An Integrated System Using Open source Nethserver OS; A Case Study of Kessben University College Local Area Network

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Abstract – **An integrated system refers to a collection of software's on a computer system that provides services to users on a network like a Local area network. These services are used by an organization in their day to day operations. The services include Email, Web service, File sharing, DHCP, DNS, Secure shell, and several others. This research seeks to implement a suite of these applications on a single computer architecture using Kessben University College local area network as a case study. Small and large organizations can benefit from such integrated systems because of reduced operating costs and the provision of an increase in business agility. This paper also proposes and explores additional services like remote network control software using open source Guacamole which is based on HTML5 technology. The advantages of integrated systems go beyond cost. Systems and network administrators will have a single point of system to control and monitor other systems for quality of service. This design ensures an improved network access to the services by implementing strong firewall designed to control inbound and outbound.**

Keywords – **Computers Network and Network Services, Firewall, NethServer Operating System.**

I. INTRODUCTION

Kessben University is one of the private University that is accredited by national accreditation board in Ghana and affiliated to Kwame Nkrumah University of Science and technology (KNUST). Kessben University has several departments and sections. These include but not limited to, Information Technology Services (ITS). The ITS is a host for the Network Operations Centre (NOC). Several computers and or server computers are setup to provide services for the campus. services such as Web service for website publishing, DHCP, DNS, VPN, Firewall, and several others. The demand for server computers is therefore an increase factor as the university develops. An integrated system is therefore a sure solution to minimize infrastructure cost apart from the added advantage of centralized administration. This system will also support a robust firewall that serves as the gateway and defend mechanism to the entire services. Resources in terms of financial capability is limited especially for private organizations or institutions. The modern day computers are also designed to handle several task as a result of multi-core architecture. Moore's law [1] explains how systems multiply in speed every two years. Unified threat management is an essential service for all computer networks. Unified threat management which is abbreviated as UTM and can be said to be an information technology or computer security term referring to a safety or security solution usually at the network level. The UTM can be a single security system that provides several defense mechanisms with the help of a collection of other software packages coming together to act as a whole. The idea behind such security solutions is to deploy using simplicity such that should an organizations have several security solutions from different vendors, the organization could easily choose one UTM that brings all solutions under a single umbrella, with a single administrative support in deploy and day to day administration. In context, UTM can be said to be an

advanced feature firewall system which is added to the user services, so that they will all be running on the same computer hardware

Research Problems

For a young institution like Kessben university, the request for electronic services rises progressively as the university grows. an increase in the number of students or staff, will call for enterprise level services like Email service run by a server computer, File and printer Server, virtual private network (VPN). These services will keep adding up, and will increase expenses of the University. System administrators and I.T professionals will also have the huge task of managing every single server either remotely or locally. According to the Moore's Law, computers double up in speed approximately in every two years. This profound law in computing originates way back 1970. As a breakdown, the Moore's law further indicates that the number of transistors on a CPU which is affordable can double in every two years but in different form.

Research Questions

In this research paper, the authors seek to ask or address the following questions.

i. What are the technology services needed for university network operation.

ii. How do these services get integrated.

iii. What firewall or UTM feature is needed for security

Objective of the Research

The objectives of this research are:

1. To solve organizations low budget need for a server system.

2. To test how the various services, integrate well in NethServer.

3. Use the firewall or Unified Threat Management (UTM) features to enable secure access to the network.

Significance of the Research

The study can be highly significant to university campuses that operates with fewer users on its campus network as well as small and medium enterprises. The study helps to evaluate capabilities of a hardware and the efficient way to maximize it use. This study also takes into consideration the size of such organization or institution making sure there is no much pressure exerted on the system that takes the role of several services. Lastly, it helps System Administrators centralize their work and manage all the network hardware infrastructures from a common terminal.

