MANAGING NETWORK INFRASTRUCTURE WITH A SMALL BUSINESS SERVER

CSIR-FRI/RE/BKA/2018/002

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ABSTRACT

At the center of every network there is a router. A router is used to connect one network to another network. It has the responsibility of routing packets across different networks. The Food Research Institute of the Council for Scientific and Industrial Research (CSIR-FRI) Local Area Network (LAN) Infrastructure uses a traditional cisco router as an internet gateway and a firewall. This makes it possible for computers on the LAN to have internet access and also control traffic in and out of the network. However, in July 2017, the router became non-functional necessitating the need for replacement. In order to save cost, the IT team explored the possibility of substituting a real-life solution of a router-based firewall with an open source solution having an easy, manageable, and centralized graphical user interface (GUI) and integrated built-in network extensions. This study describes the methods and procedures taken by the IT team to implement a Linux small business server, Zentyal, as an open source firewall/gateway router alternative to the traditional cisco router. Results of this study shows a successful deployment of Zentyal on Dell PowerEdge T310 server as an internet gateway and firewall that supports 300 windows clients and laptops of staff of CSIR FRI. This solution has provided a unified single platform for the entire network infrastructure management and security.

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1.0 CHAPTER ONE: INTRODUCTION

1.1 Background, Purpose and Motivation of the study

At the center of every network there is a router. A router is used to connect one network to another network. It has the responsibility of routing packets across different networks. The networks where this traffic is routed can either be located within the same proximity as that of the router or it can be miles away, for instance in another country.

The Food Research Institute of the Council for Scientific and Industrial Research (CSIR-FRI) Local Area Network (LAN) Infrastructure uses a traditional cisco router as an internet gateway and a firewall. This makes it possible for computers on the LAN to have internet access and also control traffic in and out of the network. However, in July 2017, the router became non-functional necessitating the need for replacement.

In order to save cost, the IT team explored the possibility of substituting a real-life solution of a router-based firewall with an open source solution having an easy, manageable, and centralized graphical user interface (GUI) and integrated built-in network extensions.

This study describes the methods and procedures taken by the IT team to implement a Linux small business server, Zentyal, as an open source firewall/gateway router alternative to the traditional cisco router.

The main objective of this study was to deploy and manage Zentyal small business server in CSIR-FRI IT Infrastructure.

1.2 Significance of the study

This study is necessary because it seeks to improve the efficiency of the network. It also reduces the cost of installing an expensive server and also provides a server that can be easily managed with fewer technicalities compared to other type of servers. Currently, the server used for this runs on ubuntu 16.04.

This project will also serve as a learning tool for installation of server and also simulation of the requirement of a small business. It will further serve as a hands-on network which students on industrial attachment can work with in networking training. With the success of this research, the FRI network infrastructure will have a server that offers multifunction purposes such as Files sharing, Printers sharing, DNS server, DHCP server and Proxy Server, Gateway and a Firewall. Zentyal server also covers all the functionality required by small and medium sized businesses: autoconfiguration of the equipment, firewall, content

filtering, Internet access optimization via http proxy, traffic shaping and hosting of shared resources.

1.3 Objectives

The specific objectives include the following:

1. To determine the required hardware for the project.
2. To install and configure the Zentyal operating system on the FRI Server.
3. To design a network based on the client-server architecture, so that the computers on the FRI LAN can reach the server.
4. To configure the Zentyal OS as a gateway for the computers on the LAN to reach the outside world.
5. To configure the Zentyal OS as a firewall to control network traffic on the LAN
6. To Implement other features the Zentyal operating system possesses such as N

2.0 CHAPTER TWO: LITERATURE REVIEW

2.1 Related Literature

In the world of Information Technology today, the need for data and resource sharing services is higher than ever. Computer networking has been developed as a solution to this huge need. This involves the exchange of information or services among individuals or groups. Prior to the age of 'networking' where exchange is just a few key strokes away, data had to be moved from one place to the other with the help of storage devices.

Networking has grown to be important in digital communication and there are broadly two types of networking configuration; peer-to-peer and client-server configuration. In the client- server configuration, local users (client) on a network sending request for a network service to a server. A server, sometimes referred to as the super-computer, is a dedicated workstation that is responsible for keeping and sharing of resources in a network. Servers operate in client-server architecture and are an integral part of computer networking and management; hence its importance cannot be overemphasized. It (server) sees to file hosting and can also provide access to them for a client on the network (Abelson, Sussman, & Sussman, 1996).

Businesses today have embraced the use of client-server configuration and it ensures the authenticity of data since every user on the network backs up on the same server i.e. the server operates as a central repository for all the documents of the organization. Servers serve as the central unit on the network that stores the data and provides it on request without having to move data around to every work station as a result, simplifies the organization and management of data efficiently (Abelson, Sussman, & Sussman, 1996).

Since 1990 when the first web server was built by Tim Berners-Lee in Geneva Switzerland, several modifications and improvements have been made to it while other types of servers have been introduced. Today several types of servers have been designed including game server, application server, mail server, file server etc. There are also several platforms that design servers, amongst them are; Microsoft, Linux, Mac, IBM, and Apple

Linux operating has notably increased in popularity because it is readily available and free. It was initially faulted due to its not so friendly first-time user understanding. Over time, it was realized that, it was a small price to pay compared to the service and advantages

it offers. There are also several versions of the Linux operating system which are built on the different kernels, which include Ubuntu, Red Hat, Fedora, openSUSE, etc.

2.2 Theoretical Perspective

During the early time of computers, they were independent and isolated and hence a way to connect computers together and exchange data / information was introduced. A computer network is made up of an array of computers, printers and other devices that are connected together so they can communicate with each other. This can be in form of a Local Area Network (LAN), Wireless Local Area Network (WLAN), Wide Area Network (WAN) and Metropolitan Area Network (MAN).

Data transfer from one computer over the network to another describes what almost everyone does each day. This involves a connection being established between systems hence, communication begins. Communication in networks is achieved by having the corresponding layers in two systems (e.g. computers) communicate. The peer layers commune by means of protocols. Protocols are formatted blocks of data that obey a set of rules or conventions. The key features of a protocol are as follows:

- Syntax
- Semantics
- Timing

Syntax defines the format of data blocks while semantics is concerned with the control information for coordination and error handling. Timing involves speed matching and sequencing. Therefore, every layer on the computer has its own protocol. The Open Systems Interconnection (OSI) by International Organization for Standardization (ISO) model of the computer is reviewed in this paper (Stallings, 2007).

2.3 OSI Model

The OSI reference model is an architectural model for networks and a blueprint of how layers should operate. It was developed to promote interoperation of devices by different manufacturers. This is a seven-layer approach (Stallings, 2007).

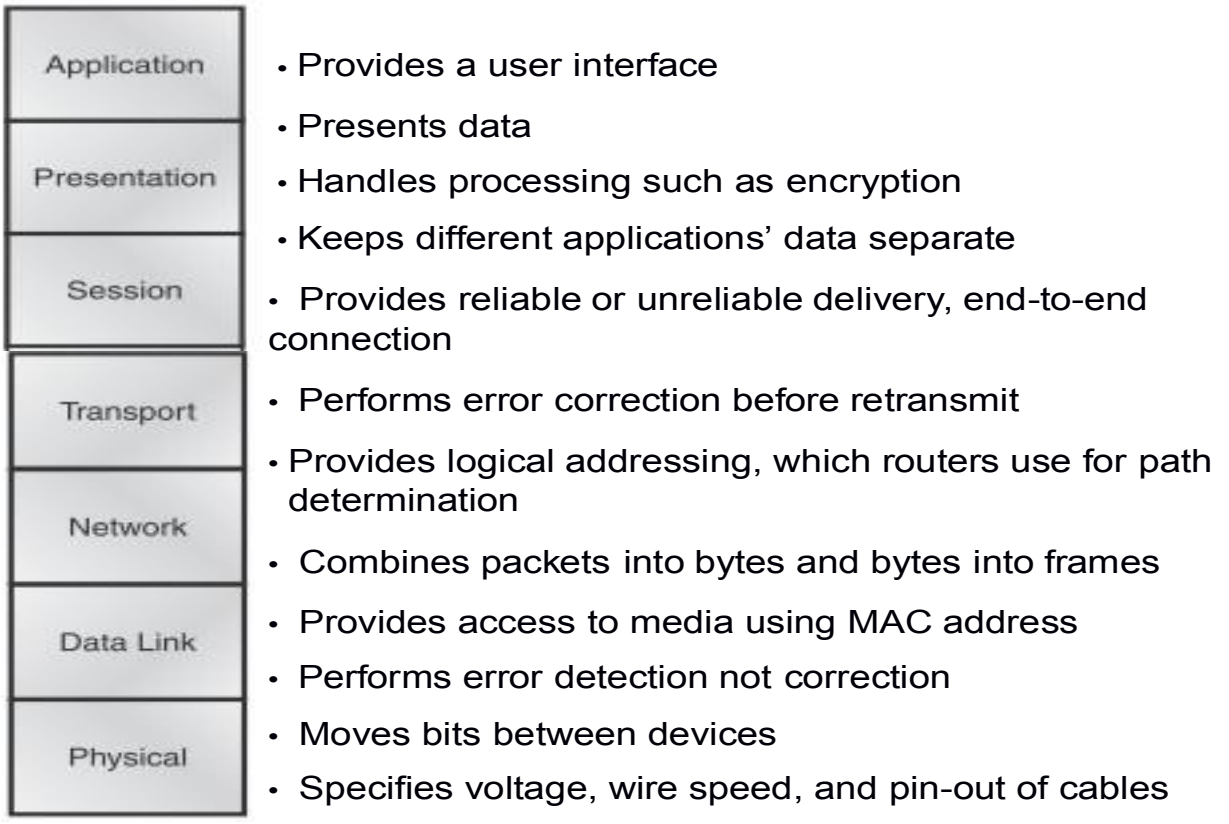


Figure 1: OSI reference model Adapted from CCNA: Cisco certified network associate study guide (Exam 640-802) by T. Lammle, 2007

2.4 Encapsulation

When a host transmits data across a network to another device, the data goes through encapsulation before it is sent out. This process involves data being wrapped with protocol information at each layer of the OSI model. This protocol information is referred to as Protocol Data Unit (PDUs). It is usually attached in front of the data block and sometimes at both ends of the block. The data from the upper layers (application, presentation and session layer) is broken into segments and a reliable connection is set up between the transmitting and receiving hosts. This connection is referred to as the three-way handshake. Each segment is given a sequence number so that when packets arrive out of order at the receiver, the receiver can arrange them

using the sequence number. All these are done by the transport layer. Figure 2 shows how Transport Control Protocol (TCP) connection is established between systems (Stallings, 2007).

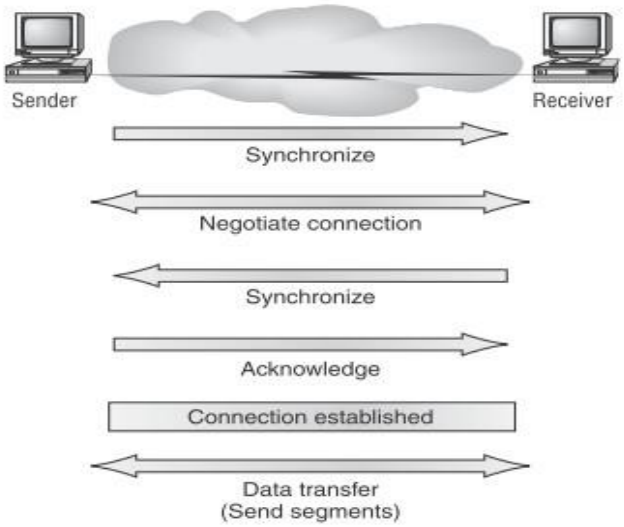


Figure 2: TCP Connection Adapted from CCNA: Cisco certified network associate study guide

Segments are converted to packets or datagrams, and a logical address is placed in the header so each packet can be routed through an Internetwork. The logical address i.e. IP address helps the network devices, also called layer 3 devices e.g. routers, to locate the receiver on the Ethernet. Packets or datagrams are converted to frames for transmission on the local network. Hardware addresses (MAC: Media Access Control) are used to uniquely identify hosts on a local network segment. These Frames are converted to bits in the physical layer, and a digital encoding and clocking scheme is used. On the receiving end decapsulation is done, which is the opposite where every layer strips the packet of its protocol header and passes it to the layer above until the data is received by the end user (Stallings, 2007). This is illustrated in figure 3:

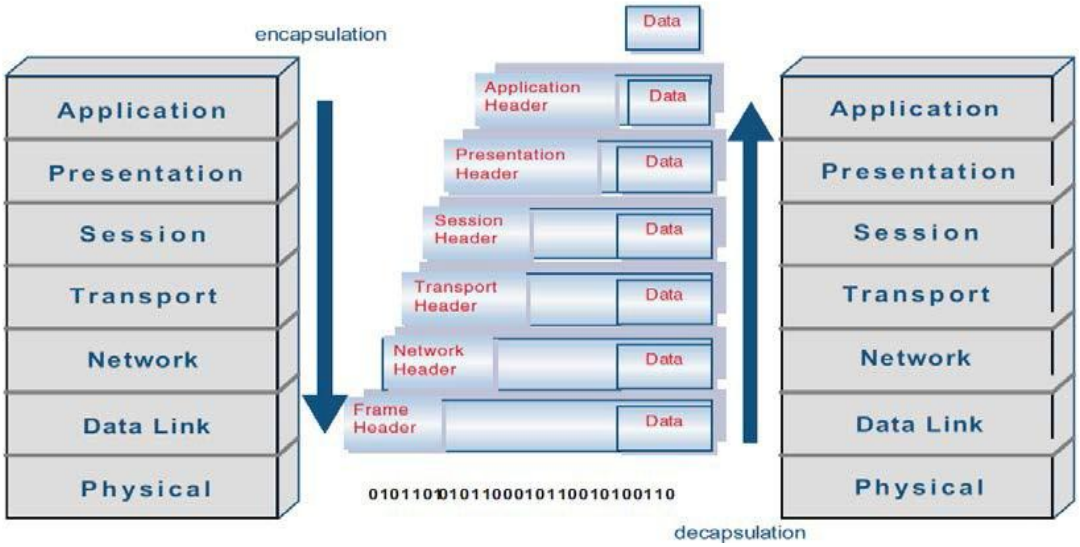


Figure 3:Encapsulation and Decapsulation process Adapted from packet header, Hanasd, 2013

An example of the TCP header of both IPV4 and IPV6 respectively is shown in figure 4;

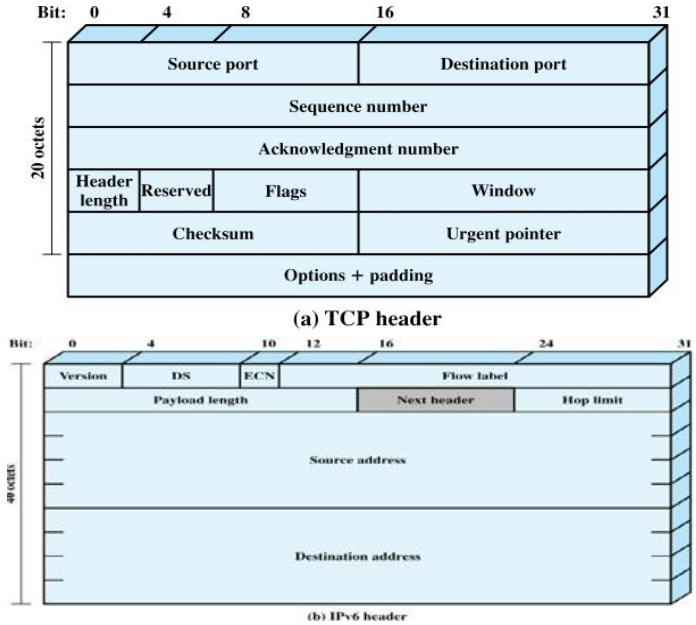


Figure 4: TCP header Adapted from Data and computer communications, W. Stallings, 2007

2.5 Peer-to-Peer Network Architecture (P2P)

In this network architecture, each workstation has the same status as well as the same capabilities and responsibility, hence the name peer. It is also referred to as democracy on the Internet because it has no centralized control. This implies that each node has the capability to function simultaneously as both server and client. P2P is a simple network which is usually employed when there is a few number of computers to be connected together. P2P networks are usually laid over the Internet hence they are referred to as overlays. Computers can share file or stream audio and connect with other devices such as printers and scanners, which are connected to any one computer (Cope, 2002). Figure 5 shows a representation of a peer-to-peer network.

