievable and consistent. This was to identify whether the questionnaires would yield similar result to the same kind of people in a different occasion.

3.7 Data Collection Procedure

The questionnaire was administered to the students during classes and at their free time by the help of a research assistant. Those students who filled them there were welcomed but those who opted for more time were granted a one-and-a-half-week period to return the filled questionnaires to the research assistant. The teachers' questionnaires were administered and collected after a week. This technique enabled the researcher to approach many respondents more easily.

Interview schedules were set up with administrators who gave appointment dates of convenience for the interviews. Guideline questions were used to guide the interview process and also ensure that all the relevant questions are covered. Through the face to face exchange of words in personal interviews with the school administrators and heads of departments, the researcher was able to get what were not mentioned by the students. The researcher carried out observation of the school. That is, visiting the four departments and library monitoring students' reaction to technology. With the guide of a checklist, the researcher ticked as well as wrote down the key features of the observation.

3.8 Data Analysis

Data was presented through quantitative methods. Open ended questions and interviews were analysed by indicating the magnitude of responses. Expressions like the bigger number, the least, to a large extent, to a small extent from most respondents and the

majority of respondents were applied. In some cases, respondents' comments were directly quoted. The feedbacks of the structured questionnaires were analysed in frequency counts, percentages and charts. Summarised data was put in a table form for clear presentation, assessment, analysis and interpretation. Data from the open-ended questions were enriching output from the closed-ended questions. Information from the documentary sources and interviews helped to bring out concrete evidence in the data analysed. Data was summarised and presented by the use of SPSS (Statistical Package for Social Science) in accordance with the objectives of the study. For this study, the researcher was interested in finding out the need for the expansion of the school LAN to enhance learning and it implement it using Cisco Packet Tracer

3.9 Network Design

After data have been analysed to find out the need for the implementation or expansion of computer network or an internet at Sefwi Bekwai Senior High School, the researcher designed the network using a diversity of important technologies for accomplishing the task. The technologies are:

i. Network architecture

ii. Network connection

iii. RIPv2

iv. VLAN (Virtual LAN)

v. DHCP (Dynamic Host Configuration Protocol)

vi. ACL (Access Control List)

The network required the technologies to work efficiently.

3.9.1 Network Architecture

This network design according to (Javapoint, 2021) is a framework for the requirement of a network's physical components and their functional organisation and configuration. And its operational principles, procedures and data formats are used.

The simulated network architecture approach was divided into these departments. The departments are:

i. Administration

ii. Teaching Staff

iii. Students

The administration or administrative section comprises of Headmasters (School Head and the Assistants), Finance, Chaplain and Senior Housemaster. Administration was put in VLAN **10** (Administration).

Teaching staff comprises of the heads of department and the teachers. All teachers were put in VLANs (VLAN **20**, VLAN **30**, VLAN **40** and VLAN **50**)

Students comprise learners from the following departments; General Science, Business, General Arts, Agricultural Science, Visual Arts, Technical and Home Economics. All students were put in VLAN **200** (Students).

The systems comprises of a Web Server and a Mail Server. Each device receives an IP address from a DHCP server.

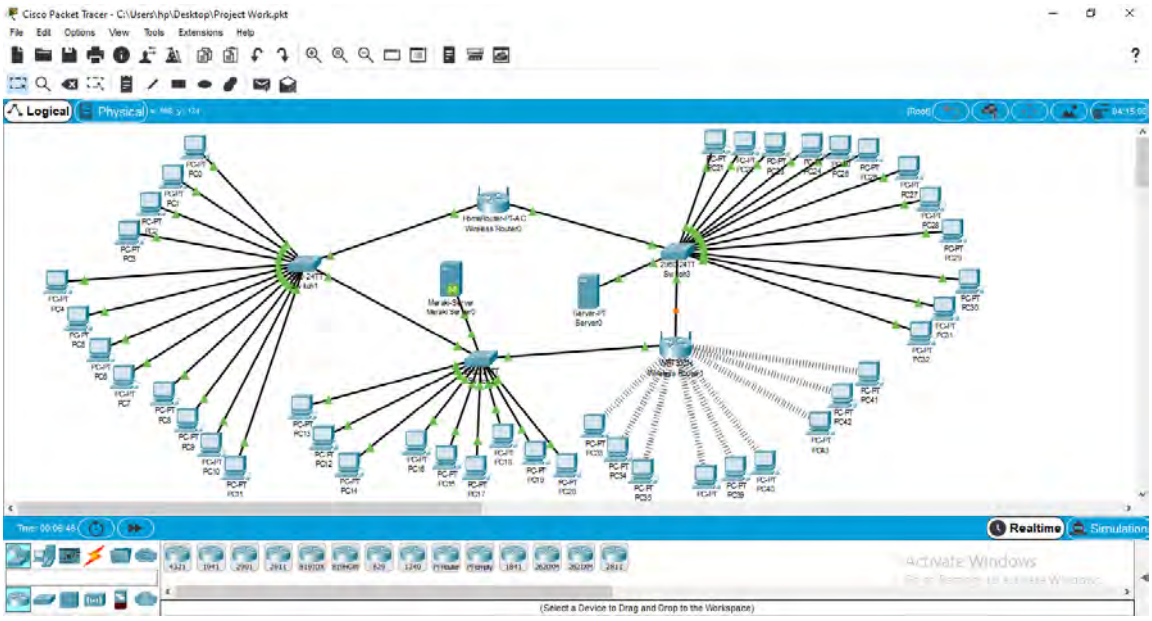

Figure 3.1: The Architectural View of the Network Design

3.9.2 Network Connection

Computer network devices interchange data with one another using data links among nodes. The data connections are established through wireless media like WiFi or cable media like wires and optic cables.

As the packet tracer layer three switches (the multi-layer switch) cannot provide fiber optic connectivity, generic devices were used. The reason was that fiber optic covers longer distances. At core and distribution level, standard routers were used since they have interfaces for fiber optic and serial connections. Generic switches were used in access level.

3.9.3 Network Protocol

RIP (Routing Information Protocol) version 2 was used as the routing protocol for inter Vlan, with RIP. A router sends its full routing information to other connected routers every thirty seconds. Triggered updates also occur when a router drives down beforehand **30** second timer expires. RIP executes “routing by rumor” and it is very

loops prone than other routing. That is because RIP router transmits its full routing information to all other routers (Labovitz et al., 2001).

3.9.4 VLAN Configuration

Cisco Systems (2006), opine that when creating and modifying VLANs in network, the following guidelines should be followed:

- ✓ Switch module accepts **1005** VLANs.
- ✓ Normal-range Ethernet VLANs are numbered from **1** to **1001** and LAN **1002** to **1005** is set aside for FDDI VLANs plus Token Ring.
- ✓ Switch module does not accept FDDI media plus Token Ring. Switch module does not forward FDDI-Net, FDDI, TrBRF, or TrCRF traffic.
- ✓ VLANs 1 to 1005 remain saved within VLAN database and switch module using configuration file.
- ✓ Configuration alternatives intended for VLANs **1006** to **4094** are inadequate to private VLAN, MTU, UNI-ENI VLAN, and RSPAN VLAN. VLAN database does not save extended VLANs.
- ✓ STP (Spanning Tree Protocol) by default is activated for NNIs on VLANs. STP can be configured on ENIs. Same VLAN for NNIs and ENIs use the same spanning-tree instance. When switch module takes many active VLANs accepting spanning-tree instances, spanning-tree may be activated in **128** VLANs and deactivated on other VLANs. See Figure 3.2.

