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Installation of Zentyal; LINUX Small Business Server

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INSTALLATION OF ZENTYAL; LINUX SMALL BUSINESS SERVER

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Final Project

Submitted to the Graduate College of Bowling Green
State University in partial fulfillment of the requirements for the degree of

MASTER IN ENGINEERING TECHNOLOGY MANAGEMENT

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CHAPTER 1

Context of problem

The laboratory of the Electrical and Computer Engineering program (ECET) of the Bowling Green State University (BGSU) presently uses a server for instructional purpose in computer networking course. This provides the student with hands-on experience of networking and also a simulation of the setup of a computer network. This aims at improving the learning process and their knowledge of networking protocols.

OpenBSD is the operating system (OS) on the server. The version of this server (OpenBSD 3.3) is outdated, dating back to May of 2003. Furthermore, the server has not really being achieving all the aims of its setup because it requires more skills and knowledge for the user to fully operate it. Hence some students find it more difficult to operate it. Therefore, there is the need to update the server to a better version of LINUX.

This project is embarked on to install Zentyal OS; which a variant of Linux because it is easier to operate and recent in version, in the ECET program. It compares both operating system and work on the installation of Zentyal. Figure 1 below shows racks of servers;



Figure 1. Server Adapted from *smtp server* [photograph]. by M. Wheatley, 2013. Retrieved from <http://siliconangle.com/blog/2013/08/29/other-server-makers-gain-ground-as-ibm-hp-oracle-all-struggle/smtp-server/>. Copyright 2014 by Media Heat. Reprinted with permission.

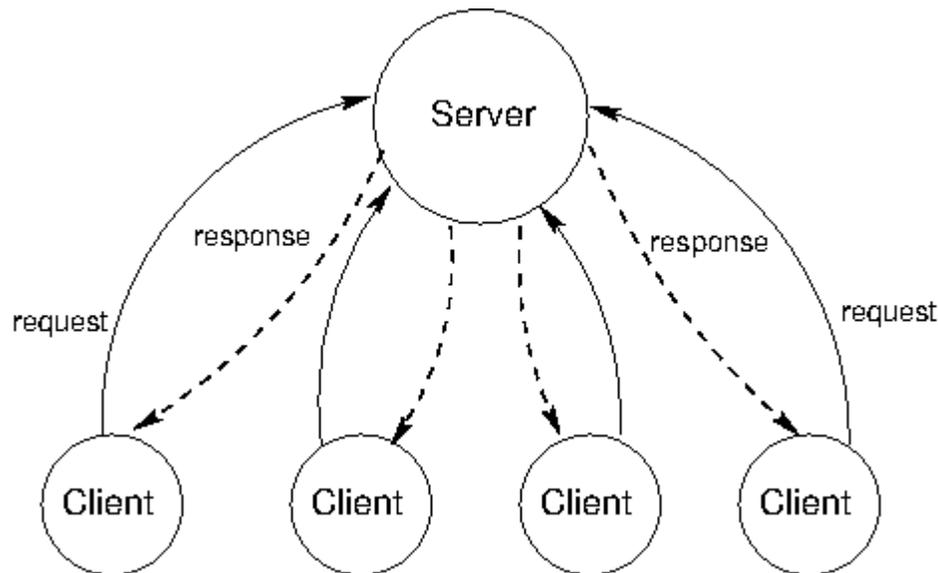


Figure 2. Server and Clients Adapted from *Structure and interpretation of computer programs*, by H. Abelson, G. J. Sussman, & J. Sussman, 1996, 2nd ed. Cambridge, MA: MIT Press. Reprinted with permission.

Figure 2 above shows a basic representation of how a server and its client communicate.

Statement of the Problem

Installation of Zentyal operating system in ECET laboratory. This was done to replace the current server i.e. OpenBSD, with Linux operating system. And also setting up Zentyal as the gateway through which computers in the ECET laboratory reaches the Internet was done.

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 computer used for this purpose in the Electronics and Computer Engineering Technology (ECET) laboratory runs on OpenBSD 3.3. This version is outdated and offers less user interactive service.

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 hand-on network which students can work with in networking courses. With the success of this research, the ECET program will have a server that offers multifunction within the program for instructional purposes.

Objectives of study

1. To determine and obtaining the required hardware for this project. The hardware requirement of Zentyal is to be checked and its specification should be noted. So that the operating system can function optimally.
2. Installation of the Zentyal operating system on the ECET computer. This was done to obtain a dedicated server for the ECET laboratory.
3. Designing a network based on the client-server architecture, so that the computers in ECET laboratory can reach the server. One wired (LAN) network consisting of the computers in the ECET laboratory and the other network is wireless which connects to the BGSU Wi-Fi.
4. Configuring the Zentyal OS as a gateway for the computers in the ECET laboratory. So that ECET computer can reach the outside world on the BGSU Wi-Fi.
5. Implementing other features the Zentyal operating system possesses such as NAT.

Definitions

1. DHCP: The Dynamic Host Configuration Protocol (DHCP) is a networking protocol used on Internet Protocol (IP) networks for dynamically distributing IP addresses for interfaces and services (Mitchell, 2014).
2. DNS: Domain Name system (or *Service* or *Server*), an Internet service that translates domain names into IP addresses (Microsoft, 2005).
3. Firewall: A network security system that controls the incoming and outgoing network traffic based on applied rule set (Neagu, 2010).
4. Form factor: This is the term given to the overall shape and size of a server (*choosing the right server*, 2008)
5. Gateway: an Internetworking system that joins two networks that use different base protocols together e.g. router (Janssen, n.d.).
6. NAT: (Network Address Translation) “an Internet standard that enables a local-area network (LAN) to use one set of IP addresses for internal traffic and a second set of addresses for external traffic” (Beal, 2014).
7. Network: A network is a group of two or more computer systems linked together (Florida center for instructional technology, 2013)
8. Operating system (OS): a software layer on which other software or application can run on the server hardware (Beal, 2014).
9. PING: (Packet Internet Groper) is a prompt command used to test the ability of the source computer to reach a specified destination computer (Fisher, 2014)
10. Server: A dedicated workstation that is responsible for keeping and also allows sharing resources among clients (computers) in a network (Abelson, Sussman, & Sussman, 1996).

11. VPN: Virtual Private Network is a network that is constructed by using public wires — usually the Internet — to connect to a private network, such as a company's network (Beal, 2014).

CHAPTER 2

Literature Review

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.

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 other 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).

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).

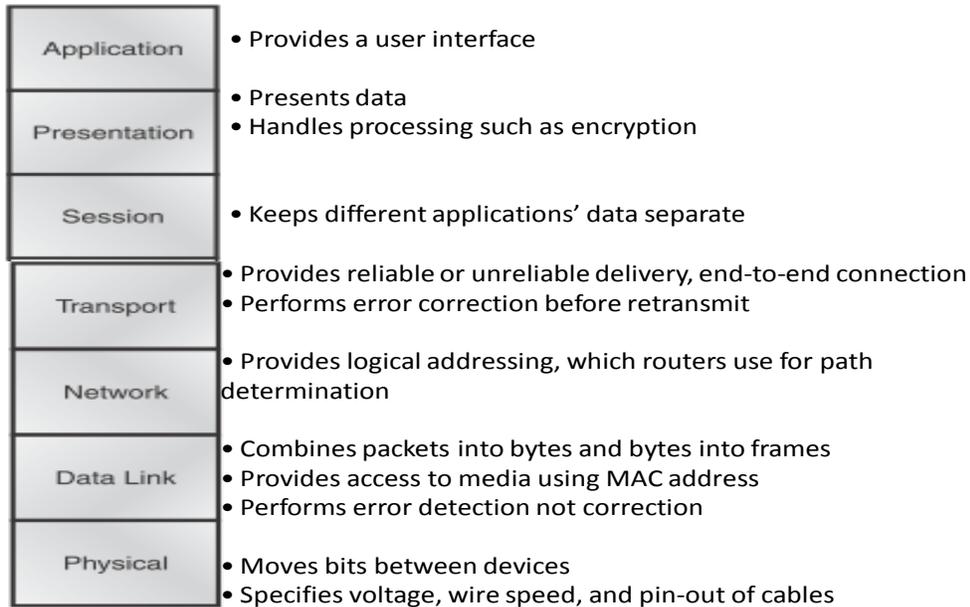


Figure 3. OSI reference model Adapted from *CCNA: Cisco certified network associate study guide ... (Exam 640-802)* by T. Lammle, 2007. 6th ed. Indianapolis, Ind: Wiley.

Copyright 2007 by Sybex, Inc. Reprinted with permission.

Figure 3 shows the OSI model and describes the function of each layer briefly.

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. The figure 4 shows the how Transport Control Protocol (TCP) connection is established between systems (Stallings, 2007).

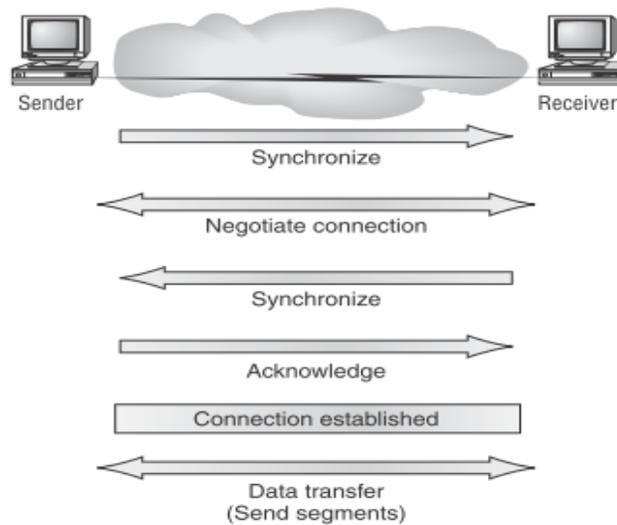


Figure 4. TCP Connection Adapted from *CCNA: Cisco certified network associate study guide ... (Exam 640-802)* by T. Lammle, 2007. 6th ed. Indianapolis, Ind: Wiley. Copyright 2007 by Sybex, Inc. Reprinted with permission.

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 5:

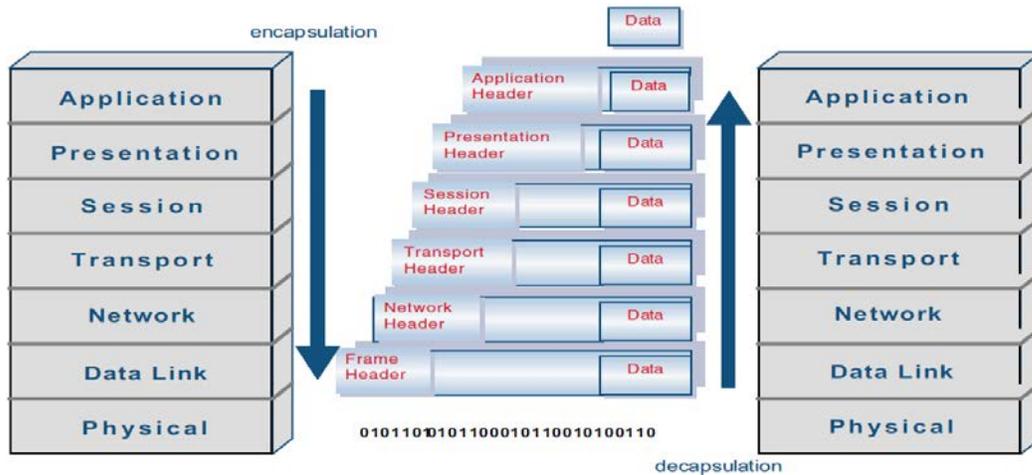


Figure 5. Encapsulation and Decapsulation process Adapted from *packet header* by Hanas, 2013. [graph]. Retrieved from <http://kalojanatanasov.files.wordpress.com/2013/02/packethheader.png>. Copyright by Wordpress. Reprinted with permission.