Figure 5: Peer-to-peer Network Architecture Adapted from Peer to Peer Risk Assessment » G2Link – Business Trust and Reputation, E. Sullivan.

There are two types of P2P connections;

Structured P2P: this is a type of P2P architecture where the overlays are arranged to follow a particular topography. This ensures that everyone on the network can effectively search and find data over the network (Cope, 2002).

Unstructured P2P: in this type of network, the overlays have no specific topography. This type of P2P is cheap and easy to setup since there is no design to follow. However, it takes a lot of time to search over the network to find data and there is no guarantee that it will be found (Cope, 2002).

2.6 Client/Server Architecture

This is a network model where computers on the network (clients) sends service request to a centralized computer (server). Clients and servers can co-exist in the same computer. Servers generally wait for request from the client and supply them with the service. It provides services such as high-volume storage capacity, heavy data crunching, data and resources sharing etc. as illustrated in figure 6 ("*Introduction to Client/Server Network Setup"*, 2012).

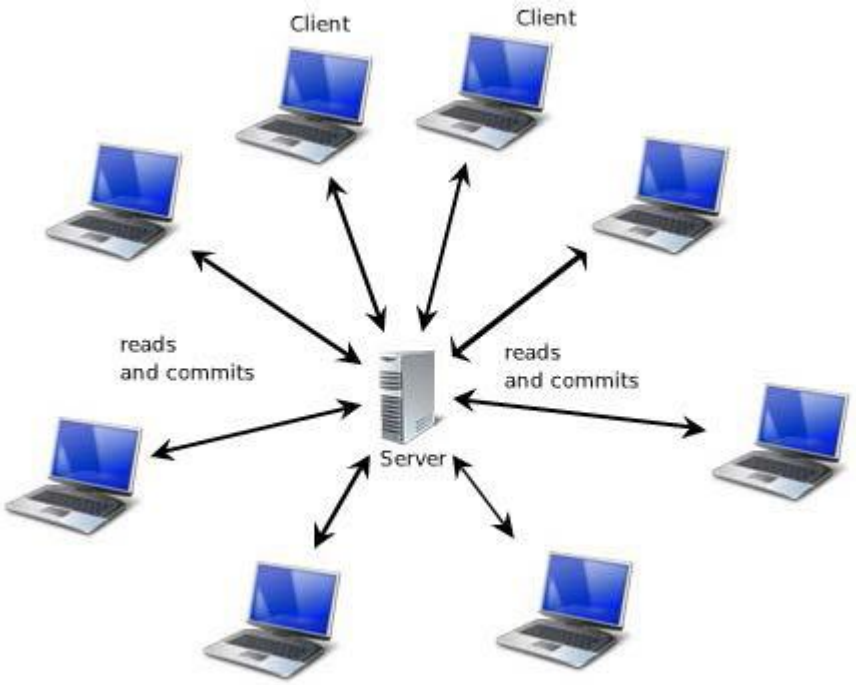


Figure 6: Client/Server Architecture

2.7 Peer-To-Peer Vs Client/Server Architecture

Table 1 below shows the comparison between Peer-to-peer networks and client/server network architecture;

Table 1: Comparing Peer-to-peer vs. Client/server networking

Peer-To-Peer	Client/Server
Every computer on the network can function as the client or the server. Considered a server when it shares resources with other computers on the network	Every computer has a distinct role in the network. There is a centralized server that is responsible for sharing resources and data while connected computers are the client.
Low setup and maintenance cost	High initial cost and maintenance cost, however, it can handle extended organizational growth.
Efficiency not guaranteed since any workstation can act as the server.	High performance and efficiency because it has dedicated workstation as the server. Servers are generally built to be more efficient.
Redundancy is not built in this network architecture.	Redundancy is built in the server to enable efficient operation.
Easy to maintain and does not necessarily require a skilled person to maintain it.	It requires skilled personnel (network administrator) to carry out its maintenance.
Security level varies. Usually not as high as client/server architecture. When password is employed for user/group it can be compared to client/ server.	Security is high as a server is accessed by a particular user or group.

For this study, the Client/Server architecture was employed.

2.8 Small Business

Small businesses are usually privately owned and basically set up for profit making. Its attribute ranges from small employees, small demographics, to small annual wages. This might vary due to various business types. Small Business Association (SBA) defined a small business as one that is owned independently, is organized for profit, and is not dominant in its field. SBA came up with standards to define a small business of different nature. They are as follows:

1. Manufacturing: Maximum number of employees may range from 500 to 1500, depending on the type of product manufactured;

2. Wholesaling: Maximum number of employees may range from 100 to 500 depending on the particular product being provided;

3. Services: Annual receipts may not exceed $2.5 to $21.5 million, depending on the particular service being provided;

4. Retailing: Annual receipts may not exceed $5.0 to $21.0 million, depending on the particular product being provided;

5. General and Heavy Construction: General construction annual receipts may not exceed $13.5 to $17 million, depending on the type of construction;

6. Special Trade Construction: Annual receipts may not exceed $7 million; and

7. Agriculture: Annual receipts may not exceed $0.5 to $9.0 million, depending on the agricultural product.

2.9 Server Market

From the day of the first web server built by Tim Berners-Lee, several vendors have ventured into the server market in recent times. This market has grown steadily over the years and has been analyzed using the number of sales and the amount of shipping made by these vendors. Over the last ten years, Gartner Inc., a world leading information and technology research and advisory company, has been notable for recording this growth, however, there were years when the growth dropped (Gartner, 2017).

In the third quarter of 2017, worldwide server revenue increased 16 percent year over year, while shipments grew 5.1 percent from the third quarter of 2016, according to Gartner, Inc. Gratner Inc. published a list of the top five vendors in this market and their relative sales and shipment in December and November 2017 respectively. This is shown in tables 2 and 3 below:

Hewlett Packard Enterprise (HPE) continued to lead in the worldwide server market based on revenue. Despite a decline of 3.2 percent, the company posted $3.1 billion in revenue for a total share of 21 percent for the third quarter of 2017 (see Table 2). Dell EMC maintained the No. 2 position with 37.9 percent growth and 20.8 percent market share.

Inspur Electronics experienced the highest growth in the quarter with 116.6 percent, driven by ongoing sales into China-based cloud providers, as well as global expansion efforts.

Table 2: Worldwide: Server Vendor Revenue Estimates, 3Q17 (U.S. Dollars)

Company	3Q17 Revenue	3Q17 Market Share (%)	3Q16 Revenue	3Q16 Market Share (%)	3Q17-3Q16 Growth (%)
HPE	3,144,197,027	21.3	3,247,173,253	25.5	-3.2
Dell EMC	3,070,405,586	20.8	2,227,185,685	17.5	37.9
IBM	1,130,618,441	7.7	889,723,595	7.0	27.1
Inspur Electronics	1,085,706,835	7.4	501,144,279	3.9	116.6
Cisco	996,248,000	6.8	929,440,000	7.3	7.2
Others	5,317,865,262	36.1	4,920,169,892	38.7	8.1
Total	**14,745,041,151**	**100.0**	**12,714,836,704**	**100.0**	**16.0**

Source: Gartner (December 2017)

In server shipments, Dell EMC maintained the No. 1 position in the third quarter of 2017 with 17.8 percent market share (see Table 3). HPE secured the second spot with 16.4 percent of the market. Inspur Electronics was the only vendor in the top five to experience positive growth in the quarter.

Table 3: Worldwide: Server Vendor Shipments Estimates, 3Q17 (Units)

Company	3Q17 Shipments	3Q17 Market Share (%)	3Q16 Shipments	3Q16 Market Share (%)	3Q17-3Q16 Growth (%)
Dell EMC	502,845	17.8	452,383	16.8	11.2
HPE	462,777	16.4	492,273	18.3	-6.2
Inspur Electronics	203,306	7.2	119,943	4.5	69.5
Lenovo	151,575	5.4	228,097	8.5	-33.5
Huawei	145,441	5.1	163,355	6.1	-11.0
Others	1,362,727	48.2	1,234,567	45.9	10.4
Total	**2,828,617**	**100.0**	**2,691,618**	**100.0**	**5.1**

Source: Gartner (November 2017)

2.10 Servers

A server is a dedicated workstation that is responsible for keeping and also allows sharing resources among clients (computers) in a network. Servers are the core of the server-client network architecture. They respond to requests of other computers i.e. the client on the network. Servers are not different from personal computer, in fact any computer can be a server depending on what specification is required. The necessary requirement includes reliability, efficiency and serviceability (Introduction to Client/Server Network Setup, 2012).

2.11 Hardware Requirement of a Server

Choosing the hardware of a server depends basically on what operation the server is needed to perform. As a result, there is really no laid down rule to distinguish a PC and a Server in terms of hardware. However, it is important to remember that servers generally require longer uptime, are supposed to be reachable at all times, tolerate fault and still keep the integrity of the data and resources it holds. Therefore, a server has to have more reliable hardware, constant power supply, enough storage, good random-access memory (RAM) and also have error detection & correction built into the hard disk (*Choosing the right server*, *2008*).

Server hardware is selected depending on the function the server is intended. This will affect the RAM size, the processor speed, operating system, storage memory, type of security, and the form factor (*Choosing the right server*, *2008*).

2.12 Types of Server

The term server can be ambiguous at times because it might refer to a software application that provides certain services to other computer or to a computer that offers services to other computers in a network. The following are the types of server available;

1. **Web Server**: Is a computer or a computer program that provides or serves client with web pages or data files to web-based application. A web server is also referred to as a computer that host websites and communicates with its clients using Hypertext Transfer Protocol (HTTP). Every web server has an IP address and possibly a domain name (“Web server,” 2011).

2. **File server**: A file server is a computer dedicated mainly to manage data. This computer serves as the 'storage box' for other computers (clients) on the network. Files stored on this computer can be accessed by other workstations who have

access to them. Organizations and businesses have a central storage thereby making it easy to protect and backup their data. A file server basically does not routinely require the use of a monitor, keyboard or mouse that is required in a basic workstation because it does not run operations for the client other than storing and retrieval of data. When setting up a file server, the size of the hard disk should be put into consideration because it would require more space depending on what the organization needs. File servers may also be categorized by the method of access: Internet file servers are frequently accessed by File Transfer Protocol (FTP) or by hypertext transfer protocol (HTTP) (Rouse, 2005).

3. **Print Server**: A server enables clients in a network share a printer connected to a print server. This helps to reduce the cost of providing a printer for each workstation. Therefore, clients send their print jobs to the print server which in-turn forwards it to the printer. It sends in the order in which they arrive and also allow for queuing up of print jobs (Choosing the right server, 2008).

4. **E-mail Server**: This serves as an agent billed with receiving and forwarding e-mails. It acts basically like a post office. This provides the organization with space for their email messages. Web based email client includes Yahoo and Gmail. Mail servers can be broken down into two main parts namely the SMTP (Simple Mail Transfer Protocol) and the POP3 (Post Office Protocol 3) or IMAP (Internet Message Access Protocol). The SMTP is responsible for the outgoing mail while the POP3 and IMAP are responsible for the incoming mail. It receives the message to be sent plus the address of the sender and receiver then it processes the address of the receiver on its domain. It transfers it to the SMTP server of the receiver if it finds it on its domains and if it does not, it employs the help of the domain name server (DNS) which helps to translate the address of the receiver to an IP address. On obtaining the IP address, SMTP sends the message to the receiver's SMTP, which forwards it to either the POP3 or IMAP server depending on which is being employed (Choosing the right server, 2008).

5. **Application server**: This server is dedicated to running certain applications on behalf of its clients. It could be a program/software or a portion of a server. Application servers are responsible for managing the business logic of its client,

allowing clients to run licensed applications without having to install it locally. Application servers save time compared to installing on every computer or client in the network. Apart from being easy to install, application servers proffer simple way to manage software licences to make sure that only the allowed number of client can run the application at any time. They offer features such as transaction management, clustering and failover and also load balancing (Beal, 2014).

6. **Database Server:** This is a server that is tasked with holding corporate information from one or more corporate applications. It basically performs the task of data analysis, archiving and data manipulation, serving a repository for its clients. Because it is argued that a single repository advantage the database server offers can result to a "bottle-neck", the option of spreading the processing load over several machines has been embraced. Its maintenance is however important since it is the central storage for its clients because damage to this can result in crippling the whole organization (Maffeis, 1997).

7. **Proxy Server:** A proxy server is a server that acts as an intermediary between a workstation (or the client application i.e. web browser) and the Internet. It receives service request such as file, or web pages from the client and goes to the Internet or other servers to obtain the data and then send it back to the client. It obtains the data from the Internet without revealing who it is sending it to hence it used for privacy. When a browser requests a webpage stored in the proxy server's collection, it is provided by the proxy server without having to go to the web which makes it faster. Proxy servers also help improve security by filtering out some web content and malicious software (Rouse, 2005).

2.13 Form Factor

This is the term given to the overall shape and size of a server. The form factor is determined by the size and shape of the case or housing in which the components are fitted. There are 3 types of form factor.

1. Rack-Mounted Server

   This is needed by bigger organizations when more than a few servers are required. It helps reduce floor space required by the large number of servers and also has a chassis that provides power supply and a cooling system. The

chassis has a standard 19-inch equipment rack which allows for vertical stacking of servers (Choosing the right server, 2008).

Figure 7: Rack-Mounted Server

Source: Etegro (2012)

2. Tower Case

Tower servers are similar to those ones used to house desktop computers though it is likely to be higher than that. The typical server tower case is 18-inches high, 20-inches deep, and 9-inches wide and has room inside for a motherboard, and can also allow for up to 10 hard drive. This type of case is suitable when a small number of servers are needed (*Choosing the right server*, *2008*).

Figure 8: Tower case

Source: Lenovo ThinkServer TS140 (2013)

3. Blade Servers

These are extremely thin stripped servers, it is a server on a single card that is mounted in a blade chassis. Blade chassis can hold up to six blade servers. Blade servers save more space than a rack-mounted server. The blade chassis often contains components such as network adapters and power supplies that are shared by all the blades in the enclosure, allowing the blades to be made as small as possible (Choosing the right server, 2008).

Figure 9: Blade Server

Source: ITWissen, IBM (2014)

2.14 Server Operating Systems

A server operating system (OS) is a software layer on which other software or application can run on the server hardware. They are specially designed to create a platform for multi-users, and also provide security, reliability and stability. In some regards, server OS are simpler than workstation OS. They are not required to support as wide a variety of accessories and generally don't need to run as wide a variety of applications compared to workstation OS. On the other hand, the applications they run, such as databases, Web servers, email servers, collaborative applications and application servers, can stress both the server OS and the hardware. So, choosing the best server operating system can be challenging. There a couple of operating systems namely; Windows Operating system, UNIX, LINUX and MAC operating system.

The server operating system selected is generally dependent on the application or the function which the server is required to perform. For example, if the server is intended to be used as a mail server running Microsoft Exchange, then a Windows server operating system would be needed. Similarly, if you want to run the Web server Apache, you will need a Linux operating system. Generally, LINUX servers are mostly favored because of its security and flexibility advantages (Noyes, 2010).

2.14.1 LINUX

Linux operating system is a free open source system that is widely used due to its reliability and stability. It was invented by Torvalds Linus in 1991. Twenty-six years later, 95% of the world's 500 fastest computers run on the Linux kernel or a variant of Linux

operating system. Open Source software means that programmers can read, distribute and change code, the code will mature. Linux is referred to as Unix-like, since it is an improved version (Beal, 2014).

Linux was developed because at that time UNIX was the operating system in use which was expensive and proprietary. Linux offers a host of free distributions, inexpensive and a portable hardware to nearly any platform. There are several versions of Linux operating system (distributions), the popular ones include; Red Hat, CentOs, Debian, Ubuntu, Arch-Linux, SUSElinux (Proffitt, 2009).

Pros and Cons of LINUX

Pros

1. It is free

   This is a very important advantage. License fee or cost per user plus update is free. It can be freely downloaded from the Internet.

2. It is secure

   Provides a high level of security and is less liable to malware attack. Linux is known for its versatility and quality.

3. Stability

   It requires less rebooting. When a reboot is absolutely necessary, it can be scheduled for a less busy time i.e. when the system is not in use.

4. It is portable and scalable;

   Works fine as in embedded systems and on super computers with the appropriate package of LINUX. It also has hardware advantage i.e. can run on the old computer without any glitch.

5. It provides High performance

   It delivers high performance as a workstation and also a server. It can handle many users on the network and also multitask.