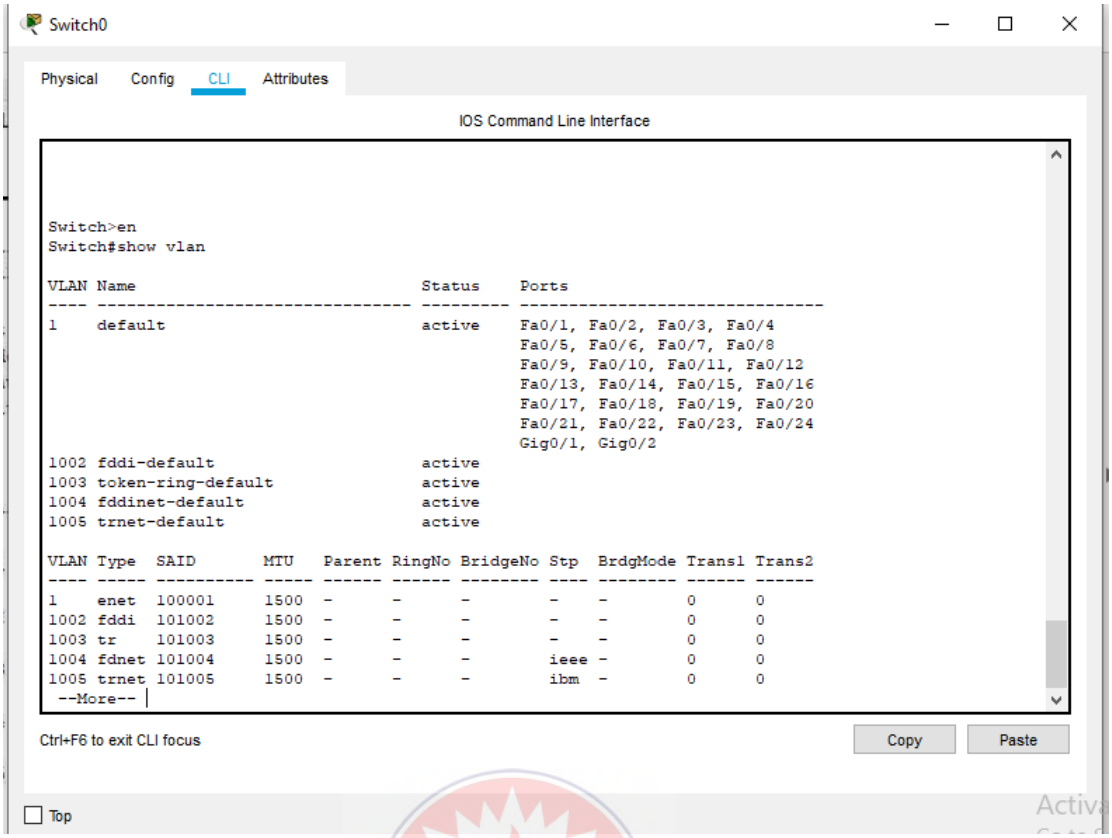

Figure 3.2: The VLAN Configurations on a switch

3.9.5 DHCP (Dynamic Host Configuration Protocol)

At the access layer, devices are many and there is the possibility it may expand. Due to this, DHCP automatically gave IP addresses by the use of routers performing as gateways to all switches.

3.9.6 Access Control List (ACL) Configuration

In order to secure and control unauthorised access to some sections of the network, network ACL was configured.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0. Introduction

This chapter discusses the findings and their interpretation in light of the research goals. The study aimed at assessing the need for the implementation or expansion of Local Area Network at Sefwi Bekwai SHS using VLAN by assessing the availability and accessibility of network resources and its impact on students' learning. The chapter is organised into four sections: section one deals with the demographic characteristics of respondents, section two offers descriptive statistics of items related to specific aims, section three presents the study's connections between variables and section four shows the testing and analysis of the VLAN network. In this study, a total number of **250** students and **10** teachers were sampled and were given **260** questionnaires to respond to. A total of 175 (67.3%) fully completed questionnaires were returned representing (66.8%) of 167 questionees and (80%) of 8 questionees. These were filled by students and teachers respectively. These will sum up the response rate of 67.3% as illustrated in Table 4.1.

Table 4.1: Questionnaire Return Rate

Respondent category	Number issued out	Number returned	Percentage
Students	250	167	66.8%
Teachers	10	8	80%
Total	**260**	**175**	**67.3%**

The information obtained is analysed in tables of frequencies, percentages and graphs. Responses from interviews and discussions with administrative staff are used to supplement responses from the closed ended questionnaires. The response rate is

considered reasonable because at least more than 50% of the targeted respondents participated in the study. The researcher feels that the views expressed in the report is therefore representative of the target population.

4.1 Section 1: Background Information of Respondents

4.1.1 Demographic Characteristics

The demographic characteristics illustrate the distribution of respondents' categories in relation to age, gender, year of study, designation and duration of service in the SHS as described in Tables 4.2 and 4.3.

Table 4.2: Distribution of Respondents According to Gender, Age and Year of Study (Students)

	Attributes	Category	Count	Percentages
	Gender	Male	87	52.1%
		Female	80	47.9%
Total			**167**	**100%**
	Age	< 17	65	38.9%
		17 – 20	82	49.1%
		> 20	20	12.0%
Total			**167**	**100%**
	Years of study	First year	22	13.2%
		Second year	72	43.1%
		Third year	73	43.7%
Total			**167**	**100%**
	Course of study	General Science	24	14.4%
		Business	23	13.8%
		General Arts	30	18.0%
		Agricultural Science	25	15.0%
		Visual Arts	18	10.7%
		Technical	22	13.1%
		Home Economics	25	15.0%
Total			**167**	**100%**

The findings in Table 4.2 show that greater number of the participants 87 (52.1%) were males while only 80 (47.9%) of them were females. This scenario is due to the fact that in the area where this study was conducted, female education is still low and this translates into their enrollment in Sefwi Bekwai Senior High School.

From Table 4.2, it can again be observed that greater number of participants 82 (49.1%) were aged between 17-20 years. This is because the greater section of the students come from the rural area and did not get the opportunity to attend school at the basic level where they could start schooling at an early age. This is further supported by the fact that in Ghana the school going age for children is **4** years. About 65 (38.9%) and 20 (12.0%) were aged below **17** years and above **20** years respectively. This forms the students who were fortunate to start school at an early age than 4 years and students who were repeated in one or two classes at their basic education respectively.

With regard to year of studies, a total of 73 (43.7%) respondents were in third 72 (43.1%), in second and 22 (13.2%) in first years. This demonstrates that the majority of respondents were either in their final or middle year of studies-a critical period in the preparation for the final test (WASSCE) and were also anticipated to have had adequate exposure to network resources at school. The gender and length of service of the teacher-respondents in the SHS were investigated by the researcher. This was done to determine the respondents' level of involvement in the teaching and learning process. The data is shown in Table 4.3.

Table 4.3: Distribution of Respondents According to Gender and Duration of Service (Teachers)

	Attributes	Category	Count	Percentages
	Gender	Male	6	75.0%
		Female	2	25.0%
Total			**8**	**100%**
	Years of teaching	Less than 3 years	1	12.5%
		Between 3-10 years	4	50.0%
		Above 10 years	3	37.5%
Total			**8**	**100%**

The findings from Table 4.3 shows that majority 6 (75%) of the teaching staff were male teachers. This is partly because in Ghana the rate of male education is higher than female education which corresponds to only 2 (25%) of the teachers in the study. It can also be seen from the table that majority (50%) of the teachers have spent **3-10** years in the school. This is partly because the school is located in a town that the teachers have good water supply, road, schools and hospital for themselves and their families. About (37.5%) of the teachers have spent more than **10** years which may also be due to the good road, water supply, electricity, schools and health services in the school's location. Only a few (12.5%) of the teachers have spent less than three years. These teachers are mostly the newly posted teachers. The teaching staff are considered central in this study because they are directly involved in the teaching and learning process using network or internet.

4.2 Section Two: Analysis on Objective One

- ✓ What are the needs for expansion of the school LAN to enhance learning?

In this section, descriptions of respondents' opinions per the items of the questionnaire relating to the objectives of the study are presented. Respondents were requested to react to the items by ticking (checking) the option that best described their opinions on a Likert scale ranging from Strongly Disagree to Strongly Agree or Available, Not Sure and Fairly Available.

4.2.1 Respondents' Opinion on the Availability of Network Resources

Several items in the questionnaire were presented to the respondents to rate their availability and the findings are shown in Table 4.4 below.

Table 4.4: Distribution of Respondents' Opinion on the Availability of Network Resources

Network resource	Status	Frequency	Percentage
Computers / PC in the classroom	Not Available	130	74.3%
	Fairly Available	30	17.1%
	Available	15	8.6%
Internet	Not Available	120	68.6%
	Fairly Available	38	21.7%
	Available	17	9.7%
Computer Laboratory	Not Available	18	10.3%
	Fairly Available	98	56.0%
	Available	59	33.7%
Video Conference like Zoom	Not Available	145	82.9%
	Fairly Available	25	14.3%
	Available	5	2.8%

As seen in Table 4.4, computers in the classroom seems to be one of the major concerns in Sefwi Bekwai SHS. This is depicted by the majority (74.3%) of respondents asserting that PCs were not available in the classroom. About (17.1%) responded that PCs are fairly available in the classroom while only a small number of respondents (8.6%) consented to the presence of PCs or computers in the classroom. The above findings suggest that the general presence of computers in the classrooms in Sefwi Bekwai SHS is still a challenge which directly hinders full integration of networking resources in the teaching and learning process as students do not have access to new and different types of productive information. Thus, the process of learning in the classroom can become significantly poorer as students do not have access to new and different types of information.