An example of the TCP header of both IPV4 and IPV6 respectively is shown in figure 6;

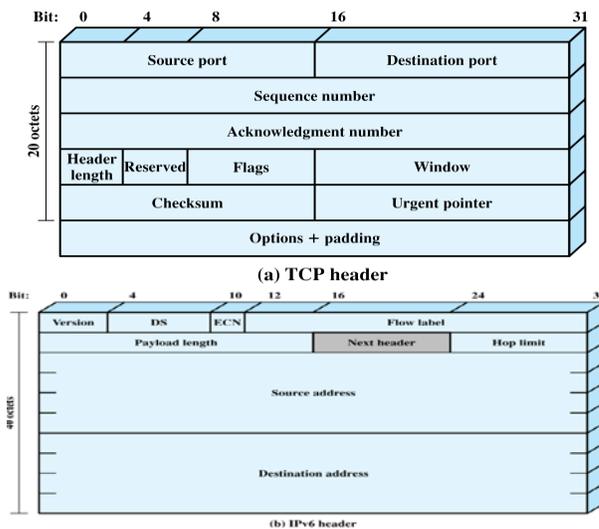


Figure 6. TCP header Adapted from *Data and computer communications* by W. Stallings, 2007. 7th ed. Upper Saddle River, N.J: Pearson/Prentice Hall. Copyright 2007 by Pearson Education, Inc. Reprinted with permission.

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 functions 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 network 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 7 shows a representation of a peer-to-peer network.



Figure 7. Peer-to-peer Network architecture Adapted From *Peer to Peer Risk Assessment* » *G2Link – Business Trust and Reputation* by E. Sullivan, (n.d.). Retrieved November 6, 2014, from <http://g2link.com/blog/2011/peer-to-peer-risk-assessment/>. Copyright 2010-2014 by G2link. Reprinted with permission.

There 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).

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 provide services such as high-volume storage capacity, heavy data crunching, data and resources sharing etc. as illustrated in figure 8 (*“Introduction to Client/Server Network Setup”*, 2012).

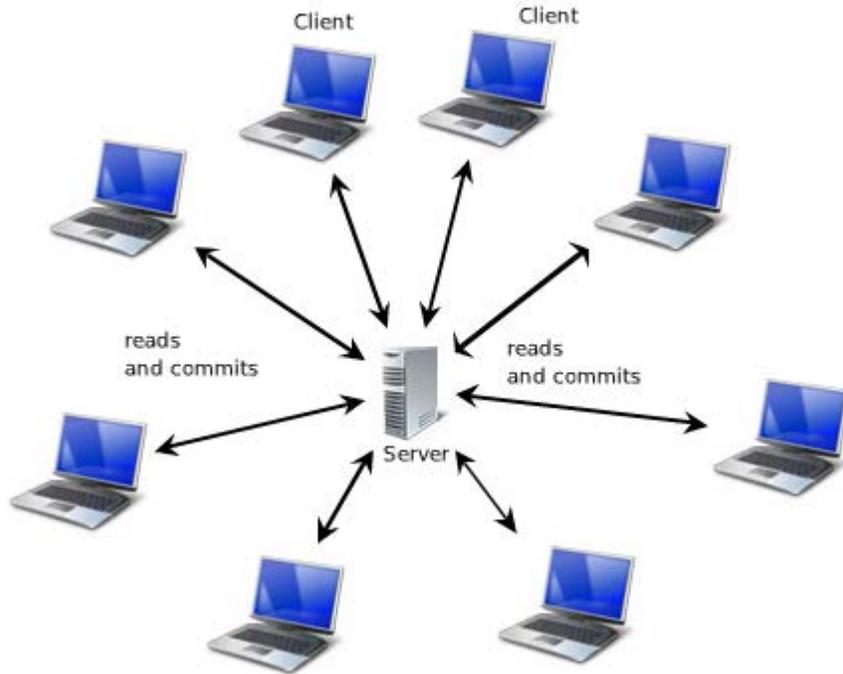


Figure 8. Client/Server Architecture Adapted from *client-server*, 2013. Retrieved from <http://wiki.squeak.org/squeak/6101>. Reprinted with permission.

Peer-To-Peer Vs Client/Server Architecture

The 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 a 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 particular user or group.

Note. Adapted From “*Client/Server Versus Peer Networks - LAN 101: Networking Basics,*” by B. Team, 2011. Copyright 2014 A Purch Company. Adapted with permission.

For this project, the Client/Server architecture is employed.

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.

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, 2014).

In 2013, there was a decline in server sales overall, though places in Asia recorded an increase in sale and shipment. To somewhat of a relief, the first quarter of 2014 has produced an increase in SHIPMENT BY 1.4% while revenue decrease by 4.1%. Gartner Inc. published a list of the top five vendors in this market and their relative sales and shipment in in May 2014. This is shown in tables 2 and 3 below:

Table 2

Worldwide: Server Vendor Revenue Estimates, 1Q14 (U.S. Dollars)

Company	1Q14		1Q13		1Q14-1Q13 Growth (%)
	Revenue	Market Share (%)	Revenue	Market Share (%)	
HP	2,890,992,229	25.5	2,959,030,197	25.0	-2.3
IBM	2,244,631,789	19.8	3,016,060,031	25.5	-25.6
Dell	2,006,639,006	17.7	2,124,462,397	17.9	-5.5
Cisco	616,620,000	5.4	450,120,000	3.8	37.0
Fujitsu	573,761,398	5.1	583,238,840	4.9	-1.6
Others	3,023,595,517	26.6	2,702,999,615	22.8	11.9
Total	11,356,239,939	100.0	11,835,911,081	100.0	-4.1

Table 3

Worldwide: Server Vendor Shipments Estimates, 1Q14 (Units)

Company	1Q14		1Q13		1Q14-1Q13 Growth (%)
	Shipments	Market Share (%)	Shipments	Market Share (%)	
HP	534,652	22.6	580,563	24.9	-7.9
Dell	464,141	19.7	516,355	22.2	-10.1
IBM	166,311	7.0	230,446	9.9	-27.8
Huawei	85,919	3.6	53,380	2.3	61.0
Inspur Electronics	80,929	3.4	20,823	0.9	288.7
Others	1,029,760	43.6	927,536	39.8	11.0
Total	2,361,712	110.0	2,329,103	100.0	1.4

Note. Adapted from Gartner “Says Worldwide Server Shipments Market Grew 1.4 Percent in the First Quarter of 2014, While Revenue Declined 4.1 Percent”, by Gartner, 2014. Copyright 2014

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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 computer 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).

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 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*).

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 machine 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 the 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).

Form Factor

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

1. **Rack-Mounted Server**

This is needed by bigger organizations when more than a few server is required. It helps reduce floor space required by the large number of server 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 9. Rack-Mounted Server Adapted from Etegro, 2012 [Photograph]. Retrieved from <http://www.etegro.com/img/company/news/big/computex-2.jpg>. Reprinted with permission.

2. Tower Case

Tower server are similar to those ones used to house desktop computers though it is likely to be higher than it. 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 numbers of servers are needed (*Choosing the right server, 2008*).



Figure 10. Tower Case Adapted from *ThinkServer TS140* [Photograph] by Levono. 2013. Retrieved from <http://www.thinkcomputers.org/lenovo-announces-new-thinkserver-models/>. Copyright 2013 by Thinkcomputers. Reprinted with permission.

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 11. Blade Server Adapted from *Blade server from IBM* by ITWissen, 2014. Retrieved from <http://www.itwissen.info/definition/lexikon/Blade-Server-blade-server.html>. Copyright by ITWissen. Reprinted with permission.

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 favoured because of its security and flexibility advantages (Noyes, 2010).

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 three 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 and version (Beal, 2014).

Linux was developed because at that time UNIX was the operating system in use then which was expensive and proprietary. Linux has 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 on 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 in Linux understand. 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.

Current technology

OpenBSD, a progeny of Berkeley Software Distribution, is a Unix-like operating system. Like other UNIX and Linux software, it is also freely available. Version 3.3 of the OpenBSD serves as the ECET department as a server and is used for instructional purpose. It offers integrated leading-edge security technology suitable for building firewalls and private network services in a distributed environment (OpenBSD, 2014)

Features of OpenBSD;

1. Runs on many different hardware version.
2. It is much secured; some professionals consider it as the most secure Unix-like operating system.
3. It offers more reliability by minimizing the need for customization.

4. It is free.

This version of the OpenBSD is outdated as the most recent version is 5.6. The current version in the ECET laboratory has no graphic user interface, therefore making interaction with user difficult. Furthermore, this tower form server has two network cards installed in it CPU i.e. they are both wired network interface cards hence offering less flexibility in the movement of the server. Also OpenBSD, requires a skilled personnel to carry out its software maintenance.

Zentyal

This is a 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 12.04 OS (Zentyal, 2014)

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 Zentyal suitable for businesses in this class because it was developed to bring Linux close to small and medium businesses. Statistics shows that Zentyal is being downloaded over a 1,000 times daily (Zentyal, 2014). Figure 12 shows a sample of Zentyal network.



Figure 12. Zentyal Network Adapted from *Internal network*, Retrieved from <https://wiki.zentyal.org/wiki/File:En-3.5-images-intro-intro1.png>. by Zentyal. Reprinted with permission.

Function

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 Zentyal UI interface. 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 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 attacked 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. There different types of active attacks;

- 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 on technology. With other platforms you find a big gap: you need to download the software updates and implement them, what takes 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 involve examining every packet that comes in or leaves the network and making sure match a set of rule that has been set. This can be difficult to achieve and s 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 provide 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 meet 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 price (\$350 and above). This is also free in Zentyal. Figure 13 and 14 dhows the packet filter and filtering rule interfaces of Zentyal respectively.

Packet Filter ► Internal networks

Adding a new rule

Decision:

Source: Inverse match:

Destination: Inverse match:

Service: Inverse match:

If inverse match is ticked, any service but the selected one will match this rule

Description:
Optional

Figure 13. Packet Filter Adapted from *Zentyal firewall*. Retrieved from http://https://wiki.zentyal.org/wiki/File:En-3.5-images-firewall-Zentyal_create_rule.png#filelinks. Copyright 2004-2014 by Zentyal S.L. Reprinted with permission.