II. LITERATURE REVIEW

The focus here is to review the current literature that are relevant to this research. The area of review can be grouped under; Computers, Network, Network softwares or Services, Firewall/UTM, Centos and Nethserver operating system. The relevant literature of each grouping is therefore discussed scholarly to review and add up to the knowledge gathered in this research area.

Types of computers

According to openlearningworld.com [2], the classification for computers may be based on the data they are designed to process or they may be classified according to their size and capabilities. computers are generally defined as electronic devices that accept input, process and therefore produce output. They are generally mathematical in their operation. As human beings understand the human language, computers on the other hand understand the binary language or the computer language which is series or zero's and ones. A computer can either be a Server computer, or Client computer. In a broader sense, we have analogue, digital and hybrid computers. The form factor of a computer can be desktop, laptop, tower, and mobile.

Types of Network and Topology

According to Pandey et. al., [3], in information technology, a computer network is defined as a combination of computers, and or other hardware devices that are connected physically or through a logically means using specialized kind of hardware, equipment and or software to facilitate the sharing of resources in both hardware or software. Thus ensuring information or a resource sharing. Computer networks are usually established by the use of wired or wireless technology. The resources shared among the devices can either be data or another hardware that is found on the network, example a network printer or scanner.

A network [4] can either be server client based or peer to peer where every single device sends and receive resources at the same time. Server client architecture is usually more scalable and efficient for organisations like university campus network. The network topology can also be star, bus, mesh, and hybrid. A typical university network will usually be a hybrid of several other topologies.
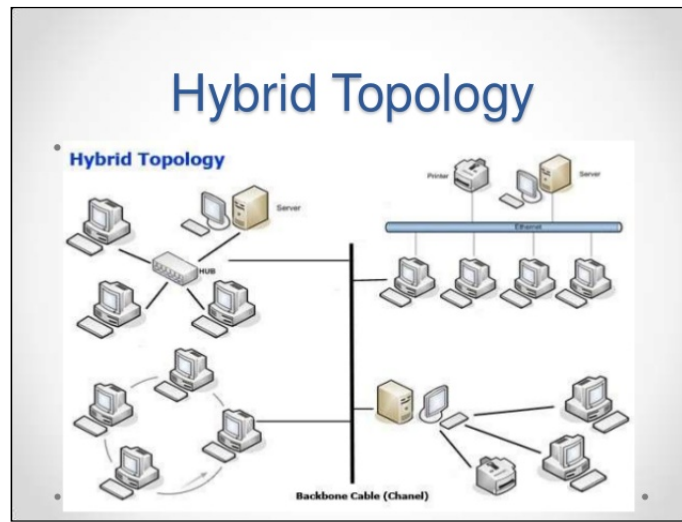

Fig. 1. Hybrid topology Credit: slideshare.net

Network software or Services

Magda [5] explains network services as a term in computing and networking, that represents application or software that runs at the network application layer and can also provide the storage of data, manipulation, presentation, and communication. Each of these services are usually provided by a server or network component that run on either one or more computers systems. This is often designed using a dedicated server system that seeks to offer a multiple services and are accessed through a network by the client components running on other devices. The network services include Domain Name service or server used to translate human readable names into computer readable and vice versa. Dynamic host configurations protocols responsible for assigning IP addresses to client computers on a network. Others include Email, File server, and Active Directory.

Firewall and Unified Threats Management Systems (UTM)

According to Chapman et. al., [6], the most effective and secured way to connect a network and its systems to a public network is by the use of a firewall to ensure security is taken care of. There are various types of firewalls, either software or hardware firewall. An example of a software based firewall is that of Microsoft windows firewall in windows operating systems. Hardware firewalls are however a dedicated box that are controlled with software to provide security. 21th century information security has intensified and hence the need for unified threat management systems which may combine the functionality of a traditional firewall and additional securities like intrusion detection (IDS) and intrusion prevention systems (IPS) among others.