The findings from Table 4.4 also reveal that majority (68.6%) of the respondents were not sure of the availability of internet connectivity in the SHS. About (21.7%) of the respondents stated that internet connectivity is fairly available at the SHS. Only a small number (9.7%) of the respondents cited that internet connection was available. Following a discussion with the administrators, it was revealed that the SHS has not had an internet connection for a very long time because of financial constraints in terms of internet subscription hence making it difficult for students and teachers to access web-based learning resources like online journals and general information for study and knowledge creation.

In Table 4.4, majority (56.0%) of the respondents said that computer laboratories at the SHS were fairly available and that was closely followed by (33.7%) percent who agreed that computer laboratories were general available. A small number (10.3%) of the respondents stated that computer laboratories were not available in the SHS. In the

open-ended questionnaire, the students noted that there is a good computer laboratory in the ICT department; they however echoed the difficulty to get easy access to computers for use especially for the non-IT classes. They also said that some computers were faulty. This suggests that though limited in number, computer laboratories in the SHS are available. The biggest challenge is that students compete to access the laboratories and this may hinder their interest in accessing and using the laboratories.

Table 4.4 also reveals that video conferences in the SHS are still lacking as supported by a majority of respondents. (82.9%) consented that video conferences like zoom is not available. About (14.3%) of the respondents said video conferences are fairly available while a small number (2.8%) of the respondents said video conferences are available. The discussion with the administrators revealed that it is true the SHS video conferences were not integrated in the teaching and learning processes of the school because it called for bigger network band width which the SHS could not afford according to the headmaster of the school.

4.2.1.1 Respondents' Opinions on Adequacy of Network Resources

One of the major factors affecting the implementation or expansion of LAN is the adequacy of the networking tools. If the available network resources are not adequate enough for both the students and teachers, full utilisation of these tools may never be realised. In view of this, respondents were requested to rate the adequacy of networking resources and the findings are presented in Table 4.5 below.

Table 4.5: Distribution of Respondents and their Opinions on Adequacy of Network Resources

Network resource	Status	Frequency	Percentage
Computers / PCs in the classroom	Inadequate	114	65.1%
	Fairly Adequate	50	28.6%
	Adequate	11	6.3%
Internet	Inadequate	105	60.0%
	Fairly Adequate	49	28.0%
	Adequate	21	12.0%
Computer Laboratory	Inadequate	100	57.1%
	Fairly Adequate	43	24.6
	Adequate	32	18.3%
Video Conference like Zoom	Inadequate	133	76.0%
	Fairly Adequate	34	19.4%
	Adequate	8	4.6%

From Table 4.5, one major factor affecting the implementation or expansion of LAN in Sefwi Bekwai SHS is the inadequacy of computers in the classroom which was cited by a majority of the respondents (65.1%). This was closely followed by at least (60.0%) of the respondents who cited inadequacy of internet services in the SHS. About (28.6%) of the respondents said computers in the classroom were fairly adequate and about an equal percentage (28.0%) responded to internet services as fairly adequate. A small number of the respondents (12.0%) said internet service was generally adequate in the SHS. This suggests that computers in the classroom were inadequate and, in some departments, non-existent and also lacking internet connection. With the increasingly growing student population in the SHS, the students and the teaching staff all have to use the available computers and internet services in turns. In this situation, the time of use may never be sufficient to carry out constructive academic work like searching for information and doing online courses among others.

Table 4.5 also shows that majority (57.1%) of the respondents responded that computer laboratories are inadequate. About (24.6%) of the respondents said that they are fairly adequate while a small number (18.3%) of the respondents acknowledged they are adequate. These findings reveal that despite the fact that computer laboratories exist in the SHS, several departments do not have their own computer laboratories; priority is always given to students of computer science and information technology but not to students from other courses which frustrate them in their efforts to use the network for learning purposes.

Table 4.5 further shows that majority (76.0%) of the respondents responded to video conferencing equipment as being inadequate in the SHS. This is supported by the views of the administrators who concurred that such equipment does not even exist in the SHS which means that they are never used in the SHS for the teaching and learning process. The findings suggest that distance education is often supported by video conferencing to link up participants in learning centres and help facilitate instruction. It provides distant learners with a host of resources and access to content providers, teachers, librarians and more that are not catered for.

4.2.2. Respondents' Opinions on Accessibility of Networking Resources

The respondents were asked how often they access networking resources in various locations in the SHS and the results are given in Table 4.6 below.

Table 4.6: Distribution of Respondents' Opinions on Accessibility of Networking Resources

Network Location category	Number	Mean	Standard Deviation
Library	175	2.59	0.96
Computer laboratory	175	3.13	0.75
Classrooms	175	2.38	1.27
Dormitories	175	1.69	1.06
Internet Kiosk	175	2.26	1.09

The analysis was done based on Never at All, Not Sure, Sometimes and Always. Judgments on every item were on the sample size in the weighted mean score premeditated by the established three-point interlude used by the analysis. This is premeditated as **1+2+3+4= 10 / 4 = 2.5.**

A mean result of **2.5** and over is considered as network accessible and mean result less than **2.5** is considered as network not accessible.

From the analysis in table 4.6, library and computer laboratory had a mean score of **2.59** and **3.13** and a standard deviation of **0.96** and **0.75** respectively for both library and computer laboratory. These represent accessibility to networking resources at both places. The researcher's discussion with some respondents revealed that this access was not frequent. This was further confirmed by the assistant headmaster who asserted that access to the few computer laboratories for non-IT students was dependent on the laboratory being free which is not frequent. This implies that students' exploration of network resources for the acquisition of information and knowledge required for their academic pursuits is hampered by restricted access to network facilities in both the computer laboratory and the library.

Classrooms indicate a mean result of **2.38** and a standard deviation of **1.27**. The findings reveal that access to network resources in the classrooms is still limited and if the classroom is a typical learning environment, then access to network resources should be improved to allow both students and teachers to access and to produce resource materials associated with the processes of learning and teaching.

Dormitories indicate a mean result of **1.69** and a standard deviation of **1.06**. This represents the inaccessibility of network in the students' dormitories. Following a chat with some students, the researcher discovered that most students are day students. That is, they travel from their homes. But even those who are accommodated in the dormitories affiliated to the SHS said that the internet access points were not in place. The finding suggests that the students are limited in their access to network from their various places of residence hindering their use of these facilities for communication and searching for information which duly affects their learning.

Internet Kiosk indicates a mean result of **2.26** and standard deviation of **1.09**. This shows that only a limited number of students are able to access internet at the internet kiosk. The students further mentioned that it is very expensive to go to commercial internet kiosk and this cost seems to hinder students' readiness to access the internet resources for communication and learning purposes. Besides, the researcher observed that the SHS does not have an internet kiosk where students could access internet services for free.

4.2.2.1. Challenges Affecting Students' Accessibility of Network or Internet Resources

The respondents were asked to give their views on the challenges affecting students in accessing network resources and their responses are presented in the distribution below and also illustrated in Figure 4.1 below.

Load Shedding	3%
Poor management	6%
Unreliable network	7%
Limited access to Lab	10%
Financial constraints	13%
Few network devices	61%