Cons

1. It is difficult for beginners to understand Linux. It requires tenacity to understand its complexity.

2. Small set of peripheral hardware drivers can run on Linux when compared to windows operating system.

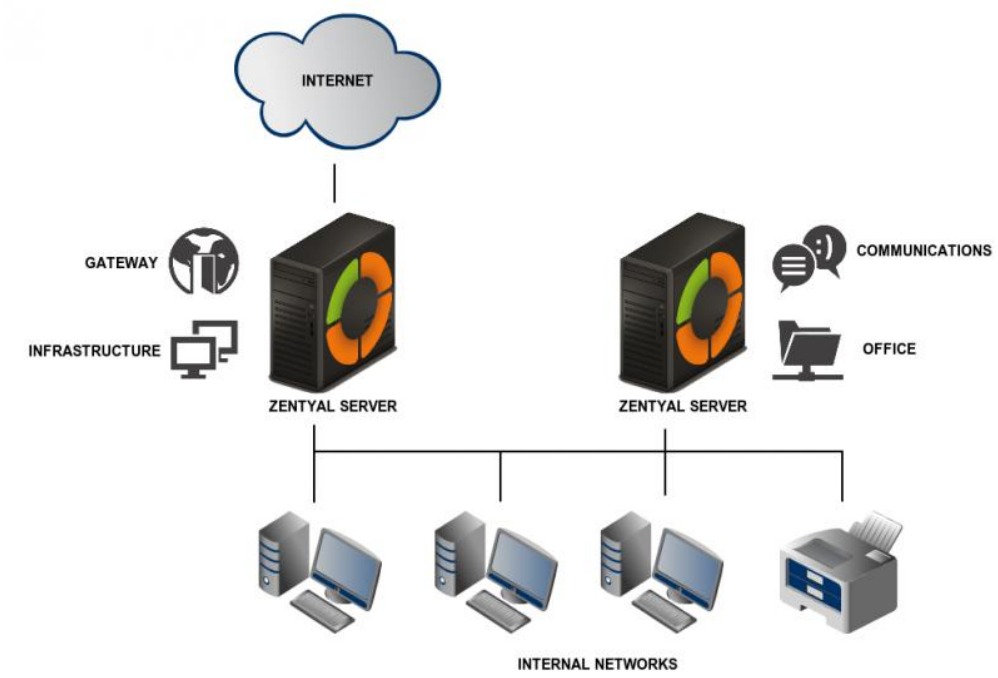
3. Most popular Windows applications will not run on Linux. Although Linux has some alternative applications which works just as fine, it takes extra effort to run windows application on a Linux workstation. Installing Virtual-box, wine or parallel can help. This disadvantage is irrelevant when running Linus OS on a server since servers are not expected to function as workstations, most servers does not require a keyboard or a monitor.

2.14.2 Zentyal

This is a Linux small business server developed basically for small and medium businesses (SMBs) and is owned and sponsored by the Spanish company eBox Technologies S.L. It offers server services such as firewall, gateway, DNS client, DHCP server, VPN, HTTP proxy, email server and several other functions in a single platform. These functionalities are closely incorporated, automating most tasks, avoiding errors and saving time for system administrators. It was first published in 2005, as an open source software, it is based on Ubuntu which is a distribution of Linux. It is a variant of Ubuntu 16.04 OS (Zentyal, 2016)

Small and medium businesses are known for running on a small budget and always looking to minimize cost and increase productivity. Therefore, the option of a Linux server is quite smart since it is free and does not require licensing. Furthermore, Linux server is not too complex to manage. This makes Zenytal suitable for businesses in this class because it was developed to bring Linux close to small and medium size businesses. Statistics shows that Zentyal is being downloaded over 1,000 times daily (Zentyal, 2016). Figure 10 shows a sample of Zentyal network.

Figure 10: Zentyal Network



Source: Zentyal (April 2017)

2.14.3 Features of Zentyal

Zentyal offers several integrated features for small businesses, which are otherwise expensive for a small business to purchase individually. It also offers an integrated management with great ease through its user interface (UI). Features offered includes:

Gateway

This can also be referred to as a router. A router is a device that is responsible for packet forwarding and traffic control between networks. It does this with the help of the routing table and routing policies. On receiving packets, a router will look at its (packet) address and send it to the desired destination with the help of the routing table and also observing all the routing policies. This service is provided by a Zentyal server which is free.

Security

Security in computing means to ensure that data on a workstation is secure. This also stretches to the network. Network security aims at making communication secure, preserve message authenticity and safe from threats from hackers. A message is considered safe when its confidentiality, integrity, availability and authenticity can be

ensured.

I. Authenticity: This is when the identity of the user can be verified. This means that the receiver of the message can be assured the authenticity of the claimed source.

II. Confidentiality: Access to data is allowed to authorized personality.

III. Integrity: Ensure that the message is received exactly as it was sent.

IV. Availability: Guarantees the data is available to authorized user when needed.

Attacks can be of two forms:

Passive attack: this type of attack seeks to compromise the confidentiality of the message. The attacker monitors the network and obtains the information being sent. In passive attack the presence of the hacker is concealed. Types of passive attacks include: traffic analysis, release of message content, eavesdropping.

- Traffic analysis: the hacker can monitor the traffic to understand the pattern of the encrypted message to understand its format. The hacker might be able to decrypt a weak encryption.
- Release of message content: third party say User 'C' (is invisible from user 'A' and 'B') read messages of user 'A' and user 'B'.

Active threat: this attack does not only compromise the confidentiality of the message, it modifies the message or masquerades as a user. Active attacks result in the disclosure or dissemination of data files. Types of active attacks include;

- Masquerading: this is when the hacker can impersonate another user.
- Relay: involves the capture of a data unit and retransmitting to produce an unauthorized effect.
- Modification of message: it involves altering the original message.
- Denial of service: this means inhibiting the use of the communication service.

Zentyal offers security through its firewall and authentication through Remote Authentication Dial In User Service (RADIUS). It is a well-tested system, with constant

security updates and also very flexible to changes in technology. With other platforms you find a big gap: you need to download the software updates and implement them, which can take a week or more, and during this time the hackers can attack your system. Zentyal offers customers fast and automatic updates. This ensures it's constantly protected from malware attacks. It also offers failover. Failover is a form of gateway redundancy; it is the switching to a redundant gateway upon failure of the running one. Failover is automatic; hence it ensures reliability of the Zentyal server.

Firewall

A firewall is considered a first line of defense in protecting private information. It is designed to prevent unauthorized access to or from a protected network or server as a tool to providing remote access to private network. It offers protection to the private network by examining packets entering or leaving and that they meet the specified security criteria. Firewalls typically have four major techniques:

1. Packet filter: this involves examining every packet that comes in or leaves the network and make sure that it matches a set of rules that has been set. This can be difficult to achieve and sometimes susceptible to IP spoofing. This technique is used in the network layer and can be of two forms i.e. stateless and stateful firewall. The stateful form treats every packet individually without considering the packets that have previously passed through the network. The stateful firewall keeps record of the previous packet that has passed through the network and hence can determine if a packet is the start of a new connection, part of an existing connection or an invalid packet (Neagu, 2010).

2. Application gateway: This operates in the network layer and has access to certain applications such FTP, hence it monitors and protects such applications from entering protected networks. It is considered as the most secure technique of firewall. It can also hide information such as IP addresses. This is because it provides Network Address Translation (NAT) functionality and can conceal the address on packets coming from the protected network.

3. Proxy server: A proxy server is the middleman between clients and the actual server.

Therefore, it offers some form of security since all traffic come through it. Thus,

it checks request and validates them before sending them out or allowing them in. it can operate both on the application and the transport level (Beal, 2014).

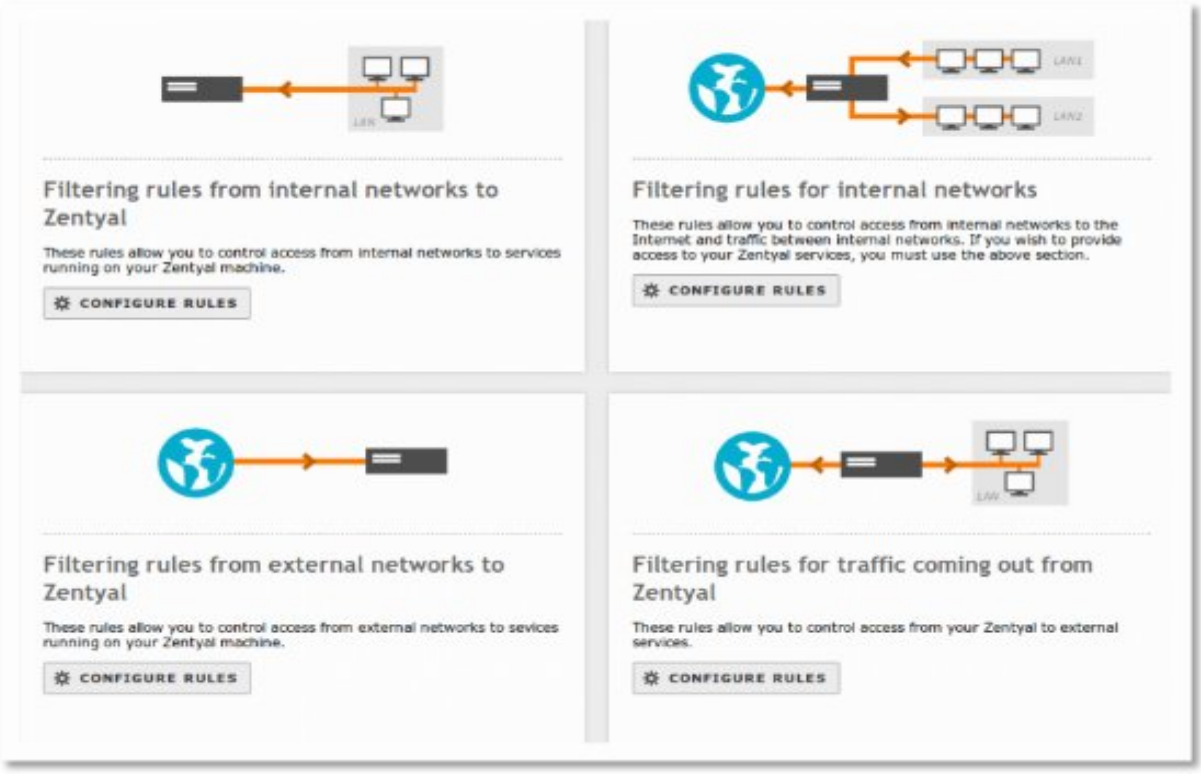
4. Circuit-level gateways: This type of firewall operates in the TCP or UDP level. It is concerned with validating that all the rules set for the connection to take place are met by every packet travelling over the network. However, it is not a secure type of firewall because once the connection is established, other applications can run across it without its knowledge (Beal, 2014).

These features are available in the Zentyal operating system. It helps to gain full control over the network by being able to manage and determine which packets are allowed through the network depending on their destination and origin. A firewall can be either hardware or software or a combination of both. In the hardware form, it can be purchased as a stand-alone and can also be available in routers. This is also free in Zentyal. Figure 11 and 12 shows the packet filter and filtering rule interfaces of Zentyal respectively.

Figure 11: Zentyal Packet Filter

Source: Zentyal (April 2017)

Figure 12: Zentyal Filtering Rules



Source: Zentyal (April 2017)

Quality of Service (QoS)

This is another service offered by Zentyal for free. Quality of service refers to the ability of a network to provide better service for some network traffic. These services can include video streaming, Virtual private network, Voice over IP (VoIP). QoS enables you to establish an end-to- end traffic priority policy to improve control and throughput of important data. This basically involves managing the available bandwidth and allocating it with reference to the importance. It is implemented in the form of rules and policies (Zentyal, 2017).

Figure 13: Traffic shaping

Source: Zentyal (April 2014)

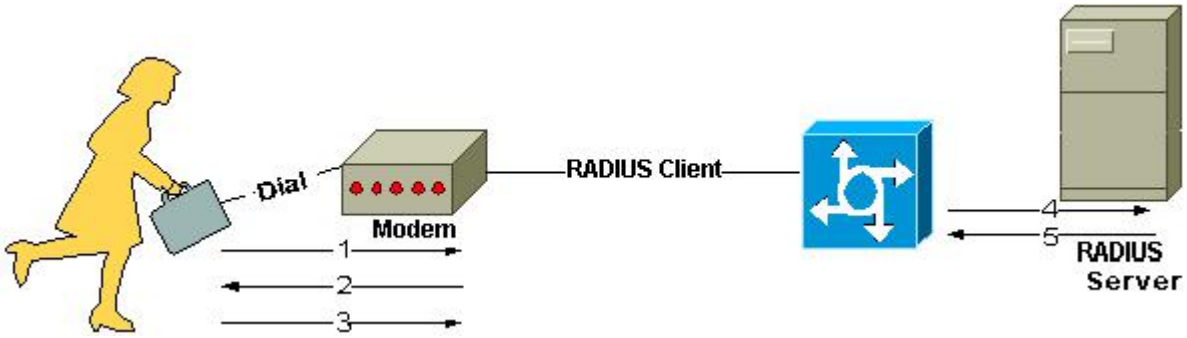
Remote Authentication Dial In User Service (RADIUS)

The Remote Authentication Dial-In User Service (RADIUS) protocol was established by Livingston Enterprises, Inc., as an access server authentication and accounting protocol. It is a networking protocol that offers centralized Authentication, Authorization, and Accounting (AAA) management for users that connect and use a network service.

RADIUS protocol is generally considered as a connectionless service though it is based on the used datagram protocol (UDP). It operates as a client/server protocol. It involves communication from a RADIUS client, typically a network access server (NAS), requesting for connection from a RADIUS server. The access request can include the username, encrypted password and NAS IP. On receiving the request, the server looks through the list of usernames it has stored in its database, if it does not find it, either a default profile is loaded or it sends an access reject message. However, if it does find a matching username and password, it sends Access- Accept reply to the user, specifying the parameters for connection. Typical parameters include service type (shell or framed), protocol type, IP address to assign the user (static or dynamic), access list to apply, or a static route to install in the NAS routing table (Zentyal, 2014).

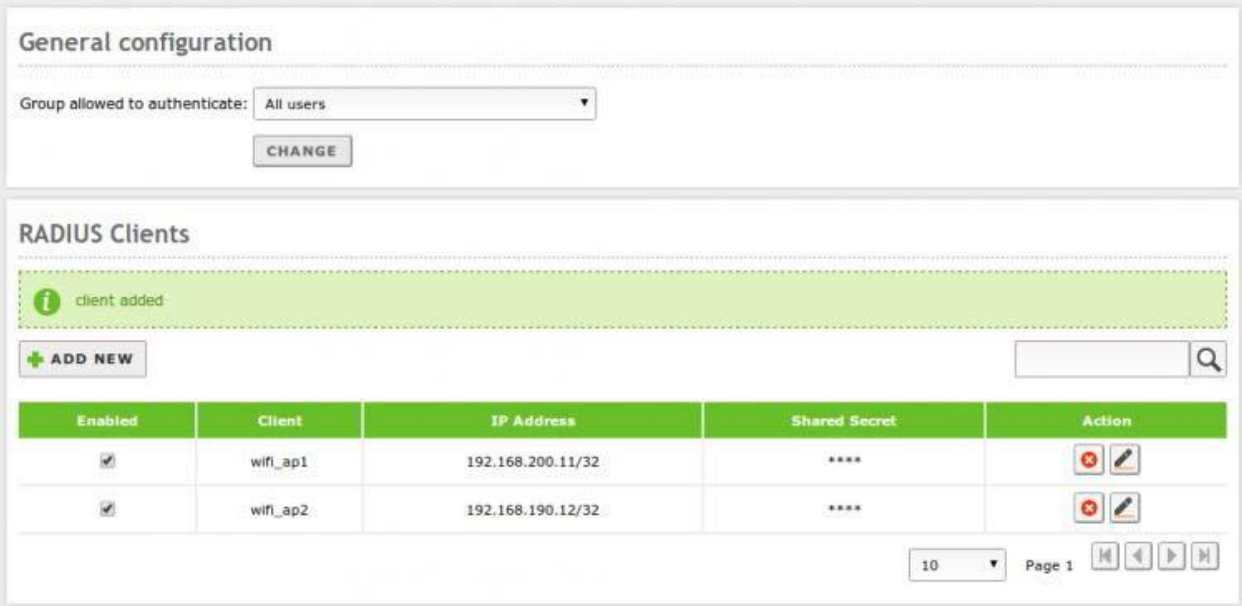
During this connection, the Radius account function keeps record of the amount of packet exchanged, the time and other information. Figure 14 and 15 illustrates RADIUS:

Figure 14: Radius Client



Source: Cisco (May 2016)

Figure 15: Zentyal Radius Client Configuration

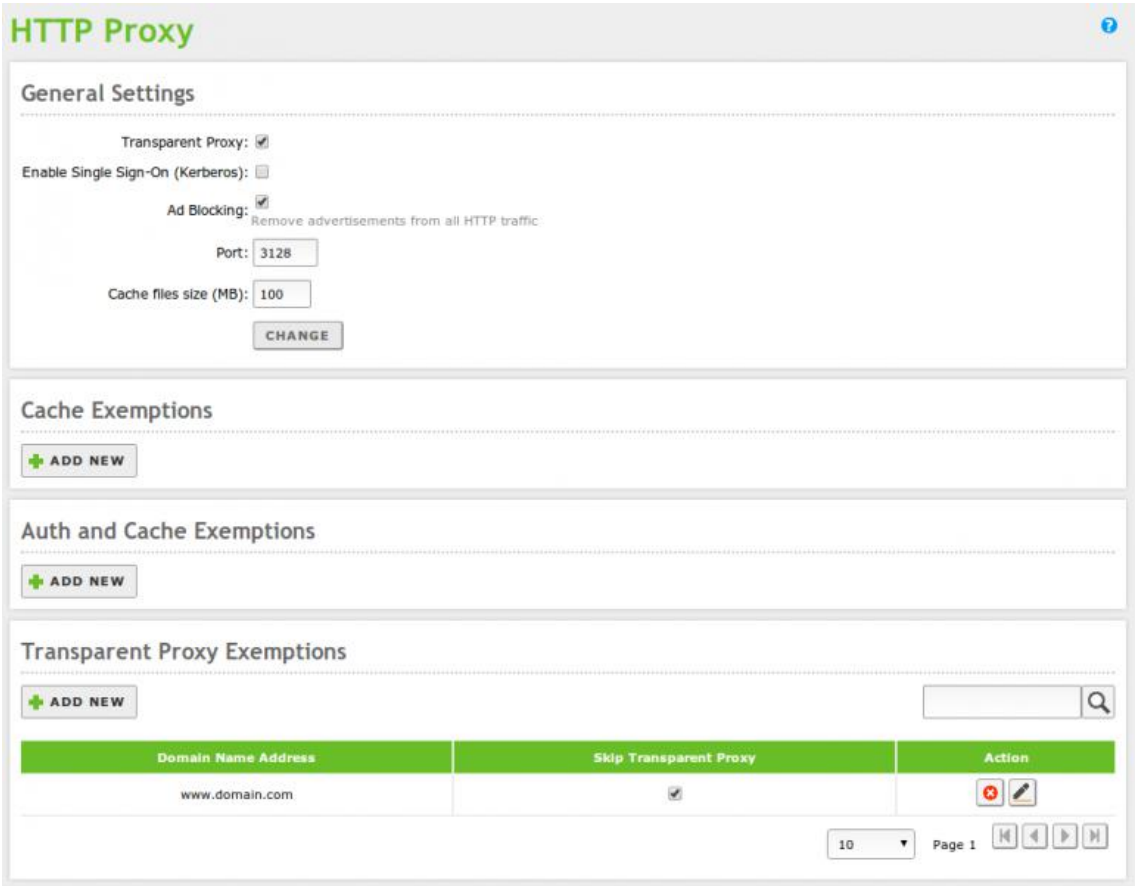


Source: Zentyal (April 2014)

HTTP Proxy service

There is sometimes also referred to as a firewall. Proxies are generally used to monitor and control the outgoing traffic of a network. They also can store the requested data in the cache memory while it is also possible to configure which domains are not going to be stored in the cache. This helps to manage bandwidth and also keep record of the data transferred. It also requires setting of the access rule just as firewalls (Zentyal, 2014). See figure 16.

Figure 16: Zentyal HTTP Proxy



Source: Zentyal (April 2014)

Hardware Requirement

The figure below shows the hardware requirement of Zentyal. This helps in the type of machine to be purchased and the specification it should possess (Zentyal, 2017). Zentyal hardware requirement is shown in figure 17:

Figure 17: Zentyal Hardware Requirements

ZENTYAL PROFILE	USERS	CPU	MEMORY	DISK	NETWORK CARDS
Gateway	<50	P4 or equivalent	2G	80G	2 or more
	50 or more	Xeon Dual core or equivalent	4G	160G	2 or more
Infrastructure	<50	P4 or equivalent	1G	80G	1
	50 or more	P4 or equivalent	2G	160G	1
Office	<50	P4 or equivalent	1G	250G	1
	50 or more	Xeon Dual core or equivalent	2G	500G	1
Communications	<100	Xeon Dual core or equivalent	4G	250G	1
	100 or more	Xeon Dual core or equivalent	8G	500G	1

Source: Zentyal (April 2017)

3.0 CHAPTER THREE: METHODOLOGY

3.1 Feasibility study

To analyze the system needs and study the feasibility of the proposed solutions, the following tasks were performed:

1. Identification of system needs and requirements. Using meetings, interviews and observation as data collection techniques, the requirements to be met by the project were determined.
2. Analysis of the initial system state, where the state of the network used is analyzed in order to be redesigned if necessary.
3. Study and evaluation of alternative solutions. In response to the needs already identified, and the analysis of the initial state of the system, an economic, technical, legal and operational evaluation of the various solutions were presented.
4. Selection of the solution, where one of the alternatives presented solution was chosen.

3.2 Analysis of requirements

After careful analysis of the existing network infrastructure, the following problems were identified:

1. Slow Internet access
2. Duplication of IP addresses
3. Unrestricted access to sites
4. Downloaded internet content are not filtered
5. Abuse of internet usage

The following solutions were proposed to overcome the problems identified at the system analysis stage:

1. Maintaining network operation around 80%.

2. Get automatic configuration of network parameters such as IP, mask, gateway, DNS, etc. for computers (physical or virtual machines) that connect to the network via wired or wireless.
3. Restrict Internet access to only staff of FRI.
4. Keep the domain name server network and have an internal name server.
5. Restrict access to inappropriate sites while maintaining access to certain sites.
6. Have a web server that can serve as a backup server.
7. Ability to add more computers to the network without affecting the network performance.

3.3 Description of FRI IT Infrastructure

The FRI IT Infrastructure is located at its okponglo site in Accra. The okponglo site is made up of the following buildings:

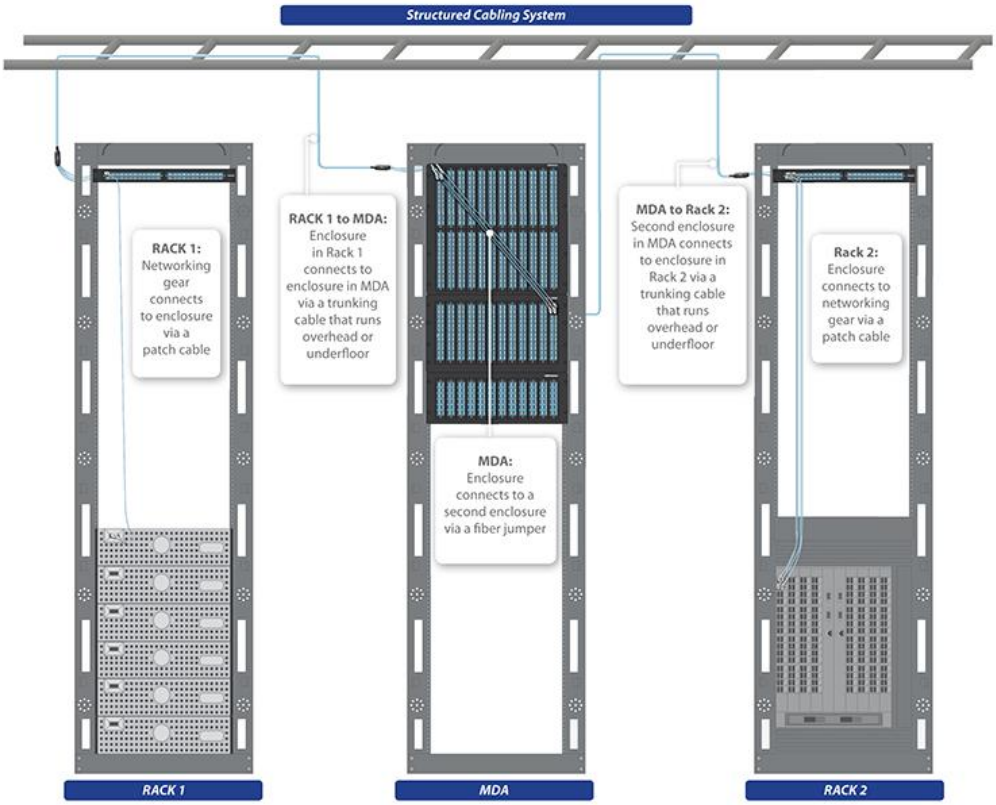
- Main block
- Fisheries block
- Microbiology block
- Processing and engineering block

There are approximately 300 computers, laptops, and smart phones & tablets connected to the LAN.

3.3.1 Structured cabling

The FRI IT infrastructure has a structured cabling system. In a structured cabling system, a series of patch panels and trunks are used to create a structure that allows for hardware ports to be connected to a patch panel at the top of the rack. That patch panel is then connected to another patch panel via a trunk in the Main Distribution Area (MDA). The horizonal subsystem cabling is the main cabling technology used. Any cabling that is used to connect a floor's wiring closet to wall plates in the work areas to provide local area network (LAN) drops for connecting users' computers to the network is termed as horizontal cabling. Figure 18 below shows a diagram of structured cabling system.

Figure 18: Structured cabling system



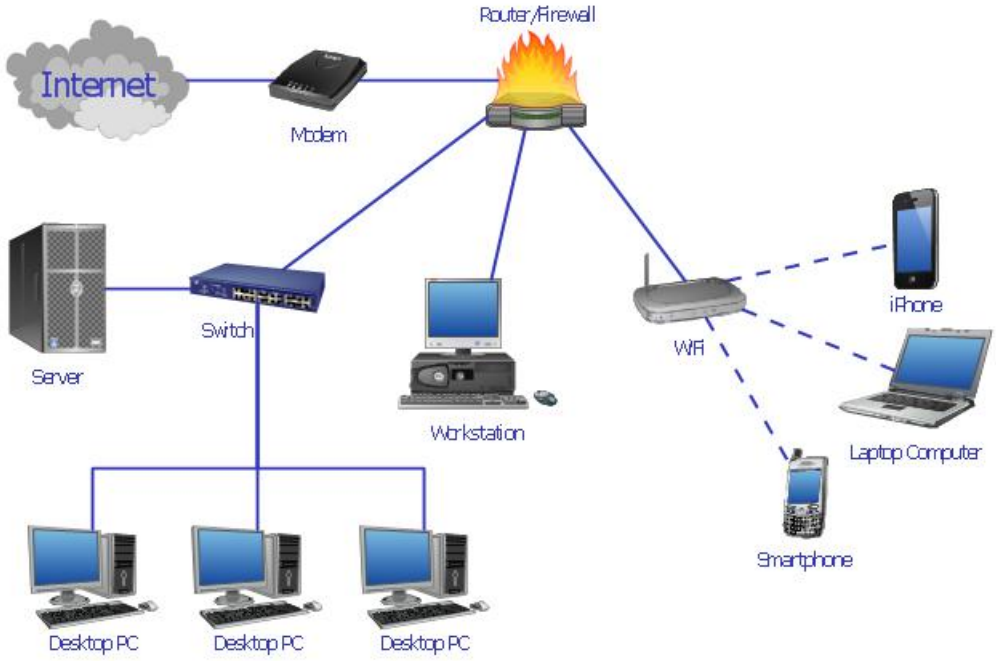
Source: http://cablexpress.com, 2017

3.3.2 Architecture, design and network functionality

The FRI network are accessible from anywhere in the physical network. Networks are not separated physically.

Figure 19 illustrates the basic configuration of the **FRI current network.**

Figure 19: FRI Local Area Network Diagram



The main function of the network is to provide access to the Internet, with a bandwidth of 4Mb dedicated internet. The LAN enables us to have a local web server to allow access to the institute intranet. It also allows communication between computers and devices as well as resource sharing. The LAN has D-Link switches for interconnection and a cisco 2900 series router that act as a Gateway, DHCP and DNS server.

3.3.3 Access points

There are eleven (11) installed and configured Wi-Fi access points strategically placed at vantage points to provide Wi-Fi Internet access to staff laptops and smart devices.

3.3.4 Maintenance of the LAN infrastructure

The FRI IT infrastructure is managed by the IT team of the information management services section (IMSS) of the food technology research division. The team has an unrestricted access to the infrastructure.

3.4 Project schedule

The execution of the project will follow the traditional phase model:

- Analysis and design.
- Development
- Implementation and testing

In the analysis and design phase, the following tasks will be carried out:

1. Detailed analysis of the chosen solution.
2. Design of the new network.

In the development phase:

1. Setting up and testing of Internet access from the ZentyFRI server.
2. Configuring basic services and security measures in the ZentyFRI server.
3. Test Configuration and Internet access from the Zentyal server room.

In the implementation phase and testing:

1. Installation and configuration of ZentyFRI server.
2. Testing the functionality of the implemented system and exploring other features of Zentyal

To develop all these phases a period of 7 weeks, divided into the following periods was estimated:

- Analysis and Design: 2 weeks
- Development: 2 weeks
- Implementation and testing: 3 weeks

3.5 Design and development phase

3.5.1 Installation and Network configuration

This phase includes setting up the Dell PowerEdge T310, which is being used as the server, for installation of the Zentyal 5.0 operating system. Firstly, the installation will be installed through a bootable USB drive; hence the Zentyal software was downloaded from the Zentyal website (http://www.zentyal.org) and a USB bootable drive was created. Once the USB drive was inserted into the USB port, the installation steps were followed to complete the installation.

The server has two inbuilt network interface cards (NIC), so one will be used as the interface of the local area network and the second one will serve as the interface for the gateway.

From the Zentyal dashboard, the interface section showed that the two interfaces were present in the server. The network interface eno1 will serve as the interface for the local area network (LAN) which will consist of the desktop and laptop computers in the institute, while the other interface (en02) will connect to the external network, i.e. the wide area network (WAN). To test both interfaces, the LAN interface will be connected to a switch on the local network and tested while the WAN interface will connect to the ISP modem. The LAN interface will obtain an IP address using the Zentyal DHCP. The network diagram of the proposed connection is shown in the figure 20.

Figure 20: Connection test Network diagram

Once the connection test has been established, the next stage will be to finalize the network test by trying to reach out to the outside world i.e. Internet. From the diagram above, the Zentyal server has an IP address of 41.66.254.106 as its static WAN interface address and the LAN interface address is on the 192.168.1.0/24 network. A Packet Internet Groper (PING) command was used to test the communication on the network. The Zentyal server (gateway) was PINGed from a laptop on the network. All packets sent there received response i.e. 100% success. Again, the Zentyal server was successfully used to reach the World Wide Web.

3.5.2 Configuration of the whole network

The figure 21 represents the design of the network. The Zentyal server serves as the gateway between the two networks. The LAN interface of the Zentyal server is connected to the Cisco 3500 switch which controls the traffic of the 192.168.1.0/24 network. From the switch, connections will be made, using CAT5 Ethernet cable, to the desktop computers and laptops in the institute. The client workstations on the local network will automatically receive a default gateway address of 192.168.1.1 from the Zentyal server. In doing this, they will use the server as the gateway to reach the outside world (Internet). The server in turn receives its requests/packets and connects to the Internet to obtain response to these requests and send it back to them. The server will therefore connect to the ISP modem. The server uses the IP address 41.66.254.106 as its own gateway to reach the Internet. Hence the Zentyal server serves as the gateway between both networks.

From this connection, all traffic to the Internet is routed through the Zentyal gateway (the 41.66.254.106 network), and all traffic to the interior network is routed through 192.168.1.0 network.