Centos and Nethserver Operating System

CentOS [7] is reported to be a community grade and an enterprise operating system made from popular and secured Linux distributions. Nethserver is provided for free even though it is classified as an enterprise class system because it can match other closed and enterprise grade systems like cisco products in terms of its firewall functionality. It has a well-resourced and community supported computing functionally that can match with its upstream system called Red Hat Enterprise Linux (RHEL), and now CentOs since RHEL went into paid enterprise system. In January 2014, CentOS announced the official joining with Red Hat while staying independent from RHEL. CentOS provides flexibility of integrating several packages and that inform producers of Nethserver OS to choose CentOs. CentOs is fully designed based on RHEL, or can be regarded as a fork of RHEL.

NethServer [8] is a free and open source software that is based on CentOS design logic and uses the concept of all in one Linux server. This is designed especially for small and medium sized businesses and enterprises to cut down infrastructure cost. NethServer can offers a number of modules or software inbuilt and can be used to turn a system into a mail server, web server, domain name system server, file transfer protocol server, a cloud server hosted privately, an intrusion detection and prevention system, Proxy server, samba sever, VPN, etc. Nethserver uses a smart and responsive web based interface for management functionality that simplifies common tasks. NethServer is a very powerful tool with solid and higher end security possibly because of its association with CentOS Linux. It comes with regular security fixes and updates can be found on the official CentOS repositories as well as the Nethserver development website.

III. METHODOLOGY

Introduction

The study was conducted at Kessben University College (KC) located at Kuntanase, Ashanti region. The University is found near Lake Bosomtwe. The university currently runs undergraduate degree programs with approximately three hundred and fifty students. There are three major type of users within the university, Staff, students and guest. Currently there are three schools; the school of Business, the school of physical sciences, and the school of Liberal Art.