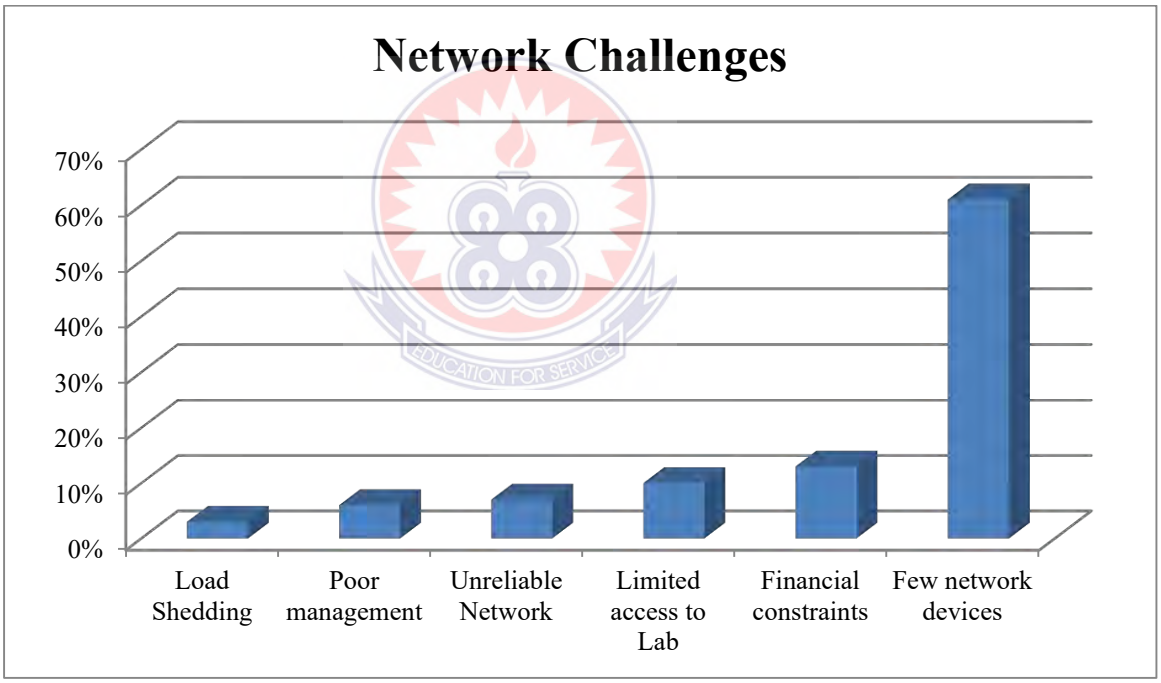

Figure 4.1: Distribution of Respondents' Views on Challenges Affecting Students' Accessibility of Network

From Figure 4.1, the findings in the open-ended question revealed that few network devices in the SHS remain the most serious challenge affecting accessibility of internet facilities in the SHS because majority of the respondents (61%) expressed this. The respondents stated that students are given limited time to practice since the computer

laboratory is always competed for by students from the different departments. Since most departments in the SHS do not have computer laboratories, priority is always given to the students of computer science or information Technology. This is further supported by (10%) of the respondents who consented that limited access to the computer laboratory remains the biggest challenge of accessing network in the SHS.

The results in figure 4.1 also reveal that financial constraints on the part of the SHS is one of the major challenges to accessibility of network. One respondent claimed that finances cannot allow Sefwi Bekwai SHS to meet all its demands. The researcher's discussion with the administrators reveals the need for increment in network facilitation so as to increase the number of technology accessories in the SHS.

About (7%) and (6%) of the respondents looked at unreliable internet and poor management respectively as challenges affecting accessibility while (3%) thinks it is power load shedding. The above findings reveal that accessibility of computers or network devices still remains a very serious hindrance to the students to engage in internet or network technological tools to improve on their learning.

4.2.3 Responses on Students' Learning

Respondents were asked to give their judgment on the different statements of how proper network or internet affects their learning. Below (Table 4.7) is the summary of their responses:

Table 4.7: Distribution of Respondents' Opinion on Performance of Learning Tasks

Learning task	Number	Mean	Standard Deviation
I learn on my own on the internet.	175	3.45	1.30
Networking or internet will help promote learning.	175	3.87	0.92
Internet provides access to information about anything and everyplace.	175	3.91	1.01
The internet offers knowledge at a variety of levels of study. Everything from scientific publications to those aimed at children is available.	175	3.59	1.14
The internet or networking functions as message boards where individuals may exchange opinions on any subject.	175	3.90	1.06
Networking or internet serves as a source of entertainment.	175	3.43	1.20

The analysis was done based on Strongly Disagree, Disagree, Don't Know, Agree and Strongly Agree. Judgments on every item were on the sample size in weighted mean score premeditated by an established five-point interlude used by the analysis. This was premeditated as **1+2+3+4+5 = 15 / 5 = 3.0.**

A mean result of **3.0** and over is considered as agreed, then a mean result between **2.5-2.99** is devised as neutral whereas a mean result below **2.5** is considered as disagreed. Item one of Table 4.7 had a mean score of **3.45** and a standard deviation of **1.30**. The finding suggests that despite the difficulties in gaining internet connection at the SHS, students are aware or agree that they may learn on their own through the internet. Item two of Table 4.7 had a mean score of **3.87** and a standard deviation of **0.92**. The finding suggests that the students agree that proper implementation or expansion of LAN at Sefwi Bekwai SHS will help to promote teaching and learning. Item three of Table 4.7 had a mean score of **3.91** and a standard deviation of **1.01**. The finding suggests that the students agree that proper implementation or expansion of LAN for the SHS will

help provide easy access to the internet. It will also provide students with every information they may need in their studies at anywhere and anytime. Item four of Table 4.7 had a mean score of **3.59** and a standard deviation of **1.14**. The findings imply that the students agree that with proper implementation or expansion of network for the SHS, students will have access to information at every level of their studies. Item five of Table 4.7 had a mean score of **3.90** and a standard deviation of **1.06**. This implies that the students agree that the internet functions as message boards for the exchange of opinions. This finding is supported by the fact that online discussion forum takes teaching and learning beyond a confined learning environment like the classroom bringing flexibility and convenience to teaching and learning. Students drive the learning process in online forums and more emphasis is placed on knowledge sharing than lesson notes (Onyema et al., 2019). Item six of Table 4.7 had a mean score of **3.43** and a standard deviation of **1.20**. This suggests that the students agree that the internet serves as a source of entertainment. The evidence in this finding suggests that proper implementation or expansion of LAN for the school will serve as a source of entertainment through the internet.

4.2.4. How Often Students Perform Various Tasks Using Internet

The respondents were asked to rate how often students perform different tasks using the internet and Table 4.8 shows their response.

Table 4.8: Distribution of Respondents' Opinion Regarding how often Students Perform various Tasks Using Internet

Task	Number	Mean	Standard Deviation
Submitting Assignments and Exercises	175	1.86	0.94
Doing research online	175	3.80	0.96
Discussing with friends and relatives	175	3.61	0.71

The analysis was summarised based on Never, Few Times a Year, Once or Twice a Month, At Least Once a Week and Every Day. Judgments on every item were on the sample size in the weighted mean score premeditated and established by a five-point interlude used by the analysis. This was premeditated as **1+2+3+4+5 = 15 / 5 = 3.0.**

A mean result of **3.0** and over is considered as agreed and a mean result between **2.5-2.99** is considered neutral whereas a mean result below **2.5** is considered as disagreed. Item one of Table 4.8 had a mean score of **1.86** and a standard deviation of **0.94**. The finding implies that the students of Sefwi Bekwai SHS disagreed that they use the internet or network to submit their assignments and exercises. The researcher's discussion with the administrators points to the fact that it is only a few students who use the internet for assignments and exercises submission and these few students may be the ICT or computer science students. Item two of Table 4.8 had a mean score of **3.80** and a standard deviation of **0.96**. This indicates that most of the students agreed they do research online. This finding makes it clear that proper implementation or expansion of LAN or internet for the SHS will help the students a lot in their research since most of them use the internet or network for their research. Discussions with the administrators revealed that the school has future plans to set up a LAN since the internet is the main information reservoir for doing research.

Item three of Table 4.8 had a mean score of **3.61** and a standard deviation of **0.71**. This indicates that a large number of the students agreed to discussing with friends and relatives online. Discussion with the students revealed that only the day students or the computer science students may possibly have the chance to discuss with relatives and friends every day through the internet. This finding implies that since students usually use the internet or network to discuss with friends and relatives, proper implementation

or expansion of LAN will give the students opportunity to have lesson discussions with their colleague students. This will help to promote teaching and learning.

4.3 Test of Relationships between Variables: The data was tested using a Pearson product moment correlation index to find out whether there is a relationship between the two variables. The outcome of the finding is shown in Table 4.9 below.

Table 4.9: Correlation between Availability, Accessibility of Network Resources and Students' Learning

	Students' Learning
Availability of Network Resources	.711*
Accessibility of Network Resources	.906*

***Correlation is significant at (0.05) tow tail**

The findings of the study indicate a positive linear link between network availability and students' learning as indicated by the positive value of the computed correlation index (.711). The p-value (.000) being less than the level of significance alpha (.05) implies that the results were statistically significant. This suggests that availability of network plays a significantly positive role towards students' learning in Sefwi Bekwai SHS hence the availability of network resources will influence students' learning in Sefwi Bekwai SHS. The results of the analysis show a positive correlation (.906) between accessibility of network resources and students' learning. The p-value (.000) being less than the level of significance alpha (.05) implies that the results were statistically significant. This suggests that accessibility of network plays a significantly positive role towards students' learning in Sefwi Bekwai SHS hence the accessibility of network resources will influence students' learning in Sefwi Bekwai SHS.

4.4 Analysis on Objective Two and Three

- ✓ How will VLAN lead to reduction in the need for routers in a network to contain broadcast traffic?
- ✓ How will VLAN increase the level of LAN security and improve network performance?