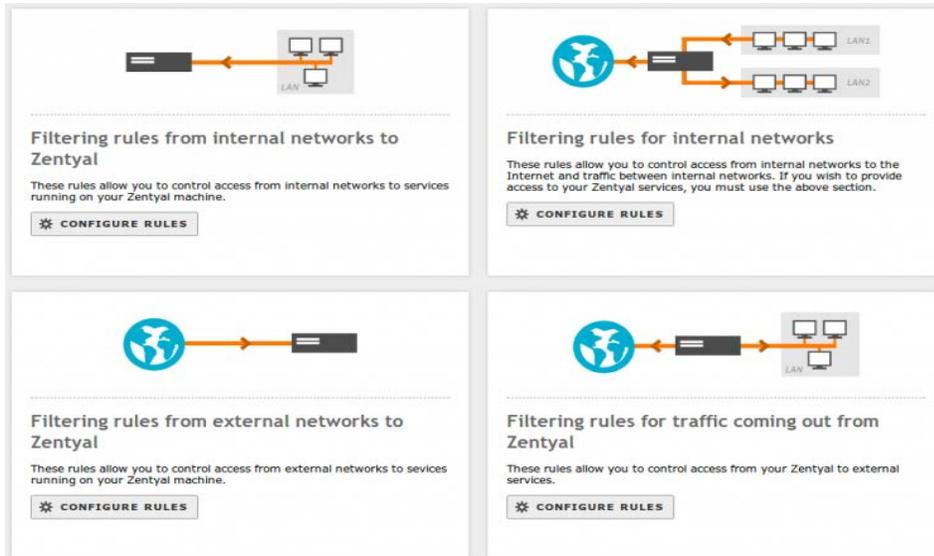


Figure 14. Filtering rules Adapted from *firewall sections*. Retrieved from https://wiki.zentyal.org/wiki/File:En-3.5-images-firewall-firewall_sections.png. Copyright 2004-2014 by Zentyal S.L. Reprinted with permission.

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 form of rules and policies (Zentyal, 2014).

Traffic Shaping



External Interface	Upload	Download	Action
eth3	16384 Kb/s	16384 Kb/s	
eth0	16384 Kb/s	16384 Kb/s	

10 Page 1 

Figure 15. Traffic shaping Adapted from *Traffic Shaping*. Retrieved from <https://wiki.zentyal.org/wiki/File:En-3.5-images-qos-tasas.png>. Copyright 2004-2014 by Zentyal S.L. Reprinted with permission.

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 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 16 and 17 illustrates RADIUS:

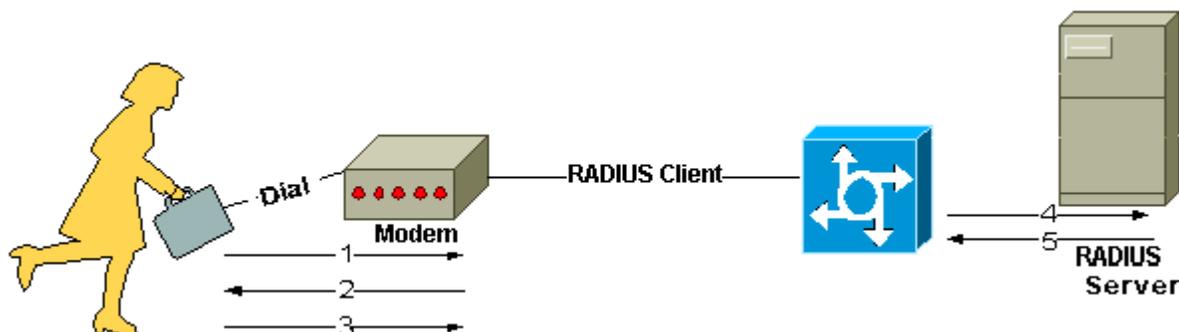


Figure 16. Radius Client Retrieved from <http://www.cisco.com/c/en/us/support/docs/security-vpn/remote-authentication-dial-user-service-radius/12433-32.html>. Copyright by Cisco. Reprinted with permission.

General configuration

Group allowed to authenticate: CHANGE

RADIUS Clients

client added

ADD NEW Q

Enabled	Client	IP Address	Shared Secret	Action
<input checked="" type="checkbox"/>	wifi_ap1	192.168.200.11/32	****	✖ ✎
<input checked="" type="checkbox"/>	wifi_ap2	192.168.190.12/32	****	✖ ✎

10 Page 1 ⏪ ⏩

Figure 17. Zentyal Radius Client Configuration Adapted from *ebox radius*. Retrieved from <https://wiki.zentyal.org/wiki/File:En-3.5-images-radius-ebox-radius-01.png>. Copyright 2004-2014 by Zentyal S.L. Reprinted with permission.

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 18.

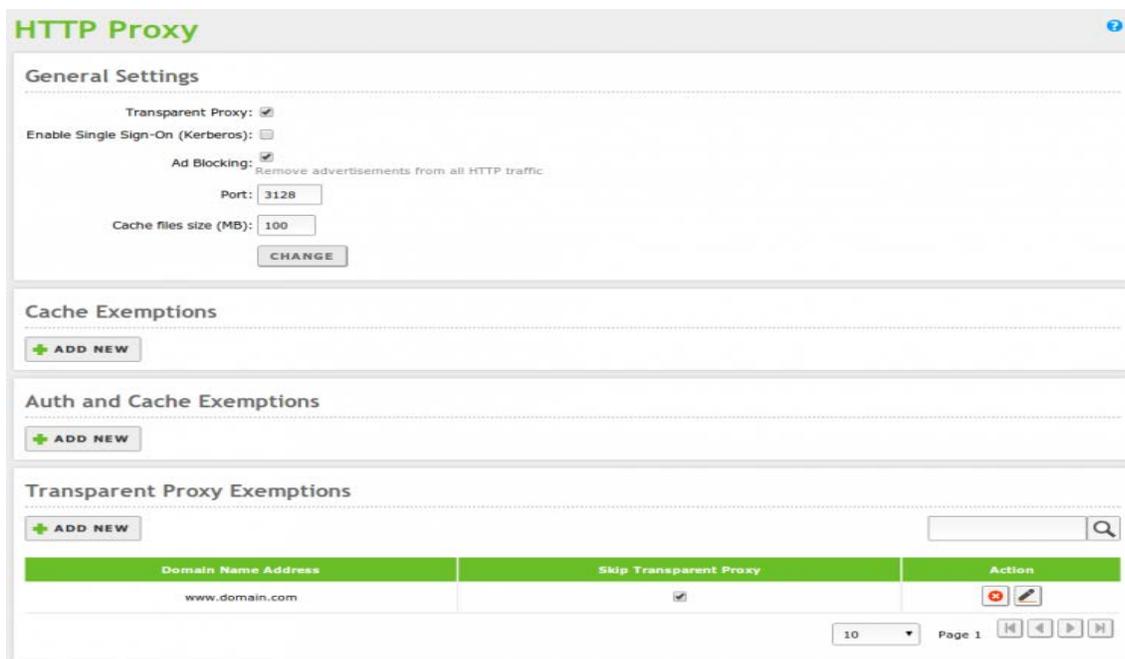


Figure 18. Zentyal HTTP Proxy Adapted from *proxy general*. Retrieved from <https://wiki.zentyal.org/wiki/File:En-3.5-images-proxy-general.png>. Copyright 2004-2014 by Zentyal S.L. Reprinted with permission.

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, 2014). Zentyal hardware requirement is shown in figure 19:

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

Figure 19. Zentyal Hardware requirement Adapted from *installation table*. Retrieved from <https://wiki.zentyal.org/wiki/File:En-3.5-images-intro-zentyal-install-tabla-installation-EN.png>. Copyright 2004-2014 by Zentyal S.L. Reprinted with permission.

Summary

In this literature survey, several different theoretical topics ranging from network architecture to OSI model were discussed. Network architecture was looked at critically, discussing the types, making comparison between both and also the design of each type. The OSI model showed the layers and their function and went further to illustrate how data is transferred and received through encapsulation and decapsulation.

The client/server was further discussed since it is the architecture that was employed in this project. The functions and type of server was explored describing each in the process. The server market was also analyzed and the definition of a small business. Operation system, which was described as the platform on which other programs run on was also defined.

Current technology used in the ECET laboratory, OpenBSD, was discussed and the reason for the change was explain. A comprehensive study of the new technology to be employed in this project, Zentyal, was done. Overall, this literature review sheds light on several aspects of

computer networks and making comparisons to arrive at the preferred operating system for the server.

CHAPTER 3

Restatement of the problem

There is a need to replace the current server i.e. OpenBSD, with another Linux operating system, Zentyal for the ECET laboratory. And also setting up Zentyal as the gateway through which computers in the ECET laboratory reaches the Internet.

Restatement of objectives

1. To determine and obtaining the required hardware for this project. The hardware requirement of Zentyal is to be checked and its specification should be noted. So that the operating system can function optimally.
2. Installation of the Zentyal operating system on the ECET computer. This was done to obtain a dedicated server for the ECET laboratory.
3. Designing a network based on the client-server architecture, so that the computers in ECET laboratory can reach the server. One wired (LAN) network consisting of the computers in the ECET laboratory and the other network is wireless which connects to the BGSU Wi-Fi.
4. Configuring the Zentyal OS as a gateway for the computers in the ECET laboratory. So that ECET computer can reach the outside world on the BGSU Wi-Fi.
5. Implementing other features the Zentyal operating system possesses such as NAT.

Development of procedure

Equipment specification.

This is done to achieve the first objective of this project. The hardware requirement of Zentyal was carefully examined and based on this, the equipment were chosen. The following equipment and devices were used for the realization of the goals of this project:

Dell Optiplex 790 desktop machine

The computer used as the server in this project is a Dell Optiplex 790 desktop machine with Intel Q65 Express Chipset. This was selected because it met the minimal requirement of Zentyal operating system when used as a gateway. It is a small-form-factor PC and it is recommended for corporate and small businesses and is also available in four different chassis sizes that blend seamlessly into office environments. It is designed for advanced performance and efficient collaboration. It enables business-class control, saves time and money. The remote management technology helps simplify systems management and protects data. Table 4 shows the full specification of Dell Optiplex 790.

Table 4

Specification of Dell Optiplex 790

General	
Desktop type	Small-form-factor
Packaged Quality	1
Recommended use	Small business, Corporate business

Built-in device	Speaker
Manufacturer	Dell Inc.
Dimensions (H×W×D) In	11.42 × 3.65 × 12.28
Processor	2 nd generation intel core; Core i5
Speed	3.4GHz 64-bit computing.
<u>Memory</u> Cache memory RAM	6MB 16GB
Hard drive	HDD
Audio	Integrated audio/microphone
Video	Integrated
<u>Expansion</u> Bays Slots	1 5.25" slim Line 1 PCI-e × 16x connector SLOT 1 1 PCI-e × 4x connector SLOT 2
<u>Operating system provided</u>	Microsoft Windows 7 Professional 64-bit Edition - English

Note. Dell optiplex specification. Adapted from “*dell optiplex 790 Technical guidebook*”. Retrieved from <http://www.dell.com/downloads/global/products/optix/en/optiplex-790-tech-guide.pdf>. by Dell. Copyright 2014 by Dell. Adapted with permission.



Figure 20 CPU Dell Optiplex 790

Windows XP machine

These are the computers in the ECET laboratory running windows operating system. These computers run on Windows operating system. They will be used to create the LAN network for this project.