Network Infrastructure

The Local Area Network (LAN) infrastructure on KC campus which spans a large area with story buildings. Each building has got a wired network, and all leading to the systems room at the Network Operations centre. There are also wireless access points with the same SSID for easy roaming within the campus which is good for bring your own device (BYOD) concept. Each complex or building takes a network feed over a higher speed uplink such as cat6 or fiber optic for longer distance or resources driven sites. At the NOC, the Internet service provider (ISP) signal is received through a microwave point to point link cap at 4mbps for both upload and download stream. Wifi Spectrum Analyser is used in the analysis of wireless signals to see where signal is weaker and access point is expected to be mounted or a repeater mounted to boost signals. The entire switching is done using cat6 copper cables, with exception of some major fibre optic uplinks. The network runs on ordinary vendor switches like d-link and tp-link. There is however two cisco manageable switches and routers. Signal is received from the outdoor unit (ODU) mounted on about 45 feet tower or mask. The receiving end which is the Indoor unit (IDU) has two network interfaces, the one for outdoor device and the one that goes into the LAN router, thus Nethserver system in this case. The IDU is Airmax brand and it is powered using Power Over Ethernet (POE). The nethserver hardware computer is deployed by using two network interface cards. One for the NIC was used for Wired area network (WAN) connection to the system whiles the other card was used for the Local area network (LAN) connection. WAN interface connects to the LAN of the Airmax Indoor Unit port and the LAN of the Nethserver connects to the main distribution switch at the NOC for switching to start taking place. indications on the Airmax indoor radio unit has IDU, ODU, Link, and service led. A yellow indication means active when powered. the Nethserver system will act as the main gateway and firewall or UTM for the network and also doubles as an active directory server, email server, a dynamic host configurations protocol server, a local DNS server, etc. Nethserver is a Centos based and therefore light in resource consumption.
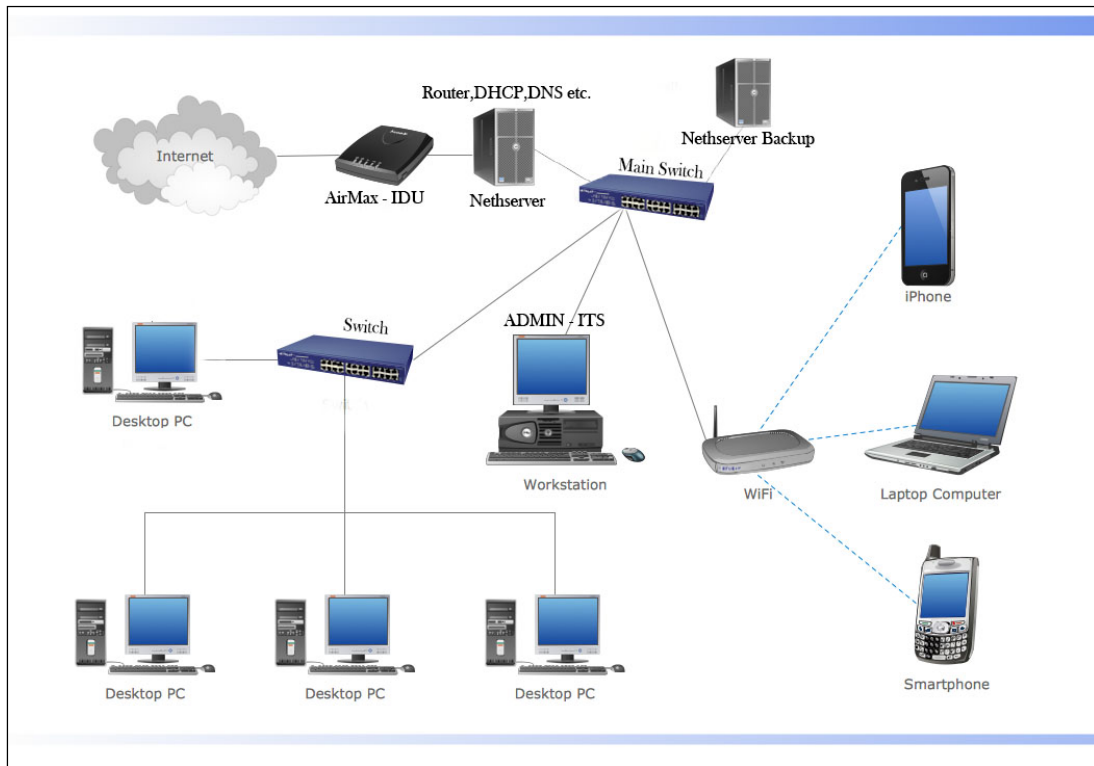
Fig. 2. Kessben College Network Design

Services or features within the Nethserver OS

According to nethserver.org, nethserver is calssified an open source operating system. It is based on another open source project called Centos which was also from RHEL and is a favourite OS for web based systems. The nethserver can either be downloaded from the website as a bundle software or installed from an existing centos system via the terminal commands. key services or features of nethserver version 7 are explained as follows (Jack Wallen) [9] 2017.

Built-in Samba Active Directory Controller

By default, NethServer 7 has Samba Active Directory Controller. This means that, the money spent on acquiring windows server license and renewal can be saved for other purposes. It comes with the native Windows management tools such as RSAT. It also includes AD PowerShell. supports deploying group policies, and Windows workstations can seamlessly join the Active Directory. NethServer 7 also includes the mechanism for centralized account management (multi-site). With support to do authorization against either a local or a remote account as well as do authentication for same accounts using services such as: OpenLDAP, Remote Active Directory through Microsoft or integration of Samba Next cloud, Samba 4 AD Domain Controller, et cetera.