4.4.1 Reduction of Routers, Increase Security and Improved Performance in VLAN Network

The researcher made an analysis and further discussed why it is very advantageous to use VLAN for implementation or expansion of the network at Sefwi Bekwai SHS.

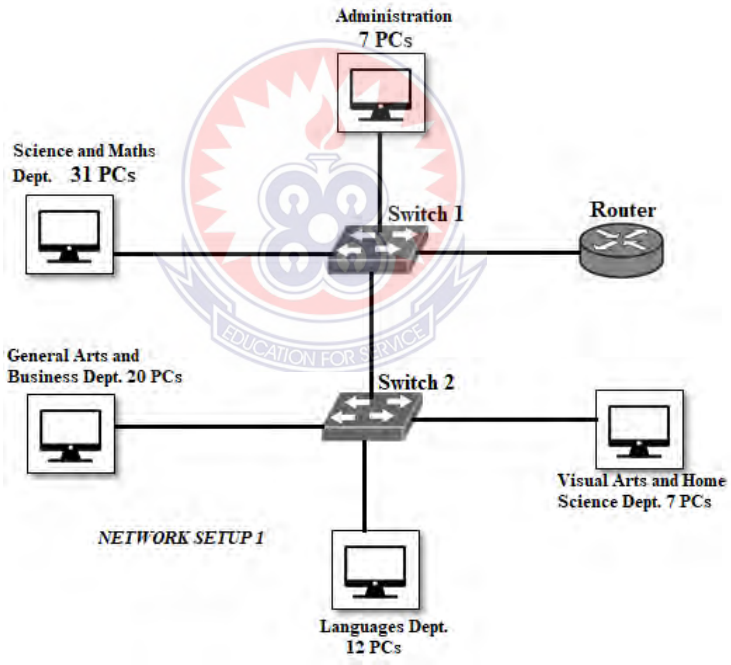

Figure 4.2: Network Setup of Offices of the 77 Staff Members

The diagram in Figure 4.2 shows the network set up of the various offices in Sefwi Bekwai SHS. With the network set up above, any broadcast message to any department (example administration) will not only get to that particular department's PCs but a copy of the broadcast message will also get to all the **77** PCs connected in the network

set up since switches by default broadcast messages to all devices connected to it. That is, there cannot be a broadcast message to only one department. However, this is not good for any organisation due to the reasons below:

- **Reduction of network performance**: The connections in the network set up above will result in poor network performance due to the unnecessary broadcast messages. That is, some messages will be sent to PCs or departments which do not even need those messages. This will create unnecessary traffic in the network leading to slow network performances.
- **Confidentiality will be problematic**: Any confidential information intended only for people in a particular department will also get to all the 77 devices connected to the network. This is because all users are able to see all devices on local area network. This is not good for any organisation.

To solve the problems above, we need to introduce more routers in the network since routers stop broadcast messages. That is, every department or network needs to have a separate switch connecting all the devices in that department and that switch also connected to a router as shown in the network set up in Figure 4.3 and Figure 4.4.

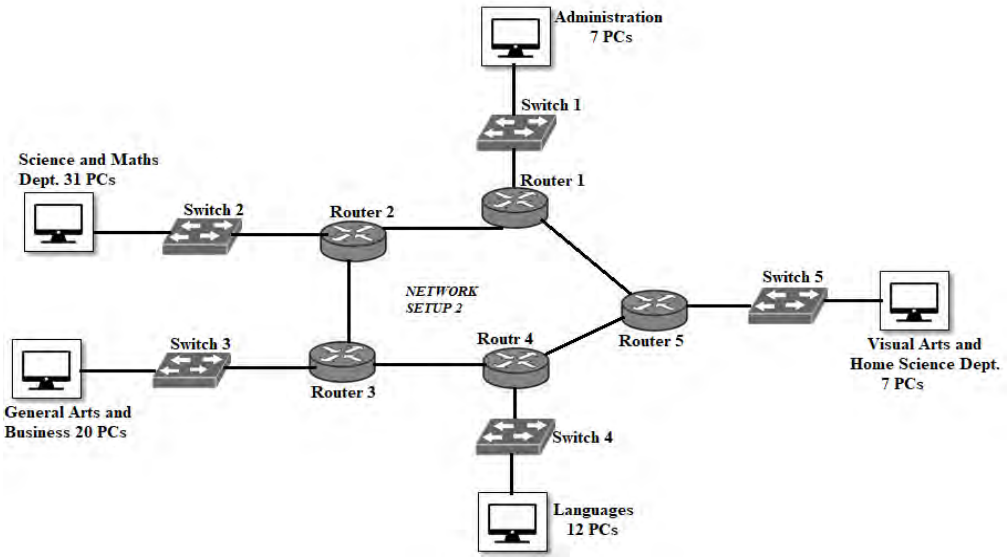

Figure 4.3: Network Set Up of Offices of the 77 Staff Members

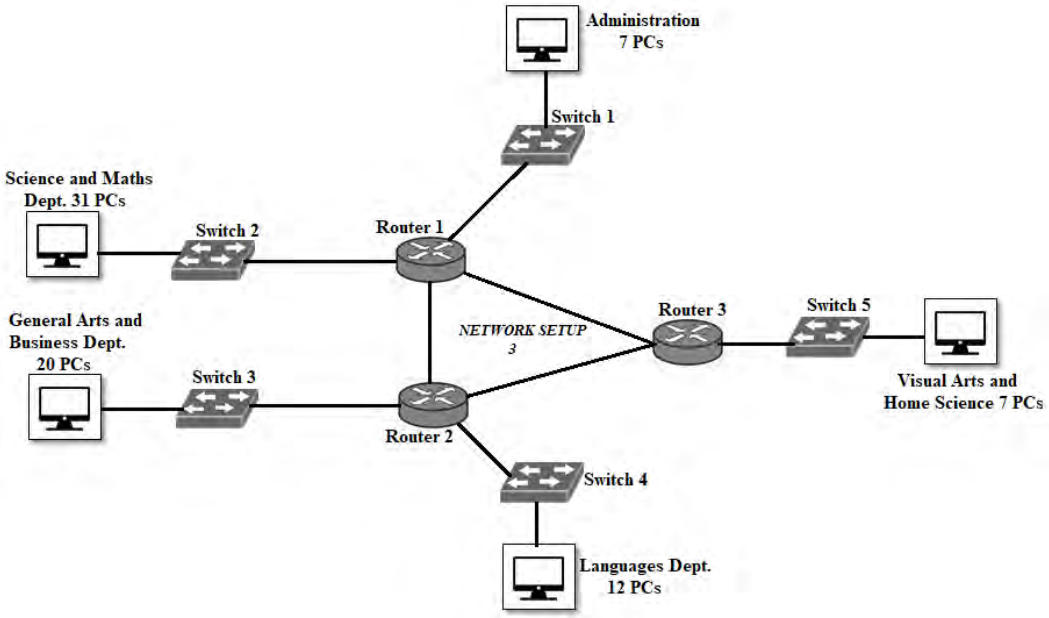

Figure 4.4: Network Set Up of Offices of the 77 Staff Members

Any of the above network set up in both Figures 4.3 and 4.4 solves the problems of network performance and confidentiality. But it also adds additional problem of high cost, flexibility problems and network management problems.

- **High Cost**: The institution has to spend more money in buying additional switches and routers. This may be problem economically.
- **Manageability problems**: Due to the many switches and routers in the network, management becomes problematic for the IT managers of the network. For example, it is very difficult to troubleshoot the network.
- **Flexibility problems**: with the network set ups in Figure 4.2, Figure 4.3 and Figure 4.4, there will be network flexibility problems if in future there is the need for network expansion. For example, if there is an introduction of a new department. Then, it may become very necessary to introduce a new router and a switch. Again, if a user of the network changes his/her room or office to a different floor or building, then joining him/her to his department will be very problematic.

All the above problems can be solved with the introduction of VLAN (Virtual Local Area Network). This is because VLAN can increase network security, performance, and manageability while decreasing costs.

A LAN can be defined as a group of computers within a certain geographical area (like an office) that are all connected. A VLAN shares similar characteristics to a LAN but a VLAN allows different computers and devices to be connected virtually to each other as if they were in a LAN sharing a single broadcast domain. In a way, a VLAN acts mini separate networks within a LAN. A VLAN can be used to segment a larger network into smaller segments. VLANs can be used for different groups of users, departments and functions without being in the same geographical area (Agwu et al., 2013).

With VLAN, we can still maintain the simple and cost-effective network set up as represented in figure 4.2 above but it will still help us resolve all the networking problems we have listed above. Just that all the devices in the network have to be in a VLAN. That is, we can group every device belonging to a department into a single VLAN regardless of its geographical location as shown in Figure 4.5 below.