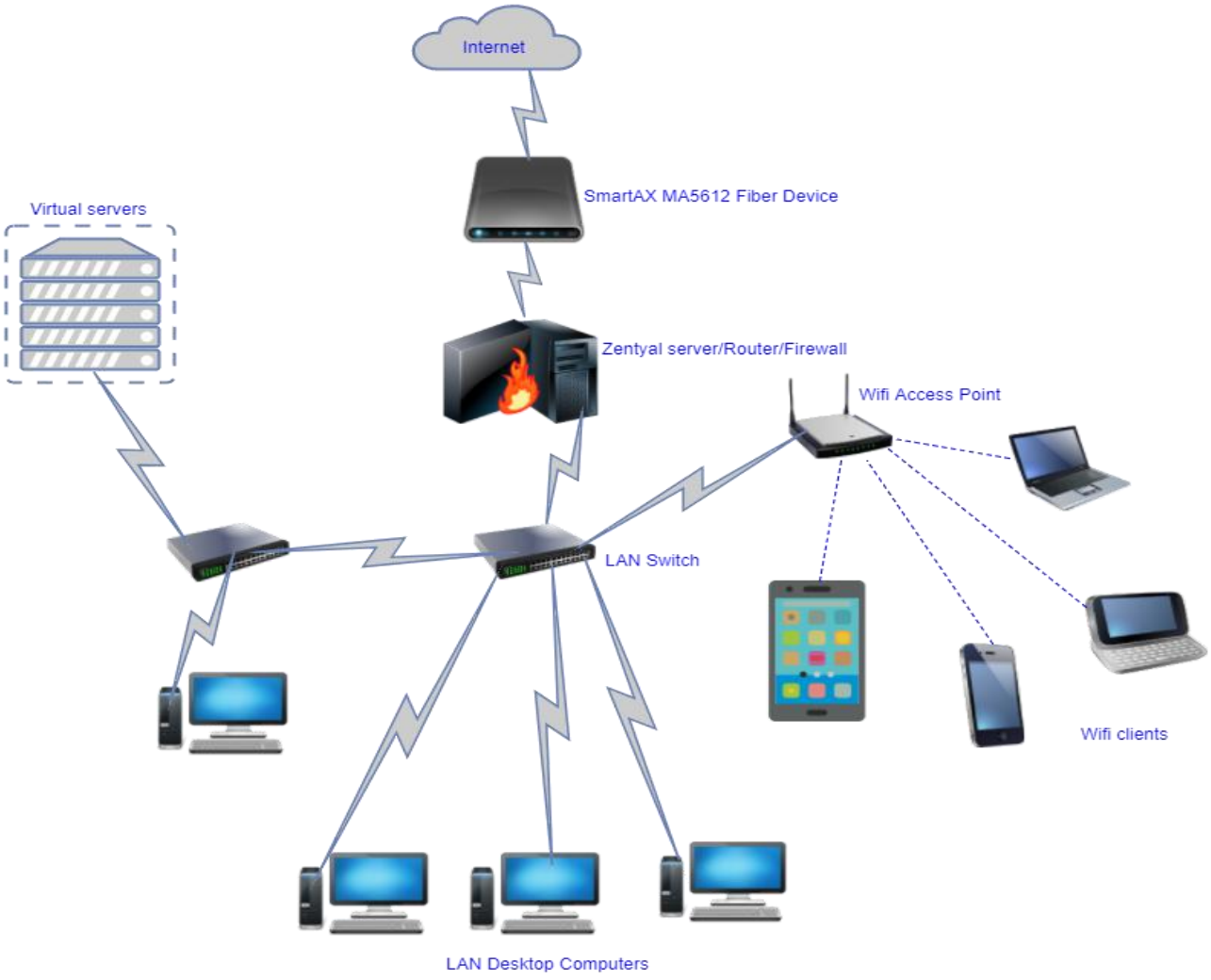


Figure 21: The network diagram

3.6 Implementation and testing phase

3.6.1 Ensure that the network works and also explore other features of Zentyal

The network routing configuration was tested through various machine terminals with PING commands and also by connecting to the Internet. From the desktop machines a PING command was used to test it connection to the 192.168.1.1 gateway. This connection was confirmed good when it returned a 100% success. From the Zentyal server a PING command was also used to test its connection on the LAN network 192.168.1.0 and the external (WAN) network 41.66.254.106. Network address translation feature of Zentyal will be turned on from the dashboard and a test will be carried out by checking the IP address of the workstations using the www.myipaddress.com. Another feature to be explored is the firewall. This can be achieved using two techniques, either by

using the options on the dashboard of Zentyal by configuring the packet filter rules or configuring the routing table through the terminal. The former technique will be employed.

3.6.2 Study of alternative solutions

Two basic approaches were adopted to choose an alternative solution:

1. The software tools to be used on the server including the operating system.
2. A network architecture capable of maintaining optimal performance and restriction of Internet access when necessary.

3.6.3 Software Tools

Given the requirements analysis, three possible solutions were selected to meet the required network needs:

- Webmin
- Windows
- Zentyal

Webmin

Webmin is a web-based server manager based on Unix operating systems family and GNU/Linux. It is accessible from any web browser using TCP over port 10000.

Operative Valuation: It can be used to configure users, space quotas, services (DNS, DHCP, Apache, FTP), computer shutdown, etc., without having to manually edit configuration files.

Technical assessment: Webmin is written in Perl version 5, and built from modules, which facilitates the addition of new functionality without too much effort.

Legal assessment: Coded by Australian Jamie Cameron, Webmin is released under BSD License.

Economic valuation:

- Hardware: the computer used as a server (PowerEdge T310).
- Software: software is free, no license cost.
- Implementation: by the IT team.

- Maintenance: by the IT team.

Windows

Windows has a whole family of servers, including Windows Server 2016, Windows Server 2012, Windows Server 2008, etc.

Operative Valuation: can be used as a file server, print, applications, email, virtual private networks, Domain Controller, DNS, DHCP, Gateway, for authentication, and user accounts (for staff) centralized group policy etc.

Legal assessment: owned by Microsoft EULA license. Windows Update is used as upgrade module.

Economic valuation:

- Hardware: the computer used as a server (PowerEdge 310).
- Software: is not free software, you can legally use it only after paying for the licensing costs
- Implementation: by IT team.
- Maintenance: by the IT team.

Zentyal

Zentyal is a Linux server developed specifically for network management through a web browser.

operational assessment: Zentyal can perform the following functions:

- Management of network infrastructure / configuration server, DNS, DHCP, and FTP, etc.
- As a gateway or gateway to the Internet.
- Managing security threats.
- As office server, sharing resources such as files and printers.
- As unified communications server or a combination of these, such as email, VoIP, instant messaging, and groupware (sharing calendars, diaries, webmail, wiki, etc.)

- Furthermore, Zentyal includes a development framework to facilitate the development of new services based on Unix.

Technical assessment: The full distribution of Zentyal 5.0 uses Ubuntu 16.04 (Xenial Xerus). It is built from components of free software, such as BIND, Squid, Samba, Apache, OpenLDAP, OpenSSL, OpenVPN, iptables, Postfix, Dovecot, CUPS, apt, Asterisk version.

Legal assessment: The project source code is available under GNU GPL license. The Spanish company eBox Technologies S.L owns and sponsor Zentyal and distribute the source code.

Economic valuation:

- Hardware: the computer used as a server (PowerEdge T310).
- Software: There is a free version (the development version), no license cost.
- Implementation: by the IT team.
- Maintenance by the IT team.

3.7 Proposed solution

After careful assessments and comparison of all the alternative solutions presented in the previous section, the team selected Zentyal.

3.7.1 Hardware equipment specification

The hardware requirement of Zentyal was carefully examined and based on this, the equipment was chosen. The following equipment and devices were used for the realization of the goals of the project:

3.7.2 The server hardware requirements and functionality

The server requirement of Zentyal was carefully examined and based on this, an already existing server was selected for the project.

Therefore, the server, from now on will be called ZentyFRI, and it will be used:

- As a gateway and firewall Internet connection.
- As a server services for the local area network.

Dell PowerEdge T310

The computer used as the server in this project was a Dell PowerEdge T310 machine with Intel Xeon CPU. This was selected because it met the minimum requirement of Zentyal operating system when used as a gateway. It is a small office tower server suitable for corporate and small and medium sized businesses. The Dell PowerEdge T310 server delivers enterprise-level performance, redundancy, and comprehensive right-sized manageability options in a 1-socket tower that is simple to own, deploy, and manage. It is designed for advanced performance and efficient collaboration. It enables business-class control, saves time and money. Table 4 shows the full specification of Dell PowerEdge T310.

Table 4: Specification of Dell PowerEdge T310

Feature	Technical Specification
Form Factor	Tower
Processor	Intel® Xeon® CPU E31270@3.4GHz
Processor Sockets	1
Front Side Bus or Hyper Transport	DMI (Direct Media Interface)
Cache	8MB
Chipset	Intel® 3400 chipset
Memory	20GB
I/O Slots	5 PCIe G2 slots: Two x8 slot, (one with x16 connector) One x4 slot (with x8 connector) Two x1 slots
RAID Controller	PERC S300 (software based)
Drive Bays	SATA drives Hot-Swap HD: Up to four 3.5” drives
Hard Drives	3.5” 2.0TB SATA
Communications	Intel® Gigabit ET Dual Port Server Adapter
Power Supply	Single-cabled power supply (375W)/Optional

	Redundant power supply (400W)
Availability	Quad-pack LED diagnostic, Interactive LCD with Hot-swap HDD chassis, Hot-swap HDD, Redundant PSU
Video	Matrox® G200eW w/ 8MB memory
Remote Management	iDRAC6
Operating Systems provided	None

Source: Dell (October 2017)

Figure 22: Dell PowerEdge T310

Source: Dell (October 2017)

Client Workstations

These are the desktop and laptop computers that are connected to the FRI local area network running windows 7 and 10 operating systems. They are the devices that needs to access the gateway for internet connectivity.

Huawei SmartAX MA5612

The SmartAX MA5612 (the MA5612 for short) is an industry-leading remote multi dwelling unit (MDU) launched by Huawei, which supports flexible configurations and provides broadband services on the Fiber To The Building (FTTB) network and leased line services on a passive optical network (PON). The MA5612 is a box-type device measuring 1-U

high and 19-inch wide and providing two GPON or GE uplink ports, 8–24 channel LAN access (LAN: POTS = 1: N) and 8–16 channel E1 access. The MA5612 features a broad temperature range, low power consumption, mute design, high stability, environment-friendlily and energy conservation, and can be used on workbenches and installed in corridors and cabinets, meeting broadband and leased line service deployment of customers. This device (Figure 23) is already in the FRI data center and serves as the main fiber line connection from the internet service provider (ISP) to the premises of FRI.

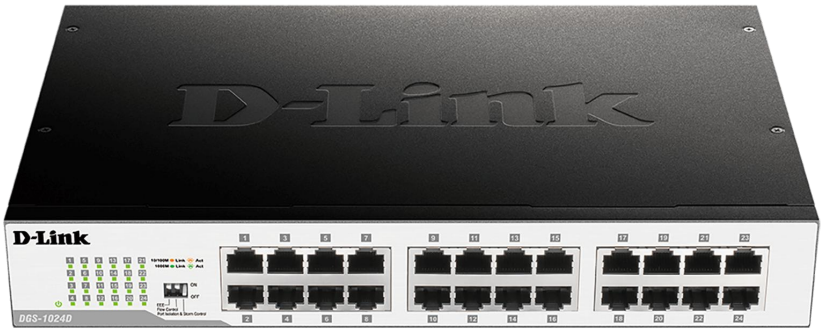
Figure 23: SmartAX MA5612

Source: huawei.com (Huawei, 2017)

D-Link DGS-1024D Switches

The D-Link DGS-1024D 24-Port Unmanaged Gigabit Switch series offer an economical way for SOHO and Small-to-Medium Businesses (SMB) to take advantage of Gigabit Ethernet speeds while reducing energy consumption and minimizing noise output. These switches were designed for Plug-and-Play and hassle-free installation. Auto-MDI/MDI-X crossover on all ports eliminates the need for crossover cables when connecting to another switch or hub. Auto-negotiation on each port senses the link speed of a network device and intelligently adjusts for compatibility and optimal performance. Diagnostic LEDs and cable diagnostics allow for quick detection and correction of network problems. Figure 24 below shows the switch.

Figure 24: D-Link DGS-1024D



Source: dlink.com (D-Link, 2017

Ethernet Cables (CAT5)

The category 5 ethernet cable is an unshielded twisted pair cable used for carrying signals such as telephony or video. It is also used in computer networks such as the ethernet. It provides a performance of up to 100MHz hence it is suitable for 10BASE-T, fast ethernet and Gigabit ethernet. It is usually connected using punch-down blocks and modular connectors. A CAT5 is shown in figure 25.

Figure 25: Ethernet cable CAT5

D-Link DAP-1360 Wireless N Access Point

The D-Link DAP-1360 Wireless N Access Point connects to a broadband modem enabling you to wirelessly share your Internet connection. It is a draft 802.11n compliant device that delivers up to 14x faster speeds and 6x farther range than 802.11g while retaining backward compatibility with 802.11g and 802.11b devices. These access points (Figure 24) are placed at strategic locations of FRI to provide wireless internet connection.

Figure 26: D-Link DAP-1360 Wireless N Access Point

Source: dlink.com (D-Link, 2017)

3.8 Ubuntu + Zentyal as a platform

Following the selection of Zentyal as an alternative solution, the installation will be done on the server exclusively, while still allowing others to install and configure additional services or applications manually, unmanaged through the Zentyal interface. Zentyal installer will be used from USB drive that allows installation and deployment of Zentyal on the distribution of Ubuntu 16.04 LTS server. In addition, the USB installer contains all the dependencies and includes a graphical environment that allows using the web interface from the server itself.

The following Zentyal modules will be installed:

- Zentyal Gateway: will act as a gateway to the network offering access to Secure and controlled internet. It will carry out load balancing between connections to Internet and will restrict traffic when the network is oversaturated.
- Zentyal Unified Threat Manager -UTM- (Unified Threat Management): will protect the local network against external attacks, intrusions, threats to internal security and enables secure interconnection between local networks through the Internet or other network external network.
- Zentyal Infrastructure: will manage the infrastructure of the local network with the basic services: DHCP, DNS, web server and ftp.
- Zentyal Office: will act as a server of shared resources of the local network: files,

- Printers, calendars, contacts, user profiles and groups, etc.

4.0 CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Project development

In this section, the installation and configuration of Zentyal 5.0 on the ZentyalFRI Server was done. Network configuration and setup, configuration of Zentyal modules as well partial validation tests were also implemented in this section.

4.1.1 ZentyFRI server installation and configuration

Installation of Zentyal on Dell PowerEdge T310 Server

Zentyal can be installed in two different ways:

- Using the Zentyal installer which is the recommended option and
- On top of an existing Ubuntu Server Edition installation.

Using the Zentyal installer is advantageous because the installation and deployment process is easier as well as all dependencies are found on a single CD or USB. Another benefit of using the CD or USB is to have a graphical environment that allows the use of a web interface and desktop environment from the server host itself.

The installation of Zentyal was done using a bootable USB. The Zentyal installer is based on Ubuntu Server installer. The first step was to select the preferred language, in this case English was chosen and country information, configuration of keyboard and network connection. The internal network (LAN) was set up on the Ethernet 1 interface (eno1).

The hard disk was partitioned then a username and password were created for login and administrative privileges. The server then rebooted. It was observed that the first boot took a long time, this was because the system core modules were been configured for the first time.