Cisco 2501 Router

The router is a device in a network that is responsible for directing traffic. It was used as an entity on the network. Routers are intermediate devices that are saddled with ensuring that a packet reaches its destination. They do so by looking at the address of the destination in the header of the packet and looking it up in their routing table and forwarding it to receiver or other intermediate device that is close to the receiver. The Cisco 2501 has a single LAN chassis. It consists of a CPU motherboard with an onboard LAN (Ethernet/Token Ring) and multiple WAN ports, and a single power supply. It has one

Ethernet interface and two serial interfaces. This router was used since it was readily available in the laboratory. This is shown in the figure 21;

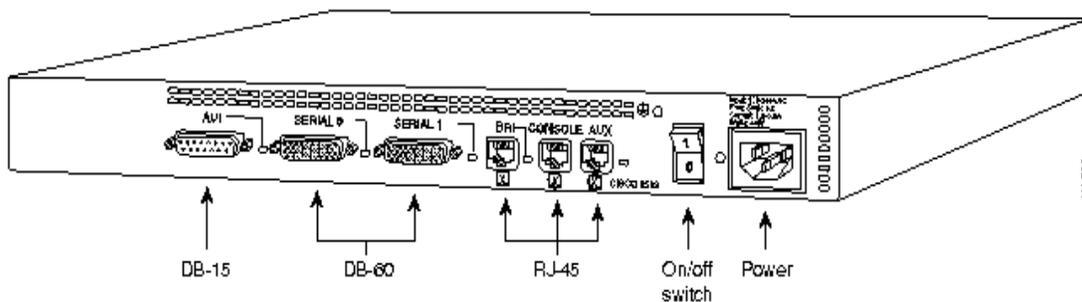


Figure 21. Chassis rear view of Cisco 2501 router. Adapted from “2500 series router”. Retrieved from <http://www.cisco.com/c/en/us/support/docs/routers/2500-series-routers/5750-arch-2500-5750.html>. Copyright 1989-2000 by Cisco Systems. Reprinted with permission.

Table 5

Cisco 2501 router specification

Enclosure type	Rack-mountable – desktop - modular
Data transfer Rate	10Mbps
Remote management protocol	SNMP
RAM	4MB
Flash memory	8MB

Note. Specification Table. Adapted from “*Cisco 2500 series*”. Retrieved from <http://www.andovercg.com/datasheets/cisco-2500-series-routers.pdf>. By Cisco Systems, 2009. Copyright 1989-2000 by Cisco Systems. Adapted with permission.

Cisco Catalyst 3500 Series XL

This switch is a scalable line of stackable 10/100 and Gigabit Ethernet switches that delivers top performance. It utilizes Cisco Switch Clustering technology and GigaStack GBICs. This technology enables users to manage over 380 ports location from a single IP address and connect up to 16 switches irrespective of physical location, with a wide-range of Ethernet, Fast Ethernet, and Gigabit Ethernet media. It will be responsible for the switching of the traffic on the 192.168.0.0 network. Again this was already in the laboratory. It is shown in figure 22.



24 fixed autosensing 10/100
Ethernet ports

2 fixed GBIC-based Gigabit
Ethernet ports

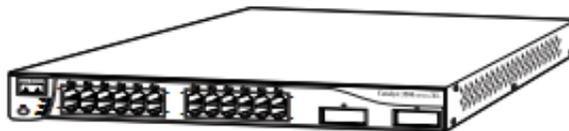


Figure 22 Cisco Catalyst 3500 Series XL Adapted from *Cisco switch*. Retrieved from http://docstore.mik.ua/univercd/cc/td/doc/product/lan/c2900xl/29_35xp/ig_3500/maoverv.htm. Copyright 1989-2000 by Cisco Systems. Reprinted with permission.

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 23.



Figure 23. Ethernet cable CAT 5 Adapted from *CAT5 and CAT5e - Category 5 Ethernet Cables.*, by B. Mitchell, Retrieved from <http://compnetworking.about.com/od/ethernet/g/cat5-cables.htm>. Copyright 2014 by About.com. Reprinted with permission.

NetGear WPN 311 Network Interface Card (NIC)

This is a hardware that is used to connect a computer to the network. It implements the circuitry needed to communicate with standards such as the Ethernet, Wi-Fi or Token ring. This is available on the motherboard of the computer and can also be used for expansion card by plugging it into the PCI bus. Figure 24 shows a WPN 311 NIC. A network server typically requires two network interfaces to serve as a gateway. It will serve as an expansion card so the server can have two network interfaces.



Figure 24 NetGear WPN 311 Adapted from *WPN 311 RangeMax Wireless PCI adapter*, by NetGear. Retrieved from http://www.downloads.netgear.com/files/GDC/WPN311/WPN311_ds_02Feb05.pdf. Copyright 2005 by NetGear. Reprinted with permission.

Table 6
NetGear WPN 311 specification

Features	
Network speed	- 1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, - 54 & 108 Mbps (auto rate capable)
Drivers	Windows® 98SE, Me, 2000 and XP
Interface	32-bit PCI bus
Frequency	2.412 ~ 2.462 GHz
Physical Specification	Dimensions (without antenna): 132.8(l) x 21.8(w) x 121(h) mm (5.23 x .86 x 4.76 in) Weight: 125 g (4.41 oz)

Note. NetGear WPN 311. Adapted from “*WPN 311 RangeMax Wireless PCI adapter*”, by NetGear. Retrieved from

http://www.downloads.netgear.com/files/GDC/WPN311/WPN311_ds_02Feb05.pdf.

Copyright 2005 by NetGear. Reprinted with permission.

ASUS USB N10 Wireless Network Adapter

The ASUS USB N10 is renowned as the world smallest USB adapter. It can be employed in-place of using network interface card if there is no free extension bus or the NIC card does not fit the size of the CPU. It is shown in figure 25:



Figure 25. ASUS USB N10 Adapted from *Asus USB N10*. Retrieved from <http://www.asus.com/us/Networking/USBN10/>. Copyright by ASUSTeK computers. Reprinted with permission.

Table 7

ASUS USB N10 Specifications

Network standard	IEEE 802.11 b/g/n
Interface	USB 2.0
Operating frequency	2.4GHz

OS support	Window 7, Windows vista, Windows XP, Windows 2000, Mac OS 10.4-10.8, Linux Kernel, Android 2.1
Utilities	Wireless setting

Note. USB N10. Adapted from “*Asus USB N10.*” By Asus Retrieved from <http://www.asus.com/us/Networking/USBN10/>. Copyright by ASUSTeK computers. Reprinted with permission.

BGSU Wireless Access Point (WAP): This is to be used as the wireless network gateway and a Zentyal bootable CD: the installation CD of Zentyal 3.3.

Procedures

This project is intended to be carried out in three phases;

1. Installation and network configuration of Zentyal
2. Configuration of the whole network
3. Ensure the network works and also exploring other features of Zentyal

These three phases were used to achieve all the objectives of this project. Phase 1 involves checking for hardware requirement and obtaining the devices and also the installation of the server. Configuration of the network involves the designing and configuration of the server as a gateway. The final procedure ensured the network works and also explored other feature of Zentyal e.g. NAT.

Phase 1: Installation and Network configuration

This phase includes setting up the Dell OPTiplex computer, which is being used as the server, for installation of the Zentyal 3.3 operating system. Firstly, the installation will be installed

through the CD drive; hence the Zentyal software was downloaded from the Zentyal website (<http://www.zentyal.org>) and burned to a CD. Once the CD was put in the CD drive, the installation steps were followed to complete the installation.

The next step would be to create a second network interfaces on the Dell machine. There is one network interface already built in the Dell machine. This can be done by inserting the network interface card into the PCI bus of the Dell Optiplex 790. However if this fails because the NIC is not compatible in size, then the wireless network adapter (Asus N10) can be used. This will serve as the second network interface for the server since it is intended to be used as a gateway.

Once the interfaces had been created, there will be two network interfaces; one wired and the other wireless. From the Zentyal dashboard, the interface section showed that the two interface were present in the computer. The wired network will serve as the interface for the local area network (LAN) which will consist of the XP machines in the ECET laboratory, while the other interface will connect to the wireless BGSU network. To test both interfaces, the wire interface will be connected to the wired BGSU network and tested while the wireless interface, the USB-based device, will connect to the NetGear wireless access point. The wireless interface obtained an IP address using the DHCP. The network diagram of the proposed connection is shown in the figure 26.

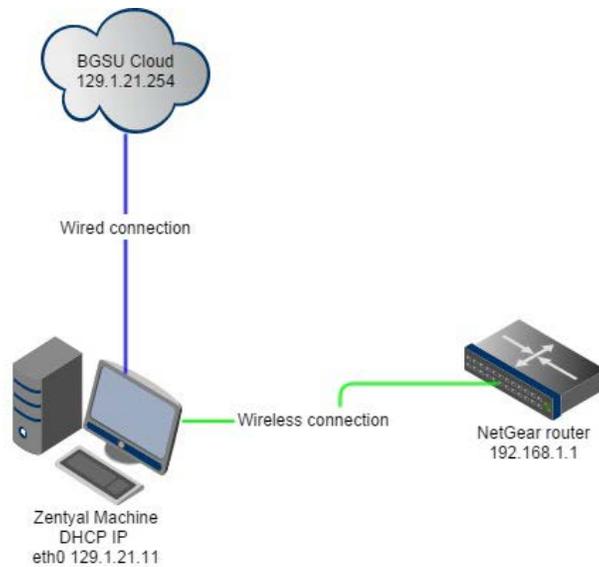


Figure 26. Connection test Network diagram

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. The wireless network will be configured to connect to the NetGear router which in-turn is connected to the BGSU wireless access point. From the diagram above, the Zentyal machine has an IP address of 129.1.21.11 as its static address and the NetGear is on the 192.168.0.0/24 network. A Packet Internet Groper (PING) command was used to test the communication on the network. The router was PINGed from the Zentyal machine. All packets sent there received response i.e. 100% success. The BGSU network was used to reach the World Wide Web, this showed that the connection works.

Phase 2 Configuration of the whole network

The figure 27 represents the design of the network. The Zentyal machine serves as the gateway between the two networks. The Ethernet interface (wired) of the Zentyal machine is connected to the Cisco 3500 switch which controls the traffic of the 192.168.0.0/24 network. From the switch, connections will be made, using CAT5 Ethernet cable, to the computers (XP machines)

in the ECET laboratory. The XP machines are to configured such that their default gateway address is the address of the server (192.168.0.1). In doing this, they will use the server as the gateway to reach the outside world (Internet). The server in turn receives their 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 wireless network through the wireless USB. It will do so by scanning for network, connecting to the BGSU wireless network and obtains an IP address using the DHCP. The server uses the 172.18.27.254 as its own gateway to reach the Internet. Hence the Zentyal machine serves as the gateway between both networks. A cisco router was connected to the XP machine through PUTTY (PUTTY is a software used for this purpose) and is also configured to be on the 192.168.0.0 network.

From this connection, all traffic to the Internet is routed through the wireless gateway (the 172.18.27.254 network), and all traffic to the interior network is route through 192.168.0.0 network.