Nextcloud

Nextcloud is a tool or software that is incredibly powerful, flexible, and reliable cloud server. Although Nextcloud is not installed by default, you can install it via the NethServer 7 Software Center.
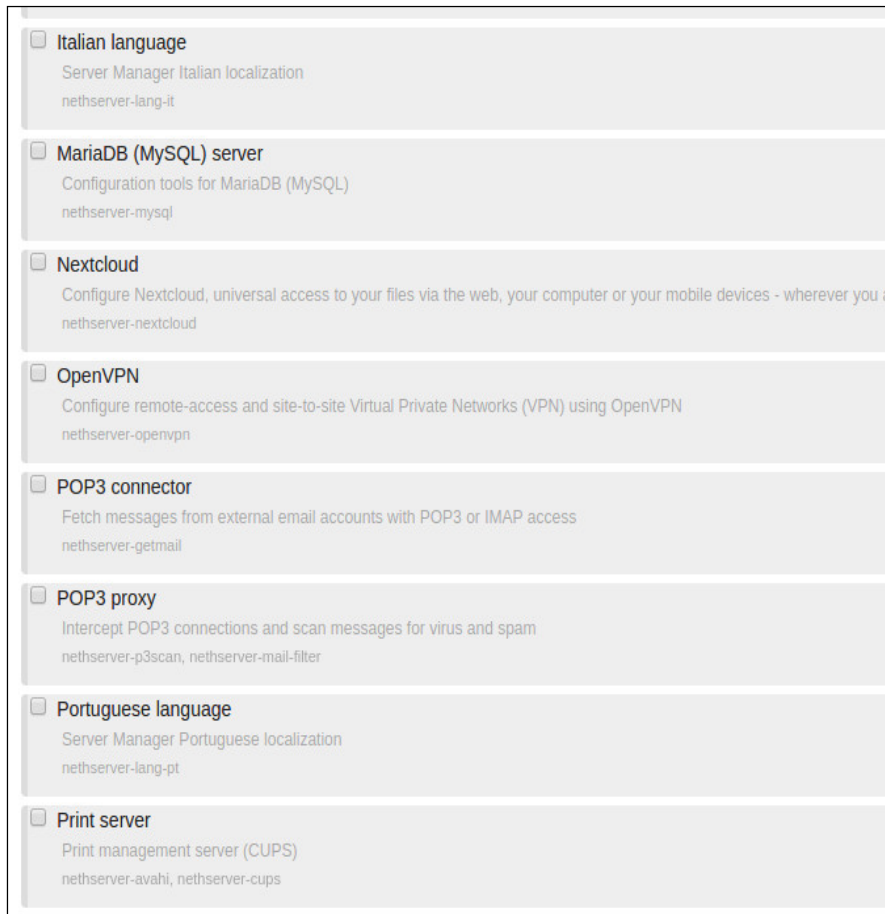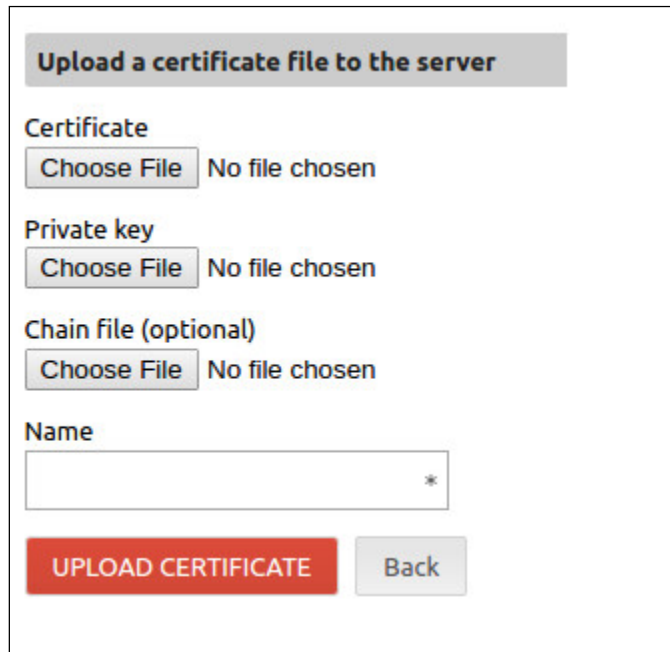
Fig. 3. Installing Nextcloud on NethServer 7. Credit: Nethserver.org