Figure 27: Installation screenshot

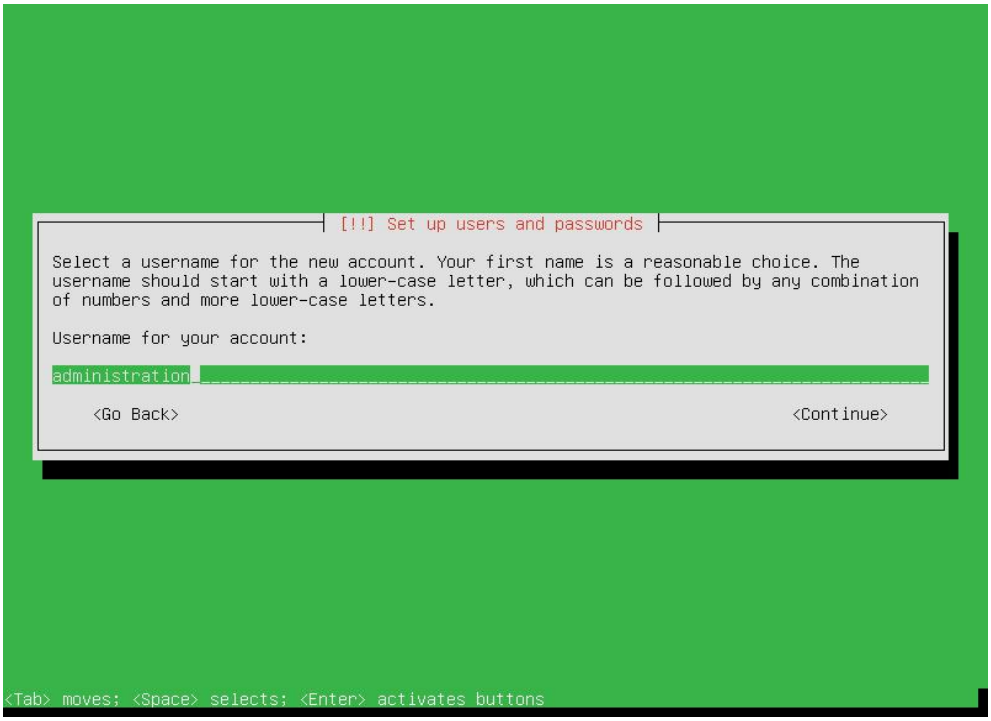


Figure 28: Installation screenshot 2

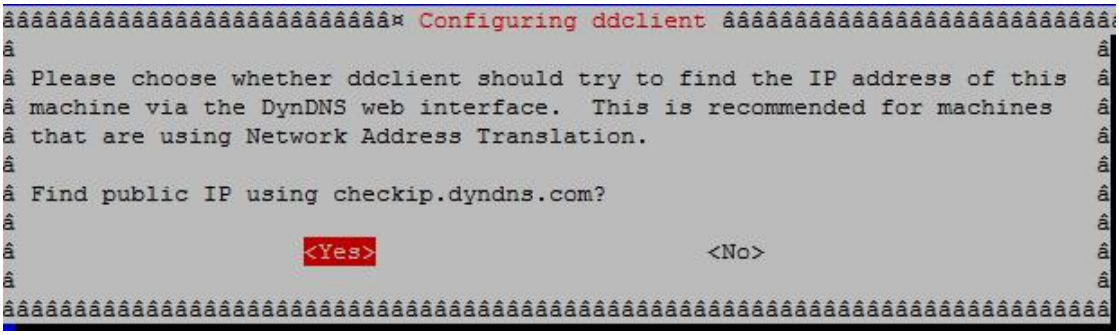


Figure 29: Installation screenshot 3

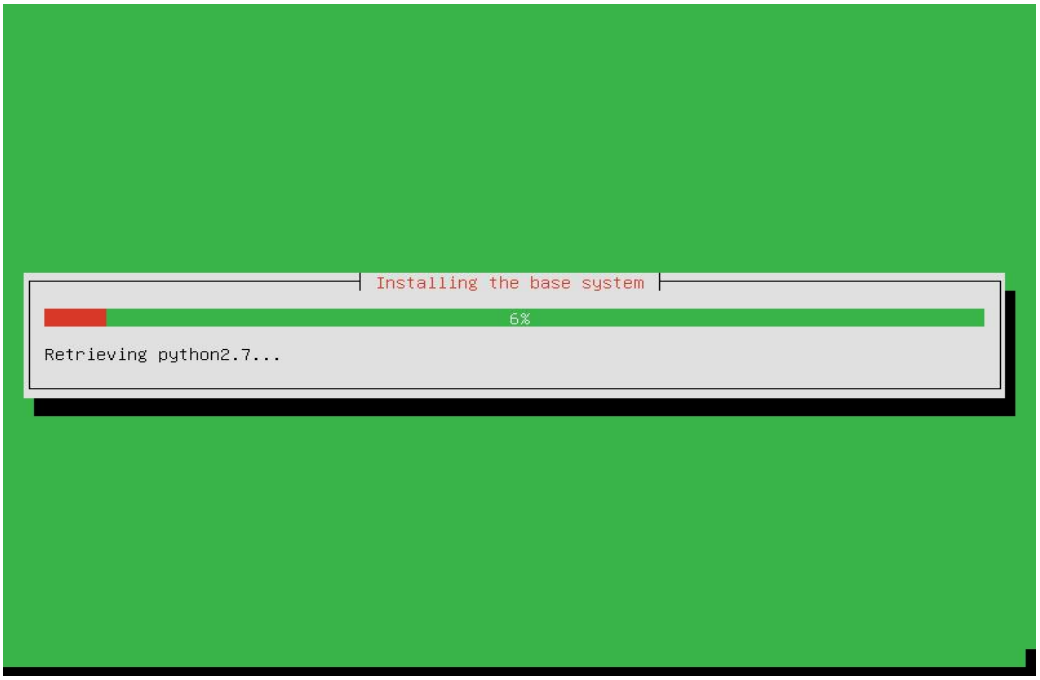


Figure 30: Installation Screenshot 4

The installation time took about 10 minutes to complete. Once the installation was completed the installation USB was removed.

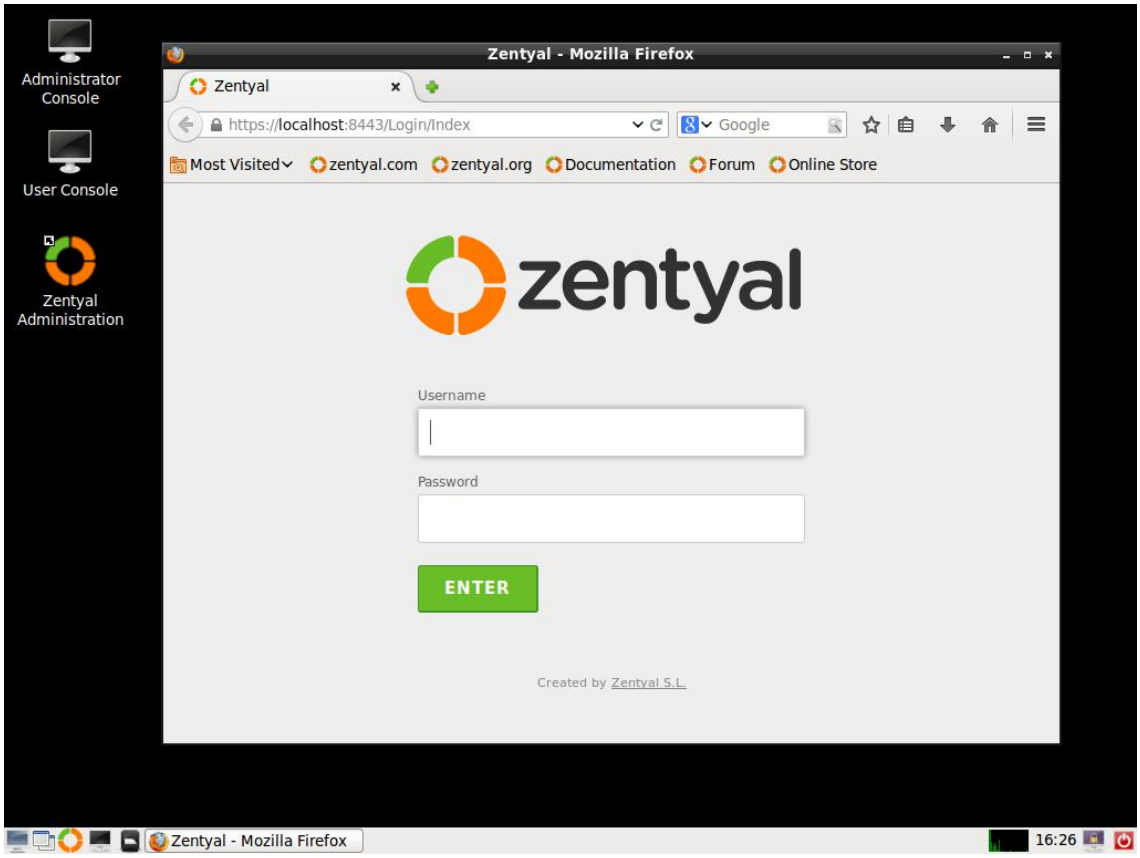


Figure 31: Administrative Interface Screenshot 2

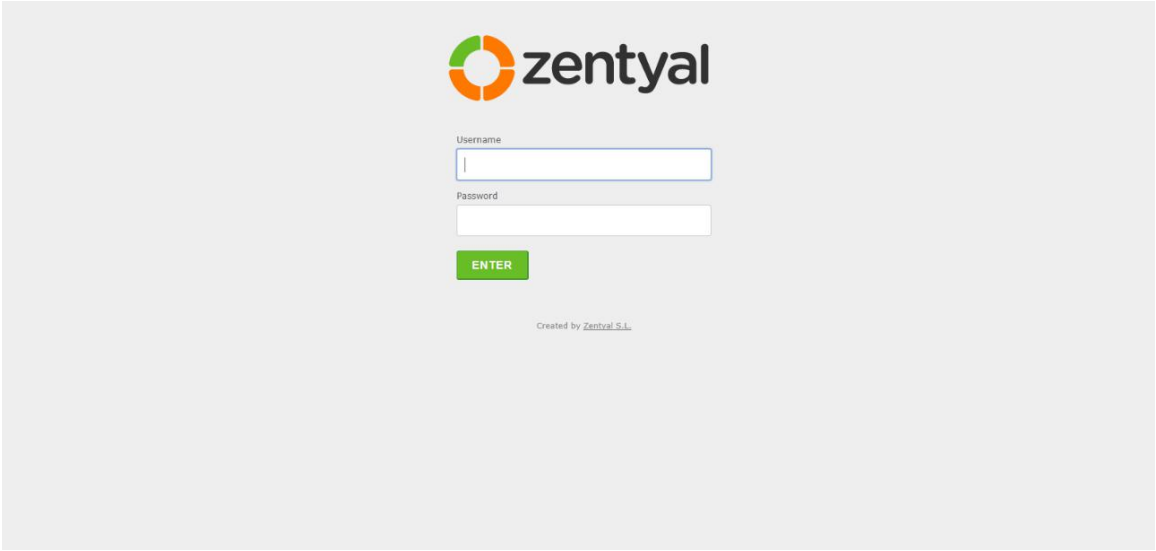


Figure 32: Administrative Interface Screenshot 2

Figure 32 shows the web administrative interface which requires the username and password that was previously set. Figure 33 shows the administrative interface of Zentyal:

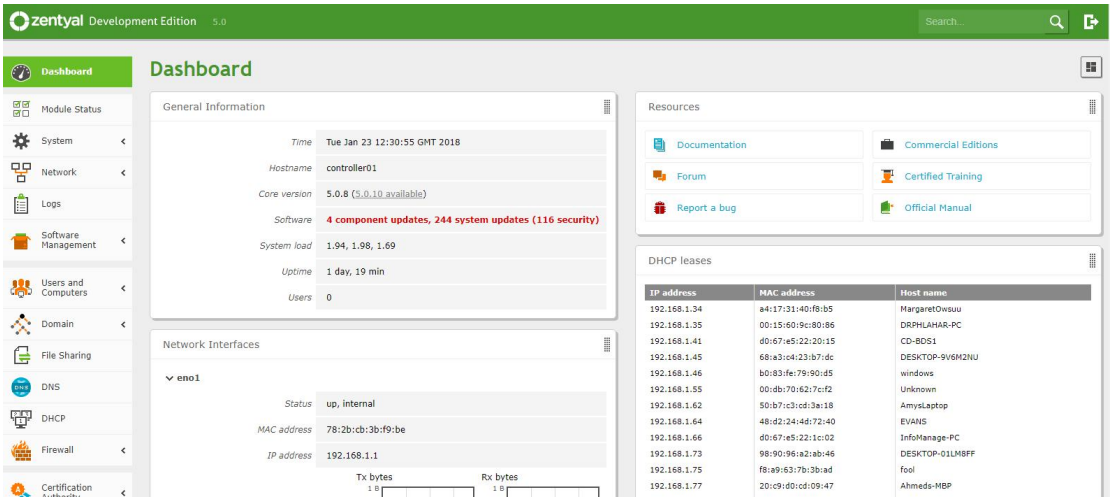


Figure 33: Administrative dashboard interface

4.1.2 Network configuration and setup.

Once the installation was completed, the next phase of the project was to execute network setup on the server. The Two network interface card (NIC) in the server were automatically recognized by the system. The initial configuration of the server was to configure the system to provide internet access, core network services and the required security levels.

4.1.3 Configuring the Zentyal Network Module

To access the Internet from the local network the first thing was to configure the network interfaces of the Zentyal server. This was done to enable the server act as a gateway. This was carried out by configuring on the administrator interface through the modules (network module). The internal connection (LAN) was setup from here. The interface was named interface *eno1*. Figure 34 below shows an example of this process.

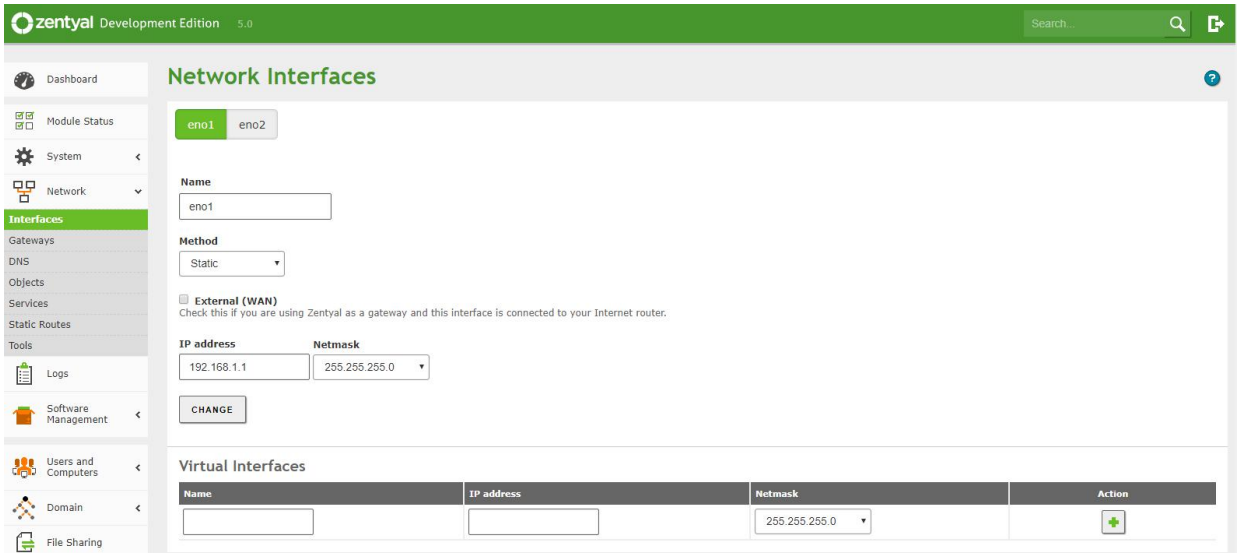


Figure 34: Network interface Screenshot

The external interface (eno2) was configured as the default gateway.

In computer networking, a default gateway is the device that passes traffic from the local subnet to devices on other subnets. In other words, if a workstation is trying to reach an address not on its subnet and does not know how to reach it, it goes through the default gateway.

The LAN network (192.168.1.0) was set up by connecting the server to a 24-port D-Link switch via an ethernet cable. The switch is connected to the Zentyal server (router) which is connected to the workstations (desktop and laptop computers) on the LAN. All these are on the 192.168.1.0/24 network. The network is shown below.