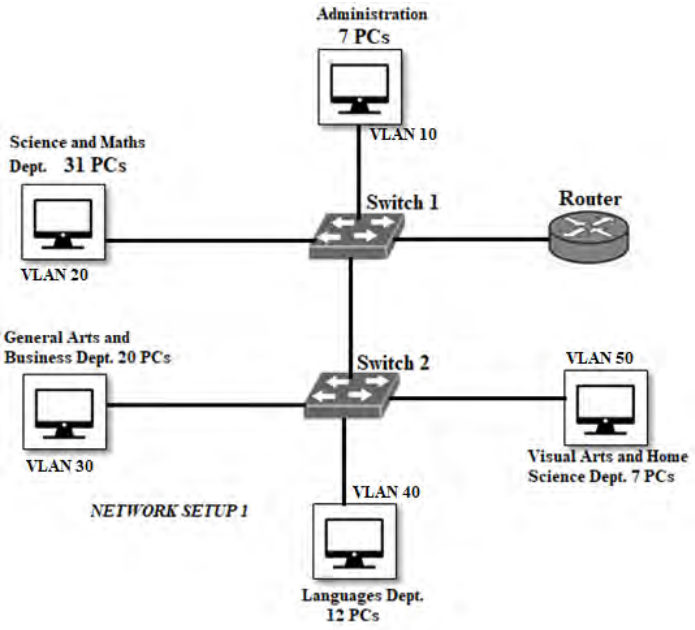

Figure 4.5: Network Set Up of Offices of the 77 Staff Members Grouped in VLAN

With the network set up in Figure 4.5, all the networking problems of performance, security or confidentiality, manageability, flexibility and cost will be resolved.

Network Performance: With VLANs as in Figure 4.5 above, there is high network performance since there is broadcast control. A broadcast message to a particular department or VLAN only gets to the people or devices in that VLAN. This helps to reduce traffic in the network leading to increase network performance. For example, broadcast message to the languages department or VLAN **40** only gets to the people or **12** PCs in the department.

Security or Confidentiality: With the VLANs in Figure 4.5, a group of users that need an unusually high level of security like the school administration can be put into its own VLAN so that users outside of that VLAN can't communicate with it. This implies that in the school, each department can be made independent from other departments.

Flexibility: With the VLANs setup in Figure 4.5 above, network adds, moves, and changes are achieved with ease by just configuring a port into the appropriate VLAN and assigning hosts to the same VLAN.

Manageability: With the VLANs setup in Figure 4.5, problems emanating from the network can easily be identified and fixed by mere tracing groups or departments such hosts belong to.

Cost: VLAN configurations can help save the institution money by eliminating the need for additional expensive network equipment like routers and switches as shown in figure 4.5. Instead, VLANs utilise existing resources in a more efficient manner. For example, regardless of the location or the switch a device is connected to, any device can be connected to any VLAN without generating any problem.

4.4.2 Test and Analysis of the VLAN Network Performance

The results and analysis of tests carried out in the network implementation or expansion of the VLAN network through Cisco Packet Tracer are shown below.

4.4.2.1 Show IP Route Command of Router

The result of the "show ip" is shown in Figure 4.6 below.

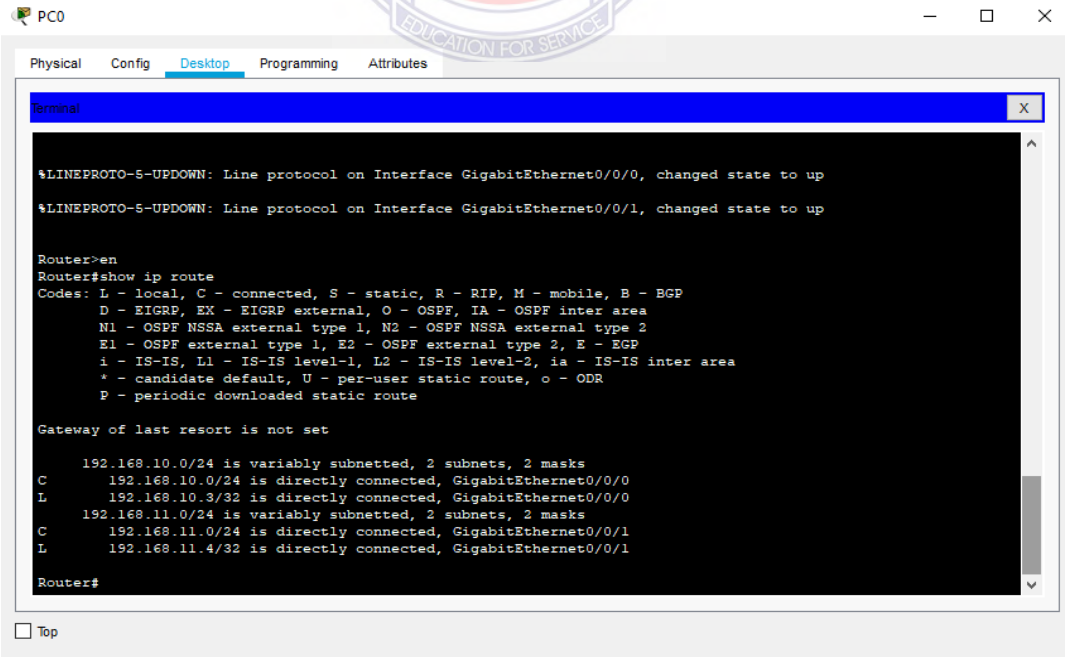

Figure 4.6: The IP Route of Router

4.4.2.2 Ping Command

The Ping command displayed in Figure 4.7 is the basic command run to verify connectivity between devices. This can be done either on switches, routers, servers or computers. In routers and switches, the command is applied in privilege mode while on servers and computers, it runs on command prompt interface. The main requirement of a network is that data be transmitted as quickly as possible. The result of ping statistics from PC2 to web Server is shown in figure 4.7 below.

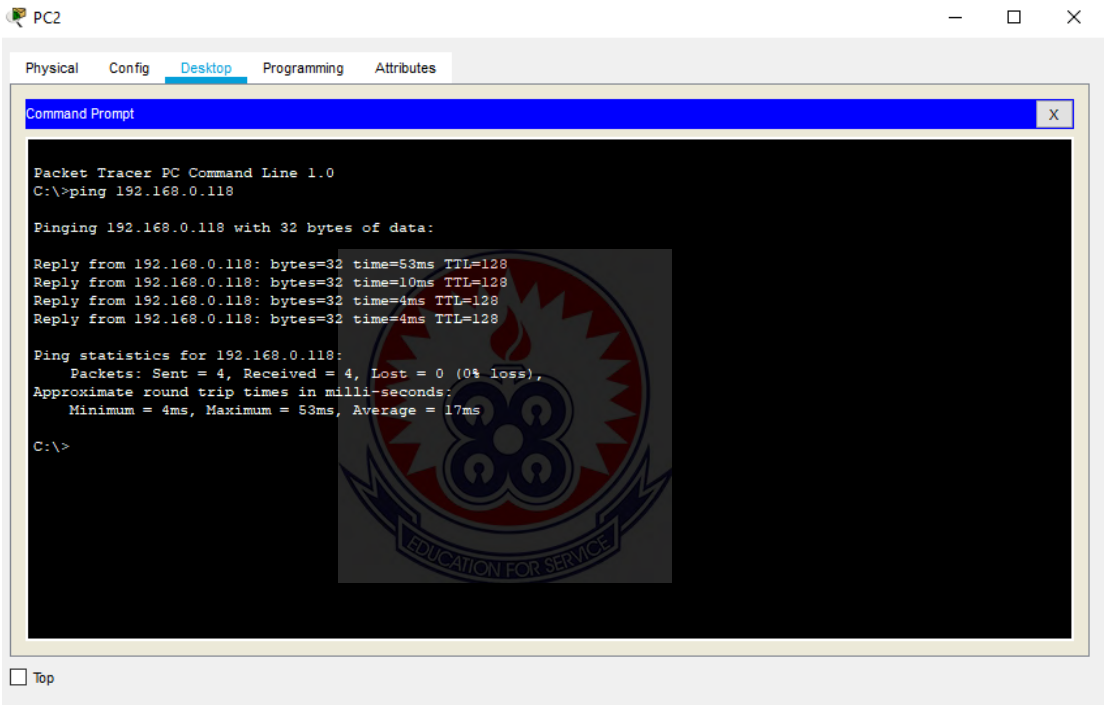

Figure 4.7: Ping Statistics from PC2 to Web Server

4.4.2.3 Access to Website

The website server as in Figure 4.8 was configured and devices in the entire network can link up to it with the IP address.