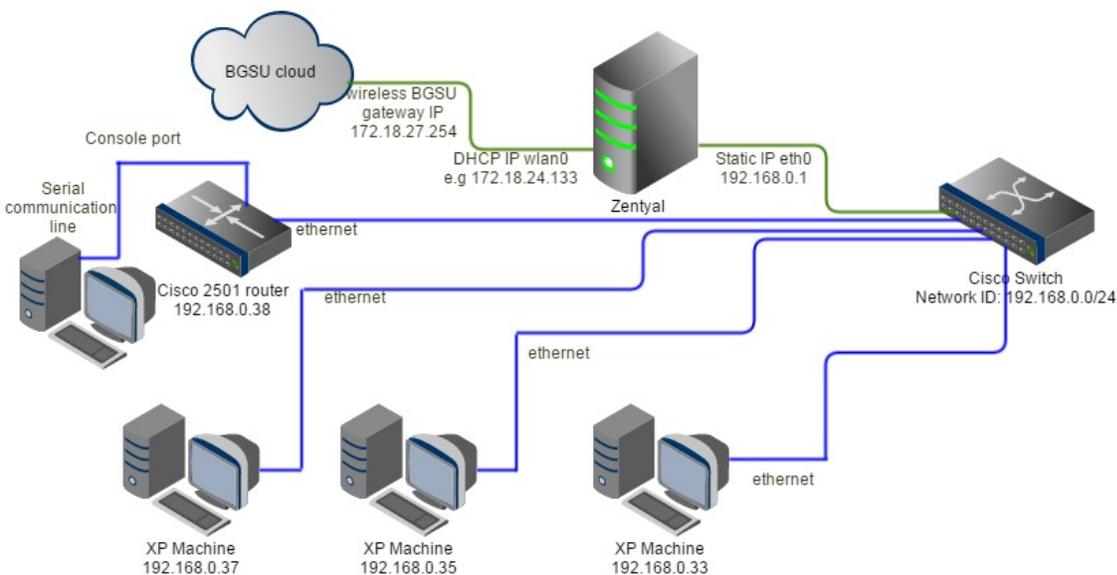


Figure 27. The network Diagram

Phase 3 Ensure the network works and also exploring other features of Zentyal

The network routing configuration is tested through various machine terminals with PING commands and also by connecting to the Internet. From the XP machines a PING command was used to test its connection to the 192.168.0.1 gateway. This connection was confirmed good when it returned a full reply was obtained i.e. 100% success. From the Zentyal machine a PING command was also used to test its connection on the wired network 192.168.0.0 and the wireless network 172.18.27.254. A PING command to the wireless network 172.18.27.254 and google website (www.google.com) was also tried from the XP machine and the router. The PING command was used because it verifies that a computer can communicate over the network with another computer or network device. If this command fails, it means that the network has some problems.

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 XP machine 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. Both techniques will be employed.

Chapter 4

Results/Findings

This installation was done using the bootable CD. The Zentyal installer is based on the Ubuntu Server installer. The first step was to select the preferred language and country information, configuration of keyboard and network connection. The wired (LAN) network was set up on the Ethernet 0 interface (eth0).

The hard disk was partitioned then a username and password was created for login and administrative privileges. The machine then rebooted itself. It was observed that the first boot took a long time, this was because it was configuring the system core module.



Figure 28. Installation screenshot

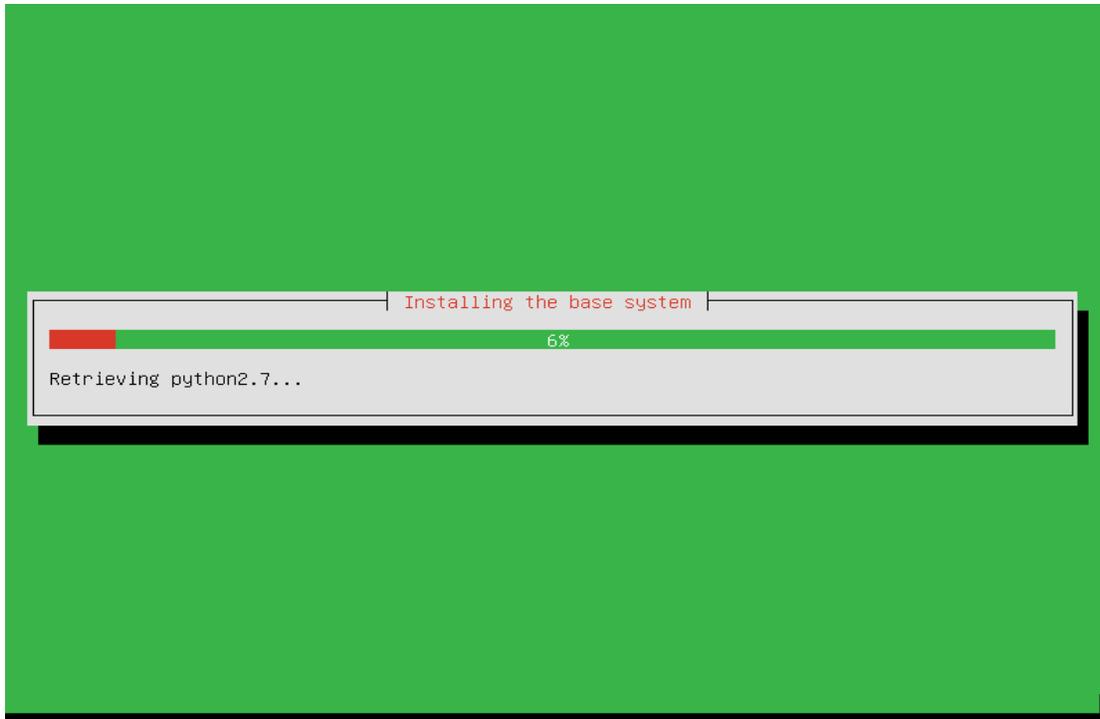


Figure 31. Installation Screenshot 4

The installation time took about 18 minutes to complete. Once the installation was completed the installation CD was removed.

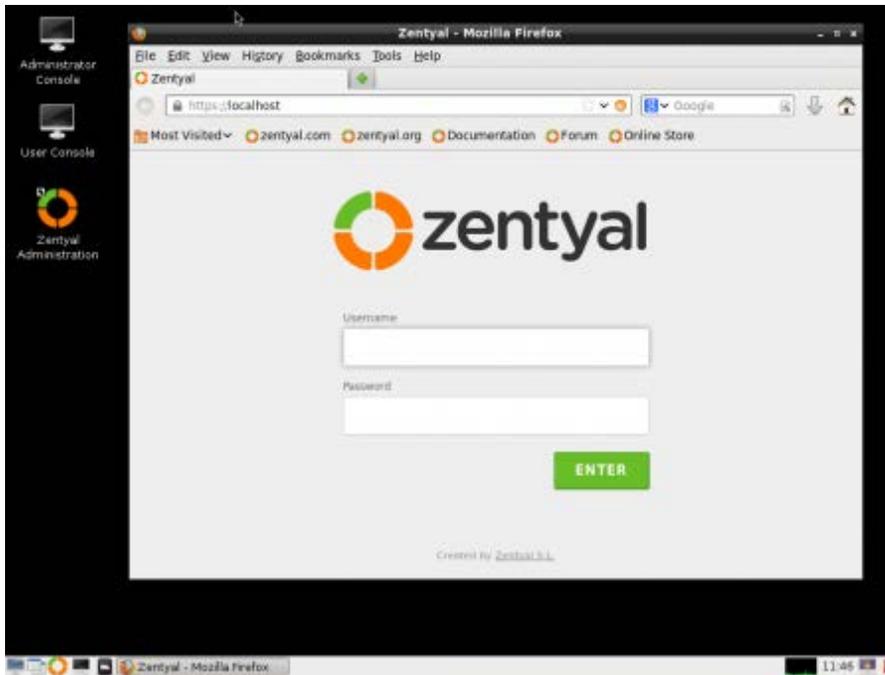


Figure 32. Administrative Interface Screenshot

The figure 32 shows the web administrative interface which requires the username and the password that was previously set.

The figure 33 shows the administrative interface of Zentyal:

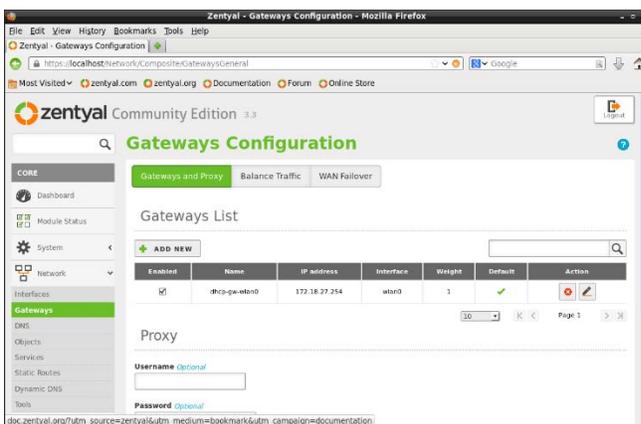


Figure 33. Administrative interface 2

Setting up Networks.

Once the installation was complete, the next phase of the project was to execute networks setup on the computer. A network interface card (NIC) and a wireless network adapter (WNA) needed to be recognized by the system. A number of ways were tried to achieve this.

1. Network Manager Application (generic Linux)

The application aims at making networking simple and straightforward. This was installed using the “*apt-get install*” command.

apt-get: This is a command used in Ubuntu to perform function such as installation of new packages, removal of packages, updating or upgrading existing packages. This is typed in the terminal as shown below:

```
sudo apt-get install –package name
```

```
sudo apt-get remove –package name
```

```
sudo apt-get update –package name
```

```
sudo apt-get upgrade –package name
```

apt-get install network manager installed the network manager on the computer. Note that the *sudo* command was not used to start the command, this is because we logged in as the administrator which made us the super user. The wire network and the wireless network were both seen on the list of network options. However, the problem of this approach was that, the network manager allowed for one connection at a time i.e. either the wireless or

the wired and not both at the same time. Figure 34 shows a network manager interface.

Hence another solution was sought.

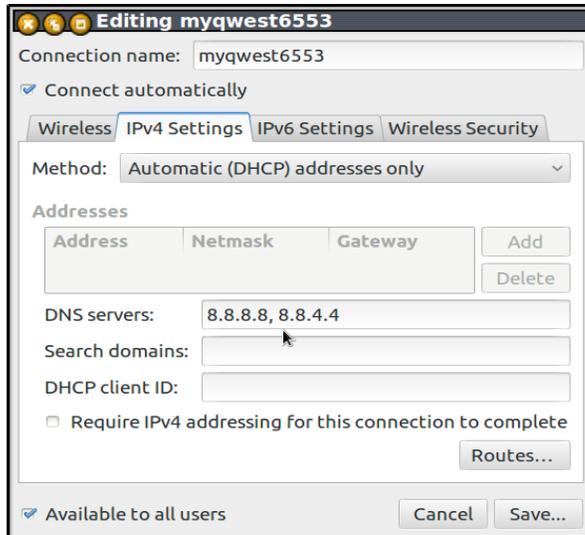


Figure 34 Network Manager interface

2. WICD (Wireless interface connection daemon)

This is another form of network manager. It provides a simple interface connection for Linux. This was option was tried hoping that it will solve the problem encounter with the network manager. However, as in the network manager, it also allowed for only one connection at a time. WICD is shown in figure 35.

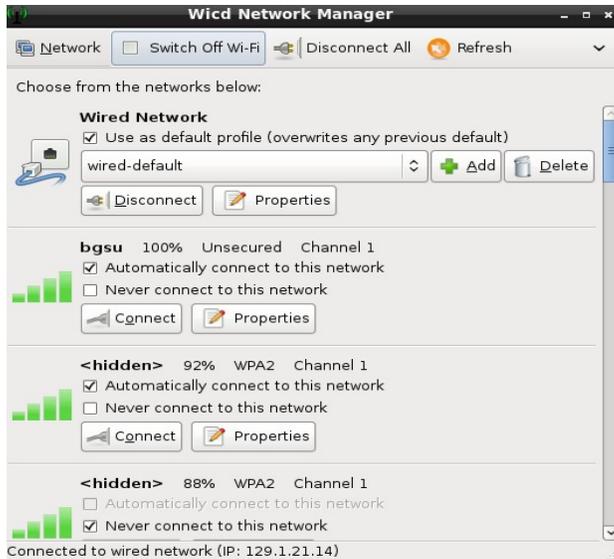


Figure 35 WICD interface

3. WPA-Supplicant

This is a software application that works as a supplicant to Wi-Fi Protect Access (WPA). It is designed as a daemon program that runs in the background and controls the wireless connection. It offers a GUI that simplifies network connection and network status. However, the same difficulty that was also encountered, the application did not support simultaneous functioning of the wireless and wired interfaces. So another method was explored.