Improved certificate management

For management of a secure socket layer certificate (SSL) for one server or another, NethServer 7 has improved upon that process to make it easy to manage certificates through deep integration of SSL in NethServer installation. The default self-signed certificate can be edited or easily upload a custom certificate that has been purchased from an SSL provider like DigiCert, Sectigo, GlobalSign or ssl.com. The NethServer panel allows for the requesting of secure socket layer certificates.

Fig. 4. Installing SSL. Credit: Nethserver.org

Improved transparent HTTPS proxy

In previous versions of NethServer, Man in The Middle (MITM) feature was used to check encrypted traffic, however in version 7 a lot has changed. This has been substituted with a transparent HTTPS proxy which sniffs out only the start of the connection, in other words, NethServer 7 there will peek at the source of the connection in attempt to discover the website that is to be used as a destination and therefore determines as to blocking or allowing the traffic to flow. Other improvements that come with this include:

It's no longer necessary to install certificates for browsers;

No more untrusted certificate warnings;

No more sniffing for incoming or outgoing information that may be sensitive; and

Filter is applied to websites that may be unwanted using both HTTP and HTTPS connections.

Firewall improvements

The NethServer firewall is greatly improved, with the help of deep packet inspection using nDPI. With this new feature, an administrator can create very granular firewall rules. Imagine being able to easily enforce rules such as only PC A can access website Y, without having to write complex iptables rules. This service is not installed by default. You must go to the Software Center and then install the Basic Firewall and the Deep Packet Inspection application. Once both are installed, firewall rules are easy to create. Add a host object (such as your CEO's PC) and then create a rule around that.
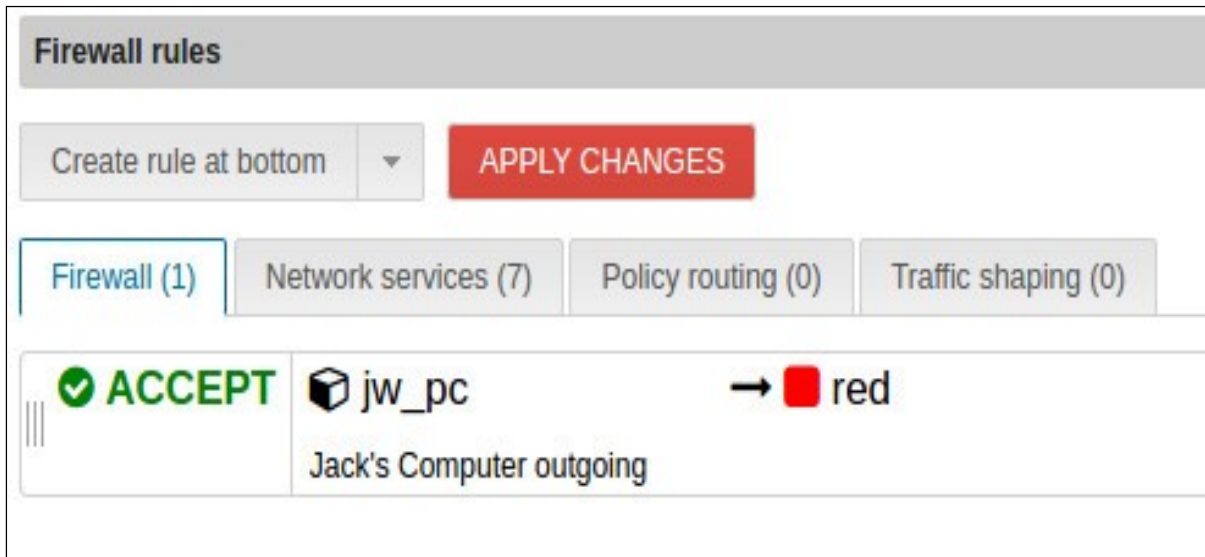
Fig. 5. Firewall rule created around a new host object. Credit: Nethserver.org

Other firewall improvements include: new time conditions, improved interface for traffic shaping, Snort replaced with suricata, reverse proxy added, and Simplified Network service panel includes Zones and new Firewall rules.