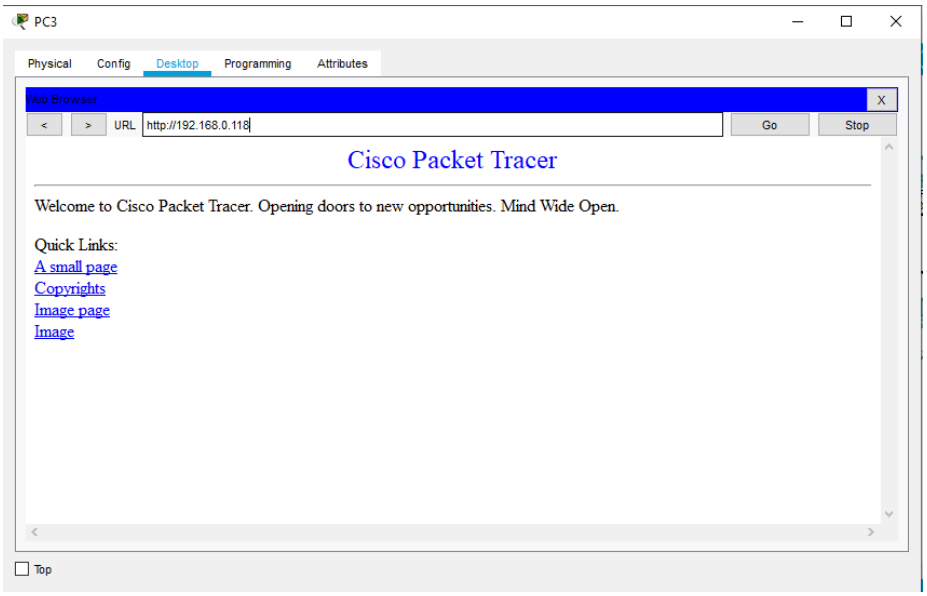

Figure 4.8: A Programmed Website

4.5 Discussion of Findings

The following are the findings according to the research objectives:

4.5.1 Findings on the Impact of Network Resources Availability on Students' Learning

The study established that the availability of the different network or internet resources in the SHS is still very much wanted. About (74.3%) of the respondents said computers were not available in the classroom. (68.6%) of the respondents stated that internet connection in the SHS is not available and also (56%) consented to computer laboratory being fairly available. Technology gadgets and their accessories should be made available for usage to produce the desired benefits for proper and full integration of internet or networking into the teaching and learning process.

According to (Siddiquah & Salim, 2017), computer and internet affect the educational process more than the previous educational technologies. ICT integration in higher education benefits both instructional and learning processes. In addition to aural and visual senses, computers and the internet engage the user's sense of touch and give the

possibility for more interaction for the development of the user's unique, creative, and intellectual talents. Furthermore, Ben Youssef & Dahmani (2008) state that students who receive ICT-based teaching perform more than those who do not get ICT-based instruction. Fourie et al. (1996) assert that when computers and related technology are made available in schools and institutions, students are forced to use databases, spreadsheets, multimedia, e-mail, and network search engines to complete their projects, and such processes have a greater potential to promote cognitive development. Computers, according to Hopson et al. (2001), have the ability to provide students with higher-order skills such as enquiry, reasoning, problem solving and decision-making abilities, critical and creative thinking and learning how to learn. According to research, using computers have a beneficial influence on students' success when compared to conventional ways.

The survey also indicates that the SHS's internet resources are insufficient. About (65.1%) percent of the respondents thought computers in classrooms were inadequate while (60%) percent agreed that the internet was inadequate and (57.1%) percent said computer labs were inadequate. (Baluku & Kasujja, 2020) indicate that the inadequacy of ICT facilities translates into lack of skills in the use of ICT equipment and software which results in a lack of confidence in using ICT tools among the students.

4.5.2. Findings on the Impact of Network Resources Accessibility on Students' Learning

Learning using internet or network is hindered by accessibility to different ICT resources. (*BarriersofICTIntegrationinTeachingLearning2016jje*, n.d.) and (Ghavifekr et al., 2016) emphasised the issue of accessibility as a feature of ICT integration into

teaching and learning process. In the same vain, (Ben Youssef & Dahmani, 2008) stressed that inaccessibility of internal school network outside the institution may limit teachers and students from accessing and using ICTs. The study reveals that because of the limitation in the numbers of functional computers and laboratories, the computer laboratories are timetabled and the time for accessibility is limited. Teachers and students from the different faculties are supposed to adhere to time schedules which do not promote accessibility at convenience. Nonetheless, timetabling is aimed at better organisation and management of the few resources and most respondents agreed that there is access though insufficient in the SHS.

The study indicates that easy access to internet facilities was a problem in the SHS. According to the findings, majority of the students hardly access network facilities from their dormitories. No time was allocated for students' practice in the computer lab. Besides, the teachers also compete for facilities in the computer lab with students. However, the survey also reveals that the computer lab and the SHS library continue to be the two most popular locations for accessing network resources. It is worth mentioning that access to the internet which is one of the most important indicators of ICT in learning in an institution is not fully implemented in all sectors, particularly dormitories and classrooms. Newhouse (2002) expressly states that the internet will positively impact teaching and learning. Furthermore, Chukwunonso et. al. (2013) emphasise that the internet and the World Wide Web have altered the face of technology particularly in the way people communicate and interact. Learning on internet conforms to constructivist instructional approach (Gold, 2001). Therefore, the limit to places is not an ideal practice.

(UNESCO, 2002) points out that the success of ICT in the teaching and learning process in education shall base on the degree with which students and teaching staff access ICT facilities. Findings from respondents echoed limited network resources as the biggest challenge affecting students' network devices (61%). This was closely followed by financial constraints cited by (13%) of the respondents. The researcher's discussion with the administrators reveals the need for increment in ICT facilitation so as to increase on the number of technology accessories in the SHS. Limited time access to the computer lab (10%), unreliable network (7%) and power fluctuation (3%) were some of the other reasons cited as affecting students' access to ICT or network resources.

4.5.3 Cisco Packet Tracer Simulation of LAN Implementation or Expansion

From the study, Local Area Network at Sefwi Bekwai SHS can easily be implemented or expanded to cover the entire campus and tested. Troubleshooting will be easy because there were no complex routing interactions in the simulation. It is guaranteed since every device could reach every point of the simulation network which means that the connectivity of all devices was guaranteed. If the network is finally implemented, it could be double or triple without major design changes that is, the network will be flexible at any time.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter gives a summary of the findings, conclusions and recommendations made from the research. These are based on the objectives and the research questions of the research. The aim of the research was to simulate the implementation or expansion of LAN at Sefwi Bekwai SHS using packet tracer through the findings on the availability and accessibility of network resources and its impact on students' learning.

5.1 Summary of Findings

The findings from the study revealed that:

- The study established that the availability of the different network or internet resources such as computers, internet, computer laboratory and video conference like zoom in the SHS is still very much wanted. That is, these network resources were fairly available in the SHS but they were not adequate to support teaching and learning
- Learning using internet or network is hindered by accessibility to different ICT resources in the various location of the school like classrooms and dormitories. Accessibility to internet or network was possible at the SHS library and computer laboratory but the computer laboratory was mostly occupied by the IT students and the library was not always accessible especially weekend. There is the accessibility to internet at the internet kiosk but it is very expensive for students to afford. The major challenge affecting students' accessibility of network or internet resources were few network devices, financial constraints and limited access the SHS computer laboratory.

- With limited capital the Local Area Network at Sefwi Bekwai SHS can easily be implemented or expanded to cover the entire campus using VLAN technology since it makes use of few routers and switches

5.2. Conclusion

From the findings, the following conclusions were drawn:

1. The ICT infrastructure of the SHS is poorly developed, unevenly distributed and inadequate. However, some ICT resources like computer lab, projectors and computers were considered to be fairly available. Though not fully adequate, the SHS recognises the essential need for good network and other ICT resources in its academic endeavours and as such there is already something to build on.
2. Network access in different sectors of the SHS for both teachers and students was not well attended to. The biggest challenge still affecting easy access to network facilities in the SHS remains the limited number of ICT resources which do not match with the ever-increasing student population. But there was at least something in place to build on though there were still limited computers.
3. To a large extent, students training in ICT in the SHS were mainly theoretical but not skill acquisition that led to ICT skill transfer to use ICT both for learning and in other settings.
4. The objective of this project is to build simulated LAN for implementation or expansion at Sefwi Bekwai SHS which will ensure that no ICT device stays on its own, that connectivity is fast, and that the addition of devices must not hinder packet transmission. It can be said that these objectives have been achieved and that the network and troubleshooting standards have been fully met.