Authentication required by wireless network

Passwords or encryption keys are required to access the wireless network 'KTHOPEN-WPA'.

Wireless Security: WPA & WPA2 Enterprise

Authentication: Protected EAP (PEAP)

Anonymous Identity:

CA Certificate: (None)

PEAP Version: Version 0

Inner Authentication: MSCHAPv2

User Name: ahi@kth.se

Password: ●●●●●●

Show password

Cancel Connect

Figure 36 WPA-Supplicant Interface

4. Configuring the Zentyal Network Module

This was done to enable the server act as a gateway; hence two networks have to be running simultaneously on the workstation. This was carried out in two ways;

I. Configuring on the administrator interface through the modules (network module)

The wired connection was setup from here. The interface was name interface *eth0*.

The figure 37 shows an example of this process;

Name	IP address	Netmask	Action
<input type="text"/>	<input type="text"/>	255.255.255.0	

Figure 37 Network interface Screenshot

The gateway is pointed to a wireless access point using *wlan0* interface (a DHCP IP address interface). This module automatically configures the network interface file, see figure 33.

II. Configuring from the terminal.

This involved using commands to carry out the configuration. The network interface file was first configured using *gedit*; a text editor.

#gedit /etc/network/interfaces: this command opened up the network file

The interface was edited as shown below;

auto lo

iface lo inet loopback

#wired network

```
auto eth0

iface eth0 inet static

address 192.168.0.1

netmask 255.255.255.0

gateway 192.168.0.1

#wireless network

auto wlan0

iface wlan0 inet dhcp
```

Note that when the # sign starts a line in an editor, it becomes a comment, hence it is not executed. The wired network was set as static with the IP address specified while the wireless connection was set for DHCP.

In the early part of this project work a default gateway was added to the routing table. 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 work station is trying to reach an address not on its subnet and does not know how to reach it, it goes through the default gateway. A routing table contains a list of specific routing destinations. When a router receives a packet of data, it references the routing table to know where to send that data. The routing table may also contain information on how far each destination can be from the router. In essence, a routing table is a map for the router. A routing table in Linux is shown using *route -n* command. The figure 38 shows a routing table.

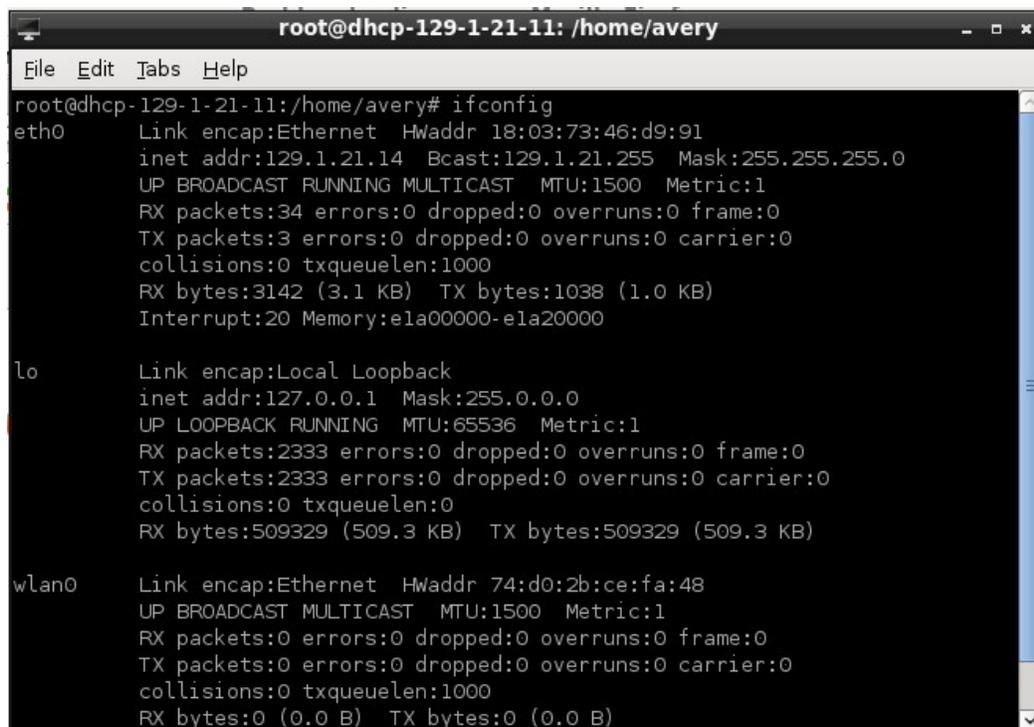


```

[root@Linux_NAT_zebra root]# route -n
Kernel IP routing table
Destination      Gateway         Gennask         Flags Metric Ref    Use Iface
192.168.6.0      0.0.0.0        255.255.255.0  U     0     0     0 eth1
10.0.0.0         0.0.0.0        255.255.255.0  U     0     0     0 eth1
211.72.111.0    0.0.0.0        255.255.255.0  U     0     0     0 eth0
192.168.8.0     0.0.0.0        255.255.255.0  U     0     0     0 eth2
169.254.0.0     0.0.0.0        255.255.0.0    U     0     0     0 eth2
127.0.0.0       0.0.0.0        255.0.0.0      U     0     0     0 lo
0.0.0.0         211.72.111.254 0.0.0.0        UG    0     0     0 eth0
[root@Linux_NAT_zebra root]#

```

Figure 38 Route -n result



```

root@dhcp-129-1-21-11:/home/avery# ifconfig
eth0      Link encap:Ethernet  HWaddr 18:03:73:46:d9:91
          inet addr:129.1.21.14 Bcast:129.1.21.255 Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:34 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:3142 (3.1 KB)  TX bytes:1038 (1.0 KB)
          Interrupt:20 Memory:ela00000-ela20000

lo        Link encap:Local Loopback
          inet addr:127.0.0.1 Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:2333 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2333 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:509329 (509.3 KB)  TX bytes:509329 (509.3 KB)

wlan0    Link encap:Ethernet  HWaddr 74:d0:2b:ce:fa:48
          UP BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

```

Figure 39 Ifconfig result

Figure 39 shows the status of the active interfaces using the *ifconfig* command. The general format of the command syntax used for the rest of the configuration is given as shown in the following:

#route add default gw xxx.xxx.x.xxx interface; this adds an IP address as the default gateway (gw) for the network and also specify the interface to be used.

#route delete default gw xxx.xxx.x.xxx interface; this deletes an IP address as the gateway.

#route add -net 192.168.76.0 netmask 255.255.255.0 dev eth0; adds a route to the network **192.168.76.x** via "**eth0**". The word "*dev*" can be omitted here.

The wireless network is configured as shown below;

Step 1 *#ifconfig wlan0 up*; this brings up the wireless device and set it up to be ready for use.

Step 2 *#iwlist wlan0 scan*; List the available wireless access points. The BGSU network was looked up and the ESSID & frequency copied.

Step 3 *#iwconfig wlan0 essid bgsu freq 2462M*; this command connects with the BGSU network.

Step 4 *#dhclient wlan0*; this obtains an IP address for the machine from the BGSU network.

Step 5 *#route add default gw 172.18.27.254*; this sets the address 172.18.27.254 as the default gateway.

Figure 40 shows the routing table of the server. It also shows the two interfaces and their respective IP addresses.

```

root@dhcp-129-1-21-11: /home/avery
File Edit Tabs Help
TX packets:2333 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:0
RX bytes:509329 (509.3 KB) TX bytes:509329 (509.3 KB)

wlan0    Link encap:Ethernet HWaddr 74:d0:2b:ce:fa:48
         UP BROADCAST MULTICAST MTU:1500 Metric:1
         RX packets:0 errors:0 dropped:0 overruns:0 frame:0
         TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
         collisions:0 txqueuelen:1000
         RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)

root@dhcp-129-1-21-11:/home/avery# ifconfig wlan0 up
root@dhcp-129-1-21-11:/home/avery# iwconfig wlan0 essid bgsu freq 2462M
root@dhcp-129-1-21-11:/home/avery# dhclient wlan0
EBox: status module network:      [ RUNNING ]
root@dhcp-129-1-21-11:/home/avery# route -n
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
129.1.21.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0
172.18.24.0 0.0.0.0 255.255.252.0 U 0 0 0 wlan0
root@dhcp-129-1-21-11:/home/avery#

```

Figure 40 Configuring Wireless interface

Step 5 was later automated from the dashboard of Zentyal, see figure 33. This was done by setting the wireless interface as the default gateway. Hence entering the command *route add default gw 172.18.27.254*, from the terminal, eventually became unnecessary.

Following steps 1-5 successfully configured both the wired and the wireless interface. Following this achievement WPA_supplicant was used for Wi-Fi Protected Access (WPA) authentication. WICD can also be used for the same purpose. Initially the network configuration was tested using figure 26. This was successful. Then the BGSU wireless was connected successfully. The World Wide Web (WWW) was tested using a “ping” command. It was successful, and results are shown in figure 41.

```

root@dhcp-129-1-21-11: /home/avery
File Edit Tabs Help
EBox: status module network: [ RUNNING ]
root@dhcp-129-1-21-11:/home/avery# route -n
Kernel IP routing table
Destination      Gateway          Genmask         Flags Metric Ref    Use Iface
129.1.21.0       0.0.0.0         255.255.255.0  U      0      0      0 eth0
172.18.24.0      0.0.0.0         255.255.252.0  U      0      0      0 wlan0
root@dhcp-129-1-21-11:/home/avery# ping www.google.com
PING www.google.com (74.125.225.112) 56(84) bytes of data.
64 bytes from ord08s08-in-f16.1e100.net (74.125.225.112): icmp_req=1 ttl=55 time
=23.1 ms
64 bytes from ord08s08-in-f16.1e100.net (74.125.225.112): icmp_req=2 ttl=55 time
=12.6 ms
64 bytes from ord08s08-in-f16.1e100.net (74.125.225.112): icmp_req=3 ttl=55 time
=13.3 ms
64 bytes from ord08s08-in-f16.1e100.net (74.125.225.112): icmp_req=4 ttl=55 time
=14.9 ms
64 bytes from ord08s08-in-f16.1e100.net (74.125.225.112): icmp_req=5 ttl=55 time
=15.5 ms
^Z
[1]+  Stopped                  ping www.google.com
root@dhcp-129-1-21-11:/home/avery#

```

Figure 41 Testing wireless interface

Figure 41 shows the commands being ran on the terminal of Zentyal. Furthermore, efforts were made to automate the process of configuring the wireless interface. This was done by creating a script to handle the task. These command was tried;

```
#!/bin/bash
```

```
ifconfig wlan0
```

```
iwconfig wlan0 essid bgsu freq 2462M
```

```
dhclient wlan0
```

The file was saved as `wireless_up` and also given executable permission with the command; ***chmod u+x wireless_u***.