Mail server improvements

The NethServer mail server received a number of improvements, including: All users automatically have a valid email address. Shared mailbox support was added (this can be used for distributed lists and/or associated with a custom mail alias). Improved full-text IMAP search; and Improved POP3 connector module.

3.4 Adding Apache Guacamole server to the system

According to Gaucomole.com, Guacamole is an open source remote tool that does not require a client software installation. It uses the web browser as it client after setting up a server that listens to all other computers within a network. This is a good tool for administrators to manage their systems while outside the walls of their work places or office. The tool can be added to the package of Nethserver to further enhance and stretch the functionality. At the CentOS terminal or the console of Nethserver OS, the command executed as follows [10];

1.) The first step is to ensure all prerequisites are installed using the commands in the terminal as follows excluding the quotation marks:

```
yum -y install epel-release wget
wget -O /etc/yum.repos.d/home:felfert.repo
http://download.opensuse.org/repositories/home:/felfert/
Fedora_19/home:felfert.repo

yum -y install cairo-devel freerdp-devel gcc java-1.8.0-
openjdk.x86_64 libguac libguac-client-rdp libguac-
client-ssh libguac-client-vnc \
libjpeg-turbo-devel libpng-devel libssh2-devel libtelnet-
devel libvncserver-devel libvorbis-devel libwebp-devel
openssl-devel pango-devel \
pulseaudio-libs-devel terminus-fonts tomcat tomcat-
admin-webapps tomcat-webapps uuid-devel
```

Fig. 6. command to install prerequisite for Apache Guacamole.

In above command execution, the NethServer system will install and add EPEL and Felfert repositories that contains the files needed, and installing all prerequisites.

2.) Installing Guacamole from source (guacd install)

Apache Guacamole can be delivered in two different approach namely the back end for core administration services, here called guacd (guacamole daemon) and the front end as client. The following command installs the backend.

```
mkdir ~/guacamole && cd ~/ wget
http://sourceforge.net/projects/guacamole/files/current/s
ource/guacamole-server-0.9.9.tar.gz
tar -xzf guacamole-server-0.9.9.tar.gz && cd
guacamole-server-0.9.9
./configure --with-init-dir=/etc/init.d
make
make install
ldconfig
```

The other piece is the guacamole client, or web frontend. This is delivered via Jetty, and installed as follows:

3.) installing guacamole client

```
mkdir -p /var/lib/guacamole && cd /var/lib/guacamole/
wget
http://sourceforge.net/projects/guacamole/files/current/bi
nary/guacamole-0.9.9.war -O guacamole.war
ln -s /var/lib/guacamole/guacamole.war
/var/lib/tomcat/webapps/
rm -rf /usr/lib64/freerdp/guacdr.so
ln -s /usr/local/lib/freerdp/guacdr.so /usr/lib64/freerdp/
```

Once the guacamole server daemon and the guacamole client is installed. The next step is to install MySQL Authentication piece, using MariaDB.