5.3. Recommendations

Based on the findings of this study to improve on the internet or network availability and accessibility, the following recommendations may be considered:

1. There is a need for the SHS to spend more on computers and associated technologies in order to not only solve the accessibility problem but also to improve the presence of facilities particularly computers in the classroom and computer lab.
2. Proper internet connection installation in the SHS is required. That is, the connection of more computers to the internet. The school should then liberalise internet access. Overall, the school will take time and effort to achieve a **1:1** ratio of student-to-ICT access to amenities. Thus, students should also endeavor to acquire themselves what they can afford or visit commercial internet providers like internet café to access internet facilities.
3. Training in ICT skills should not be limited to Ms Office suits or too theoretical. The SHS should go ahead to integrate the other internet or network programmes in the curriculum for schools. Clearly, a basic level ICT skill must be achieved but this should be followed by an integrated approach to ICT and learning. The aim should be for embedding ICT firmly into the teaching and learning process. Such changes may offer the potential to improve on teaching and learning using modern technology.

5.4 Recommendations for Future Work

a) Additional Access Control Lists (ACLs) must be implemented throughout the network to provide robust end-to-end security.

b) IPv6 addressing can be implemented to overcome restrictions on the number of hosts that can be used due to the available address space.

c) In addition to the existing VoIP functionality, further network setup can be done to enable video conferencing.

d) Investigate the relationship between technology and genuine learning in Senior High Schools.

e) Research on students' perception and use of the internet as a hub for learning.

f) Research on the effects of modern technology on students' performance

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APPENDICES

APPENDIX A

QUESTIONNAIRE ON ASSESSMENT OF VLAN FOR THE IMPLEMENTATION OR EXPANSION OF A LAN USING CISCO PACKET TRACER: THE CASE OF SEFWI BEKWAI SENIOR HIGH SCHOOL.

STUDENTS' QUESTIONNAIRE

Dear Student,

You were chosen randomly as a participant in the above captioned survey that is being conducted as part of an academic research in partial fulfilment of the requirements for the award of Master of IT in Education of University of Education, Winneba. Your collaboration in filling this questionnaire will determine the success of the study. Feel free in expressing your thoughts on the items presented by answering all of the questions and indicating your preference by placing a checkmark in the checkbox next to the answer you believe is most appropriate or fill in the blanks by providing reasons or information in relation to a specific question. The replies will be used solely for academic reasons and will be kept strictly secret.

SECTION I

Respondents' Background Information

Please fill out the following information about yourself by checking the applicable boxes.

1. Your Age: …….

2. Your Sex:

Male [ ] Female [ ]

3. Year of study:

a) First year [ ] b) Second year [ ] c) Third year [ ]

4. Course of study (optional)

General Science	[ ]	Business	[ ]
General Arts	[ ]	Agricultural Science	[ ]
Visual Arts	[ ]	Technical	[ ]
Home Economics	[ ]	IT	[ ]

Independent variable

Availability of network resources

5. How do you agree or disagree on the availability of the following network resources in your senior high school?

	Not Available	Fairly Available	Available
i) Computers / PCs in the classroom			
ii) Internet			
iii) Computer Laboratory			
iv) Video conferencing like Zoom			
Others (specify)			

6. Do you believe these resources are appropriately available, in your opinion? Please assess the sufficiency of the following networking resources.

	Inadequate	Fairly adequate	Adequate
i) Computers / PCs in the classroom			
ii) Internet			
iii) Computer Laboratory			
iv) Video conferencing like Zoom			
Others (specify)			

Accessibility of networking resources

7. At the SHS, how often do you access network resources in the following locations?

	Never at all	Not sure	Sometimes	Always
a) Library				
b) Computer Laboratory				
c) Classrooms				
d) Halls of residence				
e) Internet Kiosk				
Others (specify)				

8. In your own opinion, what do you regard as the biggest challenge affecting accessibility of network or internet and its resources in your SHS?……...

……

Dependent variable: Students' learning

9. How do you agree or disagree with the following statements about network

	Strongly Disagree	Disagree	Don't know	Agree	Strongly Agree
I learn on my own on the internet					
Networking or internet will help promote learning					
Internet provides access to information about anything and everyplace					
Internet provides information at various level of study. Everything from scholarly articles to the ones directed at children					
Internet or networking serves as message boards where people can discuss ideas on any topic					
Networking or internet serves as source of entertainment					

10. How often do you perform these tasks through internet or networking?

	Never	**Few times a year**	**Ones or twice a month**	**At least once a week**	**Everyday**
Submitting Assignments and Exercise					
Doing research online					
Discussing with friends and relatives					

End

Thank you.

APPENDIX B

QUESTIONNAIRE ON ASSESSMENT OF VLAN FOR THE IMPLEMENTATION OR EXPANSION OF A LAN USING CISCO PACKET TRACER: THE CASE OF SEFWI BEKWAI SENIOR HIGH SCHOOL.

TEACHERS' QUESTIONNAIRE

Dear Teacher,

You were chosen randomly as a participant in the above captioned survey that is being conducted as part of an academic research in partial fulfilment of the requirements for the award of Master of IT in Education of University of Education, Winneba. Your collaboration in filling this questionnaire will determine the success of the study. Feel free in expressing your thoughts on the items presented by answering all of the questions and indicating your preference by placing a checkmark in the checkbox next to the answer you believe is most appropriate or fill in the blanks by providing reasons or information in relation to a specific question. The replies will be used solely for academic reasons and will be kept strictly secret.

SECTION I

Respondents' Background Information

Please fill out the following information about yourself by checking the applicable boxes.

1. Your Sex:

Male [ ] Female [ ]

2. Name of Faculty /School/Institute (optional)

General Science	[ ]	Business	[ ]
General Arts	[ ]	Agricultural Science	[ ]
Visual Arts	[ ]	Technical	[ ]
Home Economics	[ ]	IT	[ ]

3. How long have you been teaching in the school?

Less than 3 year [ ] Between 3-10years [ ] More than 10 years [ ]

4. What is your administrative position (optional)?

Teacher [ ] Head of Department [ ]

Availability of network resources

5. How do you agree or disagree on the availability of the following network resources in your Senior High School?

	Not Available	Fairly Available	Available
i) Computers / PCs in the classroom			
ii) Internet			
iii) Computer Laboratory			
iv) Video conferencing like Zoom			
Others (specify)			

6. Do you believe these resources are appropriately available in your opinion? Please assess the sufficiency of the following networking resources.

	Inadequate	Fairly adequate	adequate
i) Computers / PCs in the classroom			
ii) Internet			
iii) Computer Laboratory			
iv) Video conferencing like Zoom			
Others (specify)			

Accessibility of networking resources

7. At the SHS, how often do you access network resources in the following locations?

	Never at all	Not sure	Sometimes	Always
a) Library				
b) Computer Laboratory				
c) Classrooms				
d) Halls of residence				
e) Internet Kiosk				
Others (specify)				

8. In your own opinion, what do you regard as the biggest challenge affecting accessibility of network or internet and it resources in your SHS? ...……

……

Dependent variable: Students' learning

9. How do you agree or disagree with the following statements about network?

	Strongly Disagree	Disagree	Don't know	Agree	Strongly Agree
I learn on my own on the internet					
Networking or internet will help promote learning					
Internet provides access to information about anything and everyplace					
Internet provides information at various levels of study. Everything from scholarly articles to the ones directed at children					
Internet or networking serves as message boards where people can discuss ideas on any topic					
Networking or internet serves as source of entertainment					

10. How often do you perform these tasks through internet or networking?

	Never	Few times a year	Ones or twice a month	At least once a week	Everyday
Giving Assignments and Exercise					
Doing research online					
Discussing with friends and relatives					

End

Thank you.

APPENDIX C

INTERVIEW GUIDE FOR ADMINISTRATORS

This interview guide is about assessment of VLAN for the implementation or expansion of a LAN using cisco packet tracer: The case of Sefwi Bekwai Senior High School.

Particulars	Responses
Sex	
Designation	
Department	

1. Comment on the presence of networking facilities in your school
2. How adequate are these facilities for students' use?
3. Do staff and students across the academic discipline have access to network or internet for academic purposes? How often?
4. What factors could affect students' access of the network or internet for academic purposes?
5. What are some of the networking skills you train your students in?
6. How are those skills (trained) relevant to your students after school?
7. What is your vision for network in students' learning?