The LAN network (192.168.0.0) was set up by connecting the server to a cisco switch via an ethernet cable. The switch is connected to a router which is connected to XP machines. All these are on the 192.168.0.0/24 network. The network is shown below;

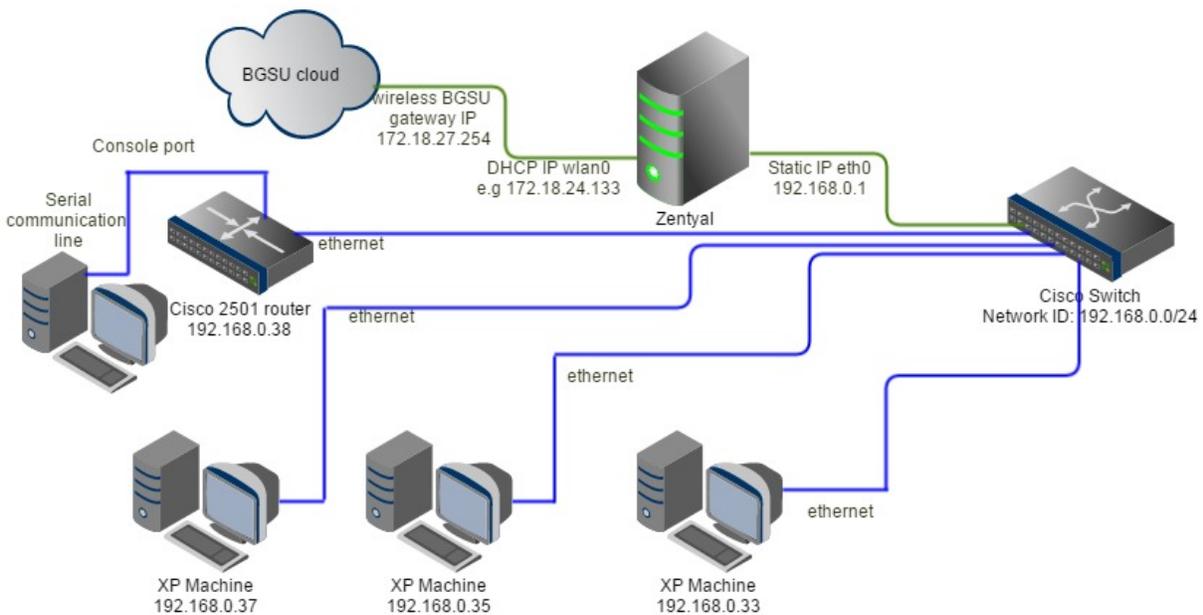


Figure 42 Network diagram

The XP machines were configured to use the 192.168.0.1, 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. The configuration is as shown below:

IP address 192.168.0.33

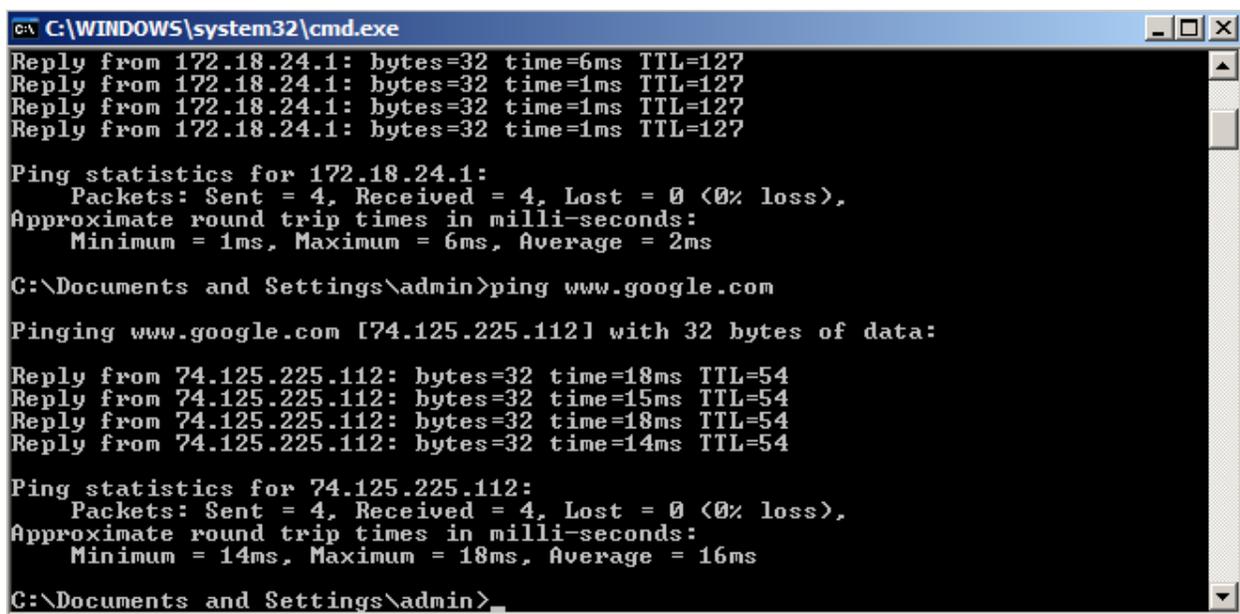
Subnet 255.255.255.0

Default gateway 192.168.0.1

DNS 129.1.2.2

129.1.2.3

On completing the configuration an attempt was made to ping the server from the machine and it reported a 100% success. This is shown in figure 43;



```

C:\WINDOWS\system32\cmd.exe
Reply from 172.18.24.1: bytes=32 time=6ms TTL=127
Reply from 172.18.24.1: bytes=32 time=1ms TTL=127
Reply from 172.18.24.1: bytes=32 time=1ms TTL=127
Reply from 172.18.24.1: bytes=32 time=1ms TTL=127

Ping statistics for 172.18.24.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 1ms, Maximum = 6ms, Average = 2ms

C:\Documents and Settings\admin>ping www.google.com

Pinging www.google.com [74.125.225.112] with 32 bytes of data:

Reply from 74.125.225.112: bytes=32 time=18ms TTL=54
Reply from 74.125.225.112: bytes=32 time=15ms TTL=54
Reply from 74.125.225.112: bytes=32 time=18ms TTL=54
Reply from 74.125.225.112: bytes=32 time=14ms TTL=54

Ping statistics for 74.125.225.112:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 14ms, Maximum = 18ms, Average = 16ms

C:\Documents and Settings\admin>

```

Figure 43 Network test from XP machine

A cisco router was connected to one of the XP machines with the aide of PUTTY, which is an application, and it was assigned an IP address. After the start-up of the Cisco router through putty, the router was changed to privilege mode using the following command;

Router>**enable**

From the privilege mode the following command was type into the computer.

```
Router#config terminal
```

```
Router(config)# hostname Thundercat
```

```
Thundercat#
```

```
Thundercat(config)#interface ethernet0
```

```
Thundercat(config-if)#address 192.168.0.38 255.255.255.0
```

```
Thundercat(config-if)#no shutdown
```

```
Thundercat(config-if)#exit
```

```
Thundercat(config)#ip default-gateway 192.168.0.1
```

```
Thundercat(config)#exit
```

On conclusion of the configuration of the router, ping message was sent to the server, which returned a 100% success. On the other end, the server was used to telnet into thundercat. The figure below shows the terminal of Zentyal during the telnet session. A ping test to the World Wide Web is shown. The router's routing table is also shown.

```

root@dhcp-129-1-21-11: /home/avery
File Edit Tabs Help
thundercatshooooooooo#ping www.google.com
Translating "www.google.com"...domain server (129.1.2.2) (129.1.2.3)
% Unrecognized host or address, or protocol not running.

thundercatshooooooooo#ping www.google.com
Translating "www.google.com"...domain server (129.1.2.2) [OK]

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 74.125.225.177, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/40/44 ms
thundercatshooooooooo#ping www.google.com

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 74.125.225.177, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 36/40/44 ms
thundercatshooooooooo#sh ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is 192.168.0.1 to network 0.0.0.0

C    192.168.0.0/24 is directly connected, Ethernet0
S*   0.0.0.0/0 [1/0] via 192.168.0.1
thundercatshooooooooo#

```

Figure 44 Telnetting Thundercat and Pinging google.

NAT configuration

Network address translation was done by enabling it on the Zentyal dashboard. This setup the network such that all computer on the network were seen as one from the outside world (Internet). This was verified by opening the www.myipaddress.com page on an XP machine. It was observed that all the computers on the network had the same IP address. This feature was successfully tested. The figure 48 shows the XP machine of the laboratory checking its IP address by entering “show my ip” in the google search box.

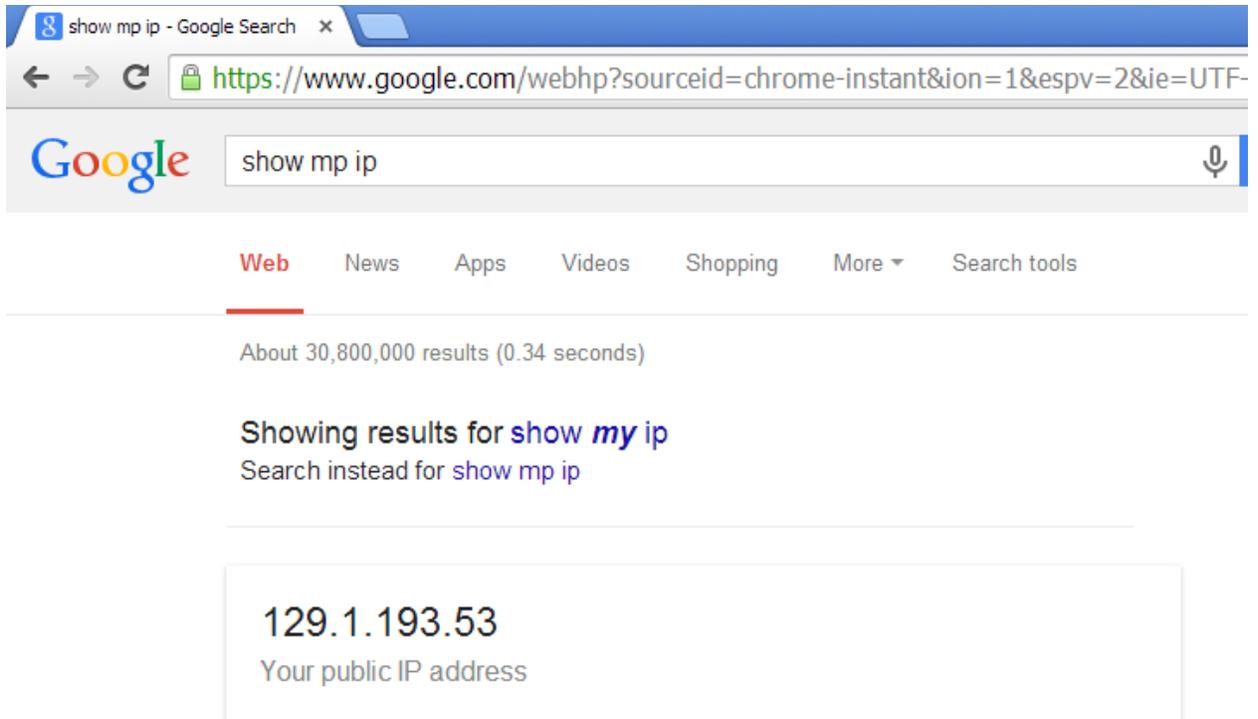


Figure 45. XP machine screenshot

Firewall configuration using packet filter / filtering rules

This was done through the Zentyal dashboard by configuring the packet and also the editing the filtering rule. However this method was not successful due to lack of expertise of its configuration. The option of configuring through the terminal was also explore to set up the firewall.