4.) MySQL authentication

```
mkdir -p ~/guacamole/sqlauth && cd
~/guacamole/sqlauth
wget
http://sourceforge.net/projects/guacamole/files/current/e
xtensions/guacamole-auth-jdbc-0.9.9.tar.gz
tar -zxf guacamole-auth-jdbc-0.9.9.tar.gz
wget
http://dev.mysql.com/get/Downloads/Connector/j/mysql
-connector-java-5.1.38.tar.gz
tar -zxf mysql-connector-java-5.1.38.tar.gz
mkdir -p /usr/share/tomcat/. guacamole/{extensions,lib}
mv guacamole-auth-jdbc-0.9.9/mysql/guacamole-auth-
jdbc-mysql-0.9.9.jar
/usr/share/tomcat/.guacamole/extensions/
mv mysql-connector-java-5.1.38/mysql-connector-java-
5.1.38-bin.jar /usr/share/tomcat/.guacamole/lib/
systemctl restart mariadb.service
```

The above is code is for installing Maria dB by downloading the needed.jar's files and moving them to the appropriate directory. All but one jar file is included in the Guacamole MySQL Auth download, which is the MySQL Java Connector.

5.) configure database

```
mysqladmin -u root password MySQLRootPass
mysql -u root -p   # Enter above password
create database guacdb;
create user 'guacuser'@'localhost' identified by
'guacDBpass';
grant select,insert,update,delete on guacdb.* to
'guacuser'@'localhost';
flush privileges;
quit
```

Here we create the database and user for guacd to use.

6.) extend database schema

```
cd ~/guacamole/sqlauth/guacamole-auth-jdbc-
0.9.9/mysql/schema/
cat ./*.sql | mysql -u root -p guacdb   # Enter SQL root
password set above
```

And here we extend the schema of the database we created.

7.) configure guacamole

```
mkdir -p /etc/guacamole/ && vi
/etc/guacamole/guacamole.properties
The above is creating our needed directories, and then
creating the guacamole.properties file. This file is what
tomcat uses to know what port to talk to guacd on as
well as how to access the database. Here is a basic
guacamole.properties file that will do what you need.
# MySQL properties
mysql-hostname: localhost
mysql-port: 3306
mysql-database: guacdb
mysql-username: guacuser
mysql-password: guacDBpass
```

```
# Additional settings
mysql-default-max-connections-per-user: 0
mysql-default-max-group-connections-per-user: 0
```

This will configure guacamole to use the database and user that was created on the default port of 4822. This port is for internal communication only and is not the port that you will be accessing over the web interface.

Finally, symlink has to be created so that Guacamole can find the config file. The command for creating is as bellow:

```
ln -s /etc/guacamole/guacamole.properties
/usr/share/tomcat/.guacamole/
```

8.) Cleanup

```
cd ~ && rm -rf guacamole*
systemctl enable tomcat.service && systemctl enable
mariadb.service && chkconfig guacd on
systemctl reboot
```

When the server boots up, Apache Guacamole will be running and ready. To access the management panel or control panel, open the address http://guac_server_ip:8080/guacamole using a web browser. The default username and password are both 'guacadmin'. To ensure security, the default login credentials must be changed.

(Installation of gaucamole. credit: DeviantEngineer)

IV. FINDINGS AND DISCUSSIONS

The study revealed the following: Results attained from the implementation of Nethserver showed that, higher end computer servers can be used to play a multiple task of servers. Installing several software servers on the same physical server to manage cost in a small and medium organisation, company or institutions. Large corporate organisations can also share services to a distributed systems ensuring maximum use of each computer. A careful analysis of the client computers expected to connect should however be taken into consideration in order not to overkill or overload the random access memory (RAM). A standard i3 or higher end commodity computer can also be used for nethserver installation, though this may be higher than the documentation requirement for Nethserver. the higher specification for the the hardware system, the better.

V. CONCLUSION

In an effort to cut down cost for deploying several services or servers in an organization, one of the top systems that could fit in is Nethserver OS. Before the installation of the various servers on one computer system. The library catalogue system running on koha open source was deployed on a separate computer hardware. The web server and DHCP server also took another computer. This can cause burden on I.T budget for small and medium scale institutions. After installation, there is effective use of hardware resources and the system seems to work very well with no recorded problems. Network access has also been improved using UTM functionality in Nethserver OS.

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