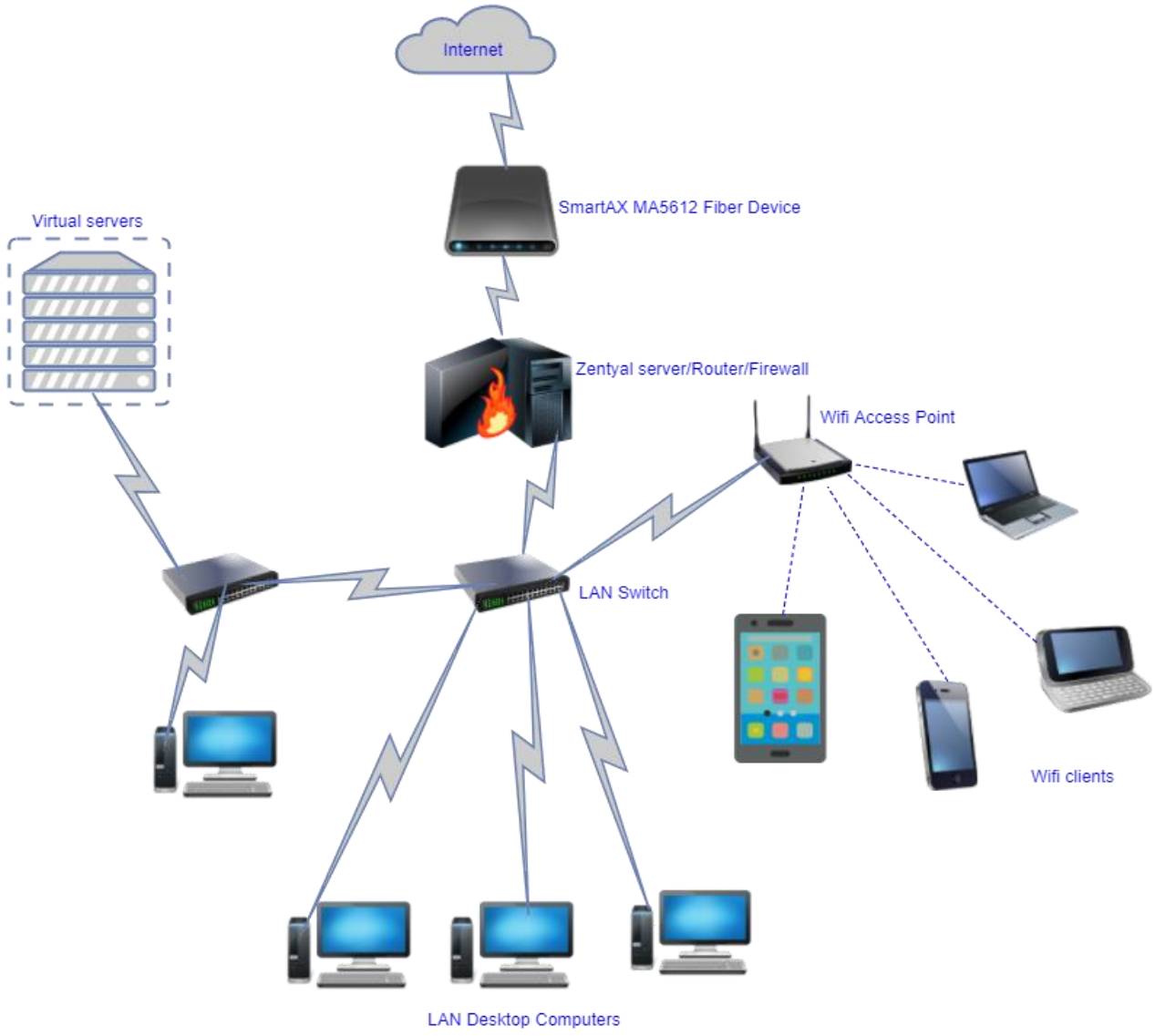


Figure 35: Network diagram

The workstations automatically receive and use the IP address 192.168.1.1, which is the address of the server, as their default gateway. This implies that they go through the Zentyal server as their link to the outside world.

4.1.4 Network Configuration Service (DHCP)

Network configuration is done by static method or dynamically by DHCP. DHCP means *Dynamic Host Configuration Protocol* and it's the protocols that allow network devices to request and obtain network parameters i.e. IP address, default gateway, network mask and the IP of the name servers. When network configuration is done statically, the entire network parameters are entered manually by the network administrator. In Zentyal configuration, both interfaces (eth0 and eth1) and the DNS (Domain Name Service) have

to be configured before DHCP configuration can be done. In this project, interface eno1 and eno2 were configured statically. The configuration of eno1 can be seen in Figure 36 and eno2 in Figure 37. The interface en02 was marked as *external (WAN)*, with IP address – 41.66.254.106 in order to serve as the gateway to the LAN.

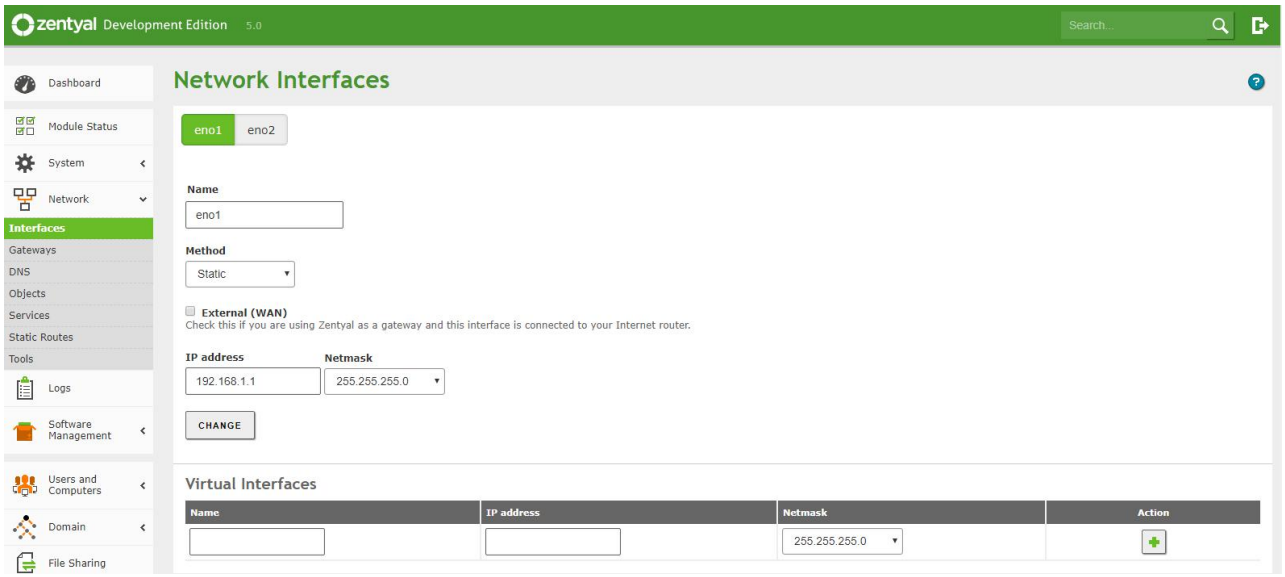


Figure 36: eno1 Interface configuration

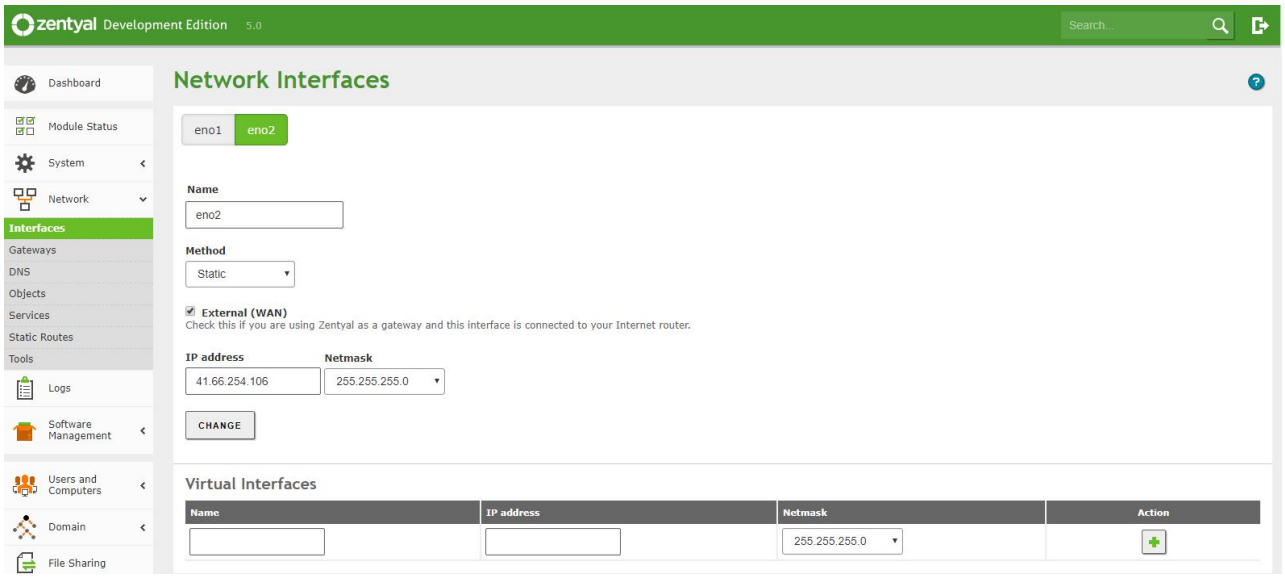


Figure 37: eno2 Interface configuration

After the interfaces configuration, the DHCP was configured in the Common options tab of the DHCP menu, on eno1 with an IP range of 192.168.1.1 – 192.168.1.254. This can be seen in Figure 38. In the Dynamic DNS Option, dynamic DNS can be enabled and domain names can be allocated to clients based on their method of network configuration. The

Advanced Option was left un-configured because there was no lightweight server present in this project and the lease time was adequate.

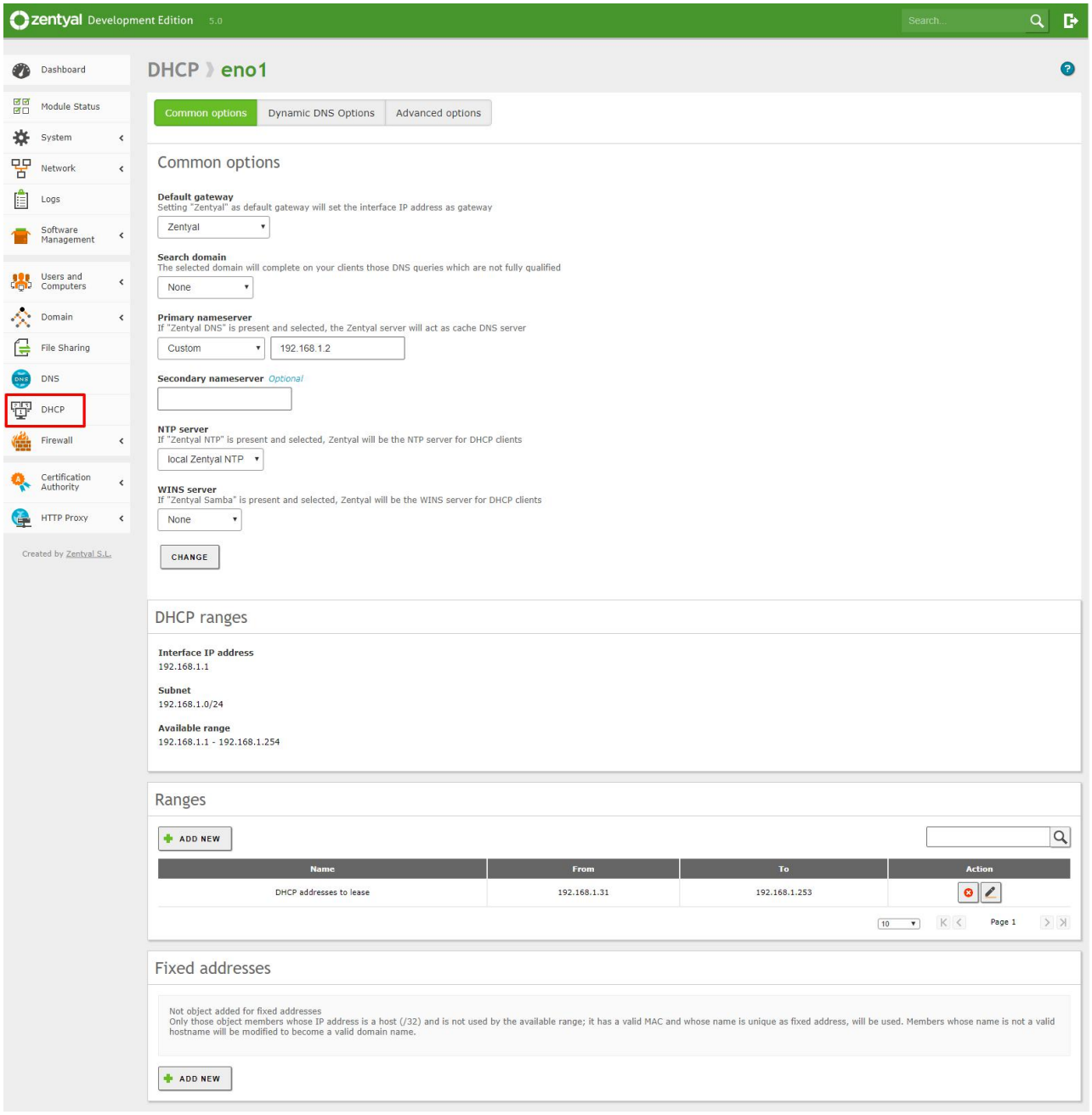


Figure 38: DHCP configuration on eno1

4.1.5 NAT configuration

Network address translation (NAT) was done by enabling it on the Zentyal dashboard. This setup the network such that all computers on the network were seen as one from the outside world (Internet). This was verified by opening the www.myipaddress.com page on windows 10 laptop. It was observed that all the computers on the network had the same IP address. This feature was successfully tested. Figure 39 shows windows 10 laptop on

the local network checking its IP address by entering “show my ip” in the google search box.

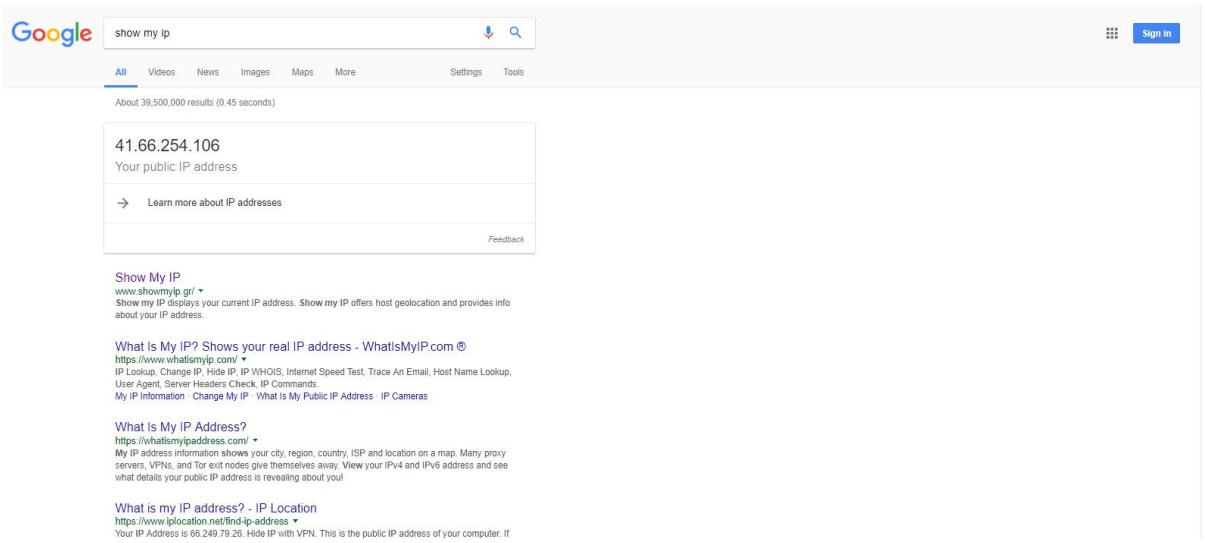


Figure 39: Windows 10 laptop screenshot

4.1.6 Port Forwarding

Port forwarding in Zentyal means *Network Address Translation* (NAT). This service checks the destination port address of an incoming packet and routes it to a host listening on a certain port that has been translated to the incoming packet port address. In this project, port forwarding was implemented to enable users have access to web applications on the local area network. Figure 40 below shows port forwarding implemented.

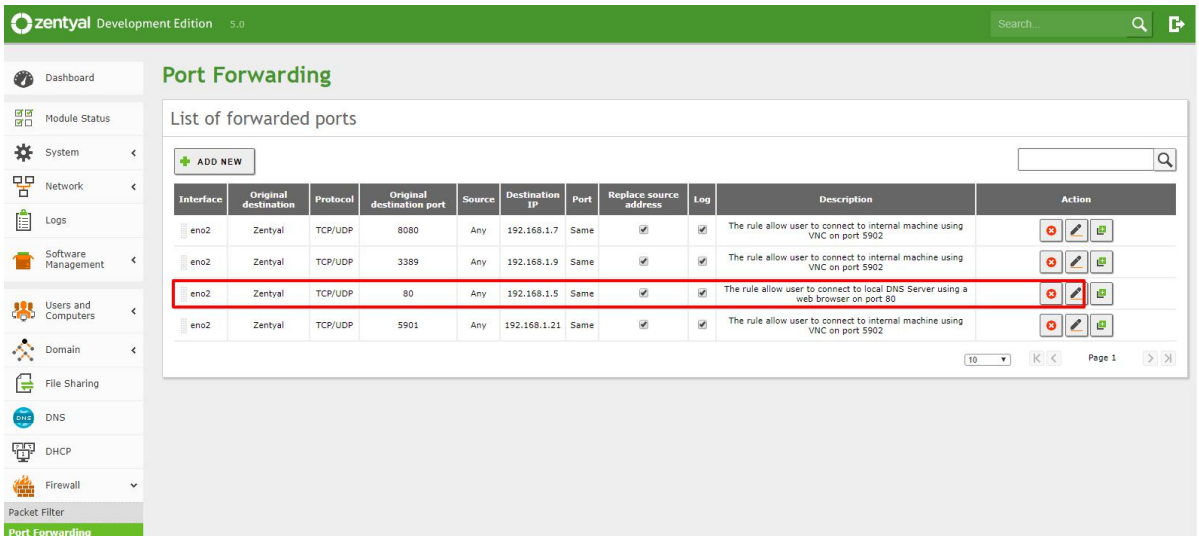


Figure 40: Zentyal port forwarding

The highlighted shows port forward rule that allows a user to connect to a local web server using a web browser on port 80.