CHAPTER 5

Summary

Below is an outline of the status of the objectives:

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.
3. The server was configured such that it possess two network interfaces i.e. eth0 and wlan0. Several methods were explored before finally achieving success in this objective.
4. Server was successfully configured as a gateway. It serves as the connection to the Internet for the LAN network i.e. ECET computers.
5. NAT was successfully implemented as feature of Zentyal.

This aim of this project was to install Zentyal OS (server) in the ECET laboratory and set it up as a gateway through which ECET laboratory computers can reach the Internet. From carrying out this project, it was discovered that using a Linux network applications by itself was not able to get both interfaces (wired and wireless) to work simultaneously. The two network cards eventually worked simultaneously by configuration commands through the terminal and a script file was added.

The command line instructions, however, failed to enable the gateway operation. It was necessary to include the firewall module since it caused NAT to work between both the wired and wireless interface cards and therefore enable gateway operation. The whole network was fully functional and contact was established between all devices on the network. NAT was also implemented successfully.

However, the firewall was not successfully setup through the Zentyal dashboard. The terminal configuration of the firewall was performed. However the firewall was not tested. This project succeeded in placing a machine (Zentyal) that has server capabilities, into the network as a gateway but did not enable or test other server functionalities.

DISCUSSION / RECOMMENDATION

The server is functional as a gateway, however some features that were implemented were not successful. The following are my recommendation for future research work;

1. This project has successfully gotten two network interface to work simultaneous but only by configuration through the terminal or script file. Future work could seek to automate this into the boot up process.
2. Although the Zentyal server works perfectly, its reliability is not very high. This is because it sometimes loses connection to the Internet and hence has to be restarted for it to properly function again. The researcher should address this problem by ensuring the wireless adapter is properly installed and functions well.
3. Firewall package was installed and setup through the administrator terminal using the following commands;

#apt-get install ufw

#ufw enable

#ufw status !to check the firewall status

#ufw default deny/allow incoming/outgoing !for general traffic

#ufw allow 22/tcp ! Port setting

#ufw reset ! To reset the firewall to default

However, this was not tested. Therefore, future research should further analyse this and test it. Setting up firewall through the dashboard of Zentyal should also be worked on. This will further improve the server.

4. Research can be performed on other features of Zentyal such as;
 - I. Email server
 - II. Virtual private network
 - III. Intrusion prevention system
 - IV. DNS client
 - V. DHCP server,
 - VI. HTTP proxy

Implementation of these recommendations would further improve the server and make it more reliable. This will also aid the student in understanding their network courses.

References

- Abelson, H., Sussman, G. J., & Sussman, J. (1996). *Structure and interpretation of computer programs* (2nd ed.). Cambridge, MA: MIT Press.
- Asus. (n.d.). *Asus USB N10*. Retrieved from <http://www.asus.com/us/Networking/USBN10/>
- Beal, V. (2014). What is Application Server? Webopedia. Retrieved from http://www.webopedia.com/TERM/A/application_server.html
- Beal, V. (2014). What is Network Address Translation NAT? Webopedia. Retrieved June 2014, from <http://www.webopedia.com/TERM/N/NAT.html>
- Blade-Server :: blade server :: ITWissen.info. (n.d.). Retrieved November 7, 2014, from <http://www.itwissen.info/definition/lexikon/Blade-Server-blade-server.html>
- Choosing the right server*. (2008). Retrieved from http://www.intelinsideidiotoutside.com/images/Choosing_the_Right_Server/5246_hp_choosingsvr.pdf
- Cisco Systems. (1999). *Cisco 2500 series*. Retrieved from <http://www.andovercg.com/datasheets/cisco-2500-series-routers.pdf>
- Cisco. (2000, April 13). *Cisco switch*. Retrieved from http://docstore.mik.ua/univercd/cc/td/doc/product/lan/c2900xl/29_35xp/ig_3500/maoverv.htm
- Cisco. (2006, January 19). *2500 series router*. Retrieved from <http://www.cisco.com/c/en/us/support/docs/routers/2500-series-routers/5750-arch-2500-5750.html>
- Cisco. (2006, January 19). Retrieved from <http://www.cisco.com/c/en/us/support/docs/security-vpn/remote-authentication-dial-user-service-radius/12433-32.html>
- client-server*. (2013, June 20). Retrieved from <http://wiki.squeak.org/squeak/6101>

- Cope, J. (2002, April 8). Peer-to-Peer Network | Computerworld. Retrieved from <http://www.computerworld.com/article/2588287/networking/peer-to-peer-network.html>
- Dell. (n.d.). *dell optiplex 790 Technical guidebook*. Retrieved from <http://www.dell.com/downloads/global/products/optix/en/optiplex-790-tech-guide.pdf>
- Dell. (n.d.). *what is a server?*. Retrieved from http://www.dell.com/downloads/us/bsd/What_Is_a_Server.pdf
- Etegro. (2012, June 15). [Photograph]. Retrieved from <http://www.etegro.com/img/company/news/big/computex-2.jpg>
- Florida center of instructional technology. (2013). Chapter 1: What is a Network? Retrieved from <http://fcit.usf.edu/network/chap1/chap1.htm>
- FunctionX. (2012). Computer Networking - Lesson 6: Introduction to Client/Server Network Setup. Retrieved from <http://www.functionx.com/networking/Lesson06.htm>
- Gartner. (2014, May 28). Gartner Says Worldwide Server Shipments Market Grew 1.4 Percent in the First Quarter of 2014, While Revenue Declined 4.1 Percent. Retrieved from <http://www.gartner.com/newsroom/id/2751519>
- Guarino, J. (2008). *Ubuntu Linux server*. Retrieved from http://www.evolutionaryit.com/presentations/Ubuntu_Linux_Server_Overview_DLSSLUG.pdf
- Hanasd. (2013, February 13). [graph]. Retrieved from <http://kalojanatanasov.files.wordpress.com/2013/02/packetheader.png>
- Harbaugh, L. (2009, February). Choosing the best server OS: Linux vs. Windows comparisons. Retrieved from <http://searchdatacenter.techtarget.com/tip/Choosing-the-best-server-OS-Linux-vs-Windows-comparisons>

- ITWissen. (2014, July 11). *Blade server from IBM* [Photograph]. Retrieved from <http://www.itwissen.info/definition/lexikon/Blade-Server-blade-server.html>
- Janssen, J. (n.d.). What is a Gateway? - Definition from Techopedia. Retrieved June 2014, from <http://www.techopedia.com/definition/5358/gateway>
- Levono. (2013, September 12). *ThinkServer TS140* [Photograph]. Retrieved from <http://www.thinkcomputers.org/lenovo-announces-new-thinkserver-models/>
- Maffeis, S. (1997). *Client/Server Term Definition*. Retrieved from http://www.maffeis.com/articles/research/client_server.pdf
- Microsoft. (2005, January 21). DNS defined: Domain Name System(DNS). Retrieved from [http://technet.microsoft.com/en-us/library/cc787920\(v=ws.10\).aspx](http://technet.microsoft.com/en-us/library/cc787920(v=ws.10).aspx)
- Mitchell, B. (2014). What Is DHCP in Computer Networking? Retrieved August 9, 2014, from http://compnetworking.about.com/cs/protocolsdhcp/g/bldef_dhcp.htm
- Mitchell, B. (n.d.). CAT5 and CAT5e - Category 5 Ethernet Cables. Retrieved from <http://compnetworking.about.com/od/ethernet/g/cat5-cables.htm>
- Neagu, S. (2010, January 5). What Is The Definition Of A Firewall? [Technology Explained]. Retrieved from <http://www.makeuseof.com/tag/technology-explained-what-is-the-definition-of-a-firewall/>
- NetGear. Retrieved from http://www.downloads.netgear.com/files/GDC/WPN311/WPN311_ds_02Feb05.pdf
- Noyes, K. (2010, August 30). Network Security Types of attacks. Retrieved from <http://computernetworkingnotes.com/network-security-access-lists-standards-and-extended/types-of-attack.html>

- OpenBSD. (2014). 1 - Introduction to OpenBSD. Retrieved from <http://www.openbsd.org/faq/faq1.html#WhatIs>
- Proffitt, B. (2009, April 3). What Is Linux: An Overview of the Linux Operating System | Linux.com. Retrieved from <https://www.linux.com/learn/new-user-guides/376-linux-is-everywhere-an-overview-of-the-linux-operating-system>
- Rouse, M. (2005, September). What is file server? - Definition from WhatIs.com. Retrieved from <http://searchnetworking.techtarget.com/definition/file-server>
- Rouse, M. (2014, October). What is proxy server? - Definition from WhatIs.com. Retrieved from <http://whatis.techtarget.com/definition/proxy-server>
- Stallings, W. (1999). *Cryptography and network security: Principles and practice*. Upper Saddle River, NJ: Prentice Hall.
- Stallings, W. (2000). *Data and computer communications*. Upper Saddle River, NJ: Prentice Hall.
- Sullivan, E. (n.d.). Peer to Peer Risk Assessment » G2Link – Business Trust and Reputation. Retrieved from <http://g2link.com/blog/2011/peer-to-peer-risk-assessment/>
- Team, B. (2011, September 14). Client/Server Versus Peer Networks - LAN 101: Networking Basics. Retrieved from <http://www.tomshardware.com/reviews/local-area-network-wi-fi-wireless,3020-2.html>
- TechTerm. (2011, February 19). Web Server Definition. Retrieved from http://www.techterms.com/definition/web_server
- What is proxy server? - Definition from WhatIs.com. (2004, October). Retrieved from <http://whatis.techtarget.com/definition/proxy-server>

- Wheatley, M. (2012, August 29). "Other" Server Makers Gain Ground As IBM, HP, Oracle All Struggle | SiliconANGLE. Retrieved November 7, 2014, from <http://siliconangle.com/blog/2013/08/29/other-server-makers-gain-ground-as-ibm-hp-oracle-all-struggle/>
- Zentyal. (2014, July 21). *Traffic Shaping*. Retrieved from <https://wiki.zentyal.org/wiki/File:En-3.5-images-qos-tasas.png>
- Zentyal. (2014, July 21). *Zentyal firewall*. Retrieved from http://https://wiki.zentyal.org/wiki/File:En-3.5-images-firewall-Zentyal_create_rule.png#filelinks
- Zentyal. (2014, July 21). *ebox radius*. Retrieved from <https://wiki.zentyal.org/wiki/File:En-3.5-images-radius-ebox-radius-01.png>
- Zentyal. (2014, July 21). *firewall sections*. Retrieved from https://wiki.zentyal.org/wiki/File:En-3.5-images-firewall-firewall_sections.png
- Zentyal. (2014, July 23). *installation table*. Retrieved from <https://wiki.zentyal.org/wiki/File:En-3.5-images-intro-zentyal-install-tabla-installation-EN.png>
- Zentyal. (2014, July 21). *internal network* [graph]. Retrieved from <https://wiki.zentyal.org/wiki/File:En-3.5-images-intro-intro1.png>
- Zentyal. (2014, July 21). *proxy general*. Retrieved from <https://wiki.zentyal.org/wiki/File:En-3.5-images-proxy-general.png>