4.1.7 Network Services

Network service is the abstraction of one or more applicable protocols that can be used in other Zentyal modules (Zentyal Technologies SL 2010, 45). In Zentyal, the management of network services requires the name of the service, protocol, source port and the destination port allocated to the application. Also, network administrators have to indicate if the service is internal or external. A *service* is internal if it is running in the Zentyal machine. Usually, it is always advisable to allow any source port because a client uses any source port to connect to a known destination port. The Zentyal network services created will be used in other Zentyal modules such as traffic shaping, firewall etc. Figure 41 shows the list of services created and enabled in this project.

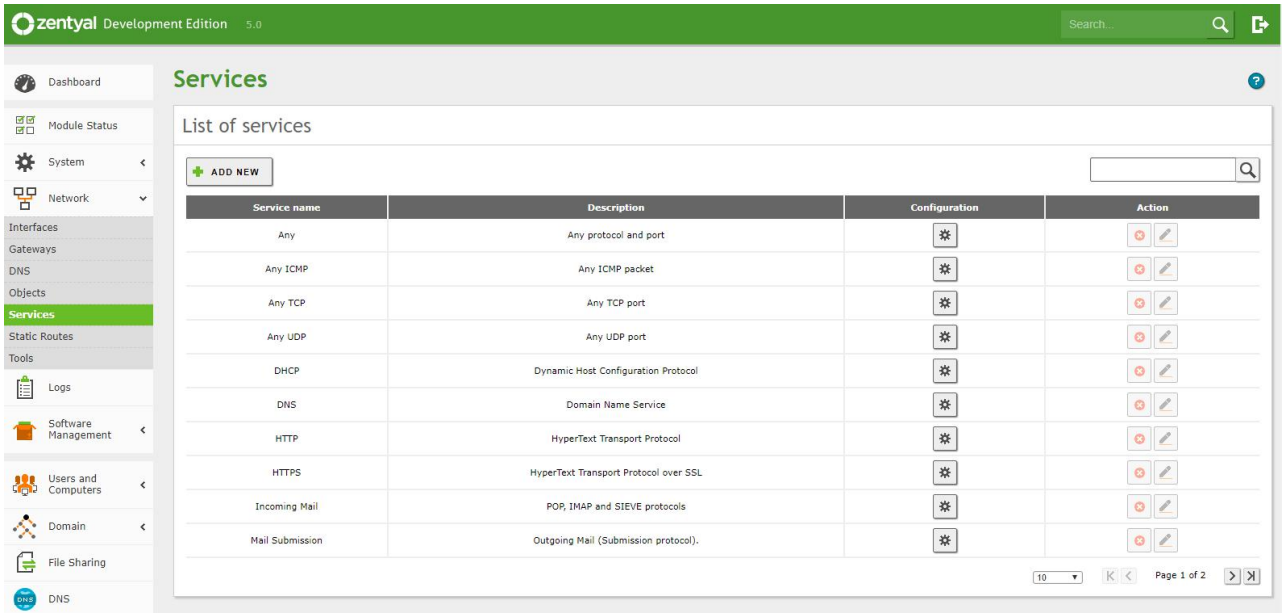


Figure 41: Network Services created and configured

4.1.8 Firewall configuration using packet filter / filtering rules

A Firewall is an application which ensures the security policies between networks connected to one another. In firewall configuration, the network administrator must define series of security/access policies by using traffic filtering rules based on the ports, protocols, source and destination IP address and physical address. For *Firewall* implementation, Zentyal uses *Netfilter*. Netfilter is a security tool that offers *packet filtering* and *Network Address Translation* (NAT). In this project, Zentyal was made to act as

firewall and the gateway to WAN. The external interface must be specified in order for the *Firewall* module to establish the filtering policies created. By default, Zentyal has established a policy for external interfaces to deny all connection attempts to Zentyal and denies all connection attempts to internal interface excepts when the internal service has been cretaed in the *Services* module. Configuring the Zentyal *Firewall* module requires creating filtering rules to control and check the traffic from a local or remote service if they can be accepted or not. In Zentyal *Firewall* configuration, network administrators can control traffic using four types of network traffic control options/filtering rules. These options/rules are;

- Filtering rules from internal networks to Zentyal: --These rules allow you to control access from internal networks to services running on your Zentyal machine.
- Filtering rules for internal networks: - These rules allow you to control access from internal networks to the Internet and traffic between internal networks.
- Filtering rules from external networks to Zentyal: - These rules allow you to control access from external networks to sevices running on your Zentyal machine.
- Filtering rules for traffic coming out from Zentyal: - These rules allow you to control access from your Zentyal to external services.

Configuring the *Firewall* module was done through the Zentyal dashboard by configuring the packet and also editing the filtering rule. The *Firewall* access rule has a *source* and *destination* which would depend on the type of filtering used. When Zentyal finally filters a traffic, it makes a decision which can either be to accept the connection or deny the connection and inform the source that connection cannot be established. The Figure 42 below shows the packet filtering from *Internal networks to Zentyal* in this project.

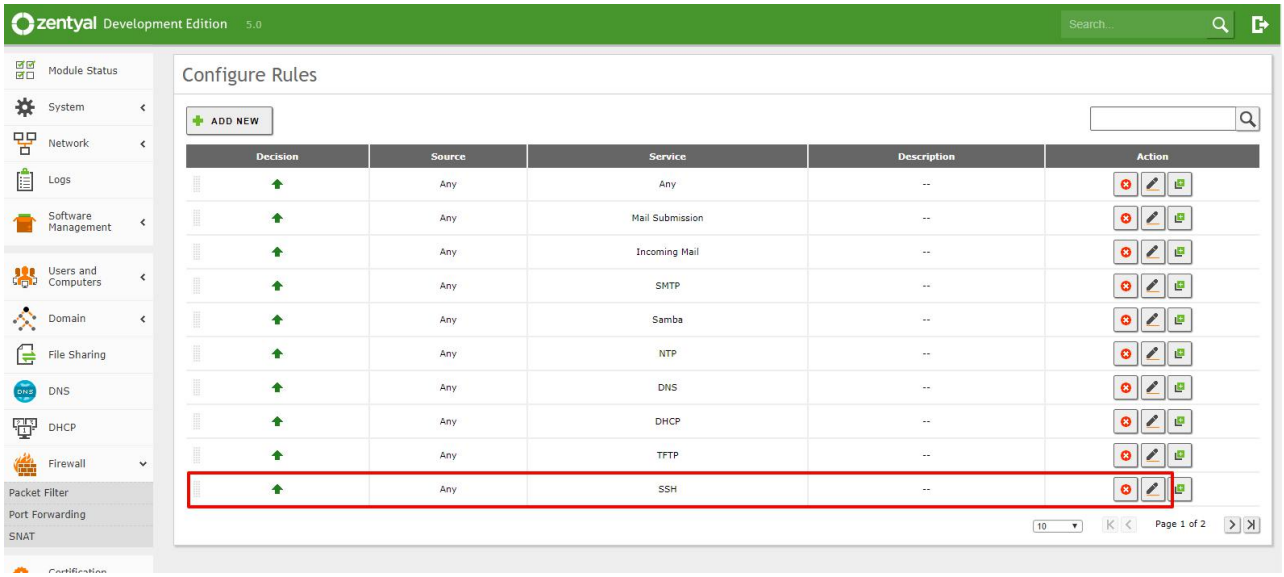


Figure 42: Packet filtering rules from Internal network to Zentyal

SSH was highlighted because a simple test was carried out using *ssh*. The *ssh* service was created but not added to the traffic rule in packet filtering from *internal network to Zentyal*. When a user tried to connect to *ssh* from the local network, the connection was unsuccessful. When the *ssh* rule was added, the connection was successful.

5.0 CHAPTER: IMPLEMENTATION AND TESTING

The implementation is the most critical phase of the project as the system goes into production, that is operating in a real environment with real users. In this project, the actual environment is the same in which the partial validation tests were conducted during the implementation phase. Users are all staff of FRI. This is a time of much psychological pressure, so it is important to remain calm during this period and carefully plan the change.

5.1 Planning

The duration for the implementation and testing of the project period was three weeks, culminating in the launch and deployment of ZentyFRI server. Human resources used for the implementation were the IT team. The team acted as a support team for any incidents that arose during the actual implementation of the system.

5.2 Deployment tests

Once the solution was implemented, one of the most important moments of every project arrives: the phase of testing and quality assurance, and the agreement with the set objectives.

For this project, two types of exhaustive tests were carried out:

Functionality tests: -The IT team performed various functionality test including internet connectivity, proper configuration of network cards and internet access etc. All the functionality tests performed were successful.

Load tests: -To assess the actual limits of the system. Once the system is in operation, these tests are done directly with end users as they it.

5.3 Testing server functionality ZentyFRI

Internet access from the server ZentyFRI

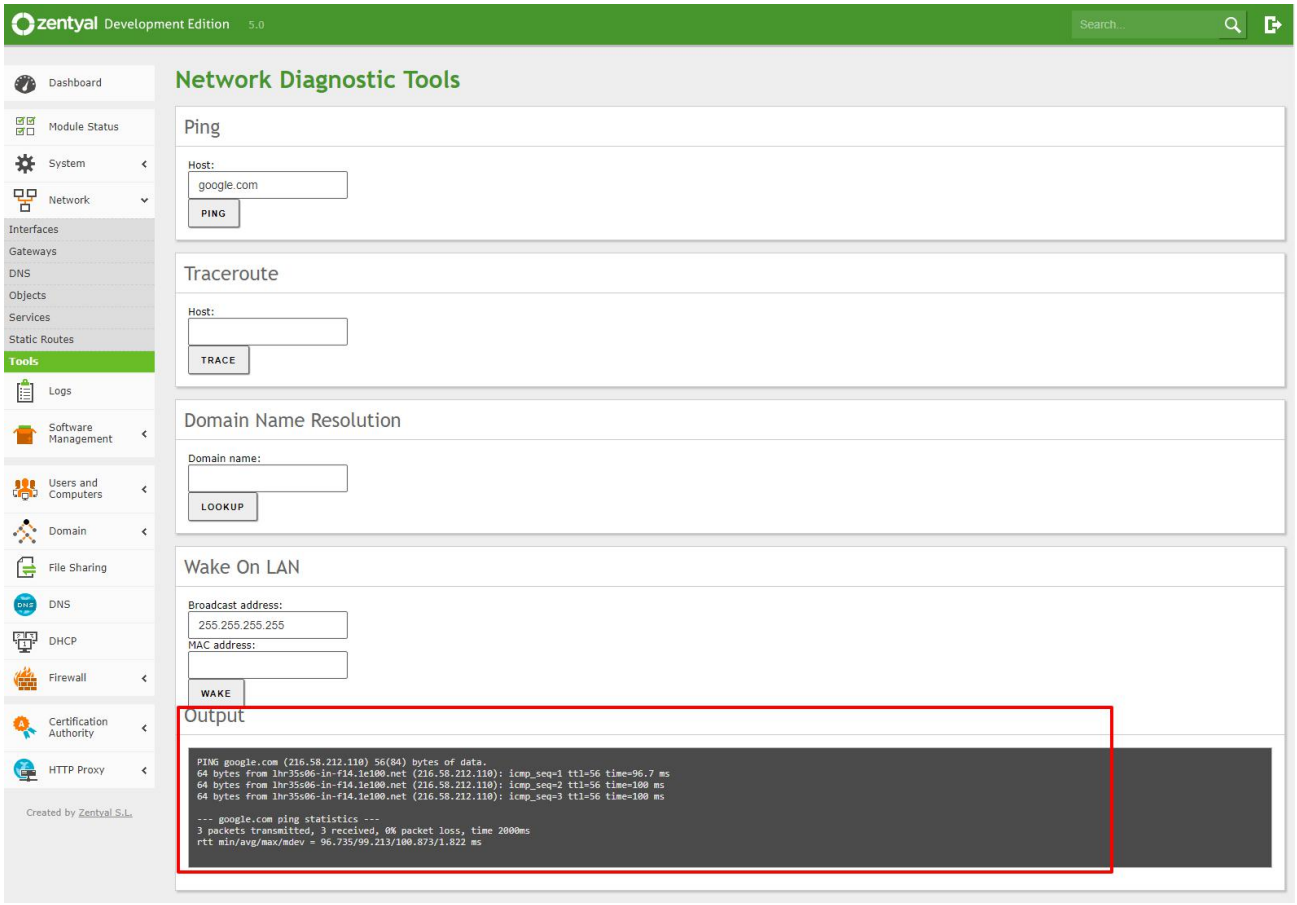


Figure 43: Network diagnostic test

It can be seen in the above figure captured from the ZentyFRI server that no packets are lost on the way to its destination.

5.3.1 ZentyFRI server functions as the DHCP server

The figure below shows that the DHCP is working

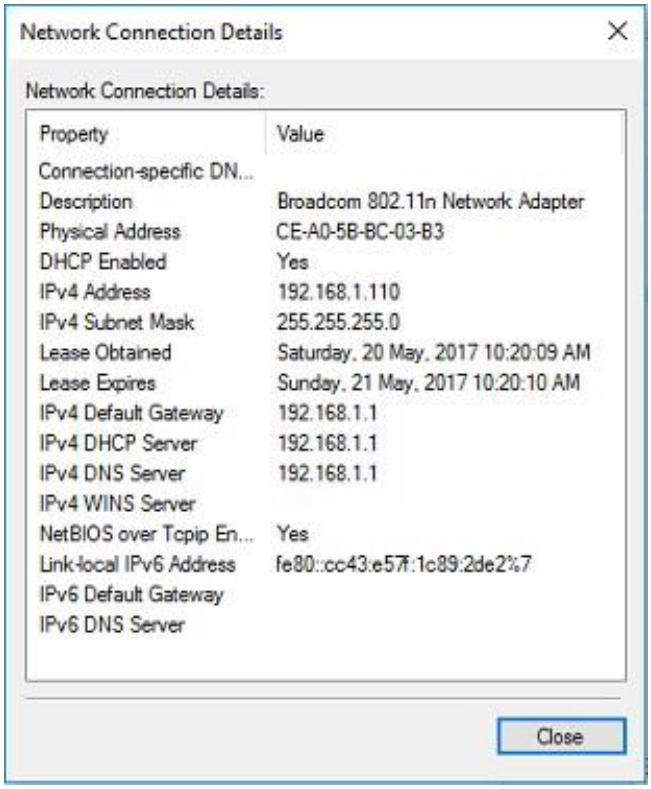


Figure 44: DHCP test

5.3.2 Security tests

Security measures tested showed that users were prohibited from unauthorize access to the server.

5.4 System Maintenance

The deployed server infrastructure is being maintained by the IT team of FRI.

6.0 CHAPTER SIX: SUMMARY AND CONCLUSION

The aim of this project was to deploy Zentyal server in the FRI IT infrastructure and set it up as a gateway through which computers on the FRI LAN can reach the Internet.

In this work, a small business server, Zentyal, has been successfully deployed on one physical server (Dell PowerEdge T310) that supports 300 windows clients and laptops of staff of CSIR-FRI.

Presently, Zentyal is mainly used as the Internet Gateway/Router, Firewall and DHCP server. This solution has provided a unified single platform for the entire network infrastructure management and security.

Summary of task carried out in this study:

1. The hardware specifications were successfully decided and implement. This is evident from the effective functioning of the server, throughout the project.
2. The Zentyal operating system was successfully installed and configured.
3. The Server was successfully configured as a Gateway/Router, DHCP server and a Firewall. It serves as the connection to the Internet for the LAN network i.e. FRI computers.
4. NAT was successfully implemented as a feature of Zentyal.

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